

Inferring Human-elephant Coexistence Based on Characteristics of Human-elephant Interactions in Nangunhe of Yunnan, China

WANG Jiahui¹, CHEN Ying^{1,2}, SUN Yakuan¹, LYU Zhuoluo³, SHI Kun^{1,3}

(1. School of Ecology and Nature Conservation, Beijing Forestry University, Beijing 100083, China; 2. School of Biological Science, The University of Hong Kong, Hong Kong 999077, China; 3. Eco-Bridge Continental, Beijing 100085, China)

Abstract: Human-wildlife conflict (HWC) negatively impacts both humans and wildlife. Attitudes of local residents have been critical in promoting wildlife conservation. It is therefore necessary to understand the characteristics of HWC and identify influential factors on attitudes towards conservation to implement conservation strategies efficiently. This research focused on features of human-elephant interactions, while attitudes and values regarding the small population of Asian elephants (*Elephas maximus*) in Nangunhe National Nature Reserve (NNR), Yunnan, China. The total of 327 valid questionnaires were gathered around the area where Asian elephants were distributed. Logistic regression models were employed to analyze the correlations among five predictor variables ('Area', 'Family size', 'Annual income', 'Quantity of family members in non-primary industries' and 'Experiencing loss or not') and three response variables ('Attitude towards elephants', 'Perception of the values of elephants' and 'Attitude towards tourism development'). The study area was densely forested with tea plants, rubber trees, corns and sugarcane. There, 25.99% of respondents reported the experience of human-elephant conflict (HEC), with crop raiding and cash crop damages being the major conflict types. To demonstrate respect for elephants and to mitigate HEC, a unique custom called 'Giving tribute to elephants' was developed long ago. Respondents' township with an official annual festival of 'Giving Tribute to Elephants' (odds ratio (OR) = 2.75, $P = 1.73 \times 10^{-6}$) and higher annual income (OR = 2.09, $P = 5.45 \times 10^{-5}$) significantly contributed to forming a more positive attitude towards elephants, whereas HEC itself have contributed to a more negative attitude (OR = 0.50, $P = 3.29 \times 10^{-3}$). Therefore, we propose that: 1) reducing human-elephant conflict by testing multiple mitigation measures and adopting the most effective one of them; 2) enhancing local livelihoods through the development of ecological products and ecotourism; and 3) preserving and developing the Wa culture in this region. The study area deserves more attention and further research to explore and obtain endorsement from the public to achieve coexistence between human and wildlife.

Keywords: Asian elephant (*Elephas maximus*); Wa people; human-elephant conflict; coexistence; Nangunhe National Nature Reserve; Yunnan; China

Citation: WANG Jiahui, CHEN Ying, SUN Yakuan, LYU Zhuoluo, SHI Kun, 2023. Inferring Human-elephant Coexistence Based on Characteristics of Human-elephant Interactions in Nangunhe of Yunnan, China. *Chinese Geographical Science*, 33(2): 363–376. <https://doi.org/10.1007/s11769-023-1332-6>

1 Introduction

Demand for food resources and spaces by both humans and wildlife inevitably results in competitions between these two, which may lead to the human-wildlife con-

flict (HWC) (Hart and O'Connell-Rodwell, 2000; Mukeka et al., 2019). Such conflicts not only bring economic losses, but also may result in fatal injuries to local residents (Wang et al., 2017; Han et al., 2018; Bombieri et al., 2019). Moreover, it poses a survival threat to

Received date: 2021-05-17; accepted date: 2021-11-08

Foundation item: Under the auspices of China National Forestry and Grassland Administration, Habitat Assessment and Piloted Maintenance for Asian Elephant (No. NGH-BFU-20180201)

Corresponding author: SHI Kun. E-mail: kunshi@bjfu.edu.cn

© Science Press, Northeast Institute of Geography and Agroecology, CAS and Springer-Verlag GmbH Germany, part of Springer Nature 2023

wildlife and increases their stress levels, possibly influencing their reproductive potentials (Tang et al., 2020). Without appropriate measures, HWC may also cause negative impressions of wildlife and lead to retaliatory killings, thus impeding the conservation projects. Besides, physical competition is not the only reason why HWC occurs and escalates. Attitudes and tolerances towards wildlife vary among different cultures. Culturally-based hostility to wildlife could lead to exaggerated conflict and increased aggression, giving rise to a growth in HWC (Dickman, 2010).

To mitigate HWC and promote wildlife conservation, it is crucial to collect different advice from local people (He et al., 2011) and trace the fundamental causes of HWC in specific regions (Nsonsi et al., 2018). A positive attitude has proved to help promote wildlife conservation (Bennett, 2016). Poverty alleviation has been considered significant in addressing this kind of conflict (Sampson et al., 2019). Income, education level, gender and other socio-demographic factors have also been identified as generating different attitudes towards wildlife (de Pinho et al., 2014; Pant et al., 2016; Neupane et al., 2017; van de Water and Matteson, 2018). However, it seems that attitudes resulting from complex causes can not be fully explained by socio-demographic factors commonly used in published studies (Kansky and Knight, 2014), especially when these same factors led to different results in different regions. While Pant et al. did not find a statistically significant relationship between attitudes and damages caused by Asian elephants (*Elephas maximus*) in Nepal (Pant et al., 2016); a study conducted in Indonesia argued that negative attitudes towards elephants were related to the human-elephant conflict (HEC) (Suba et al., 2017). Given these studies above, it becomes possible to hypothesize that cultures played a significant role in HWC, influencing human participants' attitudes toward wildlife.

HEC has been common in Asian elephant distribution areas and has become a severe issue for local development and elephant conservation. It is usually triggered by residents and elephants' competition for food and habitat (Hart and O'Connell-Rodwell, 2000). Regions closer to protected areas tended to run a greater risk of HEC (Chen et al., 2016; Naha et al., 2019). Most conflicts have caused economic losses, such as crop raiding and damages to plantations (Chen et al., 2016; Pant et al., 2016; van de Water and Matteson, 2018; Dhakal and

Thapa, 2019). Furthermore, intensive ones may pose cultural or mental influences (Dhakal & Thapa, 2019); passivity was often a feeling experienced when facing HEC. Standard methods adopted by human residents to avoid elephant-caused damages involved the hives, ditches, fences, patrolling, smells, fires, noises, guards and shootings, though they rarely showed any long-lasting effects (Nsonsi et al., 2018; Dhakal and Thapa, 2019). While some people do not react at all to such type of conflict (Su et al., 2020), at the other extreme, retaliatory killings of animals by poisonings, electric shocks and shootings have also occurred (Williams et al., 2020). Even if people did not defend themselves in such an extreme way, the faecal glucocorticoid metabolite of elephants increased when they were driven off aggressively by people (Vijayakrishnan et al., 2018) which may also lead to elephants' population decline (Tang et al., 2020). Therefore, it is critical to study the attitudes towards elephants and find positive solutions to HECs.

Attitudes towards elephants are determined by complex factors like intelligence and emotion connections of these species with humans. Averse opinions to elephant conservation often come from negative experiences with elephants. Additionally, people who benefited from elephants are more likely to coexist with elephants friendly (van de Water and Matteson, 2018). Increasing awareness and providing compensation may help reverse negative attitudes caused by previous conflicts, at least partially (Pant et al., 2016). Therefore, when considering the complex issues of HEC, it will be necessary to understand how local people coexist with Asian elephants and what their needs are in conflict cases, to take measures to ensure effective conservation of Asian elephants and promote the inheritance of an environmentally friendly culture.

