CHAPTER 3 ECOLOGICAL PROFILE OF HA TINH FOR VULNERABILITY ASSESSMENT AND EBA

3.1. Introduction

Report 1 in this series introduced the concepts and methods of Vulnerability Assessment for Ecosystem-based Adaptation (EbA) to climate change. It highlighted the idea on which EbA is predicated: the understanding that ecology, society and economy cannot be separated. Natural ecosystems are the foundation of human existence on this planet, and of all our economic activities. However, these ecological foundations have been profoundly modified and in many places weakened from their original state, by people pursuing their livelihoods (economic activities) in unsustainable ways. Although change is inherent in all global systems, eco-systems have limits to the extent of the changes they can tolerate, without losing their essential structure and functions, on which we all depend. Now climate change is adding to the stresses that people have already induced in natural systems, with potentially grave consequences. EbA identifies ecosystem degradation as a key underlying cause of vulnerability. Urgent action is needed to restore these natural systems to health, to help us sustain our socio-economic systems, indeed our very survival, to the coming challenges. We also need to harness the services of healthy ecosystems to help us adapt to the changes ahead.

To understand the issues and threats posed by climate change and devise practical and sustainable solutions, ecological, social and economic factors need to be considered together, as parts of an integrated whole. Thus, as set out in Report #1, for this EbA vulnerability assessment, the unit of analysis is the "socio-ecological system" (SES), defined as:

"complex bio-geo-physical units together with social and institutional actors and their (economic) activities"

The impacts of climate change are felt by people - on their health, their housing, the other people, infrastructure and services they rely on, the natural resources they depend on, and the other ways they earn their livelihoods. Climate change adaptation too, is entirely a human process, embedded in an ecological context and an economic structure. It is about people understanding climate change and what it means for their lives, and making the appropriate, often innovative changes (to their vision of the future and their activities) needed to secure a sustainable future for their families and communities. It is about governments supporting these processes and tackling the underlying causes of vulnerability. Climate change and our adaptation to it are thus quintessentially social issues: people are at once the major cause of climate change, its victims, and they will be the main agents of adaptation and mitigation.

Chapter 2 of this Ha Tinh Provincial Report focused the analysis on people, asking which groups are most vulnerable and why, based on an understanding of vulnerability as:

"the state of individuals, groups or communities in terms of their ability to cope with and adapt to any external stress placed on their livelihoods and well-being. It is determined by i) the availability of resources: and crucially, ii) by the entitlement of individuals and groups to call on these resources" (Adger and Kelly 1999).

This Chapter 3 now focuses on the ecosystems of Ha Tinh, asking which types of ecosystem are present, how much of them is there, and what condition are they in. Which may be critical for supporting livelihoods and the economy in the face of climate change, and how are the ecosystems themselves vulnerable to climate change.

The present chapter examines the ecological dimensions of EbA in Ha Tinh, including the contextual information at the Provincial level that any provincial department should keep in mind in analysing and planning for CCA or EbA. It also examines the key parameters used in this study to develop and describe the Socio-Ecological Systems (SES). Chapter 2 (social factors); this chapter; and Chapter 4 (economic profile) are all brought together present a classification of the main SES for Ha Tinh in Chapter 5. As with Chapters 2 and 4, this ecological profile is based on existing data made available to the study by the different departments of the provincial government, as well as through more general literature review.

3.2. Overview of Key Ecological Factors for the Provincial -Scale Analysis in Ha Tinh

This section presents information to answer key practical questions on ecological issues for climate change vulnerability assessment and adaptation planning at the provincial level. It does not attempt to provide a full ecological profile of Ha Tinh. The macro-level study is intended to use secondary data only. While many interesting and relevant questions could be posed at provincial level, there is only a limited number of ecological factors for which sufficiently comprehensive data already exists at this level. Other factors will be examined at the micro-level assessment of actual local vulnerability and adaptive capacity, supported by primary data collection where necessary. What this profile does attempt is to be "spatial explicit" - that is, to map the selected parameters - to contribute to the mapping of socio-ecological systems, and to help inform the selection of sites for the micro-level analysis.

Table 0.1: Ecological analysis at the Provincial - and Local -levels of assessment

Macro-level assessment	Micro-level (community) assessment
Based on secondary information available at provincial level	Based on secondary data available locally, primary data collection and local stakeholder participation
Focus on broad context and understanding; prioritization	Focus on planning and action
Type, extent and condition of main ecosystems found in the province	Type, extent and condition of local ecosystems in the micro-assessment site
How ecosystems contribute to the provincial economy/main economic sectors, and support provincial level resilience	How local ecosystems support local livelihoods and resilience
Vulnerability and resilience of ecosystems	Vulnerability and resilience of ecosystems
How ecosystems are managed at the provincial scale	How local ecosystems are manage by communities and other local groups

A few simple questions guide the analysis presented below:

- What are the main types of ecosystems found in Ha Tinh?
    - Where are they, how much of them are there, and what condition are they in?
    - What are the trends in their extent and condition?
- How do the ecosystems support reliance?
- How are the ecosystems themselves vulnerable to climate change?
- Conclusion: (based on contributions from ecological and social analysis) What should be focused on for the micro-level assessment.

3.3. Physical description: topography, climate and soils

Ha Tinh Province in North-central coastal Vietnam occupies a total area of just under 6,000km^2, situated between 17° 53'50 -18° 45'40 "North latitude, and 105° 05'50" - 106° 30'20 "east longitude. Ha Tinh borders Nghe An to the north and Quang Binh in the south, the People's Democratic Republic of Laos in the West and has a 137km coastline along the East Sea.

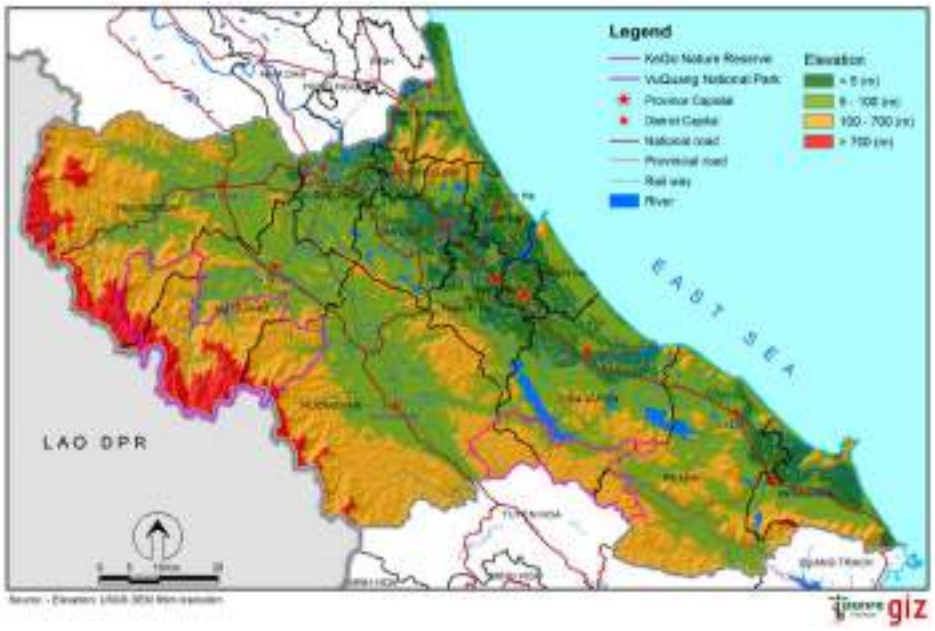
3.3.1. Topography

Based on a combination of geomorphology and ecological characteristics Ha Tinh can be divided into 4 altitudinal eco-zones or regions as follows:

- **Mountain areas:** Mountainous areas above 700m account for about 64% of the province, located mainly in the districts of Huong Son, Huong Khe and Vu Quang and west of Ky Anh district.
- **Midland - hilly areas:** These areas account for about 20% of the province. The lower foothills are surrounded by narrow carpet-like strips of flat land.
- **Lowland Delta areas:** Ha Tinh delta areas cover about 56,000ha, accounting for about 9% of land area of the province, including the districts and towns from Hong Linh town to Ky Anh district and part of Duc Tho district, and from Duc Tho town to Hong Linh town. Elevation is less than 5m with inclination gradually from west to east. The deltas are narrow narrow width, fertile soil. Consequently they have been largely been converted to paddy rice.
- **Coastal areas:** The total coastal area accounts for another 40,000ha or so (about 7% of the land area of the province, running from Nghi Xuan district to Ky Anh district. The terrain slopes from west to east, with altitudes less than 4m.

The Province also has some islands, including Hon Nom, Hon Lap, Hon En, Hon Booc, Hon Chim and Son Duong. All of these islands are within 2 - 5 km of the coastline.

Figure 0.1: Elevation map of Ha Tinh (Source: original work of the consultant team)

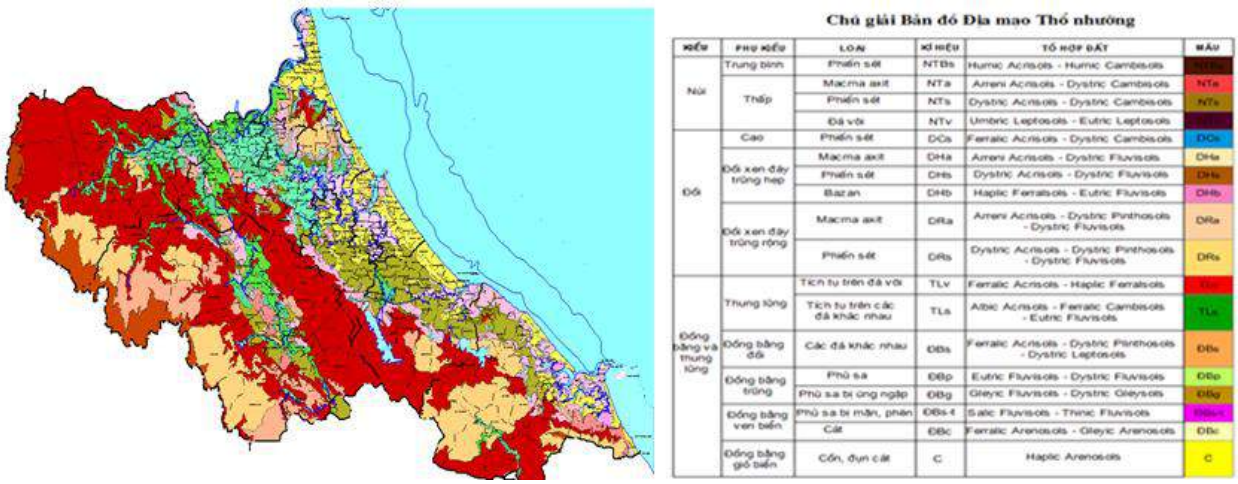


3.3.2. Soils

Soils in Ha Tinh are derived and distributed in paths that run in a Northwest-Southeast direction. They are very diverse with 8 soil groups, namely: sandy soils (Arrenosols), sulphate soils (salic Thionosols), alluvial soils (Fluvisols), degraded soils (Acrisols), ferralit

soils (Ferrasols), mountainous alit soils (Alisols), accumulated soils, and eroded rocky soils. Overall, Ferrasols and Fluvisols dominate, covering 51.6% and 17.73%, respectively of the province's area. Ferrasols are derived from Schilst material, and are characterised by red-yellow color. This soil type has a soil thickness suitable for many plants, and would normally support well developed natural vegetation cover. Because these soils are also suitable for many crops, especially perennial crops, and have high productivity potential, then areas of natural ecosystems growing on the soils are also likely to be some of the first areas converted to agriculture.

