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A threat analysis for the world's most threatened turtle (*Rafetus swinhoei*)

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ABSTRACT

We conducted a comprehensive threat analysis of the Swinhoe's softshell turtle (*Rafetus swinhoei*), the most endangered freshwater turtle in the world, historically occurring along river systems in Vietnam and China, but currently almost extinct. Here, our goal was to identify the pressures along two main rivers in Vietnam (Black and Red rivers, both extending into Yunnan, People's Republic of China), building a conceptual framework to understand the causal relationships among driving forces, threats, and the target species. We involved a panel of experts who identified two priority direct threats in Vietnam, classified following the IUCN standard taxonomy, and showing the highest Magnitude (as a proxy of threat pressure): (i) Habitat loss at nesting sites (LOS; code 1.2 - Commercial & industrial areas) and, (ii) Land conversion due to settlements (LAN; code 1.1 - Housing & urban areas). Threats showed a comparable (i.e., not significantly different) Magnitude in the two rivers (Mann-Whitney *U* test). Experts also identified the underlying driving forces behind these threats: (i) demographic drivers (due to a rapid population growth in the last decades) causing LAN and LOS, as the priority threats, but also sand mining, and water pollution; (ii) economic drivers induced by high poverty in local populations and causing harvesting (fishing activities and related markets), the needs of power supply for economic activities (e.g., dams), and recreational activities; (iii) ethical drivers linked to conservation project teams (limited funds and divergent points about strategies to carry out). Preliminary data for China suggest HAR (Harvesting by native fishers; code 5.4) and POL (water pollution; code 9.2) as priority threats. Threat analysis is an useful tool in the early stages of a conservation project during the context analysis, helping to define priorities for conservation and management.

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1. Introduction

Globally, turtles are in the midst of an extinction crisis with more than 50 % of species considered to be Threatened (Redlist status: Critically Endangered, Endangered, Vulnerable) by the International Union for Conservation of Nature (IUCN; Rhodin et al., 2018; Stanford et al., 2020; IUCN, 2023). These declines are associated with many threats such as habitat loss, consumption for food and traditional medicines, and collection for the pet trade (Rhodin et al., 2018; Stanford et al., 2018, 2020). However, how these threats effect any given species of turtle is dependent on that turtle's unique biology, taxonomy, and distribution (Rhodin et al., 2018). Thus, threats analysis are needed to help focus conservation efforts. Turtles from Asia have the highest percentages of Threatened species (83 % Threatened) primarily due to exploitation (Rhodin et al., 2018). Focusing in on the former Indochina region (Vietnam, Laos, and Cambodia), this area of the world not only has one of the greatest diversity of turtle species but also has the highest number of threatened turtle species (IUCN, 2023). For instance, all but one species of turtle in Vietnam are considered Threatened, with 17 out of 27 chelonian species listed as Critically Endangered (CR), eight as Endangered (EN), one species as Vulnerable (VU), and one as Near Threatened (NT; IUCN, 2023). Therefore, the current status of chelonians is particularly catastrophic in Vietnam due to a combination of factors such as habitat loss and overexploitation for meat and the International pet trade (IUCN, 2024).

Among the various Vietnamese turtle species, the Yangtze or Swinhoe's softshell turtle (*Rafetus swinhoei*) is currently considered the most threatened turtle in the world (Stanford et al., 2018). This is the largest softshell turtle in the world, as the males can exceed 160 kg (Pritchard, 2005; Pham et al., 2020). This species occurred historically along the Red and Black Rivers of China and Vietnam and the lower Yangtze River of China, and the associated floodplains and habitats (Pritchard, 2005, 2012). However, current knowledge is that it is almost extinct with few individuals still surviving in the wild (Wang & Shi, 2011; Liu et al., 2019; Wang et al., 2021). The near extinction of this large species is due to a plethora of reasons but is primarily drived by the negative impacts of dams on the nesting habitats, overfishing, and isolation effects (Le Duc et al., 2020a, Le Duc et al., 2020b). Apparently Swinhoe's softshell turtle began to decline in the 1980s and became rare in the 1990s (Le Duc et al., 2020a). Although it is unlikely that more than a few individuals still survive in the wild, recent field studies revealed the potential presence of the species at sites in northern Vietnam (Le Duc et al., 2020a, Le Duc et al., 2020b, 2024; ATP-WCS unpublished data).