The Asian elephant population of 221–245 individuals in China consists of five geographical groups divided into class α and class β according to their genetic characteristics (Yang and Zhang, 2012; Zhang et al., 2015). Those in Nangunhe National Nature Reserve (NNR), Yunnan, China are of class β , which has been isolated from other sub-populations since 1997, while other wild elephants in China are of class α , respectively (Zhang, 2006; Yang and Zhang, 2012; Zhang et al., 2015). Their distribution area has shrunk in the past four decades and became highly fragmented (Zhang et al., 2015; Liu et al., 2017). Rubber and tea plantations

have substantially encroached on natural forests (Zhang et al., 2015; Liu et al., 2017). While transportation networks have also resulted in wildlife's habitat fragmentation, which aggravated the isolation of their small populations (Huang, et al., 2020). Some researches have been conducted in Pu'er and Xishuangbanna of Yunnan Province of China on the characteristics of HEC (Guo et al., 2012b; Yu and Tan, 2015; Chen, et al., 2017), risk assessments and predictions (Li et al., 2018), compensations (Chen et al., 2013; Chen et al., 2017) and other factors influencing the local attitudes towards conservation. Previous studies have found that the perceptions and attitudes of local people towards Asian elephants were mainly influenced by their education levels, genders, professions, human-elephant conflicts, and frequency of encountering elephants (He et al., 2011; Su et al., 2020).

In the Nangunhe NNR and surroundings, no specific research on HEC has been carried out yet. When formerly evaluated, there were only 12 individual elephants in the Nangunhe NNR (Tang et al., 2019; Sun et al., 2021). Meanwhile, the leading ethnic group in the Nangunhe NNR and surroundings, Cangyuan County was Wa people. Moreover, both the human and Asian elephant demographics have been quite different from those around the Asian elephant distribution area in Xishuangbanna and Pu'er. It remains largely unexplored about how local people could coexist with elephants in the Nangunhe NNR and surroundings. Therefore, identifying the characteristics of HEC and its mitigation strategy in the Nangunhe NNR and surroundings will be vital to ensure the long-term sustainability of the small, isolated population of Asian elephants. In this study, we designed a questionnaire and interviewed local people in the south-west area of Nangunhe NNR and surroundings. Our objective was to reveal the status of HEC and local culture by investigating factors that may influence the attitudes of local people towards Asian elephants, alongside conservation of tourism development, in order to make proposals for local people to better coexist with Asian elephants, which would bring positive effects on both local communities and the Asian elephant population.

2 Methods

2.1 Study area

The study area was located in the Banlao and Banhong

Townships, where the Asian elephant is distributed in the west area and surroundings of the Cangyuan part of Nangunhe National Nature Reserve (WA-S-CNNR) (98°55'41"E–99°04'48"E, 23°11'16"N–23°19'34"N), Lincang City, Yunnan Province, China. It has an altitude between 640–1451 m. The region below 900 m is of sub-humid monsoon climate in North tropical valley, which is hot and dominated by latosols with strong evaporation. Main crops planted by local people were rice, corn, banana and rubber, with chicken, duck, pig and cattle being the primary livestock (Tang et al., 2015).

Information about Asian elephants' distribution region was extracted from the literature (Liu et al., 2016), officers and rangers of Nangunhe NNR when determining our study area. The 32 settlements nearby or within the distribution region of the Asian elephants (Liu et al., 2016) were chosen to conduct interviews. These settlements belonged to seven villages: Shangbanlao, Yingpan, Xinzhai and Panang of Banlao Township, and Mangku, Nanban and Banhong of Banhong Township. The settlements visited are individually marked on Fig. 1. The two areas (Banlao and Banhong Township) differed in the extent of tourism development and festival celebrations, which encouraged us to investigate whether there were differences in the attitudes of the local people regarding elephants and we, therefore, incorporated 'Area' as a predictor variable in our data analysis.

2.2 Investigation steps

The questionnaire, which categorized family as a unit, was divided into three parts: basic information, status of HEC with attitude towards conservation and resource utilization. In the basic information part, questions were issued about participants' ethnic groups, family size, family annual income, family members' quantity in non-primary industries (primary industries include crop-plantation, forestry, animal husbandry and fishery), main crops cultivated, and primary livestock raised. In the HEC part, respondents were asked if they had seen wild Asian elephants in the past three years and what kind of conflict arose from encountering Asian elephants. Respondents were also inquired if they had used any methods to avoid or reduce their losses caused by conflicts with Asian elephants. If the answer was 'yes', respondents were then asked to further explain the methods they had adopted and other methods they con-

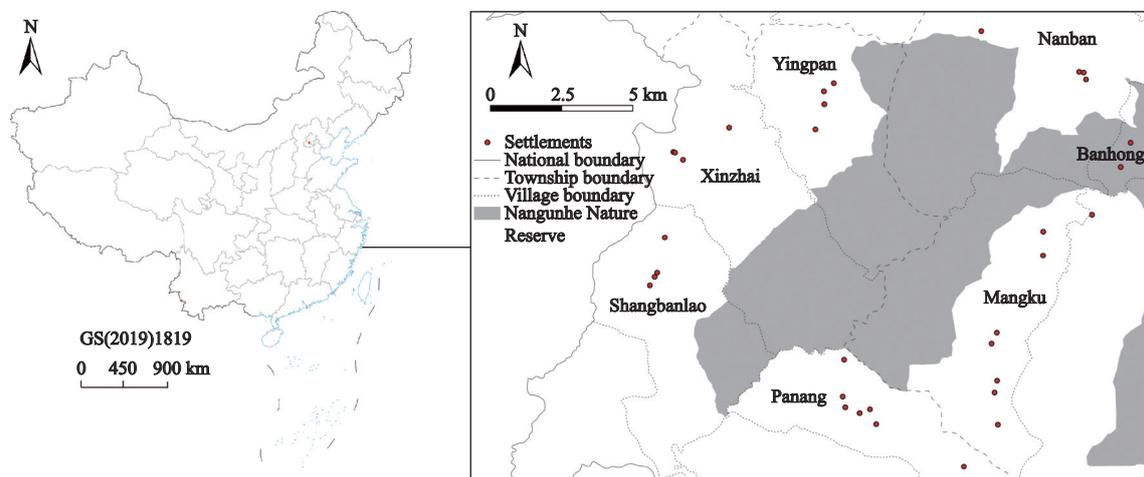


Fig. 1 Location of interviewed settlements in the west area and surroundings of the Cangyuan part of Nangunhe National Nature Reserve, Yunnan, China

sidered adequate. In the part regarding attitudes towards conservation and utilization, we investigated respondents' perceptions towards Asian elephants and the developments of tourism, and what values they perceive in elephants.

The interviews were conducted in October 2018 when researchers were divided into two groups. Each group was assigned with a local ranger to help explain the questionnaire to local people in their local dialect. The number of families interviewed was dependent on the size of the settlement being concerned. If the settlement was a regular rural group (administrative unit in China), we would interview 10 families unless there were not enough ones at home. If the settlement was incorporated by multiple groups with a greater population than one regular group, we would interview 11–20 families there. Respondents were chosen randomly and each one completed a questionnaire. Many people were unable to finish the questionnaire independently due to illiteracy, in which case the researchers would read out the questions with the interpretation of rangers for better understanding. Researchers also communicated more casually with respondents, which provided more information on what they experienced and their customs. New options would be added when respondents gave answers not initially listed in the preset options.

