

BIODIVERSITY IN HAI DUONG PROVINCE: CURRENT STATUS AND CHALLENGES

Nguyễn Thanh Lâm*, Cao Trường Sơn, Nguyễn Thị Hương Giang

*Faculty of Environment, Vietnam National University of Agriculture**Email*: ntlam_cares@vnua.edu.vn*

Received date: 20.02.2014

Accepted date: 15.07.2014

TÓM TẮT

Điều tra đa dạng sinh học (ĐDSH) đã được tiến hành trong 3 Hệ sinh thái (HST): HST trên cạn, HST thủy sinh và HST Nông nghiệp nhằm đánh giá hiện trạng và xác định các thách thức đến công tác bảo tồn ĐDSH tại tỉnh Hải Dương. Kết quả nghiên cứu đã xác định được: 1.033 loài thực vật và 881 loài động vật trong các HST trên cạn; 314 loài động, thực vật trong các HST thủy sinh. Các loài sinh vật quý hiếm gồm: 39 loài trong sách đỏ Việt Nam 2007; 28 loài trong Phụ lục NĐ 32/2006-CP và 88 thuộc Danh lục đỏ của IUCN 2011. Sự phân bố ĐDSH trên địa bàn tỉnh không đồng đều, mức độ đa dạng cao ở khu vực miền núi và đa dạng thấp ở khu vực đồng bằng. Nghiên cứu đã xác định được 8 khu vực quan trọng cần bảo tồn đa dạng sinh học trên địa bàn tỉnh Hải Dương. Các thách thức đối với công tác bảo tồn đa dạng sinh học Hải Dương được xác định bao gồm mất nơi cư trú, ô nhiễm môi trường, sinh vật ngoại lai, khai thác-sử dụng quá mức và biến đổi khí hậu, hạn chế về quản lý nhà nước và ý thức của người dân.

Từ khóa: Đa dạng sinh học, hệ sinh thái, hiện trạng, thách thức, tỉnh Hải Dương

Đa dạng sinh học tỉnh Hải Dương: Hiện trạng và Thách thức**ABSTRACT**

Biodiversity study was carried in three major ecosystems, aquatic, terrestrial and agricultural ecosystems to evaluate current status and challenges of biodiversity conservation in Hai Duong province in 2013. In this study, 1,033 species of plants and 881 species of animals in the terrestrial ecosystem; 314 species of animals and plants in the aquatic ecosystem have been identified. Rare and precious species have been identified including 39 species in the Vietnam Red Book, 28 species in Government Decree No 32/2006, and 88 species in the Red list of threatened animals of IUCN 2011. The results revealed that biodiversity resource in Hai Duong is unevenly distributed, the mountainous area being richer in biodiversity than the delta areas. The study also identified 8 hotspots for biodiversity conservation. Finally, major challenges to biodiversity loss were identified such as habitat loss, pollution, invasive species, over-exploitation and climate change, weaknesses in state management and lack of public awareness.

Keywords: Biodiversity, challenges, ecosystem, Hai Duong province.

1. INTRODUCTION

Vietnam is one among the countries with richest biodiversity in the world. However, biodiversity loss is quite alarming in Vietnam due to forest loss, illegal logging, wildlife trade, habitat loss and fragmentation, urbanization, and environmental pollution. To overcome these issues, the Vietnamese government signed the Convention on Biological Diversity in 1992. In 2001, the Law on Biodiversity was promulgated

and in the following year, the National Strategies on Biodiversity was launched. These events present great efforts of Vietnamese government towards biodiversity conservation.

Hai Duong is located in the centre of the Red River Delta of northeastern Vietnam. The natural area of the province is 1,661.2 km², of which 89% is Delta. Hai Duong enjoys tropical monsoon climate with typically cold winter, potentially hot and humid summer. Nowadays, it is among the most industrialized and

developed provinces in Vietnam. The annual economic growth rate reached 9.7% in the period of 2006 to 2010, and 9.3% in 2011. The economic structure has been strongly transformed toward industrial production and services. Current development promotes social stability and allows great improvement in the inhabitants' living standard. However, the economic growth also creates high pressure on environment, natural resources, and biodiversity.

Responding to this situation, the study was conducted to evaluate the current status and biodiversity value of the main ecosystems, to identify important areas for conservation, and to identify the main challenges of biodiversity conservation in Hai Duong.

2. RESEARCH METHODOLOGIES

2.1. Collection of secondary data

Secondary data and information were gathered from Hai Duong provincial statistics office and district departments of Agriculture and Rural Development, and Natural Resources and Environment

2.2. Collection of primary data

Field surveys were carried out in three main ecosystems, aquatic ecosystem, terrestrial ecosystem and agro-ecosystem in the dry and rainy seasons from 2012 to 2013. During the field surveys, several methods were used such as biodiversity investigation at selected plots, structured interviews with local people and officers; transect walks and farms and market visits for in-depth interview.

