

BIODIVERSITY AND ECONOMIC VALUE OF WETLAND RESOURCES AT NONG HAN, UDONTHANI PROVINCE, NORTHEAST THAILAND

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ABSTRACT

A biodiversity survey was conducted at the Nong Han wetland, Udonrthani, and within a 3-km radius from June to August, 2006, as part of Udonrthani's provincial natural resource and environmental management plan. Economic valuation was also carried out to estimate net direct benefits earned by local communities from the biodiversity resources. Nong Han is a wetland of international importance. The area is surrounded by marshes, agricultural zones, dikes, and scattered woodlands. The only populated island, called Donkaew, is situated in the southwestern end of the wetland. The survey identified 177 plant species, including 114 tree species (74 native and 40 introduced) and 63 aquatic plants (38 marginal, 10 floating, 9 emerged, and six submerged species). In total, 17 orders, 44 families, and 75 species of invertebrates were identified from Ekman grab and pond net samples. Arthropods were the most diverse and abundant invertebrates, followed by mollusks and annelids. Forty-six species of fish from 18 families were recorded from fish captured by local villagers. Fifty-two bird species, including Asian Golden Weaver *Ploceus hypoxanthus* which is globally Near-Threatened (IUCN Red List of Threatened Species, 2006), and Purple Heron *Ardea purpurea*, Steaked Weaver *P. manyar* and Asian Golden Weaver *P. hypoxanthus* which are Vulnerable in Thailand, were observed using point counts. From the economic valuation, the direct use value of the biodiversity resources estimated from gross benefits and harvesting costs, including tools, equipment, traveling and labor costs, was 10,534 baht/household. This value accounted for 32% of the annual household income for this local economy. In conclusion, as Nong Han is home of great biodiversity and contributes to local livelihoods, inventory of the resources and their economic value is necessary for effective biodiversity management. Useful data will enable decision makers to develop management plans that promote habitat protection and sustainable use.

Keywords: biodiversity, economic value, Nong Han wetland

INTRODUCTION

Biodiversity represents the foundation of wetland ecosystems that affect human well-being, especially local livelihoods. Wetlands provide feeding and breeding sites for various plants and animals, help control flooding and water quality, and support nutrient

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cycling. Wetlands are also sources of household income and provide land and resources for traditional agriculture, ecotourism, and recreational activities.

In Thailand, wetlands cover a total of 36,616 km² or approximately 7.5% of the country's total area (OFFICE OF ENVIRONMENTAL POLICY AND PLANNING, 2002), consisting of two broad categories: freshwater and coastal wetlands. One of the most important freshwater sites is Nong Han Kumpawapi in Udonthani Province, the second largest freshwater lake in the northeastern Thailand. Nong Han wetland covers an area of approximately 45 km² with an average depth of the lake of 1–2 m. The largest and only populated island, named Donkaew, is situated in the southwestern end of Nong Han, and several smaller islands are scattered in the lake area. Dikes and water channels were built for flood control and irrigation purposes. Major land uses around Nong Han include rice paddies, cassava plantations, livestock grazing, and residential areas.

The wetland consists of several habitat types, including freshwater lakes, marshes, scattered woodlands, and agricultural areas (Fig. 1). Nong Han provides habitats for over 74 bird species and at least 39 native fish species (OFFICE OF NATURAL RESOURCES AND ENVIRONMENTAL POLICY AND PLANNING, 2007). In addition, a large number of villages, including the District of Kumpawapi, are located in or around the wetland and depend on it for a variety of goods and services.

Increased economic and social development resulting from expansion of the population in this area has put intensive pressure on the wetland resources; causing deterioration of the ecosystem. Hence, the Office of Udonthani Provincial Natural Resources and Environment is now developing a natural resource and environmental management plan in order to ensure both sustainable use and conservation of wetland resources at Nong Han Kumpawapi. This survey-based research was carried out as part of this management program. The study aims to create a biodiversity inventory, including plants, invertebrates, fish, and birds at Nong Han and its 3-km radius proximity. It also aims to estimate the economic value of all direct benefits of the wetland products gained by local communities.