Figure 0.2: Soil types in Ha Tinh province



Chú giải Bản đồ Địa mạo Thổ nhưỡng

KIỂU	PHỤ KIỂU	LOẠI	KÍ HIỆU	TỔ HỢP ĐẤT	MÀU
Núi	Trung bình	Phiến sét	NTBs	Humic Acrisols - Humic Cambisols	
	Thấp	Macma axit	NTa	Arenic Acrisols - Dystric Cambisols	
		Phiến sét	NTs	Dystric Acrisols - Dystric Cambisols	
		Đá vôi	NTv	Umbric Leptosols - Eutric Leptosols	
Đồi	Cao	Phiến sét	DCs	Ferralic Acrisols - Dystric Cambisols	
	Đồi xen đầy trũng hẹp	Macma axit	DHa	Arenic Acrisols - Dystric Fluvisols	
		Phiến sét	DHs	Dystric Acrisols - Dystric Fluvisols	
		Bazan	DHb	Haplic Ferralsols - Eutric Fluvisols	
	Đồi xen đầy trũng rộng	Macma axit	DRa	Arenic Acrisols - Dystric Pinthosols - Dystric Fluvisols	
		Phiến sét	DRs	Dystric Acrisols - Dystric Pinthosols - Dystric Fluvisols	
Đồng bằng và thung lũng	Thung lũng	Tích tụ trên đá vôi	TLv	Ferralic Acrisols - Haplic Ferralsols	
		Tích tụ trên các đá khác nhau	TLa	Albic Acrisols - Ferralic Cambisols - Eutric Fluvisols	
	Đồng bằng đồi	Các đá khác nhau	DBa	Ferralic Acrisols - Dystric Pinthosols - Dystric Leptosols	
	Đồng bằng trũng	Phù sa	ĐBp	Eutric Fluvisols - Dystric Fluvisols	
		Phù sa bị úng ngập	ĐBg	Gleyic Fluvisols - Dystric Gleysols	
	Đồng bằng ven biển	Phù sa bị mặn, phèn	ĐBs-t	Salic Fluvisols - Thinic Fluvisols	
		Cát	ĐBc	Ferralic Arenosols - Gleyic Arenosols	
	Đồng bằng gò biển	Cồn, đụn cát	C	Haplic Arenosols	

Source: Van Thang, 2016

3.3.3. Climate

The area is subject to a monsoon climate with very high rainfall particularly in summer and autumn. Annual rainfall in Ha Tinh Province varies in the range of 2,300 - 3,000mm. The highest rainfall is mostly concentrated in the coastal plains. The rainy season lasts from May to October, and the dry season lasts from November to April. Occasionally, the rainy season starts early in April; however, it is often interrupted in June and July due to dry, hot westerly wind effects. Average annual evaporation rate is within the range of 800 - 1,100mm. Evaporation does not exceed 100mm in most months, except June, July and August, the hottest months of the year (ISPONRE, 2009).

Table 0.2: Summary of Climate Information for Ha Tinh Meteorological Stations

Factors	Weather Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Average sunshine hours (hour)	Huong Son	65.4	50.8	73.5	132.9	202.1	17.3	199.8	149.1	140.1	119.0	82.9	75.1	1,463.0
	Ha Tinh	75.5	51.0	74.4	136.2	216.8	206.6	226.7	189.0	155.9	134.2	95.7	78.9	1,624.6
	Huong Khe	67.0	49.7	76.9	131.6	179.3	180.0	203.0	160.9	120.5	99.3	73.6	58.5	1,371.6
	Ky Anh	77.7	58.5	92.9	150.1	219.7	217.8	237.8	192.3	162.2	125.9	82.4	73.2	1,657.9
Average temparature (°C)	Huong Son	16.9	17.8	20.6	24.4	27.4	28.6	28.7	27.8	25.7	23.6	20.4	17.7	23.3
	Ha Tinh	17.7	18.4	20.8	24.5	27.8	29.5	29.7	28.7	26.8	24.4	21.5	18.7	24.1
	Huong Khe	18.0	19.0	21.6	25.1	27.6	28.9	29.1	28.0	26.1	24.0	21.2	18.8	24.0
	Ky Anh	17.9	18.7	21.0	24.7	28.0	29.7	29.9	28.9	26.9	21.7	21.7	18.8	23.5
Average rainfall (mm)	Huong Son	6.3	57.8	67.4	126.1	199.8	163.3	144.2	261.5	537.7	445.2	226.3	88.1	2,383.7
	Ha Tinh	98.5	66.1	59.5	72.4	150.8	133.6	127.6	228.9	503.4	693.9	341.4	164.1	2,634.4
	Huong Khe	41.9	47.5	62.9	94.4	213.5	162.3	144.1	294.6	491.4	549.1	190.5	71.8	2,358.5
	Ky Anh	109.4	73.3	59.2	57.8	155.4	128.9	98.8	234.9	563.8	749.0	417.0	205.9	2,842.1
Average evaporation (mm)	Huong Son	32.2	27.6	41.4	71.0	133.3	178.1	218.7	150.7	68.1	46.6	34.3	34.5	1,036.5
	Ha Tinh	35.1	27.4	35.6	55.0	95.5	122.3	137.7	100.8	63.9	55.5	49.8	45.2	820.7
	Huong Khe	37.4	32.4	48.6	72.9	112.4	135.9	163.1	106.7	62.2	52.5	47.3	41.9	907.9

	Ky Anh	41.4	32.0	44.1	65.1	122.9	178.3	208.6	152.1	78.1	64.6	60.3	53.2	1,094.9
Average relatively humidity (%)	Huong Son	90	91	90	86	79	75	71	78	87	89	90	90	85
	Ha Tinh	91	92	92	88	81	77	74	80	87	89	89	88	86
	Huong Khe	91	91	90	86	80	78	74	81	87	88	88	89	85
	Ky Anh	90	92	91	87	89	74	70	76	82	88	88	88	84
Average wind speed (m/s)	Huong Son	1.9	1.0	1.1	1.3	1.9	2.7	3.2	2.2	1.1	0.8	0.7	0.7	1.5
	Ha Tinh	1.8	1.6	1.4	1.5	1.6	1.6	1.9	1.5	1.6	2.0	2.0	1.9	1.7
	Huong Khe	1.5	1.5	1.4	1.5	1.7	1.8	2.1	1.5	1.4	1.6	1.7	1.6	1.6
	Ky Anh	2.2	2.1	1.8	1.6	2.3	2.8	3.4	2.4	1.9	2.3	2.6	2.4	2.3

Source: Institute of Meteorology, Hydrology and Environment (Quoted in ISPONRE (2009)

2.1.3.1. Temperature

According to the records from 1958 to 2007 at the Ha Tinh, Huong Son and Ky Anh stations, the average temperature in the period of 2001-2007 was 24.5° C. This was 0.5-0.8° C higher than that of 1961-1970, and 0.3-0.6° C higher than the average value in the period of 1981-1990 (Table 3.3). Summer became hotter on average by 0.3-1.6° C throughout the observed years. Winter is also becoming warmer. The average winter temperature during the years of 2001-2007 was 0.6-1.2°C higher than that of 1961-1970.

Table 0.3: Changes in temperature over time in Ha Tinh

Parameter	Station	1958 - 1960	1961 - 1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - 2007
Average temperature (^{0}C)	Ha Tinh	-	23.8	23.8	23.9	24.3	24.5
	Huong Khe	-	23.5	23.5	23.9	24.2	24.3
	Ky Anh	-	24.0	24.2	24.3	24.5	24.6
Maximum temperature (^{0}C)	Ha Tinh	-	38.8	39.1	39.8	40.1	40
	Huong Khe	-	39.4	41.2	41.1	41.8	41
	Ky Anh	-	38.6	39.5	39.4	38.9	38.9
Minimum temperature (^{0}C)	Ha Tinh	-	8.1	7.9	7.9	7.8	9
	Huong Khe	-	4.4	4.6	5.8	4.5	8.5
	Ky Anh	-	8.9	7.9	8.2	8.8	10.4

Source: Institute of Meteorology, Hydrology and Environment and ISPONRE, 2009

2.1.3.2. Rainfall

In recent years, the total annual rainfall in Ha Tinh Province has been reduced when compared to the period of 1961-1990. The rainy season usually occurs later and ends earlier than before. The rainfall varies widely both in space and time. The rainfall period is not too long, but the intensity is relatively high and is concentrated in a small region that can cause floods and flashfloods.

According to the recorded data at the Ha Tinh station over the past 50 years, there have been 15 times that the daily rainfall has been over 30mm (Table 3.4). Whereas, at Huong Khe and Ky Anh stations, this was recorded 9 and 17 times, respectively. The highest daily rainfall observed during this period was 657.2mm at Ha Tinh station (October, 1992), 492.6mm at Huong Khe station (October, 1983) and 790.1mm at Ky Anh station (October, 1967). The highest monthly rainfall at these stations was all recorded in October 1983, which was 2,047.8mm at Ha Tinh, 1,614.6mm at Huong Khe and 2,218.4mm at Ky Anh. The highest annual rainfall is reported to be 4,391.3mm at Ha Tinh (1989), 3,784.4mm at Huong Khe (1989) and 4,386.1mm at Ky Anh (1978).

Table 0.4: Frequency of heavy rain during period (1958 - 2007)

Value	Station		
	Ha Tinh	Huong Khe	Ky Anh
Over 300 mm daily	15	9	17
Over 1000 mm monthly	14	5	17
Over 1500 mm monthly	4	2	7
Over 2000 mm monthly	1	0	1
Over 3000 mm annual	13	4	20
Over 4000 mm annual	1	0	1

2.1.3.3. Humidity

The average relative humidity in the recent years (1991-2007) is 7-10% higher than the average of 1961-1990. The relative humidity reaches a maximum during the summer (May - July). According to the historical records, the average relative humidity during the summer of 1991-2007 was 11-14% higher than that of 1961-1990. The corresponding values during winter (November - January), spring (February - April) and autumn (August - October) are 6-12%, 6-10% and 6-8%, respectively.

2.1.3.4. Evaporation

Statistics from 1961 to 2007 (Table 3.5) showed that the average annual evaporation during 1991-2007 decreased by about 1-3 mm/year relative to the period of 1961-1990.

