ASSESSMENT OF SALINITY PROCESSES ON RICE-SHRIMP FARMING MODEL IN REGIONS CONVERTED FROM AGRICULTURAL LANDS TO SHRIMP FARMING IN CA MAU PROVINCE

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ABSTRACT

The conversion of inefficient agricultural and forest land to rice - shrimp farming model in the Mekong Delta in general and Ca Mau province in particular has brought remark benefits in terms of economic development. However, the introduction of salt water into some freshwater regions have created environmental problems, which is not only impact on shrimp farming but also on many other agricultural ecosystems. Land degradation and especially soil salinization is a concern not only for soil scientists and environmentalists but also for the land managers due to its multi-dimensional impact on national sustainable development. As such, it should be considered and addressed urgently. The case study has shown actual state as well as changes in visible soil salinity over time for the rice-shrimp farming model. ESP (exchangeable sodium percentage) value is likely to decrease according to availability of rice crops and soil depth as well because there is rain water suppling during the harvest. At some of the sample points (CN8, TPCM2, PT1), these are the abandoned fields and are drained in preparation for next shrimp after the failure of rice sowing, therefore the level of sodic soils has a tendency to increase according to shrimp crops. The process of deep salinity has been shown through some sample points such as CN2, CN5, TB2, TPCM2, sodic soils of the floor 20 - 40 cm is higher than the level of the floor 0-20 cm, desalination process has only reduced the amount of salt in the surface.

***Keywords**: rice - shrimp, salinization, Ca Mau, sodic soils*

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1. INTRODUCTION

In recent years, the ecology of Ca Mau province has changed from its original natural ecosystem to a human-controlled ecosystem[12]. In 1999 to 2000, many agricurally ineffiicient coastal areas were converted rapidly from a pure freshwater rice-based agriculture model to a saltwater and brackish aquaculture ecosystem and a rice - shrimp rotational model. Developing shrimp hatching contributed to raising incomes and improved living standards for the residents. However, the use of salt water for shrimp hatching has generated many problems in regard to soil quality and has effected to other facets of agricultural ecology.

Evaluating the state of salinity concentration in the soil in the region due to shrimp hatching is necessary to ensure sustainable development of the rice - shrimp model. This research has the following objectives: (i) Survey chemical process of plant – rice – shrimp in Ca Mau province; (ii) Evaluate soil sanility to the rice – shrimp model in areas which have changed their land use from the agriculture to the shrimp hatching model.

2. MATERIALS AND METHODS

2.1. Selection of Sample Plots

57 sample points utilizing agricultural-aquicultural methods were selected for this study. These points were largely distributed in districts such as Cai Nuoc, Thoi Binh, and Ca Mau. The choice of some sample points was based the state land use and environmental planning maps of Ca Mau.

To evaluate changing soil characteristics and soil quality of agricultural – aquicultural model, sampling was performed during the growth period of the rice. Both the first and the last of the last of crop were sampled.

At every sample point, sample soils were taken at 5 locations following a diagonal and mixed to become one sample. Sample soils were taken at depth from 0 – 20 cm and 20–40 cm. About 2 kg of sample soil was collected and were stored in nylon bages.

2.2. Soil Sampling and Analysis

To determinate the salinity and sodic of the study area, the indicators in soil samples including pH, EC, Na^+ saturated, CEC were analyzed.

***Table 1:** Method analyzes some sample soils with some criterion*

No	Parameter	Unit	Method
1	CEC	cmol/kg	Measured in a 0.1M $BaCl_2$ extraction
2	Na^+	cmol/kg	Extracted by $BaCl_2$ 0.1M, measured by atom absorbing machine
3	pH	-	Saturatedly extracted by distilled water, measured by pH indicator
4	EC	mS/cm	Saturatedly extracted by distilled water, measured by EC indicator

Sampling Period: *114 total samples were taken from Aug 2011 to Dec 2011.*

2.3. Classify soil based on salinity

Exchange Sodium Percentage (ESP) which were calculated based on cation absorption ability of soil, CEC and Na exchange by this formula [8,14]:

$$ESP = \frac{Na+}{CEC} \times 100$$

Saline, sodic and saline-sodic soils are differentiated on the basis of Exchange Sodium Percentage (ESP), electrical conductivity, soil pH and their effects on soil physical conditions (Table 2) [3,13].

