LITERATURE REVIEW: BLUE CARBON RESEARCH IN THE TROPICAL WESTERN INDIAN OCEAN

PREPARED BY
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SEYCHELLES' CONSERVATION AND CLIMATE ADAPTATION TRUST
SeyCCAT

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Literature Review:
Blue Carbon research in the Tropical Western Indian Ocean

Report submitted to the
Seychelles Conservation & Climate Adaptation Trust (SeyCCAT)
in collaboration with The James Michel Foundation

March 2021

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Information should be cited as:
Palacios MM, Waryszak P, Costa, MDP, Wartman M, Ebrahim A, Macreadie PI. 2021 Literature Review: Blue Carbon research in the Tropical Western Indian Ocean WIO. A report submitted to the Seychelles Conservation & Climate Adaptation Trust (SeyCCAT). Deakin University, Australia, 80pp

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Key terms, acronyms, and definitions

Term	Acronyms	Definition
Aboveground biomass	AGB	Biomass contained within the plant's living leaves, branches, stems or aerial shoots. Values usually reported in ton DW ha^{-1} for mangroves and g DW m^2 for seagrasses.
Aboveground carbon	AGC	Organic carbon stored within the plant's AGB. Values reported in ton C ha^{-1}.
Allometric equations/models	-	Models for mangrove species are usually based on tree height, diameter at breast height (DBH). Equations can be species- or site-specific.
Belowground biomass	BGB	Biomass contained within the plant's living roots and rhizomes. May include necromass (litter or any detrital materials). Values usually reported in ton DW ha^{-1} for mangroves and g DW m^2 for seagrasses.
Belowground carbon	BGC	Organic carbon stored within plant's BGB. Values reported in ton C ha^{-1}.
Diameter at breast height	DBH	Forestry measure in which the diameter of the tree trunk is recorded at 137 cm from the ground. Values reported in cm and often used in allometric equations.
Dry Weight	DW	-
Greenhouse gases	GHG	Gases that absorb and emit radiant energy within the thermal infrared range, which can cause the greenhouse effect [e.g., carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O)]
Hectare	ha	Area metric equal to 10,000 m^2.
International Panel on Climate Change	IPCC	An intergovernmental body of the United Nations that is responsible for providing scientific information relevant to climate change and its possible risks.
Nationally Determined Contribution	NDCs	Emission reductions commitments that countries need to submit to the United Nations Framework Convention on Climate Change (UNFCCC) under the Paris Agreement.
Reducing Emissions from Deforestation and Forest Degradation	REDD+	UN program achieving CO_2 emissions reductions, forest conservation, and sustainable development by placing an economic value on forest carbon storage and facilitating the transfer of funds to developing nations through international trade in carbon credits.
Soil/sediment organic carbon	SOC	Organic carbon stored within the soil/sediment. Values reported in ton C ha^{-1}. SOC is usually reported down to a specific depth (e.g., 100 cm depth).
Soil organic matter	SOM	Organic matter is any living or dead animal and plant material.
Tonne	ton	Mass metric equal to 1,000 kilograms.
Western Indian Ocean	WIO	Province of the Indian Ocean encompassing the east coast of Africa.

EXECUTIVE SUMMARY

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Blue carbon ecosystems (i.e., mangroves, seagrass meadows, saltmarshes) are among the Earth's most efficient carbon sinks, capturing carbon up to 40-times faster than tropical rainforests and locking away carbon in the ground for millennial time scales. As a result, these costal ecosystems are increasingly recognised as a natural-based solution to reduce atmospheric carbon and mitigate climate change.

The tropical Western Indian Ocean (WIO) is rich in blue carbon ecosystems. It hosts dense mangrove forests covering more than 733,000 ha (5.3% of the total mangrove cover worldwide) and diverse seagrass meadows reaching more than 40 m deep. **Given their carbon sink potential, there is growing interest in including these blue carbon ecosystems into national climate adaptation and mitigations strategies.** Accounting for the ocean's carbon offsetting capacity can help many countries reduce their net greenhouse gas emissions and achieve their Nationally Determined Contributions (NDCs). Further, many of the costs of achieving emission reductions in the energy and transport sector could be met through Blue Carbon Markets or international climate financing such as the UN's Reducing Emissions from Deforestation and Forest Degradation (REDD+). However, to participate from these programs and capitalise from the carbon sink capacity of coastal ecosystems, countries require accurate accounting of the current blue carbon stocks and robust reporting of their changes through time.

Seychelles is a world leader in Blue Economy and the pioneer of sovereign blue bonds. Yet, little research has focussed on quantifying the carbon stocks held within Seychelles mangrove and seagrass ecosystems, thereby hindering the possibility of accounting for the nation's natural carbon offsetting potential and the inclusion of blue carbon ecosystems in Seychelles' revised NDCs. Considering the ecological similarities of blue carbon ecosystems within the tropical WIO (e.g., species occurrence, climate conditions), this report reviews mangrove and seagrass literature in the region to (i) identify trends and knowledge gaps in blue carbon research and (ii) compile data on the regional carbon pools (i.e., aboveground biomass, belowground biomass, soil organic matter).

Key findings:

(i)Trends in the literature

- Through a comprehensive search in the ISI Webs of Science and Google Scholar, we identified 633 studies of potential relevance. From this total, 131 contained relevant blue carbon information from the tropical WIO (e.g., allometric equations, plant biometrics), but only 102 included unique datasets of the biomass or carbon stored within the mangroves and seagrass beds.
- Interest in blue carbon is growing rapidly in the region, with almost 50% of the studies published within the past 10 years (2011-2021).
- Most of the research has focussed on mangrove ecosystems (62.6% of the studies) and aboveground carbon stocks (74.8% of the studies). While 53 studies have assessed the soil carbon pool, research on soil accretion rates is extremely rare.
- Studies from Tanzania and Kenya dominate the blue carbon literature, with very little research originating from Island States. Many of the most complete and robust blue carbon datasets were fuelled by peer-reviewed publications arising from academic theses.
- Several mangrove studies have developed species-specific allometric equations and estimated local wood density and carbon fractions.

(ii) Regional carbon pools

- Mangrove aboveground (AGC) and belowground carbon stocks (BGC) within the tropical WIO ranged between 0.05 – 303.9 tonnes C ha^{-1} and 0.01 – 598 tonnes C ha^{-1}, respectively, which sit within the global ranges reported. Mangrove soil carbon stocks (SOC) ranged from 87.5 to 848.2 tonnes C ha^{-1} (within 60 – 200 cm cores) depending on the species, the site, and the methods used to collect soil samples.
- The highest mean mangrove AGC and BGC stocks were recorded in Tanzania (303.9 tonnes C ha^{-1}) and Madagascar (157.5 tonnes C ha^{-1}), respectively. In relation to the carbon stored in the soil, the highest values were recorded in the mangrove forests of Kenya (405 tonnes C ha^{-1}).

