Valuation of provisioning ecosystem services from Tram Chim national park, Dong Thap province, Vietnam

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ABSTRACT

Tram Chim National Park (TCNP) conducted a community-based project from 2012 to 2016 to assess the sustainable use of wetland natural resources. The final report from this project provided valuable statistical data, such as the total number of households exploiting resources, average income, total products obtained, types of products, and estimated total revenue. However, more recent data are unavailable. This study addresses this data gap through a combination of a survey of farmers and a market-based valuation method to determine the types of resources being exploited for four groups of provisioning services: food, fuel, medicinal plants, and decorative materials. Value was assessed by estimating the proportion of households and the average amount of resources exploited using the responses from 70 survey questionnaires, and eleven resource types were identified. Exploitation rates were 90% for food, 5.5% for medicinal plants, 3.5% for fuel, and 1.0% for decorative materials. Annual extraction volumes were estimated at 284.3 tons for food, 2.0 tons for fuel, 1.4 tons for medicinal plants, and 1.2 tons for decorative materials. The total estimated annual value of exploited resources was 17.94 billion VND per year, with an average of 18.1 (±2.3) million VND/household/month. The results from this study demonstrate that TCNP continues to provide valuable provisioning services to the local community.

Key words: Tram Chim National Park, Provisioning services, Ecosystem Valuation

INTRODUCTION

Wetlands are an irreplaceable form of natural capital[1], providing high-value ecosystem services that support a wide range of economic production and consumption activities. Wetland ecosystem services (WES) encompass the various goods and services derived from wetlands and semi-wetlands, including marshes, swamps, and tidal flats[2], They contribute directly and indirectly to human welfare[3]. WES can be divided into four categories: (i) Provisioning services, providing direct-use resources, such as shrimp, fish, vegetables, medicine; (ii) Regulating services, helping reduce the impact of natural disasters, replenishing groundwater, and storing carbon through biomass (iii) Cultural services, providing resources for tourism, entertainment, aesthetics, and education activities; and (iv) Supporting services, which are the essential ecological functions that support ecosystem processes[4]. WES are inherently spatially heterogeneous in nature[5]. In some cases, the loss of these services is irreversible[6], leading to irreparable environmental damage and associated negative impacts on human welfare.

The depletion and degradation of wetlands due to overuse are occurring rapidly on a global scale, reducing both the number and quality of WES. For example, 35% of global wetlands were lost from 1970 to 2015[7], which has had a profound impact on human welfare. Therefore, wetlands need to be used strategically[8] to generate a more sustainable income stream. However, the value of WES and the changes in that value over time must be systematically and scientifically assessed.

Tram Chim National Park (TCNP) is one of the last remnants of the Dong Thap Muoi wetland ecosystem[9]. TCNP's landscape largely depends on hydrology and soil type (Shepherd, 2008). The differences in composition and structure of plant communities among the wetlands contribute to the richness of ecological functions and biodiversity of TCNP, thereby providing a variety of valuable ecological goods and services[10,11].

In their final report on the pilot co-management of natural resources in TCNP in 2009[12], the management board presented statistics on the quantity of some of the products harvested within TCNP, such as fish, grazing grass, vegetables, snails, and firewood. In 2016, authors Tran Triet and Jeb Barzen noted that the most 'desirable' resource in TCNP for the buffer zone residents was fish. The local community also exploited other resources, such as turtles,

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snakes, birds, lotus, and water lilies for food. Additionally, some types of grass, such as ginger grass or nan grass, were harvested by local vegetable growers as covering material[13]. The final report of the project on the sustainable use of wetland resources in TCNP conducted during the period 2012–2016[14] and incorporating community participation, outlined the following: (i) employment of 300–350 households in the buffer zone, with an average income of 1.5–2.0 million VND/household/month; (ii) authorized utilization of resources included aquaculture, vegetables, grass, snails, melaleuca firewood, permitted exploitation period spanned four months annually, from September to December; (iii) the total revenue generated by the project was approximately 1.740 billion VND. Consequently, the 2016 data from this study were the most recent available statistics on resource usage in TCNP. According to clause 3, article 5 of Resolution No. 04/2024/NQ-HDTP of the Supreme People's Court Council[15] , national parks are areas where fishing is prohibited under point b, clause 1 of article 242 of the Criminal Code. Therefore, it is necessary to conduct a study on the current state of resource exploitation inside TCNP to provide data to support management decisions.

