Urban Ecosystems (2024) 27:1707–1721
https://doi.org/10.1007/s11252-024-01548-8

Policy-making for peri-urban landscapes as arenas of human-wildlife interactions

Annemarie Tabea Roth[1] · Janina Kleemann[1,2] · Marcin Spyra[1,3]

Accepted: 9 April 2024 / Published online: 20 April 2024

Abstract

Peri-urban landscapes are transitional areas between urban and rural areas that are constantly changing. They are characterised by land use mixes and land cover changes, leading to significant changes in wildlife habitats. These changes, combined with an increasing anthropogenic presence, turn peri-urban landscapes into arenas of intensified human-wildlife interactions. In many scientifically documented cases, scientists are focusing on negative interactions. Furthermore, research about appropriate policy instruments for managing human-wildlife interactions is rare. This study focused on case studies and their characteristics from around the world on positive, neutral, or negative interactions between humans and wildlife at local level. In addition, influencing factors of human-wildlife interactions and policy instruments for managing human-wildlife interactions in peri-urban landscapes were addressed. A survey was conducted with an international group of scientists and practitioners working in this field. The results showed that various species were involved in human-wildlife interactions in peri-urban landscapes worldwide, with mammals as being the most common taxon. Contemporary changes in land use and land cover could be identified as a significant factor for increasing human-wildlife interactions in peri-urban landscapes. It can be highlighted that a policy mix consisting mainly of social and cultural instruments in combination with legal and regulatory instruments could be most suitable to address this situation.

Keywords Conflict · Habitat · Pressure · Species · Suburban · Urban periphery

Introduction

Interactions between human and wildlife have already existed before records began (Soulsbury and White 2015). However, today, human-wildlife interactions (HWI) become more frequently due to changes in habitat, which emerge either when humans encroach on wildlife habitat or when wildlife populations spread into areas dominated by humans (König et al. 2021a). Habitat changes that are often related to such processes are characterised by habitat loss, habitat fragmentation, and habitat degradation (Banks-Leite et al. 2020; Irwin 2016; Ullah et al. 2024). These types of habitat transformation are predominantly interrelated and co-occur in human-modified landscapes (Banks-Leite et al. 2020; Bennett and Saunders 2010), causing severe pressure on wildlife populations (Irwin 2016) and posing a threat to biodiversity worldwide (Banks-Leite et al. 2020; Fahrig 2017; Tellería 2016). Contemporary drivers of HWI are also evident in human-enforced translocation of wildlife to new habitats, natural expansion of recovered populations, people's changing attitudes towards wildlife due to climate change, human presence in wildlife habitats, and the emergence of zoonotic diseases (König et al. 2020).

The term "wildlife" refers to animal species that are not domesticated as pets or livestock (Frank and Glikman 2019; Yarrow 2009). The concept of HWI is primarily discussed in literature related to conservation (Knox et al. 2021; Su et

✉ Janina Kleemann
janina.kleemann@geo.uni-halle.de

Annemarie Tabea Roth
antaro@posteo.de

Marcin Spyra
m.spyra@po.edu.pl

1 Institute for Geosciences and Geography, Department of Sustainable Landscape Development, Martin-Luther University Halle-Wittenberg, Halle (Saale), Germany

2 German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, Germany

3 Faculty of Civil Engineering and Architecture, Opole University of Technology, Opole, Poland

al. 2022) and agriculture (König et al. 2020, 2021a). However, this concept is also adopted in social sciences (Bennett et al. 2017; Knox et al. 2021), economics (Fletcher and Toncheva 2021), psychology (Buijs and Jacobs 2021) and medical and health sciences (Mackenstedt et al. 2015). HWI are defined as events involving direct or indirect contact between humans and wildlife, either as individuals, groups, or populations (Whitehouse-Tedd et al. 2021). Most often in scientific literature and also in mainstream discourses, negative HWI are analysed (=human-wildlife-conflicts). Wildlife is causing threats to the livelihood or safety of a person or a community (Inskip and Zimmermann 2009). Negative outcomes for wildlife are often a consequence of human-wildlife-conflicts, such as the persecution or lethal control of wildlife, species habitat destruction or habitat degradation (Dickman 2010; Nyhus 2016; Ogra 2008). In contrast, a positive HWI and positive outcome can include an increase in tolerance and awareness of wildlife, as indicated by people encouraging wildlife presence and the creation of habitats (Morzillo et al. 2014). Besides the binary evaluation – positive or negative – an additional neutral option for assessing impacts is offered in the framework of Soulsbury and White (2019) for both, human and wildlife perspectives. Such a framework allows a fourth dimension that describes interventions, i.e. measures, derived from the previously analysed outcomes and impacts of HWI (Fig. 1). Positive HWI require coexistence management by improving the awareness for the wildlife species. Negative interactions require conflict management with communicating the risk and managing better wildlife.

In addition, recent literature suggested to shift the focus away from conflict to coexistence (Buijs and Jacobs 2021; Frank 2016; Frank and Glikman 2019; Glikman et al. 2019; IUCN SSC and HWCTF 2022; Marchini et al. 2019; Nyhus 2016). According to Glikman et al. (2019), coexistence describes both the well-being of people interacting with wildlife and the ethical treatment of involved wildlife. Crucially, coexistence does neither imply only positive interactions (Glikman et al. 2019) nor the absence of a conflict or negative impacts (IUCN SSC and HWCTF 2022). Despite the growing attention towards human-wildlife coexistence, some authors argue for more science related to the concept of coexistence (Carter and Linnell 2016; Knox et al. 2021; Marchini et al. 2019). In this discourse, the IUCN Species Survival Commission (SSC) Human-Wildlife Conflict and Coexistence Specialist Group (HWCTF) proposed to go beyond a single definition of coexistence. They suggested to use a pluralistic approach with a set of key characteristics including coexistence rather as a process than a fixed state (IUCN SSC and HWCTF 2022).

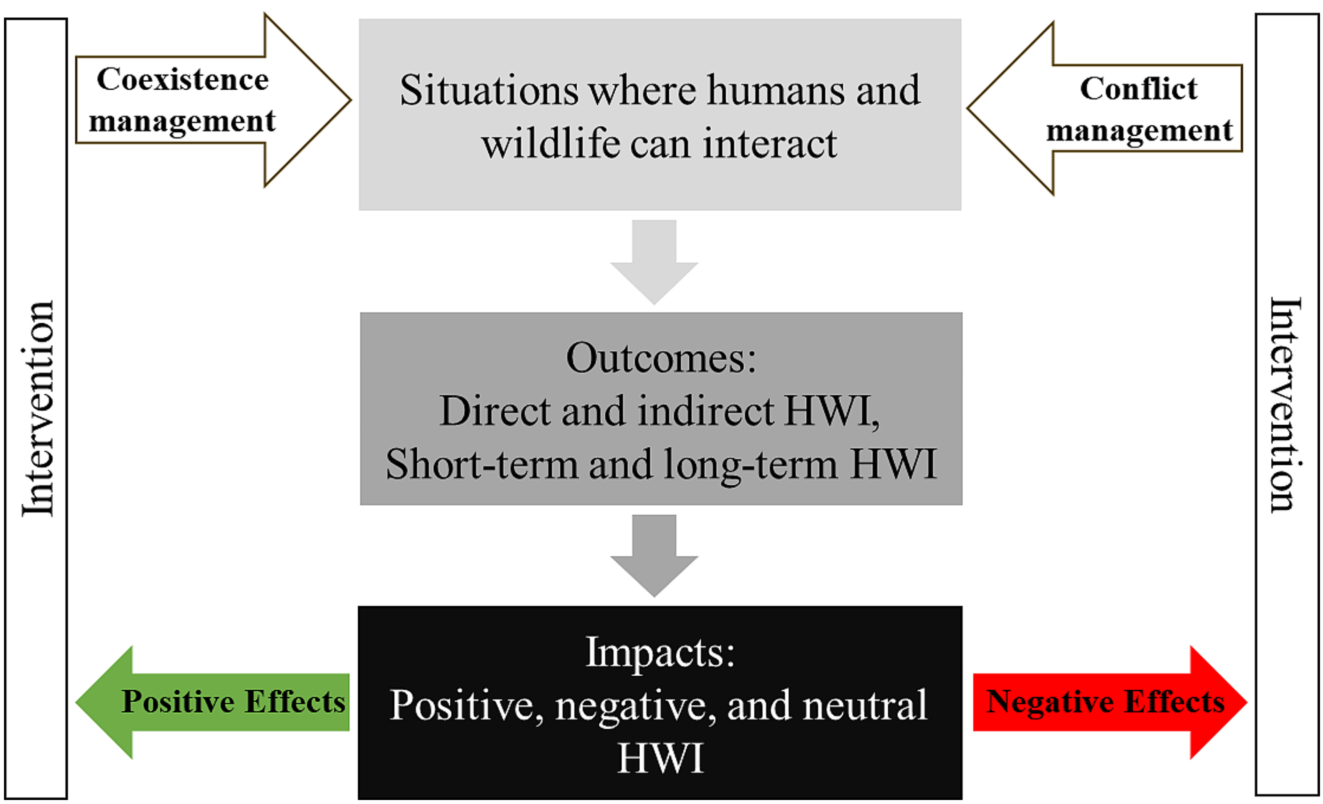

Fig. 1 Framework of human–wildlife interactions (simplified and modified version of Soulsbury and White 2019). HWI = Human-Wildlife Interactions

Literature showed that peri-urban landscapes (PUL) become specific arenas, meaning locations, or places where more HWI occur than in other urban spaces (Soulsbury and White 2015). PUL are specifically prone to such interactions due to their transitioning and dynamically changing land use character (Spyra et al. 2021). This is due to the fact that PUL are territories where urban and rural patterns are mixed (Spyra et al. 2020), forming a specific zone laid in between urban and rural areas (Simon 2021). Mostly, existing research focus on negative HWI in PUL, while positive interactions have been studied only to a limited extent. Sogliani et al. (2021), for example, described positive emotions such as joy and interest for human-rabbit interactions in a peri-urban park. Further, Dandy et al. (2009) identified several possible positive human-deer interactions in a PUL. Research on negative interactions between humans and wildlife mainly deals with accidents. It often involves wildlife-vehicle collisions (Hilário et al. 2021; Zuberogoitia et al. 2014) and their causes and consequences, which can include injuries and deaths to humans and wildlife.