- The mangrove species *Rhizophora mucronata* recorded the highest AGC (67.38 tonnes C ha^{-1}) and SOC stocks (562.8 tonnes C ha^{-1}), while *Ceriops tagal* had the highest mean BGC stock (295.83 tonnes C ha^{-1}).
- Seagrass AGC and BGC within the tropical WIO had a mean of 0.70 ± 0.03 tonnes C ha^{-1} and 2.21 ± 0.11 tonnes C ha^{-1}, respectively. Seagrass SOC had a mean stock of 116 ± 24.1 tonnes C ha^{-1}.
- The highest mean seagrass AGC, BGC and SOC stocks were recorded in Kenya (0.89 tonnes C ha^{-1}, 4.95 tonnes C ha^{-1}, and 294.03 4.95 tonnes C ha^{-1}, respectively).
- The seagrass species *Thalassodendron ciliatum* and *Cymodocea rotundata* recorded the highest AGC (1.06 tonnes C ha^{-1}) and BGC stocks (5.99 tonnes C ha^{-1}) respectively. Stands of *Thalassia hemprichii* reached mean SOC stocks of 362.34 tonnes C ha^{-1}.

Main conclusions:

- This literature review highlighted the tropical WIO is a blue carbon hotspot with significant carbon stocks being stored in its diverse and extensive coastal ecosystems. However, it also revealed that despite the increasing regional interest on blue carbon research, there are still major knowledge gaps to be addressed.
- The key research gaps include: (1) the lack of blue carbon datasets from seagrass ecosystems, specifically habitat distribution and belowground plant measures; (2) little information on soil carbon stocks on mangrove and seagrass ecosystems (particularly along deep soil profiles); and (3) a significant lack of soil accretion rates (only 3 studies). Given that the majority of the blue carbon stocks are stored in the sediments (Duarte et al. 2005, Mcleod et al. 2011), soil data are critical to fully account for the annual carbon being sequestered by these ecosystems and, be able to incorporate blue carbon ecosystems in the NDCs.
- Most blue carbon datasets have been collected in the mainland coast of East Africa, leaving a major geographical gap in Small Island Developing States

such as Seychelles. With only 4 relevant studies identified within the Seychelles archipelago, there is an urgent need for blue carbon research in the country. To efficiently fill the knowledge gaps identified above, we recommend:

- **Boost collaborations:** Align research goals between national, regional and international stakeholders (e.g., academia, government and industry) and collaborate with regional blue carbon experts, including those from the mainland East African coast (e.g., Kenya, Tanzania).
- **Build local capacity:** Invest in local training and capacity building (e.g., supporting PhD and Masters' projects, citizen science programs and training workshops) to help build a research network capable of studying and monitoring blue carbon ecosystems.
- **Targeted research:** Prioritise projects that quantify SOC stocks and soil accretion rates from seagrass and mangrove ecosystems. Fund field research that targets the collection of plant morphometrics and soil cores (>30 cm deep) and/or that improves ecosystem mapping (i.e., remote sensing, species distribution modelling).

INTRODUCTION

INTRODUCTION

Removal of atmospheric CO_2 through biosequestration is necessary to keep global warming under 2°C as the world transitions to a low-carbon economy. Among the most efficient systems for biosequestration are **'Blue Carbon'** ecosystems (i.e., mangroves, seagrass meadows, and saltmarshes). They capture atmospheric CO_2 30-50 times faster than forests, and lock it away in the sediments for millennial time-scales, thereby acting as carbon sinks and mitigating climate change (Mcleod et al. 2011, Duarte et al. 2013). In addition to sequestering carbon, blue carbon ecosystems provide other important ecosystem services: they support fisheries, enhance biodiversity, and stabilize the coast, protecting lives and infrastructure against sea level rise (Mcleod et al. 2011).

As with important terrestrial carbon sinks (e.g., tropical forests, permafrost regions), ecosystem degradation can shift blue carbon ecosystems from carbon sinks to carbon sources. Approximately half the earth's blue carbon ecosystems have disappeared due to human activities (e.g., dredging, harvesting, filling, dyking, and drainage) and climate change (e.g., sea level rise, extreme weather events), causing release of ancient carbon. An estimated 8 - 20% of annual global anthropogenic CO_2 emissions result from land-use changes occurring primarily in the tropics (van der Werf et al. 2009). These trends have led to proposals for forest-based climate change mitigation strategies, where financial incentives help developing countries reduce deforestation, build conservation capacity and enhance carbon stocks by placing an economic value on forest carbon storage and facilitating the transfer of funds from developed to developing nations through international trade in carbon credits (UN-REDD Programme Collaborative Online Workspace 2020).

Given the countries' commitment to reduce greenhouse gas (GHG) emissions and tackle climate change (registered under the Kyoto Protocol and the Paris Agreement), it is a priority for nations to learn to optimally manage their assets (including marine systems) to **enhance carbon sequestration, while reducing carbon emissions**. In the low-carbon economy the world is moving towards, blue carbon sinks represent a significant asset for which conservation and restoration can generate important monetary benefits (via carbon offset markets). Many of the costs of achieving emission reductions in the energy and transport sector could be met through blue carbon markets and international climate financing such as REDD+. Further, the recognition of blue carbon as a nature-based solution to climate change under the UN Framework Convention on Climate Change in 2015 (UNFCCC; Bindoff et al. 2019), allows nations the opportunity to include the carbon sequestered by blue carbon ecosystems when achieving their Nationally Determined Contributions (NDCs) under the Paris Agreement.

Seychelles is one of the few nations worldwide serving as a net carbon sink, with expectations to become a net emitter by 2025 (Republic of Seychelles 2015). Although Seychelles has often acknowledged the potential of coastal blue carbon systems to serve as carbon sinks (Department Blue Economy 2018), it is yet to report their carbon offsetting capacity within national GHG inventories and account them as a key mechanism to achieve the country's NDCs (i.e., reduce 29% of its baseline GHG emissions by 2030).

This report reviews mangrove and seagrass literature in Seychelles and the tropical WIO to (i) identify trends and knowledge gaps in blue carbon research and (ii) compile data on the regional carbon pools (i.e., aboveground biomass, belowground biomass, soil organic matter). This information will be critical to produce a first-pass estimate of the country's carbon stocks when combined with detailed spatial maps of Seychelles' mangrove and seagrass ecosystems. Further, it will highlight research priorities that Seychelles needs to tackle to be at the forefront of international efforts in the use of nature-based solutions for climate change mitigation.

METHODS

METHODS

STUDY SYSTEMS

The Western Indian Ocean (WIO) is a province of the Indian Ocean encompassing the African east coast from Somalia to South Africa and extending beyond Madagascar to include many Small Island Developing States (SIDS) (Figure 1). A mosaic of rich coastal ecosystems occurs in the WIO including coral reefs, mangrove forests, and seagrass meadows.

