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ASSESSMENT OF MANGROVE LITTERFALL IN MANGROVE-SHRIMP SYSTEM IN KIEN GIANG

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ABSTRACT

Mangrove-shrimp farming is practiced in the buffer zones of mangrove forest to enhance local livelihood and protect mangrove. To understand the properties of this system, this research focuses on assessing its litterfall, litter carbon accumulation, and CO2 uptake. It includes sampling the litter, simulating the carbon and the uptake, and interviewing local people. Results show that the local people considered this system a nature-based farming having minimized human effects on mangrove and shrimp growth to maintain and protect mangrove. The mean litterfall collected per a farming term for the farm I and II was 250,38 g/month and 162 g/month, respectively. The litter carbon was 112,67 g/month and 72,9 g/month, respectively. C-CO2 was about 413,5 g/month and 267,54 g/month for farm I and II, respectively.

1. INTRODUCTION

Mangrove is a crucial ecosystem which can help neutralize climate, disaster, and storm, and protect coastal areas and erosion. In addition, mangrove can provide local livelihood through mangrove-shrimp farming. Previous studies in mangrove areas often focus on mangrove plant and tidal flat; and dismiss the areas where local people take uses of for integrated farming including shrimp raising and mangrove protection.

The mangrove-shrimp system (MSS) can help local people to make income from shrimp and at the meantime creates related jobs such as pond construction, pond management, shrimp harvest, shrimp shipping and sales. It can reduce aquacultural effects on ecosystem as compared to intensive shrimp farming, particularly minimizing waste, and harmful chemicals to water environment. This system then can protect mangrove from its degradation.

In Kien Giang, such system with *Rhizophora sp.* has been widely applied to help enhance local income and mangrove protection. It can also provide the potential in accumulating carbon and reducing greenhouse gas emission, which these functions need more exploration. Accordingly, this research assesses the mangrove litter, litter carbon and CO_2 uptake in MSS to enhance understanding of the functions.

2. METHOD

2.1 Research Duration

This research was conducted from 4/2023 to 7/2023, a full MSS farming term.

2.2 Research sites

The research sites are in Vân Khánh Đông Commune, An Minh District, Kien Giang Province (Figure 1).

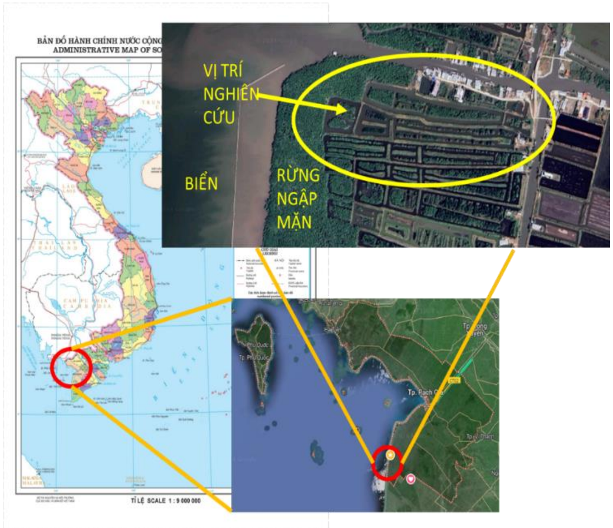

Figure 1. Research site

We selected two farms having the same farming characteristics but different mangrove area/shrimp area ratio (70% and 50% for farm I and II, respectively).

Table 1. Coordinates

Point	X	Y
	Farm I	
A	9.649309	104.852221
B	9.649700	104.847270
C	9.650488	104.847452
D	9.649700	104.852318
	Farm II	
E	9.649843	104.851904
F	9.650377	104.848246
G	9.650816	104.848396
H	9.650176	104.851996

I **II**

Figure 2. Farm I and II

2.3 Interviews

We interviewed farmers on the state of shrimp farming including farming techniques and pond properties.

