Research Article

Perception of Biodiversity versus Connection to Nature: Which Can Influence Wildlife Product Consumption in Vietnam?

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Wildlife product consumption (WPC) is a serious conservation challenge for biodiversity loss in Vietnam. A better understanding of socio-demographic factors, connection to nature (CTN) and perception of biodiversity (POB) behind WPC would improve wildlife protection. Using publicly available survey data, a preliminary investigation is conducted to explore the roles of socio-demographic factors, CTN, and POB in WPC. The computational outcomes of Bayesian logistic regressions indicate that POB and CTN are associated with consumption for bush meat, traditional medicine, and skin/leather/fur product, respectively. The structural equation models indicate that CTN mediates the association between POB and WPC. Based on the empirical results, financial penalties are advised to reduce WPC.

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Introduction

Wildlife product consumption (WPC) is a major threat to biodiversity conservation. Illegal wildlife trade has been gaining more and more attention in environmental research (Nijman & Shepherd, 2021; Do et al., 2018; Challender et al., 2015). Bush meat consumption in Africa and southeastern Asia is one of the most powerful drivers of ecosystem failure and biodiversity loss (Machovina et al., 2015). Furthermore, the illegal harvesting of wildlife remains widespread and threatens many species in Vietnam (MacMillan & Nguyen, 2014). Being overharvested for food, medicinal purposes and pets,

Vietnamese box turtle is at risk of extinction (Ly et al., 2011). Javan rhinoceros from Vietnam in 2010 is extinct (Brook et al., 2012; Brook et al., 2014). Till now, tiger product use is relatively pervasive for medicinal purposes in Vietnam (Davis et al., 2020). Moreover, there is high prevalence for the trade in wild animal parts for traditional Asian medicine ingredients in Vietnam (Nguyen & Roberts, 2020). Thus, WPC often leads to biodiversity loss in Vietnam.

Numerous advances in research have revealed that perception of biodiversity (POB) and connection to nature (CTN) are vital in biodiversity conservation. Biodiversity loss is considered to impact CTN negatively (Kaltenborn et al., 2016). Additionally, a study in the field of psychology indicates that persons with biospheric and socio-altruistic values and environmental concern are likely to conduct positive pro-environment behavior (Aguilar-Luzón et al., 2020). A meta-analysis shows that CTN is associated with great engagement in pro-environmental behavior (Whitburn et al., 2020). Also, nature connection has been recognized as an important driver of conservation behavior (Carr & Hughes, 2021). Recently, Nisiforou and Charalambides (2012) have shown that all students with a positive attitude towards biodiversity are willing to engage in environmental behaviour in an undergraduate study. More recently, researchers have showed that CTN can shape positive POB (Bernardo et al., 2021). Thus, POB and CTN could possibly lead to pro-environment outcomes.

Socio-demographic factors play an important role in WPC. Several studies explore the factors in determining bush meat consumption. For example, a study in four West African countries indicates that there are consumption differences between rural and urban areas and between age groups (Luiselli et al., 2019). A study in African savannas concludes WPC is driven by food security, financial value, and inadequate wildlife laws and enforcement (Lindsey et al., 2013). In addition, a study revealed that socio-demographic factors (education, income, and forest dependency) are positively linked to the likelihood of people's supports for management of national park as a protected area (Rahman et al., 2017). Furthermore, proximity to the reserve border might drive convenient traffic (Deng et al., 2015). Additionally, age, education, access to extension services, and amount of benefits are confirmed to be positively and significantly correlated with the willingness to pay to restore church forests (Amare et al., 2016).Thus, published studies to date provide evidence that socio-demographic factors may be confounding factors in the associations of CTN and POB with WPC.

Even though the ecological impacts of WPC have been well studied, social aspects of CTN and POB are still poorly explored. This study aimed to assess CTN and POB associated with WPC in a specific country, by using a questionnaire survey approach.

Literature Review and Main Hypotheses

Cities consists of a large number of highly scattered and disconnected small green spaces. A study in South India demonstrates that small green spaces are critical systems and help support biodiversity in urban place (Swamy et al., 2019). A long-term than contemporary ecological perspective can provide a scientifically defensible basis for conservation decisions (Willis et al., 2007). But, a failure to address social concerns in biodiversity conservation can lead to perceptions of injustice, and hence lead to conservation loss (Lecuyer et al., 2018). Thus, we speculate urban residents would not prefer WPC.

WPC is often considered an indication of species extinction risk. However, there is no strong evidence of a correlation between potential benefits of pro-environmental perspectives and reduction in wildlife protect consumption. Methodologically, a newly-developed nature connectedness measure has been conceptually related measures of environmental values, environmental behaviours, environmental awareness, and time spent in nature (Meis-Harris et al., 2021). An investigation shows that the perceived level of restorativeness of natural environments is associated with the sense of connection to nature and the biophilic quality of the environment (Berto et al., 2018). Thus, we speculate CTN could lead to decreased WPC.

POB is a source and outcome of environmental insecurity, biodiversity declines and social conflict. The crime caused by biodiversity loss is well known but not well understood by the general public (Troumbis et al., 2022). Value orientation has been confirmed as a better predictor than knowledge indicators or social-cultural variables for perceptions of conservation risk and perceived effectiveness of conservation strategies among the general public (McFarlane, 2005). For a biodiversity hotspot, conflicts of importance values between locals and urban residents often can not resist biological loss. For example, a study in residents of Madagascar's Torotorofotsy Protected Area indicates local people's perception of biodiversity risk seriousness associated with illegal biodiversity exploitation hunting may not reflect perceptions of policy-makers (Gore et al., 2016). Obviously, the general public in Vietnam had rich knowledge in conservation biology. Accordingly, the association between CTN and POB is of interest.

Nature connection is important for wellbeing at all ages with significant benefits for urban residents. For instance, a study in Singapore highlight the relationship between nature dose and mental wellbeing is moderated by a nature connection (Oh et al., 2021). In practice, changes in the spatial and temporal impacts of biodiversity offsetting can lead to social inequity and negatively impact people's

well-being (Griffiths et al., 2019). With respect to POB, behavioral outcomes of global perspectives are not the same to those of localized views.Thus, the associations among POB, CTN, and WPC are of global significance.

Here, biodiversity refers to the variety of living species in Vietnam and protects some species from extinction due to human activities. According to Theory of Change, CTN and POB cannot possibly lead to WPC. But, this judgment has been obviously violated in Vietnam. Given the concerns above, understanding the relationships among POB, CTN, and WPC is of importance to the policymakers in Vietnam. How consumers with invariable WPC perceive biodiversity and connect nature may influence biodiversity conservation. Therefore, this study aims to investigate the associations of POB and CTN with WPC. Thus, the hypotheses in this study are:

- Hypothesis 1: POB is associated with WPC.
- Hypothesis 2: CTN is associated with WPC.
- Hypothesis 3: CTN might mediate the association between POB and WPC.
- Hypothesis 4: POB might mediate the association between CTN and WPC.