Biodiversity investigation using selected sample plots: 250 plots of 1,000 m² were selected for biodiversity investigation. The locations of the sample plots are shown in Figure 1. * *Transect walks:* The transect walks were carried out in both dry and rainy seasons across various landscape types of Hai Duong from flat land in Thanh Ha district to upland areas of Kinh Mon and the town of Chi Linh. Each

transect length was approximately 5 km to 15 km. The research team consisted of experts from the Institute of Ecology and Biological Resources, Hanoi University of Agriculture and local informants.

* *Structured questionnaire:* A structured questionnaire was designed to collect information from local staff, managers, and local people about local biodiversity status and management. The structured questionnaire was sent directly to district and communal offices by regular mail with letters of request. The respondents were local managers and staff of agriculture, forestry, aquaculture, natural resource and environment sectors as well as leaders of People's Committee at district and communal level;

* *Household interviews:* structured household interviews were conducted in order to collect information relating to current biodiversity state, local needs, and awareness about biodiversity conservation. A total of 200 households were interviewed. Out of these 150 household interviews were mainly conducted on the biodiversity of the terrestrial ecosystem. The selected households are living in important agricultural production areas of each district. The survey areas were chosen under the advice of local staff that is responsible for managing agriculture at local areas. In addition, a survey was conducted of 50 households living in Bac An and Hoang Hoa Tham Communes in Chi Linh town in order to understand the current status of forest biodiversity exploitation.

* *Farm and market visits for in-depth interviews:* During transect walks, several farms and markets have been visited and in-depth interviews were employed for better understanding domestic flora and fauna and wild life exploitation.

2.3. Sampling and species identification

Samples were collected twice: the first time in the 2012 rainy season and the second time in the 2013 dry season. The sampling was taken from survey plots and species were identified.

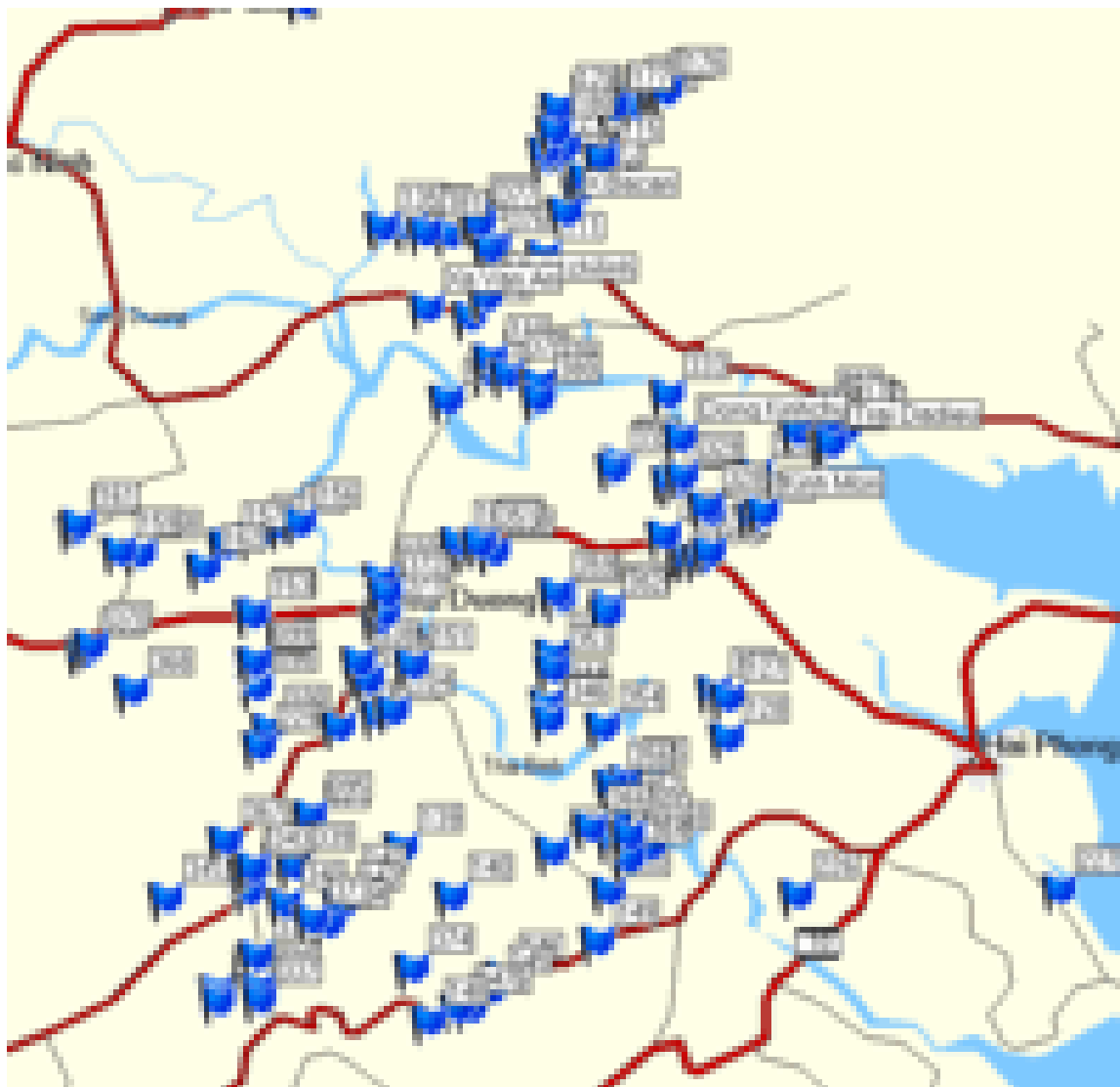


Figure 1. Locations of selected sample plots in Hai Duong

Source: Le Hung Anh, 2013

2.4. Identifying species for conservation

To identify precious and rare species for conservation, species collected were compared with the following documents.