METHODS

Biodiversity data were collected monthly from June to August, 2006¹, at selected villages representing the four sub-districts surrounding Nong Han. Aquatic and non-aquatic plants and trees at Nong Han wetland, including the main lake, islands, dikes and agricultural zones and grasslands outside the dikes but within 3-km radius proximity, were identified at the sites. Unknown species were collected and/or photographed for further examination in the laboratory. Benthic invertebrates were collected using an Ekman grab sampler and pond net sampling. Identification was based mainly on MERRIT & CUMMINS (1996) and MORSE *ET AL.* (1994). Fish species were identified from daily catches by local villagers at Don Klang,

¹The Office of Udonthani Provincial Natural Resources and Environment allocated a 5-month period (May–September, 2006) for this project. As a result, all field surveys were designed to complete in August, so data collected represented biodiversity in the rainy season.



a



b

Figure 1. Wetland habitats at Nong Han: a) the open water lake with floating plants and b) submerged and emerged plants at Dong Luang Island—one of the largest islands in Nong Han wetland.

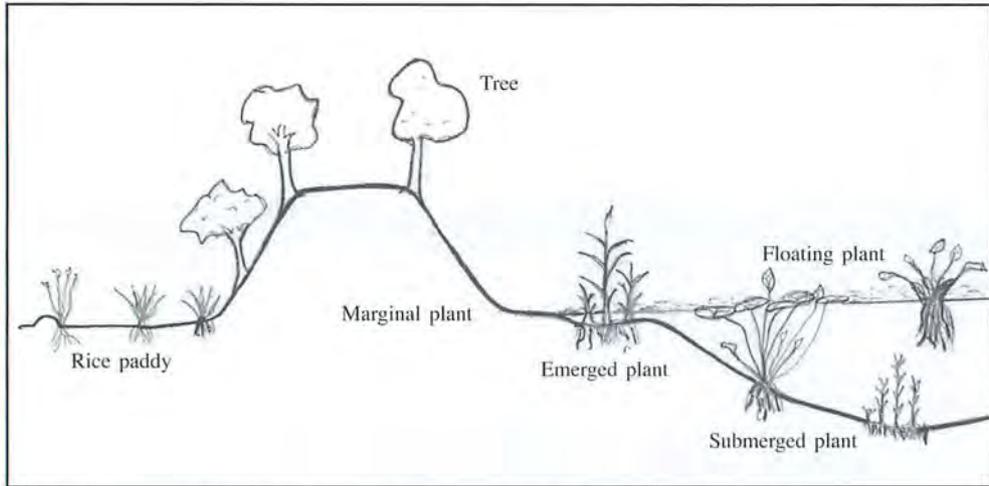


Figure 2. Diagram of where plant species were observed in the studied area

Don Nguen, Donkaew, and Dium villages. Fish were photographed and specimens were collected for preservation. Species identification was based on VIDTHAYANON (2004) and RAINBOTH (1996). For bird surveys, point counts were employed. The surveys took place at six locations, representing all habitat types around Nong Han, during two periods: morning (0700–0900 h) and afternoon sessions (1500–1700 h). Time spent at each point was approximately 10 minutes within a 1-km radius distance. LEKAGUL & ROUND (1991) was used for species identification.

Economic valuation focuses on direct use value, representing direct benefits of biodiversity resources gained by local communities. This part of the study took place in June, 2006 with groups of villagers from Don Klang, Don Nguen, Donkaew, and Dium villages. These communities represent each of the four sub-districts surrounding Nong Han where local people share common social and economic backgrounds and therefore, we assumed that their consumption practices should be similar. With a total number of 690 households from these four villages, a 200-household sample size was selected according to LOOMIS & WALSH, (1997) who suggested that a range of appropriate sample sizes for economic valuation should be 200 up to 1,000 households or individuals. Semi-structured questionnaires were used to gather data on types and amounts of wetland products harvested, market prices, and harvesting costs.

A net economic value of the resources was calculated from gross direct benefits (Eq. 1), subtracted by direct costs, including the sum of harvesting tools, equipment, traveling and labor costs (Eq. 2). Depreciation was considered to determine present values of tools and equipment (e.g., fishing nets, boats and motors, baskets, carts, and flashlights). Traveling cost was measured from fuel prices and quantities used for each harvesting trip during the year. Labor cost was estimated from local daily wages but only applied for fishermen who bore the opportunity costs. Villagers that decided to become fishermen would no longer perform most other beneficial activities. On the other hand, another group of villagers collected wetland products as alternative source of income or supplement diet during off growing seasons. Their opportunity costs are benefits of time spent in wetland product collection.

$$\text{Gross direct use value} = \sum_i (q_{ij} \times p_i) \quad \text{Eq. (1)}$$

Where q = quantity of products, p = market prices, i = product item and j = households reported of harvesting products.

$$\text{Net direct use value} = \sum_j [\sum_i (q_{ij} \times p_i) - C_j] \quad \text{Eq. (2)}$$

Where C = harvesting costs, including tools, equipment, traveling and labor costs.