To help define priorities useful to guide specific conservation strategies focused on this highly threatened species, the Threat Analysis (TA) approach seems to be particularly promising (Salafsky et al., 2008, Schwartz et al., 2018). The application of TA in ecosystem management serves as an invaluable framework for informed decision-making, ensuring that conservation actions are strategically directed to address the most pressing challenges facing our natural world. Its primary goal is to identify, characterize, and quantify anthropogenic events and impacts occurring in areas of conservation concern (Salafsky et al., 2003, 2008; Balmford et al., 2009; review in Battisti et al., 2016). This quantification enables the prioritization of threats, aiding conservation managers in developing targeted conservation strategies and actions (Salafsky et al., 2008). Consequently, TA serves as a valuable tool for conservation strategy planning, especially in contexts like nature reserves or projects focused on specific endangered species in crisis situations. This methodology has been largely applied worldwide (AlHirsh et al., 2016; Battisti et al., 2020, 2023; Bauer et al., 2022; Giovacchini et al., 2022, 2024; Luiselli et al., 2024). However, the standardized and expert-based conceptual framework, has received an incomprehensibly limited application to species and programs on the Asian continent (eg., excluding the Middle East: AlHirsh et al., 2016). Given that Asia is exceptionally rich in biodiversity, has significant resources, and substantial social and environmental challenges, this underutilization of a fast and cost-effective approach (e.g., the TA) is concerning. Moreover, among reptiles, to the best of our knowledge, TA has been applied to only one turtle species worldwide, i.e. the Nubian flapshell turtle (*Cyclanorbis elegans*), a Critically Endangered reptile inhabiting the White Nile river system in South Sudan and northern Uganda (Luiselli et al., 2024). Therefore, this is the first application of TA for a freshwater turtle (the world's most threatened) for Asia.

In this paper, we conduct a TA on the Swinhoe's softshell turtle. Our objective in this paper was to identify threats specifically affecting the target species within its habitat. We quantified these threats by using scores assigned by a panel of experts who have been actively engaged in research on the field ecology on the species during the last decade. We ranked threats based on their extent, intensity, duration, and frequency – four attributes of their impact regime, then aggregated these scores to calculate a Magnitude score, representing the total pressure exerted by all anthropogenic threats (Salafsky et al., 2008; Battisti et al., 2016). Our paper stands out as one of the most comprehensive applications of this method in Asia.

2. Materials and methods

2.1. Study areas

This study is based on field surveys that were carried out in both northern Vietnam and southern China, the known areas of occurrence of the target species. More precisely, we carried out the field surveys between 2019 and 2022 in the following areas in Vietnam: Hanoi, Thanh Hoa, Phu Tho, Yen Bai, Vinh Phuc, Hoa Binh, Son La, Lai Chau, Bac Giang, Hai Duong, Thai Binh, Hung Yen and Lao Cai along the Red River, Da River, Luc Nam River, Thuong River, Kinh Thay River, Kinh Mon River, Thai Binh River, Luoc River, Chay River, and Thac Ba is in Yen Bai province, along the Chay River. Concerning China, we carried out the field studies in 38 counties in three provinces (Yunnan, Guangxi, and Guizhou) covering the mainstems, largest tributaries, and floodplain lakes of the Mekong, Red, Pearl, Qinjiang, and Xiangjiang rivers, the latter being the southernmost tributary of the Yangtze River, from 2007 to 2010 (Wang and Shi, 2011; Wang et al., 2013). We also conducted a surveys along the Red River from Yuan Jiang county to the Vietnamese border. Additionally, in China, between 2011 and 2015, we also surveyed the Yuan Jiang (Red River) and some of its tributaries between Hekou and Yuanjiang, and the Lixian Jiang (Black River) in the area between the Vietnamese border and Jiangxi.

2.2. Field protocol

In northern Vietnam, the field surveys consisted of a suite of approaches including face-to-face questionnaires to local fishers (Le Duc et al., 2020a, 2020b) and former *Rafetus* professional hunters (Pham et al., 2020), camera trapping (Le Duc et al., 2024), examination of specimens (and parts) caught by fishers (Le Duc et al., 2020a, Ducotterd et al., 2023) and opportunistic records. In total, the team directed by LL and including OLD, TPV and BL carried out 415 interviews (Fig. 1), for a total of 74 effective days on the field. These surveys were conducted in the 13 Vietnamese provinces cited above, and 5746 km were travelled by motorbike to find interviewees and 350 km were travelled by boat.

In China, HTS and his team interviewed fishery, wildlife, and nature reserve management authorities, experienced fishers and turtle farmers with semi-structured interviews. They also investigated the use of food, traditional Chinese medicine, and pet markets in every county if possible. One hundred questionnaires were also handed out to the college students from southeast Yunnan and northern Vietnam at Honghe University. Field investigations focused mainly on the villagers living along the Red River and its tributaries, from Xinping County at the middle reaches to Hekou County on the China-Vietnam border, 350 km southeast of Xinping. Eighty-two communities from county towns to villages were visited while approximately 960 individuals were