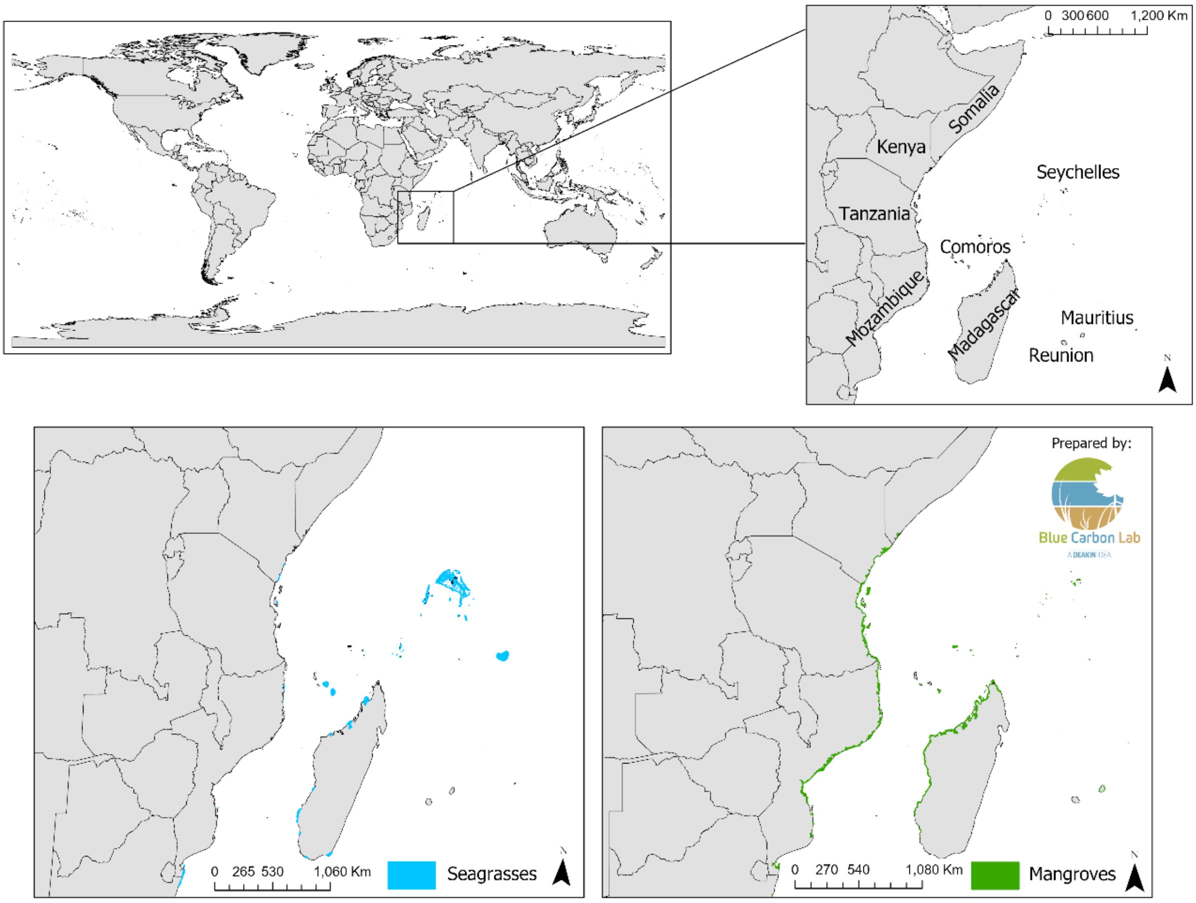

Figure 1. Distribution of seagrass meadows (Smith et al. 2020, UNEP-WCMC and Short 2020) and mangrove forests in the tropical WIO region. (Global Mangrove Watch, reference year: 2016; Bunting et al. 2018).

The climate and pattern of currents in the WIO are complex and strongly influenced by the monsoonal circulation. Two different monsoon periods affect the region. The Southeast monsoon (Apr–Oct) is distinguished by lower air temperatures, strong winds and cool water with low productivity, while the Northeast monsoon (Nov–

Mar) presents higher air temperatures, weak winds and greater rainfall (Pfeiffer and Dullo 2006). The average tidal range across the region varies from 2–4 m and is semidiurnal (Gullström et al. 2002).

(a) Mangrove forests

The WIO holds approximately 733,000 ha of mangrove forests, which represent around 5.3% of the total mangrove cover worldwide (approximately 13,776,000 ha) based on the global baseline mangrove mapping developed in 2010 (Bunting et al. 2018). Within the region, based on Bunting et al. (2018), Mozambique ranks 1st in mangrove coverage with ~300,000 ha, followed by Madagascar (~259,000 ha), Tanzania (~113,500 ha), and Kenya (~54,000 ha). Somalia only holds dense mangrove stands (~2,080 ha) on its southern coastline given the upwelling of cold waters in the north. Among the smaller Island States, Mauritius holds ~2,000 ha (Appadoo 2003), while the Seychelles Archipelago includes ~2,500 ha of mangrove forest located mainly within the Aldabra Atoll (~83% of the total mangrove area in the country; Walton et al. 2019).

Table 1. Mangrove species reported within the tropical WIO.

Mangrove species	Kenya	Tanzania	Mozambique	Madagascar	Seychelles	Somalia	Mauritius
Avicennia marina	x	x	x	x	x	x	
Bruguiera gymnorrizha	x	x	x	x	x	x	x
Ceriops tagal	x	x	x	x	x	x	
Ceriops somalensis						x	
Heritiera littoralis	x	x	x	x			
Lumnitzeria racemosa	x	x	x	x	x	x	
Rhizophora mucronata	x	x	x	x	x	x	x
Sonneratia alba	x	x	x	x	x	x	
Xylocarpus granatum	x	x	x	x	x	x	
Xylocarpus moluccensis	x	x	x		x		

Pemphis acidula may be present in some locations (e.g., Tanzania, Mozambique). However, this species is often considered an associate species, rather than a true mangrove tree (Beentje et al. 2007).
Sources: (Taylor et al. 2003, Mumuli et al. 2010, Government of Seychelles 2011, Githaiga 2013, Jones et al. 2014, Stringer et al. 2014, Lugendo 2016).

Ten species of true mangroves have been reported in the tropical WIO (Table 1, Figure 2), with *Avicennia marina*, *Bruguiera gymnorrizha*, *Ceriops tagal* and *Rhizophora mucronata* being the most dominant species, often constituting >70% of the coastline. Additional species include *Sonneratia alba, Heritiera littoralis, Lumnitzeria racemosa, Xylocarpus granatum* and *X. moluccensis*. One species (*Ceriops somalensis*) is endemic to Somalia. Primary forests can be composed of monospecific stands or a mix of species.

