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PII: S2351-9894(24)00459-1

DOI: https://doi.org/10.1016/j.gecco.2024.e03255

Reference: GECCO3255

To appear in: *Global Ecology and Conservation*

Received date: 27 May 2024
Revised date: 11 October 2024
Accepted date: 12 October 2024

Please cite this article as: Franciany Braga-Pereira, Anupana Puran, David Oswin, Evi AD Paemelaere and Nathalie van Vliet, Factors inflncing wildmeat trade in Guyana and expected changes in the context of the oil-related development prospects, *Global Ecology and Conservation,* (2024) doi:https://doi.org/10.1016/j.gecco.2024.e03255

Factors inflncing wildmeat trade in Guyana and expected changes in the context of the oil-related development prospects

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Abstract

The recent offshore oil discovery in the Guiana Shield is expected to bring about significant changes to the area, such as increased GDP per capita, infrastructure development, and urbanization. The potential impact on the wild meat trade depends on factors influencing its demand and provision. Through interviews and group discussions with trade chain stakeholders in all towns of Guyana, we evaluate wildmeat trade sector and explored predicted changes on it in 2033 with the prospects for short term oil-related development. The most traded species in Guyana included paca, white-lipped peccary, deer, tapir and capybara and a total of 38.46% (5 out of 13) of the taxa being traded is classified as threatened of extinction. Regions with higher population size and GDP per capita, are the main trade hubs for wildmeat. Access to improved preservation methods (e.g. freezers) and motorized transportation options (eg.: boat with engines and vehicles) significantly influence higher volumes of wildmeat traded. The economic growth anticipated in Guyana is expected to boost population growth and, by the same time, wildmeat demand in urban areas. Concomitantly, with improved infrastructure and increased access to electricity, wildmeat provision will be facilitated across a wider catchment area. Based on the assumption that cultural patterns shaping wildmeat demand and environmental regulations will likely not change at the same rapid path as economic growth in the next ten years, we predict wildmeat trade volumes to increase to 10,280 tons/year by 2033. We identify three main opportunities to ensure a sustainable wildmeat sector in the context of the economic boom: First, the sector requires to be

well regulated through a licensing and a quota system that can be adequately enforced. Second, efforts to curve demand on the Coast need to be strengthened based on well designed and culturally adapted behaviour change campaigns. Third, local communities and indigenous people need to be empowered to protect and conserve their territories and wildlife resources, in particular with the authority to exclude illegal hunters.

Keywords: Amazon-Caribbean regions, commercial hunters, meat vendors, trade chain

1. Introduction

In the Amazon region, the demand for wildmeat from urban areas has been largely studied over the last years, showing that despite the existence of other sources of domestic and industrial meats, wildmeat remains attractive to urban dwellers, mostly for cultural, social or taste reasons (El Bizri et al., 2022, Santos et al., 2022; van Vliet et al., 2015, Apaza et al., 2002; Braga-Pereira et al., 2021). Increased urbanization and population size therefore boosts demand for wildmeat in medium sized towns (El Bizri et al., 2022). Some studies showed that emerging urban areas in the Amazon can encourage commercial hunting by connecting consumers through telephone and internet accessibility making the access to the resource easier (Chaves et al, 2021; Lavorgna 2014; van Vliet et al., 2015b). Moreover, in urban areas, the improvement of river navigation and road infrastructure, coupled with advancements in hunting technologies and more efficient meat preservation methods has enhanced the market for wildlife products. This is due to the increased ability to capture more animals (by using flashlights and firearms Braga-Pereira et al., 2020; Bowler et al., 2020), transport meat to its final destination faster (Chaves et al., 2017; Bowler et al., 2020) and preserve larger quantities without spoilage.

In the Guiana Shield region, which shares a common pool of wildlife species with the Amazon, hunting and wildmeat consumption is known to be associated with social and cultural factors embedded in the unique socio-cultural blend of Caribbean, East Indian and Amerindian cultures (Paemelaere et al., 2024). The region remains predominantly covered by forests, with the human population primarily concentrated along the coast, a remnant from Dutch colonial times, when settlers initiated and focused their economic endeavors on polder agriculture on the coast (Khemraj, 2015). In the coastline regions of Guyana, wildmeat is largely appreciated by urban dwellers, and is not consumed as a

necessity but rather appreciated for its taste and cultural value (Paemelaere et al. in press). Demand for wildmeat thrives a relatively short value chain, with urban commercial hunters directly selling to restaurants, rum shops or final consumers (van Vliet et al., 2022).

In recent years, Guyana has made one of the world's most significant oil discoveries, boosting its economy fourfold. Beyond 2018, Guyana has seen a spike in economic growth which is attributed to the start of the country's oil boom (Hardyal et al., 2023). A steady increase in population growth (7.3%) has been observed since 2017 (MacroTrends, 2024) and the economic growth has also facilitated numerous infrastructure developments (Brathwaite, 2021). In this context, the question of whether these changes will influence the trade in wildmeat is of paramount importance to sustainable management of this value chain. Available research carried out in the Amazon has shown that urbanization, wealth and access to new hunting grounds were determinants of the dynamic of wildmeat trade chains. For example, a long-term study carried out in Peru, showed that urban population growth over the last 45 years in Iquitos-Peru fueled a steady increase of wild meat sales at a rate of 6.4 t/year and contributing US$2.6 million to GDP in 2018 (Mayor et al., 2021). Additionally, consumption of wild meat increased with wealth in small but emerging towns in the Brazilian Amazon (Chavez et al 2019; Torres et al. 2022). In the Tri-frontier Amazon region between Colombia, Peru and Brazil the road development facilitated access to hunting grounds, reducing travel costs for hunters and enabling the expansion of wildmeat trade opportunities in local markets (van Vliet et al., 2017).

In this study, we comprehensively assess factors influencing wildmeat trade in Guyana and project changes over the next decades amid potential oil-related development. Through interviews and group discussions with trade chain stakeholders, we evaluate current trade levels and species traded, trace historical sector changes, and develop statistical models linking wildmeat volumes to species characteristics and key socioeconomic variables. These include human population size, GDP per capita, access to areas with target species, and market capacity (based on transport capacity and meat preservation methods, which enhance overall wildmeat volume available for sale in consumption hubs). Considering that enforcement of wildlife regulations and quotas could remain unchanged in the next decade, as often the case where rapid economic

expansion outpaces the establishment of effective environmental regulations and enforcement mechanisms (Pellegrini & Gerlagh, 2006), we estimate potential future wildmeat trade, amidst the short term oil boom in Guyana's economy.

