Status of Riverbank Erosion and Proposal of Bioengineering Solution to Prevent Riverbank Erosion in Saline Soils Area. Case Study in Lung Tram River, Tan Hung Tay Commune, Phu Tan District, Ca Mau Province, Viet Nam

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Abstract: The riparian of the Southwest area ofHau River in the Cuu Long River Delta, Viet Nam has great socioeconomic value. In there, the vegetation of mangrove soil in the Lung Tram River area, Tan Hung Tay commune, Phu Tan district, Ca Mau province has been promoting economic value and defensive value to protect river dikes, contributing to the increase biodiversity and stabilize the living standard. The article aims to present results of analysis and assessment of the socioeconomic conditions affecting the riverbank erosion in the study area. Based on the implement of methods: Secondary research collection methods; To pography, hydrology, water and soil enviroment survey; Sample plots investigation to evaluate plant species distribution, composition and biodiversity indicators. The results of the article have been showed that the topographic characteristics of the study area: the altitude ranging from 0.5-1.5m above sea level and is an area frequently affected by tides,erosion,spring tide, etc due to the influence of the semi-diurnaltide regime. The study mainly focuses on saline soils.In addition, the vicinity areais aluminous soils and alluvial soils. The composition of mangrove species includes 9 main species. Socio-economic depends on agriculture and aquaculture. Initially, some main causes of erosion in the study area were identified: endogenous impacts (topography, soil, loss of vegetation); Exogenous impacts (currents, waves, water level fluctuations); Human impacts (constructions upstream and along the river, sand mining, waterway transportation activities). From there, research team have proposed severalbioengineering solutions to prevent riverbank erosion in saline areas by selecting appropriate mangrove species; reinforcing the foot of the riverbankto prevent and control riverbank erosion in saline lands for the study area. It was found that the bamboo fence was effective in stabilizing the ground and minimizing the impact of currents and waves, facilitating *Rhizophora apiculata* and *Avicennia alba* to grow well and survival rate is over 90% after 3 months of planting.

Key words: Lung Tram River, riverbank, bioengineering, erosion.

I. Introduction

Bioengineering is the combination of biological and irrigation works to create a new system to address human needs (Kangas, 2005). Recently, bioengineering solutions have begun to be researched. These solutions can also be understood as using ecological processes in simulations of nature or built by natural systems to achieve engineering goals (Teal, 1991). The bioengineering solution is a combination of soft solutions and support structures, in which riparian vegetation still plays the main and important role in the engineering of the solution.

Vietnam is a tropical country with a dense river density, with more than 2.360 rivers with a length of 10km or more. In there, there are 109 main rivers and over 10,600 km of river dikes protecting areas with a large population concentration (Ministry of Agriculture and Rural Development, 2021). River dikes have contributed to hedging to protecting production, the lives and property of people in riparian areas against storms, floods, high tides, etc. Many dikes encroach the sea and expand land areas, creating a premise for new urban areas and tourist areas to develop. The dykes combined with traffic make an important contribution to socioeconomic development, marine economic development and ensuring national security and defense for the region.

The Southwest area of Hau River includes of Can Tho city and Hau Giang, Soc Trang, Bac Lieu, Ca Mau and Kien Giang provinces, characterized by a dense system of rivers, and canals with many advantages for socioeconomic and environmental development. However, in recent years, riparianerosionhas become very common and tends to increase and become more serious, affecting infrastructure, people's economic livelihoods, and causing loss of productive land. caused damage to roads, subsidence of houses, and destabilization of the lives of households living along both sides of the river. In addition, riparian erosion also causes sedimentation of canal beds, affecting waterway traffic and flood drainage during the rainy season. To solve the problem of riversied erosion in localities in the study area, we have invested in building several concrete embankments to protect the banks to solve local erosion. The solution of protecting riparian with concrete embankments in practice shows some limitations such as having a very large investment cost, being difficult to apply on a large scale and not being environmentally friendly. On the other hand, hard embankments to protect the shore are at risk of being unsustainable due to being built on weak geological foundations, making construction difficult. Besides, in recent years, civil works such as melaleuca piles, coconut, sandbags, etc. have been effective in preventing riparianerosion. However, these solutions are based on people's experience, without systematic research and sufficient scientific and practical basis, especially in the division of riverbank sites and species selection plants suitable for site conditions, there are no summaries and instructions on the application of ecological measures in handling and preventing riparian erosion. The problem of solving subsidence and erosion ofriparian and canals in an ecological manner based on science and practice has become an urgent issue for residents of the Southwest Hau River region. Therefore, the implementation of research on the status quo and ecological - irrigation solutions to prevent riparian, canals and ditches in saline soils. A typical case study at Lung Tram River, Tan Hung Tay commune, Phu Tan district, Ca Mau province, Vietnam will be the scientific basis to propose ecological and irrigation technology solutions to prevent riverbank erosion and replicate the model for similar site conditions.