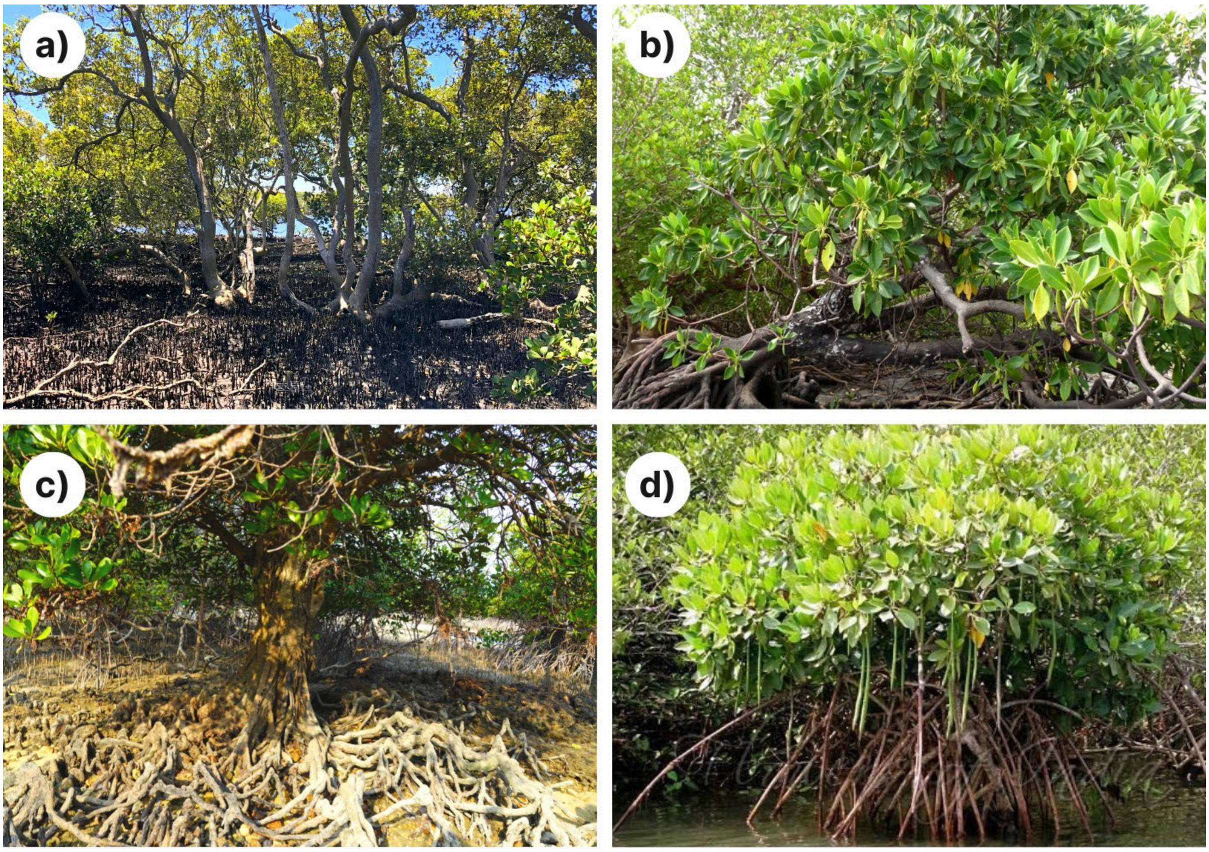

Figure 2. Common mangrove species in the tropical WIO region. (a) *Avicennia marina* (Source: MM. Palacios); (b) *Bruguiera gymnorrizha* (Source: mozambiqueflora.com); (c) *Ceriops tagal* (Source: Reuben Lim via flickr.com)*;* (d) *Rhizophora mucronata* (Source: alchetron.com). Species displayed alphabetically.

(b) Seagrass meadows

Extensive seagrass meadows occur in the tropical waters of tropical WIO (Obura et al. 2019), however due to limited spatial data on the exact distribution and coverage is unknown. There is still a great uncertainty related to seagrass distribution worldwide, with recent mapped and modelled distribution ranging from 16–165 million ha globally (Jayathilake and Costello 2018, McKenzie et al. 2020, UNEP-WCMC and Short 2020).

Within the tropical WIO region, most of the seagrass is located in Madagascar (~579,600 ha; UNEP-WCMC and Short 2020), where the extensive coastline (> 4,500 km) provides habitat to up to 10 species (Table 2). Mozambique has ~44,000 ha of seagrass meadows within its coastline (Lugendo 2016), followed by Kenya with ~31,700 ha (Harcourt et al. 2018). Both countries also have registered multiple species, ranging from 10 in Kenya to 11 species in Mozambique (Table 2). Extensive seagrass beds are usually described in the southern continental shelf of Somalia (Lugendo 2016), but accurate estimates of its distribution and cover are needed. Seychelles holds more than 2 million ha, according to the recent Seychelles Marine Spatial Planning Atlas (Smith et al. 2020), and have registered 9 known species (which can be as high as 12 species, *personal communication by Jeanne A. Mortimer*).

Table 2. Seagrass species within the tropical WIO.

Seagrass species	Kenya	Tanzania	Mozambique	Madagascar	Seychelles	Somalia	Mauritius
Cymodocea rotundata	x	x	x	x	x	x	
Cymnodocea serrulata	x	x	x	x	x	x	x
Enhalus acoroides	x	x	x	x	x		
**Halodule sp. [uninervis / wrightii]*	x	x	x	x	x	x	x
***Halophila ovalis [minor]*	x	x	x	x	x	x	x
****Halophila decipiens*	x				x[a]		
Halophila stipulacea	x	x	x	x		x	x
Syringodium isoetifolium	x	x	x	x	x	x	x
Thalassia hemprichii	x	x	x	x	x	x	
Thalassodendron ciliatum	x	x	x	x	x	x	x
Zostera capensis	x	x	x	x			

* Several authors indicate *Halodule wrightii* does not occur in the region and has been misidentified with *Halodule uninervis.*
** *Halophila minor* is often considered a member of *Halophila ovalis* complex.
****Halophila decipiens* was recently confirmed in the region (McMahon and Waycott 2009), so few published records exist on its distribution.
[a] Personal communication by Jeanne A. Mortimer during presentation in the workshop ‘The state of knowledge of seagrass habitats in Seychelles’ during April 2020.
Sources: (Aleem 1984, Kalugina-Gutnik et al. 1992, Bandeira and Björk 2001, Gullström et al. 2002, Vaïtilingon et al. 2003, McMahon and Waycott 2009, Lugendo 2016, Aboud and Kannah 2017, Global Seagrass Observing Network 2020).

From the ~50 seagrass species described worldwide (Gullström et al. 2002, Short et al. 2007), up to 14 species can be found in the tropical WIO depending on seagrass classification (Table 2). Habitat engineers such as *Enhalus acoroides*, *Thalassodendron ciliatum*, and *Thalassia hemprichii* comprise dominant seagrass species, especially in subtidal areas (Figure 3), while small, fast-growing pioneer species like *Halophila ovalis* and *Halodule uninervis* are commonly found in the intertidal zones (Obura et al. 2019). Seagrasses can reach up to 40 m depth and thrive in close connection to coral reefs and mangroves (Gullström et al. 2002, Lugendo 2016). Seagrasses occur both as monospecific stands and multispecies meadows.