2 Material and Methods

2.1 Study Site

Guyana, located northeastern of South America and shares borders with Brazil, Suriname, Venezuela, and the Atlantic Ocean. The country has ten administrative regions (towns), with Georgetown as the. Guyana's population size reached 817.555 inhabitants in 2024 (MacroTrends, 2024), with around 90% of the country's inhabitants being concentrated mainly in the capital and along the coast (Guyana Bureau of Statistics, 2016a), where the primary wildmeat markets are located. The nation is diverse, with the largest ethnic group being Indo-Guyanese (43.5%), followed by Afro-Guyanese (30.2%), mixed people (17.2%) and Indigenous people (9.1%). Coastal regions are predominantly inhabited by Indo and Afro-Guyanese, while the hinterland areas are home to Indigenous People and mixed heritage individuals (GUYANA BUREAU OF STATISTICS, 2016b). With its extensive land area of over 214,000 square kilometers, Guyana has a low population density of fewer than 4 people per square kilometer. In the Americas, only Suriname and French Guiana have lower population densities (Statista, 2023). The coastal zone is connected to the interior mainly through rivers and often unpaved roads (Rose & Corbin, 2017). This study was conducted in all regions of Guyana, covering all major human population hubs: the capital city of Georgetown, 9 towns (Bartica, Mabaruma, Mahdia, Anna Regina, Lethem, New Amsterdam, Corriverton, Rose Hall, and Linden) and among the most populated villages (n=46).

2.2) Ethics statement

This research was reviewed and approved by CIFOR Research Ethics Committee (https://www.cifor.org/fileadmin/downloads/CIFOR-Research-Ethics.pdf) and follows the Free Prior and Informed Consent and social safeguards approach from the Sustainable Wildlife Management (SWM) Programme (https://www.fao.org/3/cb7248en/cb7248en.pdf). Community meetings and coordination with communal authorities were carried out prior to conducting interviews

to agree on procedures. Prior to commencing the interviews, we provided a clear explanation of the objectives of our research to each seller. To ensure a comfortable and transparent interview process, we acquainted participants with the study's goals beforehand. Participation to the study was based on a voluntary basis grounded on free, prior and informed consent, and interviewees were assured that their identities would remain confidential.

2.3 Data collection

2.3.1 Semi-structured interviews to wildmeat vendors

Based on previous research done in the Amazon, suggesting that vendor declarations of daily meat sales provide remarkable accuracy in assessing wildmeat volumes sold (Mayor et al., 2019; Chaves et al., 2017), we conducted wildmeat vendor interviews to wildmeat sellers during December of 2021 to May of 2023.

Prior to 2019, wildmeat trade in Guyana was only regulated if it was intended for international trade and national wildlife trade was unregulated. In 2019, the Guyana Wildlife Conservation and Management Authority issued the Wildlife Act to regulate internal wildlife trade. However, at the time of the study, regulations about national wildlife trade under the Wildlife Act had not been fully issued, and enforcement was therefore not done. As such, since wildmeat trade occurred openly, we encountered no hindrances in identifying and interviewing wildmeat vendors. The interviews did not require local translators as both the interviewers and the interviewee, including those from indigenous territories, were fluent in English (Guyanese sellers), Portuguese (Brazilians sellers) or Spanish (Venezuelans sellers).

To sample wildmeat vendors, we used a snowball approach (Bailey, 1994). First, we referred to a preliminary list of wildmeat vendors provided by the Guyana Wildlife Conservation and Management Commission (GWCMC). Based on this preliminary list, we applied a snowball sampling technique asking each new vendor to provide indications of another vendor until we found no additional new vendors. We also triangulated the information on vendors based on participant observations at the market, conversations with village leaders, shop/restaurant or bar owners. In total, we interviewed 183 vendors from the sampled sites (average interviewees per site= 18.3, SD = 10.5), which likely represent 100% of established commercial wildmeat vendors in Guyana at the time of the study. The interviewees' ages ranged

from 19 to 68 years old (average = 45.9; SD =12.3) and the length of time that each seller was engaged in selling wildmeat during their lifetime ranged from 2 months to 60 years (average = 13.2; SD = 9.3).

Data were collected through structured interviews to vendors on topics that included i) vendors' socio-economic characteristics; ii) business information; iii) way to preserve and transport the meat; iv) species and amount being sold; and v) trade route (see Supplementary material S1 for more detailed information on the semi-structure questionnaire).

2.3.2 Workshop with wildmeat vendors

To complement the information gathered through the semi-structured interviews and analyse the collective perception of trends in wildmeat trade, we organized a workshop with vendors in October of 2022. We invited all (n= 111) interviewed sellers from across the coastal regions of Guyana to participate of a one-day workshop organized in Ana Regina (a small town located in Region 1). The invitation was sent through formal letters and follow-up telephone calls. A total of 48 sellers were available and able to attend the workshop.

To obtain information on the past and expected changes of the wildmeat trade along the coast, participants were placed into four groups and worked on two main questions asked to guide the discussions: i) what are the main changes observed in your wildmeat trade business in the following time periods: 1990-2000; 2000-2010; 2010-2020 (only some traders were able to describe trade in the 1990s)? ii) what do you think will be the future of wildmeat trade? Traders that were not able to attend the workshop despite their interest in participating were later contacted by phone to gather their perceptions on the changes occurred in wildmeat trade since the 1990s. Only 28 of the traders could recall experience with the wildmeat trade 30 years ago, many of the other participants had long-standing family traditions in the trade and could offer insights passed down through generations. Additionally, their engagement with the evolving aspects of the trade, even over a shorter period, provides valuable context for understanding changes in market dynamics.

2.4 Data compilation of the predictor variables

2.4.1 *Sales typology:* included the information collected during interviews regarding vendors' socio-economic characteristics; business information; way to preserve and transport the meat; and Region.

2.4.2 Species characteristics: included the information collected during interviews regarding price per Kg for each species; and additional information collected in the literature regarding species' conservation status, adult body mass and fertility rate. To classify the species, we used the most recent conservation status of the International Union for the Conservation of Nature (IUCN, 2023). To obtain information on body mass, we used the PanTHERIA (Jones et al., 2009) database. To obtain information on fertility rate we used both the PanTHERIA and AnAge (Tacutu et al., 2018) databases to obtain information on species litter size and number of litters per year. So, annual fecundity rate (defined as female young per adult female per year) were calculated as (litter size × number of litters per year)/2 (i.e., assuming a 50:50 birth sex ratio) (Ernest, 2003) (see species characteristics details in Table 1, Supplementary material).

2.4.3 Regions' characteristics

We used data from the Bureau of statistics (2016) to obtain information for each region on gross domestic product (GDP) per capita and population size.