Methodology

Data source

This study employed publicly available survey data in Vietnam (Nguyen, 2021a). Survey design and validation were published on the website (Nguyen, 2021b). Survey procedure includes three stages. In the first stage, an in-depth semi-structured interview with 38 urban residents in Ho Chi Minh City and Hanoi Capital City during November 15 to December 26, 2020 was conducted in order to design a survey questionnaire. In the second stage, the questionnaire was designed with the six major subsections (WPC, general biodiversity perceptions, biodiversity at home and neighborhood, public park visitation and motivations, national park visitation and motivations, and socio-demographic profiles). In the third stage, data collections were performed through a web-based survey via Google Forms using a snowball sampling strategy. Snowball sampling initiates with a small population of known individuals and expands the sample by asking those initial participants to increase participants in the study. At the beginning of the questionnaire, respondents were required to read and agree with the consent form, which stipulates the research purposes, questionnaire contents, and confidentiality of participants. 200 random participants who completed the questionnaire were given a gift card with

a value ranging from $1 to $10 through their email addresses. Eventually, 581 people got involved in the data collection. In the fourth stage, the raw data were cleaned. In order to ensure the dataset quality, the respondents with inappropriate residency, insufficient age, repeated reporting, simultaneous straight-lining and select-all behaviors were removed. Straight-lining happens when the respondents rush through the survey clicking on the same response every time which is a serious threat to data quality. Eventually, 535 respondents were included in the cleaned dataset.

Main variables

WPC

WPC included bush meat, products for medical treatment, and products made from animal skin/leather/fur. The consumption was reflected by the three questions: "Have you ever eaten bush meat?", "Have you ever used any of the animal bones (monkey, tiger, horse, etc.), bear bile, pangolin scales for medical treatment?", and "Do you have any products made from animal skin/leather/fur?" The response options are no (=0) and yes (=1). The reliability index of WPC in the present study is unacceptable (α = 0.4033). Moreover, the scale has slight inter-rater reliability (Cohen's Kappa coefficient= 0.1657).

POB

POB included potential consequences of biodiversity loss, preventive measures of biodiversity loss, objects affected by biodiversity loss, and contributor to biodiversity loss prevention.

Potential consequences of biodiversity loss

Participants were asked to reply the question: "To what extent do you agree that the following problems are potential consequences of biodiversity loss?" The 13 statements are: environmental pollution (air pollution, water pollution, etc.), climate change, loss of life balance, loss of daily product variety (food, medicine, etc.), negative impacts on economic growth, loss of green space, loss of natural aesthetics, loss of opportunities for nature-based recreation, loss of knowledge about nature, reduction of quality of life, reduction of physical health, reduction of mental health, and reduction of life expectancy. Each of the 13 scale items is rated on a 4-point Likert-type scale (1 =strongly disagree; 4=strongly agree), and higher scores are indicative of higher loss of biodiversity target. Thus, the loss can be grouped by less group (< median=40) and more group ($\geq$ median=40). The reliability index of

potential consequences of biodiversity loss in this sample is excellent (α = 0.9395). According to George and Mallery (2003) and Landis and Koch (1977), the scale has moderate inter-rater reliability (Cohen's Kappa coefficient= 0.4361).

Preventive measures of biodiversity loss

Participants were asked to reply the question: "To what extent do you agree that the following methods are preventive measures of biodiversity loss?" The 9 statements are: species conservation in protected areas, reduction of deforestation and exploitation, environmental law enactment, scientific research, public communication about biodiversity (loss), education about biodiversity (loss), prohibition of illegal wildlife consumption, environmental tax, and donation for biodiversity conservation. Each of the 9 scale items is rated on a 4-point Likert-type scale (1 =strongly disagree; 4=strongly agree), and higher scores are indicative of higher prevention against biodiversity loss. Thus, the prevention can be divided by less group (< median=32) and more group (≥ median=32). The reliability index of preventive measures of biodiversity loss in the present study is excellent (α = 0.9407). Simultaneously, the scale has moderate inter-rater reliability (Cohen's Kappa coefficient= 0.5035).

Objects affected by biodiversity loss

Participants were asked to reply the question: "To what extent do you agree that the following objects are affected by the biodiversity loss" The 4 statements are: my life, my family, my neighborhood, and my city. Each of the 4 scale items is rated on a 4-point Likert-type scale (1 =strongly disagree; 4=strongly agree), and higher scores are indicative of higher impact on biodiversity loss. Thus, the impact can be categorized into less group (< median=12) and more group (≥ median=12). The reliability index of objects affected by biodiversity loss in this sample is excellent (α = 0.9435). Additionally, the scale has substantial inter-rater reliability (Cohen's Kappa coefficient= 0.7122).

Contributors to biodiversity loss prevention

Participants were asked to reply the question: "To what extent do you agree that the following people can contribute to biodiversity loss prevention?" The 5 statements are: myself, my family, people in my neighborhood, government, and international organization. Each of the 5 scale items is rated on a 4-point Likert-type scale (1 =strongly disagree; 4=strongly agree), and higher scores are indicative of higher contribution to biodiversity loss prevention. Thus, the contribution can be categorized into two

groups: less (< median = 17) and more (≥ median = 17). The reliability index of contributors to biodiversity loss prevention in this sample is excellent (α = 0.9385). Moreover, the scale has substantial inter-rater reliability (Cohen's Kappa coefficient= 0.6323).

CTN

Participants were asked to respond to 5 questions on a binary scale (no=0, yes=1) to reflect CTN. These questions are “Is there any plant in your house?”, “Do you have any pet?”, “Does the presence of plants/pets affect the aesthetic of your house?”, “Is there any public park near your house?”, and “If you have chance, are you willing to visit a national park/protected area in the next 12 months?” The reliability index of CTN in our sample is unacceptable (α = 0.2868). Moreover, the scale has slight inter-rater reliability (Cohen's Kappa coefficient= 0.0098).

Socio-demographic factors

Here, socio-demographic factors include age group (18-22, 23-30, 31-40, 41-50, 51-60, > 60 years), gender (0 = female; 1 = male), education level (primary school, secondary school, high school, undergraduate, and post-graduate), and income group (no income, < 5 million VNĐ, 5-10 million VNĐ, 11-15 million VNĐ, 16-20 million VNĐ, 21-30 million VNĐ, and > 30 million VNĐ). For statistical convenience, educational level is categorized into high school and below group (=1, "primary school, secondary school, and high school”) and undergraduate group (=2), and post-graduate (=3). Age group is divided by young group (=1, "18-30 years"), middle group (=2, “31 -50 years "), and older group (=3, " ≥51 years "). Income group is classified by low group (=1, "<10 million VNĐ "), middle group (=2, "11-20 million VNĐ "), and high group (=3, " ≥ 21 million VNĐ ").

Statistical Analysis

A Chi-square test is used to compare group differences between wildlife product consumers. With Stata’s command: catplot, plots of frequencies of categorical data are used to show percents of the categories of general biodiversity knowledge and biodiversity perception as compared to WPC. The associations of items of POB, items of CTN, and socio-demographic factors with items of WPC are performed by Bayesian logistic regression with Stata’s command: bayes: logit. Suppressing constant term, Bayesian logistic regressions of WPC (bush meat, traditional medicine, and skin/leather/fur product) on potential consequences of biodiversity loss, preventive measures of biodiversity loss, objects affected by biodiversity loss, contributor to biodiversity loss prevention, in-house planting,

petting, aesthetic plants/pets affect, public park nearby, national park, gender, age group, educational level, and income group are performed.

