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SALINE SOILS AND CROP PRODUCTION IN COASTAL ZONES OF VIETNAM: FEATURES, STRATEGIES FOR AMELIORATION AND MANAGEMENT

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Abstract

Vietnam is a humid tropical country in Southeast Asia with total land of 331,000 km^2 and a long sea line of more than 3260 km. In recent decades, due to rapid population growth, demand for food and food security has increased. Today, Vietnam is one of the five countries most affected by climate change. Therefore, reclamation of coastal, saline soil has been receiving increasing attention to explore its economic potentials for agriculture. There are three main types of saline soil (i) Mangrove Saline Soil – Gleyicsalisols or Glayi Salic Fluvisols (FLsg), (ii) Strong saline soil – Hapli Salic Fluvisols (FLsh) and (iii) Medium and weak saline soil – Molli Salic Fluvisols (FLsm). The formation of saline soil in coastal Vietnam is mainly due to tidal inundation and salt-effected ground water. There are many production models such as rice cultivation, rice-fish, saline-emerged forest, aquaculture, etc in coastal zones. Rice cultivation is the most popular model. Twice-cropping rice is cultivated in the central and northern coastal area, while triple-cropping rice is just cultivated in the south and south-east region. There are large differences in climate regime, topography, soil conditions, cultivation customs, society and economic conditions between different regions in the long coastline of Vietnam. Hence, management of saline soils should be based on individual characteristics of each region.

Key words: Coastal areas, Cropping patterns, Fertility, Saline soils and tidal inundation.

Introduction

Locating on the eastern margin of the Indochinese peninsula, Vietnam has a long coastline with two archipelagoes of Truong Sa (Spratly island) and Hoang Sa (Paracel island) (Cuong & Cu, 2014) (Fig. 1). The mainland stretches from 08°10' to 23°24' northern latitude and widens from 102°09' to 109°30 eastern longitude (Rahman & Ahsan, 2001). Vietnam covers 331,000 km^2 in total, and saline soils are found in 3% of the total area, covering about 971,356 hectares (Anon., 1996). In the world, approximately 1000 million ha of land is affected by salinity (Khalid *et al*., 2016).

In coastal regions of Vietnam in specific and throughout the world in general, salinity is one of the major constraints to agricultural production (Niaz *et al*., 2019); other major factors are flooding and drought (Dasgupta *et al*., 2015). The saline-soil is characterized by water deficiently (scarcity) and is often affected by aquifers with high salinity and salinity (Zia *et al*., 2006). Main causes of salinity are the invasion of seawater during tidal action, penetrate through drainage canals, particularly in the dry season when rainfall is deficient (Lang *et al*., 2010). In this region, saltwater intrusion extended up to 20 to 90 km inland (Anon., 2016). Due to salt-affected soils, the average rice's yield in saline soils in this region is low, from 0.8 to 1.5 tons/ha and that of maize is from 1.0 to 2.0 tons/ha (Lang *et al*., 2010).

In the past, salinity used to obtain very little attention from the government (Lam *et al*., 2014). However, recently, the booming of population has created an increasing demand for more food and food security. In addition, Vietnam is one of the five countries most influenced by climate change (Vien, 2011). Therefore, in order to boost the productivity, land and water resources in salt-effected coastal areas are being overexploited. This land use practice creates a potential threat of food shortage because small farm production cannot provide sufficient food for the whole year. Consequently, saline soils reclamation gets more attention because these lands may feed the social-economic development in coastal zones.

In order to enhance of the agricultural potential of saline soils in coastal regions, it is necessary to evaluate the recent situation of crop production in saline soils. We evaluate the effects of salinity formative condition, tide, saline soil classification, fertility status, and land use and cropping patterns on crop production in this report. In addition, we also focus on study-based knowledge in relation to the management of saline soils.

Materials and Methods

Data was collected from prestigious international publishing scientific articles, books, conferences' reports from all the word. In addition, authors' knowledge and experiment in related researches in coastal regions of Vietnam were referenced.

