

INBAR Working Paper



*Technical Paper*

# Assessment of Bamboo Forest Ecosystem Services in Thanh Hoa Province, Viet Nam

## *A Comparison of Bamboo Forestry with Other Land Uses*

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### About this Working Paper

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## List of Abbreviations

AGB	Above-ground biomass
AGC	Above ground carbon
BIE	Bioenergy
BO	Biodiversity
CM	Construction material
CO <sub>2</sub>	Carbon dioxide
CS	Carbon storage
CW	Clean water
ES	Ecosystems services
FMB	Forest Management Board
FS	Food supply
G	Gram
GABAR	Global Assessment of Bamboo and Rattan
Ha	Hectares
HB	Habitat
LB	Landscape beauty
LF	Landslides and floods
Luong	Local name for the <i>Dendrocalamus barbatus</i> bamboo species
M <sup>3</sup>	Cubic Meter
OM	Other material
PFES	Payment for forest environmental services
t C	Tons of Carbon
UN-REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
US	United States
USD	United States Dollar
%	Per Cent
VND	Viet Nam Dong (the Currency of Viet Nam)

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## Executive Summary

Thanh Hoa is a province in the north-central region of Viet Nam. Diverse forests, plantations and farms characterise the province. The bamboo forest area covers 180,786 ha, accounting for 16.3% of the total natural land area. The forest plays a vital role in economic and social development and a wide range of ecosystem services (ES). There have been few attempts to assess the type and extent of ecosystem services provided by the bamboo forests in Thanh Hoa province. This study attempts to evaluate ES for several types of land use. They include the Luong bamboo plantation (*Dendrocalamus barbatus*), a natural timber forest, an *Acacia mangium* plantation, paddy rice farming, maize farming and cassava farming. Quantitative and qualitative indexes were analysed based on data and information from a literature review and interviews with experts. The study results showed that bamboo forestry provides many valuable ecosystem services similar to other forest types.

Our quantitative analysis demonstrated that the bamboo plantation provided lower monetary value per unit of land; the labour required to manage the plantation is lower than that of annual crops. However, the daily worker's income on the plantation was almost twice that of yearly crops.

The Luong bamboo plantation's carbon stock was lower than that in 11 or 12-year old *Acacia* plantations and natural forests. However, Luong plantation's carbon stock was continually stable because it has a higher annual carbon sequestration level. Annual selective cutting of 30% will be replaced within one year. While the carbon stock at the *Acacia* plantation fluctuates due to clear-cutting every 11 or 12 years, over time, the carbon sequestration at the Luong plantation is comparable to the *Acacia* plantation and the natural forest.

Our qualitative analysis showed that communities valued ecosystem services provided by bamboo forests more than those of the *Acacia* plantation, exception that carbon stock of bamboo forest was estimated lower than that of standing *Acacia* plantation and of natural forests.

Our quantitative analysis showed that several ES provided by the Luong plantation were lower in value than the natural forests and the *Acacia* plantation. The reason was that the Luong plantation was degraded after intensive exploitation for almost 50 years without nutrient supplements and

over-harvesting of the culms. Based on our study findings, we recommend new sustainable management and harvesting measures to improve conditions at the Luong plantations. We also recommend additional studies of ecosystem services to increase appropriate ES payment rates for different forest types.

## 1. Introduction

Bamboo is a diverse and abundant resource in Viet Nam. According to the Ministry of Agriculture and Rural Development (2020), Viet Nam has 239,809 ha of pure bamboo forests (1.6% of all forested areas) and 1,144,777 ha of mixed wood-bamboo (7.8% of all forested areas). The country has more than 200 species of bamboo belonging to 26 genera (Nguyen, 2006). Bamboo plays an essential role in the economy, environment, culture and landscape of Viet Nam (Nguyen, 2006; Dang, 2011; Le, 2013).

Thanh Hoa is a province in the north-central region of Viet Nam with 11,106 km<sup>2</sup> located between 20°40' in the North, 19°18' in the South, 106°04' the East and 104°22' in the West. The region consists of three zones: the coastal plain, midland, and mountain. In the midland and mountain areas, the landscape is characterised by a mix of land uses including natural forest, plantation forest, paddy rice, maize and cassava. The bamboo forest is one of the most critical ecosystems in Thanh Hoa province's midland and mountainous area.

Thanh Hoa province contains 180,786 ha of bamboo forests, 16.3% of the total land area of the province. Of that, the pure natural bamboo forest accounts for 50,749. The natural mixed wood-bamboo forest accounts for 58,662 ha (Thanh Hoa Provincial People's Committee, 2020) and the planted bamboo forest accounts for 71,375 ha. The planted bamboo forest consists primarily of *Dendrocalamus barbatus* species, locally called "Luong" in Viet Nameese (Nguyen, 2020). The average annual production of bamboo in Thanh Hoa is approximately 94 million culms per year, including 42 million culms of *Dendrocalamus barbatus* and 52 million culms of other bamboo species (*Schizostachyum* sp (locally called "Nua") and *Indosasa* sp (locally called "Vau")). Bamboo plays an essential role in the Thanh Hoa province's economic and social development and is the primary income source for households in rural and mountainous areas (Hoang et al., 2019).

Although the bamboo and other forests provide essential socio-economic, environmental and cultural services, the specific factors contributing to those services have yet to be analysed and documented. This study aims to understand better Ecosystem Services (ES) from forests in the region, especially planted bamboo forests. As assessed in this study, and based on the Economics of Ecosystem and Biodiversity (Paudyal et al., 2019), ES consists of the following

categories: provisioning, regulating, habitat and cultural services. Those categories will be presented and described in detail in the sections that follow. This report consists of five sections: 1) a brief introduction, 2, the study methodology, 3) results of the study, 4) a discussion of the study results and 5) conclusions and recommendations.

## 2. Methods

### 2.1 Literature review

The legal documents, guiding documents, and research relevant to the ecosystem service of bamboo forests in Viet Nam were collected from different sources including websites, libraries and personal networks. Significant resources included the websites of Viet Nam Government Portals: Ministry of Agriculture and Rural Development, Viet Nam Administration of Forestry, Viet Nam Forest Protection and Development Fund and Ministry of Science and Technology; and the libraries of the Viet Nameese Academy of Forest Science, Thanh Hoa Provincial Science and Technology Department, Viet Nam National University of Forestry and Hong Duc University. The data on ES for various land uses were also collected from Forest Management Boards in Thanh Hoa.