MATERIALS AND METHODS

Study site

The TCNP buffer zone is located within the administrative boundaries of five communes and one town (Phu Tho, Phu Hiep, Phu Thanh B, Phu Duc, and Tan Cong Sinh). The population of the buffer zone in 2022 was 3,429 households with 46,762 people, accounting for approximately 46.7% of the total district population. Tram Chim town and Phu Tho commune have the highest population of the communities considered in the buffer zone. The buffer zone contains 247 households classified as living below the poverty line and 119 considered near-poor (i.e., just above the poverty threshold), together accounting for 10.7% of all households, which is substantially higher than the district average of 2.26%[16]. The primary economic activities of the communes in the buffer zone are agriculture, including sectors such as rice cultivation, horticulture, livestock, and aquaculture. Additionally, the citizens in the buffer zone engage in traditional crafts (for example, plastic chair weaving, water hyacinth weaving, drying, incense making) and work as hired labor for agricultural production (for example, rice planting, weeding, spraying, fertilizing).

Data collection

The objective of this study is to provide a statistical description of two primary indicators: (i) the estimated/verified participation rate of households engaged in utilizing resources in TCNP, and (ii) the estimated/verified average monetary value derived by households that utilize resources from TCNP. The primary data used to assess the value of the services provided by TCNP were collected through structured household questionnaires.

Sample size

In light of the objectives above, we calculated the sample size needed according to formulas (1) and (2) below. The data used to calculate the sample size included (i) the total number of households in the buffer zone (3,429)[16]; (ii) the maximum number of households engaged in utilizing resources in TCNP (350)[14], and (iii) the standard deviation of the average monthly income (1.2 million VND/hh/month)[14]. Based on these data, the optimal sample sizes were n1 = 32 and n2 = 65. Therefore, a sample size of 65 ($\pm$ 5) was selected for this study.

$$n_1 = \frac{z^2_{1-\frac{\alpha}{2}} \times P(1-P)}{d_1^2} \qquad (1)$$

Where: P: the rate of households exploiting resources according to previous studies.

α: significance level, the article chooses α = 0,05, calculated z = 1,96

d_1: maximum acceptable error; in this study, d1 = 0.1 (corresponding to a 10% maximum error in the estimated household participation rate).

$$n_1 = \frac{z^2_{1-\frac{\alpha}{2}} \times \alpha^2}{d_2^2} \qquad (2)$$

Where: σ: standard deviation according to previous studies/pilot studies.

d_2: maximum acceptable error; in this study, d2 = 3.5 million VND/household/year (with a maximum error in the estimated household income of 10,000 VND/day).

Questionnaire

The questionnaire consisted of five key topics within separate sections, with a total of 18 questions: (i) listing of resources and description of extraction methods (four questions); (ii) production volume and purpose of extraction (four questions); (iii) selling price of each resource (three questions); (iv) reserve fluctuations and future plans (two questions); and (v) personal information, such as full name, address, gender, year of birth, education, and family composition. The
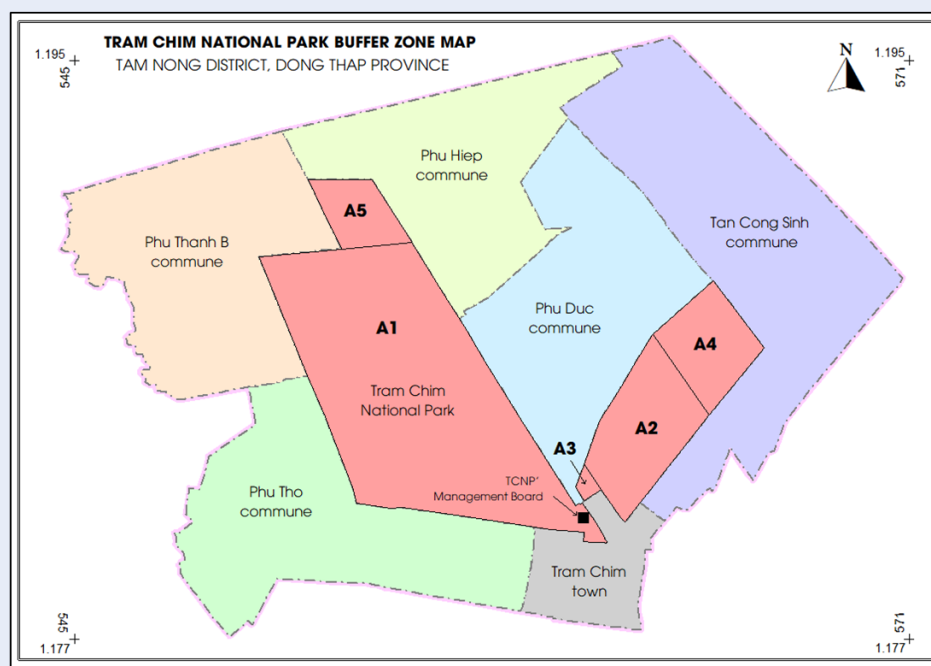
Figure 1: Administrative map of the buffer zone of Tram Chim National Park [16]