- Vietnam's Red Data Book 2007
- The Government Decree 32/2006/ND-CP.
- Red list of Threatened animals (IUCN, 2009)
- Red list of Threatened plants (IUCN, 2009).

For identifying invasive species, collected species were compared with following documents.

- Circular No 22/2011/TT-BTNMT (Ministry of Natural Resource and Environment, 2011).
- IUCN 100 of the World's Worst Invasive Alien Species

Criteria for identifying biodiversity hotpots

Biodiversity hotpots were identified based on following criteria:

- The area has precious or endemic species.
- The area has species that are valuable to the economy or culture of the local community.
- The area has high biodiversity index.

3. RESULTS AND DISCUSSION

3.1. Current biodiversity status in Hai Duong

* Terrestrial ecosystem

A total of 1,033 flora species in terrestrial ecosystem belong to 172 families of 5 divisions (Table 1). The dominant plant is *Magnoliophyta* with a total of 985 species of 148 families, followed by *Polypodiophyta* with 35 species of 15 families and *Pinophyta* or *Gymnospermae* with 9 species of 6 families; The two remaining divisions with limited number of species are *Lycopodiophyta* and *Equisetophyta* with 3 species of 2 families and 1 species of 1 family, respectively (Table 1). This result showed that Hai Duong has low diversity of plant species compared to 10,340 species and 305 families of *Tracheophyta* found in Vietnam as a whole.

In terms of fauna, the results are summarized in Table 2. The terrestrial fauna species totalled to 881 (including reptile and

amphibian) belonging to 178 families. Insects and birds had the highest degrees of biodiversity with 435 species of 63 families and 161 species of 44 families, respectively. In contrast, the diversity of other species was low: reptiles had 24 species in 7 families; earthworms had 26 species of 3 families; amphibians had 43 species of 16 families; and mammals consisted of 47 species of 18 families.

* Aquatic ecosystem

The diversity and abundance of the aquatic ecosystem in Hai Duong is presented in Table 3. 314 aquatic species were found belonging to 89 families of 33 orders. Phytoplankton had the largest number of species with 116 species belonging to 25 families of 5 orders, followed by zoobenthos with 74 species of 22 families. Hai Duong had 66 species of fish, belonging to 26 families. The smallest number of species belonged to zoobenthos with 58 species of 16 families.

Table 1. Bio-diversity of terrestrial flora in Hai Duong

Scientific name	Vietnamese name	No of species	No of families
<i>Magnoliophyta</i>	Mộc lan	985	148
<i>Polypodiophyta</i>	Dương xỉ	35	15
<i>Pinophyta</i>	Ngành thông	9	6
<i>Lycopodiophyta</i>	Thông đất	3	2
<i>Equisetophyta</i>	Cỏ tháp bút	1	1
Total		1,033	172

Source: Field survey, 2012-2013

Table 2. Bio-diversity of terrestrial fauna in Hai Duong

No	Scientific name/English name	Vietnamese name	No. of species	No. of families	No. of order
1	<i>Zelotes Duplex</i>	Nhện đất	69	12	1
2	<i>Phyllotreta striolata F.</i>	Bọ nháy	76	15	1
3	<i>Oligochaeta</i>	Giun đất	26	3	1
4	<i>Insect</i>	Côn trùng	435	63	12
5	<i>Reptile</i>	Bò sát	43	16	3
6	<i>Amphibian</i>	Lưỡng cư	24	7	1
7	<i>Bird</i>	Chim	161	44	14
8	<i>Mammal</i>	Thú	47	18	7
	Total		881	178	40

Sources: Field survey, 2012-2013

Table 3. Bio-diversity of aquatic species in Hai Duong

No	Group	No of species	No of families	No of orders
1	Phytoplankton	116	25	8
2	Zooplankton	58	16	6
3	Zoobenthos	74	22	9
4	Fish	66	26	10
	Total	314	89	33

Source: Field survey, 2012-2013

** Agricultural ecosystem*

Diversity of crop plants: the important annual crops found are paddy rice, corn, sweet potatoes, soybean, peanut and vegetables. Paddy rice was cultivated in the largest area, followed by vegetables with 31,000 hectares. Besides annual crops, perennial plants were also important species in the agricultural ecosystem. Perennial plants were mostly fruits including orange, mango, banana, guava, lemon, litchi and longan, of which litchi and longan are known as local specialties of Hai

Duong. The diversity of crops and plants is summarized in Table 4.