II. Methods

2.1 Study area

The study area belongs to the saline land affected by the tides of Lung Tram River, Tan Hung Tay commune, Phu Tan district, Ca Mau province, Vietnam (8°53'11.0"N 104°54'48.0"E) (Fig.1). This is an area characterized by mangrove vegetation with mainly woody tree species such as of *Avicennia alba, Rhizophora apiculata, Avicennia marina, Sonnaratia caseolaris*,... which have very good hedge value for the dyke. Soil characteristics are less saline soil due to the influence of the inland flow system to the sea of the Lung Tram River. The salinity of water in the study area ranges from 1,0 ppt to 8,0 ppt. Soil and coastal saltwater characteristics are relatively suitable for mangrove species.

Figure 1. Location of model implementation (source: Nguyen Hoang Hanh, 2023)

2.1 Research methods

2.1.1 Secondary research collection methods:

Synthesize, inherit documents, research works, and research results related to riparian, canal, and ditch erosion; consult with experts in the field of research; Discuss and interview with technical staff, managers and people about the causes and options for preventing bank erosion in the locality. Collect documents and data on the characteristics of natural conditions in riparian areas and canals at the Department of Agriculture and Rural Development, Ca Mau Forest Ranger; Department of Agriculture and Rural Development, Department of Natural Resources and Environment of Phu Tan district; People's Committee of Tan Hung Tay commune, Phu Tan district, Ca Mau province belongs to the research location. In addition, documents and data on natural conditions are also collected from domestic and foreign research results published in journals and published conference proceedings.

2.1.2 Topographical surveys methods:

Topographic survey to determine the geomorphological shape of the foundation, the slope of riversids, canals as a basis for dividing the level of erosion and calculating the stability of the bank area, the interaction between geomorphology with flow motivation and coastal vegetation. During the investigation and survey phase, topographic survey work only focuses on surveying typical cross-sections in each study area. Topographic survey work complies with TCVN8481-2010. Using an electronic total station, hydraulic machine has an angle accuracy of mβ =±1, an edge measurement accuracy of ms =2mm + 2ppm. Using the national coordinate elevation system based on the fourth-other benchmark. Topographic survey is conducted according to cross-section. Each typical survey points surveys 3 cross-sections, each cross-section has an average length of 200m. Survey volume: 3 typical survey points x 3 cross-sections x 200m.

2.1.3 Hydrological surveys methods:

Hydrological surveys include hydrodynamic factors that mainly affect erosion and vegetation on riparian and canals such as waves and flow velocity. Requirements for measuring techniques, accuracy, and equipment used comply with Circulars 30/2018/TT-BTNMT on technical regulations for monitoring and providing hydrometeorological information and data for meteorological stations. specialized hydrology. Hydrological surveys are conducted at temporary measuring stations. Each typical point sets up a temporary measuring station, each measuring station is measured for a period of 7 days. Wave survey volume: 3 stations x 1 period x 7 days. Flow survey volume: 3 stations x 1 period x 7 days.

2.1.4 Survey and analysis some indicators water and soil enviromental methods:

Physical and mechanical indicators of the soil environment are physical parameters intended to express the mechanical properties of the soil, that is, the properties of the soil when subjected to mechanical impact. Through physical mechanical criteria, it is possible to determine the level of stability against erosion and erosion of the riparian area. For land along the riparian, canals, and ditches, only need to determine a set of 9 criteria to ensure calculation data. During the investigation and additional survey of natural conditions, geological survey work only focuses on taking samples right at the topographic survey location of typical cross-sections. Work components and implementation methods comply with Technical Standards (TCVN) 10404:2015.Analyze 9 main physical and mechanical criteria of soil (particle composition, moisture, natural density (wet density), specific gravity, liquid limit, plastic limit, compression test, internal friction angle, cohesion) of soil according to Technical Standards (TCVN). Each survey point typically takes 3 samples. Survey volume: 3 typical survey points x 03 samples.