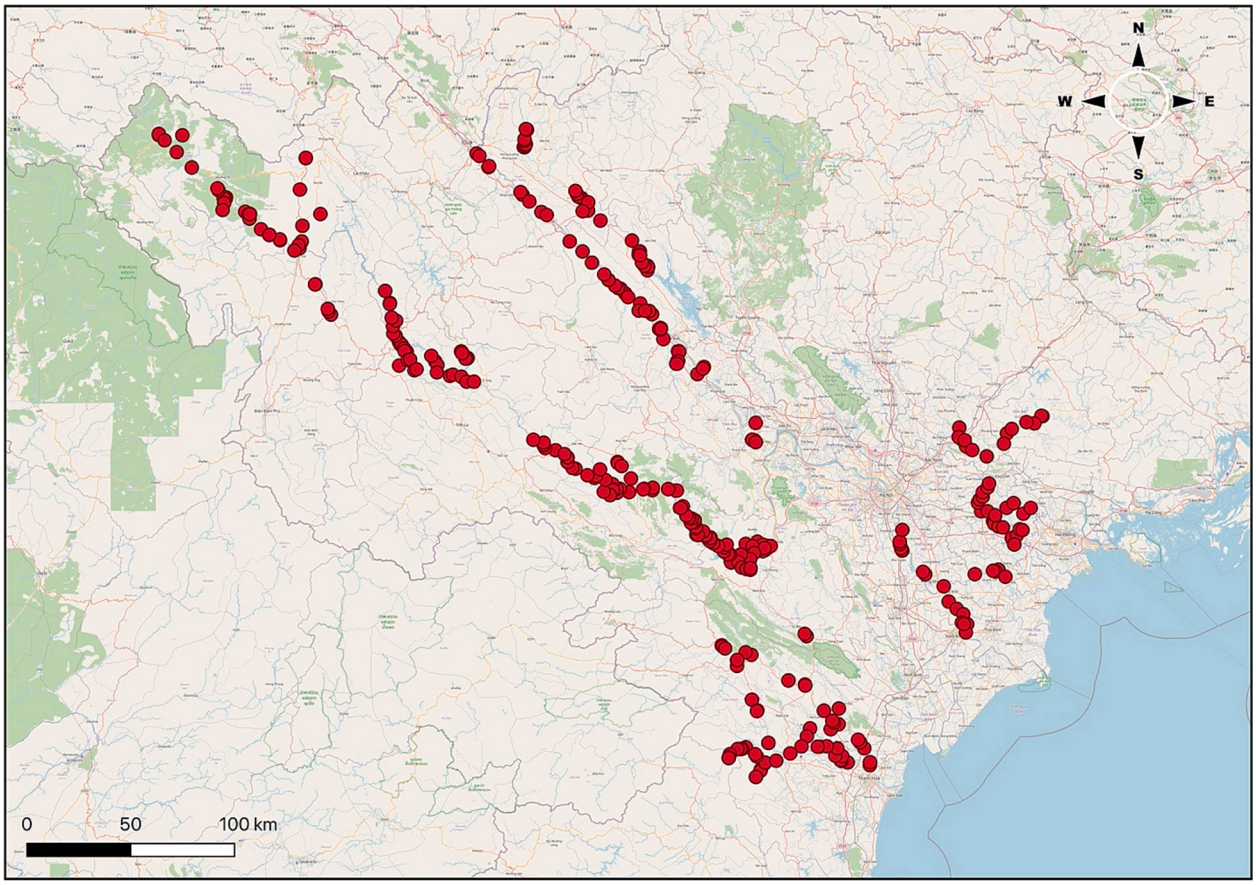

Fig. 1. Map of the study area with the exact location for interviews during the period 2019–2022.

questioned in semi-structured interviews. This team also visited knowledgeable people from local zoos, schools, institutes, and departments of government in order to gain information regarding the distribution of the target species. The team of GK carried out field surveys in China that also consisted of interviews with fishers, fishery department employees, and farmers. They used a self-published softshell turtle identification booklet entitled "Softshell Turtles of Yunnan (P.R. China) and Adjacent Areas" [Gerald Kuchling, Rao Dingqi, and Lu Shunqing, 2013, Softshell Turtles of Yunnan (P.R. China) and Adjacent Areas. Revision 2013.09] which was widely distributed to local people and authorities. They also examined specimens (and parts) caught by fishers, sold at local markets, and opportunistic records.

All of these field procedures allowed the authors to view the areas being discussed in the interviews and surveys and to get expert-based opinions on the threats and the management needs for the study species in both Vietnam and China.

2.3. The target species

The TA focused on the Swinhoe's softshell turtle (*Rafetus swinhoei*), a large-sized freshwater turtle that is classified as Critically Endangered by the IUCN (IUCN, 2023) and that is considered the most threatened chelonian species in the world (Stanford et al., 2018).