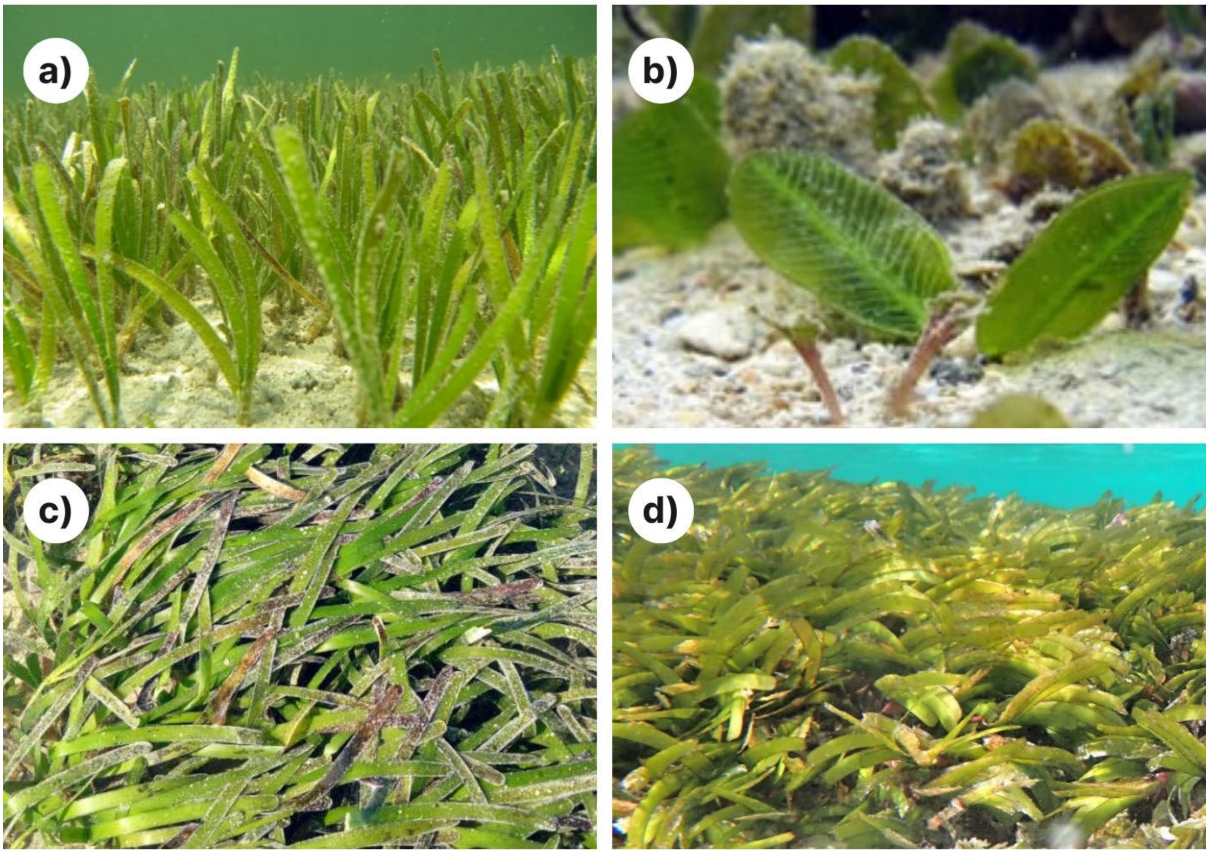

Figure 3. Common seagrass species in the tropical WIO. (a) *Cymodocea serrulata* (Source: SeagrassWatch); (b) *Halophila ovalis* (Source: SeagrassWatch); (c) *Thalassia hemprichii* (Source: SeagrassSpotter); (d) *Thalassodendron ciliatum* (Source: SeagrassSpotter). Species displayed alphabetically.

SEARCH PLAN

The literature review included peer-reviewed studies and grey literature (theses and reports) identified within the general database of the ISI Web of Science (Clarivate™;

webofknowledge.com) and Google Scholar (Google™; scholar.google.com). Using a timeframe between 1864 and 2021, the literature search incorporated a boolean logic (i.e., AND, OR, *, $) to combine terms related to the *ecosystem* (i.e., mangrove and seagrass), the *dataset* (i.e., carbon stocks, biomass), and the *location* (i.e., Seychelles) (Table 3; terms #1, #2 and #3). However, given the small number of blue carbon research published in Seychelles (~6 studies), the review was extended to include literature from other tropical locations within the tropical WIO [i.e., countries located between the Tropic of Cancer (23° 27 N) and the Tropic of Capricorn (23° 27 S)] such as Tanzania, Kenya, Mozambique, Madagascar, Somalia, and Mauritius (Table 3; term #4). South Africa was excluded from the search given its subtropical location and its biogeographical differences to Seychelles.

Table 3. Search terms used to find relevant blue carbon literature in the ISI Web of Science and Google Scholar. The initial search was conducted on 01-08-2020, but subsequent runs were executed up to 01-01-2021 to capture any new studies.

Term	Category	Search
#1	Ecosystem	TS= (seagrass* OR sea-grass* OR mangrov*)
#2	Blue carbon dataset	TS= (biomass OR soil$ OR sediment$ OR carbon OR stock$ OR organic OR below-ground OR above-ground OR allometr* OR DBH OR "Mg C" OR "dry weight" OR DW OR accumulation OR accretion OR sequestration OR 210-Pb OR Pb-210 OR lead-210 OR age-dating OR CAR OR SOC)
#3	Location	TS= (Seychelles OR Aldabra Atoll OR Mahe island OR Cosmoledo Atoll OR Praslin island OR "La Digue" OR Silhouette island OR Curieuse island)
#4	Location	TS= (Tanzania OR Zanzibar OR Mozambique OR Inhaca Island OR Madagascar OR Mahajamba Bay OR Kenya OR Gazi Bay OR Mauritius OR Somalia)

TS = Topic. ISI Web of Science searches for the term within the Title, Abstract, Author and Keywords of the publication record.

From 633 studies originally identified with the search terms (Table 3), only 131 contained relevant information of the biomass or carbon stored within the tropical WIO's mangroves and seagrass beds. Most non-relevant mangrove and seagrass studies were discarded because they focussed on: (a) general descriptions of the flora and fauna within the ecosystem; (b) the habitat use or feeding preferences of the inhabitant fauna (e.g., fish and invertebrates), (c) changes in habitat cover, d) human interactions with the ecosystem (e.g., mangrove wood extraction), and (e) perspectives on coastal management or the REDD+ program.

DATA REPORTING

From the 131 studies reviewed for this report, only 101 contained datasets that were unique (e.g., data overlapped between PhD theses and subsequent publications) and/or could be extracted from the documents. Blue carbon data were mainly collected from the tables and supplementary material of each study. However, if needed, data was also obtained from graphs and figures using a Web Plot Digitaliser tool (https://apps.automeris.io/wpd/). Data on biomass and stocks is reported in the most common units (e.g., tonnes ha^{-1}) as mean ± SE (standard error). If the study reported different units or errors, such as standard deviation (SD) or confidence interval (CI), we manually transformed and converted the values. Where data were given as a range, the mid-point was taken as an estimate of the mean from that study. If required, biomass values (tonnes DW ha^{-1}) were transformed to carbon (tonnes C ha^{-1}) using conversion factors from Fourqurean et al. (2012) and Kauffman and Donato (2012). Finally, if the research included values for ecosystems under different management or treatment scenarios (e.g., nutrient levels, degradation), we only reported the natural or control values.

Disclaimer!

Data reported in this review were copied and/or summarised from the literature. We take no responsibility on the species taxonomic identification or the precision/accuracy of the values being reported. Please access the original reference for information on the sampling protocols, experimental design, replication, or taxonomic identification.

LITERATURE OVERVIEW

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Interest in blue carbon is growing rapidly in the tropical WIO research community, with almost half of the studies identified published within the past 10 years (2011-2021; Figure 3). Following global trends, most of the research has largely focussed on mangrove ecosystems and aboveground carbon stocks (Figures 4a and b). Within the region, Tanzania and Kenya have taken the lead on blue carbon research, with 66% of the data being collected in these locations (Figure 4c).

Despite the growing recognition on blue carbon stocks for climate change mitigation, few papers explicitly examined mangrove and seagrass carbon stocks. Many of the biomass or carbon measures reviewed were collected as complementary datasets to describe the environmental context of field sites and experiments (e.g., Eklöf et al. 2006, Gullström et al. 2008, Mamboya et al. 2009, Andreetta et al. 2014, Lang'at et al. 2014). Interestingly, many of the most complete and robust blue carbon datasets were fuelled by peer-reviewed publications arising from academic theses (e.g., Githaiga 2013, 2017, Lupembe 2014, Musyoka 2015, Njana 2015, Lyimo 2016, Dahl 2017, Juma 2019), which suggests a rising interest into blue carbon research.