RESULTS

Nong Han Kumpawapi provides diverse habitats for a great number of plants and animals. Moreover, the wetland resources greatly contribute to local livelihoods both household consumption and income generation. The following sections present plant and animal diversity and direct economic value obtained by villagers.

Diversity of Plants

The survey identified 177 plant species, including 114 tree species and 63 aquatic plants. Table 1 presents numbers of species observed in each area with dominant species. Of the tree species, 74 are native and 40 are introduced. Of the aquatic plants, 38 species are marginal, 10 are floating, 9 are emerged, and 6 are submerged (Table 2). Figure 2 presents a diagram of where plant species were observed.

Table 1. Plant diversity in each area with dominant species

Area	Number of species	Dominant species
Submerged zone	14	<i>Hydrilla verticillata</i> , <i>Najas graminea</i> , <i>Nymphaea lotus</i> , <i>Nelumbo nucifera</i> , and <i>Eichhornia crassipes</i>
Open water: floating plants	31	<i>E. crassipes</i> , <i>Cyperus imbricatus</i> , <i>Mimosa pigra</i> , <i>Hymenachne pseudointerrupta</i> , <i>Leersia hexandra</i> , <i>Arundo donax</i> , and <i>Scirpus grossus</i>
Marshes	37	<i>M. pigra</i> , <i>Colocasia esculenta</i> var. <i>aquafiliis</i> , <i>S. grossus</i> , <i>C. imbricatus</i> , <i>N. nucifera</i> , <i>Brachiaria mutica</i> , <i>H. pseudointerrupta</i> , <i>A. donax</i> and <i>L. hexandra</i>
Islands	98	<i>Zizyphus mauritiana</i> , <i>Pithecellobium dulce</i> , <i>Mangifera indica</i> , <i>Dipterocarpus alatus</i> , <i>Eucalyptus camaldulensis</i> , and <i>Combretum quadrangulare</i>
Dikes	26	<i>P. dulce</i> , <i>C. quadrangulare</i> , and <i>Z. mauritiana</i>
Rice paddies/grasslands outside the dikes	20	<i>S. grossus</i> , <i>M. pigra</i> , <i>N. nucifera</i> , <i>H. pseudointerrupta</i> , and <i>C. imbricatus</i>

Table 2. Aquatic Plants indentified at Nong Han at different habitat types: open water, marshes, agricultural zones and grasslands.