2.4. The panel of experts

The Threat Analysis (TA) procedure was carried out by a qualified panel of experts. We selected several experts (professional researchers) belonging to both research institutes and local non-profit organization. Each one had a good degree of knowledge, both on the study site(s), the biology of the target species, and on the local species-specific threats (list in Table 1), so that they had all of the evidence useful for conducting the threat naming, assessment, and ranking of priorities and to select the driving forces causing the threats.

2.5. Threat analysis procedure

We defined "threats" as "any human-related process that negatively affects the specific components of ecosystems (species abundance, species-specific habitat suitability, structural characteristics at community level as species richness, diversity index, evenness; ecosystem services) in a real context" (reviewed in Battisti et al., 2016). Here, we analyze the set of threats to the selected target species, which are locally relevant to our study area.

First, we named any threat using the threat nomenclature reported in the IUCN unified classification of direct threats ("threat taxonomy"; Salafsky et al., 2008). In this report, all anthropogenic threats have been named and coded.

Second, we asked the experts the following question: what is the extent, severity, frequency, and duration of any threat (these last being considered 'regime attributes')? To respond to this question, for each direct threat, each expert assigned a single score to the four regime attributes using a scale from 1 (low) to 4 (high; Battisti et al., 2016).

More particularly, (i) 'extent' has been considered as the proportion of species habitat that has been, is, or will be affected by the threat, when compared to the total surface available, i.e., all of the suitable area of habitat for Swinhoe's softshell turtle; (ii) 'severity', represents an assessment of the past, present, or future pressure caused by the threat on target (i.e., a proxy of threat intensity); (iii) 'frequency' indicates the number of anthropic events within a time unit (here, corresponding to event/year); and (iv) 'duration' expresses the the time span of expression of the threat (Ervin, 2002).

Table 1
List of human-induced direct threats on Swinhoe's softshell turtle (*Rafetus swinhoei*) across its range in Vietnam and China identified by a panel of experts. We include acronyms, local threat, and IUCN taxonomy (code and subcode, specific name, category) are reported. See Methods for details.

Acronym	local threat	IUCN taxonomy code	threat specific name	category
HAR	Harvesting by native fishers	5.4	Fishing & harvesting aquatic resources	5: Biological resource use
MIN	Sand mining	3.2	Mining & quarrying	3: Energy production & mining
LOS	Habitat loss at nesting sites	1.2	Commercial & industrial areas	1: Residential & commercial development
IND	Industrial dams	7.2.10	Large dams	7: Natural system modifications (code 7.2 - Dams & water management/use)
DAM	Small-scale dams	7.2.9	Small dams	
CON	Internal conflicts among conservation groups	12.1	Other threats	12: Other options
LAN	Land conversion	1.1	Housing & urban areas	1: Residential & commercial development
POL	Water pollution	9.2	Industrial & military effluents	9: Pollution
BOA	Disturbance by boats	6.1	Recreational activities	6: Human intrusions & disturbance

After this step, the four scores of threat attributes, i.e., extent, severity, frequency, and duration, calculated for each threat by any expert, were summed to obtain a 'Magnitude' score, as a compound variable, representing a proxy of the threat pressure of any threat impacting the selected targets. When the experts assigned scores to any threat attribute, we calculated their averaged values and standard deviation.

After evaluation, the experts ranked the threats when regarding the Magnitude values, obtaining a list in decreasing order. The threats with the highest average value represent the priority threats.

Finally, we built a conceptual framework which, starting from the target species, shows the relationships with the direct threats. To complete the framework, experts named the indirect driving forces, i.e., the indirect political, social, and economic processes at the origin of the anthropogenic threat (Margoluis et al., 2009).

2.6. Statistical analyses

We used a score evaluation, obtaining the averaged values and dispersion measures. To compare the averaged threat Magnitudes among > 2 samples, we performed the non-parametric Kruskall–Wallis test for equal medians (Dytham, 2011), obtaining H values using the PAST 1.89 software (Hammer et al., 2001). To compare averaged values between 2 samples, we used the pairwise Mann-Whitney *U* test. To perform the box plots, we used the quartile method. The alpha level was set to 0.05. For China, we had just two experts so we could not apply statistical analyses. However, we decided to present the data because of the severe endangered status of this species, so that any available data can be available to future researchers or conservation practitioners.

3. Results

Starting from the nine human-induced local direct threats identified by the panel of experts (Table 1), we obtained the Magnitude values for the various threats in the two rivers (Red River and Black River) (Fig. 2). The threats appear to have the largest Magnitude on the Black River and Red River were LOS and LAN (Table 2), with no significant difference between them in both of rivers (Red River: $p = 0.961$, Black River: $p = 0.807$; Mann-Whitney *U* test; Table 2). Preliminary data for China suggest HAR (Harvesting by native fishers; code 5.4) and POL (water pollution; code 9.2) as priority threats (Table 3).