A total of 328 questionnaires were retrieved after the interviews, among which 327 were considered valid. There were 178 valid questionnaires from Banlao Township and 149 valid questionnaires from Banhong Township, respectively.

2.3 Data analysis

Data were logged into Excel 2003 and organized for further analysis in R (R Core Team, 2019). Family annual income, quantity of family members in non-primary industries, attitudes towards elephants, perceptions of elephants' values and attitude towards tourism development were listed in a rank from low to high (Table 1). The rank for positive part of 'Attitude towards elephants' was based on how voluntary the attitude was, and was according to respondents' reason about their positive attitude towards elephants. In our interviews, we questioned 'Why do you think elephants are good?' when respondents said they have positive attitude towards elephants. We found the culturally-motivated respondents introduced their cultures first and told us the positive meanings brought by elephants, while some only attributed to the government and the laws protecting elephants, hence these animals must be good. Therefore, we ranked a lower value for those positive attitudes based on a sense of legal enforcement than those based on cultural values. We ranked the highest score to another positive attitude that referred to the feeling of love towards elephants, without obligation from culture values or regulations from law.

Pearson's Chi-squared test was used in R (R Core Team, 2019) to examine the relationship among 'Area', 'Family size', 'Annual income', 'Quantity of family members in non-primary industries' and 'Experiencing loss or not', which all have a significant correlation with one another (Table 2), indicating that they were not assembled by the same variable combination. A group of

Table 1 The assigned items, options and ranks in the questionnaire for human-elephant interactions in the west area and surroundings of the Cangyuan part of Nangunhe National Nature Reserve, Yunnan, China

Item	Option	Rank
Family annual income	<10000 yuan (RMB) (< 1511.17 US\$)	1
	10000–50000 yuan (1511.17–7555.84 US\$)	2
	50000–100000 yuan (7555.84–15111.68 US\$)	3
	>100000 yuan (> 15111.68 US\$)	4
Quantity of family members in non-primary industries	0	0
	1	1
	2	2
	>2	3
Attitude towards elephants	Very bad (hate elephants and cannot endure to coexist)	1
	Bad (dislike elephants but can tolerate the coexistence)	2
	Somewhat bad (have average attitude towards elephants but think they have no value)	3
	Neutral	4
	Reasonably good (be willing to conserve elephants for being law-abiding)	5
	Good (consider elephants as holy and auspicious animals because of the culture rather than from powerful influences like the government and the laws)	6
	Very good (would like to protect elephants from the heart without any other influence)	7
Perception of the values of elephants	No value	1
	Existence is the only value	2
	Valuable (economic value, cultural value, ecological value, scientific value, etc.)	3
Attitude towards tourism development	It is not achievable	1
	It is achievable but the respondent will not participate in it	2
	It is achievable and the respondent wants to participate in it	3

16 logistic regression models was then applied, each model employing either the zero model or one of the 15 variable combinations (Table 3). There were three response variables: ‘Attitude towards elephants’, ‘Perception of the values of elephants’, and ‘Attitude towards tourism development’.

We used package ‘MASS’ (Venables and Ripley, 2002) in R (R Core Team, 2019) to establish 16 Ordinal Logistic Regression Models (OLRM) for each response

variable. These included models with the 15 variable combinations and a zero model. The package ‘brant’ (Schlegel and Steenbergen, 2020) was used to test if each model met the parallel regression assumption, and if OLRM was suitable for the models that did (Zhao et al., 2009). ‘Parallel regression assumption holds’ were accepted if the *P*-value for the omnibus test was higher than 0.05.

Models that met the parallel regression assumption

Table 2 Correlation of predictor variables used in logistic regression model

<i>P</i> -value	Area	Family size	Annual income	Quantity of family members in non-primary industries	Experiencing loss or not
Area	/	0.63	0.06	0.12	0.19
Family size		/	0.01 **	4.76×10^{-4} ***	0.87
Annual income			/	5.20×10^{-3} ***	0.45
Quantity of family members in non-primary industries				/	0.83
Experiencing loss or not					/

Notes: ** Significant at 1% level; *** Significant at 0.1% level

Table 3 The variable combinations used in the logistic regression models

Sequence number	Variable combination
1	Area
2	Family size
3	Annual income
4	Quantity of family members in non-primary industry
5	Experiencing loss or not
6	Area + Family size
7	Area + Annual income
8	Area + Quantity of family members in non-primary industry
9	Area + Experiencing loss or not
10	Experiencing loss or not + Family size
11	Experiencing loss or not + Annual income
12	Experiencing loss or not + Quantity of family members in non-primary industry
13	Area + Experiencing loss or not + Family size
14	Area + Experiencing loss or not + Annual income
15	Area + Experiencing loss or not + Quantity of family members in non-primary industry

were ranked according to Akaike's Information Criterion (AIC), using the R package 'MuMIn' (Bartoń, 2022). The most representative models were then analyzed further. Among models for 'Attitude towards elephants', the best predictor variable combination was 'Area + Experiencing loss or not + Annual income' (AICc = 941.5, weight = 0.98). However, for the models addressing 'Perception of the values of elephants', while all models met the parallel regression assumption, the weight of the first ranked model was 0.37, so we did not analyze it further. Among models for 'Attitude towards tourism development', four models did not meet the parallel regression assumption and the remainder did not contain a representative model therefore, a Binomial Logistic Regression Model (BLRM) was used to analyze attitude towards tourism development.

We established BLRM for two response variables: 'If people thought tourism development was achievable' (with all data), and 'If people would like to participate in tourism development' (with the data of respondents who thought tourism development achievable). We used the 'GLM' function in R (R Core Team, 2019) to establish 16 BLRMs for each response variable. The 16 models included 15 with variable combinations and a zero model. The parameter of family used was 'binomial'.

We ranked these models using the package 'MuMIn' (Bartoń, 2022).

Among models for 'If people thought tourism development was achievable', the weight of the first model in the rank was 0.19, followed by the zero model. Therefore, we did not do any further analysis. Among models for 'If people would like to participate in tourism development', the best variable combination model was 'Area + Annual income' (AICc = 270.0, weight = 0.61), which we analyzed further.

In further analysis, we calculated the odds ratio (OR) and 95% confidence interval (CI) in combination with *P*-values to assess how predictor variables affect response variables (Kabacoff, 2011).

3 Results

3.1 General attributes of respondents

Nearly all respondents were ethnically Wa people (97.86%, $n = 320$) who have lived in the study area for decades and retained their unique culture.

Families generally consisted of four (27.83%, $n = 91$) or five (24.77%, $n = 81$) members. The biggest family included 10 members (0.31%, $n = 1$) while the smallest included one member (0.92%, $n = 3$). Over half of the interviewed families earned an annual income between 10 000 yuan (RMB) and 50 000 yuan (57.10%, $n = 185$), followed by 126 families (38.89%) earning less than 10 000 yuan per year.