### 2.2 Data collection and sites of study

Data collected were from both quantitative and qualitative studies. The quantitative data on ES several land uses in Thanh Hoa were collected from project reports, journals, books, provincial decisions and plans.

Qualitative data for the study were collected using a structured questionnaire. Key participants were selected for interview including local government officers, forest managers, technical staff and farmers in three districts in Thanh Hoa (Lang Chanh, Quan Hoa and Quan Son), the richest bamboo districts in the province. The questionnaire was divided into ten indicators of ES: food supply, construction material, other materials, bioenergy, clean water supply, carbon storage, landslide and flood hazards, habitat, biodiversity, tourism and recreation. A scale of 1-10 was used to assess ES in each of the land use categories, where 1 represented the lowest level of ES, and 10 represented the highest level. The detailed methodology is described in Framework for assessing ecosystem services from bamboo forests (INBAR 2019).

Land uses were classified into the following groups: Luong plantation (*Dendrocalamus barbatus*), natural timber forest, *Acacia mangium* plantation, paddy rice, maize and cassava. The Luong plantations were established in the 1970s as a monoculture with extensive management (no fertiliser application or pest control during cultivation). Most of the 2-3-year-old culms are

harvested every year, accounting for about 30% of the stand's total culms. The natural timber forests are evergreen secondary forest with a timber volume ranging from 100 to 200 m<sup>3</sup> ha<sup>-1</sup>. The harvesting rotation of natural timber forest is typically 35 years using a selective cutting method. *Acacia mangium* plantations were established for timber production with 10 -12 year harvest cycles.

## 2.3 Analysis

To assess the ES of the land use categories in Thanh Hoa, we averaged every variable collected from different quantitative data sources. For the qualitative approach, Points given from different participants for each indicator of each land use were averaged and plotted in radar figures. Total points of ten indicators were calculated to assess the role of ES of each land use.

To convert the timber volume (m<sup>3</sup>) into biomass (ton), the wood densities from the UN-REDD Viet Nam Programme (2013) database were applied for *Acacia mangium* and natural forest timber species.

## 3. Results

### 3.1 Literature review

#### 3.1.1. Policy for Ecosystem Services

The ecosystem services (ES) in Viet Nam were recognised in some legal documents. The critical role of forests in providing ecosystem services, including soil erosion control, water regulation, microclimate regulation, biodiversity conservation, and landscape beauty for recreational purposes, was recognised in Law on Forest Protection and Development, 2004 (Viet Nam National Assembly, 2004). This law was later replaced by the Law on Forest in 2017 (Viet Nam National Assembly, 2017). ES was also addressed in the Law on Biodiversity, 2008 (Viet Nam National Assembly, 2008) and Laws on Forestry, 2017. The Law on Biodiversity, 2018 recommended that "organisations and individuals using environmental services related to biodiversity shall pay charges to service providers" and the Law on Forestry, 2017 defined the "forest environmental services are values that provide for the use of forest environment."

The national legal framework for implementing Payments for Forest Environmental Services (PFES) was issued in decrees, prime ministerial decisions and circulars. Decree No. 99 in 2010, issued by the Viet Nam National Assembly (Viet Nam National Assembly, 2010) mandated the PFES nationwide beginning 1 January 2011. The decree included five environmental services:

1. Soil protection, restriction of erosion and sedimentation of reservoirs, rivers and streams.
2. Regulation and maintenance of water sources for production and household consumption.
3. Forest carbon sequestration and retention and reduction of greenhouse gas emissions using measures to prevent deforestation and forest degradation and sustainably develop forests.
4. Protection of the natural landscape and protecting biodiversity and ecosystems for tourism.
5. Protection of spawning grounds, sources of feed, natural seeds and water for aquaculture.

Decree 156/2018/NĐ-CP in 2018 (Viet Nam National Assembly, 2018) regulated established he rates for forest environment services as (i) 0.156 US cents per kWh of commercial electricity for hydroelectricity producers, (ii) 0.226 US cents per cubic meter of clean water for commercial water suppliers, (iii) 0.217 US cents per cubic meter of water for industrial users and (iv) agreement by

service providers and users on the specific rate of payment for ecotourism, resorts, recreation and aquaculture business services; provided, that the amount should not be less than 1% of the total revenues of the users in the reporting period. When the average retail price of electricity and water specified in the decree increases or decreases by 20%, the Ministry of Agriculture and Rural Development is authorised to submit to the government a recommended price for adjustment and adoption as the payment for environmental services.

### *3.1.2. Payment for forest environmental services in Thanh Hoa*

According to the Thanh Hoa Forest Protection, Development and Disaster Prevention Fund (2018), Thanh Hoa began implementing payment for forest environmental services (PFES) in 2013. Five years after implementation, seven districts with 70 communes and 457 villages had received the PFES. By December 2019, total forest area eligible for PFES was 368,248 ha (Thanh Hoa Forest Protection, Development and Disaster Prevention Fund, 2019). Of this total, 143,650 ha belong to Forest Management Boards and Forest Companies, 3,371 ha belong to the Commune People's Committee; 21,452 ha belong to communities or villages, 199,855 ha belong to households/individuals and 1,481 ha were not identified by forest owners (due to overlap on the map or conflicting land uses). Bamboo forest owners have also received PFES similar to those of other forests.

Thanh Hoa has signed 28 trust contracts for PFES, including nine contracts with hydropower plants whose watersheds cover two or more provinces, 10 for factories, five for clean water supply, three for hydropower plants with watershed areas in the province, and one for ecotourism (Thanh Hoa Forest Protection, Development and Disaster Prevention Fund, 2020). By 31 March 2020, PFES revenue had reached USD 4.095 million.

Bamboo forests were registered for PFES as a forest category with a payment rate similar to natural forests and other plantation forests ranging from 0.1 USD to 4.5 USD per hectare per year (ha-1 year-1 ) (Thanh Hoa Forest Protection and Development and Disaster Prevention Fund, 2018). The payment rate varied depending on the forest category, and the quality and types of forest/plantation (protected area, protection forest or production forest). In general, the bamboo forest in Thanh Hoa is considered to have the same PFES value as a natural forest and planted forest.