2.4 Mangrove litter sampling

The sampling distribution is the same for the two farms. Farm I and II have the area of 3,17 ha and 2,13 ha, and the mangrove ration of 50% and 70%, respectively. In each farm, we selected 3 sampling sites to collect the litterfall (Figure 3).

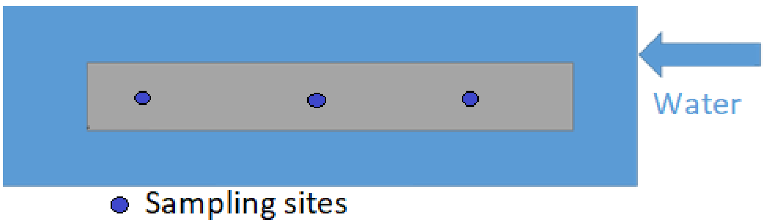

Figure 3. Mangrove litter sampling sites

In the sampling sites, we used a net 1m x 1m with the 1mm mesh size. The net bottom is set 50 cm high from ground to make sure the littlefall unflooded (Figure 4). The litterfall was collected monthly.

Figure 4. Litter collection net

2.5 Equations

The collected litterfall was weighted and then we used the Kauffman & Donato (2012) equations to estimate the litter carbon and CO2 uptake as follows

$$\text{Litter cabon} = m_{litter} \times 0{,}45 \quad (1)$$

$$CO_{2(uptake)} = C_{litter} \times 3{,}67 \quad (2)$$

3. RESULTS

3.1 Mangrove-shrimp farming state

Results show the recent change of mangrove-shrimp farming in which blood cockle and crab have been also introduced besides shrimp because shrimp farming is difficult. Shrimp seeds were purchased from business intermediaries or cooperatives or pilot projects, which were well-screened. The seedling was often in the 1st or 15th of a month (lunar calendar) when high tides had proper salinity levels for shrimp growth.

Shrimp feeds directly come from organic matters in seawater and the litterfall without an additional supply from local farmers. This is the typical characteristics of MSS defined from its biochemical processes. Each farm is an ecosystem with mangrove as a producer and shrimp as a consumer utilizing the organic matters from the litterfall to grow and then supplying nutrients to mangrove when decomposed.

The major MSS management task is water control that farmers will allow water exchange between MSS and seawater channels once per farming term. Water inflow happens on the 1st and 15th of the month when high tides occur which is 2-4 weeks from the seedling time. The purpose of water management is to help the seeds adapt to water changes (Figure 5). In one term, farmers can also proceed with water changes many times as needed to cure water pollution, salinity problems, and shallow water level.

Results reveal farming stages (Figure 5). After the seedling, the seeds will have 20 days to adapt to MSS water condition until reaching its stable state. After that, water is replaced in 1-2 days. Next, farmers treat water using lime and let the seeds adapt to new water in next 20 days. Then, there is no intervention from the farmers until the harvest (in next 70 days) except for unexpected problems of disease and water pollution.

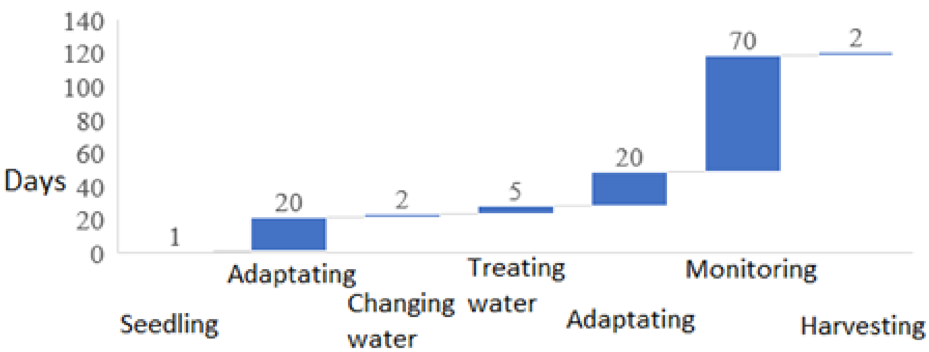

Figure 5. Mangrove-shrimp farming stages

In the farming, shrimps with disease are removed. The farmers prevent the disease by water change and lime application. The farming does not apply chemicals and antibiotics and thus shrimp quality is good but low productivity. Information of the farming is shown in Table 2:

Table 2: Farming information.