The conceptual framework linking driving forces, direct threats and the selected target (i.e., Swinhoe's softshell turtle) in the two river systems (Vietnam) is given in Fig. 3. Experts identified three main driving forces of origin for the direct threats. First, demographic drivers, due to a rapid population growth in the last decades, appeared to be the force causing dramatic settlement and industrialization expansion and, consequently, responsible for a massive increase in buildings (settlement expansion; LOS) and by civil engineering industry (LAN), sand mining (MIN), and (mainly chemical and water-related) pollution due to increased industrialization (POL). Second, economic drivers were at the origin of threats caused by high poverty in local populations resulting in unmitigated harvesting associated with fishing activities and related markets (HAR), the needs of power supply to carry out economic activities overall, including mining and dams at different scales (IND, DAM), touristic activities also related to fishing and use of boats for sightseeing (BOA). Finally, ethical issues as driving forces linked to conservation project teams including competition for the limited funds available for the conservation of this species, as well as the existence of divergent points of view concerning what to do with such a charismatic species.

4. Discussion

Expert-based evaluation highlights habitat loss, i.e. land conversion, representing the main threat impacting Swinhoe's softshell turtle. However, conceptual framework evidence is important as almost all threats are the effects of complex social-economic driving forces mainly originating by three drivers: demographic, economic and ethical. More particularly, experts identified mining economies, settlements and soil consumption, industrialization (by dams and other activities), and pollution as pressures caused by demographic and economic drivers induced by a rapid population growth, increasing poverty and a need for power supply (for China: e.g., Zhang et al., 2018). In this regard, drivers linked to the fishing market (and in part to tourism) may explain the harvesting along rivers and the use of boats for fishing and recreational activities, all factor of anthropogenic pressure. Interestingly, however, all of these drivers are essentially "historical" and in the current stage of the species' status the addressing of any or all of them may not make any difference for the conservation/survival of the species. Indeed, the last wild individuals are likely 'living dead' as, due to their rarity and dispersal barriers, they cannot effectively contribute to the survival of the species in the wild, as convincingly demonstrated by the Hoan Kiem and Dong Mo lake individuals (Hance, 2020). As such, the main threats impacting the species are more of historic interest. In addition, some measures are beyond the control of scholars and administrators, such as population expansion and industrialization, thus complicating the species' conservation scenario even more.

However, apart from the economic and demographic drivers and related threats, one of the problems that emerged from our TA approach is the competition for resources among the various conservation organizations attempting to work on *Raphetus swinhoei*. The shortage of available resources surely enhanced the competition between working groups, with the consequence that each group has carried out research and conservation activities separately and without any coordinated programme. This lack of coordination has certainly damaged the progress in the conservation of the target species, as also shown in other study cases (see Battisti, 2017; Catalano et al., 2019). We suggest that it would be necessary to create a combined multi-faceted *Rafetus* Task