***Table 2:** Characteristics of saline, sodic and saline-sodic soils*

Classification	Soil pH	Electrical conductivity ECe (mS/cm)	Exchange Sodium Percentage ESP (%)
Saline	< 8,5	> 4	< 15
High pH	> 7,8	< 4	< 15
Saline - Sodic	< 8,5	> 4	≥ 15
Sodic	> 8,5	< 4	≥ 15

Source: Davis et al. (2007)

3. RESULTS AND DISCUSSION

3.1. The status of using agricultural land

Ca Mau province, which contains 464.769 ha of agricultural land, accounts for 87,78% total of natural areas in the province. Agricultural lands are mainly centered in the Dam Doi, U Minh and Tran Van Thoi districts [5, 12]. At present, Ca Mau province has 37.642 ha rice land which is combined with shrimp hatching. These areas are mainly at Cai Nuoc, Phu Tan, Dam Doi, Thoi Binh district and a part of Tran Van Thoi and Nam Can district [5,12].

Transition areas also occur at the boundaries of freshwater areas. One reason is spontaneous because the land use plan and transition plan for agricultural manufacture have not yet been combined. So, many of these become saline/shrimp areas because of the migration of salt water into them. This made these agricultural areas increasingly narrow, ineffective and unsustainable.

Based on the state of local land use transition and aquaculture, samples were randomly taken at transition areas. There were 57 sample points which were taken at Ca Mau city, Thoi Binh, Cai Nuoc and Phu Tan district.

3.2. Chemical process of soil

a) Soil pH

Soil pH determination is an indication of the acidity or alkalinity of the soil. Soil pH requirements for good tree seedling growth given in literature are generally between pH (H_2O) 5.0 and 7.0. Within this pH range, microbial activity and nutrient availability are considered optimal [5, 6].

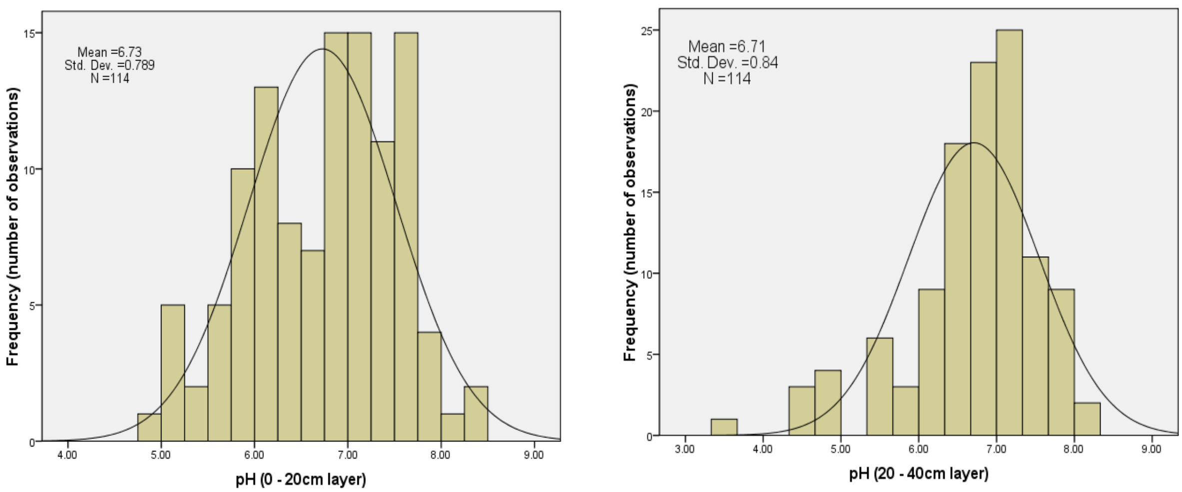


Figure 1*. Frequency distribution of pH values in soil (0 – 20 cm and 20 – 40cm layer)*

The results indicate, pH values is about 6.73 ± 0.79 in the 0 – 20 cm soil layer and 6.71 ± 0.84 in the 20 – 40 cm soil layer (Figure 1). pH values of soil oscillate from 4.99 to 8.3 in the 0 -20 cm layer and from 3.63 to 8.23 in the 20 – 40 cm layer. pH valuation of soil which has been impacted by irrigation and salinity for many years see an increase in pH values (Figure 2).