With Stata's command: medsem, structural equation models (SEMs) are used to assess the proposed mediating relationships. In the SEMs, latent variables with observable indicators (POB: potential consequences of biodiversity loss, preventive measures of biodiversity loss, objects affected by biodiversity loss, and contributor to biodiversity loss prevention; CTN: in-house planting, aesthetic plants/pets affect, petting, national park/protected area, and public park nearby; WPC: bush meat, products for medical treatment, and products made from animal skin/leather/fur) are combined empirically into a single integrated system. Thus, hypothesized mediating effects can be depicted in Figures 1 and 2. As a post-estimation command, an important advantage of medsem is that it can contribute to complete mediation analysis based on SEMs (with multiple mediators) due to the simultaneous estimation capability.

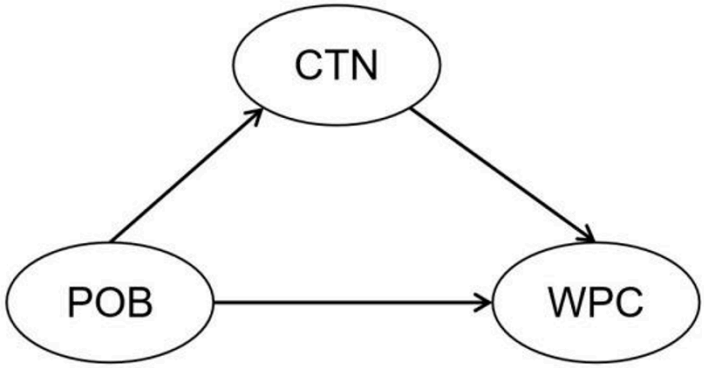

Figure 1. Hypothesized mediating effect of POB on WPC via CTN.

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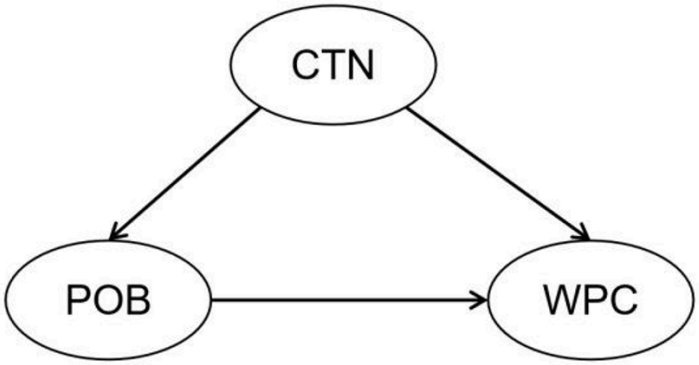

Figure 2. Hypothesized mediating effect of CTN on WPC via POB.

Results

Sample characteristics

There is high prevalence of consumption of bush meat (37.76%), traditional medicine (27.48%), and skin/leather/fur product (19.81%). There are significant differences between bush meat consumption among potential consequences of biodiversity loss, public park nearby, and gender. Simultaneously, there are significant differences between products for medical treatment consumption among petting, age group, educational level, and income group. Meanwhile, there are significant differences between skin/leather/fur product consumption among in-house planting, gender, age group, educational level, and income group. Particularly, most of the sample behaves as green consumers. On the basis of table 1, it is speculated that part of sample from visitors of public park nearby and national park and persons with higher education and higher income prefer WPC.

	Bush meat			Traditional medicine			Skin/leather/fur product		
	No	Yes	Chi-square	No	Yes	Chi-square	No	Yes	Chi-square
Potential consequences of biodiversity loss (n=535)			3.7081*			1.2790			1.5220
Less	32.15	16.26		34.02	14.39		37.76	10.65	
More	30.09	21.50		38.50	13.08		42.43	9.16	
Preventive measures of biodiversity loss (n=535)			2.5606			0.4911			0.7847
Less	28.22	19.81		35.51	12.52		37.76	10.28	
More	34.02	17.94		37.01	14.95		42.43	9.53	
Objects affected by biodiversity loss (n=535)			0.0179			0.1501			0.2382
Less	12.34	7.66		14.21	5.79		15.70	4.30	
More	49.91	30.09		58.32	21.68		64.49	15.51	
Contributor to biodiversity loss prevention (n=535)			0.5345			1.3049			0.5649
Less	25.42	16.64		31.59	10.47		33.08	8.97	
More	36.82	21.12		40.93	17.01		47.10	10.84	
In-house planting (n=535)			1.9997			1.0893			3.6978*
No	4.30	1.50		4.67	1.12		5.42	0.37	
Yes	57.94	36.26		67.85	26.36		74.77	19.44	
Petting (n=535)			1.5198			4.3799***			1.5193
No	31.40	21.12		36.07	16.45		43.18	9.35	
Yes	30.84	16.64		36.45	11.03		37.01	10.47	
Aesthetic plants/pets affect (n=535)			1.6026			0.5565			2.0843

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	Bush meat			Traditional medicine			Skin/leather/fur product		
	No	**Yes**	**Chi-square**	**No**	**Yes**	**Chi-square**	**No**	**Yes**	**Chi-square**
No	2.24	2.24		3.55	0.93		4.11	0.37	
Yes	60.00	35.51		68.97	26.54		76.07	19.44	
Public park nearby (n=535)			3.1555*			1.9227			0.0407
No	15.51	6.92		17.38	5.05		18.13	4.30	
Yes	46.73	30.84		55.14	22.43		62.06	15.51	
National park (n=535)			1.2245			0.1117			1.8079
No	6.92	5.42		9.16	3.18		10.65	1.68	
Yes	55.33	32.34		63.36	24.30		69.53	18.13	
Gender (n=532)			63.2350***			1.7079			9.7477***
Female	44.92	13.72		43.80	14.85		49.62	9.02	
Male	17.67	23.68		28.76	12.59		30.45	10.90	
Age group (n=535)			3.6106			29.5083***			4.7788*
Young	31.21	15.89		37.76	9.35		39.63	7.48	
Middle	25.23	17.20		30.09	12.34		32.71	9.72	
Older	5.79	4.67		4.67	5.79		7.85	2.62	
Educational level (n=498)			0.3118			5.4239*			7.9528**
High School And Below	9.04	6.22		11.85	3.41		12.45	2.81	
Undergraduate	38.76	23.09		45.78	16.06		51.00	10.84	
Post-Graduate	14.26	8.63		14.66	8.23		16.06	6.83	
Income group (n=405)			4.0960			8.5297**			11.0860***
Low	26.42	13.33		29.63	10.12		33.33	6.42	
Middle	24.69	15.56		28.89	11.36		32.10	8.15	
High	10.62	9.38		11.36	8.64		13.09	6.91	

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Table 1. Sample characteristics by WPC

*Note: *, **, *** denote significance at 10%, 5%, and 1% levels, respectively.*

General knowledge of biodiversity

General knowledge of biodiversity is reflected by biodiversity knowledge and perception. Biodiversity knowledge is reflected by the question: "How do you assess your knowledge about biodiversity?" The response options are "never heard about", "poor", "adequate", and "good". Biodiversity perception is reflected by the question: "What is your thinking of biodiversity loss?" The response options are "Biodiversity loss is not real", "Biodiversity loss is real but only a small problem", and "Biodiversity loss is real and a major environmental problem".