Table 0.5: Average values for evaporation and hot, dry days for every ten-year period at observed stations in Ha Tinh Province

Parameter	Station	1961 - 1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - 2007
Evaporation (mm)	Ha Tinh	824	808	736	852	908
	Huong Khe	814	985	954	723	760
	Ky Anh	1199	1107	1084	1056	984
Number of hot and dry days	Ha Tinh	73	81	92	92	
	Huong Khe	98	95	111	102	

Source: Institute of Meteorology, Hydrology and Environment and ISPONRE, 2009

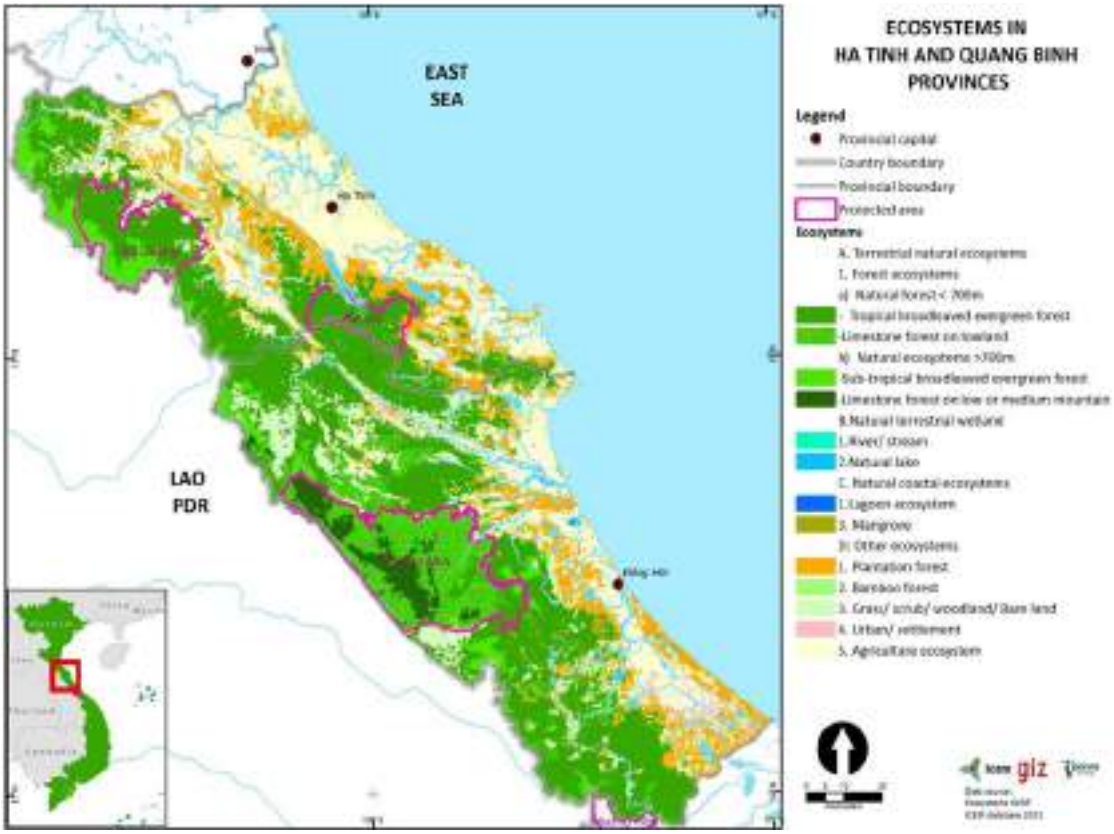
3.4. Natural Ecosystems

This section provides information on the type, amount, condition and issues facing each of the main ecosystems in Ha Tinh.

On a low resolution mapping of global ecoregions conducted by WWF, all of Ha Tinh province falls within two ecoregions, namely the Northern Annamite Rainforest Ecoregion, and the Northern Vietnam Lowland Rainforest Ecoregion. A higher resolution mapping of ecosystems at the national level of Vietnam, recognises a number of natural terrestrial, freshwater wetland and coastal ecosystems which are present in Ha Tinh. The mapping of terrestrial ecosystems is generally good, however considering coastal ecosystems, it does not identify sand areas as a specific type of coastal ecosystem, and the resolution of the mapping is too coarse to identify any small areas of sea grass and coral reefs in Ha Tinh. Furthermore, for freshwater ecosystems, the mapping does not clearly distinguish between different types beyond the classes of "river/stream" and "natural lake". Without systematic ground-truthing, it is entirely possible that many water bodies mapped as natural lakes are in fact man made reservoirs (See BCA, WWF, Stockholm University, 2013: *Ecosystems classification mapping in Vietnam*. Ha Noi, Vietnam).

While more detailed mapping of especially coastal and freshwater ecosystems would be very beneficial, it is beyond the scope of this project to conduct detailed original province-wide mapping.

Figure 0.3: Ecosystems of Ha Tinh and Quang Binh.



Source: ICEM, based on BCA, WWF, Stockholm University, 2013: Ecosystems classification mapping in Vietnam.

3.4.1. Terrestrial Ecosystems

The main terrestrial ecosystems of Ha Tinh are:

- sub-tropical broadleaf moist evergreen forests above 700m altitude
- tropical moist evergreen broadleaf forest below 700m altitude

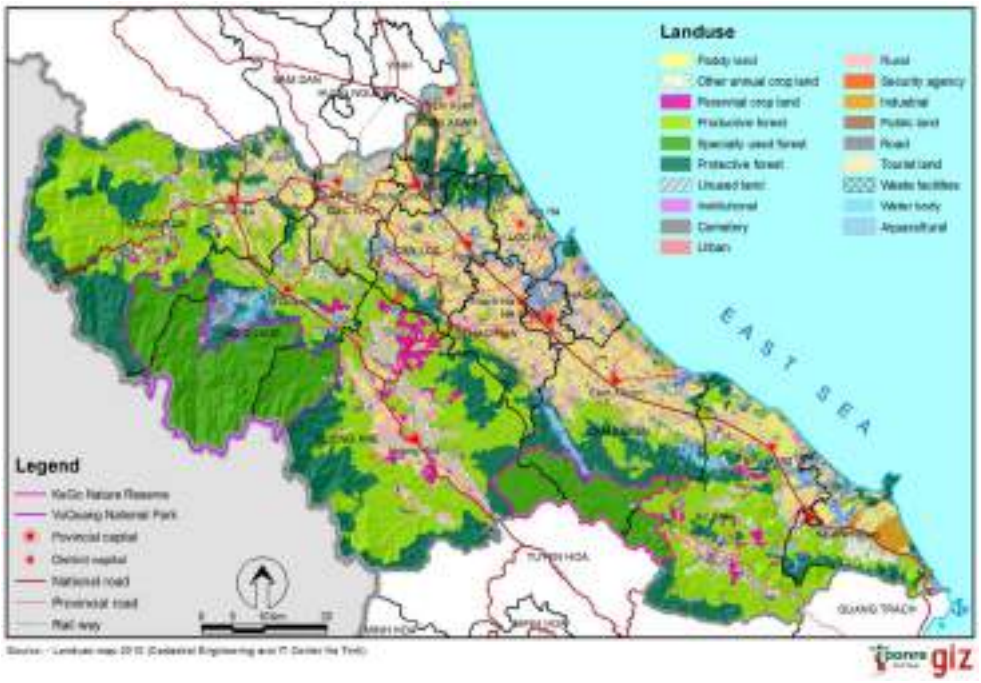
Around 351,000ha or over 58% of the land area of the province) is still identified as "forestry" land (see Table 3.6 and Figure 3.4). However, a land-use designation as forestry land apparently does not always mean that the land actually has forest cover. At the same time, land use statistics shown in Table 3.6 reveal that almost 22% of Ha Tinh's original land cover has been converted to some form of agriculture, and around a further 20% to other uses. Recent land-use patterns are shown in Figure 3.4.

Table 0.6: Land Use in Ha Tinh

Use type of land	HT Statistical Yearbook 2013		MARD-FIPI 2012	DONRE 2015
	Ha	%	Ha	Ha
Total	**599, 782**	**100**		
Agricultural land	130,117	21.69		
Forestry	**351,891**	**58.69**	**351,891**	**350, 882.67**
• *Special use Forest*			*164,014*	*161,244.38*
• *Protection Forest*			*113,300*	*115,040.48*
• *Production Forest*			*74,577*	*74,597.81*
Aquaculture land	4,661	0.78		4,096.18
Salt production land	Not specified	Not specified		423.70
Resident/homestead land	9,695	1.62		
Special use/dedicated land	44,857	7.48		
Other Non-agriculture land	43,596	7.02		
Unused land	27,963	4.66		

Source: HT statistical yearbook 2013, MARD-FIPI 2012, and DONRE Ha Tinh province, 2015

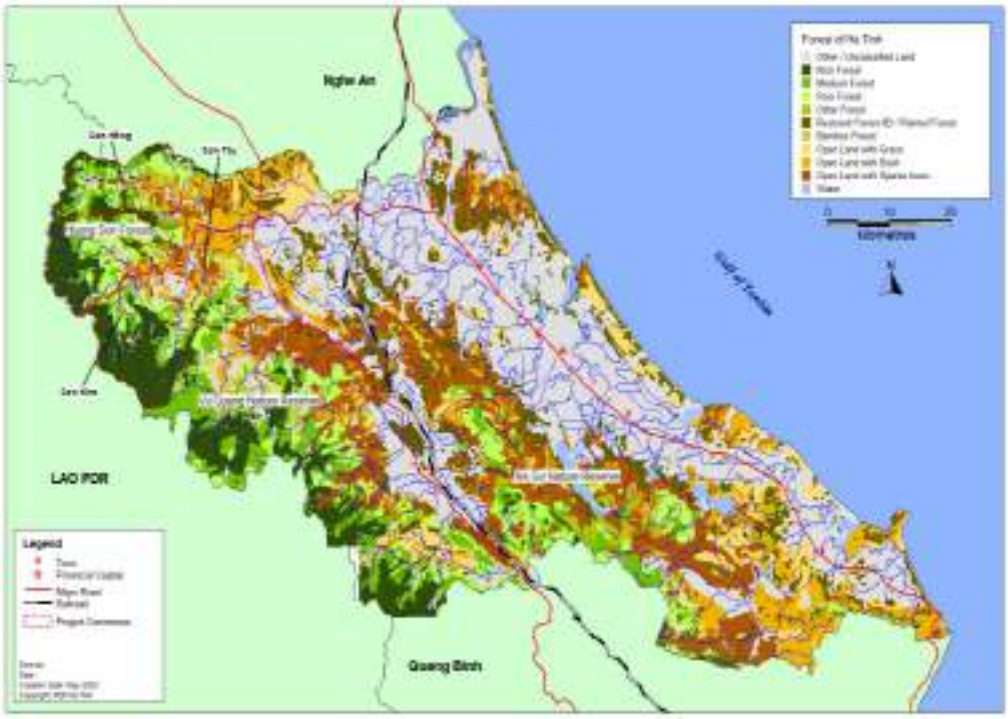
Figure 0.4: Land-use patterns in Ha Tinh



Source: map produced by the consultant team

The forests of Ha Tinh are extremely diverse with over 1600 vascular plant species in 351 genera and 138 families (IEBR, 2001). Valuable timber species include: Lim (*Erythrophleum fordii*), Sến (*Madhuca pasquieri*), Gụ đỏ (*Sindora tonkinensis*), Vang Tam(*Manglietia fordiana*), Re huong (*Cinnamomum sp.*), Gioi (*Michelia gioi*), De (*Castanopsis spp.*). In addition, a large number of plant Non-Timber Forest Products (NTFPs) have been listed, including 554 species of medicinal plant, 98 species of ornamental plant, 83 species of essential oil and tannin, and 29 species of rattan. Animal life found in these forests is also diverse. Globally important species for conservation include the Saola (*Pseudoryx nghetinhensis*), and the Mang lon (*Muntiacus vuquangensis*). Formerly the area would have been important for large mammals such as tigers and elephants, but this is no longer the case. (Mackinnon and Van Dung, 1992; Van Dung et. al, 1994; Kuznetsov, 2001).