- *Domestic animals:* The main domestic animals of Hai Duong were pig, buffalo, cow and poultry (chicken, duck, geese ...). Poultry made up the largest number of total domestic animals with over ten million. Chicken was the main poultry in Hai Duong, accounting for 80% of total number of poultry. Pig, buffaloes and cow were also important animals with 559,148, 5,418 and 22,011 in number, respectively (Table 5).

Table 4. Agro-Bio-diversity of plants in Hai Duong

Important plants	Areas (hectare)	No of breed	Common names in Vietnamese
<i>Annual crops</i>			
Spring paddy	63.616	25 (rice)	Bắc thơm số 7, Q5, Khang dân, Hương thơm 1, BT7, Nàng xuân, PC15, HT1, QR1, N.uu 69, Mộc tuyến, Bio 404, Thục Hưng 6, Laisin 6, Xi 23, BC15, Nghi Hương 305, P6 ĐB, PAC 807, TBR1, TH33, HYT 108, X21, B-TE1, Bá cửu 903 KBL
Summer paddy	62.794	07 (sticky rice)	Nếp 352, Nếp 97, Nếp 415, Nếp xoắn, Nếp cái hoa vàng, Nếp DDN20, Nếp DT22
Corn	3.610	15	HN88, MX4, MX10, Wax 44, Wax 48, Wax 50, AG 500, LVN 10, LVN4, LVN 9, LVN99, LVN885, Lai 4, P848, C919
Potatoes	1.884	9	Hồng Hà, Hà Lan, Trung Quốc, Diamant, Mỹ, Sinora, Aladin Solara, VT2, KT3
Peanut	1.071	6	D84, DDT22, DDT84, ĐT96, ĐT94, DDT12, AK03
Vegetable	30.992		Bắp cải, su hào, hành, tỏi, bí..
<i>Perennial plants</i>			
Banana	1.995	4	Chuối tây, chuối tiêu, chuối ngự, chuối Tiên hồng
Guava	1.328	4	Bo, ổi đào, ổi Đài Loan, ổi găng
Lemon	689	3	Chanh gai, tứ quý, chanh đào
Litchi	10.989	6	U hồng, u trứng, vải thiều Thanh Hà, Tân lan, Lãng xuyên, vải lai
Longan	2.039	5	Nhãn hạt Hải Dương, nhãn nước Hải Dương, nhãn Lồng Hưng Yên, nhãn Hương Chi, nhãn muện HT1

Source: Field survey, 2012-2013

Table 5. Diversity of important domestic animals in Hai Duong

No	Animal	Quantity	Common breeds in Vietnamese
1	Buffalo	5,418	Đầm lầy, trâu đen
2	Cattle	22,011	Bò vàng, bò cóc, Lasin, Brahman
3	Pig	559,148	Lợn rừng, Móng cái, Yorkshire, Duroc, Landrace, lợn lai mán ngoại, lợn mường
4	Chicken (1000)	8,458	Gà trắng, gà tây, tam hoàng, kabir, Gà ri, lương phượng, ai cập, gà ta, gà lai chọi, gà mía lai
5	Other poultry (1000)	2,086	Vịt bầu cánh trắng, Super, Pháp, vịt cỏ, vịt bầu, vịt Anh Đào, CV super H1, CV super M2, CV super M3, CV 2000, vịt super Heavy; Ngan Pháp, ngan trâu, ngan đẻ

Source: Field survey, 2012-2013

Table 6. Common wild animals found in farms in Hai Duong

No	Wild animals	Districts					
		Thanh Ha	Kinh Mon	NinhGiang	Binh Giang	Thanh Mien	Chi Linh
1	<i>Wild Boar</i>	X	X	X			
2	<i>Porcupine</i>	X	X	X	X	X	X
3	<i>Rhizomyspruinus</i>		X	X		X	
4	<i>Asian palm civet</i>			X			
5	<i>Spotted deer</i>					X	

Source: Field survey, 2012-2013

In addition to domestic animals, farmers in Hai Duong also raise wild animals for commercial purposes. According to the results of field investigation, common wild animals found in farms were crocodiles, porcupines, ostriches, wild boars, awls, civet, spotted deer, crickets, snakes, etc. The most common wild animals raised in farms were wild boars, crocodiles, and porcupines (Table 6).

3.2. Distribution of biodiversity in Hai Duong

* Spatial distribution

The distribution of species depends on many factors including climate, topography, habitat etc. Thus, the biological diversity varies with to geographical areas. Chi Linh town and Kinh Mon district had the richest biodiversity in Hai Duong compared with other districts. These two districts are mountainous areas mostly covered

by natural forests. Other districts had low density of biodiversity and mainly agrobiodiversity. Spatial distribution of biodiversity in Hai Duong is presented in Figure 2.

* Important biodiversity hotspots in Hai Duong

The study found 8 biodiversity hotspots in Hai Duong (Table 7). All identified hotspots had historical or cultural significance and might be affected by urbanization and tourist activities.

3.3. Species for conservation in Hai Duong province

Although Hai Duong is not rich in biodiversity, it still has many rare and precious species for conservation (Table 8). The research pointed out that Hai Duong currently has 39 species listed in Vietnam Red Book 2007, 28 species listed in Government Decree No 32/2006 and 88 species in The Red List of IUCN 2009.