Result and Discussion

Characteristics of the coastal regions: The 3,260 km long coastline of Vietnam begins from the north of the country (Mong Cai province) down to the south (Ha Tien province) with two fertile deltas of the River Red and the River Mekong (Fig. 1) (Rahman & Ahsan, 2011 Qarir *et al.,* 2000; Tho *et al*., 2007). This coastline is bordered by the Gulf of Tonkin and East Sea to the east and the Gulf of Thai Lan to the south (Rahman & Ahsan, 2013). The coastal zone is divided into three regions with north, central and south. They include 28 coastal provinces and inhabit nearly a one third of the total population (about 30 million people are living) (Lang *et al*., 2010).

Salinity built-up in the coastal regions: Saline soils in coastal zones are often built-up near the estuaries river where elevation is lower than 1.0 meter above sea surface level. The salts enter inland via rivers and canals, particularly during the time when fresh water becomes very low due to less rain. During this period, the salinity of the river and canal water increases. By the flooding with saline river water and the evaporation process, the salt is accumulated in the soil surface layers. In addition, the salts can also seepage to underground water to increase salinity, making it unsuitable for irrigation purpose (Haque, 2006).

Salinity has become a common problem in the Mekong Delta of Vietnam during the dry season. When the soil surface dries, the underground water become saline. Though after the rain the salinity decreases as the rain water washes the salt from the soil. High salt problem cause difficulties and loss for dry-season crops, as well as for preparation of wet-season rice. Furthermore, low level of freshwater in Mekong River and its tributaries accelerates the salt intrusion to inland fields; even reach 60 km during the peak period (April-May) (Lang *et al*., 2010).

In the central coastal region of Vietnam (Fig. 1), due to the flood season with high rainfall amount usually occurs from October to beginning of January, salinity level during this period is lowest. On the contrary, salinity from May to September is highest, and the differences in salinity between May and September were small (Lam *et al*., 2014). That is because of those months is hot (summer) season with high temperatures and surface water evaporation, salinity content become condensed and increased.

In addition, the invasion of sea water to soils has created suitable habitat for shrimp cultivation (increase in water salinity). This is one of the reasons for the blooming of shrimp cultivation in coastal regions (about 700,000 ha in 2016), which helps to improve the income of farmers but at the same time fosters the salinity content.

Tidal effects: Different geographic conditions and seasons cause different tide ranges and characteristics. According to Hanh & Furukawa (2007), the tide range reaches about 4.0 m in the north (Red River Delta) and decreases to 0.5 m in the central region, then increases up to 3.5 m in the south (Mekong River Delta). Almost all coastal zones are influenced by tide. There are diurnal tide, semidiurnal tide and mix tide system, and it often change in East-Sea (Hanh & Furukawa, 2007). The characteristics of the tide on the Vietnam coast from the north to the south are shown in Table 1.

In addition, in the tide-dominated deltas, seawater intrusion creates tidal creeks and small salt marshes. Whereas, in the wave-dominated delta, the wave dynamics creates large-scale sand dunes, thereby forming large salt marshes behind the sand dunes (Lang *et al*., 2010).

