

Development of *Rhizophora apiculata* Planting Patterns to Enhance Survival Rates, Growth rate and Mitigate Coastal Erosion for Sustainable Mangrove Restoration.



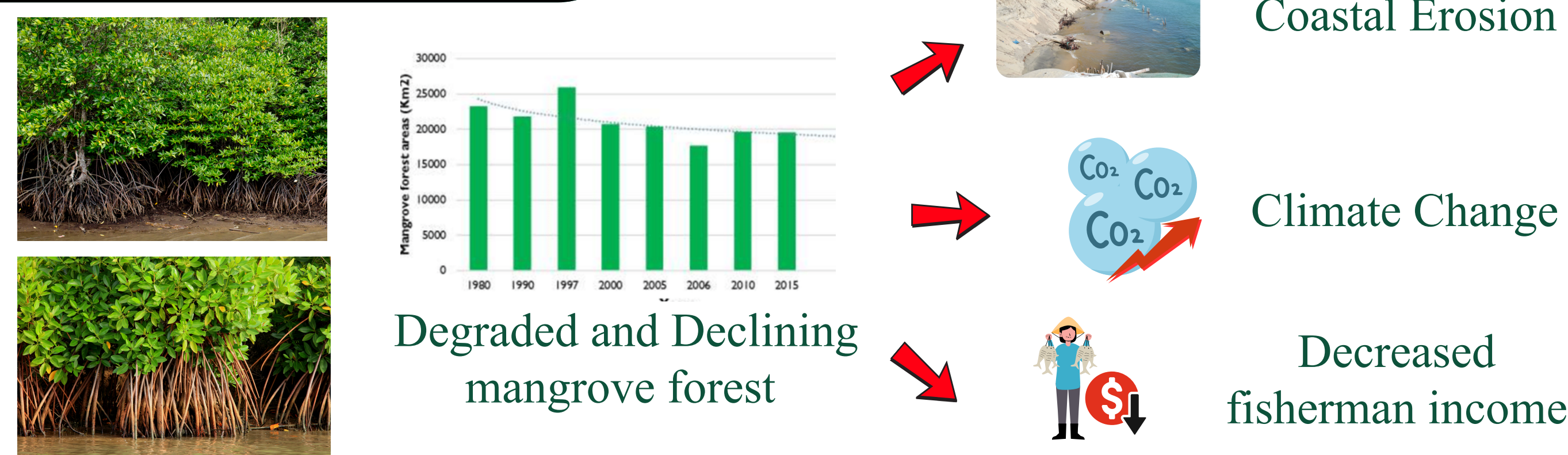
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Abstract

Currently, mangrove forests worldwide are being destroyed and degraded, making restoration essential. Restoration methods include planting *Rhizophora apiculata* (Tall-stilt mangrove) propagates and plant seedlings randomly. This study designed three mangrove planting patterns to evaluate survival and growth rates: 1) Grid, 2) Staggered, and 3) Semicircular, along with a control group (random planting). Each pattern utilized 15 trees with 1-meter spacing within a 15 m² area at the mouth of Sikao river, Sikao District, Trang Province. The results indicated that the Staggered pattern achieved the highest average survival rate at 82.22%, while the Semicircular pattern had the lowest at 40.00%. There were statistically significant differences in survival rates among the planting patterns ($p < 0.05$). However, the growth rates of the surviving mangroves specifically height, stem circumference, and leaf count showed no significant differences ($p > 0.05$). Regarding soil properties, Nitrogen (N), Phosphorus (P), Potassium (K), and organic matter content increased post-planting. Furthermore, the coastal erosion reduction analysis using CFD (Computational Fluid Dynamics) modeling revealed that the Staggered pattern was the most effective in mitigating erosion, as it resulted in a uniform reduction of wave velocity across the study area.

Introduction



Research Questions

1. Does the planting pattern of mangrove affect its survival and growth rates? If so, how?
2. Does the planting pattern of mangrove affect the soil properties in the planting area? If so, how?
3. How do different planting patterns of mangrove contribute to the reduction of coastal erosion?

Research Hypotheses

1. Different planting patterns of mangrove trees result in variations in survival and growth rates.
2. Soil properties are expected to differ significantly between pre-planting and post-planting periods under various planting patterns of mangrove.
3. Diverse planting patterns of mangrove have different impacts on the mitigation of coastal erosion.