Figures 3 to 9 report obvious differences between WPCs regarding biodiversity knowledge and perception. In Figure 3, bush meat consumers accounting for 15.7% have adequate biodiversity knowledge. In Figure 4, bush meat consumers accounting for 35.0% consider biodiversity loss as a major problem. In Figure 5, traditional medicine consumers accounting for 12.0% have adequate biodiversity knowledge. In Figure 6, traditional medicine consumers accounting for 24.9% consider biodiversity loss as a major problem. In Figure 7, skin/leather/fur consumers accounting for 8.4% have adequate biodiversity knowledge. In Figure 8, skin/leather/fur consumers accounting for 17.2% consider biodiversity loss as a major problem. Thus, there are invariable consumers of wildlife product.

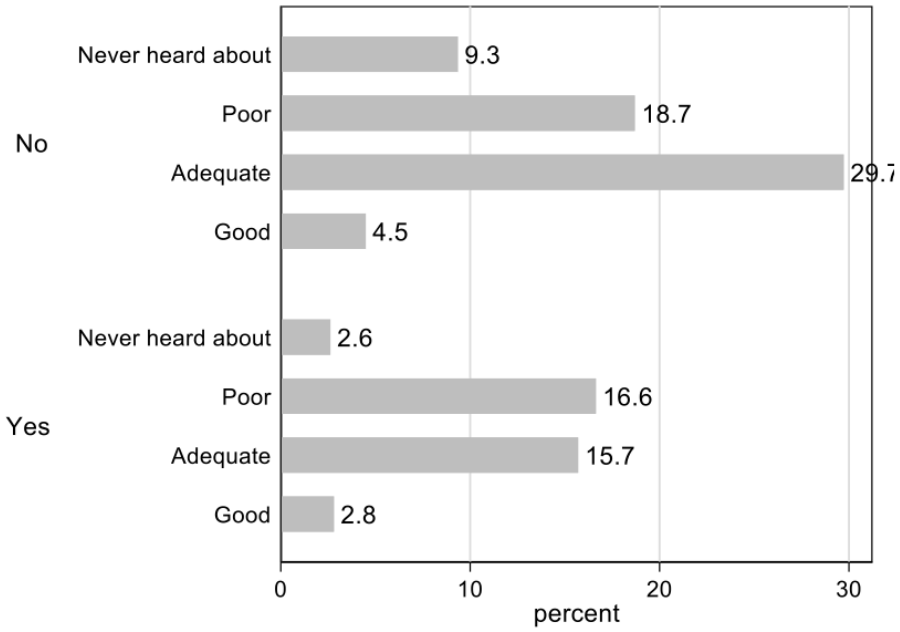

Figure 3. Biodiversity knowledge by bush meat consumption

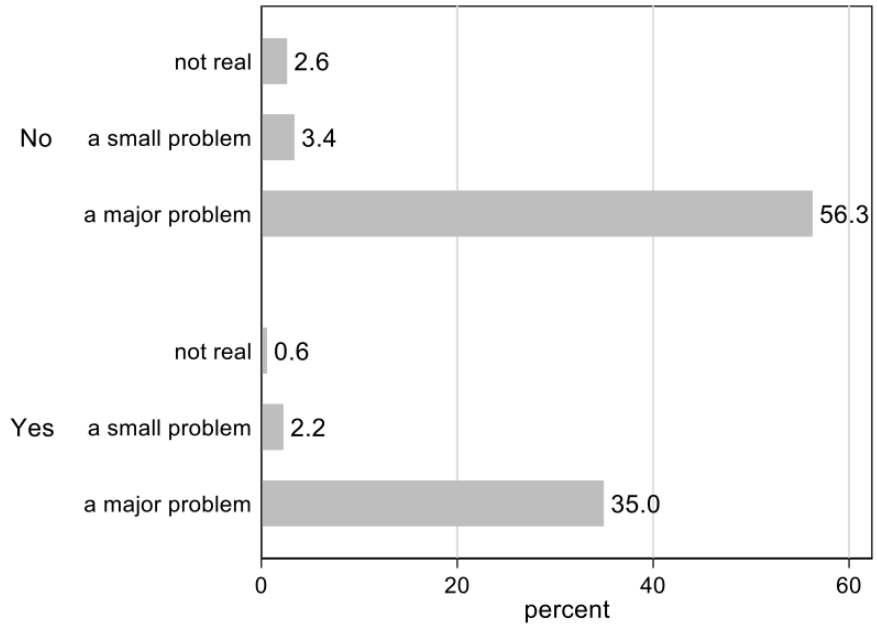

Figure 4. Biodiversity perception by bush meat consumption

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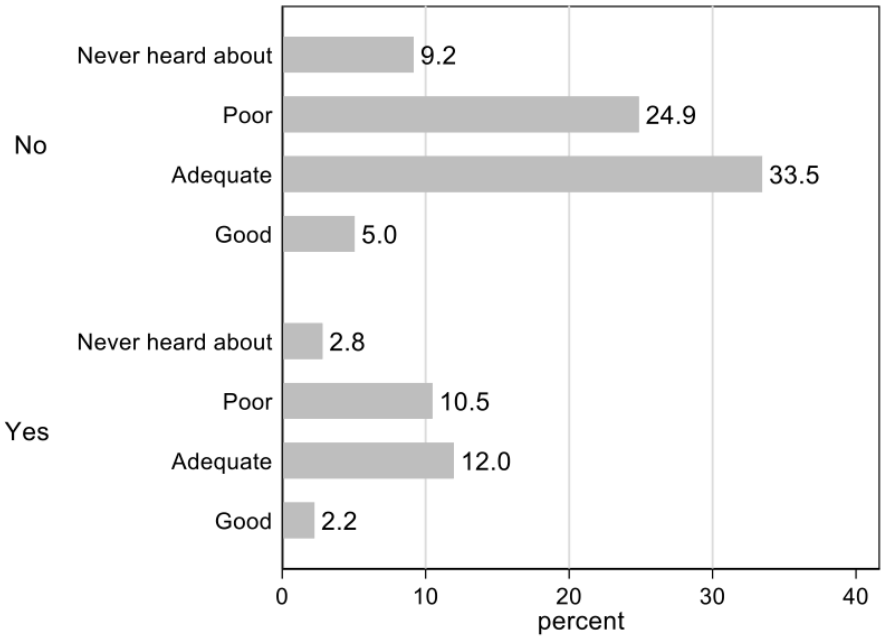