HWI in PUL as a risk to human health are also of academic interest. Acharya et al. (2017) found a positive correlation between the increase of attacks on humans by tigers *(Panthera tigris tigris*), leopards (*Panthera pardus)*, rhinoceros (*Rhinoceros unicornis*), and Asiatic elephants (*Elephas maximus*) and the fragmentation of forests in densely populated settlements in Nepal. Zoonotic diseases are also well studied (Harriott et al. 2019; Hornok et al. 2022; Sonawane et al. 2021) because growing HWI in PUL increase the risk of spillover events where pathogens are transferred from wild animals to humans. In the European context, Mackenstedt et al. (2015) identified PUL as a priority contact zone between humans and foxes (*Vulpes sp.)*, favouring the spread of parasitic zoonoses by wildlife in PUL. Obviously, there exist different anthropogenic factors that potentially influence HWI in PUL – land use/cover changes or human activities, e.g. feeding wildlife or recreational use (Castillo-Contreras et al. 2021; Das et al. 2022). In our study, we will assess selected factors that potentially influence HWI in PUL.

Despite growing interest in HWI and in PUL, research about policy-making, addressing the mentioned aspects, is largely missing. Several studies that are describing HWI in PUL focus rather on analyses of consequences of interactions, while giving less attention to approaches that are reducing negative effects of these interactions (e.g., Chaves et al. 2022; Hauptfleisch et al. 2021; Herbert et al. 2021). This study aims to close this gap by gathering knowledge that is important for policy-making in PUL as arenas of HWI. It is implemented by gathering knowledge about appropriate policy instruments, i.e., instruments aiming to support sustainable coexistence of humans and wildlife, avoiding emerging tensions and/or solving existing conflicts between humans and wildlife in PUL. Given the needs mentioned above, the following research questions were addressed:

1. Which are the characteristics of human-wildlife interactions in PUL?
2. What influence do selected factors have on PUL as arenas of human-wildlife interactions?
3. Which policy instruments are appropriate in policy-making for PUL as arenas of human-wildlife interactions?

We investigated these research questions by using an online survey as a quantitative research method (Nardi 2018). We intended to shift the focus from looking at individual species at local level to a more universal set of outcomes and classifications of HWI by considering positive, neutral and/or negative impacts (Soulsbury and White 2019). We asked scientists and practitioners working in the field of HWI and PUL to answer a structured online survey with closed- and open-ended questions.

Methodology

An online survey was used to gather data for this research. Surveys and questionnaires are common stakeholder-based (and expert-based) data elicitation tools in human-wildlife analyses (e.g., see Auster et al. 2022; Pejchar et al. 2021; Piana et al. 2024). The survey was divided into three thematic blocks according to the sequence of the three main research questions (see supplementary material S1 for the extract of the survey template). In order to categorise the answers related to the third research question, the classification of policy instruments provided by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was used in this study. IPBES is a platform for international collaboration between science and policy for the conservation and sustainability of biodiversity and ecosystem services (IPBES 2022a). The classification of policy instruments of IPBES has been used due to its international significance and the applicability of its methods and approaches in different contexts and worldviews. According to IPBES, policy instruments can be categorised into legal and regulatory instruments, rights-based instruments and customary norms, economic and financial instruments, and social and cultural instruments (IPBES 2022b). While the development and implementation of policy instruments is usually attributed to public authorities only, there is a broader understanding that key decision-makers include not only public authorities but also groups, organisations, indigenous people and local communities, entities and other stakeholders (IPBES 2022b).

For the online survey, 12 closed-ended questions were used, accompanied by six open ended questions. Open-ended questions were asked, for example, about the name of the project or case study related to HWI and for further information about the study (supplementary material S1, Q.2b scientists) or project (supplementary material S1, Q.2c practitioners). In addition, the specific wildlife species involved in HWI were asked (supplementary material S1, Q.3a). The open-ended questions were grouped into categories (Döring and Bortz 2016). In order to achieve a common understanding of selected terms, external links to IPBES' definitions of policy instruments (IPBES 2022c) and the process of policy-making (IPBES 2022b) were provided to the respondents (supplementary material S1, Q.7, Q.9). Due to the fact that the final sample size was low, we did not distinguish further in the analysis between scientists and practitioners.

Respondents were asked to rate their agreement with a series of statements (supplementary material S1, Q.6, Q.8) on a 5-point Likert-scale, ranging from "strongly agree (1)" to "strongly disagree (5)". The level of involvement of different actors (supplementary material S1, Q.9) was captured with an ordered scale with five options, ranging from "very high (1)" to "very low (5)". Likert-scale is often used for stakeholder-based and expert-based data elicitation, e.g. see Goodale et al. (2015); Kleemann et al. (2017); Spyra et al. (2021); Ten et al. (2021); White et al. (2005).

The open-source software tool LimeSurvey version 2.05 + Build 140,404 was used to operationalise the survey. The survey was activated from 22 August 2021 to 10 December 2021. Initially, a pre-test of the survey was conducted to increase its clarity, methodological and scientific soundness. Invitations to participate in the survey were sent out from 28 September 2021 to 07 November 2021. This was done in the frame of both as an active and passive sampling. The active sampling was carried out via personalised or standardised e-mails to 212 well-known experts in the field of HWI (known by publications, conferences and direct contacts), while the passive sampling was carried out by distributing the survey link through relevant websites and social media channels, especially those of the Global Land Programme (GLP 2021). The target group of the survey consisted of an international group of scientists and practitioners working on HWI in PUL. Due to the exclusive selection of respondents, this was a judgemental sampling (Nardi 2018). Since the data collection took place once, the study represents a cross-sectional study in terms of the temporal dimension (Döring and Bortz 2016).

During the survey period, the online questionnaire was accessed 123 times. A total of 123 datasets were thus available for data preparation, with one dataset representing one access to the online-survey. All datasets were checked for completeness and duplicates (Döring and Bortz 2016). A total of 82 datasets had to be removed; 79 datasets due to incompleteness (i.e., 54 datasets contained only the mandatory answers; further 16 datasets had no answers; another nine datasets included missing mandatory responses and three datasets were identified as duplicates, probably due to a temporary data storage). Finally, there were 36 datasets classified as fully completed. In addition, five datasets were regarded as mostly complete, i.e., only max. 10 answer items were missing. Thus, 41 datasets were assessed as valid and were used for the analysis. The completion rate of 33.3% was rather low which might have been related to the extent of the online survey.

We exported the collected data from the questionnaire software LimeSurvey as xls file. Statistical analysis was performed with RStudio Version 4.2.0, data preparation and presentation were done with Microsoft Excel. For research question (RQ)1, nominal-scaled variables for questions Q.3 to Q.5 were examined by indication of frequencies. For RQ2 and RQ3, interval-scaled variables of question Q.6, Q.8 and Q.9 and nominal-scaled variables of Q.7 were analysed. Data for interval-scaled variables were analysed with descriptive statistics, using univariate statistical values such as mean, standard deviation, median, minimum and maximum and range with the "summary" function in the RStudio-package "{psych}". The bivariate analysis was carried out by cross-tabulation with the "xtabs" function on the RStudio package "{stats}". In order to further address RQ3, the relationship between variables HWI classification (Q.5) and policy instrument (Q.7) was determined through correlation using the Chi-Square statistic with the RStudio function "chisq.test{stats}". The Fishers Exact Test, function "fisher.test{stats}" on RStudio, was performed for the Chi-Square test which is mandatory if more than 20% of the numerical values are less than five (Kuckartz et al., 2010). Cramer's V, with RStudio-function "cramerV{lsr}", was used as a measure for the effect size of the association, as it is applicable to cross-tabulations of any size (Kuckartz et al., 2010). For hypothesis tests, $\alpha < 0.05$ was used as the significance level. Rating scales were handled in the analysis as interval-scaled variables and were tested with the arithmetic mean (Nardi 2018). Technically, these are ordinal-scaled, but in order to be able to calculate and examine further statistical parameters such as mean values, an interval scale was assumed here. This approach is standard for rating scales (Berger-Grabner 2016; Döring and Bortz 2016; Nardi 2018).