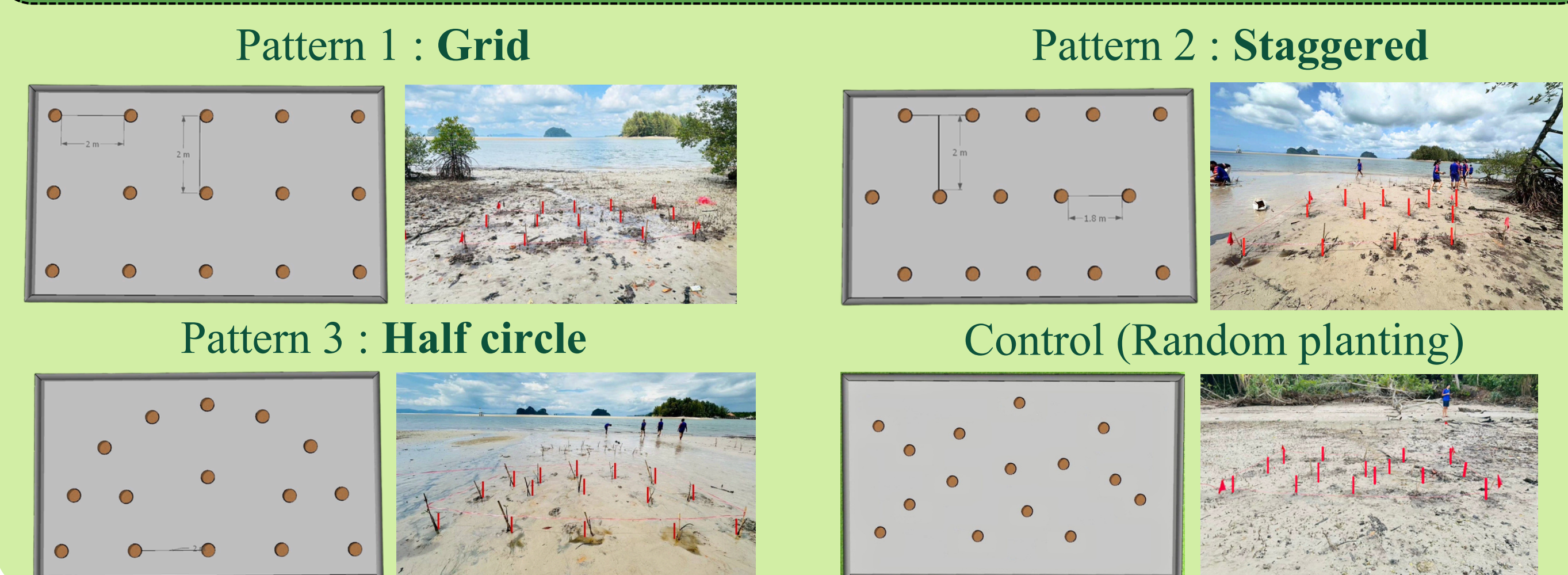
Methodology

Study Site

Pak Khlong Sikao, Mai Faad subdistrict, Sikao district, Trang province, Thailand



Design the patterns for planting mangrove trees and perform the planting.



Soil properties



Data analysis

$$\text{Survival rate} = \frac{\text{Number of plants that survived}}{\text{All Number of plants}} \times 100$$

Growth rate (Height, Circumference, Number of leaves)

Using Arithmetic mean, Standard deviation and One-way ANOVA at a significance level of .05.

Sediment Accumulation and Soil Properties (pre-planting and post-planting)

Wave Velocity (Wave speed from Flow 3D Hydro)