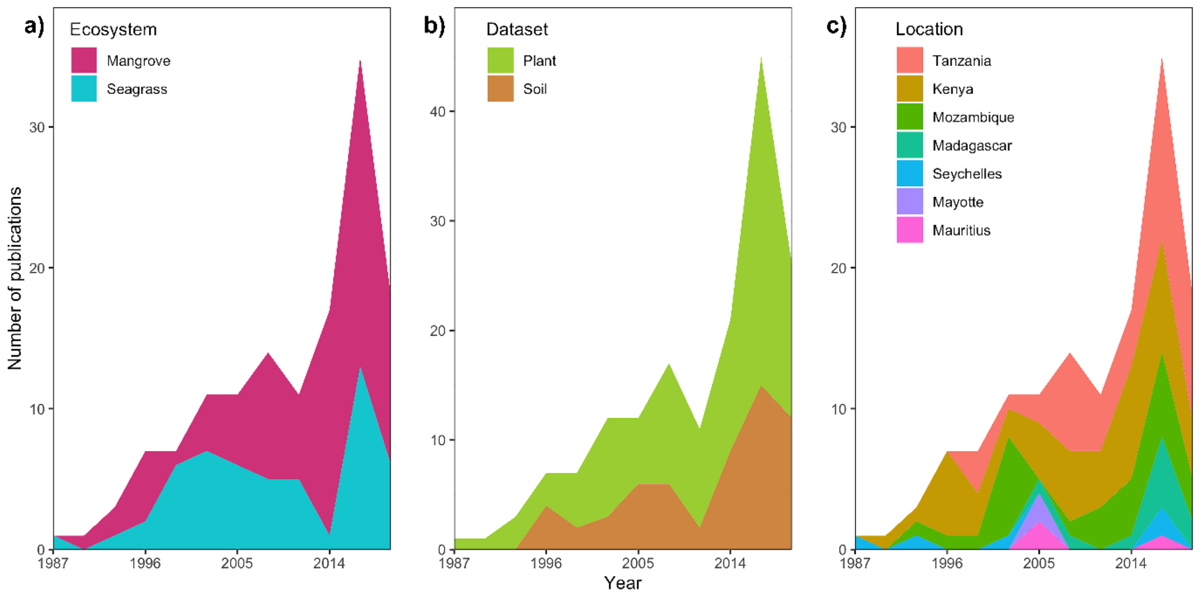

Figure 4. Trends in blue carbon literature within the tropical WIO region. Number of publications from 1987 to 2020 that included blue carbon data categorised by (a) ecosystem, (b) dataset, and (c) location. An individual study could be counted toward multiple aspects. Dataset is displayed in three-year intervals.

ECOSYSTEM

From the 131 studies reviewed, 82 were based on mangrove ecosystems, while 49 focussed on seagrass meadows (Figure 4a). Despite seagrass having higher distribution extent in the tropical WIO (i.e., >2.6 million ha of seagrass vs >771,000 ha of mangroves), mangrove research is likely favoured given (a) its higher carbon storage and potential for carbon offsetting (b); its applicability within REDD+ program; and (c) the easier sampling conditions and/or access to sites. The number of relevant publications within mangrove ecosystems is also higher given the inclusion of studies with complimentary datasets such as mangrove allometric equations and wood density (e.g., Cohen 2014, Njana et al. 2016a, Gillerot et al. 2018).

DATASET

Most of the blue carbon literature in the tropical WIO describes the *plant carbon pool* (102 studies; Figure 4b). The majority of these studies quantify aboveground biomass (e.g., Kalugina-Gutnik et al. 1992, Kairo et al. 2009, Cohen 2014, Belshe et al. 2018), with data on plant belowground biomass present in only 57% of the research (e.g., Duarte et al. 1998, Tamooh et al. 2008, Njana et al. 2015). Despite most of the blue carbon stocks are stored within the sediments, only 53 studies included data on the *soil carbon pool* (Figure 4b). From this total, 30% of the studies reported carbon stocks on shallow soil cores (i.e., shorter than 15 cm depth; e.g., Hemminga et al. 1994, Ndaro and Ólafsson 1999, Eklöf et al. 2005, Kristensen et al. 2008), while the remaining provided carbon estimates along deeper soil profiles (i.e., up to 200 cm depth; Lang'at et al. 2014, Gress et al. 2017, Belshe et al. 2018, Githaiga et al. 2019). Research that included soil carbon accretion rates comprised a small component of the literature (2.3%).

LOCATION

Mangrove and seagrass studies focused on blue carbon have been mainly conducted along the mainland East African coast (Figure 4c), revealing a major geographical gap in the Island States. Within the region, 85% of the studies have taken place in the coastal ecosystems of Kenya (e.g., Middelburg et al. 1996, Musyoka 2015, Githaiga et al. 2017, Gillerot et al. 2018, Juma 2019), Tanzania (e.g., Lupembe 2014, Belshe et al. 2018, Gullström et al. 2018, Njana et al. 2018), and Mozambique (e.g., de Boer 2002, Stringer et al. 2015, Trettin et al. 2016). Among the mainland countries, Somalia is the only one without blue carbon literature. Island States such as Madagascar, Seychelles, Mauritius, Comoros, and Reunion/Mayotte (France) have limited data, with less than 10 studies each.

Seychelles

Only four studies contained relevant blue carbon datasets in Seychelles. Three studies focused on seagrass meadows; with two providing estimates of seagrass aboveground biomass across several islands (e.g., Mahé, Aldabra; Aleem 1984, Kalugina-Gutnik et al. 1992) and one including estimates of shoot density (Ingram and Dawson 2001). A fourth study took place in the mangroves of Barbarons and Anse Boileau (Mahé), where deep soil cores were age-dated to examine Holocene sea-level changes (Woodroffe et al. 2015a). We did not identify any studies that quantify soil carbon stocks or soil accretion rates in Seychelles.

MANGROVE CARBON

MANGROVE CARBON

TRENDS IN THE DATASETS

A total of 82 studies included mangrove from the tropical WIO, however, only 60 reported unique datasets (Table S1). Among the studies reviewed, landmark contributions have been made by Jones et al. (2014) in Madagascar, Sitoe et al. (2014) and Stringer et al. (2015) in Mozambique, and Alavaisha and Mangora (2016) in Tanzania; which recognise the importance of mangroves as carbon sinks and characterise both the plant and soil mangrove carbon stocks for specific forests. Most of the mangrove studies considered mixed stands, but *R. mucronata* and *A. marina* were the most widely studied individual species. An important review of mangrove AGC, BGC, and SOC in east Africa can be found in de Jong Cleyndert et al. (2020).

We identified 34 studies that provided datasets relevant in the calculation of mangrove plant carbon stocks (i.e., mangrove biometrics or biomass). While most of the studies focussed on aboveground stocks (AGB or AGC; 33 out of 34 studies), only about half included belowground datasets (BGB or BGC; 18 out of 34 studies). Considering mangroves can store a significant amount of carbon on their root system (Hamilton and Friess 2018, Simard et al. 2018), bias towards aboveground research is likely due to the tedious excavation conditions required to collect and process belowground roots and rhizomes. Among the mangrove biomass research, an important number of studies focussed in comparing plant biomass or carbon stocks across forests of different structure (e.g., canopy types or heights; Bandeira et al. 2009, Jones et al. 2015, Trettin et al. 2016) or origin/age (e.g., natural vs. planted; Bosire et al. 2003, Tamooh et al. 2008, Kairo et al. 2009, Mutua et al. 2011, Musyoka 2015, Kyalo 2016). Several studies also aimed to optimise the quantification of mangrove biomass though the development or testing of remote sensing techniques (e.g., Fatoyinbo et al. 2008, 2018) and allometric models (e.g., Kirue et al. 2007, Kairo et al. 2008, Lang'at et al. 2013, Njana et al. 2016a; see "Allometric Equations and Wood Density" below).