Figure 0.5: Forests of Ha Tinh Province, 2003



Source: DARD Ha Tinh

MARD data for 2012 and HT DARD information for 2015 (see Table 3.7) suggests that actual forest cover is around 321,000 hectares (or about 50% of the land area of the province). Of this total amount of land with forest cover, about 70% is natural forest and about 30% is plantation forest, meaning that in total, natural forest covers about 35% of the province land area and plantation forest about 15%. About 40% of the remaining natural forest is contained within Vu Quang National Park and Kego Nature Reserve, which provide the best examples of Ha Tinh's native forests.

Information on changes in forest area in Ha Tinh from 1998 until the present, presents a picture that in some ways appears difficult to explain. Total forest area increased by 60,000ha between 1998 and 2012, and by a further 70,000ha between 2005 and 2012 - increasing at an average rate of almost 10,000ha/year during this period. Perhaps surprisingly, about 40,000ha of this increase in forest cover from 1998 to 2012 was identified as an increase in natural forest cover. In addition, HT DARD figures for 2015, suggest an additional 17,000ha increase in natural forest between 2012 and 2015.

Table 0.7: Change of forest area 1998-2005-2012-2015 in Ha Tinh Province

	1998	2005	2012	2015
Forest tree area (ha)	190,923	250,529	321,377	320,381
Natural forest (ha)	*171,181*	*186,240*	*212,884*	*229,742*
Planted forest (ha)	*19,742*	*64,289*	*108,493*	*90,639*

Source: MARD: Restructure of National Forestry, Hanoi-2014 for 1998, 2005 and 2012; and DARD HT for 2015

So where did this 57,000 hectares of additional natural forest come from in 17 years? There are two possible explanations for this increase in the area of natural forest - one is that the definition of what constitutes a natural forest and the criteria used to identify natural forest (e.g. percentage crown cover) have changed over time. The other explanation is that large areas of previously logged or otherwise severely degraded forest that previously did not meet the criteria for being identified as forest, have now recovered/regenerated to such an extent that they are now recognised and counted as forest (small trees have become big trees). Or it could somehow be a combination of both of these possibilities. Further work is required to clarify this.

The Forestry Management Boards, Forestry companies, Commune Peoples' Committees and Households are all major forest owners in Ha Tinh (see Table 3.8)

- National Parks and Nature Reserves manage the Special Use Forest which includes most of the richest forest with very high biodiversity including remaining areas of primary forest on the East flank of the North Truong Son mountain/border Vietnam-Lao PDR.
- Protection Forest Management Boards manage most protection forest and some production forest. They are responsible for large areas of natural forest, and some plantation forest.
- Forestry Companies manage most production forest including both natural and plantation forests. Combined they are managing a natural forest area that is bigger than Kego nature reserve and almost as big as Vu Quang National Park
- Forestry land allocated for households is mostly land for plantation forestry and ago-forestry practices. Very little natural forest has been transferred to households.

Table 0.8: Forest ownership and management responsibility in Ha Tinh Province

Forest Owner			Area (ha)
I. Special Use Forest Management Board	Vu Quang NP	55,341	91,893 (N: 81,155; P: 10,738)
	Ke Go Nature Reserve	36,552	
II. Protection Forest Management Board (PFMB)	Ngan Pho river PFMB	25,019	83,207 (N: 66,030; P: 17,177)
	Ngan Sau river PFMB	16,860	
	Hong Linh PFMB	6,072	
	Tiem River PFMB	12,917	
	South Ha Tinh PFMB	20,567	
III. Forestry Company	Huong Son LLC	18,728	60,745 (N: 42,359; P: 18,386)
	Chuc A LLC	14,381	
	Ha Tinh Rubber Company	12,864	
	Huong Khe Rubber Company	14,666	
IV. Other Organization			5,540 (N: 3,989; P:1,551)
V. Commune PCs			31,717 (N: 14,932; P:16,785)
VI. Private Households			31,768 (N: 5,766; P:26,002)
VII. Not yet allocated			15,511 (N)
Total Forest area of Ha Tinh province			**320,381 ha (N: 229,742ha; P: 90,639 ha)**

Source: HT DARD 2015

Vu Quang National Park and Ke Go Nature Reserve

Vu Quang National Park and Ke Go Nature Reserve together account for around 20% of the land area of the province. As such this represents a significant commitment to maintaining natural ecosystems in a protected state as Special Use Forest (SFU).

However, a large proportion of the natural forest estate of Ha Tinh (including in Vu Quang and Kego) is not however in its original natural condition. Much of it has been previously logged and is actually in various stages of regenerating secondary forest. Some areas of forest were also severely damaged by bombing in the American war. A seemingly very significant issue of smothering of trees by prolific invasive climbing plants was apparent in many patches of forest accessible by road. So far there has been no detailed study of overall forest condition in the province.

Vu Quang NP was established in 2002, in accordance with Decision No. 102/2002/QD-TTg of the Prime Minister of the Socialist Republic of Vietnam. It covers 55,029 ha lying between coordinates 18°09' to 18 °26' North Latitude and 105 °16' to 105 °33' East Longitude.

According to personal conversations with a number of leading conservation experts in Vietnam, the biodiversity importance of Vu Quang NP has declined over the last 2 decades and this is reflected in the fact that none of the major international conservation organisations have any ongoing or planned projects to support the area. If local communities were more actively involved in the management of Vu Quang NP, and if conservation agreements and benefit sharing arrangements were put in place, significant additional economic value and support for local livelihoods could be derived from sustainably managed collection of Non-Timber Forest Products (NTFPs) including rattan, resins, honey, mushrooms and medicinal herbs, etc. in Vu Quang NP. Under present management rules and structures this is unlikely to be the case, and the park is still struggling with illegal logging, poaching and harvesting of NTFPs. Tourism could also be potentially further developed.

Prior to 1990 the Ke Go area of gently undulating hills mostly under 300m elevation was under the management of Cam Ky Forest Enterprise which logged the area. In 1990 Cam Ky ceased logging operations and part of the area under its management was designated as Ke Go Reservoir Watershed Protection Forest (WPF). When Ke Go Nature Reserve was created in 1997 it combined 7,511ha previously under the management of Ha Dong Forest Enterprise and 11.38ha previously under the management of Ke Go Reservoir WPF. The initial area was later expanded to a total area (including buffer zone) of over 40,000ha with the inclusion of additional protection forest areas into the Nature Reserve. A strictly protected core zone of 22,000ha accounts for just over half of the property and is recognized as Birdlife Important Bird Area (IBA) # VN019. The core zone and buffer zone together includes parts of 23 communes in 4 districts. The Kego Nature reserve protects large parts of the watershed of the Kego Reservoir as well as some of the last remaining tropical broadleaf moist evergreen forest of the Annamese region

(although this is logged-over secondary forest). Professor Vo Quy, Vietnam's leading conservationist was a champion for the establishment of Kego Nature Reserve.

Professor Vo Quy, Vietnam's leading conservationist was a champion for the establishment of Kego Nature Reserve - particularly for the protection of pheasants, including the Vietnamese Pheasant (*Lophura hatinhensis*), discovered in 1964. Also known as Vo Quy's Pheasant, it is featured prominently as the logo for Kego Nature Reserve. More recently *L. hatinhensis* has been reclassified as a variety of Edward's Pheasant *L. edwardsi*, known originally from Ha Tinh, Quang Binh, Quang Tri and Thua Thien Hue. There have been no confirmed records of Edward's pheasant in the wild since 2000 - and it is not clear if any still survive in Kego. It is now classified as Critically Endangered by IUCN.

While there are no permanent settlements in the core area of Ke Go, there is significant human activity. Collection of any NTFPs that are not endangered species is allowed - the most important products being rattan and the palm leaves used for making traditional conical hats. However there is no information about the volume and value of these products collected; their relative importance as source of income for local people; or how many people are involved in their collection. In addition, there is no monitoring of the abundance and productivity of these species in the forest, and so no idea if their collection is sustainable or not. In addition, illegal activities including encroachment, illegal logging and poaching of wildlife as well as forest fires were identified as significant challenges faced by the nature reserve. A total staff of 77 includes 40 rangers stationed in 10 ranger stations around the property. Their main duty is patrolling for law enforcement.

Vu Quang NP and Ke Go NR both provide significant ecosystem services especially in terms of provision and regulation of water supply and quality for downstream communities, as well as carbon sequestration and climate regulation. To some extent the importance of these services is recognized simply in the decision to continue to maintain these areas as SFU areas - but the amount and value of the services has not been assessed. It is therefore difficult to try and understand if the level of investment of government budget in management of the area is appropriate or not when considering the value of services the area provides. It also makes it difficult to develop innovative financing mechanisms such as payment for Ecosystem Services (PES) when the overall importance and value of these services is largely unknown.

So far, the overall condition of the natural forest of Ha Tinh Province has not been evaluated in detail, and management measures appropriate to each type of forest and its specific context are not yet clearly understood. More detailed assessment of forest types, forest owners, the economic effectiveness and development performance of forests have to be made to evaluate more precisely how to manage, use and protect the forest estate more effectively and in a reasonable manner in the face of climate change.