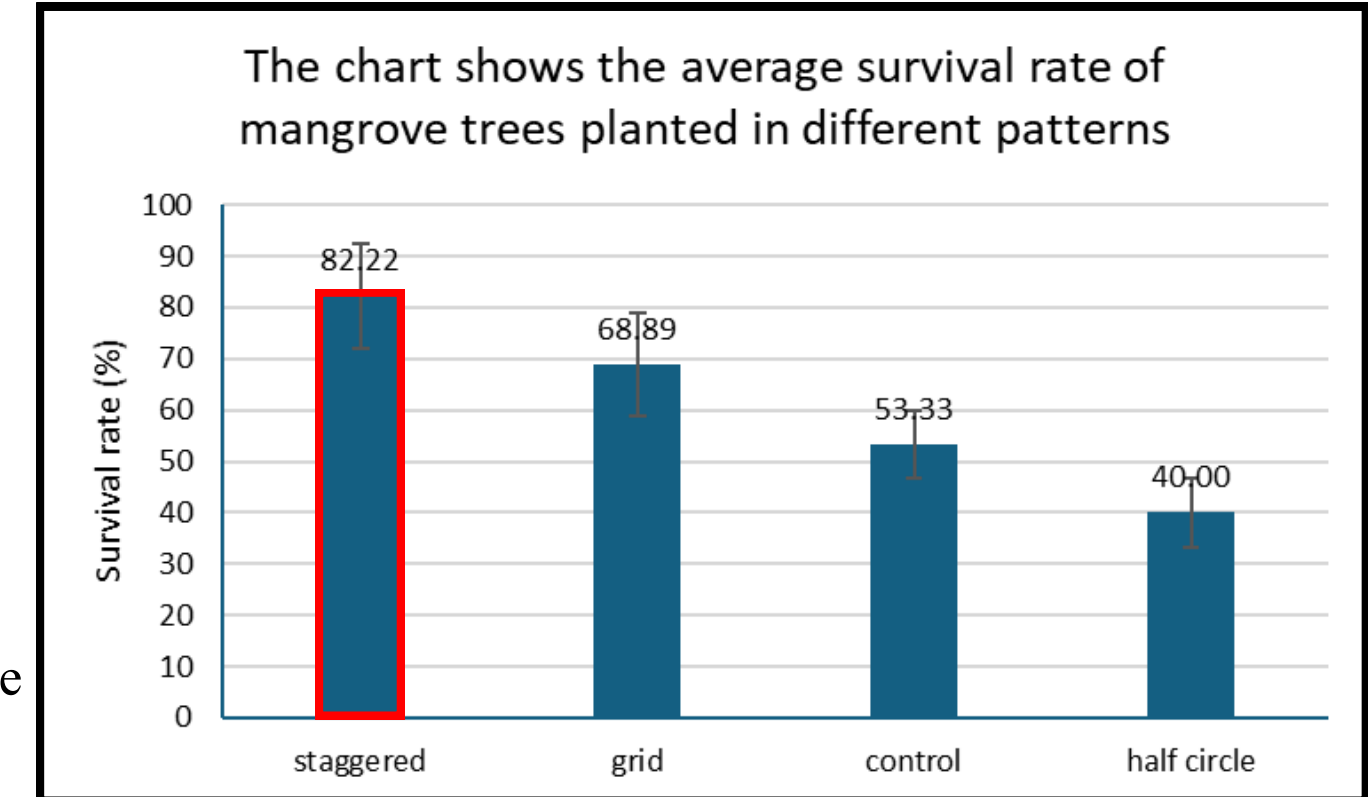
Using Arithmetic mean, Standard deviation and One-way ANOVA at a significance level of .05.

Results

1 Development of mangrove planting patterns for increase survival rate

Planting patterns	Average of survival
Grid	10.33 ± 1.53 ^a
Staggered	12.33 ± 1.53 ^b
Semicircular	6.00 ± 1.00 ^c
control	8.00 ± 1.00 ^d

Note: Differences in the displayed letters in the columns indicate statistically significant differences ($p < 0.05$).