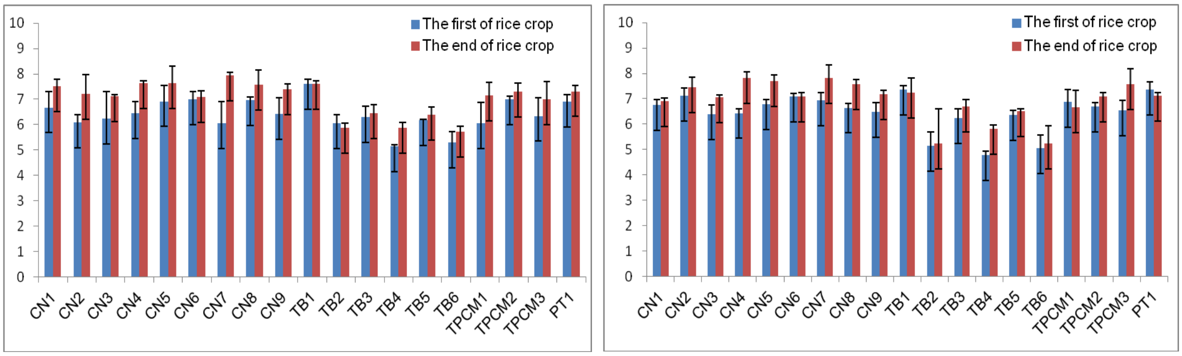


***Figure 2**: Oscillation pH of soil at A (0-20 cm) layer and B (20 – 40 cm) layer between among locations in the first and the end of the rice crop.*

b) The Electrical conductivity of the soil (EC)

Electrical conductivity (EC) is the most common measure of soil salinity. By agricultural standards, soils with an EC greater than 4 dS/m are considered saline [1, 2, 4,11]. In actuality, salt-sensitive plants may be affected by conductivities less than 4 dS/m and salt tolerant species may not be impacted by concentrations of up to twice this maximum agricultural tolerance limit. Thus, the reclamation scientist must exercise care in interpretation of salinity standards. Salinity should be defined in terms of the predisturbance land use potential, the proposed postdisturbance land use, and the plant species to be seeded on the site (Munshower, 1994).

Follow this result, EC values is about 10.69 ± 3.73 in 0 – 20 cm soil layer and 6.71 ± 0.84 in 20 – 40 cm soil layer (Figure 1). The distribution of EC values range from 5.30 to 23.35 mS/cm in 0 – 20cm soil layer and range from 3.92 to 17.81 mS/cm in 20 – 40cm soil layer. (Figure 3).