No.	Family	Scientific name	Abundance	Habitat
1	ALISMATACEAE	<i>Sagittaria sagittifolia</i> L.	*	M
2	AMARANTHACEAE	<i>Alternanthera sessilis</i> (L.) R.Br. ex DC	**	M/G
3	APIACEAE	<i>Centella asiatica</i> L.	*	M
4	ARACEAE	<i>Colocasia esculenta</i> (L.) Schott var. <i>aquafilis</i> Hassk.	***	M
5		<i>Pistia stratiotes</i> L.	*	W
6	ASTERACEAE	<i>Eclipta prostrata</i> L.	*	M/G
7	ATHYRIACEAE	<i>Ceratopteris thalictroides</i> (L.) Brongn.	*	M/A
8		<i>Diplazium esculentum</i> (Retz.) Sw.	*	M
9		<i>Lygodium</i> sp.	*	M
10	AZOLLACEAE	<i>Azolla pinnata</i> R. Brown	*	W
11	CAMPANULACEAE	<i>Sphenoclea zeylanica</i> Gaertn.	*	M/A
12	CHARACEAE	<i>Chara zeylanica</i> Kl. ex Wild.	**	W
13	COMMELINACEAE	<i>Commelina diffusa</i> Burm. f.	**	A/G
14	COMPOSITAE	<i>Ageratum conyzoides</i> L.	*	G/A
15	CONVOLVULACEAE	<i>Ipomoea aquatica</i> Forssk.	**	W
16	CYPERACEAE	<i>Cyperus corymbosus</i> Rottb.	**	M/A
17		<i>Cyperus difformis</i> L.	**	M/A
18		<i>Cyperus imbricatus</i> Retz.	***	M/A
19		<i>Cyperus procerus</i> Rottb.	**	M/A
20		<i>Eleocharis dulcis</i> (Burm.f.) Trin. ex Hensch.	*	M/A
21		<i>Fimbristylis miliacea</i> (L.) Vahl.	**	M/A
22		<i>Scirpus grossus</i> L.f.	***	M/A
23		<i>Scleria</i> sp.	**	M
24	GENTIANACEAE	<i>Nymphoides indica</i> (L.) O. Kuntz.	*	W
25	GRAMINEAE	<i>Arundo donax</i> L.	***	M
26		<i>Hymenachne pseudointerrupta</i> C. Muell	***	M/A
27		<i>Imperata cylindrica</i> (L.) Beauv.	**	G/A
28		<i>Leersia hexandra</i> Sw.	***	M
29		<i>Phragmites karka</i> (Retz.) Trin. ex Steud.	*	M
30	HYDROCHARITACEAE	<i>Hydrilla verticillata</i> (L.f.) Royle.	***	W
31	LEMNACEAE	<i>Wolffia arrhiza</i> (L.) Wimm.	*	W
32	LENTIBULARIACEAE	<i>Utricularia aurea</i> Lour.	**	W
33	LIMNOCHARITACEAE	<i>Limnocharis flava</i> (L.) Buch.	**	M
34	MARSILEACEAE	<i>Marsilea crenata</i> Presl.	**	W/M/A
35	MIMOSACEAE	<i>Mimosa pigra</i> L.	***	M
36		<i>Neptunia oleracea</i> Lour.	*	W
37	NAJADACEAE	<i>Najas graminea</i> Del.	***	W

Table 2 (continued).

No.	Family	Scientific name	Abundance	Habitat
38	NELUMBONACEAE	<i>Nelumbo nucifera</i> Gaertn.	***	W
39	NYMPHAEACEAE	<i>Nymphaea lotus</i> L.	***	W
40		<i>Nymphaea pubescens</i> Willd.	**	W
41		<i>Nymphaea stellata</i> Wild.	**	W
42	ONAGRACEAE	<i>Fissendocarpa linifolia</i> Bennet.	*	M/A
43		<i>Jussiaea repens</i> L.	**	W/M
44	PAPILIONACEAE	<i>Aeschynomene aspera</i> L.	**	M/A
45		<i>Aeschynomene indica</i> L.	**	M/A
46		<i>Phaseolus adenanthus</i> W. Mey.	**	M
47		<i>Sesbania rostrata</i> Bremek. & Oberm.	**	M/A
48	POACEAE	<i>Brachiaria mutica</i> (Forsk.) Stapf.	***	M/A/G
49		<i>Echinochloa crus-galli</i> L.	*	M/A/G
50		<i>Saccharum</i> sp.	*	M
51	POLYGONACEAE	<i>Polygonum tomentosum</i> Willd.	**	M/A
52	PONTEDERIACEAE	<i>Eichhornia crassipes</i> (Mart.) Solms	***	W
53		<i>Monochoria hastata</i> L.	*	M
54		<i>Monochoria hastata</i> Solms. var. <i>elata</i> Backer.	**	M
55	SALICACEAE	<i>Salix tetrasperma</i> Roxb.	*	M
56	SALVINIACEAE	<i>Salvinia cucullata</i> Roxb.	**	W
57	SCROPHULARIACEAE	<i>Limnophila aromatica</i> Merr.	*	M/A
58		<i>Limnophila laotica</i> Bonati.	*	M/A
59		<i>Limnophila</i> sp.	*	M/A
60	TRAPACEAE	<i>Trapa natans</i> L. var. <i>pumula</i> Nakano	*	W
61	TYPHACEAE	<i>Typha angustifolia</i> L.	**	M
62	XYRIDACEAE	<i>Xyris indica</i> L.	*	M/A
63	ZYGNEMATAACEAE	<i>Spirogyra</i> sp.	*	W
36 families		63 species		

Note: Abundance: *** = the most abundant, ** = moderately abundant, * = the least abundant. Identification for levels of abundance was based on field observations both area coverage and frequency of occurrence. Habitat (where species were observed): W = open water, M = marshes, A = agricultural zones, G = grasslands.