Most families had none family member working in non-primary industries (38.53%, $n = 126$), and the proportion of family decreased as the number of family members working in non-primary industries increased. Most of the interviewed families working in primary industry at various degrees, regardless of whether they engaged in other vocations or not. Only two families' members were not engaged in farming at all, where they were not planting any crops or other plantation, and one of these two families did not raise any livestock. According to the questionnaire, the three most widely-planted crops in both Banlao and Banhong were tea, rubber tree and corn. Those with the largest area planted in Banlao were rubber tree, sugarcane and corn, while in Banhong, the widest were tea, rubber trees and corns. The three livestock species most widely-raised in Banlao and Banhong were chickens, pigs and cattle, which also owned the largest population in these two townships.

3.2 Damages caused by elephants and the strategies of local people against conflicts

Interactions between Asian elephants and local people have been frequent. 17.48% ($n = 57$) of respondents have seen wild elephants in the past three years and 25.99% ($n = 85$) have suffered a loss due to these elephants. Panang suffered the most losses including 57.38% ($n = 35$) of interviewed families, with Mangku following at 39.36% ($n = 37$). There were 15.00% ($n = 6$) interviewed families in Nanban, 12.82% ($n = 5$) interviewed families in Shangbanlao, 4.88% ($n = 2$) interviewed families in Xinzhai which suffered losses caused by elephants over the past three years. None interviewed family experienced human-elephant conflict over the past three years in Yingpan and Banhong. Six types of HEC were reported in the area: crop raiding (71.76% of respondents reported losses, $n = 61$), damages to rubber plantations (28.24%, $n = 24$), damages to tea or coffee plantations (7.06%, $n = 6$), trampling field ridges (3.53%, $n = 3$), increased farming costs (16.47%, $n = 14$) and stepping in fishponds (1.18%, $n = 1$).

Local people have tried to avoid losses by various methods, though yielded little success. Seventy-five families have tested 12 kinds of method to protect their possessions from Asian elephants (Table 4). ‘Giving tribute to elephants’ was one of these methods, as a retained custom of the Wa people. They gave tribute, often sugarcane, bananas or other foods assumably pre-

ferred by elephants in the mountains on certain days every year; some people also paid tributes when elephants came into their fields, hoping these sacred animals would not bring too much losses.

Moreover, since elephants were considered holy and auspicious animals in the study area, some people even stated that they allowed elephants to forage in their fields. This phenomenon appeared to be more common in Banlao than in Banhong Township (Banlao: 16.28%, $n = 28$; Banhong: 2.68%, $n = 4$).

3.3 Respondents’ attitudes towards conservation and utilization

Table 5 illustrates respondents’ individual attitudes towards conservation and utilization. There were 10 kinds of values that respondents thought elephants possessed: value to nature, value to humans, value to the nation, ornamental value, value to research, commercial value, bringing eco-compensation, bringing attention, ivory and leather (some people used them years ago), and faeces as fertilizers (elephants leave faeces after foraging in the fields, which can make good fertilizers).

People’s attitudes towards elephants in Banlao Township were 2.75 times more positive than in Banhong Township, when the other two variables were kept constant (Table 6). However, if people suffered loss due to elephants in the past three years, a worse attitude towards elephants was reported. The degree of people’s

Table 4 Methods adopted by local communities to mitigate human-elephant conflicts in the west area and surroundings of the Cangyuan part of Nangunhe National Nature Reserve, Yunnan, China

Method	Number and percentage / % of people that have used this method	Number and percentage / % of people that think this method is effective
Building normal fences	2 / 2.67	4 / 5.56
Building electric fences	1 / 1.33	0
Digging ditches around the fields	1 / 1.33	0
Cultivating bees	1 / 1.33	0
Lighting up the fields	1 / 1.33	0
Approaching and driving elephants away	2 / 2.67	5 / 6.94
Making big noises	57 / 76.00	29 / 40.28
Threatening elephants by fires	7 / 9.33	5 / 6.94
Threatening elephants by gun noises	1 / 1.33	0
Guarding the field all the time	4 / 5.33	2 / 2.78
Flashlights	5 / 6.67	0
Giving tributes to elephants	17 / 22.67	11 / 15.28

attitudes towards elephants would become two times better if they did not suffer loss due to elephants in the past three years. Higher annual income also contributed to generating a more positive attitude towards elephants. People's attitudes towards elephants were 2.09 times higher if their annual income grew to the next level, given the other two variables were kept constant (Table 6).

The willingness to participate in tourism development was 2.95 times higher in Banhong Township than in Banlao Township. Among those who felt that the development of tourism was feasible, the people of Banhong Township preferred to participate in it. The willingness to participate in tourism development was 3.38 times higher among people with higher annual income

compared to those with lower annual income (Table 7).

4 Discussion

4.1 Status quo of human-elephant coexistence in the WA-S-CNNR

All six types of HEC mentioned in Section 3.2 were related to the primary industries, of which crop raiding, damages to rubber plantations, damages to tea or coffee plantations, trampling field ridges and increased farming costs happened in the farmlands. This result was similar to the findings in other regions. The most common types of conflicts were crop raiding and damages to cash crop plantations across the broader of Asian ele-

Table 5 Respondents' attitudes towards conservation and utilization (number/percentage (%) in the west area and surroundings of the Cangyuan part of Nangunhe National Nature Reserve, Yunnan, China)

Item	Option	Banlao	Banhong
Attitude towards elephants	Very bad (hate elephants and cannot endure to coexist)	1 / 0.56	3 / 2.01
	Bad (dislike elephants but can tolerate the coexistence)	1 / 0.56	4 / 2.68
	Somewhat bad (have average attitude towards elephants but think they have no value)	2 / 1.12	3 / 2.01
	Neutral	16 / 8.99	28 / 18.79
	Reasonably good (be willing to conserve elephants for being law-abiding)	29 / 16.29	48 / 32.21
	Good (considering elephants as holy and auspicious animals because of the culture rather than from powerful influences like the government and the laws)	64 / 35.96	32 / 21.48
	Very good (would like to protect elephants from the heart without any other influence)	65 / 36.52	30 / 20.13
Perception of the values of elephants	Blank	0	1 / 0.67
	No value	4 / 2.25	7 / 4.70
	Existence is the only value	35 / 19.66	37 / 24.83
	Valuable (economic value, cultural value, ecological value, scientific value, etc.)	138 / 77.53	102 / 68.46
Attitude towards tourism development	Blank	1 / 0.56	3 / 2.01
	It is not achievable	14 / 7.87	11 / 7.38
	It is achievable but the respondent will not participate in it	42 / 23.60	17 / 11.41
	It is achievable and the respondent wants to participate in it	119 / 66.85	115 / 77.18
	Blank	3 / 1.69	6 / 4.03

Table 6 The odds ratio (OR), 95% confidence interval (CI), and *P*-value of variables in the best model for 'Attitude towards elephants' in the west area and surroundings of the Cangyuan part of Nangunhe National Nature Reserve, Yunnan, China

Variable	OR	95% CI		<i>P</i> -value
		Lower	Higher	
Area (Banlao)	2.75	1.82	4.18	$1.73 \times 10^{-6***}$
Experiencing loss or not (Yes)	0.50	0.32	0.79	$3.29 \times 10^{-3***}$
Annual income	2.09	1.46	3.00	$5.45 \times 10^{-5***}$

Note: *** Significant at 0.1% level

Table 7 The odds ratio (OR), 95% confidence interval (CI), and *P*-value of variables in the best model for The willingness to participate in tourism development in the west area and surroundings of the Cangyuan part of Nangunhe National Nature Reserve, Yunnan, China

Variable	OR	95% CI		<i>P</i> -value
		Lower	Higher	
Area (Banlao)	0.34	0.17	0.64	$1.18 \times 10^{-3***}$
Annual income	3.38	1.90	6.22	$5.68 \times 10^{-5***}$

Note: *** Significant at 0.1% level

phants' range, such as those in Nepal (Pant et al., 2016), Indonesia (Suba et al., 2017), and Xishuangbanna, China (Chen et al., 2016). Incidents of crop raiding might be ascribed to the fact that these crops were highly nutritious (Dhakal and Thapa, 2019) and there was a lack of food resources due to habitat declines (Su et al., 2020).