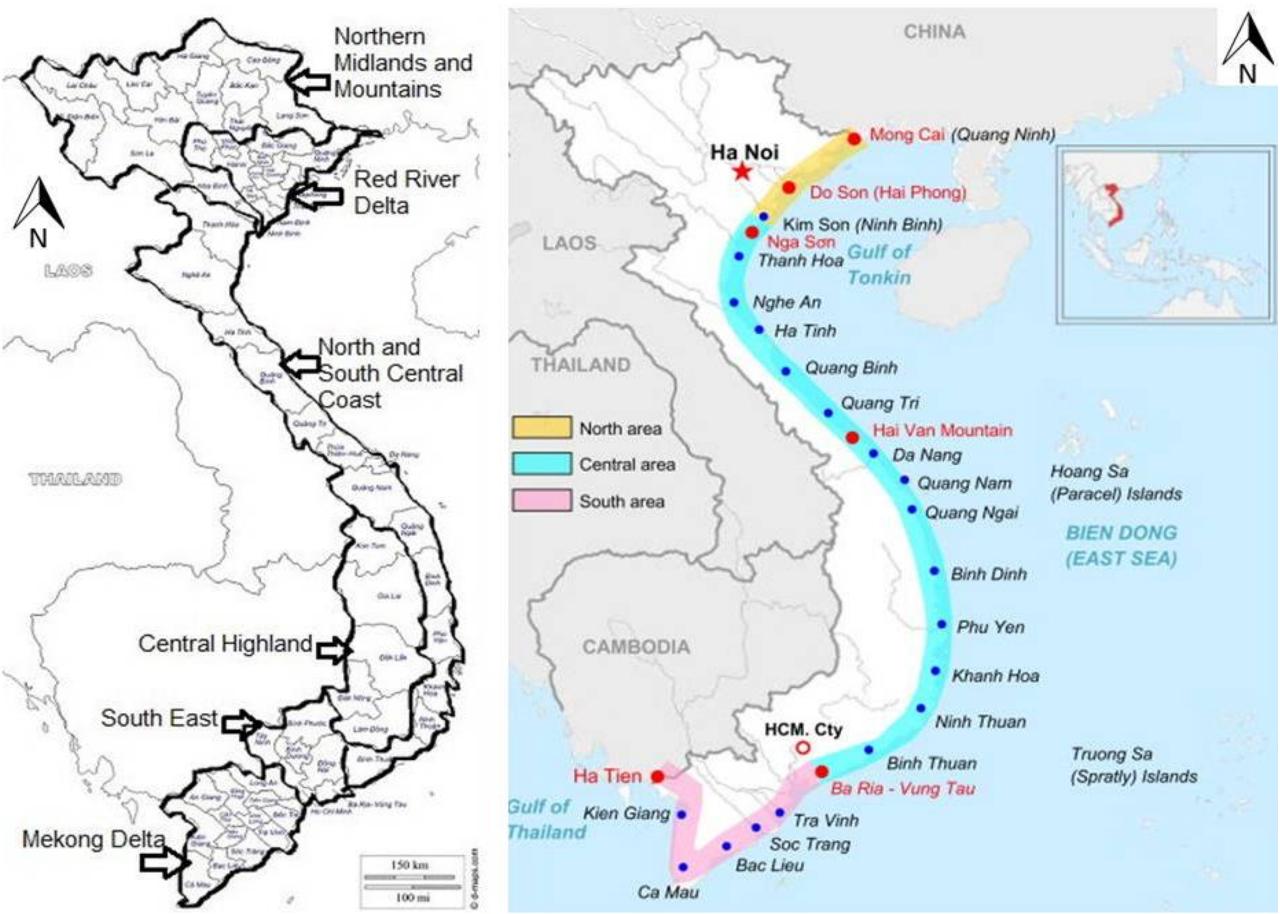

Fig 1. List of regions and coastline (color figure) of Vietnam. (Source: Le *et al*., 2014).

Table 1. Characteristics of tide on vietnam coast from north to south.

Section of region (beach)	Kind of tide	Rising & Falling times day^{-1}	Highest water level (m)
From Mong Cai to Thanh Hoa Province	Typical diurnal tide	1.0	3.0 – 4.0
From Thanh Hoa to Dong Hoi Province	Irregular diurnal tide	1.0 – 2.0	1.2 - 2.5
From Dong Hoi to Quy Nhon Province	Irregular semidiurnal tide	-	0.5 - 1.2
Thuan An mouth (Thua Thien Hue Province)	Typical semidiurnal tide	2.0	0.5
From Quy Nhon to Vung Tau Province	Irregular diurnal tide	2.0	1.2 - 2.0
From Vung Tau to Ca Mau Province	Irregular semidiurnal tide	-	1.2 - 2.5
From Ca Mau to Ha Tien Province	Irregular diurnal tide	-	2.0 - 3.5

Source: (Hanh & Furukawa, 2007).
In which:
Mong Cai belongs to Northern coastal; Thanh Hoa and Dong Hoi belong to Northern central coastal; Thuan An belongs to Central coastal; Quy Nhon belongs to Southern central coastal; Vung Tau belongs to Southern Eastern; and Ca Mau and Ha Tien belong to Mekong River Delta (Fig. 1)

Table 2. Area of saline soils in coastal regions of Vietnam.