Soil survey aims to determine soil agrochemical criteria to evaluate the suitability of soil type for vegetation. The ability of plants to grow and develop on soil along the riparian and canals. Take samples to determine soil according to Technical Standards (TCVN) 4046:1985. Analyze and determine 9 physical and chemical indicators (mechanical composition, pH (KCl); total N, P_2O_5, total K_2O; Ca^{2+}, Mg^{2+}) of soil according to Technical Standards (TCVN). Each typical point takes 03 samples. Survey volume: 3 typical survey points x 03 samples.

2.1.5 Plant investigation methods:

Using the investigate on quadrats method to determine the distribution and species composition of some typical plants in saline soil areas. Surveys and surveys were carried out using the methods of Rollet (1974) and UNESCO (1979). The main documents used in the process of determining the scientific name of plants include: Hoang Ho Pham (1991-1993, 1999-2000), Tien Ban Nguyen (1997), Van Trung Thai (1978), Hop Tran (2002), Brummitt R.K. (1992), Brummitt and Powell (1992), list of Vietnamese plant species; On each quadrats, with an area of $200m^2$, vascular plants are measured and identified: species name, morphological indicators such as total height (m), base diameter, diameter at breast height (diameter 1.3 meters).) (cm), canopy diameter (cm) using height Gauge, diameter measuring tape, tape measure. Investigate plants (shrubs, grasses, herbaceous plants, use quadrats 2mx2m to determine species name, area, average height, using specialized rulers. Tree quality is evaluated through morphological criteria according to 3 levels (good, average and bad). In which: Good trees (A) are trees that grow healthy and balanced; tree canopy evenly, no pests; Average trees (B) are trees with unbalanced trunks like type A, with average growth, Bad trees (C) are trees with pests, lopsided canopy, little prospect, and poor growth. Surveys according to quadrats are carried out in 03 lines, line length from 1,000 meters to 5,000 meters. On each survey route, 3 quadrats were surveyed. Survey volume: 03 routes x 03 quadrats = 9 representative, typical and temporary quadrats for the study area.

2.1.6 Model building techniques:

With an ecological solution based on the research results and orientation of the project, choose to plant trees (White mangrove and Rhizophora apiculata), on the semi-flooded area, partially affected by the water level, with a width of 3m. Planting density is 1 tree/m2; Plant gourd ≥12x15cm; Height ≥ 0.5m; Root diameter ≥1.0cm; Tree age ≥12 months; The tree grows well, no broken stems, no pests or diseases; Method for digging holes to plant trees: Dig a hole larger than the size of the bulb to plant the tree, plant the tree 3-5cm deeper than the surface of the hole. Plug stakes and tie ropes: apply to woody plants: to ensure they do not fall, or garbage carries away: Plug 1 stake/tree. With the irrigation solution, design 3 rows of bamboo poles (Φ7cm; length 4.5m), density 6 poles/m, use 3 rows of horizontal braces on the outside, use bundles of tree branches inserted between the rows of poles.

III. Results and discussion

3.1 Characteristics of topographic conditions in the study area

The Lung Tram river area of Ca Mau province is in the delta, with many rivers and canals, the terrain is low, flat and often flooded. The average height is 0.5m-1.5m above sea level, low-lying areas with an average height of

1-1.2m create conditions for corrasion and erosion, especially during high tides and heavy rains. and in the high-water season. The terrain tilts in the Northwest - Southeast direction and the network of canals is intertwined with an almost perpendicular flow direction. At that time, the water force at the river confluence will create very strong underground vortices. When these underground vortices move, they will create "frogs jaw" at the river's junction, intersection and penetrate deeply into both banks until the riverbank collapses. In addition, with low-lying terrain, rising tides cause the riverbank soil to become saturated with water, increasing the weight of the bank soil mass, generating seepage pressure. When the tide recedes, the river water level drops, causing the weight of the soil mass and the pressure of water seeping from the bank into the river to increase. The rise of seepage pressure and increased water pressure from the bank to the river increases the factors causing bank slope slippage.