Having suffered damage from such conflicts, local people have taken certain measures to reduce their losses; however, these methods were not always cost-effective. Making loud noises with instruments such as drums could scare elephants away, but this method was very labor-intensive. In response, elephants often returned soon after people left, or adjusted their schedules to forage in the field at night. Lighting up fields also seemed useless as elephants might stay nearby and wait until the field became unsupervised again; it has been clear that elephants were only afraid of people rather than the lights in essence. Using fire was slightly more effective as elephants tended to stay away when they sensed the smell of smoke, nevertheless, for a persistent effect, fires needed to be lit continuously, which could be dangerous and impractical. One research reported that setting off firecrackers was effective and frequently applied (van de Water and Matteson, 2018), but similar to fires, it could not be maintained all the time for safety reasons. Another research verified that digging deep ditches around fields or cultivating bees was also useless. Bees were not active during rainfalls or nights (Dhakal and Thapa, 2019). Fences were constructed in some areas in the WA-S-CNNR, with some negative comments from local people that those were again useless; however, there remained some people who believed that fences built by the government could be more helpful. Considering the local measures listed above, setting up fences with a deterring and lasting smells could be worthwhile. Replacing traditional crops with medicinal and aromatic plants might also secure in-

comes and reduce human-elephant conflicts (Gross et al., 2017), which could be a good industry alternative.

Giving 'tribute' to elephants was different from above methods. It gave food to elephants to reduce grain crop loss, maintaining the harmony between local people and elephants. Providing foods for elephants' love was similar to setting up food source bases, which has been proven attractive to elephants and thus reduced the frequency of HECs (Guo et al., 2012a; Li, 2012). However, since this method still enticed elephants who foraged around or in the village when food source bases ran out of food storage, villages nearby actually experienced more losses (Guo et al., 2012a). Giving food to elephants might also raise the chances of conflicts since elephants would come to the fields more often if they became used to being fed. In brief, the central question of what should be inherited from culture and how we could apply these heritages to mitigate HEC, still needs further research.

The tradition of 'Giving Tribute to Elephants' was usually performed when people felt necessary, but there was also an official annual celebration known as the 'Gong Xiang Festival', which has been one of Banlao township's cultural heritages. However, in Banhong, 'Giving Tribute to Elephants' was only known to a selected group of residents, typically the elderly. This tradition shares a great deal with southern Buddhism and Southeast Asian totemism, which regards white elephants as holy and beneficial (Zhang, 2018; Su et al., 2020).

4.2 Influential factors of conservation and utilization

4.2.1 Local culture benefits elephant conservation

The primary distinction of culture between Banlao and Banhong might be the existence of 'Gong Xiang Festival' celebration since their values of family size, annual income, family members' quantity in non-primary in-

dustry, experiencing loss caused or not caused by elephants were similar, and both areas had the story about auspicious elephants.

Customs play a crucial role in this complex situation. More respondents suggested that they genuinely loved elephants or considered elephants as holy and auspicious animals in Banlao Township than those in Banhong Township. People were more likely to mention the ‘Gong Xiang Festival’ and the elephants’ status for their culture based on cultural identity in Banlao instead of policies and laws. In Banhong, more people mentioned the government, nature reserve and laws when talking about the conservation of elephants and some people said elephants ‘must be good’ because they were protected by laws. It seemed that the culture was more influential to people’s perspectives where there was a unique festival ceremony related to elephants. In addition, attitudes in childhood towards animals shaped by parents’ guidance and experience would be retained into adulthood (Brom et al., 2020). We believe that respondents’ attitudes towards elephants in this research can also be seen from the same angle. Therefore, the power of their culture should be taken into consideration.

Furthermore, this environmentally-friendly value of traditional culture has helped people build up their sense of responsibility to conservation and improved their tolerance of HEC (Suba et al., 2017). Elephants are highly regarded in Buddhism, particularly in Southern Buddhism, and elephants represent good fortune in traditional Chinese culture (Cha, 2012). This culture may be helpful for people’s tolerance of the north dispersion of elephants in Yunnan that occurred from 2020 to 2021 (Xinhua News Agency, 2021).

However, some might devalue their traditions under the influence of modern education, thus act less environmentally-friendly than their elders (de Pinho et al., 2014). In our survey, one young man expressed his view that what the elders complied with was superstitious: elephants were not holy at all. The respect for elephants may seem to disappear following the loss of traditions. Facing this, we need to contemplate how to inherit and develop environmentally-friendly traditions with carrying forward the core spirit, for which both profound research and long-term practice become necessary. Furthermore, other evidences showed that villages or people who participated in conservation projects held a more positive view of elephants (Nsonsi et al., 2018;

van de Water and Matteson, 2018), and this can be important attributes contributed to the value of culture. Promoting conservation or eco-tourism projects to local people as the carrier of the development of environmentally-friendly culture should be a valuable objective.

4.2.2 Other influential factors in elephant conservation

People who suffered losses in HEC were more likely to have more negative attitudes towards elephants in our study area. Although this may differ among regions, a study in Nepal did not find significant correlation between HEC level and people’s attitudes towards elephants (Pant et al., 2016). Furthermore, HEC might impose a negative psychological influence on locals, as verified in another region (Dhakal and Thapa, 2019). A negative psychological impact cannot be fully compensated through solely financial means. Intensive conflicts could even affect the culture sometimes (Suba et al., 2017; Dhakal and Thapa, 2019). On the other hand, people became more likely to coexist with Asian elephants and more willing to help protect them if there was already a lower conflict rate (He et al., 2011), so HEC needs to be nipped in the bud.

Families with higher incomes were found to generate better attitudes towards elephants. This finding was consistent with results from researches in Nepal (Neupane et al., 2017) and Thailand (van de Water and Matteson, 2018). Annual income could better explain attitudes toward elephants than the quantity of family members employed in non-primary industry, because material wealth from the former was the direct source of a more favorable attitude. One study found that monetary compensation for livestock depredation was one of major drivers of population recovery for Asiatic lions (Jhala et al., 2019). In Botswana, negative attitudes towards wildlife were related to problems with payment of compensation for crop raiding (Mogomotsi et al., 2020). In the period of the Asian elephants’ northward movement within Yunnan from 2020 to 2021, the Chinese government conducted loss assessments and compensated people who suffered losses caused by the dispersing elephants on time. This likely increased people’s tolerance of elephants and promoted coexistence between human beings and elephants. In this study, since all the HEC types belonged to primary industry, in the long term, it would help to reduce HECs by reducing dependence on primary industries and raising incomes through ecotour-

ism development.

However, money could not change what had already been ingrained in people's minds (de Pinho et al., 2014), so the issue in our study turned back to local culture and how it was affected by both the current situations and traditions. Therefore, the more important and urgent matter is to build mitigation measures for preventing human-elephant conflicts and preserving environmentally-friendly traditions in the area.