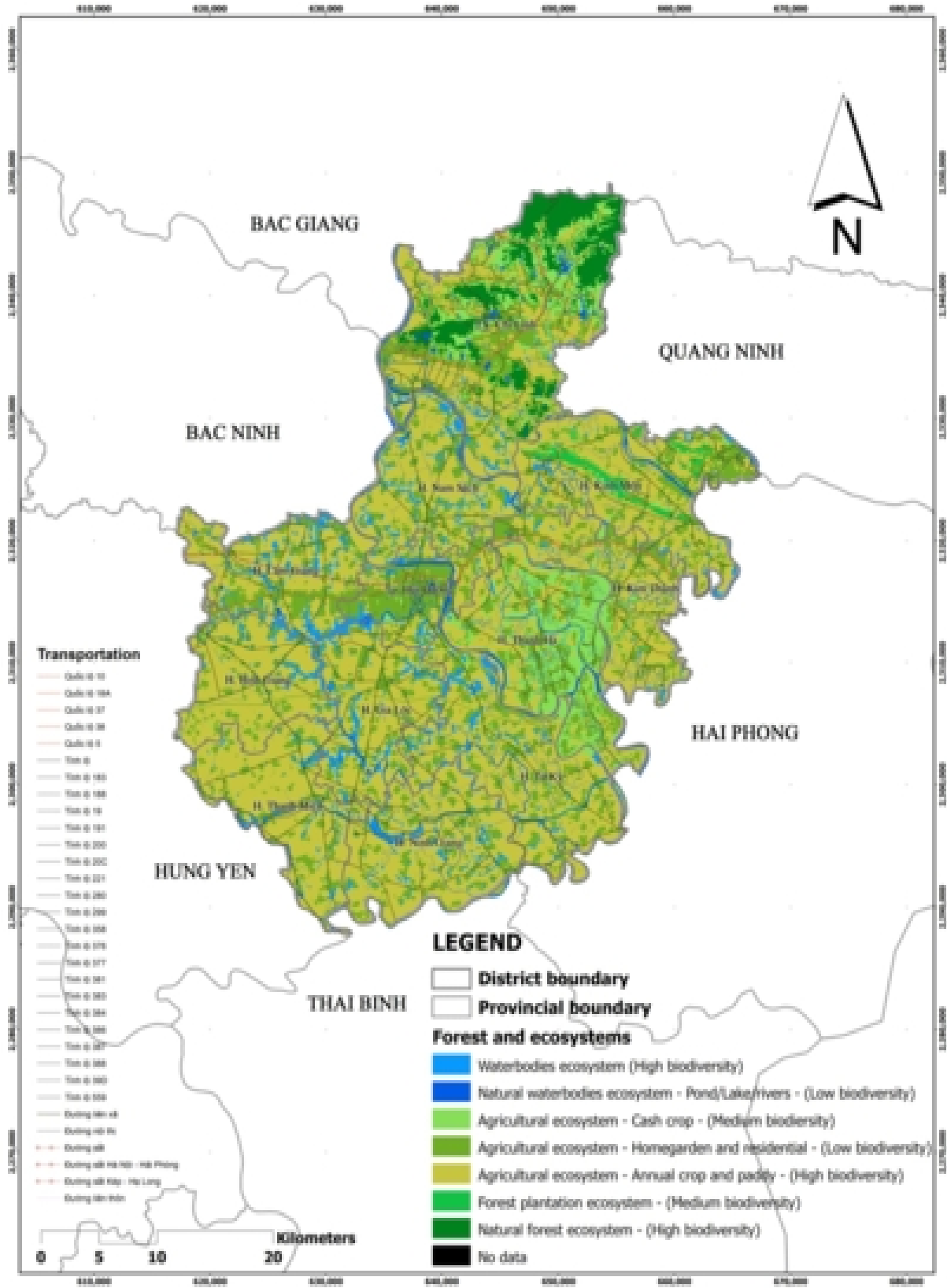


Figure 2. Biodiversity Map of Hai Duong in 2013

Table 7. Biodiversity hotspots in Hai Duong

No	Name	Biodiversity values of areas
<i>Terrestrial ecosystem</i>		
1	Natural forest of ChiLinhTown	Chi Linh has the largest area of natural forest in Hai Duong. These natural forests are rich in biodiversity and are important habitats of many rare and precious species of Hai Duong.
2	Ancient Green Ironwood population in CaoTemple, ChiLinhTown	Areas surrounding Cao Temple have 54 ancient green iron Wood trees from 100 to 800 years old. In 2011, this population of trees have been approved as heritage trees by Vietnam Association for Conservation of Nature and Environment. In addition to ancient green iron wood trees, there are young communities of iron wood which have been growing quickly with total number around 300 to 400 trees.
3	ConSonBotanical Garden an AnPhuBotanical Garden	Area of ConSonBotanical Garden is approximately 35.5 hectares locating in ChiLinhTown. An Phu Botanical Garden's belongs to Kinh Mon District with the area of 20 hectares. These two botanical gardens store 28,412 individuals belonging to 424 species of plants in Hai Duong and neighboring provinces.
4	Dao co (StorkIsland), Chi Lang Nam commune, Thanh Mien District	Dao co (StorkIsland) is the important habitat of wild birds in Hai Duong. This island has rich avifauna with 51 species belonging to 42 genera, 30 families and 12 orders. There are many precious species found here such as teal, owl ... (Tran Hai Mien, 2008). Recently, as observation, the quantity of wild birds has been increasing significantly.
5	Duoc Son Medicinal Herb Garden, ChiLinhTown	Duoc Son is precious medicinal herb garden of Chi Linh. This garden has been established and maintained since Tran Dynasty by Tran Hung Dao, a couple of hundred years ago. At the initial time, it was said that the garden had over 3,000 species which had great medical values. However, currently, there are only around 158 species and being ignored.
<i>Aquatic ecosystem</i>		
6	An Lac Lake, Chi Linh Town	An Lac Lake is rich in biodiversity of aquatic ecosystem, where a new shrimp species was found.
7	Brackish water of An Thanh commune, TuKy District	This is area for sea-slug cultivation with total areas around 108 hectares, located in two villages, An Lao and An Dinh of An Thanh Commune, Tu Ky District. This is the commercial product of local commune which could create high economic value. Comparing to the previous years, the production of sea-slug have increased significantly.
<i>Agro-ecosystem</i>		
8	Litchi plantation in Thanh Ha District	Thanh Ha is an important area for litchi conservation in Hai Duong and Vietnam.

Source: Field survey, 2012-2013

Table 8. Summary of species for conservation in Hai Duong

No	Group	Quantity of species in		
		Vietnam Red Book 2007	Decree No 32/2006	The IUCN Red List 2009
1	Plant	8	9	28
2	Insects	5	0	15
3	Reptile, Amphibian	11	9	5