### 3.2 The quantitative approach

According to Thanh Hoa Science and Technology Department, many studies on forests and agriculture have been conducted in Thanh Hoa province; however, most of them are not related to ES. We found twelve documents relevant to ES provided by different land uses. Four were project assessment reports, three were journal papers, two were graduate theses, two were project proposals, one was a book, and one was a project progress report. Only one document was written in English, two were in Viet Nameese and English, and the others were in Viet Nameese (Appendix 1). The ES indicators and methods of estimation are shown in Table 1.

**Table 1.** Ecosystem service indicators and methods for estimating them in bamboo forests and other land uses in Thanh Hoa Province

ES	Method of estimation	Indicators of ES and unit of measurement	References
<b>Provisioning services</b>			
Timber	Measurement of sample plots	Volume of <i>Acacia mangium</i> timber available: harvested at 10 years of age (ton ha <sup>-1</sup> year <sup>-1</sup> ).	Lang Chanh Protection Forest Management Board, 2018.
Raw materials	Measurement of sample plots	Volume and amount of bamboo culms available for harvesting (poles ha <sup>-1</sup> year <sup>-1</sup> ).	Dang Thinh Trieu 2011, pp. 84-95.
Labour	Interview	Workday requirement for bamboo plantations, paddy rice, maize and cassava (day ha <sup>-1</sup> year <sup>-1</sup> ).	Proyuth et al. 2012, p. 19.
	Interview	Working day (ha <sup>-1</sup> year <sup>-1</sup> ).	Do Van Nha and Nguyen Quang Tuan 2017, p. 86.
Labour	Interview	Return to labour (VND per working-day).	Proyuth et al. 2012, p. 19.

ES	Method of estimation	Indicators of ES and unit of measurement	References
PFES	Review decisions and agreements	Payment (VND ha <sup>-1</sup> year <sup>-1</sup> ).	Thanh Hoa Forest Protection, Development and Disaster Prevention Fund 2019, p. 2.
Economic return	Interview	Net economic returns for Luong plantation, paddy rice, maize and cassava (VND ha <sup>-1</sup> year <sup>-1</sup> ).	Proyuth et al. 2012, p. 19.
	Interview	Net economic returns for paddy rice, maize and cassava (VND ha <sup>-1</sup> year <sup>-1</sup> ).	Do Van Nha and Nguyen Quang Tuan 2017, p. 85.
	Interview	Current conditions and development solutions of bamboo value chains in SCBV project provinces (VND ha <sup>-1</sup> year <sup>-1</sup> ).	Hoang et al., 2018.
<b>Regulating services</b>			
Biomass and carbon	Measurement of sample plots	Biomass and carbon stock in natural forests and the Luong plantation (ton ha <sup>-1</sup> ).	Proyuth et al., 2012, p. 20.
	Measurement of sample plots.	Biomass and carbon stock in the Luong plantation (ton ha <sup>-1</sup> ).	Nguyen Duc Hai 2019, pp. 85 and 99. Nguyen Xuan Truong et al. 2013, p. 66.
	Measurement of sample plots	Biomass and carbon stock in the <i>Acacia mangium</i> plantation: 12 years old (ton ha <sup>-1</sup> ).	Vo Dai Hai 2008, pp. 103 and 162.

ES	Method of estimation	Indicators of ES and unit of measurement	References
Litter	Measurement of sample plots	Amount of litter in natural forest and the Luong plantation (ton ha <sup>-1</sup> ).	Proyuth et al., 2012, p. 20.
	Measurement of sample plots	Amount of litter in the <i>A. mangium</i> plantation at 12 years old (ton ha <sup>-1</sup> ).	Vo Dai Hai 2008, p. 103.
Litterfall	Measurement of sample plots	Amount of litterfall in the Luong plantation (ton ha <sup>-1</sup> year <sup>-1</sup> ).	Dang Thinh Trieu 2011, p. 90.
Soil organic matter	Soil analysis	Soil organic matter (0-30 cm) in the natural forest and the Luong plantation (%).	Proyuth et al. 2012, p. 20.
	Soil analysis	Soil organic matter (0-30 cm) in the natural forest, Luong plantation and <i>A. mangium</i> plantation (%).	Nguyen Huu Tan, 2014, p. 89.
	Soil analysis	Soil organic matter (0-30 cm) in the Luong plantation (%).	Dang Thinh Trieu 2011, p. 75.
Soil nitrogen	Soil analysis	Soil nitrogen (0-30 cm) in the natural forest, Luong plantation and <i>A. mangium</i> plantations (%).	Nguyen Huu Tan, 2014, p. 67.
	Soil analysis	Soil nitrogen (0-30 cm) in the Luong plantation and <i>A. mangium</i> plantations (%).	Dang Thinh Trieu 2011, p. 75. Bui Thi Huyen and Pham Van Dien 2014, p 17.
Soil bulk density	Soil analysis	Soil bulk density in the natural forest and the Luong plantation (g 100cm <sup>-3</sup> ).	Proyuth et al. 2012, p. 20.

ES	Method of estimation	Indicators of ES and unit of measurement	References
	Soil analysis	Soil bulk density (0-30 cm) in the natural forest, Luong plantation and <i>A. mangium</i> plantation (g 100cm <sup>-3</sup> ).	Nguyen Huu Tan, 2014, p. 89.
	Soil analysis	Soil bulk density (0-30 cm) in the Luong plantation and <i>A. mangium</i> plantation (g 100cm <sup>-3</sup> ).	Dang Thinh Trieu 2011, p. 75. Bui Thi Huyen and Pham Van Dien 2014, p 18.
Soil porosity	Soil analysis	Soil porosity in the natural forest, Luong plantation and <i>A. mangium</i> plantations (%).	Nguyen Huu Tan, 2014, p. 89.
	Soil analysis	Soil porosity in the Luong plantation (%).	Dang Thinh Trieu 2011, p. 75. Bui Thi Huyen and Pham Van Dien 2014, p 18.
Soil erosion		Soil erosion in the natural forest, Luong plantation and <i>A. mangium</i> plantations (ton ha <sup>-1</sup> years <sup>-1</sup> ).	Nguyen Huu Tan, 2014, p. 110.
<b>Habitat services (not available)</b>			
<b>Cultural services</b>			
Recreation and ecotourism	Planning in the project proposal	Area of bamboo plantation for recreation and ecotourism.	Lam Son Sugar Joint Stock Corporation, 2017.