Invertebrate Diversity

In total, 17 orders, 44 families, and 75 species of invertebrates were identified (Table 3). Arthropods represent the most diverse and abundant invertebrates, followed by mollusks and annelids. Many of these invertebrates, especially golden apple snails (*Pomacea canaliculata*) and shrimps, are collected for animal feed (e.g., ducks and fish), household consumption, and for sale in fresh markets. In addition, some invertebrates are considered biological indicators of water quality. From this study, the majority of invertebrates identified (i.e. *Ephemera* sp.,

Ephemeraeidae; *Caenoculis* sp., Caenidae; *Dipseudopsis* sp., Dipseudopsidae; and *Ecnomus* sp., Ecnomidae) indicate that the water quality at Nong Han is fair to slightly poor (SANGPRADUB ET AL. 1997).

Fish Species

Forty-six species of fish classified into 18 families were recorded from fish captured by local villagers (Table 4). The majority of fish (16 out of 46 species) were in family Cyprinidae. All fish species except one are native; the introduced species is *Oreochromis niloticus* (family Cichlidae). None of the fish species is considered endangered according to IUCN Red List of Threatened Species. Only *Betta splendens* is considered Threatened in situ and one species of catfish (*Clarias batrachus*) is considered Vulnerable (VIDTHAYANON, 2005).

Bird Diversity

Fifty-two bird species and 1,917 individuals were observed from point counts at six locations around Nong Han. According to LEKAGUL & ROUND (1991), 36 species are resident, 8 are winter visitors, and 4 are breeding visitors. The Asian Golden Weaver *Ploceus hypoxanthus* is considered globally Near Threatened (IUCN, 2006) and Purple Heron *Ardea purpurea*, Steaked Weaver *P. manyar* and Asian Golden Weaver *P. hypoxanthus* are Vulnerable in Thailand (SANGUANSOMBAT, 2005), although they are globally listed as species of Least Concern (IUCN, 2006). Table 5 summarizes bird species that are considered Threatened according to IUCN, CITES and Thailand's Red Data.

Wetland Resources and their Economic Value

Use of the wetland resources ranges from fishery to non-fish product collection (e.g., aquatic vegetables, fibers, medicines, amphibians and reptiles), water supply, agriculture, irrigation, transportation, and ecotourism. Wetland product collection is maintained according to traditional practice. Villagers gather what is available during all times of the year, basically for subsistence economy rather than massive commercial (Fig. 3).

From the economic valuation survey, approximately 97% of respondents reported that they accessed Nong Han for wetland product collection. Villagers spent about 5.29 hours a day in wetland product collection and 13.7 days a month for an average of 11.5 months per year. Approximately 83.5% of the participants indicated that they used these products for both household consumption and market sale; only 16.5% reported gathering these products for household consumption alone. With an average family income of 32,923 baht per year, a household earns about 9,700 baht per year from selling wetland products, especially fish.

A variety of wetland products is reported being gathered by villagers (Fig. 4). These can be classified into three major groups, including fish, aquatic plants and algae (e.g., water lily, lotus, morning glory and water hyacinth), and animals (shrimps, frogs, and golden apple snails). Fish account for the largest proportion of all harvested products, comprising at least 46 species. From the total estimated amount of wetland products (142,274 kg), 121,732 kg or approximately 86%, come from captured fish (Table 6). Gross direct use value of wetland products was estimated 4,201,150 baht in 2006.