survey topics were introduced by the resource management staff and local authorities. Information on the selling prices of the resources was collected and subsequently adjusted to reflect current local market prices.

Valuation method

The monetary value of different resources is estimated using the Market Price Method, as applied in previous studies [17]. In general, the annual income of a household exploiting j resources from the i-th ecosystem service (where food = 1, fuel = 2, medicinal plants = 3, and decorative materials = 4) is calculated using formula (3). For example, if Mr. A's household extracts fish and vegetables from TCNP, both of which are part of the food provisioning service, then i = 1 and j = 2.

$$R_i = \sum_{j-1}^{m} l_j k_j t_j y_j p_j \qquad (3)$$

Where: Rij: income from j resources belonging to the i-th ES (m VND/hh/y).

l: number of household members exploiting in the protected area.

k: number of times to the protected area for exploiting each month (times)

t: number of months of utilization in a year (months)

y: average yield per use (kg)

p: market price of the resource according to survey or market research.

The results obtained from the pricing process are five sets of annual income data corresponding to the provision of food, fuel, medicine, decorative materials, and the total annual household income derived from these services. These results were then statistically described using SPSS software to determine the average value and average level of resource use per household per year.

Data analysis

A descriptive statistical analysis was undertaken to determine the average income of households exploiting each ecosystem service and for the population. The variables used for this analysis are presented in Table 1. The calculated average incomes were then tested using a one-sample t-test to determine whether the survey results on the sample were representative of the population. Finally, the proportion of households exploiting ecosystem services and the monetary value of the services provided by TCNP were assessed, and these results were interpreted.

RESULTS AND DISCUSSION

Results

Characteristics of resource exploitation activities in TCNP

Notable findings based on the 70 household survey responses included the following: (i) resource ex-

Table 1: Variables used in this study

Objective	Variable Name	Variable Description	Variable Type	Data Collection method
Household Participation Rate in	hh_N	Household code, encoded by the order of the data entry form	Norminal	Encryption
	pers_EX	Number of household members involved in extraction activities (person)	Scale	Interview
	nots_EX	Number of extractions per month (times)	Scale	Interview
	mth_EX	Number of months of extraction in a year (months)	Scale	Interview
	type_RS	Type of resource extracted	Norminal	Interview
	yield_RS	Yield in a extraction (kg)	Scale	Interview
	fob_RS	Price at the field (Free on Board) (VND/kg)	Scale	Interview Market Survey
Average Household	food_Y	Household food yield (kg/year)	Scale	Statistical
	fuel_Y	Household fuel yield (kg/year)	Scale	Statistical
	medic_Y	Household medicinal yield (kg/year)	Scale	Statistical
	decor_Y	Household decorative material yield (kg/year)	Scale	Statistical
	food_R	Household income from food (mVND/year)	Scale	Statistical
	fuel_R	Household income from fuel (mVND/year)	Scale	Statistical
	medic_R	Household income from medicinal (mVND/year)	Scale	Statistical
	decor_R	Household income from decorative material (mVND/year)	Scale	Statistical
	total_R	Total household income (mVND/year)	Scale	Statistical

ploiters in TCNP range in age from 35 to 75 years old, with 73% under the age of 55; (ii) 78% of respondents have completed primary education, while the remaining 22% have received secondary education; (iii) 48% of households only exploit resources during the 3 months of the flood season, 42% exploit for more than 6 months of the year, of which up to 20% utilize resources year round (the average number of months of exploitation per household is 6.6 months per year); (iv) 44% of households enter TCNP fewer than 10 times, 26.5% enter more than 20 times, with up to 14% entering daily; (v) the surveyed households currently exploit 11 different types of resources in TCNP: various types of freshwater fish; various types of crabs and snails; rice field rats; snakes; eels; various types of vegetables; other types of food crops; grass; melaleuca firewood; medicinal plants; honey; and water hyacinth. Details of the types of resources and the proportion of households engaged in their extraction are presented in Table 2. Types of resources with more than 10% of households engaged in utilization include various types of freshwater fish, various types of vegetables, snakes and eels, as well as various types of crabs and snails; the rest are exploited by less than 10% of households.