Cost-effectiveness study of planting patterns

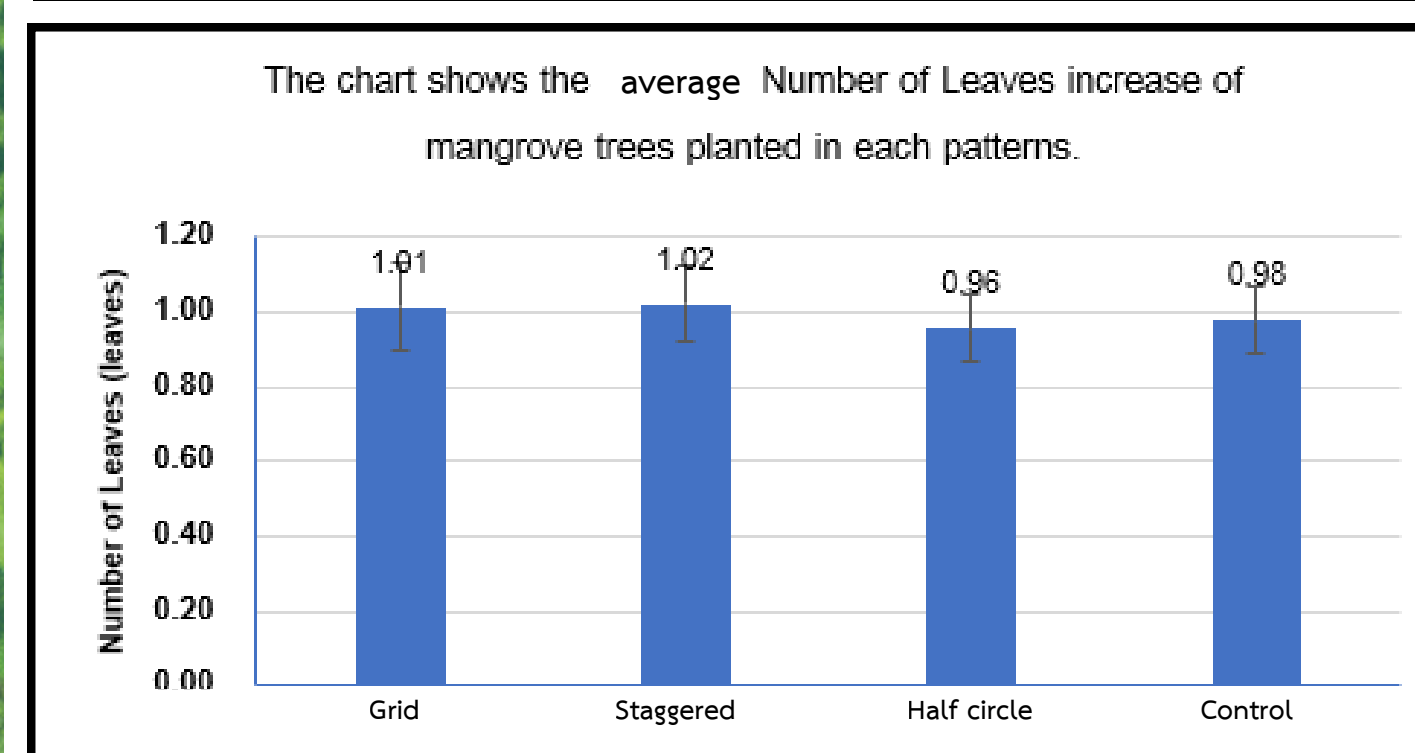
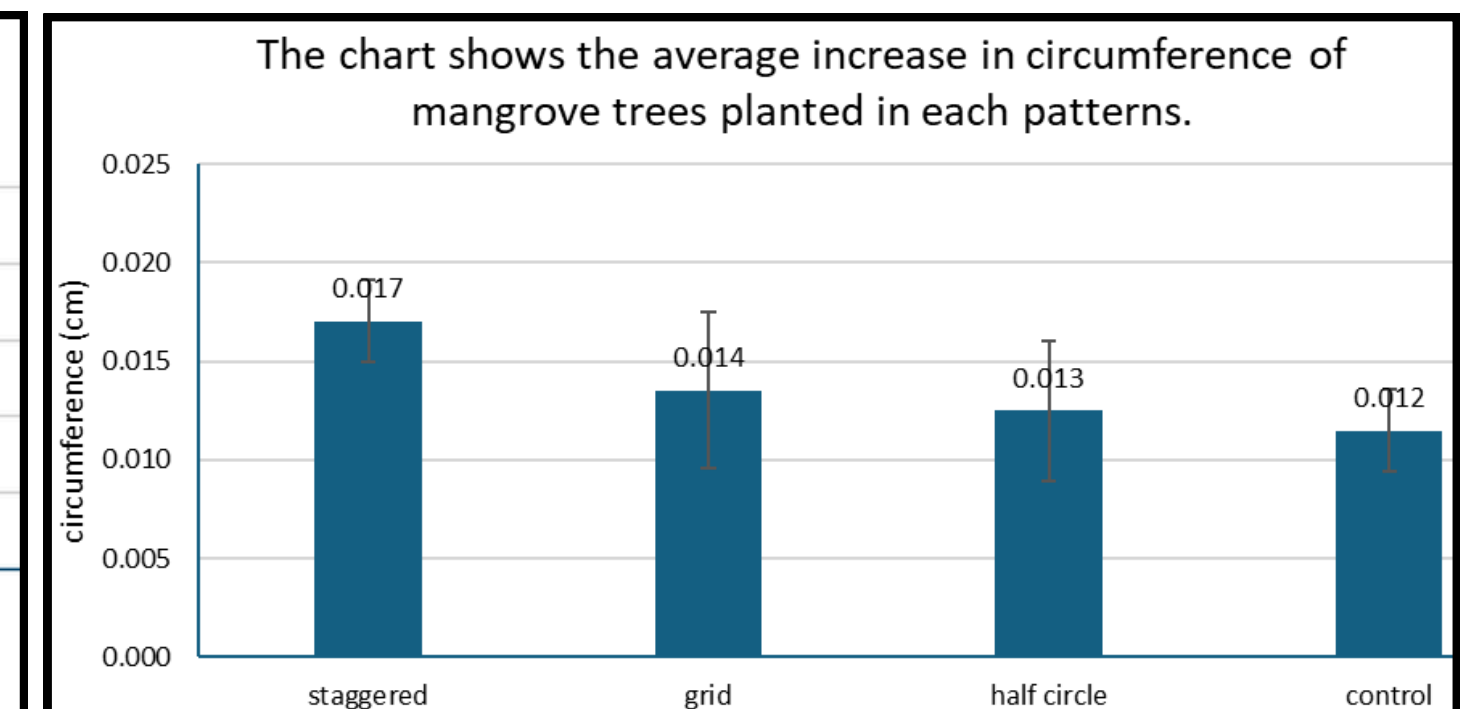
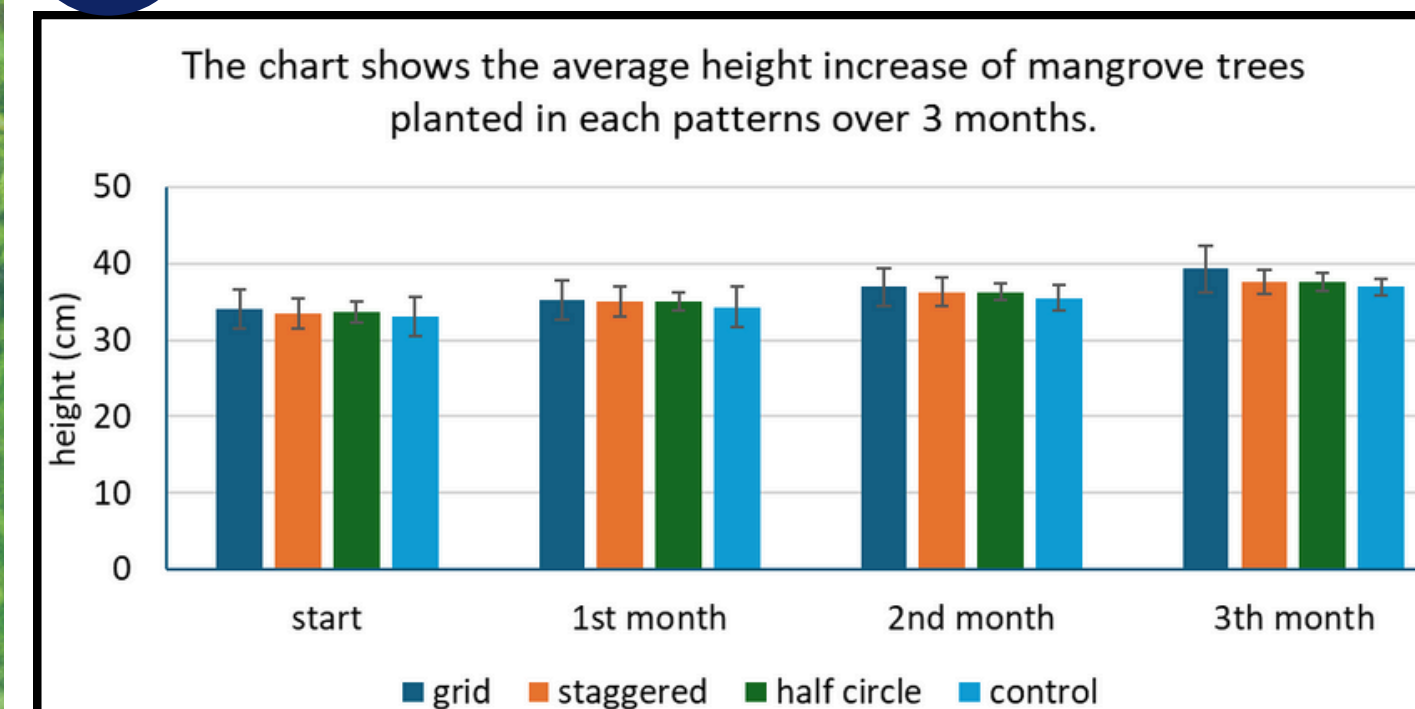
Planting patterns	cost (Bath)	Time (hour)	Survival rate (%)	Break-even
Grid	225	0.75	68.89	40.22
Staggered	225	0.75	82.22	48.72
Semicircular	225	1.00	40.00	17.78
control	225	0.60	53.33	39.50

