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Preliminary Assessing Species Susceptibity to Climate Change for Terrestrial Vertebrates in Phu Canh Nature Reserve, Hoa Binh Province

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Abstract: Phu Canh Nature Reserve is located in Da Bac district, Hoa Binh province. The reserve covers an area of 5.647 ha and plays an important role in the conservation of biodiversity resources, in supporting many rare wildlife species with high conservation value. In this nature reserve, we identified 48 reptilian species of 16 families in 2 orders; 28 amphibian species of 6 families in 2 orders; 65 bird species of 24 families in 7 orders; 57 mammal species of 25 families in 8 orders. Many of which are rare, endangered, and listed in the Vietnam Red Data Book, IUCN Red List and Decree 32/2006/ND-CP. Among threatened species, the mammals made up the highest percentage (31.6%) and the amphibians made up the lowest (10.7%). In terms of species that are susceptible to climate change, the amphibians made up the highest percentage (42.8%) while the birds made up the lowest (35.3%). The reptiles made up the relatively high proportion of threatened species (20.9%) and "climate-change-susceptible" species (37.5%), while the percentage of mammals species that were both susceptible and threatened was 38.6%. The amphibians and mammals seem to face their extinction risk if there exist no timely conservation action plans in the area. This is the first data assessing the susceptibility of terrestrial vertebrates to climate change at Phu Canh Nature Reserve.

Keywords: Terrestrial vertebrate, Susceptibility, Climate Change, Phu Canh.

1. Introduction

General Circulation Models (GCMs) predict that climate change will affect different areas of the world to different degrees. But it is also widely recognized that not all species will respond in the same way, even to similar levels of climatic change. There is a growing evidence that climate change will become one of the major drivers of species extinction in the 21st century. A number of published studies have documented a variety of environmental changes attributable to climate change [1], for example, changes in species breeding times and distribution range. One study suggested that 15-37% of terrestrial species may be "committed to extinction" by 2050 due to climate change [2]. How can we predict which species will become most threatened by climate change and how best can we mitigate the impacts?

Recently, most assessments of species extinctions under climate change have been based on either isolated case studies or large-scale modelling of species' distributions [3-5]. These

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methods depend on broad and possibly inaccurate assumptions, and generally do not take account of the biological differences between species. As a result, meaningful information that could contribute for conservation planning at both fine and broad spatial scales is limited. Conservation decision-makers, planners and practitioners currently have few tools and little technical guidance on how to incorporate the differential impacts of climate change into their plans and actions.

In the context of global climate change and in Vietnam, northwest region including Đà Bắc district in Hoa Binh province that is one of the places affected by climate change. Climate here is most evident manifestation of extreme climatic phenomena such as prolonged drought, abnormal floods, damaging cold and these phenomena occur erratically unpredictable. Phu Canh Nature Reserve (Phu Canh NR) is assessed as one of the largest three reserves in Hoa Binh province and it is considered to be representative of the type of evergreen tropical and low mountain subtropical, typically for the northwest region in Vietnam. In addition, Phu Canh NR has a great value in regulating and providing water for agriculture, hydropower as well as environmental protection. In this study, we assessed susceptibility to climate change according to taxon-specific biological traits of terrestrial vertebrate species most susceptible to climate change (temperature, rainfall and the extreme weather events of Da Bac district) at Phu Canh NR and compared these items to the existing assessments of threatened species in two important references such as IUCN Red List of Threatened Species [6] and 2007 Vietnam Red Data Book [7].

2. Materials and Method

2.1. Study Area

The study was carried out at Phu Canh Nature Reserve (20°56'18" N; 105°01'04" E) located in four communes: Doan Ket, Dong Chum, Dong Ruong and Tan Pheo of Da Bac District in Hoa Binh Province, northwestern Vietnam (Fig.1).