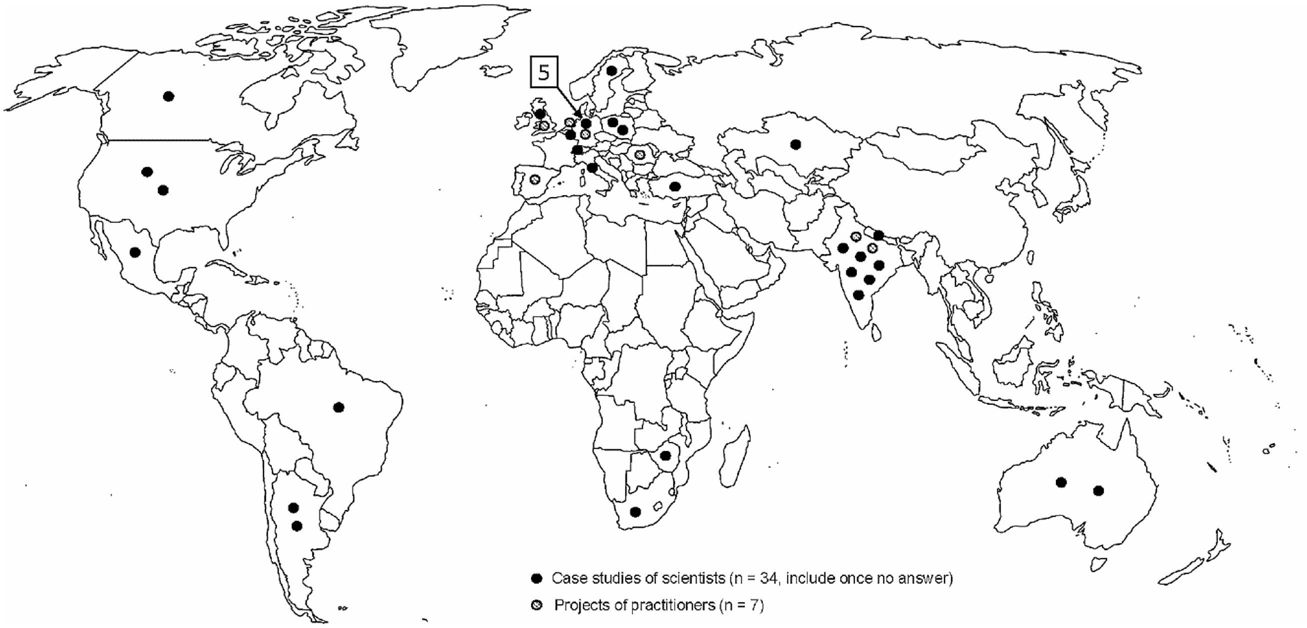

Fig. 2 Distribution of case studies of scientists and practitioners by country. However, we did not distinguish further in the analysis between scientists and practitioners due to the fact that the final sample size was low. Map reproduced from Wikimedia and edited by the author

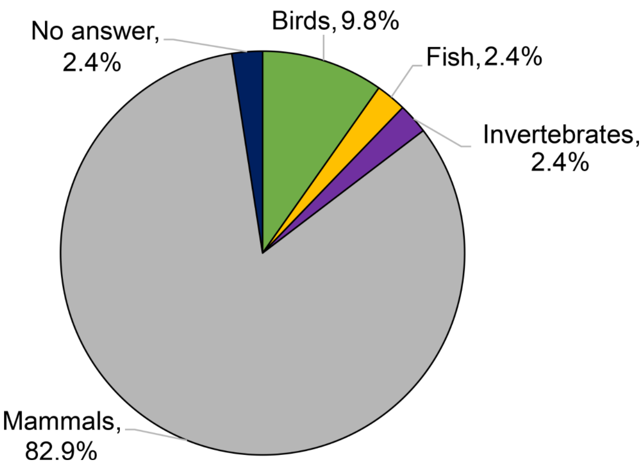

Fig. 3 Distribution of animal groups involved in human-wildlife interactions. (Question 3. Which wildlife was involved in the human-wildlife interaction investigated? Please assign the animal group.)

Results

Characteristics of human-wildlife interactions in peri-urban landscapes

The sample of the online survey included a total of 41 valid responses. As a professional background, 83% of the respondents stated that they were scientists and 17% worked as practitioners in the field of HWI and PUL. Almost half of the respondents stated Europe (49%) as their continent of origin (Fig. 2). Approximately a quarter of the respondents came from Asia (24%) and 12% from North America. In decreasing order, respondents were from South America (7%), Australia (5%) and Africa (2%).

In their case studies, respondents were mainly concerned with human-wildlife conflicts (15 mentions), HWI (14 mentions) and human-wildlife management (12 mentions, supplementary material S2, Q.2b). Research on human-wildlife coexistence was mentioned eight times. Further topics were habitats (5 mentions) and collaborations (4 mentions). With two mentions respectively, respondents addressed human and wildlife health, landscape change, planning and policy. Land use was mentioned once as a focus of research. The countries where the studies took place show an emphasis on European countries and India (Fig. 2).

With 82.9%, mammals accounted for the largest share of wildlife involved in HWI (Fig. 3). This was followed by 9.8% of interactions with birds and 2.4% with fish and invertebrates, respectively. Carnivores, as a sub-group, were involved in 41.4% of the HWI and they were mentioned on different taxonomic levels. Big cats (*Pantherinae*, 11 mentions), wolves (*Canis sp.*, 10 mentions), bears (*Ursidae*, 7 mentions), small cats (*Felinae*, 6 mentions) and foxes (*Vulpes sp.*, 5 mentions) accounted for the majority of carnivores that were named. Interactions with even-toed ungulates (*Artiodactyla*) accounted for 30.2% of all mentioned wildlife species (supplementary material S2, Q.3a). In this case, deer (*Cervinae*, 13 mentions), wild boar (*Suidae*, 12 mentions), and medium-sized bovids (*Caprinae*, 5 mentions) formed the majority. In 16.4% of the case studies, other mammals were involved in the HWI. Primarily monkeys (*Primates*, 7 mentions), rodents (*Rodentia*, 5

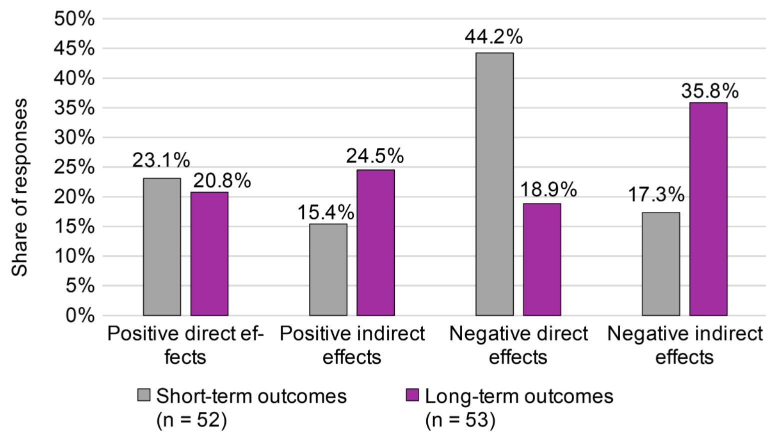

Fig. 4 Distribution of different effects of human-wildlife interactions by short- and long-term outcomes. (Question 4. What outcomes of the human-wildlife interaction with the wildlife species mentioned before [in Question 3a] were typical in the context of your studied peri-urban landscape?)

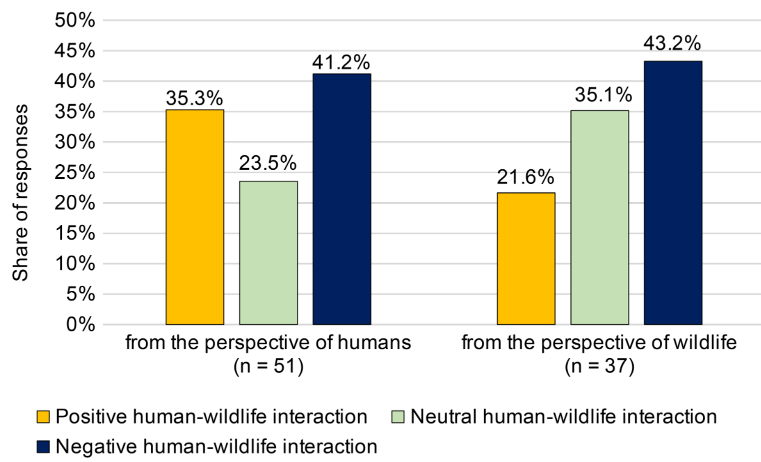

Fig. 5 Distribution of assessment of human-wildlife interactions. (Question 5. How would you classify the human-wildlife interaction described above from the perspective of human and wildlife?)

mentions) and elephants (*Elephantidae*, 4 mentions) were described here. Different bird species (*Gruidae, Laridae, Psittaciformes, Sturnidae, Picidae)* represented 6.9% of the total interactions.

Outcomes of HWI can be examined in three dimensions: direct to indirect, positive to negative, and in a temporal scale of short- to long-term. We recorded a total of 105 outcomes of HWI in the survey; almost equally divided into short-term and long-term outcomes (Fig. 4). Short-term negative direct effects had the highest value (44.2%), even though long-term negative direct effects were only 18.9%. By contrast, the short-term indirect negative effects were rated as 17.3% while the long-term indirect negative effects were 35.8%. For positive effects, the differences were not as strong as for the negative effects. The direct positive effects remained similar in short-term and long-term, but the fluctuation was slightly more pronounced for indirect positive effects, which increased by 9.1% from short- to long-term. Indirect effects, both positive and negative, showed a clear increase from short- to long-term scale. Among the short-term outcomes, 61.5% were negative and 38.5% positive effects. Thus, 67.3% of the short-term outcomes were direct and 32.7% indirect. The long-term outcomes were classified as negative at 54.7% and positive at 45.3%; with 60.3% of the effects considered indirect and 39.7% direct.

The respondents were asked to give a conclusive assessment of the HWI described previously from the perspective of humans and wildlife. From a human perspective for humans, the majority of HWI were evaluated as negative, followed by positive and neutral ratings (Fig. 5). From a human perspective for wildlife, the majority of interactions were also rated as negative, but followed by neutral and finally positive ratings. In this closed-ended question, it was possible to evaluate the interaction multiple times, i.e., positive, neutral and/or negative.