Regions of coastal	Mangrove saline soil (ha)	Strong saline soil (ha)	Medium and weak saline soil (ha)
Cuu Long River Delta	56,448	102,000	586,422
Former Zone 4	1,796	6,609	38,358
Central Coastal	5,166	11,426	35,561
South East	-	19,592	2,500
Mountainous Northern	-	18,704	16,360
Red River Delta	15,807	-	-
Others	-	14,318	53,307
Total	105,318	133,288	732,584

Source: (Hoc & Dat, 2005)

Saline soil classification: To classify saline soils, there are number of different methods. According to original classification, saline soils are classified on the basis of total major salt dissoluble (TSD), such as Cl^- and SO_4^{2-}. Meanwhile, FAO-UNESCO classifies saline soils on the basis of electro-conductivity (EC) and dissoluble salt ratio (shown in %). In addition, various kinds of dissoluble salts (Cl^-, SO_4^{2-}, CO_3^{2-}, Na^+, Mg^{2+},…) combined with soil texture are used to classify saline soils. In Vietnam, the saline soil classification system of FAO-UNESCO is used (Hoc & Dat, 2005). Saline soils in coastal Vietnam are classified as following:

- Mangrove Saline Soil – Glayi Salic Fluvisols (FLsg). There are approximately 105,318 hectares, and it covers over 0.34% of total national soil area and 10.63% of total saline soils. Mangrove saline soils are distributed in many seashore areas, however, the biggest areas are in the plain at the south seashore of Ca Mau and Ben Tre.

- Strong Saline Soil – Hapli Salic Fluvisols (FLsh): There are approximately 133,288 hectares, and it covers 0.42% of total national area, and 15% of total saline soils. Strong saline soils are mainly distributed in the plain at the seashore of the North coastal such as Thai Binh, Nam Dinh, Ninh Binh etc. (Cuu Long River Delta region).

- Medium and Weak Saline Soil – Molli Salic Fluvisols (FLsm): There are approximately 732,584 hectares, and it covers 2.4% of total national area, and 75% of total saline soil area. These soils are the biggest concentrating in the Cuu Long River Delta.

The area of saline soils in coastal regions of Vietnam is indicated in Table 2.

Fertility status of saline soils: Chemical characteristics of saline soils types are indicated in Table 3. In general, the fertility of saline soils is low in coastal regions of Vietnam. pH values of these soils vary from 7.1 to 8.2, with the exception in the layer of 0-20 cm of the Hapli Salic Fluvisols (FLsh) soil where pH is just 5.1 on average. Thus, most of soil and soil layer are moderate to strong alkaline soil reaction. The low soil pH has many consequences. When the pH of the surface soil is smaller than that of the subsurface soils, then micronutrients' deficiencies are expected (Haque, 2006). These soils are low in the content of organic matter (OC). Most of these soils have OC lower than 2.0%, except for the surface soil of Glayi Salic Fluvisols (FLsg) soil with OC of 2.45%. The low OC of these soils indicates poor physical conditions in coastal regions, especially in the top layer. The CEC of these soils ranges from 11.21 to 22.52 mmol/100g. The higher CEC values of Glayi Salic Fluvisols (FLsg) soils are due to higher OC contents. The Sodium and Magnesium saturation of the exchange complex is harmful to soils and crops because they destroy the physical properties of soils and offset plant nutrients. Magnesium has synergistic effect of plant uptake of Na as well as antagonistic effect on the uptake of Calcium and Potassium (Haque, 2006). The total Nitrogen contents of the soils are very low, mostly lower than 0.15%. The low Nitrogen content may be due to low OC of most of the soils. Available Phosphorus status of the soils varies from low to very low, 3.65-14.48 mg/100 g soil.

Table 3. Chemical properties of saline soils in coastal regions of Vietnam.