2.5 Data analysis

2.5.1 Key species driving regional sales variations

We performed a Principal Component Analysis (PCA) to find out which species explain the variance between the regions in Guyana regarding the most traded species for wildmeat. We interpreted the results when the first two components of the PCA (PC1 and PC2) represented at least 70% of the variation in the data.

2.5.2 *Characteristics influencing the meat trade volume*

We used two statistical models to examine meat trading volume: regional Generalized Linear Models (GLMs) for per-region analysis and national Generalized Linear Mixed Models (GLMMs) for an all-region analysis. In the GLMM, "region" was included as a random variable, and other predictors (see below) as fixed effects (Zuur et al., 2007).

With meat trade volume being the response variable, we organized the predictor variables (section 2.4) into six main themes for analysis including sales typology, species characteristics, and Regions' characteristics (see table 1). Subsequently, we assessed collinearity ($p > 0.05$) among these variables. In instances where collinearity was detected, we addressed it by including the predictor variables in separated models. The Akaike information criterion (AIC) guided our model selection process. The model with the lowest AIC was considered the most suitable, and other models were ranked based on their Akaike differences (ΔAIC) in comparison to the best model (Harrison et al., 2018; Burnham, 2008). We chose the Negative Binomial distribution for all models based on data characteristics and conducted residual checks to assess model suitability. All analyses were conducted in R version 3.5.3 (R Core Team, 2019) using the "MuMin," and "lme4" (Oksanen et al., 2013) packages.

Table 1. Organization of predictor variables in six main themes and assessment of collinearity in the analysis of meat trading volume

Model	**Theme 1 - Species Characteristics***
model 1	Price
model 2	adult body mass
model 3	fertility rate and conservation status
Model	**Theme 2 - Seller Attributes**
model 1	hunter, time (in years) selling wild meat, and proportion of household income depending on wild meat
	Theme 3 – Business Type
model 1	Restaurant, bar, food truck, and row meat vendors
	Theme 4 - Meat Preservation Methods as a proxy to access from hunting grounds to markets and market capacity
model 1	salted or smoked, freezer, on ice, and fresh
	Theme 5 - Meat Transportation means as a proxy to access from hunting grounds to markets
model 1	bike or foot, boat with engine, boat with paddle, motorcycle, and car
	Theme 6 - Regional socio-economic characteristics*
model 1	human population size
model 2	GDP

*Models were separated to prevent collinearity.

2.5.3 Exploring Interconnections among meat trade volume, preservation methods, transportation means, and regional factors

We employed Multiple Factor Analysis (MFA) (Husson et al., 2018) to examine the interconnections among meat trade volume, preservation methods, transportation means, and regional factors on a per-region basis. MFA accommodates the structured nature of the data, organized into distinct groups representing different regions, ensuring a balanced consideration of each group's significance in the analysis. The characteristics more frequent in specifics regions were grouped together in the analysis. The FactoMineR package (Le et al., 2008) served as the foundation for conducting these MFAs.

2.5.4 Wildmeat trade evolution since the 1990s

The answers to the questions on the evolution of the wildmeat sold in the last 30 years were classified into common subjects (Braun and Clarke, 2006). Coded responses were summarized, and the frequency of each concept was quantified. This method of open-ended questioning provided the flexibility to explore different topics of relevance if necessary while providing rapid anthropological assessments valid for wildmeat trade monitoring.

2.5.5 Projecting wildmeat trade for the next decades

In forecasting wildmeat trade volumes over the next decades, our approach involved determining the proportionate increase in the trade volume over the 10 and 27-year period and applying this proportion to the 2023 wildmeat trade volume. The calculation is represented by the following equation:

Projected Wildmeat Trade in 2033 or 2050 = Wildmeat Trade in 2023
**Proportion of Increase in 10 or 27 Years*

To establish the proportion of increase in wildmeat trade over the next years, we employed the estimate values of variables with $p<0.05$ obtained from the GLMM analysis. The final formula was:

*(income estimate * proportion of income growth) + (population estimate * proportion of population growth) + (vehicle estimate * proportion of paved road growth)*

Guyana's GDP per capita was of $18,990 in 2023 and assuming an annual growth rate of 89.93% (MacroTrends, 2024), the GDP per capita would be approximately $5,922,489.30 in 2033 (an increase of 311.8740 times) and $78,415,029.90 in 2050 (an increase of 4,129.2800 times).

Guyana's population in 2023 was of 813,834 in 2023, and in 2033 it is expected to be of 876,106 (an increase of 1.0765 times) and in 2050 of 985,980 (an increase of 1.2115 times) (Worldometer, 2024; MacroTrends, 2024).

Currently, the road mileage in Guyana consist in 799km of paved road and 3,196km of unpaved road (Meijer et al., 2018). Here, we assume that with the economic growth all 3,995km of road will be paved in the future. In this scenario, the increase ratio would be of 5 times.

3 Results

3.1 Key species driving regional sales variations

Thirteen taxa were identified as being traded by the interviewees. Among these taxa, 38.46% (5 out of 13) is classified as threatened of extinction (Supplementary material, Table 1). The most traded species included paca, white-lipped peccary, deer, tapir and capybara. However, specific regions exhibited variations: capybara surpassed tapir as a top-selling species in the most urbanized regions (also more populated and with higher GDP per capita), with the opposite occurring in less urbanized regions. Iguana is among the top-selling species only in more urbanized regions (Fig. 1 and 2).

In the PCA analysis, deer, white-lipped peccary, paca, agouti, and tapir were really important for the first set of results, PCA1, explaining 73% of the observed variance. Capybara, armadillo, and iguana were pivotal species explaining variance in more urbanized regions (Regions 2, 3, 4, and 6), while black curassow, collared peccary, and duck were similarly important in less urbanized regions (Regions 1, 8, and 10) (Fig 2). Regarding the trade route, we found that species dominating in the trade in urbanized coastal regions, such as capybara, armadillo, and iguana, originated from the less urbanized hinterland. We did not find a significant effect of any bioecological variables on the top-five species being traded. However, regarding the trends, most models at the regional level aligned with the national-level model, except for Regions 5 and 6, which predominantly had non-endangered species like capybara and paca mentioned. In contrast, the national and other regional models showed that these endangered species were commonly cited (Fig. 1, Supplementary Material Table 2).