Farm	Area (ha)	Mangrove portion %	Mangrove	Management	Feeds	Chemical/ Fertilizer	Duration (month)	Bed removal (year)	Types
I	3.17	50	*Rhizophora sp.*	Maintain water	Litter	No	3-4	5	Asian tiger shrimp
II	2.13	70	*Rhizophora sp.*	Maintain water	Litter	No	3-4	4	Asian tiger shrimp, blood cockle

3.2 Litterfall estimation

The litterfall samples were dried in 2h at 105°C and shown in the Table 3. Results from Table 3 show that in Farm I, the litter amount was different among the sampling sites (the site 3 with the highest value of 495,12 g/month). This indicates that the litterfall distribution was various in the farm, which depends on weather, due to plant density, wind, and human effects. Similarly, in the farm II, the various litterfall distribution was observed with the greatest of 183,85 g/month in the sampling site 2. In common, the results of sampling times III showed the litterfall amount is more than the other sampling times, which was due to strong winds as reported by the farmers.

Table 3. The litter in one term (g/month)

Sampling times	Farm I			Farm II		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
I	128.11	142.77	403.50	109.08	78.60	137.22
II	57.99	134.81	501.29	96.24	86.04	142.38
III	101.42	203.91	648.50	219.31	476.73	276.54
IV	115.54	139.52	427.20	98.52	94.01	129.30
Average	100.76	155.25	495.12	130.79	183.85	171.36

3.3 Litter carbon

***Farm I**

Figure 6 shows the litter carbon in the farms. The highest carbon amount is in the sampling site 3 with 222.8 g/month. According to Kauffman & Donato (2012) , the mean litter carbon portion is 38 - 49%. The litter is part of mangrove ecosystem and related to carbon accumulation in plant biomass and sediment, which various by location and time in MSS.

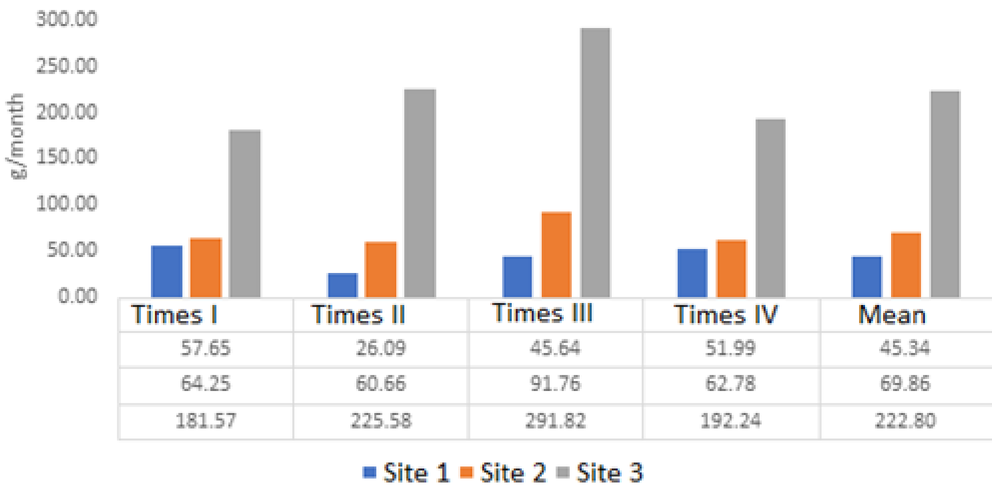

Figure 6. Litter carbon in Farm I

Notes: "Sites" is sampling sites.