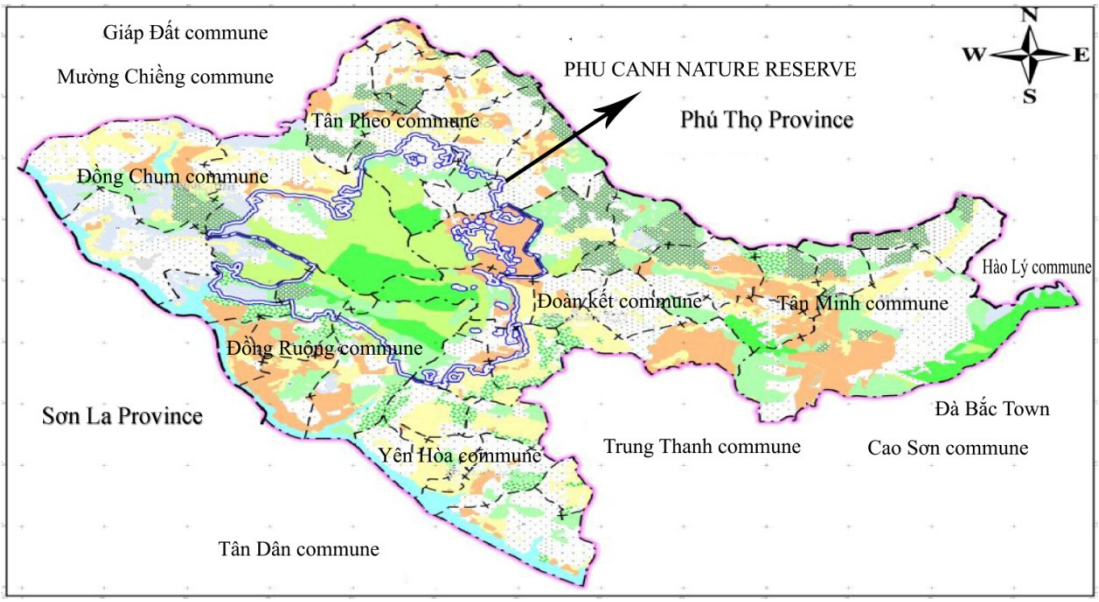

Figure 1. Phu Canh Nature Reserve, Hoa Binh Province.

2.2. Study Methods

- Data collection of terrestrial vertebrates was based on the reference method [8] and field survey method (from 4 to 12 April, 2016). Investigation and collection of specimens were mainly carried out with tools such as traps to catch small mammals; hand nets and hooks to collect frogs; tough and thin rods to catch snakes and lizards. Flashlights were used to collect and observe amphibians at night. Besides collecting samples directly, we also bought samples of frogs, reptiles, birds and small mammals from local people. Specimens were fixed in formalin 4 - 10% (depending on animal group) or ethanol 70% and labelled in the field. For big mammals, we observed the footprints, faeces, food, and scratches on the trunk. We also took interviews to the local people for getting information of vertebrates in the area. In these interviews, open questions in combination with using colour photographs of animals were applied. Identification of species composition for terrestrial vertebrate groups in the field and laboratory by specific method and relevant taxonomic documents corresponding to relevant group [9-15].

- Assessment of the susceptibility of terrestrial vertebrates to climate change followed methodology in [16, 17].

3. Results and Discussion

3.1. Diversity of Terrestrial Vertebrates at Phu Canh Nature Reserve

- Amphibians and Reptiles

Totally, 48 reptilian species of 16 families in two orders and 28 amphibian species of six families in two orders were determined. In 76 species of reptiles and amphibians recorded, three amphibian species and 10 reptile species are threatened in the different level enlisted in IUCN Red List of Threatened Species, 2007 Vietnam Red Data Book and 2006 Decree 32 [6, 7, 18] (Table 1). Through interviewing the management Board of Phu Canh NR and local people by using colour photographs, we recorded the present of *Paramesotriton deloustali* at Phu Canh NR and further studies are needed to confirm the existence of this population in here. The rare amphibian and reptile populations declined drastically due to over-hunting and habitat was impacted strongly therefore they are needed specially conservation priorities, such as *Chaparana delacouri, Varanus salvator, Naja naja Ophiophagus hannah,* and *Palea steindachneri ...*