Characteristics of selected factors on human-wildlife interactions in peri-urban landscapes

Participants were asked for an evaluation of different statements related to selected characteristics of PUL that make them arenas of HWI. The results of the rating in Fig. 6 showed a range between 1 (strongly agree) and 3 (neutral). The ratings of statements PUL_1 and PUL_2 were similar, both achieved high levels of agreement. PUL_1 achieved a strong agreement. A total of 85.4% of respondents strongly

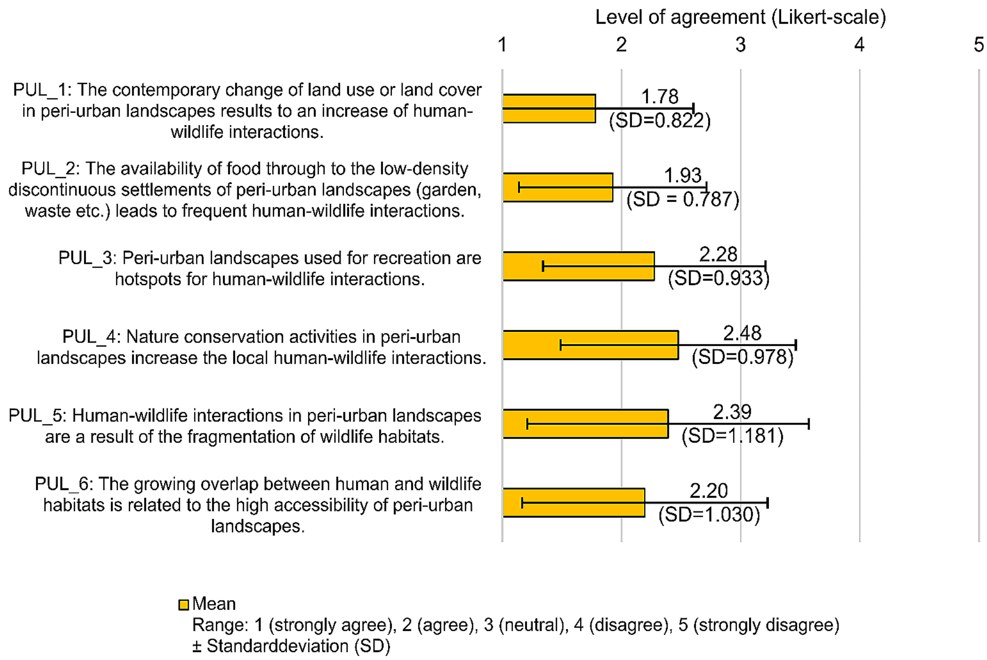

Fig. 6 Mean values with standard deviation showing rating of statements on characteristics of peri-urban landscapes as arenas of human-wildlife interactions (supplementary material S2, Q.6)

agreed or agreed with this statement (supplementary material S2, Q.6). For PUL_2, 78.0% of respondents gave a rating of "strongly agree" or "agree". Lowest agreement, but still in the range of "neutral" was shown for the statement PUL_4. The dispersion of the values resulted in a distribution between 2 (agree) and 4 (disagree). Beside a comparatively low agreement level with 47.5% of the respondents with "strongly agree" and "agree", PUL_4 also received a strongly neutral evaluation (37.5% of the respondents selected "neutral" for PUL_4). PUL_5 also achieved a rather low level of agreement but with a high dispersion of values. Approximately 61.0% of the respondents rated PUL_5 with "strongly agree" or "agree" (supplementary material S2, Q.6).

Characteristics of policy-making for human-wildlife interactions in peri-urban landscapes

The survey was carried out using the classification of policy instruments according to IPBES (IPBES 2022c). Survey respondents were asked to select a policy instrument that was in their opinion most suitable for managing the HWI described previously. The majority of respondents chose social and cultural instruments with 41.5%, followed by legal and regulatory instruments (31.7%) as appropriate policy instrument. Approx. 14.6% of the respondents preferred economic and financial instruments and 9.8% favoured rights-based instruments and customary norms (supplementary material S2, Q.7).The highest agreement across all policy instruments was given to the statement that rights-based instruments and customary norms provide incentives to achieve certain goals or behaviours (Fig. 7, PI_5). In contrast, the highest disagreement across the policy instruments was shown for the statement PI_4 that sanctions for non-compliance are included in social and cultural instruments. According to the respondents, the protection of affected wildlife (Fig. 7, PI_7) was mainly ensured by rights-based instruments and customary norms. When examining the relationship between the classification of HWI and the chosen policy instrument, the *p*-values of both, the Chi-Square test (X-squared = 20.839, df = 15, *p*-value = 0.1421) and the Fisher's exact test (*p*-value = 0.1199), indicated that there is no statistically significant relationship between the classification of HWI and the chosen policy instrument (supplementary material S2, Q.7).

On average, respondents rated that the level of involvement of stakeholders and scientists in the policy process of social and cultural instruments is high (Fig. 8); with stakeholders attaining a slightly higher level of involvement. Similar responses exist regarding economic and financial instruments. The involvement of experts/scientists, stakeholders and citizens/lay persons was rated lowest among all policy instruments (as moderate) for legal and regulatory instruments (Fig. 8).

Discussion

Human-wildlife interactions in peri-urban landscapes

Mammals are the most common taxa of wildlife being involved in HWI (Distefano 2005; Soulsbury and White 2019) – also confirmed by our findings (82.9% of the cases).

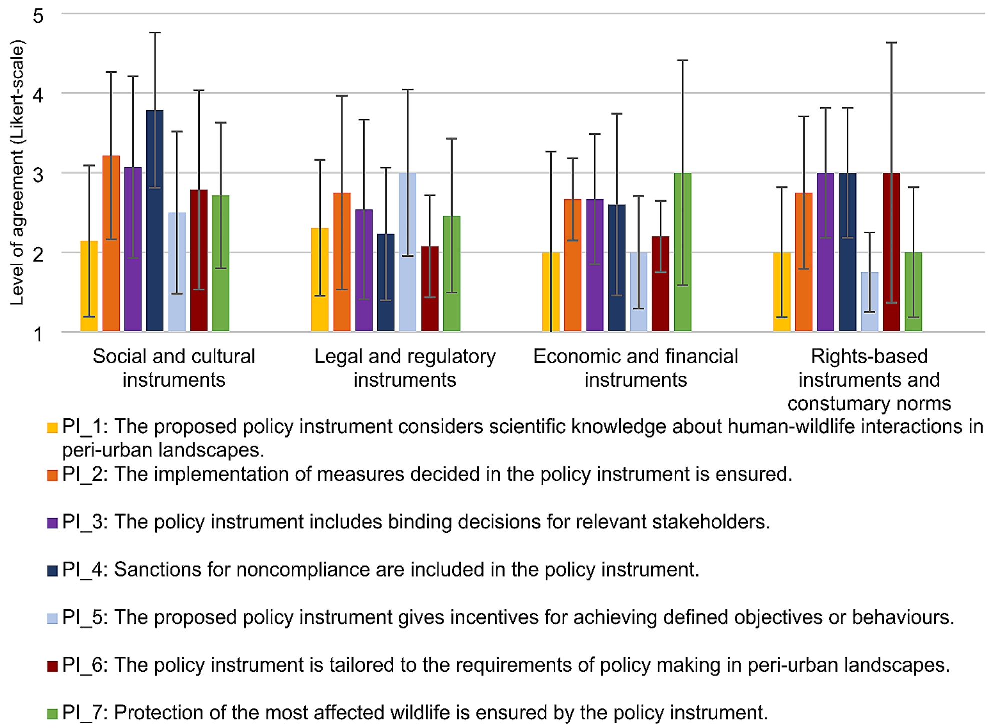

Fig. 7 Mean values with standard deviation showing rating of statements for different policy instruments (supplementary material S2, Q.9). Likert-scale is ranging from "strongly agree (1)" to "strongly disagree (5)"

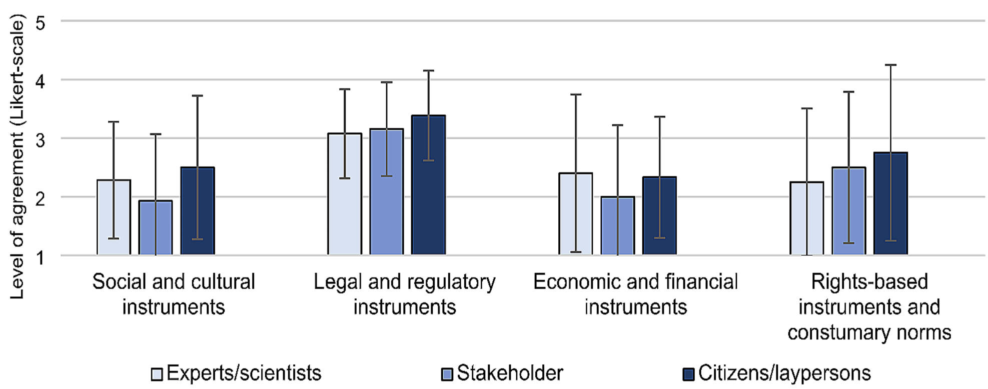

Fig. 8 Mean values with standard deviation showing rating of actor´s involvement for different policy instruments. (Q.9. What level of involvement into the process of policy-making does your previously selected political instrument allow the following actors?) Likert-scale is ranging from "very high (1)" "to very low (5)". Definition of actors according to Spyra et al. (2020).

More than 40% of the interactions described in our study involved carnivores, which are particularly predisposed to participate in HWI due to their large range and dietary requirements (Linnell et al. 2001). The importance of animal size was also reflected in frequent mentions of bears (*Ursidae*) and elephants *(Elephantidae)* in our study, which are also among the conflicting wildlife species (Torres et al. 2018).

Looking at the findings on the outcomes of HWI in PUL, the balance of short-term and long-term results seems remarkable as the literature tends to report about the lack of awareness and research on long-term outcomes (Chaves et al. 2022; IUCN 2020; König et al. 2021b). Indirect negative effects have increased from short-term to long-term level, and in the indirect negative long-term effects become evident through potential late effects such as additional financial expenses or losses and shortages in food provision (Ogra 2008). Positive effects do not show as much variation as negative effects between the different dimensions and appear more consistent than negative effects. This may be due to the fact that positive outcomes of HWI are often intangible (Soulsbury and White 2015) or less well-documented than negative effects. Our data clearly showed more negative than positive outcomes, which can also be attributed to a biased analysis of HWI that often focus on conflict and its negative consequences (Bhatia et al. 2020; Glikman et al. 2019; Knox et al. 2021; König et al. 2021a).

