Reforestation based on the ditch-and-embankment technique increased soil carbon stock and alleviated soil salinity in a coastal area subject to land subsidence- a preliminary study

Chun-Yu Lee[1], Guan-Yin Lin[1], Hsiang-Hua Wang[2], Yu-Hsuan Liu[2], Chien-Fan Chen[2], Li-wan Chang[3*]
[1] Silviculture Division, Taiwan Forestry Research Institute,10060 No.67, Sanyuan St., Zhongzheng Dist., Taipei City, Taiwan.
[2] Forest Ecology Division, Taiwan Forestry Research Institute,10060 No.67, Sanyuan St., Zhongzheng Dist., Taipei City, Taiwan.
[3] Technical Service Division, Taiwan Forestry Research Institute,100051 No.60, NanHai Rd., Zhongzheng Dist., Taipei City, Taiwan. *email: liwanc@tfri.gov.tw

1. Introduction

- Reforestation in coastal area is considered a suitable practice to protect residents from blowing aeolian sands and salt sprays and to enhance carbon sequestration.
- Over 310 km^2 lands in Taiwan are subject to land subsidence in 2022.
- The benefits of reforestation in coastal areas are hindered by land subsidence and seawater intrusion.
- A reforestation practice named “ditch-and-embankment technique (D-E technique)” is adopted to overcome the land subsidence by constructing inter-parallel ditches and hills (Fig.1).
- The D-E technique is expected to alleviate soil salinity through salt leaching, and to enrich soil organic carbon (SOC) stock by organic matter inputs from reforested trees.
- The effectiveness of the D-E technique in terms of soil carbon and soil amelioration lacks empirical evidence.

2. Objectives

- Evaluate to what extent the ditch-and-embankment technique can increase SOC and alleviate soil salinity.
- Test whether tree species will influence the effects of ditch-and-embankment technique on SOC and soil salinity.

3. Summary of the ditch-and-embankment technique

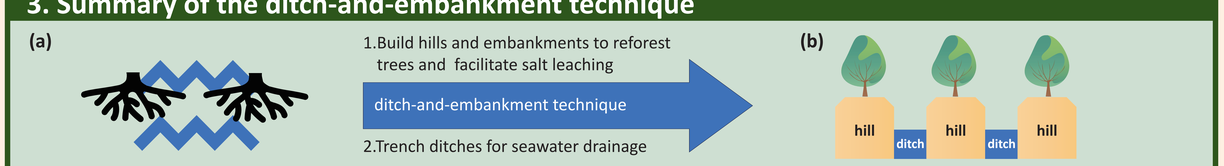

Fig.1 Trees become snags due to land subsidence and seawater intrusion. By applying the ditch-and-embankment technique, inter-parallel ditches and hills are constructed to prevent trees from being submerged by intruded seawater therefore succeeding in reforestation in coastal area to land subsidence. In addition, soil properties could be improved through salt leaching and organic matter inputs from reforested trees.

4. Sites and sampling design

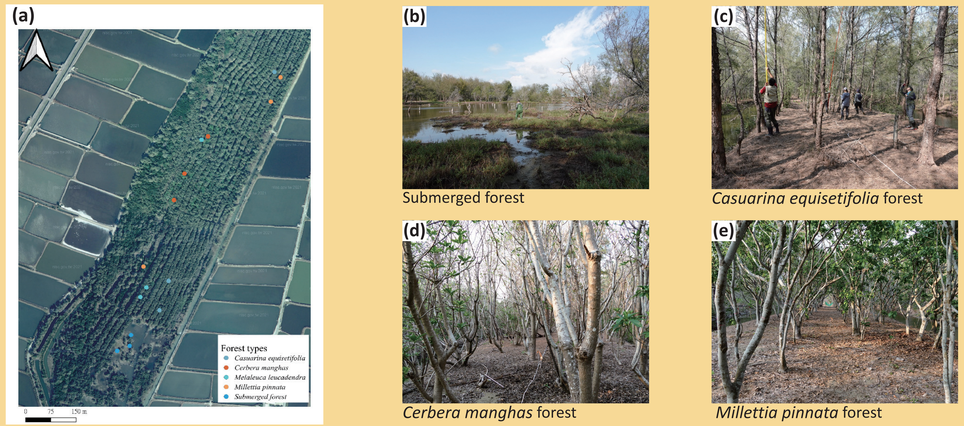

Fig.2 Twelve plots were established in a 15-year-old coastal plantation at the western coast of Taiwan consisting of four dominant species (*Casuarina equisetifolia, Millettia pinnata, Cerbera manghas, Melaleuca leucadendra*). This coastal plantation was established by the D-E technique conducted by Forestry and Nature Conservation Agency. Three plots were established in a proximate submerged forest as the reference baseline.