We calculated the ES for each type of land use in the Thanh Hoa province based on available data. The results are shown in Table 2. There were 14 indicators for ES in the land use categories, of which four were recorded for provisioning services, nine for regulating services and one for

cultural services. However, there were no indicators of habitat services due to the absence of related studies.

**Table 2.** Ecosystem service values for selected land uses in Thanh Hoa province

#	Ecosystem service indicator	Land use					
		Bamboo plantation	Natural forest	<i>Acacia mangium</i> plantation	Paddy rice	Maise	Cassava
<b>Provisioning services</b>							
1	Labour (working day ha <sup>-1</sup> year <sup>-1</sup> ) in 2009	28.0	-	-	234.0	267.8	330.5
2	Return to labour (USD working day <sup>-1</sup> ) in 2009	6.5	na	na	3.5	3.3	4.2
3	Economic return (USD ha <sup>-1</sup> per year <sup>-1</sup> ) in 2009	183.1	na	na	750.0	865.0	1,438.1
4	PFES (USD ha <sup>-1</sup> per year <sup>-1</sup> ) since 2017	2.8	2.8	2.8	-	-	-
<b>Regulating services</b>							
5	AGB stock (ton ha <sup>-1</sup> )	36.1	197.4	117.9	na	na	na
6	Carbon stock (ton ha <sup>-1</sup> )	17.5	96.7	58.7	na	na	na
7	Dried biomass of litter (ton ha <sup>-1</sup> )	2.36	3.61	7.04	na	na	na
8	Dried biomass of litter (ton ha <sup>-1</sup> year <sup>-1</sup> )	3.51	na	na	na	na	na
9	Soil erosion (ton ha <sup>-1</sup> year <sup>-1</sup> )	45.6	20.8	37.1	na	na	na
10	Soil bulk density (g/cm <sup>3</sup> )	1.17	1.06	1.11	na	na	na
11	Soil porosity (%)	49.1	51.6	47.2	na	na	na

#	Ecosystem service indicator	Land use					
		Bamboo plantation	Natural forest	<i>Acacia mangium</i> plantation	Paddy rice	Maise	Cassava
12	Soil organic matter at 0-30cm (%)	1.95	3.45	2.08	na	na	na
13	Soil nitrogen (%)	0.12	0.20	0.08			
<b>Habitat services</b>							
		na	na	na	na	na	na
<b>Cultural services</b>							
14	Area of bamboo forest for recreation and ecotourism (ha)	150	na	na	na	na	na

For the labour ES, cassava cultivation required the highest amount labour: 1.2 times higher than paddy rice; 1.4 times higher than maise, and 11.8 times higher than the Luong plantation. At the time of the study (2009), the economic return per unit of land for the Luong plantation was equal to 24.4% 21.2%, 12.7% of those from paddy rice maise and cassava respectively. However, because the Luong plantation required fewer workdays, the return on labour was the highest (USD 6.5 per working day in 2009).

In contrast to agricultural land use, forestland uses are paid for environmental services. Five years after implementing the PFES, the average price paid for a watershed in Thanh Hoa was 2.8 USD ha<sup>-1</sup> year<sup>-1</sup> in 2019. The same payment was applied to all types of forests in the same watershed, with the water user paying the same price per unit of water.

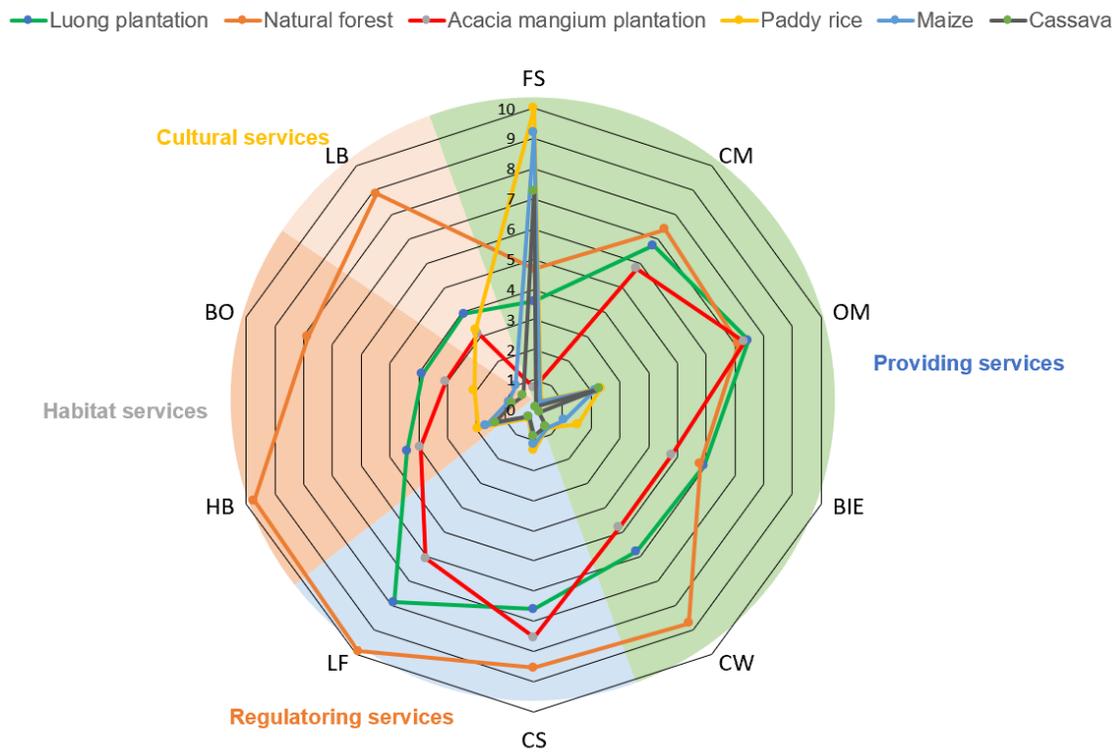
Data for regulating services were available for forests only; no data were available for crops. In general, the highest values for regulating services were always found in the natural forest, while regulating services of the Luong plantation were lower (Table 2). The carbon stock in above-ground biomass on the Luong plantation was equal to 18.1%, 29,8% of those in natural forest and *Acacia mangium* plantations respectively. However, in the Luong plantation case, selective cutting of 2 - 3-year-old culms accounted for about 30% of the plantation's total culms. This volume is