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Table 1. List of threatened amphibian and reptile species in Phu Canh NR

No.	Scientific name	Rec. type	Threatened Level		
			IUCN	Vietnam Red Data Book	Decree 32
A	**Amphibian**				
	Salamandridae				
1	*Paramesotriton deloustali*	In.	VU	EN	IIB
	Ranidae				
2	*Rana andersonii*	In.	LC	VU	
3	*Chaparana delacouri*	In.	DD	EN	
B	**Reptiles**				
	Gekkonidae				
1	*Gekko gecko*	C	NE	VU	
	Agamidae				
2	*Physignathus cocincinus*	In.	NE	VU	
	Varanidae				
3	*Varanus salvator*	O,In.	LC	EN	IIB
	Colubridae				
4	*Ptyas korros*	In.	LC	EN	
5	*Coelognathus radiata*	In.	LC	VU	IIB
	Elapidae				
6	*Naja naja*	C,In.	LC	EN	IIB
7	*Ophiophagus hannah*	C,In.	VU	CR	IB
8	*Bungarus fasciatus*	O, In.	LC	EN	IIB
	Trionychidae				
9	*Pelodiscus sinensis*	In.	VU	VU	
10	*Palea steindachneri*	In.	EN	VU	

Note: Rec. type: Recording type; In.: Interview; C: Specimen; O: Observation; Mark: M. VU: Vulnerable; EN: Endangered; CR: Critically Endangered; DD: Data deficient; NT: Near threatened; Least concern (LC); LR nt: Lower Risk near threatened; NE: Not Evaluted; IB, IIB: Annex in 2006 Decree 32.

- ***Birds:*** 65 bird species were recorded in Phu Canh NR belong to 24 families of seven orders, most are heavily exploited or threatened with extinction locally (Table 2). Among them, there are 8 species enlisted in IUCN Red List of Threatened Species, 2007 Vietnam Red Data Book and 2006 Decree 32 [6, 7, 18].

Lophura nycthemera and *Polyplectron bicalcaratum* are two rare species, small quantities and difficult to catch in the reserve. We determined the presence of two species through feather samples retained in a household at Khèm village in Doan Ket commune and interviewing local people. The remaining species also identified as priority species conservation in the reserve. At present, these species are still quite common in the reserve, but are hunted intensively and their number would decline rapidly without proper conservation measures (Table 2).

- ***Mammals:*** Preliminary investigation results showed that Phu Canh NR contained 57 mammal species of 25 families belong to eight orders; 18 species of which are threatened at the national and global levels with different levels in IUCN Red List of Threatened Species, 2007 Vietnam Red Data Book and 2006 Decree 32 [6, 7, 18] (Table 3).

Results in table 3 shown that, there are many rare mammal species with high conservation value occur in Phu Canh NR. However, these species only exist in very small number such as: *Ursus thibetanus* currently with only about two individuals and inhabiting mainly near Phu Canh Mountain, located in Nhạp village of Dong Chum commune; *Captopuma temmincki* which is so elusive in the reserve; *Capricornis milneedwardsii* only with 2 or 3 individuals and occurring at Ta Khop, Nhap village and other limestone forest areas; *Belomys pearsoni* with small number and only occurring in the big timber forest areas of the reserve (Table 3).

3.2. Identifying Susceptibility of Terrestrial Vertebrates to Global Climate Change

According to the assessment as [16, 17] and through community survey in conjunction with the collection of data from the report on the socio-economic and anti-flood report of Đà Bắc district (from 2005 to present) show that the extreme events caused by climate change were mainly floods, droughts, damaging cold. These phenomena were unusual changes and had significant impact on the livelihoods of the local people especially to the poor.