Figure2+3. Status of model construction location

3.2 Characteristics of hydrological regime in the study area

Ca Mau has a dense system of rivers and canals, with more than 1,000 large and small rivers and canals flowing through with a total length of about 5,700 km. The system of rivers and canals in Ca Mau province, in which the Lung Tram river plays a huge role - is the main transportation system connecting localities in the province, bridges connecting with provinces and cities, flood drainage and preserving ecosystems, seafood supplies, and potential eco-tourism routes. Therefore, the number of boats traveling is very large, both transporting goods and transporting tourists with many different loads and capacities. Therefore, waves in rivers and canals are part of the cause of erosion. The Lung Tram river area, Ca Mau province is influenced by the tidal regime of both the East and West seas, so the flow regime of rivers and canals is very complex. At some survey locations on rivers and canals in the province, the flow regime still follows the regime of 2 high tides and 2 low tides during the day. Along with that, the interlaced system of rivers and canals not only functions to regulate water, serve agriculture, but also is an important transportation system of the province. Therefore, the natural flow of the area combined with the flow of boats has impacts on the stability of riparian canals here.

3.3 Environmental characteristics of soil and water in the study area

Ca Mau is a new land deposited by alluvium, formed by two ocean currents in the East Sea and the Gulf of Thailand, receiving alluvium from the Mekong river. The province's land is young, newly exploited, has average fertility, high organic matter content, but due to alum and salinity contamination, it is suitable for aquaculture and flooded forest planting salty, brackish.Ca Mau has main soil groups: Saline soil group has an area of 150,278 hectares, accounting for 28.84% of the natural area, distributed mainly in the districts of Dam Doi, Cai Nuoc, Ngoc Hien, Nam Can, Tran Van Thoi, U Minh, Thoi Binh, formed on marine sediments and river and sea sediments. This is a young soil type, subject to regular or periodic tidal flooding. The alum soil group has an area of 334,925 hectares, accounting for 64.27% of the natural area; distributed mainly in Thoi Binh, U Minh and Tran Van Thoi districts. The saline alum soil group is distributed in coastal areas. For non-saline alum soil areas, rice can be grown during the rainy season, and alum-tolerant industrial crops can be planted such as: Sugarcane, Pineapple, Banana, Acacia Auriculiformis Magium, etc. For saline alum areas, there is Can plant mangrove forests and raise aquaculture products. In addition, there is also a group of peat soils under the melaleuca forest, with an area of about 10,564 hectares, distributed in U Minh and Tran Van Thoi districts and a group of alluvial soils with an area of 9,507 hectares, distributed in Ngoc Hien and Phu Tan districts. The model research area has an area of about 20 hectares of saline riparian land, mainly semi-submerged land, affected by the tides of the East and West seas.

3.4 Distribution and composition of typical plant species in the study area

The composition of mangrove species and participation in mangroves in the study area recorded 09 plant species belonging to 08 families (Table 1). Species distribution is often mixed in clumps or distributed according to water level. These are fast-growing native tree species that are common in the study area. Easy to sow, with suitable leaf and root system and adaptable to changing saline water in Ca Mau.

Table 1. List of plant species found commonly riparianLung Tram river, Tan Hung Tay commune, Phu Tan district, Ca Mau province, Viet Nam

No		Scientific Name	Local Name
Family	**Species**		
1		**Asteraceae**	**Họ Cúc**
	1	*Pluchea indica*L.	Cúc tần
2		**Arecaceae**	**Họ Cau**
	2	*Nypa fruticans* Wurmb	Dừa nước
3		**Pteridaceae**	**Họ Nguyệt xỉ**
	3	*Acrostichum aureum* L	Ráng đại
4		**Lythraceae**	**Họ Bằng lăng**
	4	*Sonneratia caseolaris* (L) Engl.	Bần chua
5		**Rhizophoraceae**	**Họ Đước**
	5	*Rhizophora apiculata* Blume	Đước đôi
6		**Verbenaceae**	**Họ Cỏ roi ngựa**
	6	*Avicennia marina* (Forssk.) Vierh.	Mắm biển
	7	*Avicennia alba* L.	Mắm trắng
7		**Euphorbiaceae**	**Họ Thầu dầu**
	8	*Excoecaria agallocha* L.	Bình bát (Na biển)
8		**Malvaceae**	**Họ Cẩm quỳ**
	9	*Thespesia populnea*(L.) Sol. ex Corrêa	Tra lâm vồ