Table 3. Orders, families, and species of invertebrates identified at Nong Han

Order	Family	Genus/species	
Amphipoda			
Buccinacea	Buccinidae	<i>Clea helena</i>	
Coleoptera	Dytiscidae	<i>Hyphydrus</i> sp.	
	Dytiscidae	<i>Laccophilus</i> sp.	
	Dytiscidae		
	Gyrinidae	<i>Orectochilus</i> sp.	
	Hydrophilidae		
Collembola			
Dacapoda	Palaemonidae	<i>Macrobrachium lanchesteri</i>	
	Parathelphusidae	<i>Parathelphusa</i> sp.	
Diptera	Ceratopognidae	<i>Bezzia</i> sp.	
	Chaoboridae	<i>Chaoborus</i> sp.	
	Chironomidae	<i>Crytochironomus</i> sp.	
	Chironomidae	<i>Dicrotendipes</i> sp.	
	Chironomidae	<i>Einfeldia</i> sp.	
	Chironomidae	<i>Pentaneura</i> sp.	
	Chironomidae	<i>Polypedilum</i> sp.	
	Chironomidae	<i>Pupa</i>	
	Chironomidae	<i>Tanypodina</i> sp.	
	Chironomidae		
	Tabanidae	<i>Tabanus</i> sp.	
	Tipulidae	<i>Limnophila</i> sp.	
	Ephemeroptera	Baetidae	<i>Baetis</i> sp.
		Baetidae	<i>Cloeon</i> sp.
Caenidae		<i>Caenoculis</i> sp.	
Ephemeridae		<i>Ephemera</i> sp.	
Polymitaroyidae		<i>Povilla heardi</i>	
Hemiptera	Belostomatidae	<i>Diplonychus rusticus</i>	
	Corixidae	<i>Micronecta</i> sp.	
	Gerridae	<i>Neogerris</i> sp.	
	Gerridae	<i>Rheumatogonus</i> sp.	
	Mesoveliidae	<i>Mesovelia</i> sp.	
	Naucoridae	<i>Naucoris</i> sp.	
	Nepidae	<i>Ceracotmetus</i> sp.	
	Nepidae	<i>Cercometus asiaticus</i>	
	Nepidae	<i>Ranatra</i> sp.	
	Notonectidae	<i>Aphelonecta</i> sp.	
	Notonectidae	<i>Nychia</i> sp.	
	Notonectidae	<i>Walambianisops</i> sp.	
	Hirudinea	Glossiphoniidae	
Lymnaeacea	Lymnaeidae	<i>Lymnaea</i> sp.	

Table 3 (continued).

Order	Family	Genus/species
Mesogastropoda	Ampullariidae	<i>Pomacea</i> sp.
	Bithyniidae	<i>Bithynia siamensis</i>
	Bithyniidae	<i>Bithynia</i> sp.
	Bulinidae	<i>Indoplanorbis exustus</i>
	Hydrobiidae	<i>Clenchiella</i> sp.
	Thiaridae	<i>Brotia pseudoasperata</i>
	Viviparidae	<i>Filopaludina martensi</i>
Odonata	Coenagrionidae	<i>Acriagrion</i> sp.
	Coenagrionidae	<i>Agriocnemis</i> sp.
	Coenagrionidae	<i>Cercion</i> sp.
	Coenagrionidae	<i>Coenagrion</i>
	Coenagrionidae	<i>Ischnura</i> sp.
	Coenagrionidae	<i>Pyrrhosoma</i> sp.
	Gomphidae	<i>Orientogomphus</i> sp.
	Gomphidae	<i>Trichophus</i>
	Gomphidae	<i>Trigomphus</i> sp.
	Libellulidae	<i>Brachythermis</i> sp.
	Libellulidae	<i>Libellula</i> sp.
	Libellulidae	<i>Nannophya</i> sp.
	Libellulidae	<i>Pantala</i> sp.
	Libellulidae	<i>Pseudothemis</i> sp.
	Macromiidae	<i>Macromia</i> sp.
Macromiidae	<i>Epophthalmia</i> sp.	
Protoneuridae		
Oligochaeta		
Ostracoda		
Trichoptera	Dipseudopsidae	<i>Dipseudopsis</i> sp.
	Dipseudopsidae	<i>Pseudoneureclipsis</i> sp.
	Ecnomidae	<i>Ecnomus</i> sp.
	Leptoceridae	<i>Ocetis</i> sp.
Unionoida	Amblemidae	<i>Scabies crispata</i>
	Amblemidae	<i>Physunio</i> sp.
	Amblemidae	<i>Ensidens ingallsianus</i>
Veneroida	Corbiculidae	<i>Corbicula</i> sp.

Table 4. Fish species identified from daily fish catches by local fishermen at Nong Han.