3.4.2. Freshwater Ecosystems

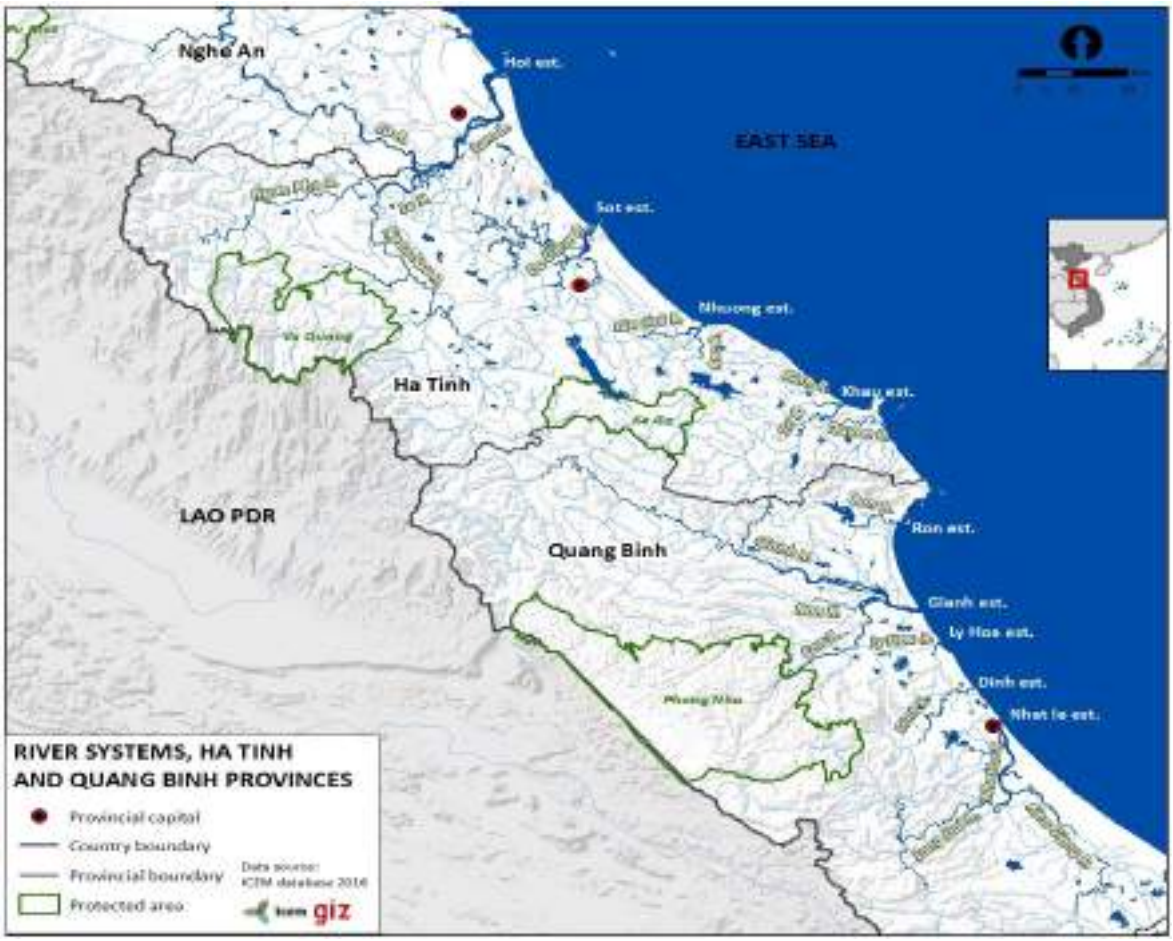
Freshwater ecosystems fall into the classes of riverine (rivers and streams) and lacustrine (open water bodies such as lakes and ponds)

3.4.2.1. Riverine Ecosystems

The abundant rainfall combined with the topography of the province and limited evaporation gives rise to more than 100 relatively short and steep rivers and streams with a total combined annual flow volume of 13 billion cubic metres (bcm). This includes 13 major river systems with a combined length of 400km. The longest river is the Ngan Sau, which is 131km long, and the shortest is the Cay River with a total length of only 9km. The largest river in the province in terms of channel size and volume is the La-Lam River, which forms the border between Ha Tinh and Nghe An Provinces. The La-Lam River system has its origins at Mt. Muong Khut and Muong Lap in Thanh Hoa (1,800 and 2,000m, respectively) and runs from the northwest to the southeast through the three Provinces of Thanh Hoa, Nghe An and Ha Tinh before flowing out into the East Sea via the Hoi river mouth. In the portion of the La-Lam Basin in Ha Tinh Province, we can distinguish two main sub-basin systems: (i) Ngan Pho river system, which has a total basin area of 2,061km^2 and consists of various small rivers, creeks and streams such as the Tiem, Rao Tro, Ngan Truoi; and (ii) Ngan Sau river system, which has a total area of 1,065 km^2. The Ngan Pho and Ngan Sau Rivers empty their water into the 12km long La River, which in turn flows into the 37km Lam River. In addition, the Do Diem and Rao Cai rivers have a basin area of 1,349 km^2, and the Gia Hoi and Rac rivers have a basin area of 356 km^2, while the Kinh, Tri and Quyen rivers have a combined basin area of 510 km^2 (Investment Promotion Center for North Vietnam, 2016).

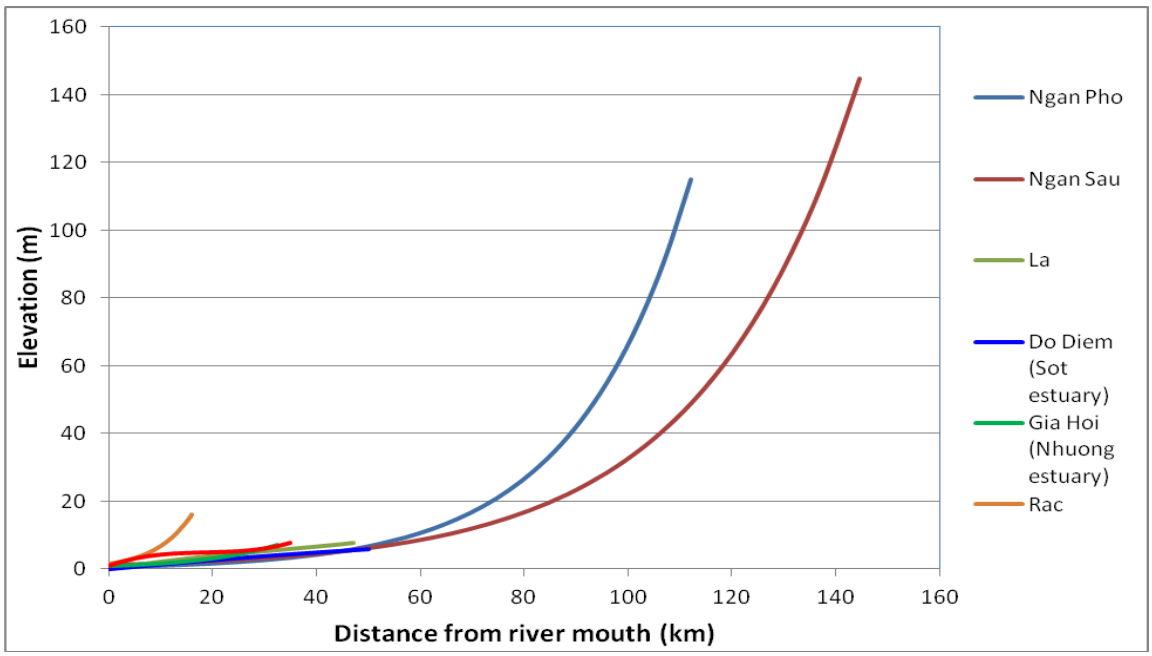
Figure 3.6 shows the major river systems of Ha Tinh and Quang Binh, while Figure 3.6 shows the longitudinal profile for some of the major rivers in Ha Tinh.

Figure 0.6: Map of river systems and estuaries in Ha Tinh and Quang Binh Provinces



Source: original work of the consultants

Figure 0.7: Longitudinal profiles of major river in Ha Tinh Province.



Source: original work of the consultants

Photo 0.1: Lac Giang River - most riversine vegeatation is removed and rice fields come right up to the river bank

No informaton was available on the ecological condition of the rivers. Headwaters areas and upper reaches of rivers, especially where forested watersheds are contained within national parks, nature reserves and other protected forests (and in some cases natural production forest) are likely to still be in relatively good condition. However the

middle and lower reaches of most rivers in the province have been impacted by various forms of development including hydropower and irrigation reservoirs, saline intrusion barriers, flood prevention dykes, and human settlement. natural flow patterns have been changed, and natural riparian vegetation has largely been removed (see example in Photo 3.1).

The Rac River fluvial morphology is threatened by sand extraction. A number of local people illegally take sand out from the river through day and night (See Photos 3.2)

Photo 0.2: Sand extraction from the Rac River, and no evolution of sand filling-in between 2 consecutive groynes, becuae of the due to sand extraction

Photo 0.3: Lac Giang River, 31 km from Cua Nhuong river mouth River water at this location is still salty and cannot be used for irrigation

3.4.2.2. Lacustrine Ecosystems

Lacustrine ecosystems include lakes, lagoons and ponds. Ha Tinh has about 340 recognised water bodies (including both natural and man-made lakes and reservoirs), with a combined storage capacity of over 700 million m^3. Without significant detailed survey effort across the province it is impossible to know how many of these are actually natural water bodies, what their specific ecology is like, and what condition they are in. On the other hand, some of the largest reservoirs are however well-known and immediately obvious, including Ke Go, Song Rac, Cua Tho (Cửa Thờ), Trai Tieu and Ngan Truoi - Cam Trang (which is still under construction).

Lagoons and lakes are not a very characteristic open water ecosystem in Ha Tinh province. Typically lakes and lagoons in North-central Vietnam are located on the sandy land of coastal areas. They contain fresh water when located in the inner sandy areas and brackish water in when closer to thesea. This wetland type plays an important role in biodiversity and local microclimate impacts.

Althought some coastal land in Ha Tinh is still identified as wetland areas but in fact local people have converted almost all of these wetlands to agricultural land, and only some smaller areas of open water remain. In the local language, Ha Tinh people call lakes and lagoons "đồng" the same word they use to identify other land use types such as paddy fields or crop fields. Hoi Thong lagoon is one of these area . This lagoon is called as "đồng thủy sản" meaning aquacultural production field".

Hoi Thong lagoon is located close to the Hoi estuary of Lam river and is managed for fish cultivation. More than 20% of local people, who live in Xuan Hoi commune get their daily income from Hoi Thong and some other smaller lagoons alongthe Lam river. Intensive fishing is for for the local market and for Vinh market. Both the diversity of native fish species and the abundance of fish, shrimp and other aquatic species have been dramatically reduced. Most of the native vegetation around the lagoon has also been destroyed and replaced with plantings of Acacia hybrid and *Casuarina equisetifolia*. Native tree species regernation is surpressed as any regrowth is cut down in weed control every year.

Photo 0.4: Hoi Thong lagoon, Xuan Hoi commune, Nghi Xuan district

Water infrastructure developed so far is significant, and includes 345 reservoirs, 57 weirs, 381 pumping stations, 318.5km of dykes and 19.2km of tier 2 river dykes. Current storage capacity is 745 million cubic metres, and Irrigation water is provided to 50,000ha. PPC of HT has approved a plan for an enhanced dyke system and are preparing dyke management planning.