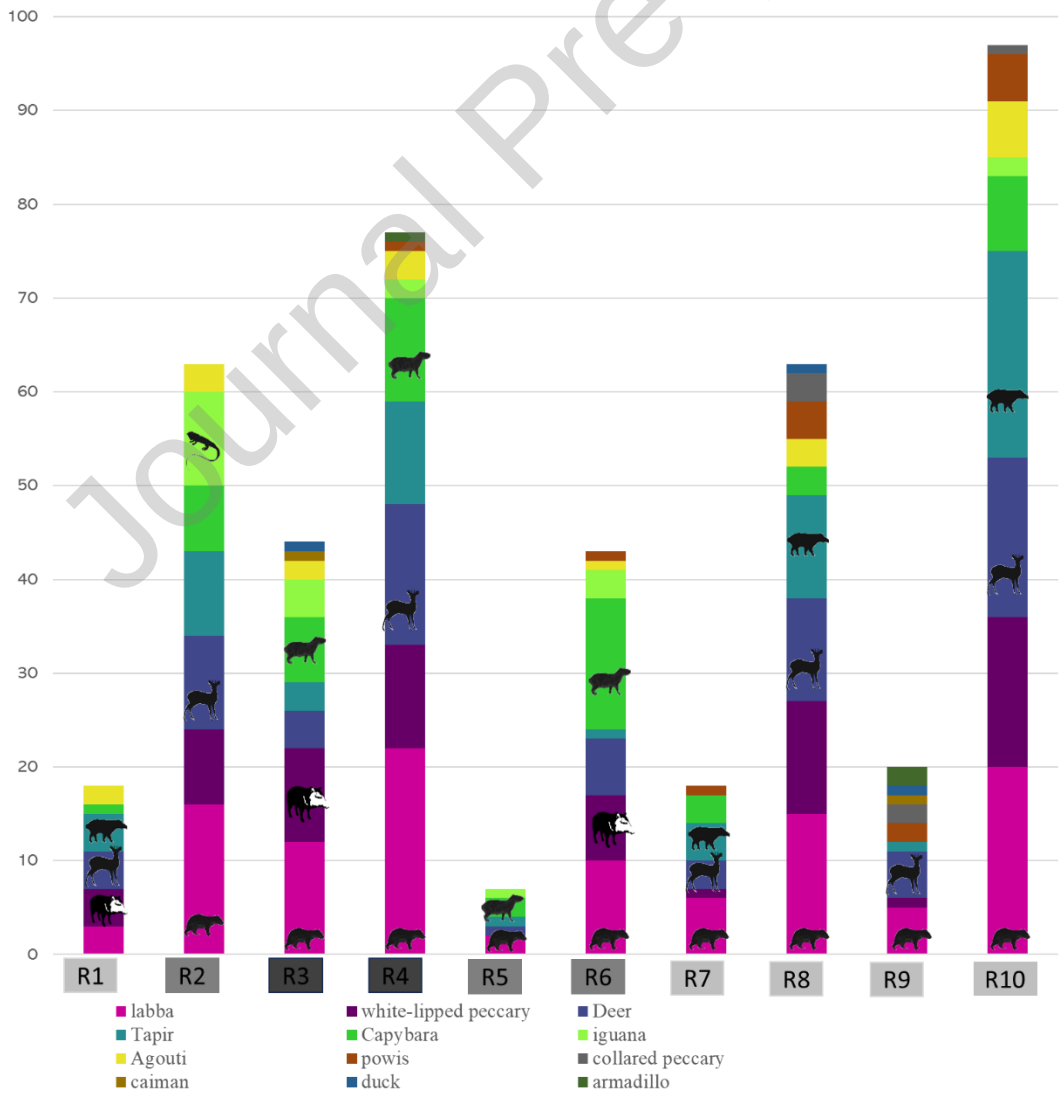


Figure 1. Representation of each taxon cited as most traded in each region. The species are ordered in accordance with their frequency of citations for all regions.

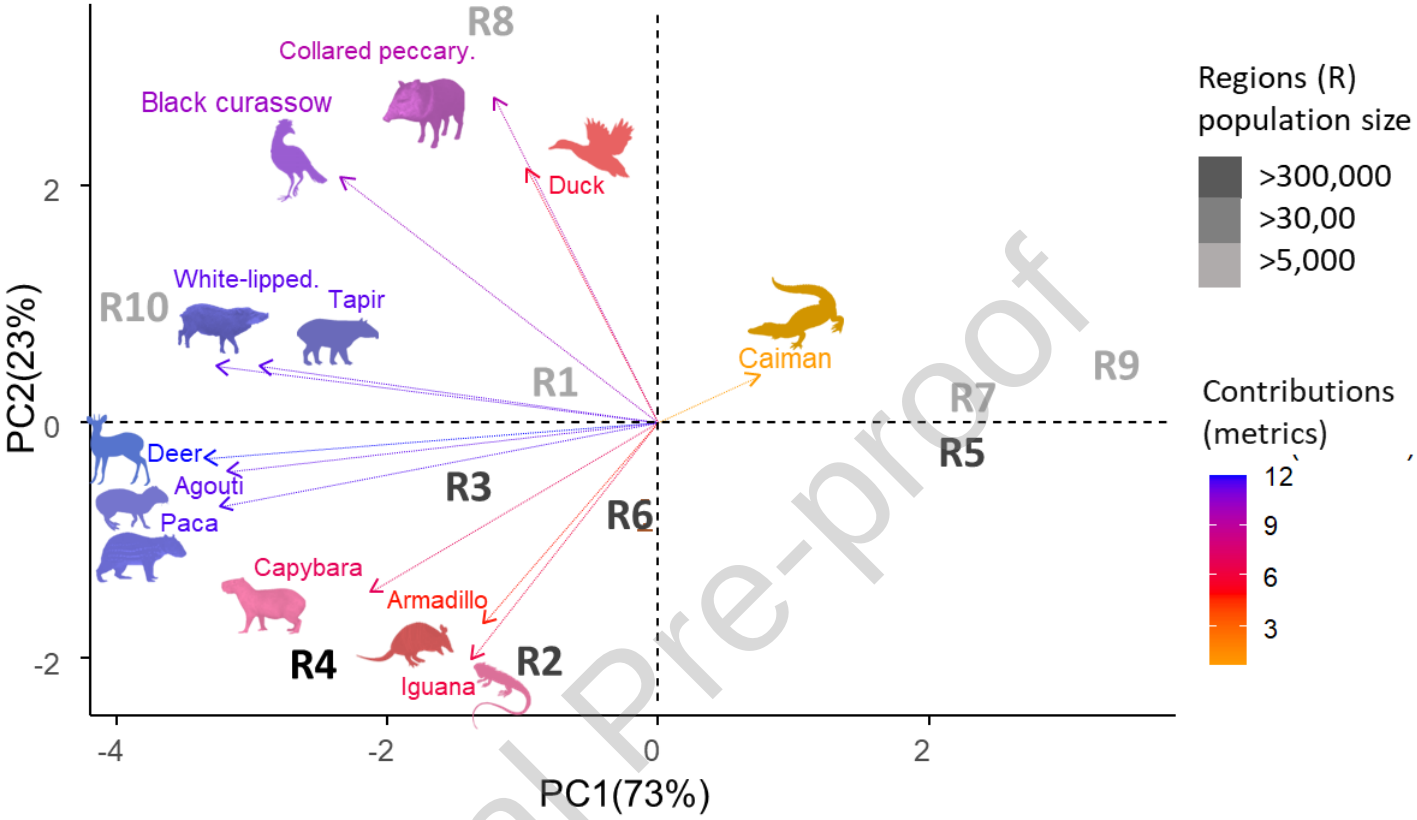


Figure 2. Contribution of each species of the variance among different regions where the animal were trade obtained from a Principal Component Analysis (PCA).