Order	Family	Species	
Beloniformes	Belonidae	<i>Xenentodon cancila</i>	
Cypriniformes	Cobitidae	<i>Acantopsis</i> sp.	
		<i>Pangio anguillaris</i>	
	Cyprinidae	<i>Barbodes altus</i>	
		<i>Barbodes gonionotus</i>	
		<i>Clupeichthys goniognathus</i>	
		<i>Cyclocheilichthys apogon</i>	
		<i>Cyclocheilichthys repasson</i>	
		<i>Epalzeorhynchus frenatum</i>	
		<i>Hampala dispar</i>	
		<i>Henicorhynchus siamensis</i>	
		<i>Labiobarbus siamensis</i>	
		<i>Luciosoma bleckeri</i>	
		<i>Morulus chrysophekadion</i>	
		<i>Osteochilus hasselti</i>	
		<i>Parachela siamensis</i>	
		<i>Puntioplites proctozyron</i>	
		<i>Puntius brevis</i>	
<i>Rasbora trilineata</i>			
Osteoglossiformes	Notopteridae	<i>Notopterus notopterus</i>	
Perciformes	Anabantidae	<i>Anabas testudineus</i>	
	Belontiidae	<i>Betta smaragdina</i>	
		<i>Trichogaster pectoralis</i>	
		<i>Trichogaster trichopterus</i>	
		<i>Trichopsis vittata</i>	
		Chandidae	<i>Parambassis siamensis</i>
		Channidae	<i>Channa lucius</i>
			<i>Channa micropeltes</i>
			<i>Channa striata</i>
		Cichlidae	<i>Oreochromis niloticus</i>
		Eleotrididae	<i>Oxyeleotris marmorata</i>
		Nandidae	<i>Nandus oxyrhynchus</i>
			<i>Pristolepis fasciata</i>
Siluriformes	Bagridae	<i>Hemibagrus filamentus</i>	
		<i>Mystus multiradiatus</i>	
		<i>Mystus mysticetus</i>	
		<i>Mystus singaringan</i>	
		<i>Mystus singaringan</i>	
	Clariidae	<i>Clarias batrachus</i>	
		<i>Clarias macrocephalus</i>	
	Siluridae	<i>Ompok bimaculatus</i>	
		<i>Wallago attu</i>	
		<i>Wallago attu</i>	
Synbranchiformes	Chaudhuriidae	<i>Chaudhuria caudata</i>	
	Mastacembelidae	<i>Macrognathus siamensis</i>	
		<i>Mastacembelus favus</i>	
	Synbranchidae	<i>Monopterus albus</i>	
Tetraodontiformes	Tetraodontidae	<i>Tetraodon palembangensis</i>	

Table 5. Bird species that are considered endangered, threatened, near threatened or vulnerable according to IUCN, CITES, Thailand's Red Data List.

No.	Common name	Scientific name	Conservation status			Migratory status
			IUCN	CITES	Thai List	
1	Purple Heron	<i>Ardea purpurea</i>	-	-	VU	Winter visitor
2	Steaked Weaver	<i>Ploceus manyar</i>	-	-	VU	Resident
3	Asian Golden Weaver	<i>P. hypoxanthus</i>	NT	-	VU	Resident
4	Little Egret	<i>Egretta garzetta</i>	-	III	-	Winter visitor
5	Cotton Pygmy-Goose	<i>Mettapus coromandelianus</i>	-	-	NT	Winter visitor
6	Lesser Whistling-Duck	<i>Dendrocygna javanica</i>	-	III	-	Winter visitor
7	Brahminy Kite	<i>Haliastur indus</i>	-	II	NT	Resident
8	Spotted Dove	<i>Streptoplia chinensis</i>	-	III	-	Resident

Note: EN = Endangered, VU = Vulnerable, NT = Near Threatened, and II, III = CITES Appendices II and III

To calculate the net direct use value, harvesting costs were subtracted from estimated gross benefits. The costs involved tools and equipment, traveling and labor costs. The sum of these costs represents the total harvesting expense equivalent to 2,157,604 baht. As a result, the net economic value of wetland resources is equal 2,043,546 baht or approximately 10,534 baht¹ per household.

DISCUSSION AND CONCLUSIONS

Nong Han wetland provides goods and services that are critical to the majority of lives in the area. It is considered an important source of biodiversity, providing feeding and breeding sites for numerous plants and animals. These biodiversity components help maintain the wetland ecosystem and enable it to continue functioning. Nong Han supplies local communities with food and other resources, especially fish for household consumption and for sale. The annual direct benefits derived from the wetland were estimated at 10,534 baht per household, accounting for approximately 32% of the annual household income. This illustrates how important the wetland is to local livelihoods, especially as an alternative source of income and supplement to the diet. In addition, survey data indicate nearly all local people (97%) have utilized the wetland resources but without the presence of effective enforcement of rules and regulations governing harvest. According to local officers from the regional fishery department, certain harvesting tools and equipment, especially stationary lifting-meshes, are prohibited as well as fishing in spawning areas. However, the majority of villagers are not aware of or choose to ignore these rules and regulations, coupled with lack of enforcement by responsible authorities. Hence, resources are likely to be overexploited if no action is taken in a timely manner.