Break-even calculation

$$\frac{\text{survival rate}^2}{\text{time} \times \text{cost}} = \text{Break-even}$$

Planting mangroves in a staggered pattern has a payback rate of 40.22, making it the most cost-effective method of cultivation.

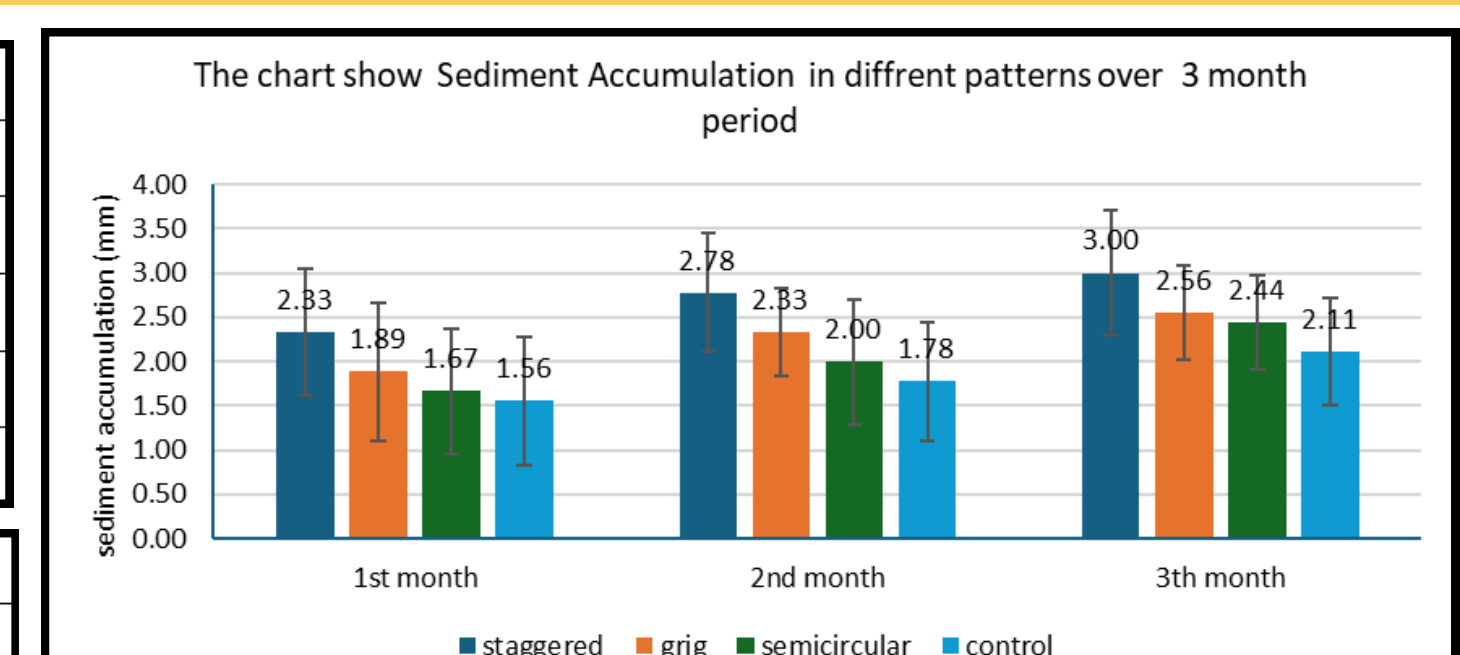
2 Development of mangrove planting patterns for increase growth rate



Analysis of growth rates, including height, stem circumference, and leaf count, revealed no statistically significant differences among the different planting patterns at the .05 level.