3.2 *Sale topology characteristics influencing on the trade*

Sellers trading larger quantities of wildmeat were typically those who actively hunted, had a longer history of meat sales and relied more on meat trade income (Figure 3A). Raw meat vendors traded more wildmeat compared to those in restaurants, bars, or food trucks (Figure 3B). Sellers using freezers handled larger quantities, while those keeping meat fresh handled smaller amounts (Figure 3C). Additionally, sellers using motorized boats and private vehicles for transportation traded larger volumes, while those using other modes handled smaller quantities (Figure 3D).

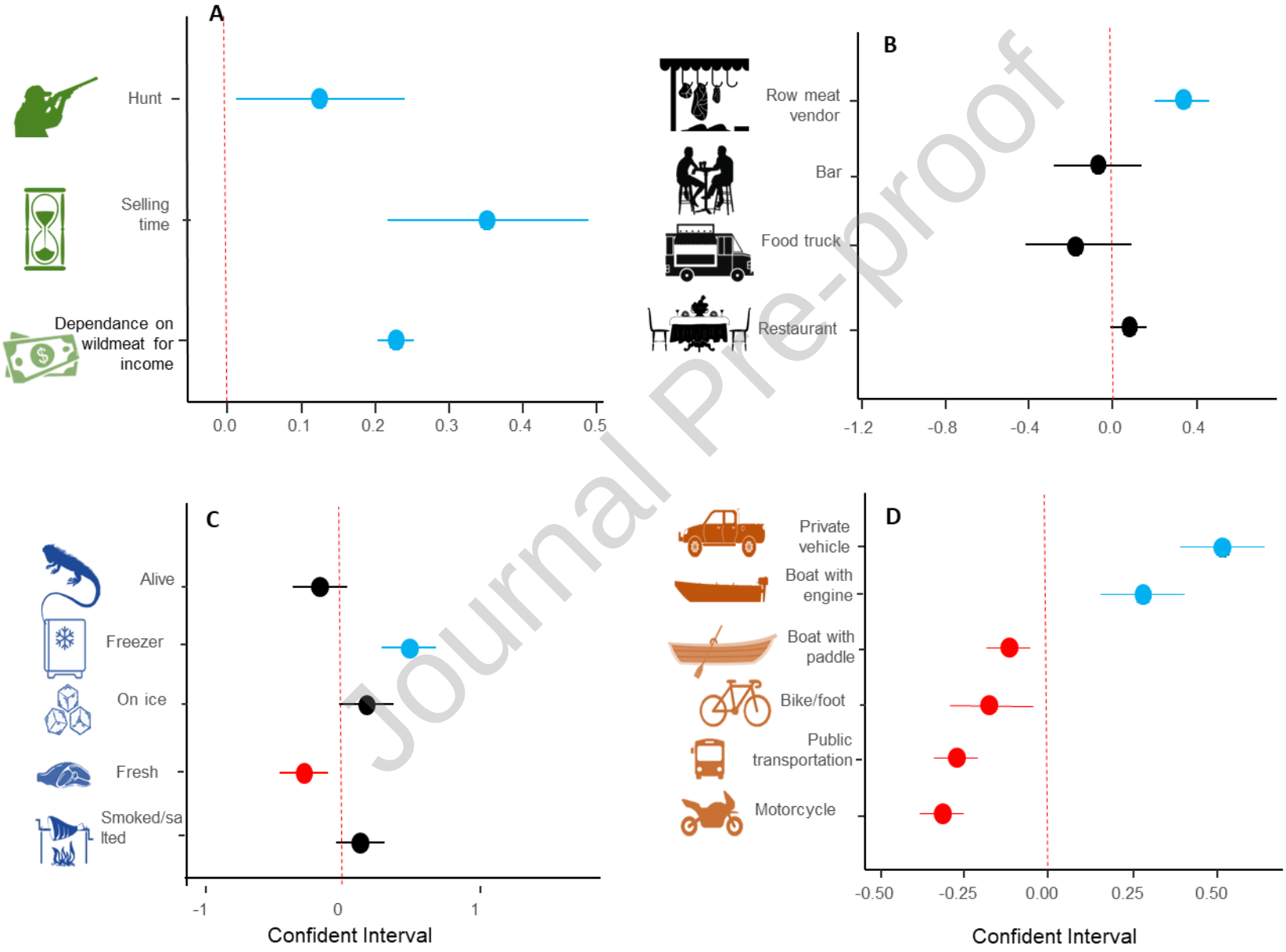
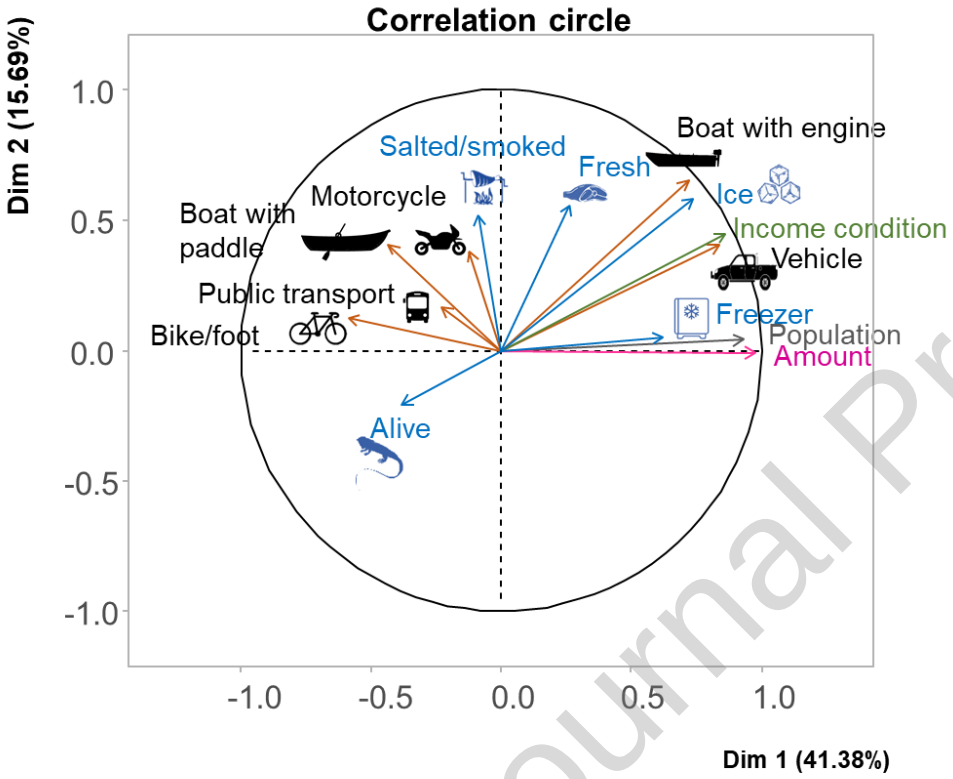