Taking the perspective of animals as a human is an emerging field of human-animal studies (Taylor and Signal 2011) that seeks to provide valuable insights into how animals experience and perceive human interactions. The HWI in our study were seen from both, human and wildlife perspective, predominantly as negative, and correlated with our data of negative effects. Results of positive interactions from a wildlife perspective were consistent with the positive effects, but the rating of positive HWI from the perspective of humans was significantly higher than the rating of positive effects from the wildlife perspective (as perceived by humans; supplementary material S2, Q.4, Q.5). This finding can be interpreted as a confirmation that the respondents rated HWI as positive, but at the same time, there are limitations in perceiving specific positive effects. Fundamentally, it is also important to recognise that, in addition to individual perceptions, evaluations and classifications of positive and negative effects of HWI, individual attitudes towards the relevant wildlife species can also influence the results (Basak et al. 2022). Our data furthermore showed that most of the HWI were considered as negative from the perspective of humans and the perspective of wildlife. It can be emphasised that negative effects of HWI are not limited to wildlife; they can also have significant impacts for humans. It is important to approach this issue with an awareness of the limitations of interpreting animal behaviour, as in this case, it is critical to assume that animals have human-like thoughts, emotions and intentions (Griffin 2013). In the context of our study, the change of perspective as a human towards wildlife can be considered as experimental.

Influence of selected factors on human-wildlife interactions in peri-urban landscapes

Landscape changes create relevant habitat alterations that bring wildlife and humans into proximity and cause interactions as they compete for resources (Acharya et al. 2017; Distefano 2005; IUCN SSC and HWCTF 2022). The majority of the respondents agreed or strongly agreed that contemporary changes in land use/land cover in PUL lead to an increase in interactions between humans and wildlife. The main processes of land use/land cover changes leading to intensified HWI in PUL are deforestation (Chaves et al. 2022; Hilário et al. 2021; Mustățea and Pătru-Stupariu 2021; Rodamilans et al. 2020) and the conversion of agricultural land (Geneletti et al. 2017; Patel et al. 2019). Furthermore, the development of infrastructure (Chaves et al. 2022; Zuberogoitia et al. 2014), residential areas (Billah et al., 2021; Dadashpoor and Ahani, 2021), and recreation areas (Lamhamedi et al. 2021; Mustățea and Pătru-Stupariu 2021) are driving forces of HWI in PUL.

Our results showed that the availability of food due to the low density of discontinuous peri-urban settlements lead to frequent HWI. There are some other studies confirming this aspect – for example, Das et al. (2022) found that food from human food waste accounts for a considerable part of the diet of foxes (*Vulpes bengalensis*) in Indian PUL, leading to an increasing risk of human-wildlife conflicts. Sonawane (2021) highlighted the elimination of pathogens that pose a health risk to humans and livestock as a benefit, if species in PUL depend on food waste as a food source. In addition, the relationship between food availability and the increase of HWI strongly depends on the wildlife species and not all species may be affected in the same way. For instance, dingoes (*Canis lupus ssp. dingo*; Allen et al. 2016) and brown bears (*Ursus arctos;* Lodberg-Holm et al. 2019) do not appear to be significantly dependent on the availability of food from human waste. Consequently, other factors may be considered as crucial for intensified HWI with these species.

PUL are highly accessible areas for both humans and wildlife. From the human perspective it is most often related to the development and use of transportation infrastructure (Gagnon et al. 2015; Herbert et al. 2021) and power lines for energy supply (Chaves et al. 2022; Hilário et al. 2021). Most of the respondents agreed or strongly agreed that the growing overlap of human and wildlife habitat is related to the high accessibility of PUL. Changes to wildlife habitats due to road and transport infrastructure development is a major cause of collisions between vehicles and mammals and is responsible for serious injuries to people and animals as well as expensive property damage (Gagnon et al. 2015; Mustățea and Pătru-Stupariu 2021). The characteristics and consequences of vehicle-wildlife collisions depend on the speed of the vehicles, the type of road, trees next to roads and distance to urban areas (Hilário et al. 2021). The growing overlap of human and wildlife habitats has been associated with behavioral changes and habituation of wildlife to human presence and anthropogenic disturbance (Castillo-Contreras et al. 2021; Ziege et al. 2016). Formative factors may include specific human interventions such as artificial feeding (Hegglin et al. 2015; Mustățea and Pătru-Stupariu 2021), the removal of habitat elements, e.g. plant removal by its collection (Irwin 2016) and fuelwood harvesting (Billah et al., 2021). Furthermore, hunting practises (Lodberg-Holm et al. 2019; Morzillo et al. 2014), noise, and air pollution play a role in this case (La Rosa et al. 2018).

Especially fragmentation can substantially modify corridors for species, or isolate populations by reducing habitats until they fall below a certain threshold necessary for species survival (La Rosa et al. 2018). We identified an average agreement, based on a diverse set of opinions, for the statement that HWI in PUL are a consequence of wildlife habitat fragmentation. Again, roads are often regarded as a source of such fragmentation (Ramp et al. 2006) and a reason for individual injures through collisions with vehicles. Acharya et al. (2017) argue that forest fragmentation is a key factor causing human-wildlife conflict, although the extent of the impact depends on the specific habitat requirements of species. Further, it is emphasised that few studies have been conducted to determine as whether and to what extent landscape fragmentation leads to human-wildlife conflicts. The fact that almost a quarter of the respondents disagreed or strongly disagreed with the statement that HWI are a result of habitat fragmentation may hint to the aspect that fragmentation (as a species-specific factor) was less relevant in the respondents' case studies.

Policy-making for human-wildlife interactions in peri-urban landscapes

There exist different types of policy instruments to address HWI in PUL. Most respondents chose social and cultural instruments as the most suitable policy instrument to address HWI in PUL. Our data suggest that the integration of scientific evidence and the involvement of stakeholders and experts are major advantages of this type of policy instrument. The use of social and cultural instruments is often proposed through the implementation of information and awareness-raising campaigns or environmental education programmes (Piorr et al. 2011; Soulsbury and White 2015). For example, Hegglin et al. (2015) sensitised the public in campaigns to keep distance and not to feed or tame red foxes *(Vulpes vulpes)* because they are considered as potential hosts and distributors of zoonotic diseases. In addition, the involvement of different stakeholders plays an important role in applying these tools to meet the needs of policy-making for PUL as arenas of HWI.

In our analysis, legal and regulatory instruments were chosen by our respondents in second place. Legal and regulatory instruments show strong advantages in terms of its adaptability to policy-making addressing HWI in PUL, by the possibility to include sanctions and to integrate scientific knowledge. It seems surprising that these instruments were chosen only in second place, as the literature shows their very common use for policy-making in PUL (Llausàs et al. 2016; Melot and Hamilton 2016; Mortoja et al. 2020; Spyra et al. 2021).

Economic and financial instruments were assessed as being suitable for the needs of policy-making in PUL but, in this case, the enforcement of wildlife protection measures can be considered as a challenge (supplementary material S2, Q.9). In contrast, rights-based instruments and customary norms received agreement to ensure the protection of affected wildlife, but meeting the requirements of PUL for policy-making can be challenging (concluded from the rating of Q.8). For both policy instrument types, the provision of incentives to achieve certain goals or behaviours was seen as a strong benefit. Economic and financial instruments in particular provide good stakeholder participation according to our results (supplementary material S2, Q.9). For example, Piorr et al. (2011) highlighted the indispensability of incentives for nature conservation and for the provision of ecosystem services in PUL. König et al. (2021b) described compensation schemes as a anticipatory policy and stressed the fact that these compensation schemes should be developed in cooperation with businesses, scientists, local authorities and other stakeholders in order to target problems and achieve desired outcomes. Measures seek to reimburse especially farmers for crop and livestock losses through compensation payments or licenses for natural resource use. Other financial programmes include insurances for crop or livestock losses and subsidy-based incentives to offset the costs of conservation-friendly practices (Hodgson et al. 2020; IUCN and SSC 2022).

Based on our results, we suggest that the implementation of policy mixes (composed of various types of policy instruments) could be a sustainable approach to address HWI in PUL. The combined use of social and cultural instruments as well as legal and regulatory instruments to manage HWI is recommended, for example, in case studies by Soulsbury and White (2019) and Fernández-Juricic and Tellería (2000). Further examples for the recommended use of a policy mix can be found in the cases of different wildlife species like wild boar, cranes, wolves, and European bison in Brandenburg, Germany (König et al. 2021b) and for a shared landscape by humans and large carnivores (Carter and Linnell 2016).

The specific nature of HWI rarely allows to transfer potential solutions from one setting to another (König et al. 2021b; Zimmermann et al. 2020). A common aspect in scientific literature on HWI in PUL addresses the need for context-dependent, adapted and effective management, planning strategies and policy approaches in order to reduce HWI with primarily negative outcomes for humans (Castillo-Contreras et al. 2021; Chaves et al. 2022). The analysis of the survey results supports these findings – due to the fact that a general relationship between the classification of HWI and policy instruments could not be demonstrated (supplementary material S2, Q.7). The weak effect of this correlation can be attributed to several strong associations at the level of individual links, indicating a tendency to apply a specific policy instrument for a particular classification of HWI. Based on our study, the recommendation emerged to use legal and regulatory instruments for neutral HWI from a human perspective and negative HWI from a wildlife's perspective. Rights-based instruments and customary norms can be recommended for positive HWI, and economic and financial instruments for negative interactions, both from the perspective of wildlife and humans. Basically, the correlation analysis supports the recommendation for the use of social and cultural instruments with a particular focus on positive and negative HWI from the perspective of humans as well as for neutral interactions from the perspective of wildlife (supplementary material S2, Q.7).