Table 2. List of threatened bird species in Phu Canh NR

No.	Scientific name	Rec. type	Threatened Level		
			IUCN	Vietnam Red Data Book	Decree 32
	Phasianidae				
1	*Lophura nycthemera*	In., M	LC	LR	IB
2	*Polyplectron bicalcarratum*	In.	LC	VU	IB
	Alcedinidae				
3	*Megaceryle lugubris*		LC	VU	
	Accipitridae				
4	*Spilornis cheela*		LC		IIB
	Tytonidae				
5	*Tyto alba*		LC		IIB
	Turnidae				
6	*Copsychus malabaricus*	O	LC		IIB
	Pittidae				
7	*Pitta nympha*	O, In.	VU	VU	
	Sturnidae				
8	*Gracula religiosa*	In.	LC		IIB

Note: Rec. type: Recording type; In.: Interview; C: Specimen; O: Observation; Mark: M. VU: Vulnerable; EN: Endangered; CR: Critically Endangered; DD: Data deficient; NT: Near threatened; Least concern (LC); LR nt: Lower Risk near threatened; NE: Not Evaluted; IB, IIB: Annex in 2006 Decree 32.

Table 3. List of threatened mammal species in Phu Canh NR

No.	Scientific name	Rec. type	Threatened Level		
			IUCN	Vietnam Red Data Book	Decree 32
	Loricidae				
1	*Nycticebus bengalensis*	In.	VU	VU	IB
2	*Nycticebus pygmaeus*	In.	VU	VU	IB
	Cercopithecidae				
3	*Macaca mulatta*	In.	LC	LR nt	IIB
4	*Macaca arctoides*	In.	VU	VU	IIB
	Ursidae				
5	*Ursus thibetanus*	In.	VU	EN	IB
	Mustelidae				
6	*Lutra lutra*		NT	VU	IB
7	*Aonyx cinera*		VU	VU	IB
8	*Arctonyx collaris*	M	LC		
	Viverridae				
9	*Viverricula indica*	M	LC		IIB
10	*Viverra zibetha*	In.	LC		IIB
11	*Prionodon pardicolor*	In.	LC	VU	IIB
12	*Chrotogale owstoni*	In.	VU	VU	IIB
	Felidae				
13	*Prionailurus bengalensis*	In.	LC		IB
14	*Captopuma temmincki*	In.	NT	EN	IB
	Bovidae				
15	*Capricornis milneedwardsii*	In.	NT	EN	IB
	Pteromyidae				
16	*Petaurista philippensis*	In.	LC		IIB
17	*Belomys pearsoni*	In.	NT	CR	
	Sciurida				
18	*Ratufa bicolor*	In.	NT	VU	

Note: Rec. type: Recording type; In.: Interview; C: Specimen; O: Observation; Mark: M. VU: Vulnerable; EN: Endangered; CR: Critically Endangered; DD: Data deficient; NT: Near threatened; Least concern (LC); LR nt: Lower Risk near threatened; NE: Not Evaluted; IB, IIB: Annex in 2006 Decree 32.

Results collected from household surveys showed that the extreme weather events related to meteorology, hydrology have been occurring in Đà Bắc district with increasing frequency and intensity recently, such as droughts, damaging cold and heavy rain. They were more severe and had greater impact on the community especially the poor, such as reduced crop yields, livestock die cold, lack of water for farming and living activities leading to increase moths food shortages.