4.2.3 Factors influencing attitudes towards participation in tourism development

In our data gathering, the term 'ecotourism' was difficult to explain because many people associate tourism with damage to nature and disturbance to the lives of both Asian elephants and the local people. Based on this premise, among people who thought tourism development was achievable, respondents in Banlao Township had a lower willingness to participate in tourism development. Banlao is an area containing fewer tourism projects, and the inhabitants had better attitudes towards elephants. The higher level of uncertainty tourism brought and concern about the environment and wildlife could be the cause of the lower willingness to participate in tourism development. It has been previously reported that the higher the benefit from tourism, the higher is the willingness of the local people in accepting tourism development (Mbaiwa and Stronza, 2011; Sun et al., 2013). Respondents with higher annual income were more willing to participate in tourism development, as they were more likely to support tourism if they thought tourism development could bring a positive impact to the local economy and environment (Lu et al., 2008; Demirovic et al., 2020). Therefore, a community-based management of tourism development could be considered (Mbaiwa and Stronza, 2011).

4.3 Limitations and future expectations

In this research, individual factors like education, age and sex were not considered, which may be the reason why the results of the models could not fully explain the response variables. Further research is required to broaden our perspective by covering all age groups, genders and education levels. Instead of using 'Area' as a variable, culture should be carefully unwrapped into multiple dimensions such as 'If there is a celebration or other physical activities', 'If the respondent heard a story about elephants', and 'If the respondent believed

elephants to be holy animals'. Additionally, the default options may regulate respondents' responses, besides the option to add additional information such as their personal opinions. Then, the nature of this research's data restricted the analytic methods. We felt it more reasonable to leave open questions. In general, the study area deserves more attention and investigation to avoid the limitations mentioned previously.

Based on our research, we suggest three ways which might promote human-elephant coexistence in the WA-S-CNNR: 1) reducing human-elephant conflicts through testing multiple measures of mitigation; 2) enhancing local livelihoods through the developments of ecological products and ecotourism; and 3) preserving and developing the Wa culture.

Numerous mitigation strategies for HEC in the WA-S-CNNR must be tested. Paola Branco and colleagues asserted that all types of experimental fences they have tested (beehive, chili, combination of beehive and chili, and procedural controls) could mitigate HECs outside Mozambique's Gorongosa National Park (Branco et al., 2020), though beehives could not deter elephants from farmlands in Bahundangi, Nepal when it was raining or at nights (Dhakal and Thapa, 2019). In the WA-S-CNNR, stronger fences with smells that elephants dislike, such as chili, should also be tested. Alarm systems and patrolling should also be experimented around agricultural areas in the peak season of HEC. Changing the type of crops is also a good alternative under the guidance of optimal foraging theory (Simon and Fortin, 2020) which requires thorough considerations on both the crops planted and the local plannings of land use.

Local people who could not benefit from the existence of Asian elephants were more inclined to clear out them (van de Water and Matteson, 2018). Therefore, addressing such societal challenges may also help conserve elephants (Sampson et al., 2019). Building environmentally-friendly brands for agricultural products and developing ecological tourism could be implemented synergistically. Rubber trees were an essential source of cash crops for local people, but large areas of their plantations have proved as harmful to the environment (Ning and Qing, 2018). Several plant species, like tea bushes with waters, which grow in these rubber plantations, can transform the area to perform both as plantations and tourist attractions. Previous research has also found that the nutrient contents in soil increased when

chickens were raised in rubber plantations (Yin et al., 2018); this could be a good case for future planning in our study area, since chickens have been raised by most families in this region. Ecological tourism projects oriented on wild elephants have the potential to improve local livelihoods by increasing job opportunities and decreasing residents' reliance on primary industries, thus mitigate HECs and organize support for elephant conservation (He et al., 2011). They could also provide a chance for residents to see and appreciate the beauty of their natural neighbors. It might offer an opportunity to advertise local culture like 'Gong Xiang Festival' for further reducing HECs. Last but not least, the central concept is to deepen and promote the idea that humans can and will coexist with elephants if we make the valid efforts.

5 Conclusions

Practical solutions and actions are in dire need to mitigate the HECs in the WA-S-CNNR, where damages caused by elephants accounted for the losses by 25.99% of residents' livelihoods around the Asian elephants' distribution area. Traditional anti-elephant methods did not exert positive effects, but fences with a repellent and persistent smell should be tested in future research.

Respondents' township with an official annual celebration 'Giving tribute to elephants' ($OR = 2.75$, $P = 1.73 \times 10^{-6}$) and higher annual income ($OR = 2.09$, $P = 5.45 \times 10^{-5}$) contributed significantly to generating more favorable attitudes towards elephants, while HEC have caused more negative attitudes ($OR = 0.50$, $P = 3.29 \times 10^{-3}$). Residents of Banlao Township had a lower overall willingness to participate in tourism development ($OR = 0.34$, $P = 1.18 \times 10^{-3}$); however, a higher annual income contributed to a higher willingness to participate in tourism development ($OR = 3.38$, $P = 5.68 \times 10^{-5}$). Nevertheless, we were unable to ascertain why people believed elephants to be valuable and the influential factor of whether people thought tourism development was achievable or not.

Most respondents thought tourism development was achievable in this area. We thus suggested that developing more ecological tourism projects centered on wild elephants and the environmentally-friendly cultures will not only improve local livelihoods but also lead to the inheritance and blossoming of the Wa culture. Promot-

ing this culture lays a solid foundation for mitigating HECs and enabling people to benefit from elephants. We believe in a more harmonious future for both local people and Asian elephants with a rich cultural heritage and more holistic management measures.

Acknowledgement

The study was jointly conducted by Beijing Forestry University and Eco-Bridge Continental. The authors are grateful to the Second National Survey of Terrestrial Wildlife in China, National Forestry and Grassland Administration of China and Yunnan Forestry and Grassland Administration. We also thank CHEN Deming, LI Yongxiang, YANG Shaobing, WANG Zhisheng, LI Chunlian, LI Zhimin and all other staffs of Nangunhe Nature Reserve Management Bureau for their assistance in our questionnaire survey and fieldwork. We feel appreciative of Jessica G. Vigneron, Leigh-Ann Barran and Liu Dan who also contributed substantially to editing of this manuscript.