Depth	Soil type	Area	EC	pH		Total amount (%)				Available (mg/100g)		CEC	Soluble anions (%)		Exchangeable cations (mmol/100g)			
(cm)		(ha)	dS/m	H_2O	KCl	OC	N	P_2O_5	K_2O	P_2O_5	K_2O	(cmolc/kg)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	K^+	Na^+
0-15	Glayi Salic		4.5	7.2	6.8	2.45	0.15	0.22	2.22	14.48	86.6	21.12	1.15	0.14	1.36	3.88	1.84	11.45
15-60	Fluvisols	105.318	5.6	7.6	7.0	1.40	0.07	0.15	2.47	12.17	97.1	17.06	0.98	0.51	1.02	2.21	2.06	11.21
60-110	(FLsg)		6.0	7.5	6.9	1.86	0.07	0.11	2.32	10.67	93.3	17.72	1.15	0.61	1.48	2.14	2.19	10.66
110-150			5.5	7.6	7.1	1.48	0.05	0.11	2.13	7.00	74.9	22.52	1.17	0.40	2.02	4.85	1.54	10.05
0-20			6.5	5.1	5.0	0.95	0.07	0.12	2.58	5.29	44.3	16.32	1.13	0.09	5.34	2.69	0.94	3.60
20-50	Hapli Salic		6.0	7.4	6.4	0.36	0.02	0.15	2.17	6.24	65.0	18.08	0.14	0.07	4.39	3.30	1.38	6.15
50-100	Fluvisols	133.288	2.5	7.3	7.1	1.28	0.04	0.13	2.01	4.25	65.0	19.52	0.56	0.29	4.98	2.85	1.38	8.67
100-120	(FLsh)		1.7	7.5	6.9	0.95	0.03	0.12	1.91	8.02	42.9	15.58	0.43	0.11	2.51	2.30	0.91	7.65
120-140			2.7	7.1	6.9	1.50	0.05	0.12	1.91	5.22	51.3	18.23	0.69	0.33	2.02	3.05	1.09	6.97
140-160			2.9	7.8	7.2	1.61	0.04	0.13	2.17	3.65	69.3	19.41	0.58	0.30	2.88	3.19	1.47	7.75
0-20				7.3	5.9	0.14	0.11	0.04	2.05	8.15	8.47	12.58		-	4.19	3.17	0.18	0.32
20-60	Molli Salic			7.5	5.9	0.85	0.10	0.04	2.05	8.00	4.23	11.21		-	4.49	1.83	0.09	0.29
60-85	Fluvisols	732.584	< 4.0	7.7	6.3	0.43	0.06	0.03	2.00	7.63	2.82	13.98	< 0.25	-	3.40	3.36	0.06	0.27
85-105	(FLsm)			7.9	6.5	0.62	0.07	0.03	1.65	6.15	2.82	14.66		-	4.55	3.96	0.06	0.15
105-125				8.2	6.9	0.21	0.04	0.03	1.09	6.10	2.82	17.77		-	7.25	5.77	0.06	0.25

Source: (Hoc & Dat, 2005).
In which:
- Glayi Salic Fluvisols (FLsg) soil was collected at Thach Duoc Commnue, Binh Dai Commune, Ben Tre Province, latitude of 10°08'45N, longitude of 106°43'30'E, and elevation of 1 meter
- Hapli Salic Fluvisols (FLsh) soil was collected at Hiep Thanh Commune, Bac Lieu Commune, Bac Lieu Province, latitude of 09°15'30'N, longitude of 105°44'15'E, and elevation of 2 meter
- Molli Salic Fluvisols (FLsm) soil was collected at Rang Dong Farm, Nghia Hung Commune, Nam Dinh Province, latitude of 20°00'00'N, longitude of 106°06'00'E, and elevation of 1 meter

Land use and cropping patterns: Crops such as rice, sugarcane, spices, vegetables, etc., are grown in the saline soils of coastal area, apart from aquaculture production. However, their contributions to the cultivation system and income differ from region to region. In areas affected adversely by salt stress, rice is the main crop with about 0.7 million hectares (Lang *et al*., 2010). Over the past decade, earlier-maturity and high-yield rice has gradually replaced the local rice cultivars (low-yield) grown in the rainy season and short-statured varieties have been used in areas with shallow flood depth (Truong *et al*., 2003). Because of the differences in climatic regimes of Vietnam from north to south, farmers cultivate rice with twice-cropping and triple-cropping a year. Twice-cropping rice (the winter-spring crop from December to April and Summer-Autumn cropping from May to September) is grown in areas of Red river delta, Former Zone 4, and Central coast. The triple-cropping rice cannot be grown in those regions, because these regions have a lot of storms, floods, and low temperature from September to December. In the other regions of coastal areas including the Cuu Long River Delta and South East, the triple-cropping rice has been grown, and particularly in areas where salinity is leached out by early rainfall, which allows the third cropping (from September to December) to be cultivated.

In many areas, dykes are built-up nearby seashore to prevent inundation of seawater, especially in dry season. Thanks to salt preventing of dykes, many strong saline soils and depression areas in coastal zone have been used for rice cultivation. Since 1994, the Vietnamese government has constructed a series of sluices along the coastal region, especially in Ca Mau Peninsula in the southern part of the Mekong River Delta, to increase rice production. Consequently, farmers can intensify their rice cropping and increase their livelihood in coastal zones (Truong *et al*., 2003).