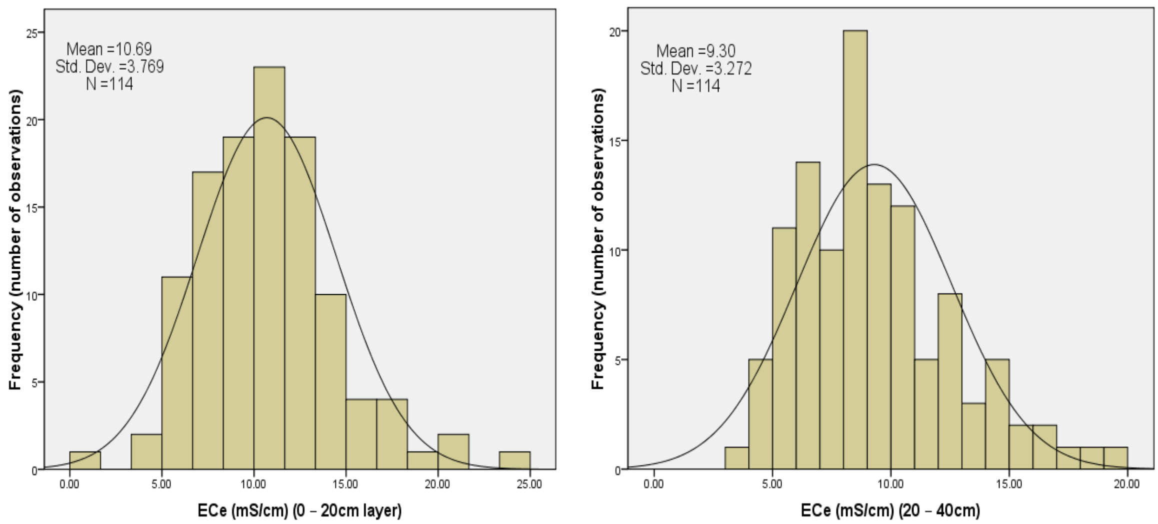


***Figure 3**. Frequency distribution of EC (mS/cm) values in soil (0 – 20 cm and 20 – 40cm layer)*

The conductivity in surface layer is high at the first of rice crop and decrease gradually by the end of rice crop. This happens because the effect of rainfall which dilutes the salt concentration in the surface layer. However, at locations CN8, TPCM2, and PT1, the trend of EC value increases with time (Figure 4), for the following reasons: (1) After the first sow spreadly, all farmers didn't use land for rice cultivation anymore; (2) Farmers lead saline water into the pond for shrimp hatching.

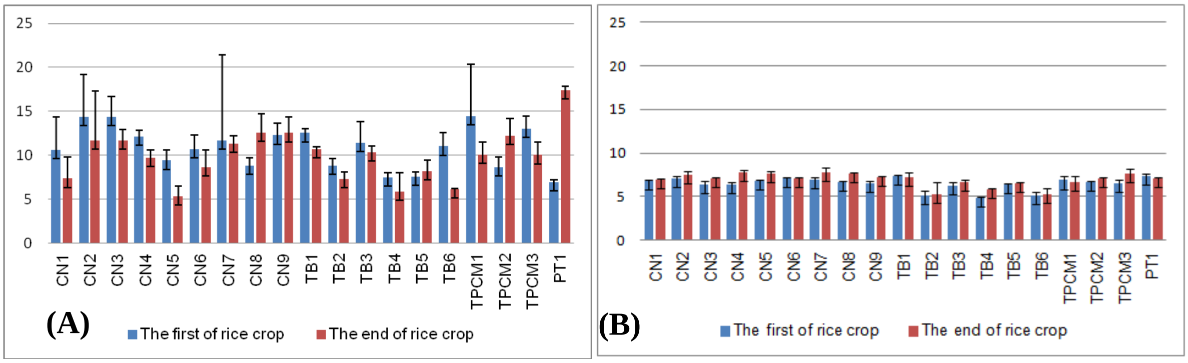


***Figure 4**: Oscillation EC in soil of A layer (0 – 20 cm) and B layer (20 – 40 cm) bewteen some locations at the first and the end of rice crop. The vertical bar in the chart represents the standard diviation value.*

The salinity trend at Thoi Binh district is lower than at Cai Nuoc, Phu Tan district and Ca Mau city when analyzing some soil samples; The salinity trend at Thoi Binh district is lower than at Cai Nuoc, Phu Tan district and Ca Mau city. This can be explained by the fact that the Thoi Binh district is under the planning of north of Ca Mau. That area is investing some important irrigation projects which belong to desalination project of Ca Mau province. This desalination project results in Thoi Binh salination levels being more favourable than other districts. However, if considering the total salinity of all locations at the soil layer as above it still exceed ecological threshold of rice; which can't grow with these levels of soil salinity. This is quite consistent with the results of the actual survey.

The results also show that desalination process is not thorough and salinity concentrates in the 20 – 40cm layer. This happened because Ca Mau province occurred drought and low rainfall.

c) Na^+ cation

The distribution of Na^+ concentration value is about 9.0 ± 2.71 in the 0 – 20cm layer and 8.12 ± 2.57 in the 20 – 40cm layer. The frequency distribution of Na^+ concentration value showed at Figure 5.