Figure 5. Biodiversity knowledge by traditional medicine

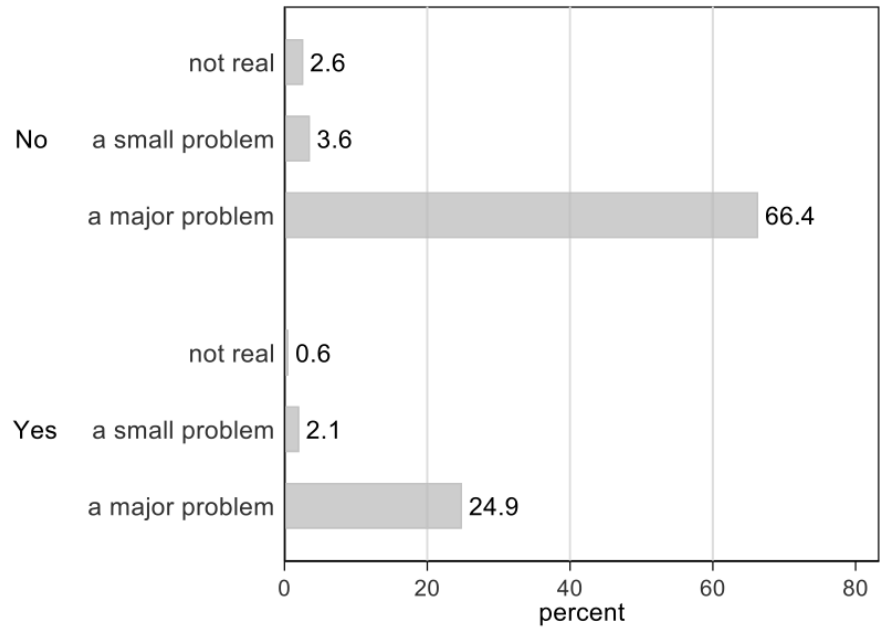

Figure 6. Biodiversity perception by traditional medicine

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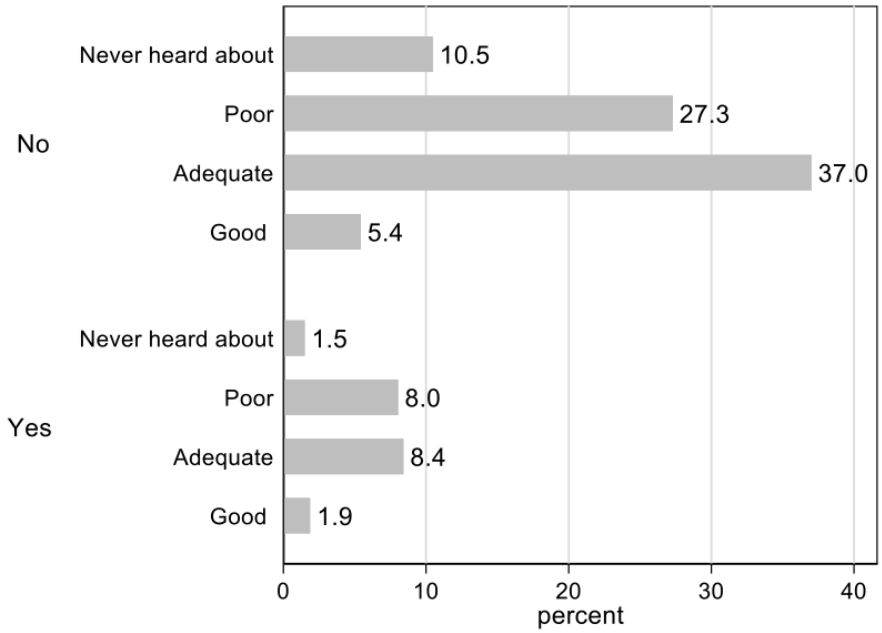

Figure 7. Biodiversity knowledge by skin/leather/fur consumption

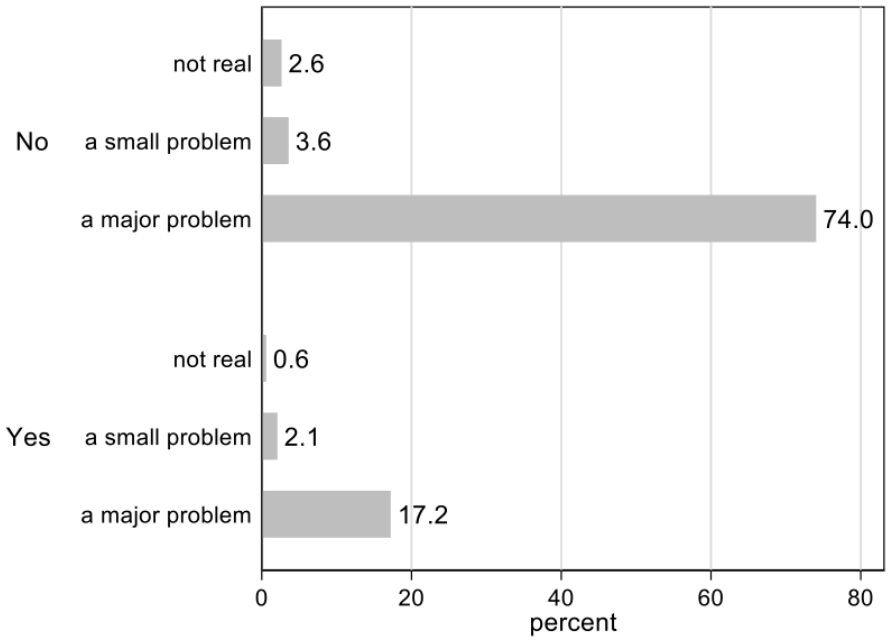

Figure 8. Biodiversity perception by skin/leather/fur consumption

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Associations with WPC

In table 2, the respondents with high perspectives of potential consequences of biodiversity loss and in-house planting were more likely to consume bush meat than those without. Also, the respondents with high preventive measures of biodiversity loss were more likely to consume traditional medicine than those without. Similarly, the male respondents with petting, aesthetic plants/pets affect, willingness to visit a national park were more likely to consume skin/leather/fur than those without. Moreover, the respondents with preventive measures of biodiversity loss were more likely to consume traditional medicine and skin/leather/fur than those without. Thus, hypotheses 1 and 2 are supported.

Meanwhile, the respondents with availability of Public Park nearby were more likely to consume bush meat and traditional medicine than those without. Additionally, the male respondents were more likely to consume bush meat and skin/leather/fur than those without. Furthermore, the older respondents were more likely to consume traditional medicine and skin/leather/fur than those without. Especially, the respondents with post-graduate and middle to high income groups were more likely to consume bush meat, traditional medicine, and skin/leather/fur than those without.