equivalent to 5.5 tC year<sup>-1</sup>. The harvested amount is compensated for by new bamboo culms within one year; therefore, the carbon stored in the Luong plantation is maintained at almost the same level every year. Over 12 years, the amount of carbon extracted from the Luong plantation was about 66 tC ha<sup>-1</sup>, higher than the carbon stored in 11 or 12 years of the *Acacia* plantation. The carbon stock in the *Acacia* plantation will become zero as the plantation is totally clear-cut over a period of 11 or 12 years.

Amount of Litter in the Luong plantation was 65.4% of that in the natural forest. Soil erosion in Luong plantation was higher than those in the natural forest and *Acacia mangium* plantation.

### 3.3 The qualitative approach

The results of the qualitative assessment of the selected land uses in Thanh Hoa province are shown in Figure 1. The Luong plantation's total ES score ranked it second with 56.2 points after natural forest (78.6 points). The land use scores were 47.2 for the *Acacia mangium* plantation, 23.9 for paddy rice, 18.4 for maize and 14.3 for cassava (Figure 1 and Appendix 1).



**Figure 1.** Comparison of ES with other land uses in Thanh Hoa province

BO is Biodiversity, BIE is Bioenergy, CM is Construction Material, CW is Clean Water supply, FS is Food Supply, HB is Habitat, LB is Landscape beauty, LF is Landslide and Flood control, OM is Other Material

## 4. Discussion

Above-ground carbon (AGC) at the Luong plantation was estimated at 17.5 tons/ha<sup>-1</sup> (Table 2). This yield is relatively low for large bamboo such as *Dendrocalamus barbatus*. In general, AGC for bamboo forests ranges from 16 tons/ha<sup>-1</sup> to 128 tons/ha<sup>-1</sup> (Yuen et al., 2017). The AGC of bamboo forests in Colombia ranges from 26.5 tons/ha<sup>-1</sup> to 180.9 tons/ha<sup>-1</sup> (Garcia and Long, 2020). The AGC for *Dendrocalamus strictus* grown in Uttar Pradesh, in the Indian dry tropics, is 19 tons/ha<sup>-1</sup> (Tripathi and Singh, 1996), comparable to the AGC of Luong in this study. The difference in AGC volumes within the forests can be explained by many factors: species composition and distribution, quality and management methods, biodiversity and the structure of plant communities.

Although carbon stock in the Luong plantation was low compared to that of natural forests and the *Acacia mangium* plantation if we consider total carbon sequestration over a specific period, Luong may sequester more carbon than the natural forest or the *Acacia mangium* plantation. The Luong plantation is selectively harvested every year, with about 30% of the culms extracted. The *Acacia* plantations are clear-cut every 11 to 12 years. According to Nguyen (2019), total carbon from Luong harvests over 25 years was 117.5 tons/ha<sup>-1</sup> (4.7 t/ha<sup>-1</sup>/yr<sup>-1</sup>) excluding leaves, branches, vegetation and litter on the ground. This amount is the same as total carbon sequestered by the *Acacia plantation* in two rotations, or 24 years (Table 2).

For the increment of timber volume in the natural forest in Viet Nam, Nguyen et al. (2010) found that timber volume increased in the range of 1.3 – 2.2 t C ha<sup>-1</sup> year<sup>-1</sup>. This increase was much lower than the annual rate of carbon sequestration at the Luong plantation (4.7 tC ha<sup>-1</sup> year<sup>-1</sup>)

Soil erosion in the Luong plantation is consistent with the rates of soil erosion in other studies. Soil loss caused by agricultural land uses in northwest Viet Nam ranged from 43 to 112 tons ha<sup>-1</sup> yr<sup>-1</sup> (Vu, 2015). Different soil erosion rates were also recorded by Birgitta, Sjödel and Hanna for various land uses in northwest Viet Nam (2020). That range was 1.3 – 182.2 tons ha<sup>-1</sup> year<sup>-1</sup>. In general, bamboo effectively controls soil erosion because of its extensive fibrous roots and rhizome system predominantly in the top 30 cm of the soil. However, the Luong plantation did not perform well in the control of soil erosion. Soil erosion is affected by many factors such as site conditions, percentage of canopy cover, forest structure, soil structure, rainfall, etc. The rate of

soil erosion can vary substantially from year to year and from site to site (Phong, 1995; Phien and Loan, 2005; Dung et al., 2008). Soil erosion at the Luong plantation was higher than the natural forest and the *Acacia mangium* plantation. The structure of the bamboo forest could explain it.

The evergreen natural forest in Viet Nam has several distinct vertical layers, from the forest floor layer to the emergent layer (Tran, 2001; Ho, 2001). The number of trees and regeneration seedlings in the natural forest is much more abundant than the Luong plantation (Dang, 2011; Nguyen, 2014). Furthermore, to ease annual harvesting operations, farmers at the Luong plantation clear undergrowth. Consequently, there are only one or two layers in the forest. Litter on the natural forest floor and the *Acacia mangium* plantation was higher than that in the Luong plantation. These factors could contribute to higher soil erosion at the Luong plantation than the natural forest or the *Acacia* plantation.

This study showed that soil nutrients at the Luong plantation were deficient compared to those in the natural forest. According to Alrasjid (2003), bamboo and other fast-growing species are "greedy" for soil nutrition; without soil amendments, the soil's productivity or nutrients will drop over time. In Indonesia, Sutiyono (2004) conducted a study of a *Dendrocalamus asper* forest's soil nutrition needs. The results showed that levels of humus, nitrogen, potassium, K<sup>+</sup>, Na<sup>+</sup> ions, Ca<sup>2+</sup>, Mg<sup>2+</sup> and exchanged cations were deficient. These findings emphasise the importance of using soil amendments or fertilisers at bamboo plantations producing intensively-harvested bamboo.