Thirty-four studies reported mangrove SOC content. Half of the data were generated from superficial sediment cores (≤30 cm depth; e.g., Hemminga et al. 1994, Muzuka and Shunula 2006) given the presence of a shallow bedrock or the lack of adequate coring equipment. Deep sediment cores (40 cm – 200 cm deep) were often collected with an auger corer, sliced at 5 – 15 cm intervals, and analysed in the laboratory using either the Walkley-Black method (e.g., Jones et al. 2014, Lupembe 2014, Magalhães 2019, de Jong Cleyndert et al. 2020), loss-on-ignition (LOI; e.g., Bosire et al. 2012, Musyoka 2015, Alavaisha and Mangora 2016, Gress et al. 2017), or an elemental CN analyser (e.g., Lang'at et al. 2014, Arias-Ortiz et al. 2020). Many of the studies reviewed did not estimate sediment dry bulk density nor SOC stocks, but only report the percentage of SOC% or SOM% (e.g., Hemminga et al. 1994, Middelburg et al. 1996, Machiwa 1998).

Only three studies report soil accumulation rates for mangroves in the tropical WIO (Lang'at et al. 2014, Minu et al. 2018, Arias-Ortiz et al. 2020). However, several studies examining Holocene sea-level changes have used radiocarbon to age-date sediment cores from mangroves in Tanzania, Seychelles, and Mayotte (e.g., Zinke et al. 2003, 2005, Punwong et al. 2013c, 2013b, 2013a, Woodroffe et al. 2015a, 2015b).

Allometric equations, wood density and carbon fractions

Most studies in the tropical WIO use generalised allometric models and carbon conversion factors to predict mangrove tree biomass and carbon stocks (e.g., Fatoyinbo et al. 2008, Jones et al. 2014, Stringer et al. 2015, Alavaisha and Mangora 2016, Trettin et al. 2016, Benson et al. 2017, Arias-Ortiz et al. 2020). However, several studies have developed mangrove species-specific allometric equations for the most common species in the region (Table 4). All of these models incorporate field measurements of tree diameter (DBH) and/or tree height (h) to predict mangrove tree biomass. In addition, four studies within the tropical WIO report mangrove species-specific wood density values (ρ; Table 5) which can be used in generalised allometric models, such as those developed by Komiyama et al. (2005).

Following the IPCC recommendations (Kennedy et al. 2014), most studies convert mangrove AGB and BGB estimates to AGC and BGC by using concentration factors of 0.47 and 0.39, respectively (Kauffman and Donato 2012). However,

Table 4. Allometric equations developed to estimate mangrove AGB and BGB within the tropical WIO.

Location	Mangrove species	Tree Biomass (kg DW)	R^2	N	DBH (cm)	Source
Kenya	Mixed forest	ABG= exp[-2.29711+ (In DBH × 2.54528)]	0.9	337	0.9 - 48.9	Cohen et al. (2013)
	R. mucronata (12yrs)	AGB= 1.6E - 0.5 $(D^2 \times h)^2 + 0.45(D^2 \times h) + 0.495$	0.98	35	> 2.5	Kairo et al. (2008)
	R. mucronata (5yrs)	AGB=$10^{[-0.1811 +0.6590 \times \log (D2 \times h)]}$	0.84	56	-	Kairo et al. (2009)
	R. mucronata	AGB= 0.8069 x $DBH^{2.5154}$	0.98	15	5 to 25	Kirue et al. (2007)
	A. marina	AGB= (0.6896 x $D^{2.0095}$)/1000	0.93	-	-	Lang'at et al. (2013)
	B. gymnorrhiza	AGB= (0.6494 x $D^{1.7132}$)/1000	0.64	-	-	Lang'at et al. (2013)
	C. tagal	AGB= (0.4112 X $D^{2.1032}$)/1000	0.94	-	-	Lang'at et al. (2013)
	C. tagal	AGB= exp[2.31 x In(circumference) - 9.93]	0.98	116		Slim et al. (1996)
	R. mucronata	AGB= exp[2.20 x In(circumference) - 7.81]	0.95	64		Slim et al. (1996)
Tanzania	*A. marina*	AGB= 0.19633 x $(DBH)^{2.07919}$ x $(h)^{0.29654}$	*	40	1.1 - 70.5	Njana et al. (2016a)
	S. alba	AGB= 0.19633 x $(DBH)^{2.04113}$ x $(h)^{0.29654}$	*	39	1.1 - 47.5	Njana et al. (2016a)
	R. mucronata	AGB= 0.25128 x $(DBH)^{2.26026}$	*	40	1.4 - 41.5	Njana et al. (2016a)
	A. marina	BGB= 1.42040 x $(DBH)^{1.44260}$	*	10	1.1 - 70.5	Njana et al. (2016a)
	S. alba	BGB= 1.42040 x $(DBH)^{1.59666}$	*	10	1.1 - 47.5	Njana et al. (2016a)
	R. mucronata	BGB= 1.42040 x $(DBH)^{1.68979}$	*	10	1.4 - 41.5	Njana et al. (2016a)
Mozambique	Mixed forest	AGB= 3.254 × exp(0.065 × DBH)]	0.89	31	0.5 - 42	Sitoe et al. (2014)

*These models include random effects and therefore a R^2 was not calculated.

Table 5. Wood density* (g cm^{-3}; mean ± SE) for mangrove species within the tropical WIO.

Mangrove species	Bosire et al. (2012)	Lupembe (2014)	Njana et al. (2016)	Gillerot et al. (2018)
	Mozambique	Tanzania	Tanzania	Kenya
Avicennia marina	0.9 (0.0)	0.65 (0.01)	0.60 (0.0)	0.76 (0.02)
Bruguiera gymnorrizha	1.3 (0.1)	0.66 (0.03)	-	0.84 (0.01)
Ceriops tagal	1.1 (0.0)	0.67 (0.02)	-	0.85 (0.01)
Heritiera littoralis	0.8 (0.1)	0.57 (0.03)	-	0.84 (0.01)
Lumnitzeria racemosa	-	0.33 (0.01)	-	0.82 (0.03)
Rhizophora mucronata	1.1 (0.1)	0.65 (0.03)	0.69 (0.01)	0.86 (0.03)
Sonneratia alba	0.8 (0.0)	0.57 (0.0)	0.54 (0.01)	0.58 (0.03)
Xylocarpus granatum	0.8 (0.1)	0.56 (0.01)	-	0.71 (0.02)
Xylocarpus moluccensis	-	-	-	0.82 (0.04)

*Wood density for stems and branches. Root wood density is often lower than the aboveground sections of mangrove trees. See Lupembe (2014) and Njana et al. (2016b) for root densities.

mangrove species-specific carbon fractions have been reported by Njana et al. (2016b) and Gillerot et al. (2018) and should be used when transforming mangrove biomass to carbon (e.g., AGB to AGC) within the region. Several studies highlight that using general equations or wood densities (instead of species-specific or site-specific values) can lead to significant errors in carbon accounting (Kairo et al. 2009, Njana 2015, Njana et al. 2016a).