References

- Bartoń K, 2022. *MuMIn: Multi-Model Inference*. R package version 1.46.0. Available at: <https://CRAN.R-project.org/package=MuMIn>.
- Bennett N J, 2016. Using perceptions as evidence to improve conservation and environmental management. *Conservation Biology*, 30(3): 582–592. doi: 10.1111/cobi.12681
- Bombieri G, Naves J, Penteriani V et al., 2019. Brown bear attacks on humans: a worldwide perspective. *Scientific Reports*, 9: 8573. doi: 10.1038/s41598-019-44341-w
- Branco P S, Merkle J A, Pringle R M et al., 2020. An experimental test of community-based strategies for mitigating human-wildlife conflict around protected areas. *Conservation Letters*, 13(1): e12679. doi: 10.1111/conl.12679
- Brom P, Anderson P, Channing A et al., 2020. The role of cultural norms in shaping attitudes towards amphibians in Cape Town, South Africa. *PLoS One*, 15(2): e0219331. doi: 10.1371/journal.pone.0219331
- Cha Maoying, 2012. *Research on Elephant Culture of China*. Shaanxi: North West Agriculture and Forestry University. (in Chinese)
- Chen S, Yi Z F, Campos-Arceiz A et al., 2013. Developing a spatially-explicit, sustainable and risk-based insurance scheme to mitigate human-wildlife conflict. *Biological Conservation*, 168: 31–39. doi: 10.1016/j.biocon.2013.09.017
- Chen Wenhui, Wang Meili, Xu Danyun, 2017. Current situation and policy analysis of the loss and compensation caused by the

- Asian elephants in China. *Ecological Economy*, 33(6): 140–145. (in Chinese)
- Chen Y, Marino J, Chen Y et al., 2016. Predicting hotspots of human-elephant conflict to inform mitigation strategies in Xishuangbanna, southwest China. *PLoS One*, 11(9): e0162035. doi: [10.1371/journal.pone.0162035](https://doi.org/10.1371/journal.pone.0162035)
- Demirovic D, Radosavac A, Cimbalevic M et al., 2020. Determinants of residents' support for sustainable tourism development: implications for rural communities. *Sustainability*, 12(22): 9438. doi: [10.3390/su12229438](https://doi.org/10.3390/su12229438)
- de Pinho J R, Grilo C, Boone R B et al., 2014. Influence of aesthetic appreciation of wildlife species on attitudes towards their conservation in Kenyan agropastoralist communities. *PLoS One*, 9(2): e88842. doi: [10.1371/journal.pone.0088842](https://doi.org/10.1371/journal.pone.0088842)
- Dhakal B, Thapa B, 2019. Residents' perceptions of human-elephant conflict: case study in Bahundangi, Nepal. *Environment, Development and Sustainability*, 21(1): 461–481. doi: [10.1007/s10668-017-0047-1](https://doi.org/10.1007/s10668-017-0047-1)
- Dickman A J, 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human-wildlife conflict. *Animal Conservation*, 13(5): 458–466. doi: [10.1111/j.1469-1795.2010.00368.x](https://doi.org/10.1111/j.1469-1795.2010.00368.x)
- Gross E M, Drouet-Hoguet N, Subedi N et al., 2017. The potential of medicinal and aromatic plants (MAPs) to reduce crop damages by Asian elephants (*Elephas maximus*). *Crop Protection*, 100: 29–37. doi: [10.1016/j.cropro.2017.06.002](https://doi.org/10.1016/j.cropro.2017.06.002)
- Guo Xianming, He Qingcheng, Wang Lanxin et al., 2012a. Effects of Asian elephant food source base on the mitigation of human-elephant conflict in Xishuangbanna of Yunnan Province, Southwest China. *Chinese Journal of Ecology*, 31(12): 3133–3137. (in Chinese)
- Guo Xianming, Yang Zhengbin, Wang Lanxin et al., 2012b. Causes and mitigating strategies for human-elephant conflicts in Xishuangbanna prefecture. *Forest Inventory and Planning*, 37(2): 103–108, 126. (in Chinese)
- Han Xufang, Zhang Ji, Cai Ping et al., 2018. The status and characteristics of, and solutions to, human-Tibetan brown bear conflicts in the Qinghai Province. *Acta Theriologica Sinica*, 38(1): 28–35. (in Chinese)
- Hart L A, O'Connell-Rodwell C E, 2000. *Human Conflict with African and Asian Elephants and Associated Conservation Dilemmas*. USA: Center for Animals in Society in the School of Veterinary Medicine and Ecology Graduate Group, The University of California, 1–14.
- He Qingcheng, Wu Zhaolu, Zhou Wai et al., 2011. Perception and attitudes of local communities towards wild elephant-related problems and conservation in Xishuangbanna, southwestern China. *Chinese Geographical Science*, 21(5): 629–636. doi: [10.1007/s11769-011-0499-4](https://doi.org/10.1007/s11769-011-0499-4)
- Huang C, Li X Y, Hu W Q et al., 2020. Predicting indirect effects of transportation network expansion on Asian elephants: implications for environmental impact assessments. *Biotropica*, 52(1): 196–202. doi: [10.1111/btp.12726](https://doi.org/10.1111/btp.12726)
- Jhala Y V, Banerjee K, Chakrabarti S et al., 2019. Asiatic Lion: Ecology, economics, and politics of conservation. *Frontiers in Ecology and Evolution*, 7: 312. doi: [10.3389/fevo.2019.00312](https://doi.org/10.3389/fevo.2019.00312)
- Kabacoff R I, 2011. *R in Action: Data Analysis and Graphics with R*. Shelter Island: Manning Publications Co, 317–323.
- Kansky R, Knight A T, 2014. Key factors driving attitudes towards large mammals in conflict with humans. *Biological Conservation*, 179: 93–105. doi: [10.1016/j.biocon.2014.09.008](https://doi.org/10.1016/j.biocon.2014.09.008)
- Li W W, Liu P, Guo X M et al., 2018. Human-elephant conflict in Xishuangbanna Prefecture, China: Distribution, diffusion, and mitigation. *Global Ecology and Conservation*, 16: e00462. doi: [10.1016/j.gecco.2018.e00462](https://doi.org/10.1016/j.gecco.2018.e00462)
- Li Zhongyuan, 2012. Effects of Asian elephant food source bases on alleviating human-elephant conflict. *Forest Inventory and Planning*, 37(5): 81–84. (in Chinese)
- Liu P, Wen H, Lin L et al., 2016. Habitat evaluation for Asian elephants (*Elephas maximus*) in Lincang: conservation planning for an extremely small population of elephants in China. *Biological Conservation*, 198: 113–121. doi: [10.1016/j.biocon.2016.04.005](https://doi.org/10.1016/j.biocon.2016.04.005)
- Liu P, Wen H, Harich F K et al., 2017. Conflict between conservation and development: cash forest encroachment in Asian elephant distributions. *Scientific Reports*, 7: 6404. doi: [10.1038/s41598-017-06751-6](https://doi.org/10.1038/s41598-017-06751-6)
- Lu Song, Zhang Jie, Li Donghe et al., 2008. Comparison of resort residents' perceptions and attitudes: Case studies in Xidi Village and Jiuzhaigou. *Acta Geographica Sinica*, 63(6): 646–656. (in Chinese)
- Mbaiwa J E, Stronza A L, 2011. Changes in resident attitudes towards tourism development and conservation in the Okavango Delta, Botswana. *Journal of Environmental Management*, 92(8): 1950–1959. doi: [10.1016/j.jenvman.2011.03.009](https://doi.org/10.1016/j.jenvman.2011.03.009)
- Mogomotsi P K, Stone L S, Mogomotsi G E J et al., 2020. Factors influencing community participation in wildlife conservation. *Human Dimensions of Wildlife*, 25(4): 372–386. doi: [10.1080/10871209.2020.1748769](https://doi.org/10.1080/10871209.2020.1748769)
- Mukeka J M, Ogutu J O, Kanga E et al., 2019. Human-wildlife conflicts and their correlates in Narok County, Kenya. *Global Ecology and Conservation*, 18: e00620. doi: [10.1016/j.gecco.2019.e00620](https://doi.org/10.1016/j.gecco.2019.e00620)
- Naha D, Sathyakumar S, Dash S et al., 2019. Assessment and prediction of spatial patterns of human-elephant conflicts in changing land cover scenarios of a human-dominated landscape in North Bengal. *PLoS One*, 14(2): e0210580. doi: [10.1371/journal.pone.0210580](https://doi.org/10.1371/journal.pone.0210580)
- Neupane D, Kunwar S, Bohara A K et al., 2017. Willingness to pay for mitigating human-elephant conflict by residents of Nepal. *Journal for Nature Conservation*, 36: 65–76. doi: [10.1016/j.jnc.2017.02.004](https://doi.org/10.1016/j.jnc.2017.02.004)
- Ning Qingtong, Qing Jiao, 2018. Discussion on ecological risk management of natural rubber planting under the principle of protection priority. *State Academy of Forestry Administration Journal*, 17(3): 26–32. (in Chinese)
- Nsonsi F, Heymans J C, Diamouangana J et al., 2018. Perceived human-elephant conflict and its impact for elephant conserva-