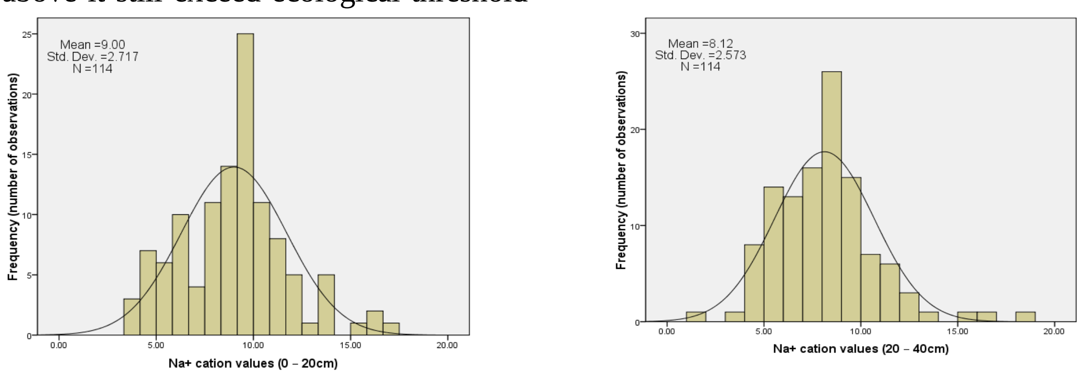


***Figure 5**. Frequency distribution of Na^+ cation values in soil (0 – 20 cm and 20 – 40cm layer.*

The concentration of Na^+ in the 0 – 20cm layer tends to be greater than the 20 – 40cm layer in many study regions (Figure 6). This is explained by the cultivation process involving the exchange of salt water from canals outside and rice – shrimp fields regularly. So, the deposition and accumulation of sodium (Na) at the lower layer is less than at the surface layer. Following the trend of the EC data, at some sample points such as: CN8, TPCM2, PT1, the Na^+ value tends to decrease over time.

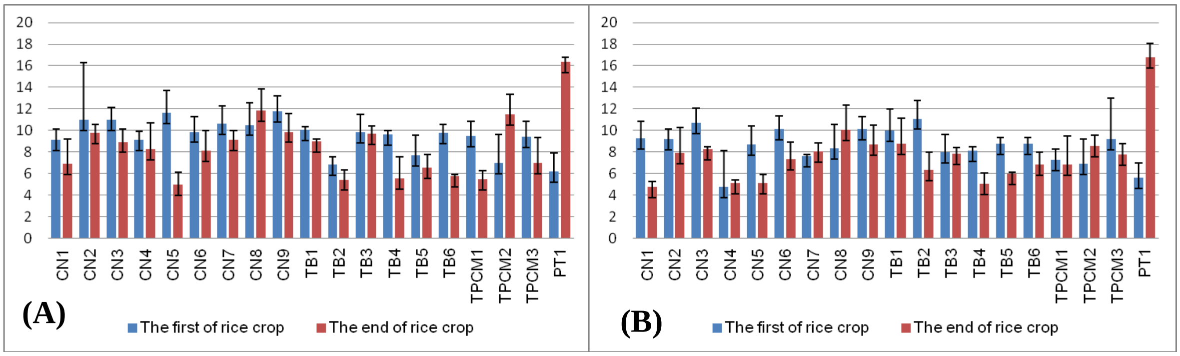
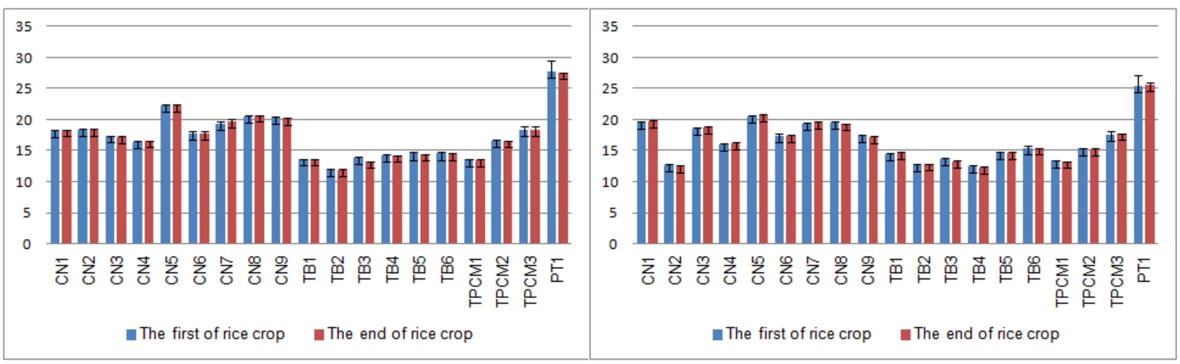


Figure 6. *Na^+ value of some samples at 2 layers: (A) 0 – 20cm and (B) 20 – 40cm. The vertical bar in the chart represents to the standard diviation value.*

d) CEC of the soils

The cation exchange capacity (CEC) of a soil is defined as the total sum of exchangeable cations that can adsorb at a specific pH. Cation exchange of exchangeable cations in reversible chemical systems is a quality important in terms of soil fertility and yeild nutrition studies. Mekong Delta soil often contains more clay and less organic material so the cation exchange capacity are average to good (Hung Ngo Ngoc et al, 2004).