Table 2: Statistics of resource types being exploited in TCNP in 2024

ESs	No.	Code	Description of the resource	Household exploitation rate
Food	1	TN_CA	Various types of freshwater fish	100%
	2	TN_OC	Pila conica, apple snails, freshwater crab	34,4%
	3	TN_CHUOT	Ricefield rats	9,4%
	4	TN_BS	Snakes, eels	37,5%
	5	TN_RAU	Lotus, water lily, water spinach, sesbania sesban, amaranth, water mimosa, pickled small leeks	45,3%
	6	TN_KHAC	Young lotus leaves, broodstock, terrestrial turtles	4,7%
Fuel	7	TN_CO	Water chestnut plant, dry grass	7,8%
	8	TN_CUI	Melaleuca firewood	1,6%
Medicinal herbs	9	TN_THUOC	Creek premna, asiatic pennywort, periwinkle, stinking passion flower	9,4%
	10	TN_MAT	Wild honey	4,7%
Decorative materials	11	TN_BEO	Water hyacinth	3,1%

Valuation of ecosystem provisioning services

Household income from the exploitation of various types of resources in TCNP was evaluated using formula (3), then aggregated by type of ecosystem service to estimate household yield and the average income in the survey sample. Finally, we extrapolated to determine the yield and value of ecosystem services for the entire TCNP. The results of these calculations are detailed in Table 3. Key findings are as follows: (i) the average income of each household utilizing resources from TCNP is approximately 133 million VND per year, equivalent to an income level of 18 million VND per months of utilization; (ii) the annual exploitation yield for the entire TCNP is approximately 284 tons for food, approximately 2.0 tons for natural and raw materials, approximately 1.4 tons for medicinal plants, and approximately 1.2 tons for decorative materials; (iii) the value of TCNP's ecosystem provisioning services is approximately 17,690 million VND/year for food, approximately 60 million VND/year for natural and raw materials, approximately 170 million VND/year for medicinal plants, and approximately 25 million VND/year for decorative materials. Therefore, the estimated value of TCNP's provisioning services is approximately 17,945 million VND per year.

Maximum number of households exploiting resouces reported by TCNP, 2016[14].

Discussion

We conducted a comparison of the results of this study with the data published by TCNP in 2010 and 2016, as well as Triet & Barzen 2016[12–14]. This comparison included characteristics of resource extraction activities in TCNP, household income from resource extraction, and the results of the valuation of services provided by TCNP. Several differences were noted for several aspects, including types of extracted resources, household income from extraction activities, and the estimated value of ecosystem provisioning services:

The types of resources extracted: this study recorded an additional six types of resources being extracted in TCNP: (i) melaleuca honey, (ii) ricefield rats, (iii) some medicinal plants such as creek premna, asiatic pennywort, periwinkle, stinking passion, (iv) water hyacinth (stem and flower), (v) young lotus leaves, and (vi) broodstock. Among these resources, the largest extraction output is water hyacinth (about2.7 tons/year), followed by ricefield rats (about 2,1tons/year) and medicinal plants (about 2.6 tons/year). The remaining resources have a smaller extraction yield.

The time and frequency of extraction: previous docu- ments determined about 4 months (from September to December)[14] . However, the results of this study show that the number of households extracting for

Table 3: Results of valuation of yield and value of TCNP's provisioning services in 2024

No.	ESs	Yield	Income	hh' rate	No of hhs for TCNP *	Yield for TCNP	Value for TCNP
		(kg/hh/yr)	(mVND/hh/yr)	(%)	(hh)	(ton/yr)	(mVND/yr)
1	Food	891,35	55,45	91,14	319	284,34	17.690
2	Fuel	152,08	4,62	3,80	13	1,98	60
3	Medicinal	107,73	13,13	3,80	13	1,40	170
4	Decorative	302,00	6,04	1,3	4	1,21	25
	Total		132,84		350		17.945

up to 4 months accounts for 53% and the number of households extracting year-round accounts for 20% of the interviewed households. The average number of months of extraction is 6,6 with an average extraction frequency of 15 times/month.