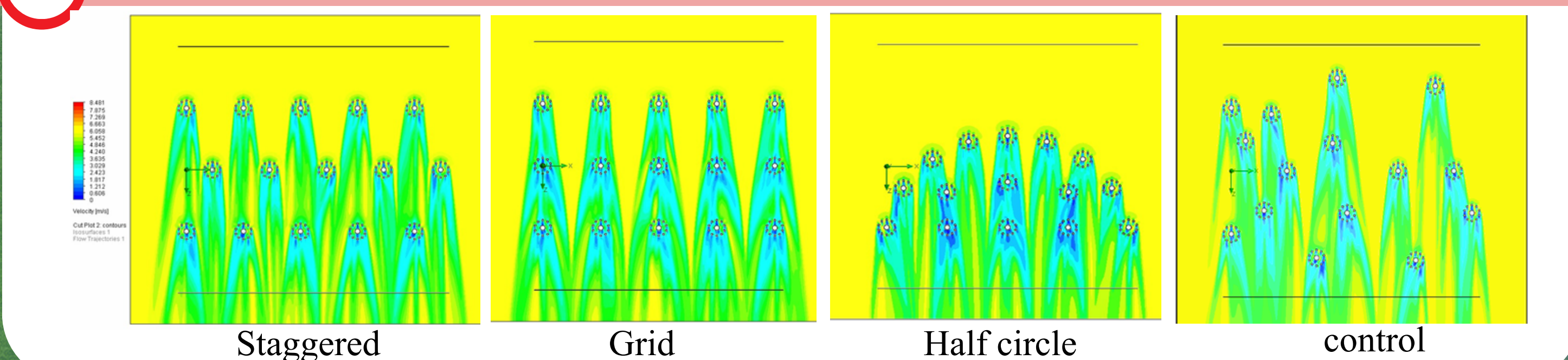
3 Studies on sediment accumulation and soil properties before and after planting

Planting patterns	Soil texture	pH		organic matter	
		before	after	before	after
Grid	Sandy loam	6.21 ± 0.42 ^a	6.17 ± 0.26 ^a	1.87 ± 0.03 ^a	2.26 ± 0.02 ^b
Staggered	Sandy loam	6.43 ± 0.38 ^b	6.42 ± 0.20 ^b	1.84 ± 0.02 ^a	2.66 ± 0.02 ^c
Semicircular	Sandy loam	6.26 ± 0.41 ^a	6.25 ± 0.42 ^a	1.86 ± 0.03 ^a	2.14 ± 0.03 ^b
Control	Sandy loam	6.24 ± 0.41 ^a	6.24 ± 0.20 ^a	1.84 ± 0.20 ^a	2.21 ± 0.02 ^b



The study found that the soil's pH before and after planting was not significantly different, but there was an increase in organic matter, nutrients, and sediment retention.

4 Study on wave velocity passing through mangrove was planed in each patterns



Conclusion

Survival Rate of staggered planting pattern achieved the highest survival rate of *Rhizophora apiculata*. Statistical analysis at a significance level of .05 revealed that different planting patterns significantly influenced the survival rates. Regarding growth performance, there were no significant differences ($p > .05$) in the average increase of stem circumference and leaf count among the different planting patterns. Soil pH levels showed no significant difference between pre-planting and post-planting periods. Soil nutrients (N, P, and K) and Organic Matter increased significantly after planting at the .05 significance level. The staggered pattern resulted in the highest rate of sediment accumulation post-planting. Wave Velocity, The staggered configuration demonstrated the highest efficiency in wave attenuation. Cost-Effectiveness, The staggered planting pattern proved to be the most cost-effective approach for *Rhizophora apiculata* restoration.

Acknowledgement

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Reference

Horstman. et al. (2014). Influence of mangrove pioneers on tidal hydrodynamics and sediment dynamics. *Geomorphology*, 227, 127139. <https://doi.org/10.1016/j.geomorph.2014.03.046>