According to scenarios of climate change and sea level rise in Vietnam Institute of Meteorology, Hydrology and Climate Change [19] can be summarized as follows: Temperatures in all regions of Vietnam have uptrend versus base period (1986-2005), with the largest increase is the northern area: Representative Concentration Pathway (RCP) RCP 4.5 scenario shown that, by the end of the 21st century, in the north, temperature increases from 1.9 to 2.4°C mainly in the south and from 1.7 to 1.9°C during RCP 8.5 scenario is shown that, the corresponding temperature rise from 3.3 to 4.0°C in the north and from 3.0 to 3.5°C in the south. The average lowest temperature and the highest average apparently uptrend. Annual rainfall tends to increase across the country compared to the base in all scenarios: RCP 4.5 scenario, the end of the 21st century, and the annual rainfall increased popularity from 5 to 15 %. RCP 8.5 scenario, an increase of more than 20% possible in most of the northern area, the Central, a part of the Southern and the Highlands. Dry season rainfall in some areas tends to decrease. Droughts could become more severe in some areas due to rising temperatures and reduced rainfall in the dry season.

Table 4. The numbers and percentages of species assessed for "climate-change-susceptibility" for amphibians, reptiles, birds and mammals in Phu Canh NR

Amphibians		**Threatened**	**Non-threatened**	**Total**
Climate Change Susceptible	Yes	(i) 2 (7.1%)	(iii) 10 (35.7%)	**42.8%**
	No	(ii) 1 (3.6%)	(iv) 15 (53.6%)	**57.2%**
	Total	**10.7%**	**89.3%**	**28%**
Reptiles		**Threatened**	**Non-threatened**	
Climate Change Susceptible	Yes	(i) 7 (14.6%)	(iii) 11 (22.9%)	**37.5%**
	No	(ii) 3 (6.3%)	(iv) 27 (56.2%)	**62.5%**
	Total	**20.9%**	**79.1%**	**48%**
Birds		**Threatened**	**Non-threatened**	
Climate Change Susceptible	Yes	(i) 7 (10.7%)	(iii) 16 (24.6%)	**35.3%**
	No	(ii) 1 (1.5%)	(iv) 41 (63.2%)	**64.7%**
	Total	**12.2%**	**87.8%**	**65%**
Mammals		**Threatened**	**Non-threatened**	
Climate Change Susceptible	Yes	(i) 13 (22.8%)	(iii) 9 (15.8%)	**38.6%**
	No	(ii) 5 (8.8%)	(iv) 30 (52.6%)	**61.4%**
	Total	**31.6%**	**68.4%**	**57%**

Note: These values fall into categories in Table 4 such as: (i) threatened and "climate-change-susceptible"; (ii) threatened but not "climate-change-susceptible"; (iii) not threatened but "climate-change-susceptible"; and (iv) neither threatened nor "climate-change susceptible".

According to the above scenario of climate change above and taxon-specific biological traits of terrestrial vertebrate species in Phu Canh NR, we evaluated the susceptibility of species to temperature, rainfall and extreme events (Table 4). For each taxonomic group, we assessed all species into the following two categories (threatened/ non-threatened) according to [6, 7] for "climate-change-susceptible". For these susceptibility assessments to climate change, we based on information about distribution, habitat and reproduction of the terrestrial vertebrate species following [9, 11, 12, 14, 15].

The results in table 4 showed that each taxonomic group within species faced different challenges in response to climate change detailed such as:

- The amphibians made up the highest percentage of susceptible species to climate change (42.8%), greatly exacerbating their extinction risk [20]. In addition, 35.7% of currently non-threatened species were "climate-change-susceptible".

- Among four assessed groups, the reptiles made up the relatively high proportion of threatened species (20.9%) and the percentage of species are both susceptible and threatened was 37.5%.

- The overall percentage of threatened birds was lower than mammals and reptiles (12.2%), but most threatened birds (10.7%) were susceptible to the impacts of climate change. In addition, 24.6% of non-threatened species were susceptible to climate change. Among four assessed groups, the birds made up the lowest percentage of susceptible species to climate change (35.3%).

- The mammals made up the highest percentage of threatened species (31.6%) and amphibians made up the lowest (10.7%). The percentage of species that were both susceptible and threatened was 38.6% and these species also seem to face their extinction risk if there exist no timely conservation action plans in Phu Canh NR.