The types of resources extracted: this study identified six additional types of resources being extracted in TCNP: (i) melaleuca honey, (ii) ricefield rats, (iii) some medicinal plants such as creek premna, asiatic pennywort, periwinkle, and stinking passion, (iv) water hyacinth (stem and flower), (v) young lotus leaves, and (vi) broodstock. Among these resources, the largest extraction output is water hyacinth (approximately 2.7 tons/year), followed by ricefield rats (approximately 2,1 tons/year) and medicinal plants (approximately 2.6 tons/year). The remaining resources have a smaller extraction yield.

The time and frequency of extraction: previous documents considered approximately 4 months (from September to December) of data[14]. However, the results of this study show that the number of households extracting for up to 4 months accounts for 53% and the number of households extracting over the entire year accounts for 20% of the interviewed households. The average number of months of extraction is 6.6, with an average extraction frequency of 15 times/month.

Extraction output: TCNP records in 2009[12] reported 15.526 tons of fish, 6.2 tons of vegetables, and 18.6 tons of snails. The reported figures in 2016 were 43.3 tons of aquatic products, 5.0 tons of vegetables, and 1.7 tons of snails[14]. In contrast, the estimated data from this study show numbers that are 10 times higher than the above statistics. Specifically, 359 tons of fish are harvested, 35 tons of vegetables are produced, and 125 tons of snails are harvested.

The average income of extracting households: the data in 2016 estimated approximately 1.4–2.0 million VND/person/month[14], whereas the estimated value from the study is 18 million VND/month. This is approximately nine times higher than the data in 2016. As a result, the estimated value of TCNP's provisioning services is substantially greater than previously reported.

The results of this study were converted into international dollars per hectare per year (int$/ha/year) to facilitate comparison with findings from other similar studies set in various regions (seeTable 4). The provisioning service value estimated for TCNP is higher than those reported for wetland areas in Mozambique (by 71%) and Taiwan (by 73%). However, our estimate is significantly lower than values found in studies conducted in Laos (1.419% higher), Botswana (474% higher), and Uganda (231% higher). These disparities may be attributed to differences in the intensity and scale of resource exploitation, ecological characteristics, levels of market integration, and variations in national policies governing wetland use and conservation. Furthermore, methodological differences in resource valuation and data availability may also contribute to the observed variation in estimates.

CONCLUSIONS

The goal of this study was to identify the types of resources currently being exploited in TCNP, estimate the annual extraction output, and subsequently estimate the total value that these resources bring to the people in the TCNP buffer zone. The estimated amount represents the value of the provisioning ecosystem services of TCNP. This was achieved by using structured questionnaires to conduct interviews with 70 households currently engaged in resource extraction in TCNP. The most significant findings include: (i) the identification of 11 types of resources currently being exploited, including the addition of 6 new types to the previous TCNP resource list: honey, ricefield rats, medicinal plants, water hyacinth, young lotus leaves, and broodstock; (ii) the

Table 4: Comparison with other studies

No.	Year	Country	Value of provisioning services (int$/ha/y)	Compare with this paper's result (%)	Authors
1	1991	Nigeria	141,80	39,64	Barbier, E.B.
2	1998	Uganda	336,23	231,11	Emerton, L., et al.
3	1999	Mozambique	28,45	-71,98	Turpie, J., et al.
4	2000	Cambodia	259,03	155,09	Hap, N., et al.
5	2001	Botswana	583,11	474,23	Seyam, I. M., et al.
6	2004	Laos	1.542,77	1.419,28	Gerrard, P.
7	2012	Taiwan	27,05	-73,36	Chiueh, Y.
8	2012	Indonesia	226,45	123,00	Hanafi, I., et al.

identification of the average annual extraction yield, with food accounting for the largest volume at approximately 284 tons/year, representing 98.4% of the total annual output of TCNP; (iii) the average calculated income of households when exploiting resources in TCNP was an estimated 18 million VND/month, nine times higher than the data provided by previous studies; and finally, (iv) the total estimated value of the ecosystem provisioning services of TCNP based on these data was 17,945 million VND/year.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Author 1: Methodology, Funding acquisition. Author 2: Formal analysis. Author 3: Investigation. Author 4: Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ACKNOWLEDGEMENTS

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