The Luong plantations are currently degraded. After more than 40 years of cultivation, 98% of households have never applied fertiliser (Thanh Hoa Department of Forestry, 2014) while continuing intense annual harvesting. Overharvesting over long periods has led to both degraded Luong plantations and soils. According to the guidelines for Luong management of Ministry of Agriculture and Rural Development (MARD, 2000), only culms older than three years will be harvested, and a maximum of 30% of culms are allowed to be harvested. However, in Thanh Hoa, residents harvest culms after two years and, in many cases, after only one year (Trieu, 2014).

Results of the qualitative study showed that Luong bamboo is valued higher than bamboo from *Acacia*. However, the quantitative research concluded that the quality at *Acacia* is higher. Luong

is characterised by multipurpose species, native to Thanh Hoa and used by communities for construction material, food (shoots) and as a source of livelihood and income (handicraft, furniture, etc.) (Nguyen, 2020). Luong has played a significant role in the life of people in Thanh Hoa for several decades. Based on most criteria, the natural forest is considered the highest ES provider; exceptions are food supply, which is lower in value than agriculture, and bioenergy, which is lower in value than bamboo. These findings mirror those of several studies (Paudyal et al., 2019).

The quantitative data were collected from several sources, each collected using different methods and sites, and at different times. The cultivation practices for each land use changed over time, depending on economic development and growing techniques in place. Shi and Liu (2016) reviewed the methods for estimating forest biomass and concluded that each method has its advantages and disadvantages; none of the methods was considered superior because of the considerable uncertainties about available biomass data. As a result, the quality of the data for the purpose ES comparison was a limitation of this study.

## 5. Conclusions

This study showed that the Luong plantation in Thanh Hoa province plays a vital role in providing ES services and is comparable to other forest types in the region based on 14 indicators in the study area. Ecosystem services have gained traction, and PFES has been implemented in the Thanh Hoa province. The Luong plantation was paid the same PFES as the natural forests and the *Acacia* plantation. Qualitative research showed that ES provided by Luong bamboo was lower than that of the natural forest but higher than that of the *Acacia* plantation. In contrast, the quantitative results showed that the volume of carbon stored in Luong plantation bamboo was lower than that of the natural forest and *Acacia* plantation. However, over time, carbon sequestration (through the annual harvest of bamboo culms) in bamboo forests is comparable to the *Acacia* plantation and the natural forests.

## 6. Recommendations

The assessment results showed that the Luong plantations in Thanh Hoa had been degraded by intensive harvesting for a half-century. Improvements at the Luong plantations that build residents' capacity to practice sustainable harvesting and maintenance of the Luong plantations are essential. Once those improvements are made (e.g., clump intensity and age composition), the ES provided by the Luong plantation will increase productivity, the volume of carbon stocks, nutrient recycling and soil erosion control.

The knowledge of ES provided by forests, especially bamboo forests and plantations, are still minimal and fragmented. A particular example is an experience with water recharge on bamboo plantations and quantitative data of ES for other forests. Therefore, more studies of the Luong and other forests should be conducted to improve knowledge of ES and provide the basis for appropriate PFES payment rates for each type of forest (performance based incentive approach). This will encourage owners to manage forests better.

## References

- Alrasjid, H. (2003) 'The effect of nitrogen, phosphor, and potassium fertilisers to the clump growth and pulp quality of *Bambusa bamboos* at Turaya Log over forest area, South Sulawesi (Indonesia)'. *Bul. Pen. Hutan*, 619, pp 13-36.
- Birgitta, Sjödel, and Hanna, Thelberg. (2020) '*Impact of agroforestry on soil loss mitigation in the sloping land of Northwest Viet Nam*'. Master thesis. Department of Soil and Environment, Swedish University of Agricultural Sciences. Available at: <http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1433053&dswid=8982> (Accessed: 25 September 2020)
- Dang Thinh Trieu. (2011) *Restoration of degraded Bamboo Dendrocalamus barbatus plantations in Thanh Hoa province. Project report*. Viet Nameese Academy of Forest Science.
- Dang Thinh Trieu. (2014) 'Developing guidelines for sustainable management of bamboo forests in Thanh Hoa province. *Assignment report of The United States Agency for International Development (USAID) Viet Nam Forest and Deltas Program*.
- Dang Thinh Trieu, Vu Tan Phuong, and Phung Van Khoa. (2012) 'Biomass and Carbon stocks of natural forest in Centre Highland of Viet Nam book'. *Agricultural Publishing House*, pp 148.
- Do Van Nha and Nguyen Quang Tuan. (2017). 'Assessing the efficiency of agricultural production land use in Thach Thanh district, Thanh Hoa province'. *Journal of Viet Nam Soil Science*, 50 (2017), pp 82-89.
- Nguyen Van Dung, Tran Duc Vien, Nguyen Thanh Lam, Tran Manh Tuong, Cadisch Georg. (2008) 'Analysis of the sustainability within the composite swidden agroecosystem in northern Viet Nam. 1. Partial nutrient balances and recovery times of upland fields. *Agriculture Ecosystems & Environment*, 128 (1-2), pp 37-51.
- Ho Duc Soa, (2001) 'Results of research on natural forest of Centre for Forestry in Kon Ha Nung'. Statistical Publishing House, pp 69-82.
- Hoang Vu Quang, Nguyen Tien Dinh, and Nguyen Van Ba. (2019) 'Current situation and development solutions of Bamboo value chains in "Inclusive and Sustainable Clam and Bamboo Value Chain Development in Viet Nam" project'.  
[http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class\\_id=1&\\_page=1&mode=detail&document\\_id=96829](http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=1&_page=1&mode=detail&document_id=96829) (Accessed: 25 July 2020)