Figure 3) Linear coefficient estimates (±95% confidence intervals) showing the magnitude and direction of the amount of wildmeat traded by the seller characteristics (A), type of business (B), ways to preserve wildmeat (C), and ways to transport wildmeat (D). Blue and red solid dots represent either significantly positive or significantly negative effects, respectively; and black solid dots represent non-significant effects. The iguana silhouette is indicating this is the only species sold alive for meat consumption purpose.

3.3 Regional overview

When analyzing the wildmeat trade by region, both the GLM (Supplementary material, Table 3) and the MFA (Fig 5A) indicated a robust correlation between a larger volume of traded meat and: i) prevalence of freezer and ice preservation methods, ii) prevalence usage of vehicles and boats with engine, iii) elevated GDP per capita; and iv) larger human population size. This also aligned with workshop findings (see section 3.4). Vehicles dominated transportation means in Regions 2, 3, 4, 6, and 10, followed by motorized boats. In Regions 1, 7, and 9, paddle-driven boats were common, while in Region 5, motorcycles, vehicles, bicycles, and foot travel were equally prevalent (Fig 5B; Supplementary material, Fig 2). In more populated Regions 3, 5, 6, and 7 over 50% of sellers use freezers; and in Regions 4 and 10 at least 40% use ice. In less populated Regions 1, 8, and 9, smoked meat prevailed, often due to Amerindian cultural preferences and the absence of electricity at sales points (Fig 5B; Supplementary material, Fig 3).



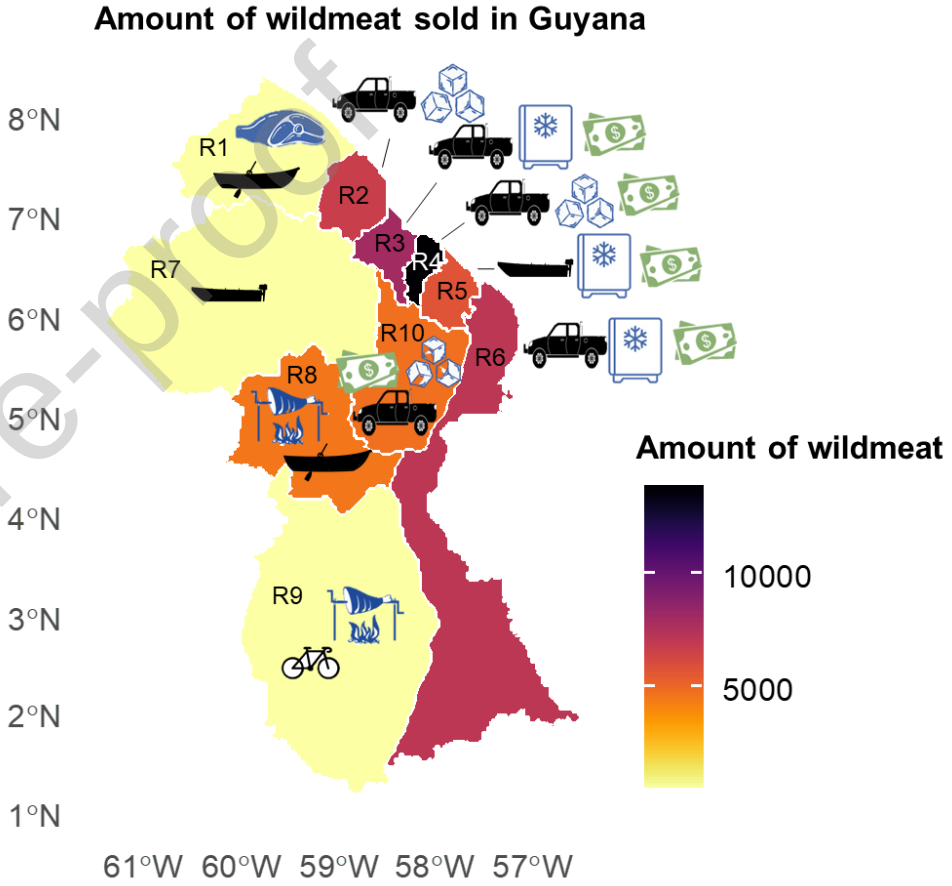


Figure 5A) Contribution of each means to transport and preserve the meat, population size, GDP per capita, and amount of meat traded to the variance among different regions obtained from a Multiple factor analysis (MFA). B) Main means of meat transportation (black symbols), meat preservation (blue symbols), and the regions with higher GDP per capita (money symbol). The amount of meat traded monthly by all interviewee in each region is represented in the color scale.

3.4 Wildmeat trade evolution in the last 30 years

The workshop findings align with interview results. Along the coast, preservation techniques have evolved from smoking and salting to more efficient cooling and freezing, enabling longer storage with less effort. Transportation has shifted from mechanical to motorized modes, leading to faster transport and improved sales. Furthermore, the transition from traditional bow and arrow hunting to firearms has increased the number of animals killed (Fig. 4A and B). Interview data indicated a consensus on the wildmeat trade's growth, attributed to increased demand and a higher number of hunters (Fig. 4C), with rising demand especially during peak seasons like Christmas and Annual Amerindian Heritage celebrations. They also noted a significant increase in the price of wildmeat per pound in the last 30 years (going from US$0.65 to $1.83 per Kg on the coast), primarily due to elevated transportation costs resulting from higher fuel prices and the necessity for hunters to cover longer distances to reach hunting grounds (Fig. 4A).