4	Bird	3	7	-
5	Mammal	2	3	-
6	Zoobenthos	5	-	-
7	Fish	5	-	40
Total		39	28	88

Source: Field survey, 2012-2013

The 29 species in the Vietnam Red Book 2007 were as follows:

- Plants: there are 8 plant species in which 6 species ranked at vulnerable level (VU) These are *Calamus platyacanthus*, *Canarium tramdenum*, *Chukrasia tabularis*, *Disporopsis longifolia*, *Drynariabonii* H. Christ, *Rauvolfia verticillata* (Lour.) Baill. 2 species ranked at Endangered level (EN) which are *Sindora tonkinensis* and *Fernandoa collignonii*.

- Insect: 5 species are vulnerable species which are: *Byasa crassipes*, *Papilio noblei*, *Troideshelena*, *Troides aeacus* and *Jumnosruckeri*.

- Reptile and Amphibian: 11 species include: 4 species ranked at VU- *Gekkogeck*, *Physignathus cocincinus*, *Coelognathus radiatus* and *Orthriophismoelleldorffii*; 05 species ranked at EN level include *Varanussalvator*, *Ptyaskorros*, *Ptyas mucosa*, *Bungarus fasciatus*, *Naja atra*; and 02 species ranked at Critical Endangered (CR) which are *Ophiophagushannah* and *Python molurus*.

- Wild Bird: There are 2 vulnerable species which are *Tyto capensis* and *Anastomus oscitans*; 01 near threatened species is *Lophuranycthemera*.

- Mammal: 2 vulnerable species are *Nycticebus pygmaeus* and *Prionodon pardicolor*.

- Zoobenthos: 5 vulnerable species are *Indochina monkimboiense*, *Indochina montannanti*, *Hyriopsis cummingii*, *Cristaria bialata* and *Lamprotula lei*.

- Fish: 2 vulnerable species are *Hemibagrus guttatus* and *Bagarius rutilus*, 2 endangered species are *Channamaculate* and *Clupanodon thrissa*; 1 species ranked at Extinct in the Wild (EW) is *Anguilla japonica*.

3.4. Causes of biodiversity loss and challenges for biodiversity conservation in Hai Duong

* Direct impacts

Habitat loss: This is a vital factor leading to the decline in quantity or disappearances of many species. Due to the demand of economic

and population growth, total areas of natural forest ecosystem, aquatic ecosystem and agro-ecosystem have been declining significantly. Particularly, during the period from 1998 to 2010, natural forest decreased from 3,104 hectares to 2,335 hectares; agricultural cultivation areas reduced from 91,440 hectares to 85,570 hectares; surface water area decreased nearly 1000 hectares (General Statistics Office of Hai Duong, 2012).

Invasive species: The expansion of invasive alien species might be harmful for the development of other living organisms. According to the results of the study, there were 5 alien invasive species which are on the list of 100 of the World's Worst Invasive Alien Species of IUCN and the list of invasive species in Circular No 22/2011 issued by Ministry of Natural Resource and Environment and 01 invasive alien issued by Ministry of Agriculture and Rural Development. These invasive species were *Eichhornia crassipes*, *Mimosa pigra*, *Lantana camara*, *Pomacea canaliculata*, and *Trachemys scripta elegans* (Table 9).

