Structural Dynamics, Carbon Sequestration and Species Diversity in a Mature Mangrove Forest: A 15-Year Assessment of the Negombo Estuary, Sri Lanka

K.S.I. Fernando[1], S.H.S. Gunarathna[2], K.A.R.S. Perera[1*]
[1]*Department of Plant Sciences, Faculty of Natural Sciences, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka.*
[2]*Ecosphere Resilience Research Centre, University of Sri Jayewardenepura, Sri Lanka.*
**kaper@ou.ac.lk*

Mangrove forests are globally recognized as critical blue carbon ecosystems that play a vital role in climate change mitigation. However, these coastal systems undergo continuous structural and compositional changes driven by natural succession, species competition, and anthropogenic pressures, particularly in urbanized environments. This study evaluates a 15-year ecological dataset (2010–2025) from Kadolkele, Negombo estuarine mangrove forest in Sri Lanka to examine the long-term relationship between stand maturation, biomass accumulation, and species richness. Forest inventory surveys were conducted across 12 permanent sampling plots (10m × 10m) established along two transects to assess long-term structural and demographic changes. The structural characteristics of the forest changed considerably over the study period. Tree density declined by approximately 75%, from 5,972 to 1,508 trees ha^{-1}, while *Avicennia marina* remained the dominant species. In contrast, stand development indicators significantly increased. Total basal area increased from 15.97 to 145.51 m^2 ha^{-1}, and the mean Diameter at Breast Height (DBH) of *A. marina* increased from 5.21 cm to 35.05 cm. Total biomass increased by 11.02%, from 195.62 t ha^{-1} to 217.19 t ha^{-1}, while total organic carbon increased from 95.85 t ha^{-1} to 106.42 t ha^{-1}. At the same time, mangrove species richness declined from nine to five species. Five species (*Bruguiera gymnorhiza, Bruguiera cylindrica, Excoecaria agallocha, Ceriops tagal and Acanthus ilicifolius*) were absent in the 2025 survey, whereas very few shade-tolerant *Scyphiphora hydrophyllacea* plants were newly recorded, and *Rhizophora apiculata* exhibited a reduced mean DBH of 2.80 cm. The marked reduction in stem density, together with the significant increase in basal area, indicates that the Negombo Kadolkele mangrove forest has undergone natural stand maturation through the self-thinning process (Yoda's Law) rather than forest degradation. The moderate increase in biomass and organic carbon suggests that the forest is approaching an advanced stage of development while continuing to function as an effective carbon sink. However, canopy closure associated with stand maturation appears to have favored shade-tolerant species while reducing the survival rate of shade-intolerant species. These findings highlight the importance of balancing blue carbon conservation with biodiversity protection to maintain the long-term resilience of mangrove ecosystems.

Keywords: *Stand maturation, Self-thinning, Estuary ecology, Total biomass, Blue carbon sequestration, Species richness*