	Bush meat	Traditional medicine	Skin/leather/fur
Potential consequences of biodiversity loss			
Less	1[Reference]	1[Reference]	1[Reference]
More	2.496 (1.559-3.784)	0.552 (0.323 -0.856)	0.759 (0.400 -1.203)
Preventive measures of biodiversity loss			
Less	1[Reference]	1[Reference]	1[Reference]
More	0.554 (0.362 -0.803)	2.145 (1.405 -3.213)	1.143 (0.598 -2.023)
Objects affected by biodiversity loss			
Less	1[Reference]	1[Reference]	1[Reference]
More	0.833 (0.520 -1.317)	0.946 (0.594 -1.434)	0.761 (0.426 -1.321)
Contributor to biodiversity loss prevention			
Less	1[Reference]	1[Reference]	1[Reference]
More	0.820 (0.480 -1.329)	1.233 (0.655 -2.118)	0.682 (0.353 -1.161)
In-house planting			
No	1[Reference]	1[Reference]	1[Reference]
Yes	1.160 (0.741 -1.721)	0.733 (0.425 -1.227)	0.039 (0.015 -0.096)
Petting			
No	1[Reference]	1[Reference]	1[Reference]
Yes	0.988 (0.663 -1.384)	0.726 (0.486 -1.035)	1.326 (0.752 -2.135)
Aesthetic plants/pets affect			
No	1[Reference]	1[Reference]	1[Reference]
Yes	0.498 (0.241 -0.894)	0.900 (0.434 -1.681)	5.037 (1.940 -11.288)
Public park nearby			
No	1[Reference]	1[Reference]	1[Reference]
Yes	1.300 (0.839 -1.947)	1.124 (0.692 -1.756)	0.890 (0.476 -1.558)
National park			

	Bush meat	Traditional medicine	Skin/leather/fur
No	1[Reference]	1[Reference]	1[Reference]
Yes	0.601 (0.271 -1.071)	0.343 (0.178 -0.591)	1.950 (0.605 -5.127)
Gender			
Female	1[Reference]	1[Reference]	1[Reference]
Male	5.419 (3.877 -7.479)	0.863 (0.527 -1.338)	1.722 (1.097 -2.657)
Age group			
Young	1[Reference]	1[Reference]	1[Reference]
Middle	1.000 (0.619 -1.479)	1.305 (0.761 -2.115)	0.942 (0.609 -1.457)
Older	0.692 (0.321 -1.287)	4.919 (2.850 -7.939)	1.207 (0.694 -1.896)
Educational level			
High school and below	1[Reference]	1[Reference]	1[Reference]
Undergraduate	0.904 (0.499 -1.461)	1.207 (0.720 -2.081)	1.300 (0.603 -2.174)
Post-graduate	1.080 (0.495 -2.101)	1.457 (0.731 -2.640)	3.034 (1.247 -5.754)
Income group			
Low	1[Reference]	1[Reference]	1[Reference]
Middle	1.050 (0.651 -1.603)	1.171 (0.772 -1.648)	1.062 (0.557 -1.886)
High	1.186 (0.626 -1.977)	1.893 (1.267 -2.792)	1.951 (1.107 -3.414)
Number of observations	370	370	351
Acceptance rate	.1945	.2478	.2778

Table 2. Bayesian logistic regression on WPC, Odds Ratio (95% credible interval)

Mediating analyses

Fit statistic in Figure 9 are $\chi^2(df)$= 1.809, p > chi2=0.000, RMSEA=0.039, 90% CI: 0.026-0.051, pclose= 0.925, AIC=5846.719, BIC=6013.727, CFI=0.921, TLI =0.898, SRMR=0.040, and CD=0.765. Regarding

significance testing of indirect effect (standardised), indirect effect (significant estimates, confidence interval (CI), p<0.001) of Delta's test, Sobel's test, and Monte Carlo's test in model 1 were 0.057 (-0.016, 0.130), 0.057 (-0.015, 0.128), and 0.056 (-0.008, 0.141), respectively. Due to indirect effect/total effect = 0.939, about 94 % of the effect of POB on WPC is mediated by CTN. Accordingly, hypothesis 3 is supported.

Fit statistic in model 2 in Figure 10 are $\chi^2(df)$ = 1.809, p > chi2=0.000, RMSEA=0.039, 90% CI:0.026-0.051, pclose=0.925, AIC=5846.719, BIC=6013.727, CFI =0.921, TLI=0.898, SRMR=0.040, and CD=0.430. Regarding significance testing of indirect effect (standardised), indirect effect (significant estimates, CI, p<0.001) of Delta's test, Sobel's test, and Monte Carlo's test in model 2 were -0.031 (-0.082, 0.020),-0.031 (-0.080, 0.018), and -0.031 (-0.089, 0.013), respectively. Because standardized path coefficient of POB → WPC is not significant in Table 3, the effect of CTN via POB on WPC does not exist. Thus, hypothesis 4 is rejected.

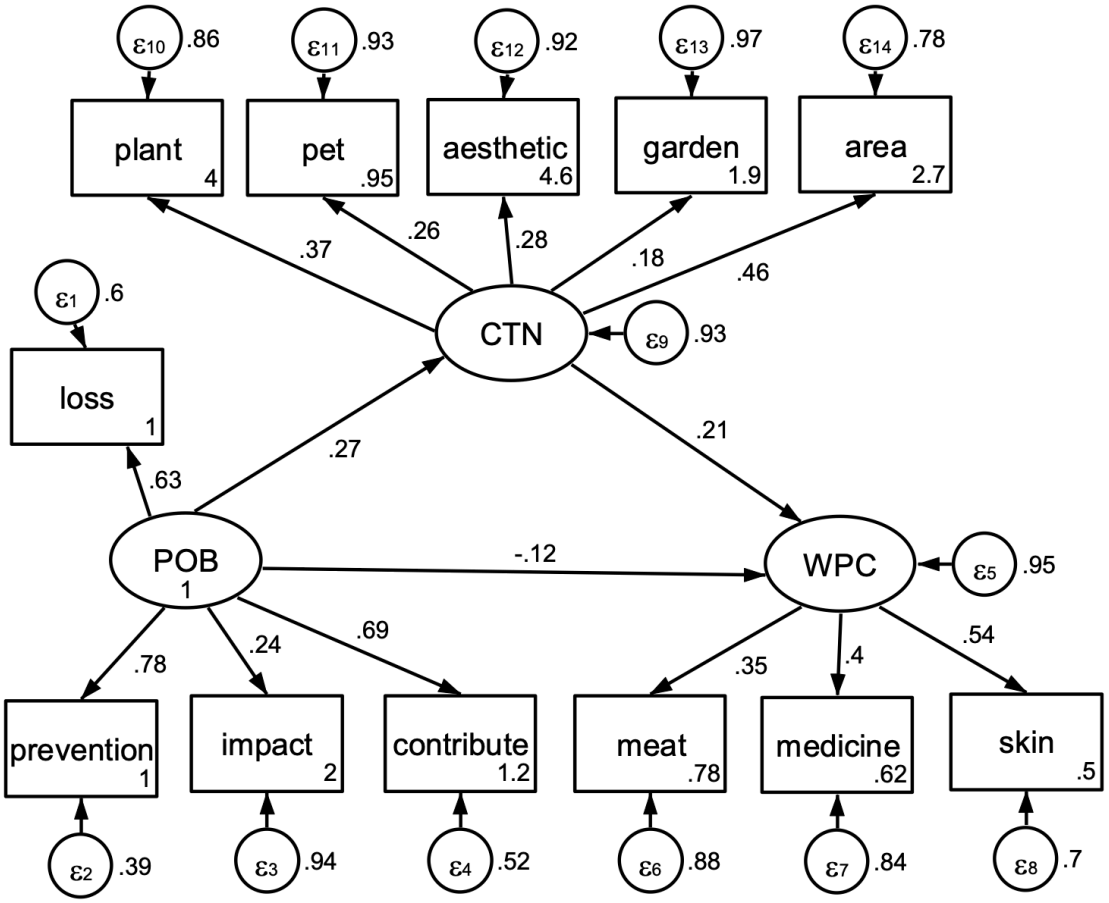

Figure 9. Mediating effect of POB on WPC via CTN.