In comparison with other invasive species, *Eichhornia crassipes*, *Mimosa pigra* and *Pomacea canaliculata* were the most harmful species for the biodiversity of agro-ecosystem in Hai Duong. Other species, *Trachemys scripta elegans*, *Cavia porcellus* and *Trachemys scripta elegans* appeared recently in this province, thus their effects are limited.

Environmental pollution: Due to social and economic development and population growth, solid, liquid and gas waste also quickly increased. Pollution of the aquatic ecosystem happened rapidly, affecting aquatic organisms. In addition, the overuse of pesticides created another threat to the sustainability of biodiversity in the agro-ecosystem. According to results of the survey in 150 households living in agricultural production areas, 100% of households reported that the quality of water for agricultural production had decreased due to waste water from industry and human activities. In addition, 27.5% interviewees claimed that, the overuse of pesticide led to the disappearance or decline of crab, frog, snails, etc.

Table 9. Invasive alien species in Hai Duong

No	Scientific name	Vietnamese name	Hazardous level
1	<i>Eichhornia crassipes</i> (Mart.) Solms	Bèo Lục bình (Bèo tây)	In the list of 100 of the World's Worst Invasive Alien Species of IUCN 2011.
2	<i>Mimosa pigra</i> L.	Cây Mai dương	In the list of invasive species in Circular No 22/2011 issued by Ministry of Natural Resource and Environment
3	<i>Lantana camara</i> L	Cây Ngũ sắc Bông ổi	
4	<i>Pomacea canaliculata</i>	Ốc Bươu vàng	In the list of 100 of the World's Worst Invasive Alien Species of IUCN 2011.
5	<i>Trachemys scripta elegans</i>	Rùa Tai đỏ	In the list of invasive species in Circular No 22/2011 issued by Ministry of Natural Resource and Environment
6	<i>Cavia porcellus</i>	Chồn Nhung đen	Being warned by Ministry of Agriculture and Rural Development.

Source: Field survey, 2012-2013

Table 10. Population and biodiversity resources exploited in Hai Duong from 2005 to 2011

	2005	2007	2009	2011
Population (in person)	1.685.512	1.694.699	1.706.808	1.718.895
Log (m ³)	1.850	1.768	2.224	2.500
Firewood (Ste)	124.500	121.650	161.620	-
Forest loss (hectare)	4	24	11	14,3
Aquatic food(ton)	2.336	2.302	2.287	2.203

Source: Hai Duong Statistic Office, 2012

Overexploitation: rapid increase in demand as well as social and economic development resulted in overexploitation of resources (Table 10). Illegal logging and hunting happened quite frequently. According to the results of key informant interviews and field surveys in Chi Linh Town, 90% households in Chi Linh possessed hunting equipments stuffs and actively involved in hunting activities. This is one of the main reasons of the decline in of wild life in Chi Linh, and in Hai Duong province in general (Le ĐìnhThuy, 2012).

Climate change: evidence of climate change has been observed in Hai Duong such as drought, extremely cold and hot weather, and, especially, the increase of annual average temperature .

Figure 3 points out an annual temperature increase of 0.5 - 1.0°C in the period of 30 years

(from 23.1°C to 23.8°C). Climate change has many negative impacts on biodiversity in Hai Duong including increase in forest fire risks (Figure 4), change of biodiversity distribution in nature, and challenges for agricultural development.

Figure 3 shows that the area of forest fire was larger in the years with high temperatures in 2004, 2006 and 2009. Furthermore, climate change could change the habitat for some species, for instance the appearance of *Anastomusoscitans* in “Đao co” (Stork Island). As claimed by scientists, the original habitat of *Anastomusoscitans* is the South of Vietnam with warmer climate. However, the presence of *Anastomusoscitans* in the last three years, in Hai Duong was probably because of the increase of annual temperature. Nevertheless, it needs a more specific study to verify.

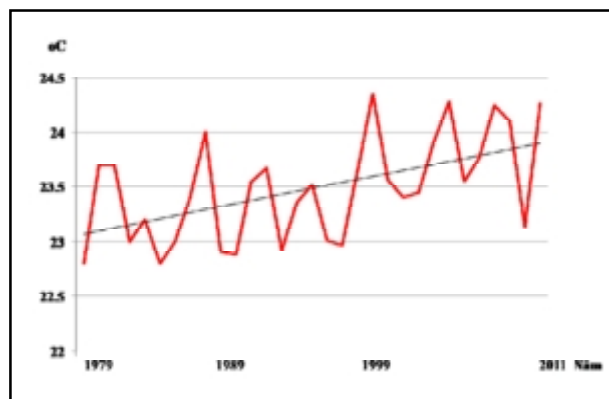


Figure 3. The increase of annual temperature from 1979 to 2011 in Hai Duong

Source: Hai Duong Hydro-Meteorological Center 2012

*** Indirect impacts**

In addition to direct impacts indirect impacts might cause the decline of biodiversity in Hai Duong. These were weakness of staff and management system and lack of public awareness.

Weakness of staff and management system on managing biodiversity resource: For instance, lack of legal document and instruction for implementation of legal documents in managing biodiversity resources; incomplete legislation on biodiversity and bio-safety management; lack of professional staff (there is only one or two staff in charge of environmental management and none of them had a background in biodiversity); lack of efficient cooperation among local institutions in managing biodiversity resource; and lack of local biodiversity databases.