The observed strong negative correlation between social and cultural instruments and negative interactions from a wildlife perspective (supplementary material S2, Q.7) was unexpected, as these instruments (e.g., education programmes) are recommended to address negative impacts of HWI on wildlife, such as inappropriate feeding of species, human disturbance and killing (Fernández-Juricic and Tellería 2000; Hodgson et al. 2020). Rather, the results showed a tendency towards the use of legal and regulatory instruments and economic and financial instruments to reduce negative outcomes for wildlife. This could indicate, for example, that policy instruments developed and implemented by public authorities, such as laws and regulations, are more appropriate and that financial incentives have the potential to encourage people to reduce or avoid actions that harm wildlife.

Limitations of the research method and future research directions

Our study provided new insights in characterising HWI in PUL and especially entered the urgently needed discussion about appropriate policy instruments in order to reduce emerging human-wildlife conflicts. However, we are aware that HWI in PUL is a complex topic that cannot be easily addressed in an online survey. Despite the advantages of using an online survey (e.g., see Evans and Mathur 2005), many participants did not finish our survey which could hint towards some potential difficulties, e.g., the complex or incomprehensive formulation of questions, potentially too many questions, or unclear survey formulation, which was also identified as a survey limitation by Evans and Mathur (2005). The mode of an online survey did not allow to investigate direct and concrete demands (even though we expressed our availability regarding inquires) that could have brought in some misunderstandings and that could have influenced our findings. The later could be reflected by the missing correlation in the statistical tests. A larger sample size could have reduced the variability in answers and could have improved the robustness (White et al. 2005). On the other hand, the survey allowed participants to describe their specific case in open-ended questions because closed-ended questions might artificially constrain the participant (Patton 2002).

HWI are manifold as our study showed. Therefore, also the policy instruments that address specific interactions are diverse and should be context-specifically selected in order to solve individual cases. The geographical location of the mentioned studies showed also a bias towards Europe and India. In addition, the survey mainly covered the individual perspectives of respondents which might not have resulted in professional and objective answers but rather opinions that emerged due to observed or experienced problematic HWI. Therefore, it might be possible to observe an inherent tendency towards negative perspectives on HWI. The individual background by scientific training of the respondents can also shape the selection and assessment of the respective policy instrument, e.g., a biologist might be less familiar with socially-related policy instruments and would (maybe) give higher importance to regulatory instruments. Overall, the findings emphasise the need of a careful consideration of the individuality of the cases; recognizing the local context and actors. However, this approach might increase also subjectivity which cannot be excluded in participatory methods in general (Cooke 1991; Tolma and Brydon-Miller 2001).

As shown, the generalisation of the findings is limited. Only tendencies can be shown with limited sample size (Nardi 2018). For future studies, it is suggested to differentiate between the perspectives of scientists and practitioners in order to understand (e.g., a scientific) bias and to be able to compare and discuss the results under the aspect of the relevance of practice. This will be in line with observations from Gundersen (2018) who sees the role of scientists and experts in policy-making processes in a different way. Further research, focusing on practitioners, is recommended to gain a more comprehensive understanding of the practical application of appropriate policy instruments (e.g., in the frame of a policy mix) and to confirm or reject current findings. In order to improve the statistical robustness of a quantitative survey, more active motivation of potential participants and more international outreach would be needed. In addition, affected citizens could enrich this part with their experiences and insights. Furthermore, qualitative research such as interviews with experts and stakeholders could complement the quantitative approach to further explore and elaborate the context, suitability, and applicability of recommendations.

Conclusion

The findings of this research confirmed that HWI with different species occur in PUL and that interactions with mammals are the most common taxa. Based on our collected information from scientists and practitioners working in the field of HWI, negative effects of HWI tended to have a strong direct impact on a short-term scale, while indirect effects become evident on a long-term scale. Positive effects of HWI appeared more consistent but were lower or less visible. HWI from the perspective of humans and wildlife showed that for both perspectives, most interactions were rated as negative. The respondents perceived that humans and wildlife are affected differently by the interactions, while the outcomes and effects vary across different dimensions and scales. The results also showed that respondents assume that HWI in PUL are influenced by a variety of factors like land cover changes in PUL, or availability of food in peri-urban settlements. The increasing overlap between human and wildlife habitats is mostly related to the high accessibility of PUL, and moderately related to the use of PUL for recreational purposes and for conservation activities. The respondents further believed that social and cultural instruments, along with legal and regulatory instruments, might be the most appropriate policy instruments to address HWI in PUL. Social and cultural instruments can address the specificities of HWI in PUL through the involvement of relevant actors. Legal and regulatory instruments have strengths in terms of their adaptability to policy-making for PUL, the inclusion of sanctions and the integration of scientific knowledge. The findings suggest that a policy mix including specifically social and cultural instruments and legal and regulatory instruments can be recommended as a valuable and effective combination of policy-making for PUL as arenas of HWI.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11252-024-01548-8.

Acknowledgements We highly appreciate the support of the Global Land Program, especially Brigitte Portner, Lauren Hertel and Dominik Kaim in supporting us in one of the workshops (even though this content was not part of this manuscript). We also thank Nica Claudia Calò for the workshop documentation. We are grateful for the support of Yanina Benedetti, Christine Fürst, Małgorzata Grodzińska-Jurczak, Hannes König, Federiko Morelli, Marcin Rechciński, Ileana and Mihai Stupariu, Piotr Tryjanowski, Joanna Tusznio and Natalia Yakusheva for their contributions into framing the research topic and for their valuable and active support in preparing the first (unpublished) version of the online survey. We would also like to thank all participants of the online survey.

Author contributions Roth, Annemarie Tabea: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Resources; Software; Validation; Visualization; Writing - original draft; Writing - review & editing. Kleemann, Janina: Conceptualization; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Visualization; Writing - original draft; Writing - review & editing. Spyra, Marcin: Conceptualization; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Writing - original draft; Writing - review & editing.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability Data were gathered via an online survey - see supplementary material.

Declarations

Competing interests The authors declare no competing interests.

References

Acharya KP, Paudel PK, Jnawali SR, Neupane PR, Köhl M (2017) Can forest fragmentation and configuration work as indicators of human–wildlife conflict? Evidences from human death and injury by wildlife attacks in Nepal. Ecol Ind 80:74–83. https://doi.org/10.1016/j.ecolind.2017.04.037

Allen BL, Carmelito E, Amos M, Goullet MS, Allen LR, Speed J, Gentle M, Leung LK-P (2016) Diet of dingoes and other wild dogs in peri-urban areas of north-eastern Australia. Sci Rep 6(1):23028. https://doi.org/10.1038/srep23028

Auster RE, Barr SW, Brazier RE (2022) Renewed coexistence: learning from steering group stakeholders on a beaver reintroduction project in England. Eur J Wildl Res 68(1):1. https://doi.org/10.1007/s10344-021-01555-6

Banks-Leite C, Ewers RM, Folkard-Tapp H, Fraser A (2020) Countering the effects of habitat loss, fragmentation, and degradation through habitat restoration. One Earth 3(6):672–676. https://doi.org/10.1016/j.oneear.2020.11.016

Basak SM, Hossain MS, O'Mahony DT, Okarma H, Widera E, Wierzbowska IA (2022) Public perceptions and attitudes toward urban wildlife encounters – A decade of change. Sci Total Environ 834:155603. https://doi.org/10.1016/j.scitotenv.2022.155603

Bennett AF, Saunders DA (2010) Habitat fragmentation and landscape change. In: Sodhi NS, Ehrlich PR (eds) Conservation Biology for all. Oxford University Press, pp 88–106

Bennett NJ, Roth R, Klain SC, Chan K, Christie P, Clark DA, Cullman G, Curran D, Durbin TJ, Epstein G, Greenberg A, Nelson MP, Sandlos J, Stedman R, Teel TL, Thomas R, Veríssimo D, Wyborn C (2017) Conservation social science: understanding and integrating human dimensions to improve conservation. Biol Conserv 205:93–108. https://doi.org/10.1016/j.biocon.2016.10.006

Berger-Grabner D (2016) Wissenschaftliches Arbeiten in den Wirtschafts- Und Sozialwissenschaften. Springer Fachmedien Wiesbaden, Wiesbaden

Bhatia S, Redpath SM, Suryawanshi K, Mishra C (2020) Beyond conflict: exploring the spectrum of human–wildlife interactions and their underlying mechanisms. Oryx 54(5):621–628. https://doi.org/10.1017/S003060531800159X

Billah MM, Rahman Md. M, Abedin J, Akter H (2021) Land cover change and its impact on human–elephant conflict: a case from Fashiakhali forest reserve in Bangladesh. SN Appl Sci 3(6):649. https://doi.org/10.1007/s42452-021-04625-1

Buijs A, Jacobs M (2021) Avoiding negativity bias: towards a positive psychology of human–wildlife relationships. Ambio 50(2):281–288. https://doi.org/10.1007/s13280-020-01394-w

Carter NH, Linnell JD (2016) Co-adaptation is key to coexisting with large carnivores. Trends Ecol Evol 31(8):575–578. https://doi.org/10.1016/j.tree.2016.05.006