Note: loss = potential consequences of biodiversity loss. prevention = preventive measures of biodiversity loss. impact = objects affected by biodiversity loss. contribute = contributor to biodiversity loss prevention. plant = in-house planting. aesthetic = aesthetic plants/pets affect. pet = petting. area = national park/protected area. garden = public park nearby.

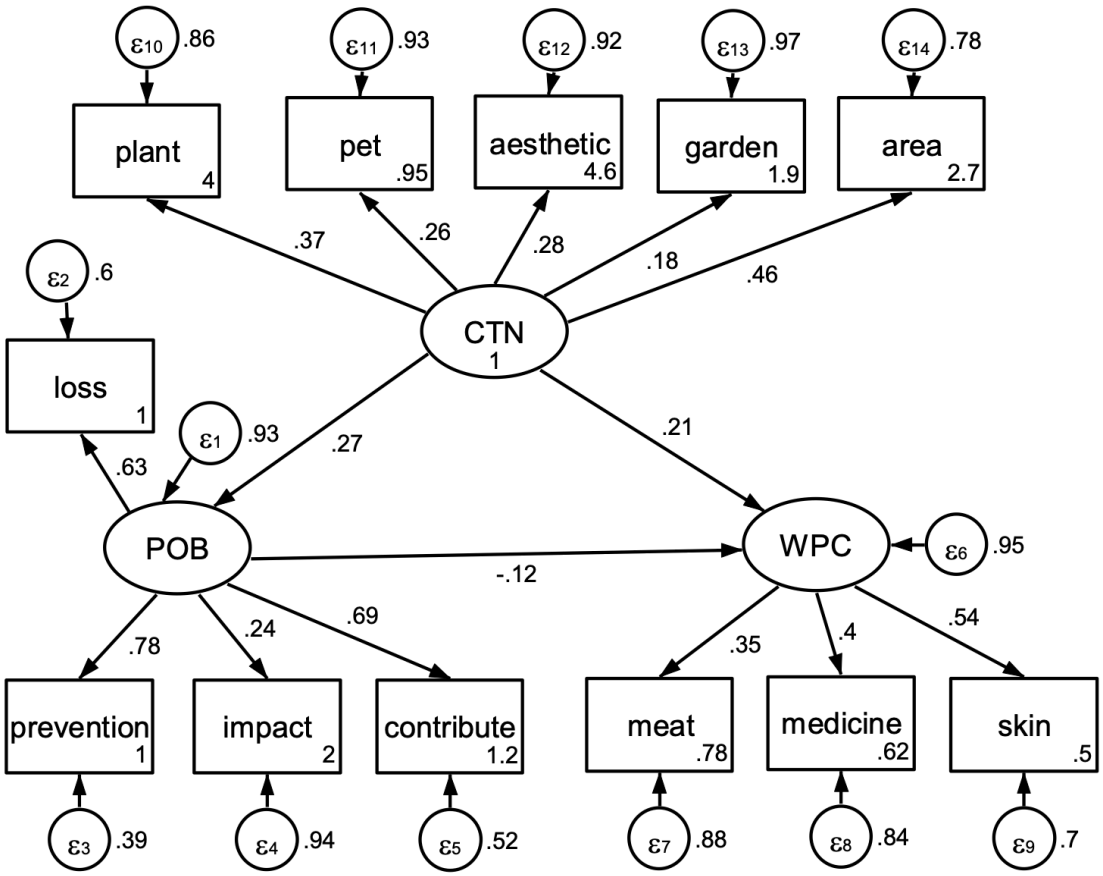

Figure 10. Mediating effect of CTN on WPC via POB.

Note: loss = potential consequences of biodiversity loss. prevention = preventive measures of biodiversity loss. impact = objects affected by biodiversity loss. contribute = contributor to biodiversity loss prevention. plant = in-house planting. aesthetic = aesthetic plants/pets affect. pet = petting. area = national park/protected area. garden = public park nearby.

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	Model 1	Model 2
WPC <-CTN	0.995 *** (0.149)	0.995 *** (0.149)
WPC<-POB	-0.167 (0.157)	-0.167 (0.157)
CTN <-POB	0.936 *** (0.012)	
POB <-CTN		0.936 *** (0.012)
loss <-POB	0.815 *** (0.018)	0.815 *** (0.018)
prevention <-POB	0.820 *** (0.020)	0.820 *** (0.020)
impact <-POB	0.908 *** (0.014)	0.908 *** (0.014)
contribute <-POB	0.842 *** (0.018)	0.842 *** (0.018)
meat <-WPC	0.719 *** (0.024)	0.719 *** (0.024)
medicine <-WPC	0.631 *** (0.026)	0.631 *** (0.026)
skin <-WPC	0.564 *** (0.029)	0.564 *** (0.029)
plant <-CTN	0.974 *** (0.005)	0.974 *** (0.005)
pet <-CTN	0.705 *** (0.016)	0.705 *** (0.016)
aesthetic <-CTN	0.977 *** (0.004)	0.977 *** (0.004)
garden <-CTN	0.887 *** (0.010)	0.887 *** (0.010)
area <-CTN	0.947 *** (0.007)	0.947 *** (0.007)

Table 3. Standardized path coefficients in the SEMs suppressing constants, Coefficient (Standardized Error) (N = 535)

*Note: ***p<0.01. loss = potential consequences of biodiversity loss. prevention = preventive measures of biodiversity loss. impact = objects affected by biodiversity loss. contribution = contributor to biodiversity loss prevention. plant = in-house planting. aesthetic = aesthetic plants/pets affect. pet = petting. area = national park/protected area. garden = public park nearby.*

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Discussion

Summary of the findings

There is high prevalence of consumption of bush meat, traditional medicine, and skin/leather/fur product in the sample. The regression analyses indicate that socio-demographic factors, POB and CTN are associated with consumption for bush meat, traditional medicine, and skin/leather/fur product, respectively. The effect of POB on WPC via CTN is greater than the effect of CTN on WPC via POB. Obviously, there are persons with active connection to nature and positive perception of biodiversity have high likelihood of consuming wildlife products in Vietnam. CTN is known to be associated with both pro-environmental behaviours and well-being. But, this study identify CTN is facilitator of POB and WPC. With respect to Vietnam, conservation efforts are requisite to preserve biodiversity and protect endangered species and their habitats.

Explanations of main findings

Regarding socio-demographic factors, the empirical outcome in this study is in line with the studies in other counties. For instance, a study in the Brazilian Amazon shows that wild meat consumption is influenced by age of the head of household, poverty, and years the head of household lived in urban areas (Chaves et al., 2021). In addition, a study in the Atacora Chain of Mountains showed that socio-demographic factors can predict local people's perception of ecosystem services (Moutouama et al., 2019). Likewise, a study indicates demographic characteristics such as age and level of activity explained the great proportion of variance in well-being and CTN (Luck et al., 2011). Rapid growth in household numbers (Liu et al., 2003) and place of residence (Duron-Ramos et al., 2020) are also important covariates. But, nature connection opportunities are valued by nearly all adults irrespective of age and health (Freeman et al., 2019).