*** Farm II**

Results shown in Figure 7 show the litter carbon in Farm II in four sampling times. The highest carbon amount was at the sampling site 2 in this farm at 82.73 g/month. The Farm II is like the Farm II in terms of various litter carbon distribution through the farm.

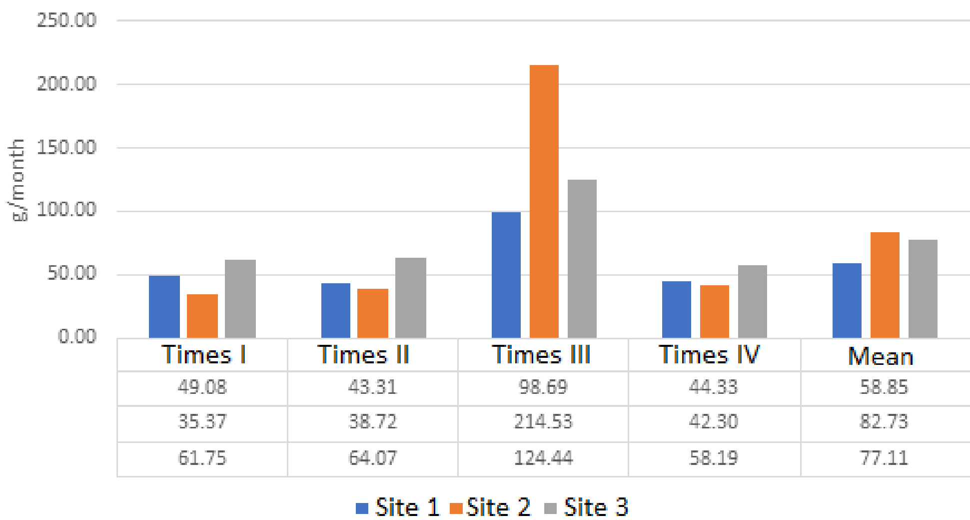

Figure 7. Litter carbon in Farm II

3.4 CO_2 uptake

*** Farm I**

The CO_2 data in Farm I in Figure 8 shows the highest uptake in the sampling site 3 at 817.69 g/month. Kauffman & Donato (2012) suggested converting carbon accumulation to CO_2 uptake by multiplying the litter carbon by CO2 weight. Using this approach, we found the positive correlation between CO2 uptake and the litter carbon accumulation.

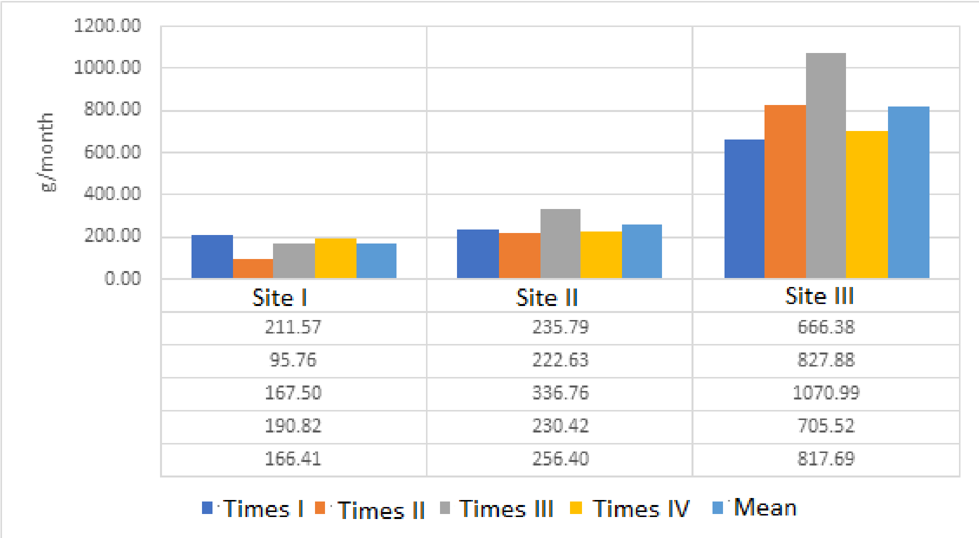

Figure 8. CO_2 uptake in the litter in Farm I

*** Farm II**

In Figure 9, CO_2 uptake is the highest in the site 2 at 303.62 g/month. Like Farm I, the CO_2 uptake varies in the farm.