Castillo-Contreras R, Mentaberre G, Fernandez Aguilar X, Conejero C, Colom-Cadena A, Ráez-Bravo A, González-Crespo C, Espunyes J, Lavín S, López-Olvera JR (2021) Wild boar in the city: phenotypic responses to urbanisation. Sci Total Environ 773:145593. https://doi.org/10.1016/j.scitotenv.2021.145593
Chaves Ó, Júnior JS, Buss G, Hirano Z, Jardim M, Amaral E, Godoy JC, Peruchi AR, Michel T, Bicca-Marques JC (2022) Wildlife is imperiled in peri-urban landscapes: threats to arboreal mammals. Sci Total Environ 821:152883. https://doi.org/10.1016/j.scitotenv.2021.152883
Cooke RM (1991) Experts in uncertainty. Opinion and subjective probability in science. Oxford University Press, New York, Oxford
Dadashpoor H, Ahani S (2021) Explaining objective forces, driving forces, and causal mechanisms affecting the formation and expansion of the peri-urban areas: a critical realism approach. Land Use Policy 102:105232. https://doi.org/10.1016/j.landusepol.2020.105232
Dandy N, Ballantyne S, Moseley D, Gill R, Quine C (2009) Management of roe deer in peri-urban Scotland. Forest Research. https://www.forestresearch.gov.uk/publications/management-of-roe-deer-in-peri-urban-scotland/. Accessed 02 February 2023
Das UP, Acharya A, Palei HS (2022) The diet of Indian foxes in a peri-urban area of eastern India. Acta Ecol Sin 42(6):679–683. https://doi.org/10.1016/j.chnaes.2021.04.002
Dickman AJ (2010) Complexities of conflict: the importance of considering social factors for effectively resolving human-wildlife conflict: social factors affecting human-wildlife conflict resolution. Anim Conserv 13(5):458–466. https://doi.org/10.1111/j.1469-1795.2010.00368.x
Distefano E (2005) Human-Wildlife Conflict worldwide: collection of case studies, analysis of management strategies and good practices. https://www.fao.org/publications/card/en/c/e21b6162-b3ad-4661-8c52-710f95ebeaf7/. Accessed 19 September 2022
Döring N, Bortz J (2016) Forschungsmethoden und evaluation in den Sozial- Und Humanwissenschaften. Springer-Lehrbuch. Springer, Berlin Heidelberg, Berlin, Heidelberg
Evans JR, Mathur A (2005) The value of online surveys. Internet Res 15(2):195–219. https://doi.org/10.1108/10662240510590360
Fahrig L (2017) Ecological responses to Habitat Fragmentation per Se. Annual Review of Ecology. Evol Syst 48(1):1–23. https://doi.org/10.1146/annurev-ecolsys-110316-022612
Fernández-Juricic E, Tellería JL (2000) Effects of human disturbance on spatial and temporal feeding patterns of Blackbird Turdus merula in urban parks in Madrid, Spain. Bird Study 47(1):13–21. https://doi.org/10.1080/00063650009461156
Fletcher R, Toncheva S (2021) The political economy of human-wildlife conflict and coexistence. Biol Conserv 260:109216. https://doi.org/10.1016/j.biocon.2021.109216
Frank B (2016) Human–Wildlife conflicts and the need to Include Tolerance and Coexistence: an introductory comment. Soc Nat Resour 29(6):738–743. https://doi.org/10.1080/08941920.2015.1103388
Frank B, Glikman JA (2019) Human–Wildlife interactions: turning conflict into coexistence, 1st edn. Cambridge University Press
Gagnon J, Loberger C, Sprague S, Ogren K, Boe S, Schweinsburg R (2015) Cost-effective Approach to reducing collisions with elk by Fencing between existing highway structures. Human–Wildlife Interact 9(2). https://doi.org/10.26077/z5kk-s204
Geneletti D, La Rosa D, Spyra M, Cortinovis C (2017) A review of approaches and challenges for sustainable planning in urban peripheries. Landsc Urban Plann 165:231–243. https://doi.org/10.1016/j.landurbplan.2017.01.013
Glikman JA, Frank B, Marchini S (2019) Human–Wildlife interactions. In: Frank B, Glikman JA, Marchini S (eds) Human–Wildlife interactions. Cambridge University Press, pp 439–452
GLP (2021) GLP Workshop on Governance of Human-Wildlife-Interactions in Peri-Urban Landscapes Global Land Programme. https://glp.earth/news-events/events/glp-workshop-governance-human-wildlife-interactions-peri-urban-landscapes. Accessed 11 February 2023
Goodale K, Parsons G, Sherren K (2015) The nature of the nuisance—damage or threat—determines how Perceived Monetary costs and cultural benefits Influence Farmer Tolerance of Wildlife. Diversity 7(3):318–341. https://doi.org/10.3390/d7030318
Griffin DR (2013) Animal minds: beyond cognition to consciousness. University of Chicago Press, Chicago, IL
Gundersen T (2018) Scientists as experts: a distinct role? Studies in history and philosophy of science. 69:52–59. https://doi.org/10.1016/j.shpsa.2018.02.006
Harriott L, Gentle M, Traub R, Cobbold R, Soares Magalhães R (2019) Geographical distribution and risk factors for Echinococcus granulosus infection in peri-urban wild dog populations. Int J Parasitology: Parasites Wildl 10:149–155. https://doi.org/10.1016/j.ijppaw.2019.08.005
Hauptfleisch ML, Sikongo IN, Theart F (2021) A spatial and temporal assessment of human-snake encounters in urban and peri-urban areas of Windhoek, Namibia. Urban Ecosyst 24(1):165–173. https://doi.org/10.1007/s11252-020-01028-9
Hegglin D, Bontadina F, Deplazes P (2015) Human–wildlife interactions and zoonotic transmission of Echinococcus Multilocularis. Trends Parasitol 31(5):167–173. https://doi.org/10.1016/j.pt.2014.12.004
Herbert CA, Snape MA, Wimpenny CE, Coulson G (2021) Kangaroos in peri-urban areas: a fool's paradise? Ecol Manage Restor 22(S1):167–175. https://doi.org/10.1111/emr.12487
Hilário RR, Carvalho WD, Gheler-Costa C, Rosalino LMC, Marques TA, Adania CH, Paulino JS, Almeida PM, Mustin K (2021) Drivers of human-wildlife impact events involving mammals in Southeastern Brazil. Sci Total Environ 794:148600. https://doi.org/10.1016/j.scitotenv.2021.148600
Hodgson ID, Redpath SM, Sandstrom C, Biggs D (2020) The State of Knowledge and Practice on Human-Wildlife Conflicts. Luc Hoffmann Institute. https://luchoffmanninstitute.org/the-surprising-new-way-to-approach-human-wildlife-conflict-a-new-report/. Accessed 18 October 2022
Hornok S, Szekeres S, Horváth G, Takács N, Bekő K, Kontschán J, Gyuranecz M, Tóth B, Sándor AD, Juhász A, Beck R, Farkas R (2022) Diversity of tick species and associated pathogens on peri-urban wild boars – first report of the zoonotic babesia cf. crassa from Hungary. Ticks Tick-borne Dis 13(3):101936. https://doi.org/10.1016/j.ttbdis.2022.101936
Inskip C, Zimmermann A (2009) Human-felid conflict: a review of patterns and priorities worldwide. Oryx 43(01):18. https://doi.org/10.1017/S003060530899030X
IPBES (2022c) Policy Instruments. Retrieved 14 October 2022, from https://ipbes.net/node/15263. Accessed 14 October 2022
IPBES (2022b) Agenda-setting and decision support approaches. Retrieved 14 October 2022, from https://ipbes.net/scenarios-models/new-scenarios/agenda-setting. Accessed 14 October 2022
IPBES, About IPBES (2022a) Retrieved 16 October 2022, from https://ipbes.net/node/40. Accessed 16 October 2022
Irwin M (2016) Habitat change: loss, fragmentation, and degradation. In: Wich SA, Marshall AJ (eds) An introduction to Primate Conservation. Oxford University Press, pp 111–128
IUCN (2020) IUCN SSC Position Statement On the Management of Human-Wildlife Conflict. https://www.hwctf.org/_files/ugd/7acc16_df35c11aaf9c460894f26a5cd5f1a5b9.pdf. Accessed 17 October 2022
IUCN, SSC (2022) IUCN issues brief June 2022: Human-wildlife conflict. https://www.iucn.org/sites/default/files/2022-06/