PLANT CARBON

Mangrove AGC and BGC within the tropical WIO ranged between 0.05 – 303.9 tonnes C ha^{-1} and 0.01 – 598 tonnes C ha^{-1}, respectively (Figure 5; Table S1). Although these values sit within the global ranges reported for mangroves (global average of 129.1 ± 87.2 tonnes C ha^{-1}, with maximum AGB of 910.5 ± 84.2 tonnes C ha^{-1}; Simard et al. 2018), the wide AGC and BGC variability in the tropical WIO indicates mangrove biomass stocks are largely influenced by the site conditions, species mixture, and forest structure (Jones et al. 2014, 2015, Kamau et al. 2015, Simard et al. 2018). For example, the range of AGC stocks found in the dataset compiled for this report is higher than the one estimated by de Jong Cleyndert et al. (2020), who found values in the range of 11 and 55 tonnes C ha^{-1}. Variability among mangrove species and locations may be further exacerbated by methodological or analytical differences across studies. For example, mangrove BGB can be significantly over- or under-estimated depending on the allometric equations used (Njana et al. 2015).

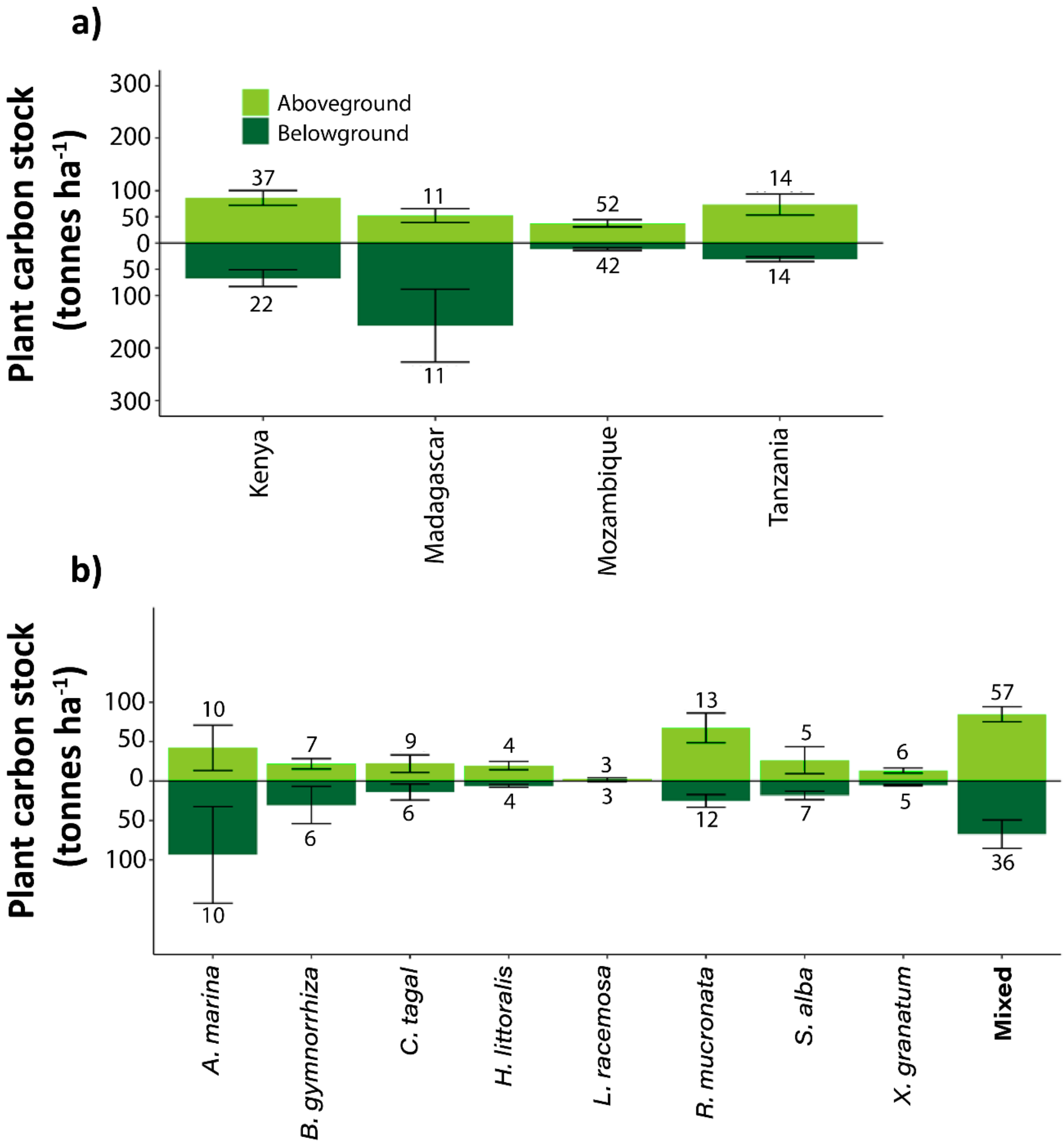

Figure 5. Mangrove plant carbon stocks (mean ± SE) within the tropical WIO region. Above- (AGC) and belowground carbon stocks (BGC) according to (a) country and (b) mangrove species. Values on the bars indicate the number of datapoints used to calculate the mean. A single study can provide multiple datapoints. If required, values for above- and belowground biomass (tonnes DW ha^{-1}) were transformed to carbon (tonnes C ha^{-1}) using the conversion factors of 0.47 and 0.39, respectively (Kauffman and Donato 2012).

AGC and BGC estimates varied considerably across the tropical WIO countries (Figure 5). For example, the lowest and highest mean AGC in mangroves was ~0.05 tonnes C ha^{-1} and ~303.9 tonnes C ha^{-1} in Tanzania. Variation across sites was evidenced in Alavaisha and Mangora (2016). Forests with a mixture of mangrove species had a mean AGC stock of 84.5 ±9.6 tonnes C ha^{-1}, ranging from 10.9 to 303.9 tonnes C ha^{-1}. In terms of mangrove species, the highest AGC stocks was recorded for *R. mucronata* (67.38 tonnes C ha^{-1}; Figure 5 and Table S1). The tallest height of 18.7 m in the region and the widest DBH were reached for *S. alba*. The lowest AGC stock in the dataset was ~0.5 tonnes C ha^{-1} and it was recorded for *X. granatum*.

BGC stocks also varied across countries in the tropical WIO region. For example, Madagascar has the highest mean BGC in mangroves (approximately 157.5 tonnes C ha^{-1}) with Mozambique showing the lowest mean BGC stocks (11.43 tonnes C ha^{-1}). Furthermore, there was also variation in BGC stocks across different species, with *A. marina* having the highest mean stock of 93.7 tonnes C ha^{-1} (Figure 5b) followed by forests with a mixture of mangrove species with BGC stocks of 67.4 tonnes C ha^{-1}. The lowest mean BGC stock was recorded for *L. racemosa* at approximately 0.65 tonnes C ha^{-1}.

SOIL CARBON

Mangrove soil carbon stocks within the tropical WIO region ranged from 43.08 to 848.20 tonnes C ha^{-1} (Figure 6, Table S1). These values are within the range of the predicted global average reported for mangrove soil stocks, with an average soil carbon stock of 283 ± 193 tonnes C ha^{-1} being found by Atwood et al. (2017) and 361 ± 136 tonnes C ha^{-1} (ranging from 86 to 729 tonnes C ha^{-1}) found by Sanderman et al. (2018). The soil carbon ranges found in this report are also within the ranges found by de Jong Cleyndert et al. (2020), who evaluated SOC stocks in Tanzania. The variation of soil stocks registered from the tropical WIO region can be associated with the species occurring in the region and/or to the methods used to collect soil samples. For example, different studies have collected soil at different depths (e.g., