

Mangrove traits influencing coastal protection under varying environmental and eco-geomorphic conditions.

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1 What's Happening: The Rising Threat

Small Island Developing States (SIDS) are experiencing rapid and measurable impacts from climate change across natural and manmade systems. The cumulative effects of rising temperatures, intensified storms, and sea-level rise (SLR) present an ongoing threat and current crisis in some areas. Conventional **"grey" infrastructure**, such as embankments, dykes, and sea walls, has primarily been the standard for coastal defence. However, these methods face growing criticism.

A **Nature-Based Solution (NBS)** like **Mangroves** can provide natural coastal protection, but their effectiveness is not constant across space and time.

2 Research Gap

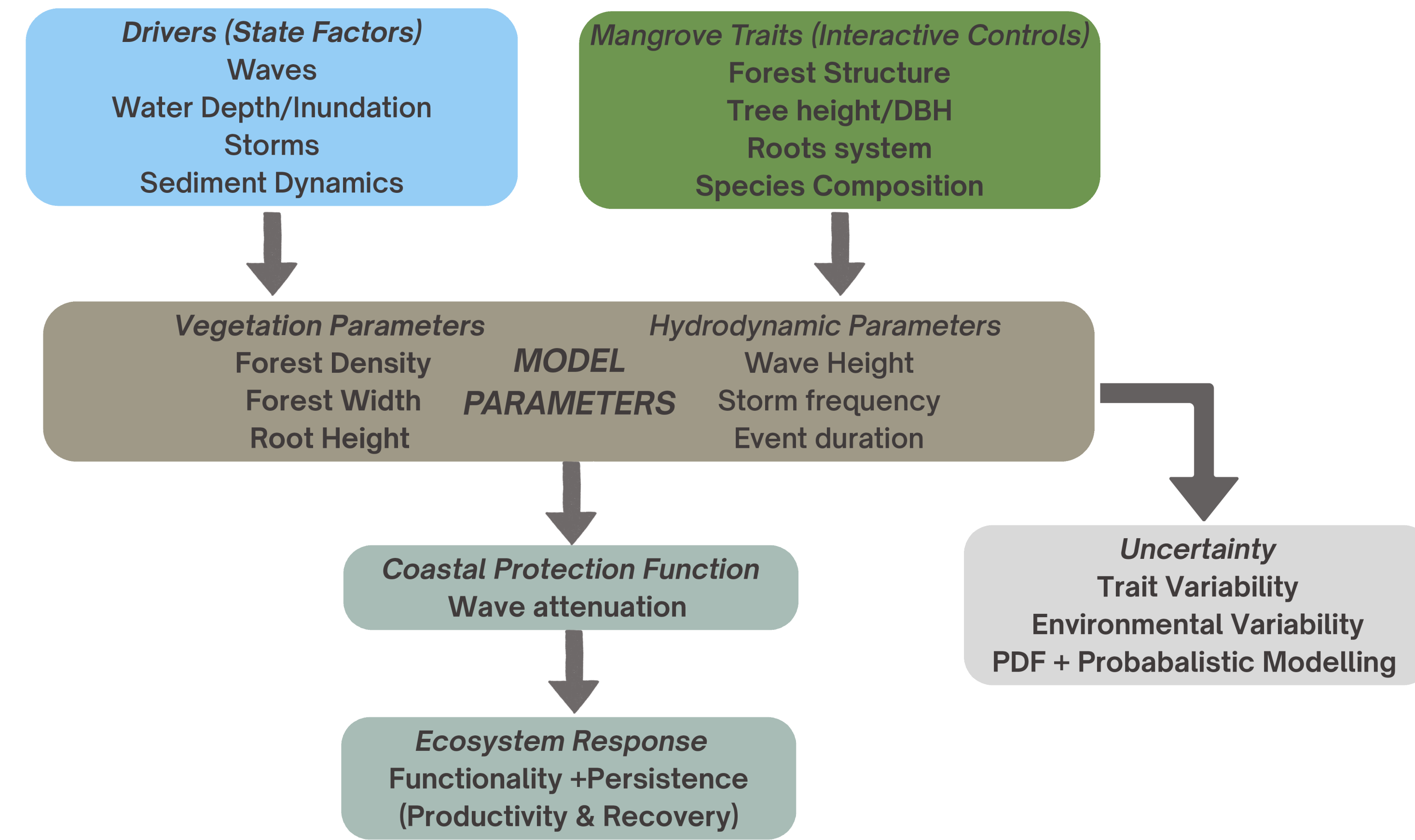
Strategies often incorporate mangroves as Nature-Based Solutions for building climate resilience. However, there is **limited integration of ecological variability and trait-based dynamics in predicting coastal protection.**

Defining a systematic modelling approach that captures these interactions and feedback mechanisms is critical to improving the reliability of mangrove-based coastal protection.

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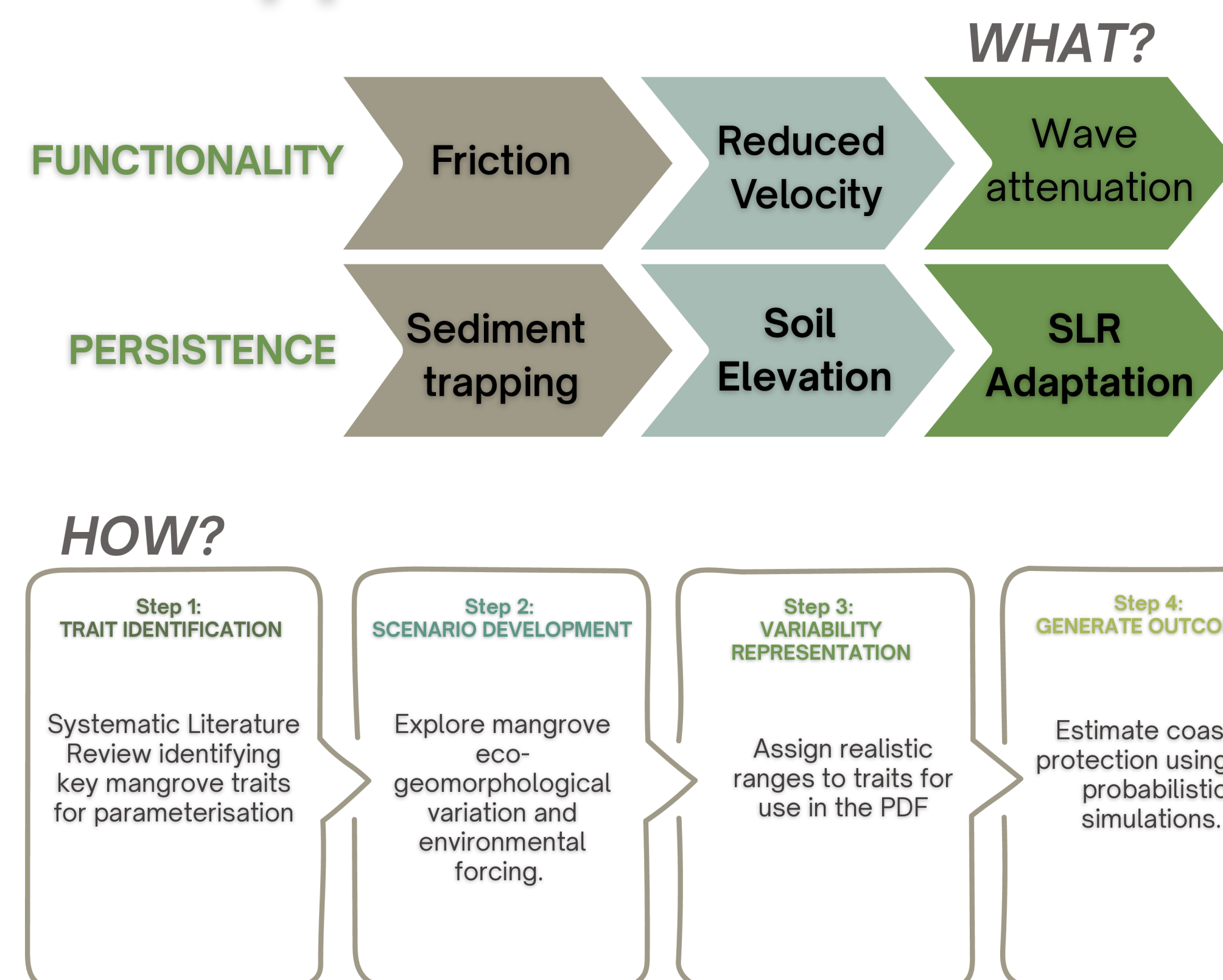
3 Conceptual Framework & Modelling Approach



4 Proposed Approach

To determine how mangroves provide a reliable and stable coastal defence, the interplay between hydrodynamic, morphological, and ecological processes must be examined.

These processes can be grouped into **functionality and persistence**, where interacting components influence wave attenuation, sediment dynamics, and long-term ecosystem stability.



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5 Key Mangrove Traits Influencing Coastal Protection

Trait	Physical Mechanism	Influence Level	Supporting Evidence
Forest width	Increases the distance for wave dissipation; influenced by forest type	HIGH	(Cuc et al., 2015) (Dasgupta et al., 2019), (Horstman et al., 2012) (Mazda & Kamiyama, 2007) (Mazda, 2013) (Zhang et al., 2012)
Root system	Generates drag and turbulence	HIGH	(Du et al., 2021; Massel et al., 1999)
Tree height & DBH	Controls interaction with water depth and velocity	MEDIUM	(Gijón Mancheño et al., 2024) (Dang et al., 2023)
Canopy structure	Intercepts flow at high water levels; wind breaker	LOW	(Gijón Mancheño et al., 2024)
Species composition	Influences structural variation	MEDIUM	(Dasgupta et al., 2019) (Du et al., 2021) (Horstman et al., 2012)

6 Key Insights

- Mangrove coastal protection is **trait-dependent**, not uniform
- Systematic model development is essential
- Effectiveness **varies** under different hydrodynamic conditions
- **Probabilistic approaches** are needed to capture real-world variability