3.5 Characteristics of socioeconomic conditions in the study area

Production activities: Maintain the commune's current aquaculture area of 3,836 hectares. Total seafood output in the year was 5,520 tons, reaching 102% over the same period, an increase of 500 tons. Shrimp output in the year was 4,650 tons, an increase of 155 tons compared to the same period. The stocking area in the year is 135.5 hectares with 156 households. The average harvest of intensive shrimp is 4-5 tons/ha, the yield of super-intensive shrimp is 30-40 tons/ha. The average harvest yield is 400 - 500kg/ha. Animal husbandry: Deploy production registration in 07 hamlets: Aquaculture 3,117.3 hectares/1,899 households; Livestock production is 21,415 heads/702 households. In the year of new development, 36,846 cattle and poultry were developed. Of which: 2,214 cattle and 34,632 poultry with 1,290 raising households, an increase of 6,726 cattle and poultry over the same period. culture and society activities: Improve the quality of teaching and learning; At the same time, maintain and improve the quality of schools that have met national standards. The entire commune has 4/5 schools that have met national standards. Medical station facilities and equipment are invested in, and the medical staff is standardized, contributing to maintaining the commune meeting national standards for commune health. The commune has 7/7 hamlets recognized as cultural standard hamlets, accounting for 100% of the total number of hamlets. The entire commune currently has 2,536/2,615 households meeting cultural family standards, accounting for 96.98%. The work of creating jobs is focused, in 2022, 720 workers have been confirmed, reaching 115% compared to the Reslution.

3.6 The main cause of riverbank erosion in saline soil areas

Research results show that the causes of riverbank erosion in the Southwest of Hau river include 03 main causes: endogenous impacts, exogenous impacts and human impacts.

Among the endogenous impacts, topography, river morphology, soil texture are the factors identified that cause erosion. The system of rivers, canals in Ca Mau province has a dense network, complex terrain, weak and unstable geology, and is very susceptible to erosion and riverbank erosion near the river mouth.

Regarding external impacts, factors causing erosion include currents, waves, water level fluctuations, and tides. Flows in rivers and canals is greater than the allowable non-eroding velocity of the channel mud and sand most of the time (over 50% of the measurement time), so the riverbed and bank slope the river is dug up by the current, causing erosion. The wave factor that has a high potential to cause erosion is generated from the traffic of ships. Fluctuations in water levels and tides are considered the main factors causing erosion in riverbanks and canals. When the amplitude of fluctuations is quite large, in the range of 0.71 - 1.14m and takes place in a short time. The riverbank soil changes continuously from dry to wet, causing cracking, reducing the binding force.

Human activities are also an important factor causing erosionon riverbanks. These include works upstream and along the river that change the flow regime and affect the balance of sedimentation. Sand mining activities cause a serious shortage of sand and mud. The traffic of boats causes waves to destabilize riverbanksand canals. In addition, the decline of large areas of mangrove forests also causes the loss of the shield that protects the shore from waves and currents.

3.1 Proposing bioengineering solution to prevent riparian landslide in saline soils area

3.1.1 Biological solution

Criteria for selecting mangrove species in the study area:

Criterion 1: Mangrove trees are popular in the study area. This means that the tree species has a natural distribution in the garden, has existed and grown for a long time, has morphological and ecological characteristics, and is stable in participating in biological communities that create a typical mangrove forest situation for the research area or is a plant species that has been acclimatized and grown stably as a perennial.

Criterion 2: Plant species have the ability to adapt to changing saline water. This means that the species can be grown in all seasons of the year, can be planted from February to September every year, with a wide salinity range from 5%o to 25%o, suitable for planting in estuaries and mudflats.

Criterion 3: Having a suitable leaf and root system means that the species has a root system and aerial roots to adapt to changes in tidal water levels that may be due to changes in climatic conditions or sea level rise in a long time. The green leaf system and thick canopy layer create conditions for blocking waves, reducing waves, reducing coastal currents, protecting tree belts in other areas or protecting riparian.

Criterion number 4: It is a mangrove species that is easy to sow. Mangrove seed work is an important condition for success in tree planting. If you want to increase the survival rate of mangrove trees or the coverage of mangrove trees, tree variety is an important criterion that affects the area and quality of mangrove crops.