¹The value per household was computed from 97% of 200 samples who reported using Nong Han for wetland product collection.



a)



b)

Figure 3. Local fishing practices: a) a group of women fishing with portable lift-nets; indeed stationary lift-nets are prohibited; and b) fishermen gathering fish from nets. Fishing as a group is common in the area.



Figure 4. Examples of important wetland products collected by villagers: a) water lilies—all parts are used for cooking; b) fish—the most important wetland product harvested; and c) golden apple snails being processed for household use and sale.

Table 6. Wetland products harvested by villagers, market prices, amounts of products harvested summed from all households and gross direct benefits in 2006.

Product types	Examples of products	Price (baht/kg)	Amount harvested (kg)	Gross direct benefits (baht)	
Fish	Small-sized	15–30	85,042	2,064,860	
	Medium-sized	35–60	30,432	1,477,782	
	Large-sized	>60	6,258	498,655	
Aquatic plants and algae	<i>Colocasia esculenta</i> var. <i>aquafilis</i>	5–10	55	280	
	<i>Nymphaea lotus</i> (stems)	5–10	2,993	15,845	
	<i>Nelumbo nucifera</i> (stems)	10–15	998	9,745	
	<i>Commelina diffusa</i>	10–20	556	6,220	
	<i>Phaseolus adenanthus</i>	10–15	256	3,120	
	<i>Monochoria hastate</i> var. <i>elata</i>	10–40	324	3,610	
	Algae	5–10	7	95	
	<i>Ipomoea aquatica</i>	5–10	4,893	24,945	
	<i>Neptunia oleracea</i>	5–50	24	425	
	<i>N. nucifera</i> (roots)	10–15	400	4,000	
	<i>N. nucifera</i> (fruits)	5–25	50	300	
	<i>N. nucifera</i> (flowers)	5–10	250	2,500	
	<i>Scirpus grossus</i>	2	1,200	2,400	
	Others (water hyacinth and ferns)	5–50	252	1,295	
	Other animals	Shrimp	50	459	29,370
		Frogs	80–100	204	17,060
Small frogs		50–60	49	2,420	
Insects (e.g., giant water bugs)		100	4	400	
Golden apple snails (non processed)		3–5	7,568	35,823	
Golden apple snails (processed)		15–30	142,274	4,201,150	
Total					

Note: The majority of wetland products are used for food, except lotus flowers are usually used for religious rituals and *S. grossus* is used for mat weaving.

Rules and regulations need to be enforced effectively soon, to ensure that users utilize the resources sustainably and equitably. Furthermore, a monitoring mechanism to evaluate conformance and violations is necessary. Punishment of rule breakers needs to be graduated with a higher penalty for repeated violators, so infraction becomes unattractive. In doing so, users need to be informed of what rules and regulations are in effect through designated signs and community meetings. Unfortunately, legal ownership rights to the resources are not granted to local communities. However, their usufruct rights should at least be recognized so that local groups can enforce rules and regulations more effectively.

Habitat restoration and protection is another key concern for sustainable utilization of this wetland ecosystem. Although no significant evidence indicates severe degradation of Nong Han, an increasing area of water hyacinth and other aquatic weeds covers the wetland, especially around lake sides. Moreover, environmental problems such as trash and oil leaks from fishing and transport boats can be observed. These can lead to habitat deterioration and decline of wetland productivity, particularly fish. Wetland clean-up, especially removal of dense water hyacinth and weeds, is needed. This would help improve water quality and restore habitats for other plants and animals. Furthermore, Nong Han should be designated for specific management and use in which rules and regulations compatible with ecological conditions can be implemented. This includes protected areas for nursing and hatching purposes and zones for wetland use and product collection.

Lastly, periodic wetland inventories, including biodiversity and economic values, are crucial for sustainable use and effective conservation of this ecosystem. These will help us better understand Nong Han's current status and contribution to local communities, and monitor ecosystem change. As a result, proper decisions about potential development and management activities will be possible. From this inventory, it is evident that Nong Han is the major source of wetland products in the area, especially fish, on which local communities depend for household consumption and income generation. Hence, management policy and planning should focus on activities that help promote sustainable harvesting of wetland products, while maintaining the ecosystem.

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