If soils are not suitable for rice growing, famers convert rice-fields into shrimp ponds. Since the mid-1990s onward, farmers are attracted by the high profits of producing Tiger shrimp *(Penaeus monodon)* for exporting. Thus, shrimp cultivation has become popular (Bremen & Pons, 1978). However, shrimp aquaculture has created many environmental concerns regarding the using of resources and the subsequent release of wastes into the environment (Beverige *et al*., 2007).

Increase in salinity levels: The coastal zones of Vietnam are especially vulnerable to challenging impacts of climate change including rise of sea level, intensification of storm surges, and floods and droughts. Tropical storms can greatly expand the inundation of seawater into low-lying coastal areas. It is estimated that the sea level will rise up to 9 cm in 2010, 33 cm in 2050, 45 cm in 2070, and 100 cm in 2100. Moreover, rising of temperature due to global warming and climate change will also result in increased salinity. The average temperature will increase by 2.5°C in 2070 and the number of days with temperature higher than 25°C will also increase (Jeremy, 2008; Huan, 1996).

By 2100, 14.528 km^2 or 4.4% of Vietnam land area is predicted to be permanently inundated. More than 60% or 39 of the 64 provinces and six of Viet Nam eight economic regions will be influenced. The Mekong River Delta is the most likely to be influenced by climate change, where inundation will affect 12 provinces or approximately account for 85% of the total national inundation area. More than 1,100 km^2 will be inundated in the Southeastern economic region or 7.65% of the national inundated area. The other four economic regions the Red River Delta, the Northeast, the North Central Coast, and the South Central Coast will have permanent inundation ranging from 180 to 340 km^2 per each, or together close to 7% of the national land area to be inundated (Jeremy, 2008).

As rise in sea level becomes permanent and when it is combined with severe storms and flooding, high temperature then finally it will threaten coastal cities and increase salinity of rivers and groundwater (Jeremy, 2008). The depth of the freshwater in the coastal zone is greatly reduced, leading to salinization of water supplies. The intrusion of saline water into near coastal aquifers and surface water (wetlands, rivers, lakes) will threaten the fresh-water supply for both sectors of agriculture and aquaculture, as well as domestic and industrial freshwater consumers (Hanh & Furukawa, 2007; Jeremy, 2008).

Constraints for agricultural development: There are many different physic-chemical, natural, and social factors which impede the agricultural development in the coastal saline soils (Haque, 2006) as described as follow:

- High content of salts in soils can lead to drastically changes in some of soil's physico-chemical characters resulting in the development of an unsuitable environment for the growth of most crops (Qarir *et al*., 2000) and produces low yield (Lang *et al*., 2010). Thus, constrains of agricultural development increase with rising level of salinity. Soil salinity is the most serious limiting factor in coastal regions, particularly in the hot (dry) season as evaporation rate is high, rain is scarce and irrigation water is in limited quantity.

- Salt invasion from shrimp ponds and brackish water aquaculture into agricultural lands has widely been recognized (Smit, 1999; Raux & Bailly, 2002). The increase in shrimp farming industry in some coastal areas has exacerbated the salinity problem, in both surface water and soil environment (Smit, 1999).

- Salinity decreases the fertility of soils ranging from low to very low in respect to organic matter content, nitrogen, phosphorous and micronutrient, such as zinc and copper (Haque, 2006). The crop yields obtained in these soils are also low, especially in summer-autumn rice cropping.

- Along coastal areas, particularly in central coast, there are annually many natural hazards, such as long droughts during dry season and severe flash floods and storms in the rainy season (Tho *et al*., 2007). These natural hazards delay the sowing/transplanting calendar and damages dykes, infrastructure, property, people's lives, and wash away the standing crops (Lang *et al*., 2010).

- Scarcity of good quality irrigation water during dry season is one reason that limits the cultivation of rice and the other crops.

- Although many salt-tolerant rice varieties have been created for saline soil conditions, they are still not suitable for all coastal regions because the climate regimes of coastal regions are greatly different.

- There is a lack of appropriate extension programs to transfer modern technologies about how to prevent, use and manage the saline soils. In addition, in many provinces, extension officers cannot participate in adequate training programs to help farmers.