Select mangrove species for the study area: The mangrove tree species selected to restore and develop the mangrove tree belt in the study area is a popular tree species, has a wide ecological range, has a suitable morphology and is easy to sow. On that basis, three promising tree species were selected for experimentation: *Rhizophora apiculata*, *Sonnaratia caseolaris*, *Avicennia alba*

Table 2. Summary of monitoring the survival rate and growth of mangrove trees

	Experimental species	**Survival rate (%)**				**Average growth index after 3 months**		
		1 month	2 months	3 months	Average	Total heigh (m)	Base diameter (cm)	Quality
1	*Rhizophora apiculata*	95	94	94	94,3	0,67	2,0	Good
2	*Sonnaratia caseolaris*	50	45	40	43,0	1,2	1,9	Bad

3	*Avicennia alba*	90	88	85	87,7	1,0	1,2	Good

Through assessment of the growth situation, it was found that: the trees selected to be planted in riparian areas, canals are Rhizophora apiculata and Avicennia alba. In there, Rhizophora apiculata is a tree species prioritized for planting in riparian areas with difficult site conditions for planting new mangrove trees. Avicennia alba is a tree species planted in riparian areas with difficult site conditions to create conditions for accretion of riparian for *Rhizophora apiculata* to develop.

Based on experimental results on density selection, reports on biological characteristics, nursery techniques, planting and tree care. Select planting density of mangrove trees *Rhizophora apiculata* and *Avicennia alba*: 1 tree/m2.

-Tree standards:

+ Method for digging holes to plant trees: Dig a hole larger than the size of the bulb to plant the tree, plant the tree 3-5cm deeper than the surface of the hole.

+ Plug stakes and tie ropes: apply to woody plants: to ensure they do not fall, or garbage carries away: plug 1 stake/tree.

Table 3. Summary of crop technical standards in the model

No	Species	Dimensions	Plant age	Quality
1	*Avicennia alba*	Gourd≥12x15cm; Height≥0,5m; Base diameter ≥1,0cm;	Plant age ≥12 months;	Grow healthy, no broken stems, no pests or diseases
2	*Rhizophora apiculata*	Gourd≥18x20cm; Height≥0,5m; Base diameter ≥1,0cm;	Plant age ≥12 months;	

3.1.2 Irrigation solution

-Results of selecting and designing measures to prevent foot erosion: Experimental results determined that preventing foot erosion with bamboo fence (1 layers with2 rows of piles) is the most effective.

-Conduct selection and design along the length of the model on the riverbed and canal in saline land to retain footfall.

-Design: 2 rows of bamboo poles, using horizontal and vertical ties, with a bundle of bunch branches in the middle.

Table 4. Summary of irrigation solution design in saline soil model

Irrigation solution	Technical standards
Prevent foot erosion	Design 3 rows of bamboo poles (Φ7cm; length 4.5m) Density 6 poles/m Use 3 rows of horizontal braces on the outside Use bundles of tree branches inserted between the rows of poles.

Based on the assessment of site conditions and the results of experiments on selecting species suitable to the conditions of the planting site, the research team have been proposed bioengineering solutions suitable for the area. Saline soil at Lung Tram river, Tan Hung Tay commune, Tan Phu district, Ca Mau province, Vietnam is as follows (Table 5).

Table 5. Proposing bioengineering solution to prevent riparian landslide in saline soils area

No	Categories	Technical solutions	
1	Species selection	*Rhizophora apiculata*, *Avicennia alba*	
2	Seedling	Seedlings with polyethylene pots	
3	Seedling standard	*Rhizophora apiculata*	*Avicennia alba*
		Age:	Age:

		≥ 12 -18 months Doo ≥ 0,5-1,0 cm Total height ≥ 0,5-0,8 m	≥ 12 -18 months Doo ≥ 1,0-2,0 cm Total height ≥ 1,2 m
4	Planting density (trees/ha)	10,000	10,000
5	Planting season	From January to June	
6	Planting method	Mixed	
7	Foundation improvement	Sand ratio: <50% No need for renovation Sand ratio: ≥50% renovation	
8	Technical support	Installing 3 poles to hold the tree	
9	Auxiliary works: Use solutions to prevent foot erosion using organic materials	Combining a bamboo fence with two rows of piles (1 layer, symbol B1) (B=0.4 m; H=1.5 m) to increase the ability to reduce waves, cause sedimentation, and increase survival rate for flooded plants, salty.	

IV. Conclusions

Through research results on topological characteristics, hydrological regime, environmental characteristics of saline soil and riparian saline water, distribution of plant components, socioeconomic characteristics of the study area, the proposed is bioengineering solution: The solution choose *Avicennia alba* and *Rhizophora apiculata*which are two species with suitable seedling standards to build the model with silvicultural techniques such as digging holes, arranging planting density, planting distance, support measures such as installing rope stakes and the solution of using 1-layer bamboo fences, with 2 bamboo fences, etc. to help prevent foot erosion for mangrove trees to grow and develop stably.

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