5. Analysis methods

- Soil samples were collected from hills (O horizon and mineral soil) and ditches were collected using shovels, soil cores and a piston sampler.
- Soil carbon was determined as organic, inorganic, and elemental carbon with a TOC analyzer.
- Soil salinity was measured in terms of soil pH and electrical conductance ($EC_{1:5}$).

Fig.3 Soil samples were collected using soil cores and shovels in hills or a piston sampler in ditches and the submerged forest.

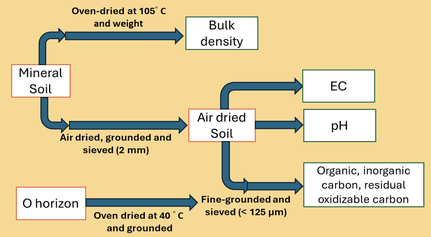

Fig.4 The analysis workflow of soil samples in this study.

6. Results and Implications

- The total SOC stocks of hills ranged from 20.10-31.36 Mg C ha^{-1}, significantly higher than the submerged forest (10.19 Mg C ha^{-1}), except for *Melaleuca leucadendra* (Fig.5(a)) .
- Consistent with total SOC stocks, mineral SOC stocks of hills (13.91 -24.49 Mg C ha^{-1}) were generally higher than the submerged forest, with only those from *Cerbera manghas* and *Millettia pinnata* dominated forests being significantly or marginally higher (Fig.5(a)) .
- The total inorganic carbon stocks of hills between different forests species are similar, suggesting the contributions of the D-E technique reforestation practice (Fig.5(b)) .
- Soil pH at the 0-5 cm layer of hills were lower than those in the deeper soil layer and soils from the ditch.
- EC generally were lower at soil at 0-5 cm or 5-10 cm layers, suggesting the occurrence of salt leaching.

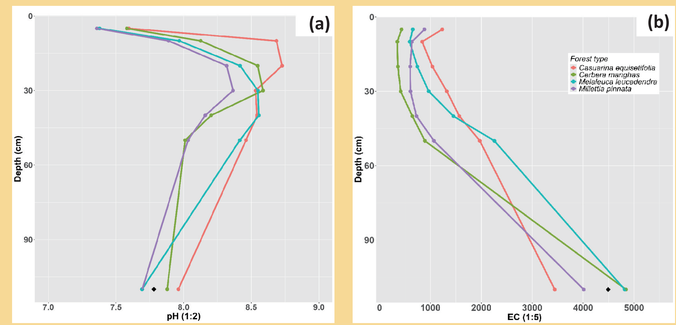

Fig. 6 Soil pH (a) and EC (b) of different forest types at depth of 0-5 cm, 5-10 cm, 15-20cm, 20-30cm, 30-40cm, 40-50cm, ditches (ca. to 110 cm deep). Black diamond represents value from submerged forest (baseline).

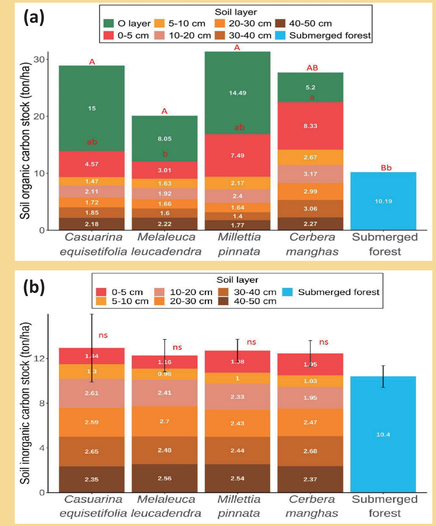

Fig. 5 The total SOC stocks and mineral SOC stocks (a), inorganic carbon stocks of hills (b) among five forest types. For fig.5 (a), bars with different capital letters and lower case letters represent significant differences in total SOC stocks and mineral SOC stocks respectively. ns means no significant differences were observed.

7. Conclusion

Our preliminary study suggests that the D-E technique could be an appropriate reforestation approach to establish coastal plantations in areas subject to land subsidence, meeting multiple objectives, including protecting residents' well-being, soil carbon sequestration, and soil salinity amelioration.