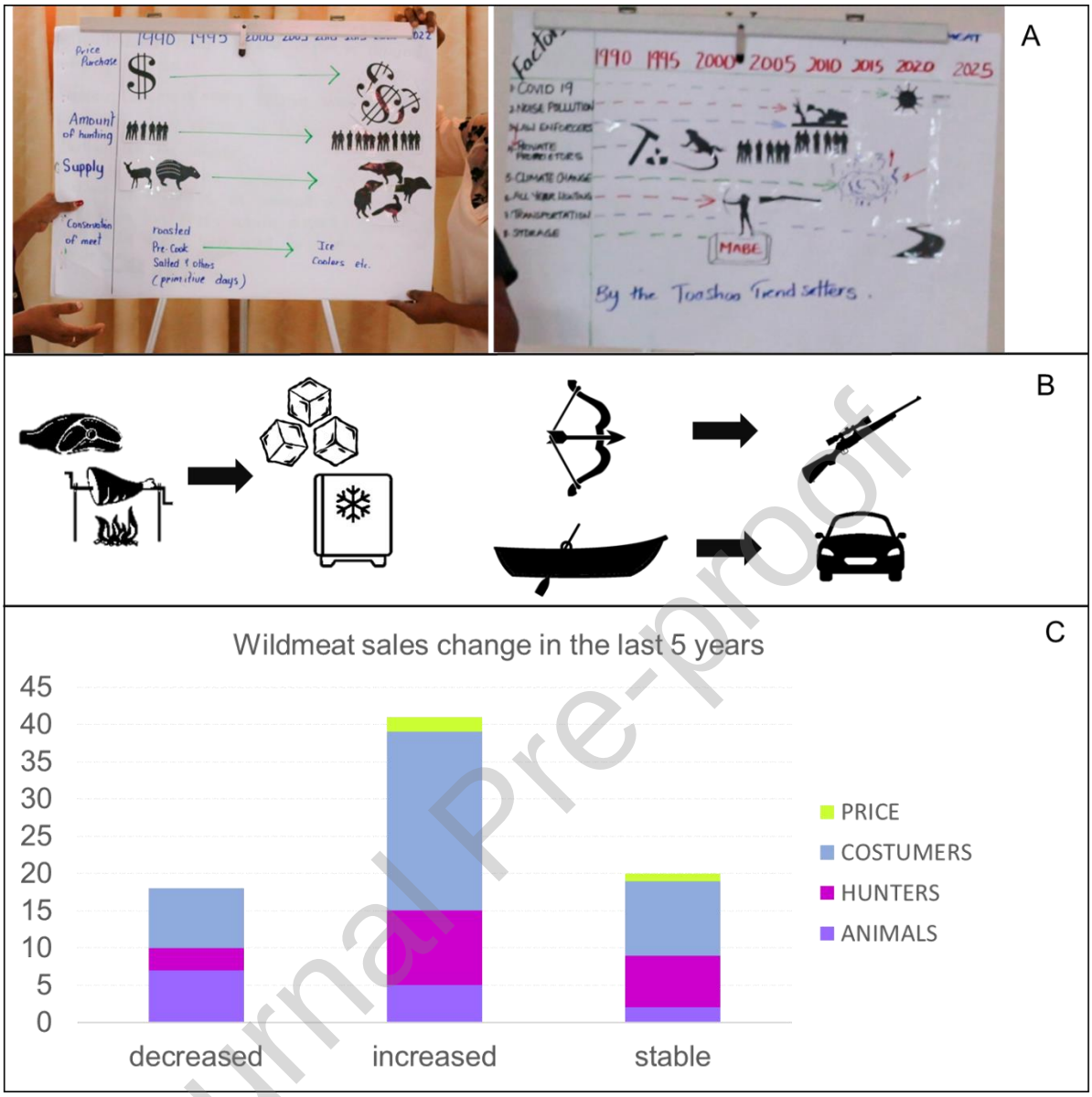


Figure 4. Evolution of the wildmeat trade in the last 5 years

3.5 Projection for the wildmeat trade in the next 10 years in Guyana

Proportion of wildmeat trade increase to 2033= (0.0004_{estimate} * $292.74_{\text{increase rate}}$) + (0.000005* 1.0765) + (2.03152* 5)= 0.12 + 0.0000054+ 10.160= 10.2800054

Proportion of wildmeat trade increase to 2050= (0.0004* 4,129.28) + (0.000005* 1.2115) + (2.032* 5)= 1.65 + 0.000006 + 10.160=11.810006

The calculation of the amount of wildmeat projected to be traded the next years, indicated that the quantity of meat traded could increase from around 1,000 tons

(1.23Kg/person/year) in 2023 to 10,280tons (11.73Kg/person/year) in 2033, and to 11,810tons (11.97Kg/person/year) in 2050 in Guyana if environmental public policies remain unchanged.

4 Discussion

Our study highlights the financial significance of the wild meat trade at national scale in Guyana, estimating a current volume of approximately 1,000 tons (1.23 kg/person/year), valued at 1,779,750 USD. The per capita volume of wildmeat traded in this study is comparable with findings from Iquitos, a large town in the Peruvian Amazon (Mayor et al., 2021) but is lower than that reported in medium sized towns from the Amazon (3.2 kg/person/ year in the tri frontier region van Vliet et al., 2014); 6,49 kg/person/year in the Brazilian Amazon El Bizri et al., 2019). This smaller volume of per capita consumption recorded for Guyana is probably because the meat in the country is significantly obtained through informal channels such as subsistence hunting, informal distribution networks among hunter's relatives and local barter (Paemelaere et al., 2022). This informal sharing is common due to the predominance of rural residency in Guyana (72.98%; World Bank, 2018). For comparison, the volumes traded per km^2 in Guyana (0,005 tons/km^2) are 6 times smaller than those estimated for Cameroon in Central Africa (0,03 tons/km^2) (Lescuyer and Nasi, 2015).

In our research in Guyana, the most traded wild meat species were paca, deer, tapir, white-lipped peccary and capybara. These top sold species were also identified among the most traded species in other parts of the Amazon as described by van Vliet et al. (2014) in the Amazonian tri-frontier, by Suárez et al., (2009) in Equador and by Mayor et al. (2021) in the Peruvian Amazon. Among those species, tapir and white-lipped peccary are classified as vulnerable according to IUCN Red List criteria, being their decline evident in Amazonia, with hunting identified as one of the primary threat (IUCN, 2024, Parry & Peres, 2014). Lowland paca and the other top sold species are impacted by hunting in Amazonia (Valsecchi et al., 2014; El Bizri et al., 2019) but they are currently listed as least concern by IUCN (IUCN, 2024).