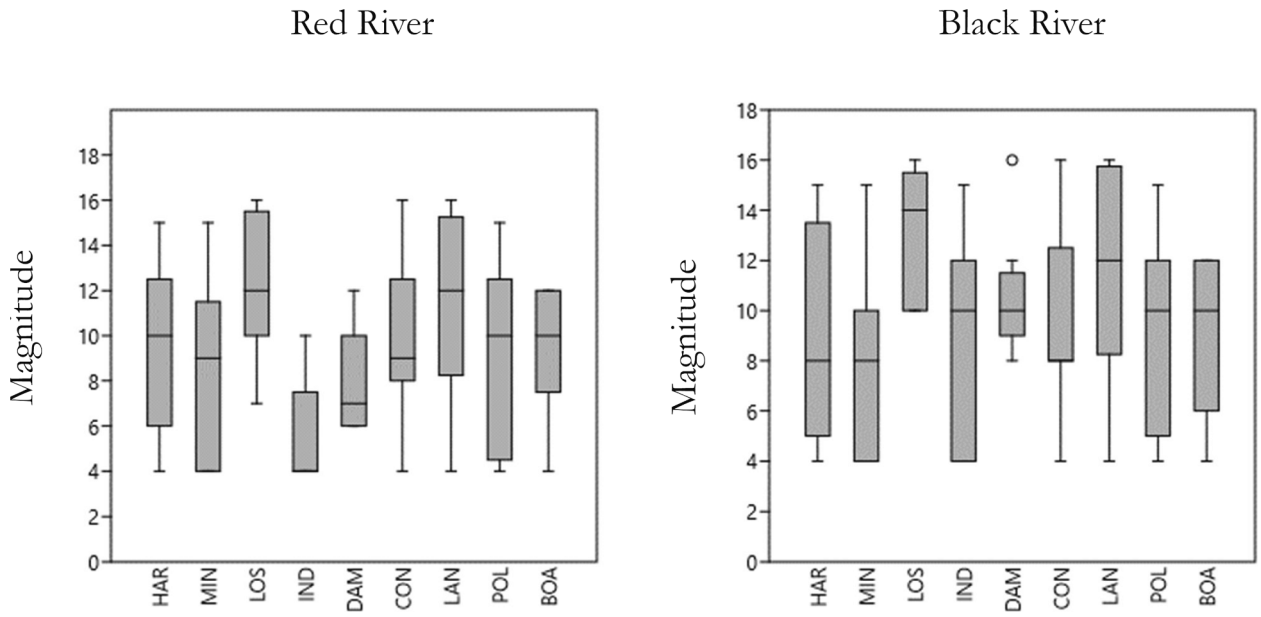

Fig. 2. Box plots of Magnitude values for the selected threats to the Swinhoe's softshell turtle (*Rafetus swinhoei*), in the two Vietnam rivers (Red River and Black River). The minimal and maximal values are shown with short horizontal lines ("whiskers"); 25–75 percentiles are drawn using a box; horizontal line shows the median values. HAR: Harvesting by native fishers; MIN: Sand mining; LOS: Habitat loss at nesting sites; IND: industrial dams; DAM: small-scale dams; CON: internal conflicts among conservation groups; LAN: land conversion; POL: water pollution; and BOA: disturbance by boats. See text for IUCN categories and codes.

Table 2
Threat Analysis procedure applied to the Swinhoe's softshell turtle (*Rafetus swinhoei*), along the Black and Red rivers (Vietnam). Mean values (and ± standard deviation) in regime attributes (extent, intensity, frequency, duration, and Magnitude, M) for the human-induced direct threats selected have been reported. HAR: Harvesting by native fishers; MIN: Sand mining; LOS: Habitat loss at nesting sites; IND: industrial dams; DAM: small-scale dams; CON: internal conflicts among conservation groups; LAN: land conversion; POL: water pollution; and BOA: disturbance by boats. See text for IUCN categories and codes.

	Red River					**Black River**					
	area	intensity	frequency	duration	M	area	Intensity	frequency	duration	M	n
HAR	2.44 (1.24)	2.44 (1.33)	1.89 (1.05)	2.33 (0.87)	9.11 (3.86)	2.44 (1.33)	2.33 (1.41)	1.78(0.97)	2.33 (1)	8.89 (4.28)	9
MIN	1.67 (0.71)	2.22 (1.20)	2 (1.22)	2.22 (1.39)	8.11 (4.14)	1.56 (0.73)	1.78 (1.09)	2 (1.22)	2.22 (1.39)	7.56 (3.75)	9
LOS	3 (1)	3.11 (1.05)	3.11 (1.05)	3.11 (1.17)	12.33 (3.28)	3.22 (0.67)	3.33 (0.71)	3.33 (0.71)	3.11 (1.17)	13 (2.55)	9
IND	1.33 (0.71)	1.56 (1.01)	1.22 (0.44)	1.33 (0.5)	5.44 (2.30)	2 (1)	2.44 (1.24)	2.11 (1.17)	2.33 (1.22)	8.89 (4.23)	9
DAM	3.11 (0.78)	2.67 (0.71)	2.56 (1.01)	2.89 (1.05)	8.11 (2.26)	2.67 (1.12)	2.44 (0.73)	2.56 (1.01)	3 (1.12)	10.67 (2.40)	9
CON	2.78 (1.09)	2.11 (0.93)	2.44 (1.13)	2.44 (1.13)	9.78 (3.56)	2.67 (1.12)	2.11 (0.93)	2.44 (1.13)	2.44 (1.13)	9.67 (3.61)	9
LAN	2.75 (1.04)	2.88 (0.99)	2.88 (1.25)	3 (1.07)	11.5 (4.14)	2.75 (1.04)	3 (1.07)	2.88 (1.25)	3.13 (1.13)	11.75 (4.30)	8
POL	2.44 (1.01)	2 (1.12)	2.22 (1.30)	2.44 (1.33)	9.11 (4.08)	2.33 (1)	2.11 (1.05)	2.22 (1.30)	2.44 (1.33)	9.11 (3.89)	9
BOA	2.22 (1.09)	1.89 (0.78)	2.89 (1.17)	2.44 (1.01)	9.44 (2.74)	1.89 (1.05)	1.78 (0.83)	2.78 (1.30)	2.44 (1.24)	8.89 (3.18)	9

Table 3
Threat Analysis procedure applied to the Swinhoe's softshell turtle (*Rafetus swinhoei*) for China.