- tion in northern Congo. *African Journal of Ecology*, 56(2): 208–215. doi: [10.1111/aje.12435](https://doi.org/10.1111/aje.12435)
- Pant G, Dhakal M, Pradhan N M B et al., 2016. Nature and extent of human-elephant *Elephas maximus* conflict in central Nepal. *Oryx*, 50(4): 724–731. doi: [10.1017/S0030605315000381](https://doi.org/10.1017/S0030605315000381)
- R Core Team, 2019. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. Available at: <https://www.R-project.org/>.
- Sampson C, Leimgruber P, Rodriguez S et al., 2019. Perception of human-elephant conflict and conservation attitudes of affected communities in Myanmar. *Tropical Conservation Science*, 12: 1–17. doi: [10.1177/1940082919831242](https://doi.org/10.1177/1940082919831242)
- Schlegel B, Steenbergen M, 2020. *Brant: Test for Parallel Regression Assumption*. R package version 0.3-0. Available at: <https://CRAN.R-project.org/package=brant>
- Simon R N, Fortin D, 2020. Crop raiders in an ecological trap: optimal foraging individual-based modeling quantifies the effect of alternate crops. *Ecological Applications*, 30(5): e02111. doi: [10.1002/eap.2111](https://doi.org/10.1002/eap.2111)
- Su K W, Ren J, Yang J et al., 2020. Human-elephant conflicts and villagers' attitudes and knowledge in the Xishuangbanna Nature Reserve, China. *International Journal of Environmental Research and Public Health*, 17(23): 8910. doi: [10.3390/ijerph17238910](https://doi.org/10.3390/ijerph17238910)
- Suba R B, van der Ploeg J, van't Zelfde M et al., 2017. Rapid expansion of oil palm is leading to human-elephant conflicts in North Kalimantan Province of Indonesia. *Tropical Conservation Science*, 10: 1–12. doi: [10.1177/1940082917703508](https://doi.org/10.1177/1940082917703508)
- Sun Y, Dela Cruz M J, Min Q et al., 2013. Conserving agricultural heritage systems through tourism: exploration of two mountainous communities in China. *Journal of Mountain Science*, 10(6): 962–975. doi: [10.1007/s11629-013-2632-6](https://doi.org/10.1007/s11629-013-2632-6)
- Sun Y K, Chen Y, Díaz-Sacco J J et al., 2021. Assessing population structure and body condition to inform conservation strategies for a small isolated Asian elephant (*Elephas maximus*) population in southwest China. *PLoS One*, 16(3): e0248210. doi: [10.1371/journal.pone.0248210](https://doi.org/10.1371/journal.pone.0248210)
- Tang Fanglin, Du Fan, Sun Guozheng, 2015. *National Nature Reserve of Nangunhe, Yunnan Province Comprehensive Scientific Investigation Research*. Beijing: China Forestry Publishing House. (in Chinese)
- Tang R C, Li W W, Zhu D et al., 2020. Raging elephants: effects of human disturbance on physiological stress and reproductive potential in wild Asian elephants. *Conservation Physiology*, 8: coz106. doi: [10.1093/conphys/coz106](https://doi.org/10.1093/conphys/coz106)
- Tang Yongjing, Wang Zhisheng, Jiang Guilian et al., 2019. Population dynamics analysis of Asian elephant in Nangunhe River basin. *Forestry Construction*, (6): 97–102. (in Chinese)
- van de Water A, Matteson K, 2018. Human-elephant conflict in western Thailand: socio-economic drivers and potential mitigation strategies. *PLoS One*, 13(6): e0194736. doi: [10.1371/journal.pone.0194736](https://doi.org/10.1371/journal.pone.0194736)
- Venables W N, Ripley B D, 2002. *Modern Applied Statistics with S. Fourth Edition*. New York: Springer. Available at: <https://www.stats.ox.ac.uk/pub/MASS4/>
- Vijayakrishnan S, Kumar M A, Umopathy G et al., 2018. Physiological stress responses in wild Asian elephants *Elephas maximus* in a human-dominated landscape in the Western Ghats, southern India. *General and Comparative Endocrinology*, 266: 150–156. doi: [10.1016/j.yggen.2018.05.009](https://doi.org/10.1016/j.yggen.2018.05.009)
- Wang Bin, Li Wenwen, Xu Lijian et al., 2017. Conflict characteristic of human-elephant and its damage in Mengyangzi natural reserve, Xishuangbanna nature reserve. *Forest Inventory and Planning*, 42(1): 118–123,129. (in Chinese)
- Williams C, Tiwari S K, Goswami V R et al., 2020. *Elephas maximus*. *The IUCN Red List of Threatened Species*. 2020: e.T7140A45818198. Available at: <https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T7140A45818198.en>
- Xinhua News Agency. Wonderful Journey of Elephants: A Record of the Migration of Asian Elephants in Yunnan. 2021-08-31. Available at: http://www.gov.cn/xinwen/2021-08/11/content_5630737.htm. (in Chinese)
- Yang Fan, Zhang Li, 2012. Population genetic structure and population genetic diversity analysis based on mitochondrial DNA of Asian elephant (*Elephas maximus*) in China. *Acta Theriologica Sinica*, 32(2): 90–100. (in Chinese)
- Yin Hongxing, Luo Qing, Xu Zhiping et al., 2018. Poultry under forest affecting the soil nutrients in natural rubber plantations. *Tropical Agricultural Science & Technology*, 41(3): 16–18. (in Chinese)
- Yu Lingjiang, Tan Aijun, 2015. Causes and countermeasures for human-elephant conflicts in Simao, Pu'er. *Shandong Forestry Science and Technology*, 45(2): 74–78. (in Chinese)
- Zhang Li, 2006. Current conservation status of Asian elephant and its research progress in China. *Bulletin of Biology*, 41(11): 1–3. (in Chinese)
- Zhang L, Dong L, Lin L et al., 2015. Asian elephants in China: estimating population size and evaluating habitat suitability. *PLoS One*, 10(5): e0124834. doi: [10.1371/journal.pone.0124834](https://doi.org/10.1371/journal.pone.0124834)
- Zhang Weiguo, 2018. *A Study on the Worship of White Elephants in Myanmar*. Guangdong: Guangdong University of Foreign Studies. (in Chinese)
- Zhao Jinfang, Fan Yueling, Zeng Ping et al., 2009. The parallel line assumption of ordinal logit regression model and its test. *Chinese Journal of Health Statistics*, 26(1): 11–13. (in Chinese)