iucn-issues-brief-human-wildlife-conflict_final.pdf. Accessed 27 June 2022
IUCN SSC, HWCTF (2022) Perspectives on human-wildlife coexistence. Briefing Paper by the IUCN SSC Human-Wildlife Conflict Task Force. https://www.hwctf.org/_files/ugd/7acc16_c762b1900d044294b8e7bad6b1e55e09.pdf. Accessed 13 July 2022
Kleemann J, Baysal G, Bulley HNN, Fürst C (2017) Assessing driving forces of land use and land cover change by a mixed-method approach in north-eastern Ghana, West Africa. J Environ Manage 196:411–442. https://doi.org/10.1016/j.jenvman.2017.01.053
Knox J, Ruppert K, Frank B, Sponarski CC, Glikman JA (2021) Usage, definition, and measurement of coexistence, tolerance and acceptance in wildlife conservation research in Africa. Ambio 50(2):301–313. https://doi.org/10.1007/s13280-020-01352-6
König HJ, Kiffner C, Kramer-Schadt S, Fürst C, Keuling O, Ford AT (2020) Human–wildlife coexistence in a changing world. Conserv Biol 34(4):786–794. https://doi.org/10.1111/cobi.13513
König HJ, Carter N, Ceaușu S, Lamb C, Ford AT, Kiffner C (2021a) Human–wildlife coexistence in science and practice. Conserv Sci Pract 3(3). https://doi.org/10.1111/csp2.401
König HJ, Ceaușu S, Reed M, Kendall H, Hemminger K, Reinke H, Ostermann-Miyashita E-F, Wenz E, Eufemia L, Hermanns T, Klose M, Spyra M, Kuemmerle T, Ford AT (2021b) Integrated framework for stakeholder participation: methods and tools for identifying and addressing human–wildlife conflicts. Conserv Sci Pract 3(3). https://doi.org/10.1111/csp2.399
Kuckartz U, Rädiker S, Ebert T, Schehl J (eds) (2010) Statistik: Eine verständliche Einführung (1. Aufl). Springer-Verlag
La Rosa D, Geneletti D, Spyra M, Albert C, Fürst C (2018) Sustainable planning for peri-urban landscapes. In: Perera AH, Peterson U, Pastur GM, Iverson LR (eds) Ecosystem services from Forest Landscapes. Springer International Publishing, Cham, pp 89–126
Lamhamedi H, Lizin S, Witters N, Malina R, Baguare A (2021) The recreational value of a peri-urban forest in Morocco. Urban Forestry Urban Green 65:127339. https://doi.org/10.1016/j.ufug.2021.127339
Linnell J, Swenson J, Andersen R (2001) Predators and people: conservation of large carnivores is possible at high human densities if management policy is favourable. Anim Conserv 4:345–349. https://doi.org/10.1017/S1367943001001408
Llausàs A, Buxton M, Beilin R (2016) Spatial planning and changing landscapes: a failure of policy in peri-urban Victoria, Australia. J Environ Planning Manage 59(7):1304–1322. https://doi.org/10.1080/09640568.2015.1074888
Lodberg-Holm HK, Gelink HW, Hertel AG, Swenson JE, Domevscik M, Steyaert SMJG (2019) A human-induced landscape of fear influences foraging behavior of brown bears. Basic Appl Ecol 35:18–27. https://doi.org/10.1016/j.baae.2018.12.001
Mackenstedt U, Jenkins D, Romig T (2015) The role of wildlife in the transmission of parasitic zoonoses in peri-urban and urban areas. Int J Parasitology: Parasites Wildl 4(1):71–79. https://doi.org/10.1016/j.ijppaw.2015.01.006
Marchini S, Ferraz, Katia MPMB, Zimmermann A, Guimarães-Luiz T, Morato R, Correa PLP, Macdonald DW (2019) Planning for coexistence in a Complex Human-dominated World. In: Frank B, Glikman JA (eds) Human–Wildlife interactions: turning conflict into coexistence. Cambridge University Press, pp 414–438
Melot R, Hamilton P (2016) How to regulate the peri-urban town: local political decisions and styles of justification. Revue francaise de sociologie (English Edition) 57(4):501–521
Mortoja MG, Yigitcanlar T, Mayere S (2020) What is the most suitable methodological approach to demarcate peri-urban areas? A systematic review of the literature. Land Use Policy 95:104601. https://doi.org/10.1016/j.landusepol.2020.104601
Morzillo AT, de Beurs KM, Martin-Mikle CJ (2014) A conceptual framework to evaluate human-wildlife interactions within coupled human and natural systems. Ecol Soc 19(3):art44. https://doi.org/10.5751/ES-06883-190344
Mustăţea M, Pătru-Stupariu I (2021) Using Landscape Change Analysis and Stakeholder Perspective to identify Driving forces of Human–Wildlife interactions. Land 10(2):146. https://doi.org/10.3390/land10020146
Nardi PM (2018) Doing survey research: a guide to quantitative methods, Fourth edition ed. Routledge, New York
Nyhus PJ (2016) Human–Wildlife Conflict and Coexistence. Annu Rev Environ Resour 41(1):143–171. https://doi.org/10.1146/annurev-environ-110615-085634
Ogra MV (2008) Human–wildlife conflict and gender in protected area borderlands: a case study of costs, perceptions, and vulnerabilities from Uttarakhand (Uttaranchal), India. Geoforum 39(3):1408–1422. https://doi.org/10.1016/j.geoforum.2007.12.004
Patel SK, Verma P, Shankar Singh G (2019) Agricultural growth and land use land cover change in peri-urban India. Environ Monit Assess 191(9):600. https://doi.org/10.1007/s10661-019-7736-1
Patton MQ (2002) Quantitative research and evaluation methods, 3rd edn. Sage, London, UK
Pejchar L, Medrano L, Niemiec RM, Barfield JP, Davidson A, Hartway C (2021) Challenges and opportunities for cross-jurisdictional bison conservation in North America. Biol Conserv 256:109029. https://doi.org/10.1016/j.biocon.2021.109029
Piana P, Brocada L, Hearn R, Mangano S (2024) Urban rewilding: human-wildlife relations in Genoa, NW Italy. Cities 144:104660. https://doi.org/10.1016/j.cities.2023.104660
Piorr A, Ravetz J, Tosics I (2011) Peri-urbanisation in Europe: towards a European policy to sustain Urban-Rural futures. University of Copenhagen / Academic Books Life Sciences, Frederiksberg
Ramp D, Wilson VK, Croft DB (2006) Assessing the impacts of roads in peri-urban reserves: Road-based fatalities and road usage by wildlife in the Royal National Park, New South Wales, Australia. Biol Conserv 129(3):348–359. https://doi.org/10.1016/j.biocon.2005.11.002
Rodamilans GM, Fonseca MS, Paz LN, Fernandez CC, Biondi I, Lira-da-Silva RM, Meyer R, Pinna MH, Portela RD (2020) Leptospira interrogans in wild Boa constrictor snakes from Northeast Brazil peri–urban rainforest fragments. Acta Trop 209:105572. https://doi.org/10.1016/j.actatropica.2020.105572
Simon D (2021) Peri-urbanization. The Palgrave Encyclopedia of Urban and Regional futures. Springer International Publishing, Cham, pp 1–5
Sogliani D, Cerri J, Turetta R, Crema M, Corsini M, Mori E (2021) Feral rabbit populations in a peri-urban area: insights about invasion dynamics and potential management strategies. Eur J Wildl Res 67(3):60. https://doi.org/10.1007/s10344-021-01505-2
Sonawane C, Yirga G, Carter NH (2021) Public health and economic benefits of spotted hyenas Crocuta crocuta in a peri-urban system. J Appl Ecol 58(12):2892–2902. https://doi.org/10.1111/1365-2664.14024
Soulsbury CD, White PCL (2015) Human–wildlife interactions in urban areas: a review of conflicts, benefits and opportunities. Wildl Res 42(7):541–553. https://doi.org/10.1071/WR14229
Soulsbury CD, White PCL (2019) A Framework for assessing and quantifying Human–Wildlife interactions in Urban Areas. In: Frank B, Glikman JA (eds) Human–Wildlife interactions: turning conflict into coexistence. Cambridge University Press, pp 107–128
Spyra M, La Rosa D, Zasada I, Sylla M, Shkaruba A (2020) Governance of ecosystem services trade-offs in peri-urban landscapes. Land Use Policy 95:104617. https://doi.org/10.1016/j.landusepol.2020.104617

Spyra M, Kleemann J, Calò NC, Schürmann A, Fürst C (2021) Protection of peri-urban open spaces at the level of regional policy-making: examples from six European regions. Land Use Policy 107:105480. https://doi.org/10.1016/j.landusepol.2021.105480

Su K, Zhang H, Lin L, Hou Y, Wen Y (2022) Bibliometric analysis of human–wildlife conflict: from conflict to coexistence. Ecol Inf 68:101531. https://doi.org/10.1016/j.ecoinf.2021.101531

Taylor N, Signal T (2011) Theorizing animals: re-thinking humanimal relations. Human-Animal Studies. Brill, Leiden, Boston

Tellería JL (2016) Wildlife Habitat requirements: concepts and Research Approaches. In: Mateo R, Arroyo B, Garcia JT (eds) Current trends in Wildlife Research. Springer International Publishing, Cham, pp 79–95

Ten DCY, Jani R, Hashim NH, Saaban S, Abu Hashim AK, Abdullah MT (2021) Panthera tigris Jacksoni Population Crash and Impending extinction due to Environmental Perturbation and Human-Wildlife conflict. Anim open Access J MDPI 11(4). https://doi.org/10.3390/ani11041032

Tolma, Brydon-Miller (2001) From subjects to subjectivities: a handbook of interpretive and participatory methods, 5th edn. New York University, New York

Torres DF, Oliveira ES, Alves RRN (2018) Conflicts between humans and terrestrial vertebrates: A Global Review. Trop Conserv Sci 11:194008291879408. https://doi.org/10.1177/1940082918794084

Ullah SA, Asahiro K, Moriyama M, Tsuchiya J, Rahman MA, Mary M, Tani M (2024) Causes and consequences of forest cover transformation on human-wildlife interaction in the Teknaf Wildlife Sanctuary, Bangladesh. Trees Forests People 15:100476. https://doi.org/10.1016/j.tfp.2023.100476

White PCL, JENNINGS NV, RENWICK AR, BARKER NHL (2005) Questionnaires in ecology: a review of past use and recommendations for best practice. J Appl Ecol 42(3):421–430. https://doi.org/10.1111/j.1365-2664.2005.01032.x

Whitehouse-Tedd K, Abell J, Dunn AK (2021) Evaluation of the use of psychometric scales in human–wildlife interaction research to determine attitudes and tolerance toward wildlife. Conserv Biol 35(2):533–547. https://doi.org/10.1111/cobi.13599

Yarrow G (2009) Wildlife and wildlife management Fact Sheet 36. https://dc.statelibrary.sc.gov/bitstream/handle/10827/41263/CU_ES_FNR_Fact_Sheet_36_2009-05.pdf

Ziege M, Babitsch D, Brix M, Kriesten S, Straskraba S, Wenninger S, Wronski T, Plath M (2016) Extended diurnal activity patterns of European rabbits along a rural-to-urban gradient. Mammalian Biology 81(5):534–541. https://doi.org/10.1016/j.mambio.2016.07.002

Zimmermann A, McQuinn B, Macdonald DW (2020) Levels of conflict over wildlife: understanding and addressing the right problem. Conserv Sci Pract 2(10). https://doi.org/10.1111/csp2.259

Zuberogoitia I, Del Real J, Torres JJ, Rodríguez L, Alonso M, Zabala J, Chapman MG (2014) Ungulate vehicle collisions in a peri-urban environment: consequences of transportation infrastructures planned assuming the absence of ungulates. PLoS ONE 9(9):e107713. https://doi.org/10.1371/journal.pone.0107713