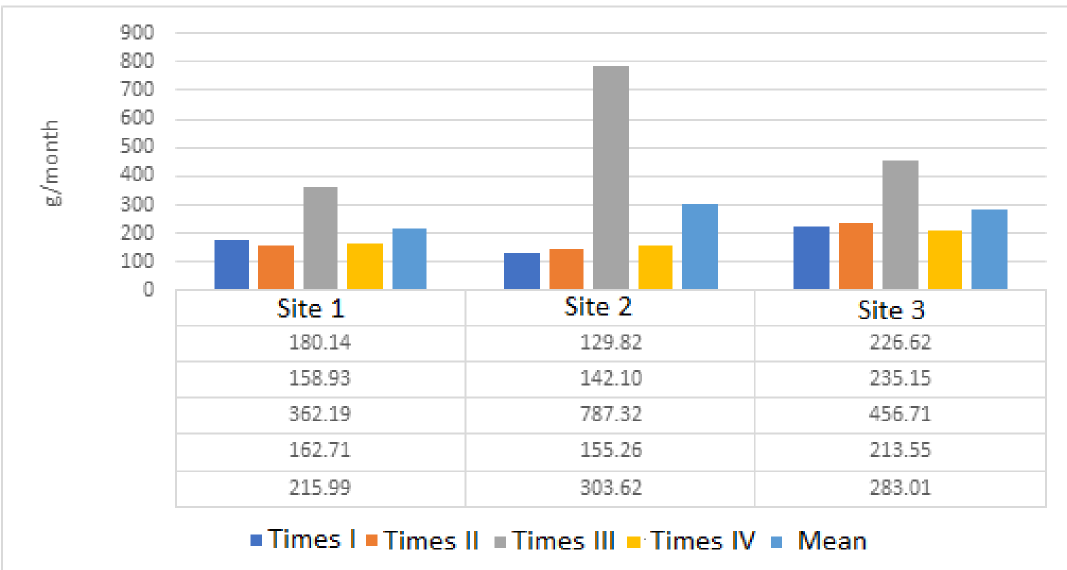

Figure 9. CO_2 uptake in Farm II

3.5 Simulation results

Simulation results showed that litter, litter carbon, and CO2 uptake in Farm I is higher than those in Farm II (Table 4).

Table 1. Mangrove litter simulated (g/month)

Items	Farm I				Farm II			
	Site 1	Site 2	Site 3	Mean	Site 1	Site 2	Site 3	Mean
Litter amount	100.76	155.25	495.12	250.38	130.79	183.85	171.36	162.00
Litter carbon accumulation	45.34	69.86	222.80	112.67	58.85	82.73	77.11	72.90
CO2 uptake	166.41	256.40	817.69	413.50	215.99	303.62	283.01	267.54

Results reported the effects of environment (i.e., wind) on the litter and then carbon accumulation and carbon cycle in MSS. The litter amount in our study is approximately equal to that in the other mangrove without shrimp farming as reported by Võ Nguơn Thảo & Trương Thị Nga (2015) , Hoàng Trọng Khiêm & cs (2022) .

4. CONCLUSION

MSS is a nature-based farming with low costs and less labor work requirement which can help farmers gain income and mangrove protection. MSS has a recent change with including crab and blood cockle besides shrimp. The litter carbon and CO_2 uptake vary in the farms due to farm characteristics and weather (i.e., wind). For this reason, MSS management should consider these factors.

CO_2 uptake in MSS is similar to natural mangrove systems and thus it should be paid attention to. It is suggested that more similar research should be continued to clarify this issue more.

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