The large overlap between threatened and "climate-change-susceptible" of amphibian, reptile, bird and mammal species suggests that, ideally, they must receive conservation priorities. Species that have already faced a high risk of extinction, irrespective of the threat type, are far less likely to be resilient to environmental and climatic changes. A large overlap between threatened and "climate-change-susceptible" species may therefore indicate that climate change may cause a sharp rise in both the extinction risk and extinction rate of threatened species. Some species are much more susceptible to climate change impacts than others due to inherent biological traits related to their life history, ecology, behaviour, physiology and genetics. High risks of extinction occur when species with high susceptibility to climate change encounter large climatic changes [3, 5]. It is also important to identify susceptible species which, while currently not threatened, are likely to become so in the future as climate change impacts may intensify. By highlighting such species before they decline, we hope to promote pre-emptive and more effective conservation actions.

4. Conclusion

- We have identified 48 reptilian species of 16 families in two orders; 28 amphibians species of six families in two orders; 65 birds species of 24 families in seven orders; 57 mammals species of 25 families in eight orders at Phu Canh NR.

- Many species are rare, endangered and listed in the Vietnam Red Data Book, IUCN Red List and Decree 32/2006/ND-CP. The mammals made up the highest percentage of threatened species (31.6%) and amphibians made up the lowest (10.7%).

- The amphibians made up the highest percentage of susceptible species to climate change (42.8%) while the birds made up the

lowest percentage (35.3%); the reptiles made up the relatively high proportion of threatened (20.9%) and "climate- change-susceptible" species (37.5%) while the percentage of mammals species that were both susceptible and threatened was 38.6%. The amphibians and mammals seem to face their extinction risk if there exist no timely conservation action plans in Phu Canh NR.

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Bước đầu đánh giá tính nhạy cảm của biến đổi khí hậu đến động vật có xương sống trên cạn của khu bảo tồn thiên nhiên Phu Canh, tỉnh Hòa Bình

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Tóm tắt: Khu Bảo tồn thiên nhiên Phu Canh, huyện Đà Bắc, tỉnh Hòa Bình có diện tích 5.644 ha, giữ vai trò quan trọng trong việc bảo tồn tài nguyên đa dạng sinh học. Chúng tôi đã ghi nhận được 48 loài bò sát thuộc 16 họ trong 2 bộ; 28 loài lưỡng cư thuộc 6 họ trong 2 bộ; 65 loài chim của 24 họ thuộc7 bộ; 57 loài thú của 25 họ thuộc 8 bộ tại khu bảo tồn. Trong đó, nhiều loài quý hiếm có tên trong Sách Đỏ Việt Nam, Danh lục Đỏ IUCN và Nghị định số 32/2006/NĐ-CP. Với 31.6%, các loài thú bị đe dọa có phần trăm cao nhất và thấp nhất là lưỡng cư (10.7%). Lưỡng cư có phần trăm cao nhất của các loài nhạy cảm với biến đổi khí hậu (42.8%) trong khi ở chim là thấp nhất (35.3%); bò sát có phần trăm tương đối cao các loài bị đe dọa (20.9%) và tính cả các loài nhạy cảm với biến đổi khí hậu là 37.5%; trong khi ở thú, cả các loài bị đe dọa và nhạy cảm với biến đổi khí hậu là 38.6%. Lưỡng cư và thú dường như đối mặt với nguy cơ tiệt chủng nếu không có các kế hoạch bảo tồn kịp thời trong thời gian tới tại khu bảo tồn. Đây là số liệu đầu tiên đánh giá tính nhạy cảm đối với biến đổi khí hậu của động vật có xương sống ở cạn tại khu bảo tồn thiên nhiên Phu Canh.

Từ khóa: Động vật có xương sống ở cạn, tính nhạy cảm, biến đổi khí hậu, Phu Canh.