Strategies for management and usage of coastal saline soils: Amelioration and management of saline soils can be accomplished using a number of methods.

+ Irrigation strategies

- Protective dyke construction: Land may be protected from invasion of saline water by construction of dyke with suitable size and place (Haque, 2006). In addition, sluice gate system should be built up in dyke to remove excess water, and to prevent and reduce incursions of seawater during high tide and dry season (Truong *et al*., 2003; Hoc & Dat, 2005).

- Rainfall and irrigation can only remove salt from the soil. However, this method is effective when there is good drainage, since it lowers the ground water level and removes salt away from salt storage (Hoc & Dat, 2005). For this method, it is necessary to build up the irrigation and drainage systems, and as a result to bring fresh water into fields and then to drain the excess water away. Adequate soil drainage is supposed as an essential prerequisite for successful soil amelioration (Qarir *at al*., 2000). An artificial system must be supplied if such natural drainage is not present. The washing/removal of salt requires many years and the successful application of this method is based on topography, salinity level, kind of crops and fresh water sources.

- Excess of irrigation water should be stored. Excess water stored in ponds or reservoirs during the rainy season can be utilized in the next dry season or when irrigation requires that.

+ Agricultural strategies

- Land leveling: Leveling results in more efficient irrigation and can prevent to the accumulation of saline water in low spots. Land should be property leveled so that fertilizers and pesticides are more efficiently used for better growth of crops (Haque, 2006).

- Apply proper cultivation methods including plough deeply without flipping, many times of turn-up. The purpose of this method is to cut the capillaries in soils, thus salt cannot rise-up to the surface layer (Hoc & Dat, 2005).

- The crop pattern in saline areas should also being adjusted (Lang *et al*., 2010). With the strong saline soil level, it is better to cultivate the crops that have high saline tolerance such as Sedge (Cyperus papyrus), later to green manure/cover crops first in several years to reclaim soil's conditions, and then to cultivate rice and other vegetables. Crop rotational models should be applied in soils with medium and weak saline level to limit salt accumulation and water evaporation away from soil surface. Water should remain regularly on the soil surface to avoid soil surface condition to be dry (Rahman & Ahsan, 2001).

- In areas where salinity is too high and fresh water is unavailable during the dry season, rice –aquaculture systems/models should be applied. Some integrated models are rice-shrimp, rice-fish; rice-groundnut integrates with mung bean or maize, rice-watermelon-sesame, etc. (Lang *et al*., 2010).

- Selection of salt-tolerant rice cultivars: For saline soils, the use of salt-tolerant crop species and cultivars is the most economical and effective strategy (Lang *et al*., 2010). Nevertheless, the climate and soil condition in coastal areas is greatly different in regions, thus, it should collect property the salt-tolerant rice varieties for each region in coastal area.

- Fertilization of crops: Saline soils are very poor in fertility with low organic matter content; therefore, it is necessary to apply appropriate fertilizers to boost up crop production and productivity of the soils. Some kinds of organic sources such as residues of crop, fertilizers of green and manure are used. Organic fertilizer not only supplies nutrients but also ameliorates the physical condition of soils (Rahman & Ahsan, 2001). Some kinds of fertilizer such as Potash fertilizer has been recognized suitable for saline soil since it lowers down harmful Na-uptake by plant and of course increases K uptake (Haque, 2006).

- Protect the saline-submerged forest and fisheries resources near the sea. The protection of saline emerged forest can be combined with raising fish in order to ensure farmer's income and encourage them to protect natural environment.

- Training workshops should be organized yearly and regular site visits are necessary to transfer new knowledge and technology to farmers. Short-term training courses can be about the following topics: selection and management of suitable salt-tolerant cultivars, and effective nutrient and water management technologies for salt-effected coastal regions (Lang *et al*., 2010).

Conclusion

Soil salinity is a worldwide problem and it occurs in almost all continents. Vietnam is no exception to it. In Vietnam, salinization is considered as one of the most serious and harmful problems to agricultural production and productivity/fertility/quality/health of soils. Vietnam has nearly 1 million hectares of saline soils stretching across the coastline with more than 3,260 km long, divided into 3 regions, with large differences in climate regime, soil conditions, cultivation customs and society and economic conditions. Thus, methods of usages and managements of saline soils should be based on characters of each region.

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