- Jia Qi Yuen, Tak Fung and Alan, D., Ziegler (2017) 'Carbon stocks in bamboo ecosystems worldwide: Estimates and uncertainties. *Forest Ecology and Management*, 393, pp 113-138.
- García Juan Carlos Camargo and Trinh Thang Long. (2020) 'Assessment of ecosystem services from bamboo dominated natural forests in the coffee region, Colombia. Comparisons of bamboo with other land uses. INBAR working paper No. 85. Available at: <https://www.inbar.int/wp-content/uploads/2020/06/Colombia-Ecosystem-Services.pdf> (Accessed: 10 August 2020)
- Kang Min Ngo, Benjamin, L., Turner, Helene, C., Muller-Landau, Stuart, J., Davies, Markku Larjavaara, Nik Faizu bin Nik Hassan, Shawn Lum (2013) 'Carbon stocks in primary and secondary tropical forests in Singapore'. *Forest Ecology and Management*, 296 (2013), pp 81–89.
- Lam Son Sugar Joint Stock Corporation. (2017) 'Thanh Tam Bamboo Eco-park – Experience with Nature'. Unpublished.
- Lang Chanh Protection Forest Management Board. (2012) 'Planning for selected harvesting of natural forest'.
- Lang Chanh Protection Forest Management Board. (2020) 'Planning for selected harvesting of natural forest'.
- Le Thi Anh Hong. (2013) '*Assessing the economic efficiency of Luong (Dendrocalamus barbatus) model plantations in Thanh Hoa province*'. Master thesis. Viet Nam National Forest University.
- Lei Shi and Shirong Liu. (2016) 'Methods of estimating forest biomass: A review'. Available at <https://www.intechopen.com/books/biomass-volume-estimation-and-valorization-for-energy/methods-of-estimating-forest-biomass-a-review> (Accessed: 25 October 2020)
- Ministry of Agriculture and Rural Development. (2020) 'Decision No. 1423/QĐ-BNN-TCLN issued on 15 April 2020 about the Forest Cover Change in Viet Nam for 2019'.
- Nguyen Duc Hai. (2014). *Study on carbon accumulation dynamics of Luong plantation, (Dendrocalamus barbatus)*. PhD thesis. Viet Nam National Forest University.
- Nguyen Hoang Nghia. (2006) 'Bamboos of Viet Nam'. Agricultural Publishing House, pp. 199.
- Nguyen Huu Tan. (2014) *Silvicultural measures for applications in watershed protection forests in Cua Dat reservoir, Thuong Xuan district, Thanh Hoa province*, PhD thesis. Viet Nam National Forest University.

- Nguyen Quoc Dung, Le Manh Tuan, Mai Van Hung, Le Duc Thanh and Nguyen Manh Hung. (2010) *Report on the establishing the increment criteria for some natural forest types from permanent plots*, Programme of National Forestry Inventory Cycle 4 (2006-2010), Forest Inventory and Plan Institute.
- Nguyen Song Hoan. (2020) 'Current situation and solutions for bamboo development in Thanh Hoa province'. Presentation in the Dialogue on Policy for sustainable bamboo sector development in Viet Nam. 18 June 2020. Vinh City Nghe An Province.
- Nguyen Xuan Truong. (2013) *Study on carbon sequestration of Luong plantation (Dendrocalamus membranaceus Munro) in Thanh Hoa province. Project report*. Viet Nam National Forest University.
- Paudyal, K., Adhikari, S., Sharma S., Samsudin, Y.B., Paudyal, B.R., Bhandari, A., Birhane, E., Darcha, G., Trinh, T.L., and Baral, H. (2019). 'Framework for assessing ecosystem services from bamboo forests: Lessons from Asia and Africa. Working Paper 255. Bogor, Indonesia: CIFOR'. Available at: <https://www.cifor.org/knowledge/publication/7433/> (Accessed: 20 July 2020)
- Pham, T.T., Bennet, K., Vu, T.P., Brunner, J., Le, N.D. and Nguyen, D.T. (2013) 'Payments for forest environmental services in Viet Nam: From policy to practice. Occasional Paper 93. Bogor, Indonesia: CIFOR'. Available at [http://www.cifor.org/publications/pdf\\_files/OccPapers/OP-98.pdf](http://www.cifor.org/publications/pdf_files/OccPapers/OP-98.pdf) (Accessed: 10 August 2020)
- Phien, T., Loan, L.D. (2005) establishment of cultivation model on sloping lands of small households. "Proceeding on National Institute for soil and fertiliser 30 years anniversary Hanoi, Viet Nam" pp 470-484.
- Phong, T.. A. (1995) 'Bare land in our country'. Journal of *Viet Nam Soil Science*. 5, pp 67-69.
- Proyuth Ly, Didier Pillot, Patrice Lamballe and Andreas de Neergaard. (2009) 'Evaluation of bamboo as an alternative cropping strategy in the northern central upland of Viet Nam: above-ground carbon fixing capacity, accumulation of soil organic carbon, and socio-economic aspects'. Available at [https://www.gret.org/publication/evaluation-of-bamboo-as-an-alternative-cropping-strategy-in-the-northern-central-upland-of-Viet Nam-above-ground-carbon-fixing-capacity-accumulation-of-soil-organic-carbon-and-socio-economic-aspects/](https://www.gret.org/publication/evaluation-of-bamboo-as-an-alternative-cropping-strategy-in-the-northern-central-upland-of-Viet-Nam-above-ground-carbon-fixing-capacity-accumulation-of-soil-organic-carbon-and-socio-economic-aspects/) (Accessed: 10 August 2020)