Our study suggests that wildmeat demand hubs are located in urban areas with highest purchasing power. Indeed, wildmeat volumes traded are higher in regions with higher

population density on the Coast (in Regions 2-6) which also coincide with highest GDP per capita. The conjunction of both preference and purchasing power constitute the foundations of wildmeat demand on the coast of Guyana. Among urban dwellers, wildmeat is generally purchased rather than gifted, as opposed to rural settings where wildmeat is most often either self-procured or gifted (Paemelaere, 2022). While wildmeat is more expensive than other sources of meat on the Coast of Guyana (van Vliet et al., 2022), it represents a highly preferred food for its taste, cultural symbol, unique experience, and general enjoyment, particularly among men living in urban areas on the Coast (Paemelaere et al., 2024). These results support finding from other parts of the Amazon where wealthier populations were found to buy a more diverse diet and higher volume of wildmeat (Parry et al.,2014; Chaves et al. 2019).

On the other hand, we found that factors affecting wildmeat provision were related to access to transportation means from the hunting ground to the demand centers, access to basic services such as electricity and higher GDP per capita levels. Roads and rivers facilitate access further into forested areas, and significantly influence meat provision. Access to electricity provides opportunities to keep the meat on ice from the hunting ground to the consumption hub, while absence of the same requires salting or smoking the meat, which implies loss in volume and value. Studies in Brazil, Colombia, and Peru demonstrate that meat prices are significantly influenced by preservation methods (Mayor et al., 2021; van Vliet et al., 2014; Morsello et al., 2015). Notably, smoked or salted bushmeat is approximately 20% cheaper than fresh bushmeat (van Vliet et al., 2014). Higher GDP per capita among traders also enables them to adopt efficient meat preservation methods (e.g. coolers) and faster transportation (outboard boats, vehicles) (Godoy et al., 2010), preventing spoilage during transport and sales, and ultimately boosting trade provision. According to wildmeat traders in Guyana, wild meat provision has been increasing steadily over the past 30 years, particularly due to increased wealth, which facilitated investment in preservation and transportation methods.

Nevertheless, based on observations from wildmeat traders, demand appears to be increasing faster than provision, leading to scarcity of wildmeat and higher prices at the level of consumers. This also suggests that if limiting factors to provision were removed, such as through road network development, infrastructure development and

increase in wealth, then there would be scope for the wildmeat sector to significantly increase. Our projections indicate that with current enforcement levels, Guyana's economic expansion could result in the sharp increase in wildmeat trade volumes reaching an estimate of 11,810 tons per year by 2050. The development of road networks and proliferation of vehicles has already shown to alter hunters' behavior, towards more commercial hunting (Levi et al., 2011; Espinosa et al., 2014; Fahrig & Rytwinski, 2009; Branch et al., 2022; Wilkie et al., 2000; van Vliet et al., 2022). In Guyana, the ongoing road expansion efforts, aimed at fostering hinterland development and resource extraction access, may, on the other hand, compromise the sustainable use of wildmeat in the country. Particular attention should be placed to region 9, which is not currently fully integrated in the wildmeat trade value chain but may become so, as the plans to upgrade and tar the main road traversing the country and connecting it to Brazil, becomes a reality.

While provision is likely to increase based on current development scenarios, demand is likely to grow concomitantly, leading to a vicious circle between demand and provision. Wildmeat consumption in Guyana is a deep-seated cultural tradition (Paemelaere et al, 2024) and even if behaviors could be curved over time, these cultural changes are likely to be slower than the extremely rapid changes that the country is expected to experience. If Guyana rapidly expands its lucrative natural resource exports, particularly in oil, its currency will strengthen, and non-resource sectors, such as those on which rural population depend, are likely to lose appeal. This phenomenon, known as Dutch Disease, may have the potential to push some individuals towards alternative sources of income, such as engaging in the commercial hunting and wildmeat trade (Douglas et al 2014).

From a sustainable management perspective, our study identifies three main opportunities to ensure that the much-desired improvement in GDP per capita , expected from the oil sector, does not hinder the possibility to maintain a sustainable wildmeat sector. First, the sector requires to be well regulated through a licensing and a quota system that can be adequately enforced (van Vliet et al., 2022). The effectiveness of wildlife conservation and sustainable management hinges on establishing and effective enforcing rules and regulations governing both the hunting and trade of wild meat (Coad et al., 2019). Existing laws addressing hunting and wild meat trade in Guyana

require further enforcement to prevent the 'tragedy of the commons' and foster a sustainable wild meat provision aligning with local needs. Second, efforts to curve demand on the Coast need to be strengthened based on well designed and culturally adapted behaviour change campaigns (Paemelaere et al., 2024). Evidence of the effectiveness of social marketing approaches to reduce unsustainable is growing in tropical contexts and has started to show potential in the context of hunting (Chavez et al., 2017; van Vliet et al. 2022; Chausson et al.,2019). Third, local communities and indigenous people need to be empowered to protect and conserve their territories and wildlife resources, in particular with the authority to exclude illegal hunters (Coad et al., 2019). Collaborative efforts involving Indigenous Peoples, local communities, NGOs, and the private sector are crucial for sustainable wild meat provision, emphasizing evidence-based approaches and community participation.

Funding

This research received financial support from the European Union as part of the Sustainable Wildlife Management Programme, an initiative of the Organization of African, Caribbean, and Pacific States (OACPS). Additional funding was provided through co-sponsorship from the French Facility for Global Environment and the French Development Agency, facilitated by the Food and Agriculture Organization of the United Nations (FAO), the French Agricultural Research Centre for International Development (CIRAD), the Centre for International Forestry Research (CIFOR), and the Wildlife Conservation Society (WCS). Turtle Conservation Fund.

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Declaration of Competing Interest

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

Ethics statement

This research was reviewed and approved by CIFOR Research Ethics Committee (https://www.cifor.org/fileadmin/downloads/CIFOR-Research-Ethics.pdf) and follows the Free Prior and Informed Consent and social safeguards approach from the Sustainable Wildlife Management (SWM) Programme (https://www.fao.org/3/cb7248en/cb7248en.pdf). Community meetings and coordination with communal authorities were carried out prior to conducting interviews to agree on procedures. Prior to commencing the interviews, we provided a clear explanation of the objectives of our research to each seller. To ensure a comfortable and transparent interview process, we acquainted participants with the study's goals beforehand. Participation to the study was based on a voluntary basis grounded on free, prior and

informed consent, and interviewees were assured that their identities would remain confidential.