3.4.2.3. Ngan Truoi-Cam Trang irrigation and hydropower project

According to information provided to the team in meetings with DARD staff, adn during visits to the site in December 2015, the Ngan Truoi reservoir is being developed by the Ministry of Agriculture and Rural Development, Vietnam starting in June 2009 with a total capital investment of approximately VND 6 trillion, raised mainly from the Vietnamese government bonds. The project was initially approved in 2006, and is considered to be one of the most critical development projects in Ha Tinh province. The project is being built on the Ngan Truoi River in Huong Dai commune in Vu Quang district. It is designed with a capacity of 775 million cubic meters (equal to the total existing capacity of all reservoirs in Ha Tinh). Upon completion, the reservoir will provide water to 35,400ha of farming land in seven districts of Ha Tinh, including Vu Quang, Huong Son, Duc Tho, Can Loc, Nghi Xuan, north Thach Ha and Hong Linh, with a capacity of 56.8m^3/s. It will supply

water for domestic uses in the surrounding districts and for 12 industrial zones, especially the Thach Khe iron ore mining with a capacity of 6 m^3/s, and will also provide water for about 6,000ha of aquaculture, of which 3,500ha will be freshwater and 2,500ha brackish water. It is also claimed that the project will also help to reduce the damages caused by floods in the Ngan Sau and hence the La river, and at the same time will continue to contribute an environmental flow with a discharge of 4m^3/s for the lowland areas and estuaries. The work also includes a hydro-electric power system with a capacity of 16 MW.

The catchment area is 408km^2, located in Vu Quang NP, while the area of the reservoir itself will be 43km^2, including approximately 2,000ha of forest of VQNP. The project has so far relocated over 600 households with 2,977 inhabitants in 2 communes in Huong Quang and Huong Dien and some villages in Vu Quang district. Villages located inside Vu Quang National Park along the river valley that will be flooded by the reservoir, have been relocated to areas outside of the park. When the team visited in December 2015, main dam construction was nearing completion. It is expected to come into operation in 2017. The team also visited some of the total of 898 households who were resettled and provided with forest land in the buffer zone - which is being cut down and converted to agriculture.

This project involves the conversion of protected forest and a natural river to other development purposes. Essentially it implies a trade-off between irrigation/agricultural production on the one side and biodiversity conservation plus other ecosystems services that the forest and river supplied, on the other side. Between managed provision of water for downstream economic activities and livelihood development and the maintenance of a broad suite of services that can be considered as public goods.

3.4.3. Estuarine Ecosystems

Estuarine ecosystems include the estuaries themselves, together with associated mangroves and mud-flats. The Province has four major estuarine systems. From the most northerly to the most southerly these are the Hoi, Sot, Nhuong and Khau. The Hoi estuary is the outlet for the La-Lam River, the Sot estuary is the outlet for the Do Diem and Rao Cai rivers, and the Nhuong estuary is formed by the Gia Hoi and Rac rivers, while the Khau estuary river is the outlet of the Vinh, Tri and Quyen rivers.

Mangrove forest is found along banks of the four main river estuaries of Ha Tinh province and has been identified in Xuan Hoi, Xuan Truong of Nghi Xuan district, Thach My, Ho Do, Thach Chau and Thach Bang of Loc Ha district, Ky Ha and Ky Trinh of Ky Anh town. Ha Tinh PPC (2015) 302/QD-UBND-2014 and 1457/QD-UBND-2015 recorded a total area of only 510 ha of mangroves remaining in 2015 (a 33% decline from the 750 ha found in 2011).

Table 0.9: Mangrove forest in Ha Tinh province 2011

No	District	Total area (ha)	With mangrove	No mangrove	Aquacultural practice	Salt field
1	Ky Anh	568.0	360.5	207.5	0.0	0.0
2	Cam Xuyen	231.4	48.4	143.0	40.0	0.0
3	Ha Tinh city	74.2	66.4	7.8	0.0	0.0
4	Thach Ha	220.4	117.1	103.3	0.0	0.0
5	Loc Ha	265.1	113.6	19.4	118.2	14.0
6	Nghi Xuan	227.2	46.7	136.5	44.0	0.0
	TOTAL	**1,586.3**	**752.6**	**617.6**	**202.2**	**14.0**

Sources: Ha Tinh PPC, 2011. Report on Mangrove protection forest in Ha Tinh and action plan in 2014-2022

While the remaining area of mangroves is small, and *Rhizophora stylosa, Sonneratia caseolaris* and *Kandelia obovata* were recorded as dominant mangrove tree species, overal 27 species of 18 families were recorded in mangrove forests of Cua Sot. Six types of forest structure communities were found including *Avicennia lantana* community; Avicennia and Rhizophora community; Avicennia, Kandelia and Rhizophora community; Avicennia, Aegiceras, Kandelia and Rhizophora community; Avicennia, Aegiceras and Kandelia community; and , *Sonneratia casseolaris* community. In addition, more than 30 species of fish, shrimp, and clam species were caught daily by 25% of the local population Daily income from native fishing practices brings in more than 200,000 VND/day/person in the Cua Sot research area (Nguyen Thu Hien and Ho Dac Thai Hoang, 2015).

According to planning, the total area of mangrove forest in Ha Tinh is expected to increase from 752.6ha in 2015 to 1,162.1ha in 2022, as a result of new planting of 409.5 ha of mangroves in currently bare land. 36ha of this new planting will be in old shrimp ponds in Nghi Xuan District, while all the rest will be in tidal areas on the seaward side of existing mangroves (DARD, 2015). However it is worth noting that survival rates of recent

mangrove planting schemes have been quite low. Some additional planting may be carried out in existing mangrove protection forests, and enrichment planting will be implemented in plots in poor condition with low densities of mangroves.

Table 0.10: Mangrove forest development planned for 2022 in Ha Tinh by District

Activities	Total	District					
		Ky Anh	Cam Xuyen	Ha Tinh city	Thach Ha	Loc Ha	Nghi Xuan
Existing mangrove area (ha)	752.6	360.5	48.4	66.4	117.1	113.6	46.7
New planting bare land (ha)	409.5	170.0	92.7	7.8	24.5	18.4	96.0
Total area by 2022 (ha)	1,162.1	530.5	141.1	74.2	141.6	132.0	142.7
Protection forest planting	499.2	192.5	38.4	54.4	115.1	60.1	38.7
Enrichment planting in poor and low density plots	253.4	168.0	10.0	12.0	2.0	53.5	8.0

Sources: DARD, 2015

Photo 0.5: New mangrove stand planted in January 2016, viewed from Cua Nhuong Bridge toward the river mouth

Photo 0.6: Newly planted mangroves in the Rac River

The area of the lac Giang River shown in Photo 3.7, used to have dense Sonneratia trees, but people cut most of them down them down. Those remaining in the picture are around the pond of Mr. Luu and Mrs. Huong who have lived here for over 20 years. According to Mr. Luu, his Sonneratia trees trees help to cool down the water temperature during the summer, so it's good for fish and shrimp.

Photo 0.7: Lac Giang River, Cam Quan commune, Cam Khe district

In addition to mangroves, there are some mud flat areas in the estuary of Cua Hoi - Song Lam in Nghi Xuan District; My Duong river estuary in Cuong Gian commune, Nghi Xuan District; the estuary of the Lac Giang River, Cam Nhoung Commune, Cam Xuyen District, and in Ky Ha commune of Ky Anh District. No detailed assessment of their status was available, but in general estuary and river mouth areas of all four main estuaries are highly developed and normal ecological functioning is disrupted.

Photo 0.8: Cua Nhuong Bridge - 1,390 m long, built 2010-2015, second longest bridge in Central Vietnam. Google Earth, Aug 2014

Normal ecological functioning of freshwater ecosystems upstream of the estuaries, and downstream coastal ecosystems, is also disturbed by saline intrusion barriers. The intention of these barriers is to maintain freshwater conditions suitable for rice growing, upstream of the barriers. However this also impacts sediment transport to the coastline and reduces freshwater mixing with the saltwater downstream of the barrier, making conditions too salty for many mangrove species to survive.

Photo 0.9: Do Diem saltwater barrier on the Nghen River (đạ[Font chữ UTM sử dụng Bảng mã UNICODE Vui lòng thiết lập lại trình điều khiển bàn phím]p nga[Font chữ UTM sử dụng Bảng mã UNICODE Vui lòng thiết lập lại trình điều khiển bàn phím]n mạ[Font chữ UTM sử dụng Bảng mã UNICODE Vui lòng thiết lập lại trình điều khiển bàn phím]n Đò Điệ[Font chữ UTM sử dụng Bảng mã UNICODE Vui lòng thiết lập lại trình điều khiển bàn phím]m)

3.4.4. Coastal Ecosystems

The main coastal ecosystems of Ha Tinh are

- sandy beaches and sandy soil ecosystems (together with coastal forest formations at the landward edge of these systems)
- coral reefs
- sea-grass beds
- Deeper water (50m+) offshore marine ecosystems (not considered in this study)
- Island ecosystems (not considered in this study).

3.4.4.1. Coastal forests in sandy areas

Sandy areas in Ha Tinh province stretch along the sea shore about 100 km from the Lam river estuary, Nghi Xuan district to Con Bo river estuary in Ky Anh district. Sandy areas occupy about 12.7% of the total land area. According to DONRE (2015) Sandy areas include 2 main soil types, sandy soil and sand dunes (38,222 ha) and saline soils (22,405 ha). Main land uses in this sandy area are for protection forests, agriculture, aquaculture and residential land.

Similar to other coastal provinces in Central Vietnam, *Casuarina equisetifolia* is identified as the main tree species for plantation in sandy areas of Ha Tinh province. According to Van Thang, 2016 (quoting Ha Tinh PPC 2014, 2015) protection forest in sandy land areas of Ha Tinh province is 5,855.4 ha distributed in 33 coastal communes of 5 districts, Nghi Xuan, Loc Ha, Thach Ha, Cam Xuyen and Ky Anh. Of this, windbreak and environmental protection forest cover 885.9ha and 4,451.2 ha respectively.

Historically, sandy areas in Ha Tinh province were covered by more than 250 indigenous tree species. In most cases the original natural habitat has been highly degraded. With increasing population and expanding residential land, sandy natural forests were clear cut and replaced with *Casuarina equisetifolia* for fuel wood needs of local people. In addition to the main tree species only a small number of other species can be found growing with the casuarina, such as *Axonopus compressus, Pandanus humilis,* and *Pandanus odoratissimus* (Van Thang, 2016, and personal observations of consultants).