- Sutiyo (2004) 'Soil fertility under the Bamboo plantation of *Dendrocalamus asper* Back'. *Bamboo Journal*, 21, pp 66-71.
- Thanh Hoa Forest Protection and Development Fund. (2018) 'Report on forest owners who have received money from payment for forest environment services', 28 September 2018.
- Thanh Hoa Forest Protection and Development Fund. (2020) 'Report on implementing of payment for forest environmental services', 04 May 2020.
- Thanh Hoa Forest Protection Department. (2020) 'Report on the implementation of the provincial policy of supporting the development of Luong in Thanh Hoa province', Unpublished.
- Thanh Hoa Provincial People's Committee. (2020) 'Decision No. 721/QĐ-UBND issued on 28 February 2020 about the Forest Cover Change in Thanh Hoa for 2019'.
- Thanh Hoa Statistics Office. (2018) Statistical Publishing House. p 498.
- Tran Van Con. (2001) 'Research on the structure of natural forest and application of management in Central Highland', Statistical Publish House. pp 44-60.
- Tripathi, S., Singh, K. 1996. 'Culm recruitment, dry matter dynamics and carbon flux in recently harvested and mature bamboo savannas in the Indian dry tropics', *Ecological Research*, 11, pp 149-164.
- UN-REDD Viet Nam Programme. (2013) 'Tree and forest allometric equation database of Viet Nam', Available at <http://Viet Nam-redd.org/en/news/docdetails/tree-and-forest-allometric-equations-database-viet-nam-updated-12-11-2013-u-863.html> (Accessed: 25 July 2020)
- UN-REDD Viet Nam Programme. (2012) 'Tree allometric equations in Evergreen broadleaf and Bamboo forests in the North Central Coastal region, Viet Nam. Part B-4'. Available at [http://Viet Nam-redd.org/Upload/Download/File/PartB-4-VFU NCC \(EB Bam\)-final\\_4916.pdf](http://Viet Nam-redd.org/Upload/Download/File/PartB-4-VFU NCC (EB Bam)-final_4916.pdf) (Accessed: 25 October 2020)
- Viet Nam National Assembly. (2004) 'Law 29/2004/QH11 on Forest Protection and Development, dated on 03 December 2004'. Available at [http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class\\_id=1&page=1&mode=detail&document\\_id=13658](http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=1&page=1&mode=detail&document_id=13658) (Accessed: 25 July 2020)
- Viet Nam National Assembly. (2008) 'Law No 20/2008/QH12 on Biodiversity, dated on 13 November 2008'. Available at [http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class\\_id=1&mode=detail&document\\_id=81137](http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=1&mode=detail&document_id=81137) (Accessed: 25 July 2020)

- Viet Nam National Assembly. (2017) 'Decree 99/2010/NĐ-CP, dated 24 September 2010, on Policy for payment for forest environmental services'. Available at [http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class\\_id=1&page=1&mode=detail&document\\_id=96829](http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=1&page=1&mode=detail&document_id=96829) (Accessed: 25 July 2020)
- Viet Nam National Assembly. (2017) 'Law 16/2017/QH14 on Forestry dated 15 November 2017'. Available at [http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class\\_id=1&page=1&mode=detail&document\\_id=192329](http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=1&page=1&mode=detail&document_id=192329) (Accessed: 25 July 2020)
- Viet Nam National Assembly. (2018) 'Decree 156/2018/NĐ-CP on Detailed regulations for the implementation of some articles of Forestry Laws'. Available at [http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class\\_id=1&page=1&mode=detail&document\\_id=195435](http://vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=1&page=1&mode=detail&document_id=195435) (Accessed: 25 July 2020)
- Vo Dai Hai, Dang Thinh Trieu, Nguyen Hoang Tiep and Nguyen Van Bich. (2008) *Research on carbon stock of plantations in Viet Nam. Project report*. Viet Nameese Academy of Forest Science.
- Vo Dai Hai, Dang Thinh Trieu, Vu Tan Phuong, Ngo Van Cam and Nguyen Van Bich. (2012) *Research on carbon stock of some forest types in Centre Highland, Viet Nam. Project report*. Viet Nameese Academy of Forest Science.
- Vu Dinh Tuan. (2015) *Soil conservation methods and their impact on nitrogen cycling and competition in maize cropping systems on steep slopes in Northwest Viet Nam. Master thesis*. Institute of Plant Production and Agroecology in the Tropics and Subtropics. University of Hohenheim, Germany.

## Appendix

**Appendix 1:** Summary of studies on the ecosystem services provided by bamboo forests and other land uses in Thanh Hoa province

#	Reference	Type of reference document					Progress Report	Languages
		Project report	Journal paper	Graduated thesis	Book	Project proposal		
1	Nguyen Duc Hai, 2019			x				Viet Nameese
2	Lang Chanh FMB, 2018					x		Viet Nameese
3	Do Van Nha and Nguyen Quang Tuan, 2017		x					Viet Nameese
4	Proyuth et al., 2009		x					English
5	Nguyen Huu Tan, 2014			x				Viet Nameese
6	Thanh Hoa Statistical officer, 2018				x			English and Viet Nameese
7	Thanh Hoa Forest Protection and Development Fund, 2019						x	Viet Nameese
8	Dang Thinh Trieu, 2011, 2014	x						Viet Nameese
9	Nguyen Xuan Truong, 2013	x						Viet Nameese
10	Vo Dai Hai, 2008	x						Viet Nameese
11	Bui Thi Huyen and Pham van Dien, 2014		x					Viet Nameese

12	Lam Son Sugar Joint Stock Corporation (2017)					x		English and Viet Name
	<b>Total</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	

**Appendix 2: Results of the qualitative analysis of ecosystem services**

#	Ecosystem service indicator	Scores for ecosystem services in selected land uses					
		Luong plantation	Natural forest	Acacia plantation	Paddy rice	Maize	Cassava
1	Food supply capacity	3.60	4.67	0.73	10.00	9.20	7.27
2	Construction materials supply capacity	6.73	7.40	5.80	0.40	0.33	0.13
3	Other industry materials supply capacity	7.47	7.13	7.33	2.33	2.13	2.27
4	Bioenergy (coal, pellets, fuel) supply capacity	5.93	5.80	4.80	1.53	1.07	0.20
5	Clean water supply capacity	5.80	8.73	4.80	0.73	0.73	0.67
6	Carbon storage capacity	6.60	8.53	7.53	1.33	1.13	0.87
7	Reduce landslides and floods capacity	7.87	9.87	6.07	0.33	0.27	0.27
8	Habitat	4.40	9.73	3.93	1.93	1.67	1.33
9	Maintaining biodiversity	3.87	7.87	3.07	2.07	0.87	0.73
10	Landscape beauty capacity	3.93	8.87	3.13	3.27	1.00	0.60
	<b>Total of score</b>	<b>56.20</b>	<b>78.60</b>	<b>47.20</b>	<b>23.93</b>	<b>18.40</b>	<b>14.33</b>



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