The fact that part of Vietnamese consumers preferring wildlife products can partially explained by consumer behaviour theory in the wildlife trade (Feddema et al., 2021). Regarding consumer's motivations, bear products are taken as medicine products and a daily tonic in Vietnam (Davis et al., 2019). Moreover, the urban public in Vietnam shows high levels of fidelity to tiger bone wine (Coals et al., 2020). Furthermore, rhino horn often is used to display economic wealth, acquire social status, and initiate business and political relationships in Vietnam (Truong et al., 2016). Similarly, bush meat is a source of protein and micronutrients important to rural households (Nielsen et al., 2017).This is

also consistent with several American findings. Logically, the achievement of biodiversity conservation is often threatened by economically productive activities and market development (Strauss et al., 2017; Bidegain et al., 2019).

The mediating effects can be indirectly explained by some published articles. Regarding mediating effect of POB on WPC via CTN (Hypothesis 3), a study from Estonia and Finland indicates persons with positive perceptions to wildlife have willingness to undertake wildlife-friendly measures (Herzon & Mikk, 2007). Simultaneously, a study in eastern China concludes persons with love of nature have positive biospheric values and personal norms and are potential green consumer behaviors (Wu & Zhu, 2021). Additionally, an online sample from the United Kingdom indicates that connectedness to nature significantly mediates the direct relationship between nature exposure and body appreciation (Swami et al., 2020). Regarding mediating effect of CTN on WPC via POB (Hypothesis 4), human well-being shows a positive relationship with the species richness in urban greenspaces (Dallimer et al., 2012).

Consistent with early studies, this study highlights the importance of the relationships between green behaviors and perspectives. For example, a study concludes enhancing biodiversity values of private green spaces (yards) are effective in facilitating CTN (Freeman et al., 2018).Simultaneously, another study indicates that most aquarium visitors maintain or increase their positive attitudes toward marine life (Kidd & Kidd, 1997). Thus, biodiversity values can be enhanced by green education.

Accompanied by the research outcome in this study, invariable wildlife product consumers can be defined on the basis of relevant literature. Regarding public preferences, a contingent valuation survey finds most of sample is willing to pay biodiversity conservation in Vietnam's Tam Dao National Park (Le et al., 2016). Moreover, an investigation indicates knowledge, perceptions and feelings help support interventions and policies to protect biodiversity (Tonin & Lucaroni., 2017). Invalid regulations of conservation in Vietnam possibly are partially explained by the frictions among international, national, and local interests in biodiversity resources (Zingerli, 2005). Undoubtedly, local governments are responsible for fighting illegal wildlife trade in Vietnam (Song, 2008). This is because prevalence of wildlife meat consumption is caused by the preference of government staff in restaurants (Sandalj et al., 2016).

To the key point, utilitarian and hedonic values are reported in determining the demand for WPC (Vu & Nielsen, 2018). For example, a study in southern Vietnam reports people who prefer consuming wild meat are found to be more likely to illegally harvest natural resources (Nuwer & Bell, 2014).

Particularly, demand for wild meat is heterogeneous between societal hierarchies in Vietnam (Shairp et al., 2016). Another study in Vietnam indicates lower cost is a major factor driving the trade in wild animals (Brooks et al., 2010). Thus, high financial penalties are possibly an effective tool to biological protection.

Using the same survey dataset, an eco-surplus culture study finds that consequences of biodiversity loss has indirect effects on willingness to pay for the entrance into protected areas through the mediation of the attitude towards conservation (Nguyen & Jones, 2022, January 5). Obviously, ex post facto remedies are not the best choices. Another investigation by the same authors finds that eco-surplus culture can prohibit illegal wildlife consumption among the Vietnamese urban residents (Nguyen & Jones, 2021, November 25). However, a causal effect reported in a cross-sectional study is not scientific and rigorous. Remarkably, some frequent bushmeat consumers with high income and educational levels are found to support the biodiversity loss preventive measures. Those urban residents are possibly the targeted population that need to be educated further.

Policy implications

Low level of diversity knowledge is the main determinant of current dramatic biodiversity loss. But, in developed country like France, environmental education also can not develop conservation consciousness and concerns about local biodiversity and positive attitudes toward nature among schoolchildren (Ballouard et al., 2011). Similarly, increased WPC may curb children knowledge and concerns about local biodiversity in Vietnam. However, well-known pollution and poisons are often thought as the dominant opportunity to biodiversity. Thus, with limited biological knowledge, residents from European countries hold an overwhelmingly proecological worldview (Kochalski et al., 2019). Likewise, a study in central Ecuador indicates biodiversity loss caused by eating traditional foods can be reduced through nutrition education in schools and prevents dietary changes toward unhealthy eating (Penafiel et al., 2016). Thus, nutrition and health education can serve as optimal solution to reduce WPC. If education has no effects, financial penalties are the necessary tools.

Academic contributions

This study contributes to the wider area of knowledge of biological conservation, governmental management, regional development, and consumer behavior. Obviously, Vietnam is facing the challenges of biodiversity loss and species extinction. This study discovers the mechanisms of the

biological tragedies. In order to pursue the national development, Vietnam indulges the passion for WPC among government staff, common persons, and international trade.

Strengths

There are three obvious strengths in this study. First, Bayesian logistic regression is superior to logistic regression when causal relationships of consuming preferences are explored. Second, SEMs are used to assess the proposed mediating relationships among the latent variables. Finally, self-reported responses reflect motivation, behaviors, and preferences of Vietnamese consumers.

Limitations

There are three notable limitations in this study. First, the participants in this sample are not nationally representative due to web-based survey strategy. Second, cross-sectional data cannot lead to causal relationship. Finally, socioeconomic factors are not analyzed in the mediating effects.

Directions for future direction

There are three possible future directions from this study. First, national samples are needed to corroborate or refute the data presented here. Second, longitudinal survey or panel data are beneficial to produce causal relationships. Finally, socioeconomic factors are needed to be considered in the mediating or moderating analyses.

Conclusion

In conclusion, the findings in this study support the idea that there exists repeated violation of injunction against WPC in Vietnam. Socio-demographic factors, POB and CTN are associated with WPC. Furthermore, the association between POB and WPC is mediated by CTN. The financial penalties may be effective for the policymakers to reduce WPC in Vietnam. This work may be generalized to other geographical regions and disciplines that deal with consumer behaviors for WPC.

Abbreviations

- WPC: wildlife product consumption
- CTN: connection to nature
- POB: perception of biodiversity

- SEMs: structural equation models

Declarations

Ethics Approval and Consent to Participate

The data adopted was from a publicly available survey dataset whose ethical approval was obtained from the institutional review board at Phenikaa University. All methods were carried out in accordance with relevant guidelines and regulations. Written informed consent was obtained from all participants before they agreed to participate in the study. Participants were informed that they could leave the study at any time without penalty, and all personal information was kept confidential. Thus, it was not necessary to obtain ethical approval from the institutional review board at the author's institution.

Availability of Data and Material

https://datapid.cn/31253.11.sciencedb.j00104.00097

Competing Interests

The authors declare no potential conflict of interest with respect to the research, authorship and/or publication of this article.

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Authors' Contributions

BXH designed the study and completed the original version. HYG performed literature search, statistical analyses, Tables and Figures under the tutorship of BXH. The authors read and approved the final manuscript.

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