threats	area	Intensity	frequency	duration	M
HAR	4 (0)	4 (0)	3.5 (0.71)	4 (0)	15.5 (0.71)
MIN	2 (1.41)	2.5 (2.12)	1.5 (0.71)	1.5 (0.35)	7.5 (4.95)
LOS	3.5 (0.71)	3 (1.41)	2.5 (0.71)	3 (0.71)	12 (1.41)
IND	2 (1.41)	2 (1.41)	1.5 (0.71)	1.5 (0.35)	7 (4.24)
DAM	1.5 (0.71)	1.5 (0.71)	1 (0)	1 (0)	5 (1.41)
CON	1 (0)	1 (0)	1 (0)	1 (0)	4 (0)
LAN	1.5 (0.71)	2 (1.41)	1 (0)	1 (0)	5.5 (2.12)
POL	3.5 (0.71)	2.5 (0.71)	3 (1.41)	3.5 (0.35)	12.5 (3.53)
BOA	2.5 (2.12)	2 (1.41)	2 (1.41)	2.5 (1.06)	9 (7.07)

Force of participants and organizational leaders from all the relevant organizations. This task force should focus their collective energies and resources on clear end objectives: (i) finding a few living wild animals, (ii) ensure the conservation at a local level to protect the habitat and animals in some small natural sites where the species might begin to reproduce naturally, and (iii) eventually grouping the newly discovered individuals into a "semi-natural area" to enhance their chance to breed.

Intensive captive breeding of *R. swinhoei* has previously been attempted in China with the only remaining two surviving old individuals of the former Yangtze population which had already been in captivity for well over 60 years (Turvey, 2008). Natural copulation and insemination of the female proved impossible due to an old injury of the male's penis. This required application of, by then in turtles untested, procedures of semen collection and artificial insemination. Unfortunately, the female did not recover from her last anaesthesia in 2019, terminating these desperate breeding attempts (Kuchling and Shunqing, 2020). However, individuals of this species have been successfully maintained in captivity for many decades (Pritchard, 2012), captive breeding of softshell turtles is well understood and, apart from the current lack of facilities and capacity for the breeding of large softshell turtles in Vietnam, there is no reason why, dependent on the number of surviving individuals and their situation, captive breeding should not be eventually considered for saving this species in the future.

Expert-based approaches like the one presented here offer an initial assessment and is a highly effective when dealing with critically endangered species. Indeed, using the TA expert approach we may identify priorities which aid in informing decision-making processes, especially in crisis contexts (McCarthy & Possingham, 2007; Margoluis et al.,