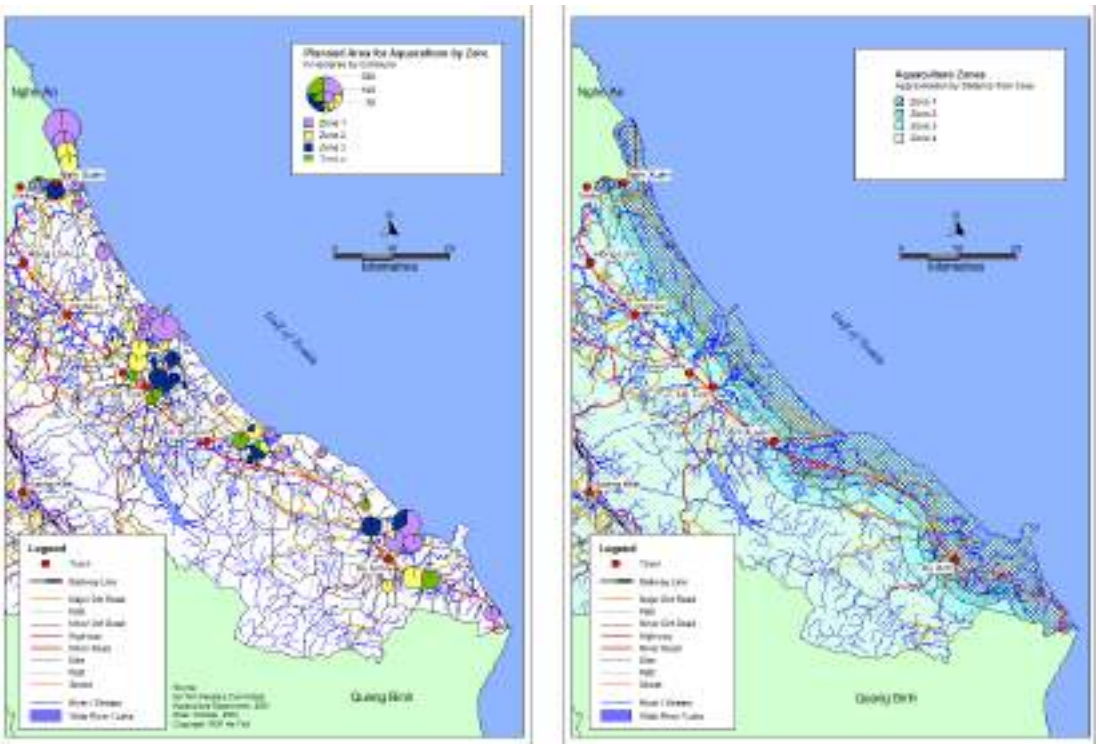
Small remnant patches of Melaleuca forests are still found in some parts of Ha Tinh province such as in Cam Duong, Cam Hoa communes of Cam Xuyen District. But it is difficult to know their original extent (Van Thang, 2016).

Photo 0.10: Land use in sandy areas - Cam Duong commune, Cam Xuyen District, Ha Tinh Province

Shrimp cultivation in Vietnam has experienced many periods of ups and downs. Nowadays, dry sandy areas have been identified as the best location to practice shrimp pond cultivation. Before 2013, most shrimp ponds in Ha Tinh province cultivated giant tiger prawn but faced many problems of yield, market and also disease. In 2014 - 2015, the local goverment in Ha Tinh has started promoting new practices, raising white shrimp in sandy areas. Ha Tinh DARD (2015) recorded some 160ha of sandy land were converted to shrimp pond and were yielding 20 tons of shrimp per ha per rotation. It is anticipated that in coming years, with further development of the ASEAN Economic Community (AEC) both demand and price will increase. Consequently it is planned that large tracts of sandy areas will be converted to shrimp ponds for white shrimp cultivation. In addition to the transformation of sandy ecosystems, waste water drainage from shrimp ponds in Ha Tinh causes strong pollution to not only the sandy areas but also to nearby sea water and beaches.

Photo 0.11: Aquaculture in sandy areas of Xuan Pho Commune, Nghi Xuan District

Figure 0.8: Aquaculture zoning and planning in Ha Tinh (Source Ha Tinh PPC, 2003)



Planting of sandy protection forest in Ha Tinh has been promoted to expand forest cover to face the challenges of disaster risk reduction and climate change. According to Ha Tinh PPC (2014, 2015) protection forests in sandy land areas of Ha Tinh province cover 5,855.4ha in 38 coastal communes of 6 districts (Nghi Xuan, Loc Ha, Thach Ha, Cam Xuyen and Ky Anh district and Ky Anh town), and are clasified into 3 main protection

forest types: (i) mangrove forest along banks of rivers in estuaries; (ii) windbreak forest; and (iii) environmental protection forest. Windbreak and environmental protection forest cover 885.9ha and 4,451.2ha, respectively. Similar to other coastal provinces in Central Vietnam, *Casuarina equisetifolia* is the main tree species that has been widely planted in sandy areas of Ha Tinh province as protection forest. However in many large areas of Ha Tinh province with poor sandy soil *Casuarina equisetifolia* can not grow well as a tree form but is creeping on the ground.

Photo 0.12: Casuarina planting at the mouth of the Song Lac Giang River/Cua Nhuong Estuary

It is true that *Casuarina equisetifolia* plays an important role in fuel wood supply and also provides some benefit as a windbreak; in partiallty stabilising moving sand; regulating microclimate and protecting underground water in sandy areas. Nevertheless, at the end of the day it is still a monoculture tree plantation, poor in biodiversity, with very basic ecological funtions and greatly reduced ecosystem service values. While new casuarine planting is still going on, at the same time, clear-cutting of large areas of coastal protection forest for residential land and aquaculture has recently been recorded in all 6 coastal districts of Ha Tinh province.

3.4.4.2. Coral Reefs

Vietnam's coastal waters contain a wide range of reef diversity and structures supporting over 350 species of hard corals in an estimated area of 1,122 km^2. Coral reefs in Vietnam's coastal waters are mostly fringing and patch reefs, with sparse cover and are limited in size compared to barrier reefs and atolls. The condition of 60% of Vietnam's reefs has been described as fair, 20% as poor, 17% as good, and only 3% as excellent (Chou *et al.* 2002). These coral reefs continue to be stressed by a variety of threats, particularly in areas of dense human populations. Including over-fishing, destructive fishing, pollution, coastal development and sedimentation, coral exploitation, and

tourism, as well as from bleaching events and outbreaks of crown-of-thorns starfish (Tuan et al. undated National Report on Coral Reefs of Vietnam fort UNEP South China Seas Project).

In the last decade, the Vietnamese government has become interested in the study of coral reefs, demonstrated by the investigation of reefs in the Cat Ba - Ha Long coastal area, the monitoring of reefs in Nha Trang Bay, Con Dao Archipelago and Phu Quoc Islands (Tuan et al. 2005; Tuan et al. 2008), towards development of a network of marine protected areas. However, no specific information or studies could be found on coral reefs in ha Tinh Province. From the coastal morphology and oceanic conditions, we might expect there to be some fringing reefs running parallel to the shore line.

Coral reefs are important in supporting fisheries productivity, and in providing physical protection to the coastline from storms and strong waves. It is important to find out more about the location, size and condition of coral reefs in Quang Binh. This can be done by starting from local knowledge of fishermen about the location of reefs, as well as using the remote sensing methodology recently developed and tsted by Tran et. al. (2012) for mapping the benthic cover of coral reefs n Vietnam's coastal waters from high-spatial resolution, multi-spectral satellite image data.

3.4.4.3. Sea-grass beds

Sea-grass areas are common at the edges and landward sides of typical fringing reefs. The effects of typical fringing reefs in reducing the effects of wave action on the coastline, creates an environment suitable for sea-grass development. A good example of this mix of coral reefs and sea-grass beds can be observed at the Southeastern Bay of Con Dao Island, in Binh Thuan Province along the Vinh Hao coast, and along the Ninh Hai coast in the Ninh Thuan Province. As with coral reefs, sea-grass beds are extremely important in supporting fisheries productivity. And similarly to the case of coral reefs in Ha Tinh, no specific information could be found on sea-grass in Ha Tinh.

3.5. Ecosystem resilience and EbA

Natural ecosystems provide a wide array of goods and services to human societies. Amongst these ecosystems services are the many ways in which nature helps support human resilience in the face of climate change, and extreme events associated with climate change. "Natural infrastructure" such as coastal mangrove forests, and melaleuca forests, can provide a "bio-shield" offering protection from storms and strong winds. Under certain conditions silt trapped by mangroves can raise the level of the land to keep pace with sea-level rise, and large sand dunes constitute a natural sea wall offering very significant protection against sea level rise. Similarly, forest cover on steep slopes can offer protection against soil erosion and flash flooding which are likely to be increasingly serious issues with the more frequent heavy rainfall events predicted to come with climate change. Significant areas of tree cover can also have a cooling effect on air temperature and soil surface temperature. Natural wetlands can help

absorb flood-waters, reducing the onset, severity, depth and duration of downstream flooding, also likely to become an even bigger problem under climate change scenarios.

However, to play these roles effectively, natural ecosystems clearly need to be present not only in the required location but also in an appropriately large area (relative to the size of the problem faced and the protection required). At the same time, natural ecosystems themselves are also threatened by climate change, and so to ensure survival and effective functioning of the ecosystems and to allow them to continue to provide the services that support human resilience, the ecosystems must also be maintained in good condition. In general resilience of ecosystems to climate change can be improved by first reducing other non-climate stresses on the ecosystems. More specifically characteristics that are important for ecosystem resilience (that management needs to take into account, according to Bezuijen et. al. 2011; Bickford et. al., 2010; Bobenreith et.al. 2012) include:

- **size of ecosystem area** (larger areas of natural ecosystems will be more resilient)
- **connectivity of ecosystems across landscapes**, (more connected areas have higher resilience - necessary to allow both latitudinal and altitudinal movement of species in response to changing conditions, e.g. a one degree change in temperature means organisms need to move either 55km away from the equator towards the poles, or to 100m higher altitude in dry areas or 200m higher altitude in wet areas, to find the same climate conditions that they are used to)
- **species and genetic diversity within the ecosystem** (more diverse systems have higher resilience)
- **phylo-geographic diversity** (the extent to which genetically different populations of a species are dispersed across the landscape, with more diverse and widely scattered populations probably being more resilient to change)
- **functional redundancy of species** (the higher number of species that can play a similar role in the ecosystem functioning, then the greater the resilience - if some of these species disappear because of climate change the overall ecosystem will still continue to function)

When further considering the resilience of individual key species within each ecosystem, the following are also important:

- **Life history traits of species** will determine the ability to adapt to change (species with high reproductive rates, fast life history, short life span and ability to disperse widely across habitats to track the preferred climate space, are predicted to be more resilient and recover faster from change)
- `**Ecological' plasticity of species** or the ability of individuals and populations to make active changes in the short- term - both physiological changes (e.g. acclimation, modified thermoregulation) or behavioural changes (e.g. seeking out shelter within the existing habitat, dispersing away from the site to more suitable areas, changes in daily or seasonal temporal activity, changes in

microhabitat use within the site, changes to biotic interactions) allows species to cope with change.