Lack of public awareness on biodiversity conservation: the biggest challenge of managing biodiversity resources was a lack of public awareness on the importance of biodiversity and a lack of responsibility in protecting these resources. Thus, it led to inappropriate activities that are harmful to biodiversity conservation

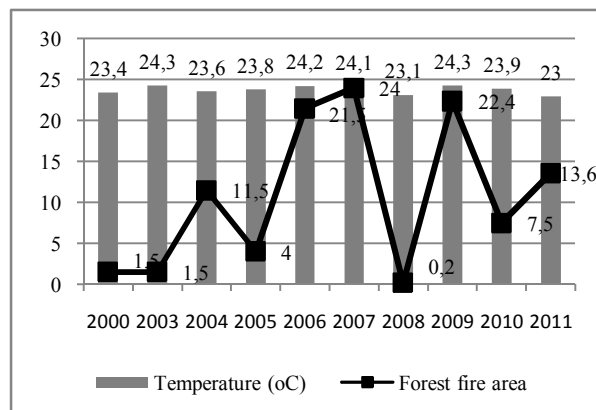


Figure 4. The relationship between temperature and forest fire in Hai Duong

Source: Hai Duong Statistic Office, 2012

such as overexploitation, importing invasive alien species, illegal logging and hunting ...

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

In the terrestrial ecosystem, the research identified 1,033 species of plant belonging to 172 families of 5 divisions; and 881 species of animal belonging to 89 families. In the Aquatic ecosystem, the research found 314 aquatic species of 89 families in 33 orders. Many rare and precious species were found, of which 39 species are in the Vietnam Red Book 2007, 28 species in the Annexes of Vietnam Government Decree No32/2006-CP and 88 species in The Red List of IUCN 2009.

Biodiversity in Chi Linh was unevenly distributed. The rich biodiversity regions were mountainous areas (Chi Linhtown and Kinh Mon District), whereas delta areas were poor in biological diversity.

The study found 8 biodiversity hotspots in Hai Duong Natural forest (Chi Linh), Community of ancient Green Ironwood in Cao Temple (Chi Linh), Con Son Botanical Garden and An Phu Botanical Garden (Kinh Mon

District), Stork Island (Chi Lang Nam commune, Thanh Mien District), Duoc Son Medicinal Herb Garden (Chi Linh Town) An Lac Lake (Chi Linh Town) Brackish water of An Thanh commune, TuKy District, Litchi areas (Thanh Ha District).

Factors that caused biodiversity loss in Hai Duong were identified as habitat loss, environmental pollution, overuse and overexploitation, climate change and invasive species, weakness in state management, and lack of public awareness.

4.2. Recommendations

- Local institutions of Hai Duong should maintain habitat in hot spots of biodiversity, especially in Chi Linh town and Kinh Mon district.

- Provincial People's Committee of Hai Duong and Department of Natural Resources and environment have to control environmental pollution, overuse and overexploitation of natural resources. Department of Agriculture and Rural Development of Hai Duong has to control invasive alien species and illegal logging.

- Local institutions in charge of biodiversity conservation need to be quickly improved and must consolidate state management and enhance public awareness about biodiversity.

- Biodiversity conservation should be integrated into economic and tourist development programs.

ACKNOWLEDGEMENT

We would like to express our sincere thanks to the experts of Institute of Ecology and Biological Resource for their contribution to this

study. We also thank the local institutions in Hai Duong, especially Hai Duong Department of Environment and Natural resources for their helpful cooperation in this research. We also would like to thank Associate Professor Ole Bruun, Rockide University for reviewing this manuscript.

REFERENCES

- Hai Duong Department of Natural Resource and Environment (2013). Project Report: "Investigating and evaluating current state of biodiversity; building biodiversity action plan for Hai Duong Province by 2020 and orientation to 2030", Hai Duong.
- Hai Duong Statistics Office (2013). Statistical Yearbook 2005-2012, Hai Duong.
- IUCN (2011). Red list of Threatened animals. <http://www.redlist.org>. Achieved date 22/9/2013.
- IUCN (2011). Red list of Threatened plants. <http://www.redlist.org>. Achieved date 22/9/2013.
- Le Dinh Thuy (2012). Provincial Scientific and Technological Report: "Investigating and evaluating current status of species which has value for genetic conservation and economic development in natural system in Chi Linh, Hai Duong", Hai Duong.
- Ministry of Natural Resource and Environment (2011). Circular No 22/2011/TT-BTNMT on regulating criteria for determining invasive alien species and the list of invasive alien species in Vietnam.
- Ministry of Science and Technology (2007). Vietnam Red Book, Natural Science and Technology Publishing House, Ha Noi.
- Tran Hai Mien (2008). Studying composition and ecological characteristics of water bird which nesting in Chi Lang Nam, Thanh Mien, Hai Duong, Master Thesis in Biology, Ha Noi Pedagogical University.
- Vietnamese government (2006). Decree No 32/2006/NĐ-CP on managing the flora and fauna of forest which are rare, specious and endangered, Ha Noi.