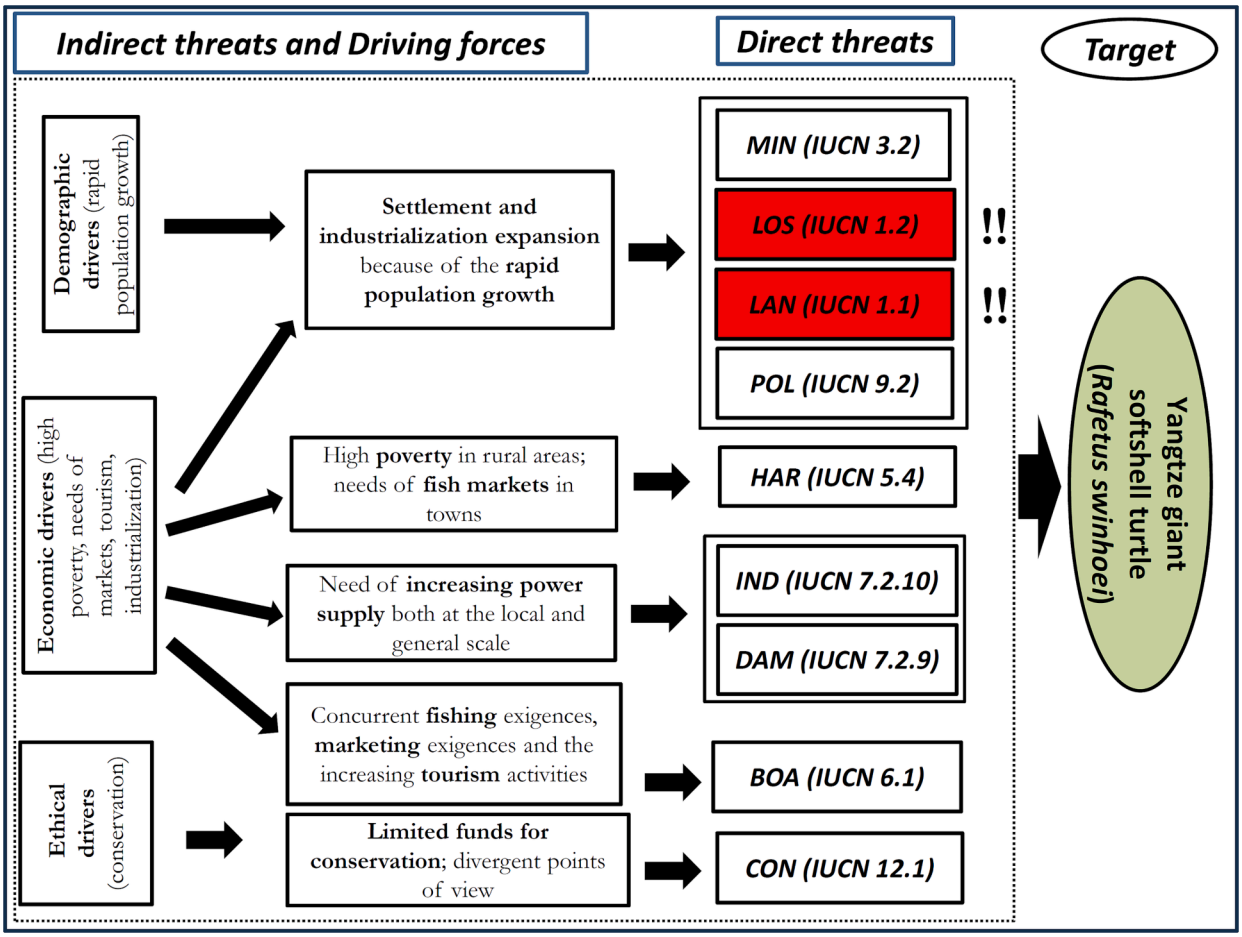

Fig. 3. Conceptual framework linking driving forces and, direct threats against and the selected target (Swinhoe's softshell turtle, *Rafetus swinhoei*), in two Vietnam rivers (Red River and Black River). Threats showing priority (highest Magnitude) have been reported in red boxes and with the symbol '!!'.

2009), and is particularly helpful during the early stages of a conservation project cycle (context analysis; Hockings et al., 2000; Battisti, 2018). The effectiveness of this approach is strongest when resources (budget, time, operators) are limited and threats are difficult to compare using analytical approaches (Johnson et al., 2012). This fact is particularly strategic, since time and economic resources are often scanty in conservation (Margoluis & Salafsky, 1998), and may overcome the points of weaknesses in this type of evaluation as there is often lack of analytical data to understand the severity of threat Magnitude.

In theory, having identified priority threats, further steps may be planned as, for example, the application of specific indicators of pressure and impact (DPSIR approach; Binimelis et al., 2009) associated with any priority threat. Finally, knowing the threat Magnitude may be of use for before-after comparisons after carrying out specific projects. In this regards, these data will be useful for procedures of Threat Reduction Assessment (Salafsky and Margoluis, 1999; Mathar & Anthony, 2010; Giovacchini et al., 2022) focused on priority threats acting on this critically endangered species. In practice, as previously outlined, at this critical stage these 'priority threats' are likely beyond factual relevance for conservation of Swinhoe's softshell turtle. However, of highest relevance is that any remaining individuals are so isolated and fragmented that they can no longer find a partner and reproduce. Therefore, if we want *R. swinhoei* to survive, our immediate actions must be to intensify field surveys with more "aggressive" methodologies, such as the use of an expanded program using floating camera traps, in order to discover a given area where the species is still present and potentially reproducing in the wild. There is promise in this area of focus as reliable interviews suggest that several individuals may still be found in the wild in various areas. Additionally, we need to focus on developing a plan to bring any surviving individuals together at a secure site which can facilitate reproduction and plan follow up conservation measures once they managed to reproduce. To date, the conservation of the target species has been hampered by a lack of funding to comprehensively identify sites that remnant individuals may exist and by a lack of follow-up recovery actions once such sites and individuals have been identified (e.g., Dong Mo and Xuan Khanh lakes). In this regard, sampling efforts should be increased in order to enhance the chance to uncover potential new sites of occurrence (e.g., Le Duc et al., 2020b).

The future of this species, at least in the short term, relies on identifying any surviving animals and bringing them together for a chance to propagate a new generation, and not necessarily in addressing threats according to their priorities identified in this analysis.

CRediT authorship contribution statement

Luca Luiselli: Writing – review & editing, Writing – original draft, Validation, Supervision, Investigation, Data curation, Conceptualization. **Olivier Le Duc:** Writing – review & editing, Investigation, Logistics. **Thong Pham Van:** Investigation. **Thuan Nguyen Xuan:** Investigation. **Phong Bui Dang:** Investigation. **Gerald Kuchling:** Writing – review & editing, Investigation. **Benjamin Leprince:** Writing – review & editing, Funding acquisition. **Hai-Tao Shi:** Writing – original draft, Investigation. **Lonnie McCaskill:** Investigation. **Pietro Giovacchini:** Writing – original draft, Investigation, Conceptualization. **Letizia Marsili:** Writing – review & editing, Conceptualization. **Andrew D. Walde:** Writing – review & editing, Investigation. **Corrado Battisti:**

Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

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

Data availability

Data will be made available on request.

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