CEC values of soil samples are shown at Figure 7. The CEC values of the 0 – 20 cm layer range from average to high, the lowest CEC value is 11.78 cmol(+) kg^{-1} (TB2), the highest CEC value is 27.69 cmol(+) kg^{-1} (PT1); CEC value in the 20 – 40cm layer changes from 11.93 cmol(+) kg^{-1} to 27.47 cmol(+) kg^{-1}. CEC value don't correspondingly change with shrimp hatching time.



(A) **(B)**

Figure 7. *CEC value in soil of some samples at 2 layers: (A) 0 – 20cm and (B) 20 – 40cm). The vertical bar in the chart represents to the standard diviation value.*

3.3. Soil classification in research region

All ESP values of samples exceed sodic soil threshold (Table 1). ESP values tend to decrease following the rice crop and with decrease with depth of the soil because of the addition of water to the rice crop. Some samples points (CN8, TPCM2, PT1), included fallow fields which had been irrigated with salt water to prepare for the next shrimp hatching after the failure of the last crop. In such cases sodic level trend to increase following said crop. Some sample points such as: CN 2, CN5, TB2 and TPCM2, sodic level of 20 – 40 cm layer is higher than 0 – 20 cm layer. This result could be explained as follows:

– Salinity has penetrated deeply at these locations.

– The process of saline washing only makes the salt at surface layer decrease

Therefore, at 2 layer 0 – 20cm and 20 – 40cm, soils of rice – shrimp model are saline – sodic. This shows that all rice – shrimp cultivation regions are saline because famers have used saline water for shrimp hatching for a long period without following them with effective desalination methods. Weather and salination patterns contribute as well. With high sodic concentration like these, it would be so difficult for famers to cultivate rice again because of the lengthy time required to improve the soil.

4. CONCLUSION

After a long time applying the shrimp hatching – rice planting technology, it causes the increase in the salinity and sodic in soil that create the difficulty in salt removing process. This situation is presented by the increase in EC, Na^+ saturated and ESP (>15%).

This study that suggests the solutions to improve the quality of soil in area study toward the sustainability of shrimp hatching – rice planting model should have the experimental researches about the salt removing technology. To do this, the factors including the total volume of using water, the time to steep the lake, the improvement technology after shrimp hatching season.

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ĐÁNH GIÁ DIỄN BIẾN ĐỘ MẶN TRÊN MÔ HÌNH CANH TÁC LÚA – TÔM Ở TỈNH CÀ MAU

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TÓM TẮT

Việc chuyển đổi đất nông, lâm nghiệp kém hiệu quả sang mô hình canh tác lúa - tôm ở đồng bằng sông Cửu Long nói chung và Cà Mau nói riêng đã mang lại lợi ích nhất định trong phát triển kinh tế xã hội của địa phương. Tuy nhiên, quá trình chuyển đổi đã làm cho môi trường và hệ sinh thái khu vực không ngừng biến đổi, không chỉ ảnh hưởng đến nuôi tôm mà còn trên nhiều hệ sinh thái nông nghiệp khác. Một số vấn đề về môi trường bắt đầu nảy sinh như mặn hóa đất đã và đang gây ra mối quan ngại về tính bền vững của mô hình này. Qua nghiên cứu tại địa phương cho thấy, các thông số đặc trưng cho độ mặn trong đất

gia tăng theo thời gian nuôi. Tại một số điểm mẫu (CN8, TPCM2, PT1) chỉ số này đã vượt qua ngưỡng đất mặn nhiều (> 4mS/cm) gây bất lợi cho canh tác lúa và làm ảnh hưởng đến tính bền vững của mô hình lúa – tôm.

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