Table 0.11: Summary of Key Points of Quang Binh Ecosystems for Resilience and EbA

Ecosystem type	Amount	Status (condition) & main threats	Main Climate Vulnerability
Semi-tropical broadleaf moist evergreen forest >700m altitude	26,000 ha	Medium size area, good condition some in Vu Quang National Park SFU, and some in other high elevation Protection Forest areas	Already at high altitude, may have restricted opportunity to move to when temperature increases; Increased risk of forest fire with more very hot days and longer/drier dry season Conditions may become too wet for some species as soils get waterlogged with more abundant and intense rainfall in the rainy season. Species composition may change over time
Tropical broadleaf moist evergreen forest <700m altitude	205,000 ha	Very large area but of varying condition. A lot of secondary forest that had previously been logged. Large areas smothered by invasive climbers. Illegal logging a problem in some areas. A large proportion is in Vu Quang National Park and Ke Go Nature reserve, as well as a nuber of different protection forests	Conditions may become too dry for some species in longer hotter dry seasons, so species composition of the forest may change over time Conditions may become too wet for some species as soils get waterlogged with more abundant and intense rainfall in the rainy season. Species composition of the forest may change over time
Rivers and streams	100+ short rivers with 400 km combined length, 13 billion cubic metres	Headwaters in forested areas can be expected to be in reasonable condition; In lower reaches riparian vegetation has been removed as crop fields go right to the river edge; Natural movement of rivers	Rivers will have lower flows in dry season and higher flows in rainy season due to changed rainfall patterns. Saline intrusion up rivers will increase with sea level rise and with lower dry season flows

Ecosystem type	Amount	Status (condition) & main threats	Main Climate Vulnerability
	annual flow	across the floodplain has been restricted by dykes and polders; Natural flows of water and sediment have been interrupted by construction of reservoirs and saline intrusion barriers	
Open water bodies (ponds, lakes and lagoons)	700 million m^3	Natural vegetation around open water bodies has been mostly replaced by casuarina and acacia, and the water bodies themselves have mostly be trained for agriculture. At least one lagoon is still managed for fisheries production.	Heavy rains and storms may cause increased erosion in headwaters areas that will cause faster in-filling of the water bodies with sediment The overall net effect on the size of water bodies of increased rainfall in the rainy season and increased evaporation in the hotter dry season is unclear
Mangroves	752 ha	Mangroves are found in scattered patches in the estuaries, and are heavily degraded, and of low stature	Small remaining area, with lack of connectivity of different patches and barriers to landward movement makes mangroves very vulnerable to SLR and temperature changes
Melaleuca Forests	N/A	Only very small remnant areas remain. Even these small area are still being cut for firewood by local people	The small size of remaining areas greatly reduces resilience to climate changes
Sandy beaches and sand dune /sandy	38,000 ha	Sandy areas account for a significant part of the coastal zone – but have mostly been heavily degraded by a combination of human	Stronger and more unpredictable storms will blow more sand and blow it more vigorously. As there is very little natural vegetation

Ecosystem type	Amount	Status (condition) & main threats	Main Climate Vulnerability
area ecosystems		settlement, tourism development, aquaculture, agriculture, titanium mining and development of a Special Economic Zone. Native species tree cover has been replaced with casuarina and some acacia	to hold the sand, the ecosystem is likely to be further degraded by climate change
Sea-grass beds	Unknown area	Unknown – but based on overall trends in Vietnam, are expected to be fairly degraded	SLR, higher water turbidity from storms
Coral reefs	Unknown area	Unknown - but based on overall trends in Vietnam, are expected to be fairly degraded	SLR, increased sea water temperature, ocean acidity

As identified in Chapter 2, the population in 2002, 2006, 2011 and 2015 was 1,277,878; 1,288,513; 1,237,809 and 1,261,288 people, respectively. Overall, about 16 % of the provincial population is urban, including the district headquarters, and 84% rural (Statistics Office, Ha Tinh, 2015). The mean population density is 211 persons/km^2 in 2015, but there are very distinct patterns in population distribution, which are reflected in land-use patterns and have implications for the extent, condition and resilience of ecological systems, as well as for climate change adaptation.

The majority of Ha Tinh's population (~ 80%) is concentrated in the lowland and coastal areas, broadly mirroring the distribution of paddy rice cultivation areas, the provincial capital of Ha Tinh and the route of the main national road 1A. It is therefore understandable that the ecosystems found in the lower reaches of river basins, in the estuaries river mouths and along the coastlines have been the most transformed from their original state. In the lowlands and coastal area, most areas of original natural ecosystems have either disappeared entirely or been highly degraded. Mangrove forest, and Melaleuca forest only exist in small remnant patches. Sandy beaches have been impacted by tourism development, fishing village settlement and the development of aquaculture on sandy areas, as well as titanium mining and the development of the Vung Ang Special Economic Zone. There is very little natural riparian vegetation and floodplain vegetation in the lower reaches of the main rivers, and the flow regimes of these rivers have been altered through water infrastructure development. Estuaries have been highly developed and estuarine ecosystem functioning significantly altered. The people living in these areas are also most exposed to some of the most extreme climatic events - tropical storms, tidal surges, saline intrusion, while at the same time has the least remaining natural environment to support their resilience.

- **In this situation, most of the remaining lowland and coastal ecosystems are not in a good position to be able to offer significant ecosystem services that help build resilience to climate change - and these ecosystems themselves may not survive the double stresses of their current degradation together with climate change for much longer**

The large number of small densely populated communes in the lowlands contrasts with the large sparsely populated districts in the upland areas, where large areas of uninhabited forests remain. In Huong Khe district, the average population density is less than 50 persons/km^2. At the same time Huong Khe has over 95,000 ha of forest and Huong Son over 80,000ha - together accounting for over half of the remaining forest land of the province (MARD-FIPI, 2012). As identified in Chapter 2, the poverty rate is also high in the mountainous districts. Poverty increases vulnerability to climate change and reduces the capacity to adapt. Livelihoods that are dependent on natural resources such as forestry tend to be more vulnerable to the changing climate. Furthermore, the less diversified a family's livelihood is,

the more vulnerable it is likely to be since if one livelihood aspect suffers impacts of climate change, they lack alternatives to fall back on. Settlements in the mountainous areas are still quite concentrated in river valleys or other transport routes. People inhabiting the narrow inland valleys are subject to flash flooding and cold snaps, and on the mountain slopes to landslides, drought, high temperatures and hot winds from Laos.

A significant proportion of rthe remaining forest is protected in Vu Quang National Park and Ke Go nature reserve, as well as their adjacent buffer zones.

- **In this situation the forest still provides very significant ecosystem services, and can make a huge contribution to building increased resilience to climate change if managed properly.**

3.6. Conclusions

Reviewing the extent condition and trends of ecosystems in Ha Tinh, it seems that in the lowlands and coastal areas most original natural ecosystems have disappeared or been highly degraded. There is very little mangrove forest, and only small patches of melaleuca forest. Most coastal protection forest is single species casuarina plantation. Large sandy areas have been removed for the Formosa development or otherwise degraded or destroyed by titanium mining and aquaculture development. There is very little natural riparian vegetation and floodplain vegetation in the lower reaches of the main rivers, and the flow regimes of these rivers have been altered through water infrastructure development.

At the same time, as already identified in Chapter 2, the densest human populations in Ha Tinh are in the coastal lowlands. Here too are the largest numbers of poor people, who are on the front-line for many of the region's most severe climate events. Although the provincial population is increasing slowly, the fastest increase is taking place in the lowlands, where exposure is greatest. The growing population is accompanied by increasing urbanisation, which may exacerbate certain climate related problems - like flooding and heat stress.

- **In this situation, these remaining lowland and coastal ecosystems are not in a good position to be able to offer ecosystem services that help build resilience to climate change - and these ecosystems themselves may not survive the double stresses of their current degradation together with climate change for much longer. Any EbA intervention in the lowland and coastal areas of Ha Tinh would have to involve a large-scale ecosystem restoration effort. It would require significant investment but could also provide very significant returns on investment. For example mangroves can increase surface elevation from 1-10mm/year, keeping pace with sea level rise; and because 75% of all tropical fish species spend some part of their life cycle associated with mangroves, then each hectare of mature mangroves roughly translates to one additional ton of**

fisheries production per year; and for the best return on investment of all, each $1 million invested in mangroves in Vietnam can reduce the budget needed for dyke maintenance by over $6 million (Schmitt et.al., 2013)

In the hilly and mountainous areas there is still significant forest cover. A large proportion of this is natural forest, of varying condition. As identified in Chapter 2, the poverty rate is high in the mountain districts. Poverty increases vulnerability to climate change and reduces the capacity to adapt. Livelihoods that are dependent on natural resources such as forestry tend to be more vulnerable to the changing climate. Furthermore, the less diversified a family's livelihood is, the more vulnerable it is likely to be since if one livelihood aspect suffers impacts of climate change, they lack alternatives to fall back on. In this situation the forest still provides very significant ecosystem services, and can make a huge contribution to building increased resilience to climate change if managed properly.

In this assessment, 'ecosystem-based approach to climate change adaptation' is understood as promoting the conservation and restoration of ecological processes and habitats that build both ecosystem and community resilience to climate changes by maintaining ecosystem services that protect and support livelihoods and infrastructure. This initial analysis suggests that, from the ecological perspective, priority areas for further assessment at the local level, and development of EbA interventions could be formerly logged-over and partially degraded watershed forests, such as those of Ke Go. Improved management in general, together with a number of specific interventions could greatly enhance the resilience of these forests, and the ecosystem services they supply, in the face of climate change. Climate change mitigation, and biodiversity conservation co-benefits would also result from these interventions.

A micro-level assessment of Ke Go Nature Reserve could focus on:

- Getting a better understanding of the success of enrichment planting with indigenous species and assessing the effectiveness of this in reducing sensitivity to climate hazards, as well as identifying options and possibilities for further expansion of this approach
- Compiling information on temperature tolerances of different indigenous species and identifying the species that should be prioritized for planting based on their suitability for the expected future climate conditions
- Getting a better understanding of the level of illegal logging, poaching and encroachment (including through use of remote sensing and drones)
- Getting a better understanding of NTFP collection and its relative importance to local livelihoods
- Identifying a list of possible interventions that could improve management outcomes of the nature reserve, while also contributing to livelihood diversification and income generation for local people

Some initial ideas for EbA and related interventions might include:

3.6.1. Improved management of Ke Go nature reserve and Ke Go Reservoir

- Involving local communities in enrichment planting of NTFPs (rattan and other palms) while at the same time setting harvesting agreements and quotas for sustainable collection (this will create more good habitat for the pheasants as well it has been suggested that the pheasants eat rattan seeds and make their nests under the palms collected for conical hats)
- Establishing a captive breeding centre for Vo Quy Pheasant which could also generate income as a tourist attraction, and preparing for eventual reintroduction of the pheasants at a time when conservation agreements can be reached with communities to eliminate snaring
- Introduction of bamboo growing in degraded areas and development of bamboo products

3.6.2. Maintaining/restoring natural flows and rewilding rivers

- At least one of the main rivers in Ha Tinh could be maintained in a relatively natural state. Release of water from upstream reservoirs could be managed to maintain environmental flows. In the lower reaches, dykes/polders could be removed and space should be provided to allow the river to move naturally. No additional saline intrusion barriers should be built. Crop fields should be set back from the river's edge and riparian vegetation replanted.

3.6.3. Landscape connectivity of natural terrestrial forest

- To enhance the resilience of natural forest, corridors should be maintained linking different areas of natural forest together. In this way connectivity can be maintained between SFU Forest in Vu Quang and Ke Go, as well as other forms of forest in the wider landscape.

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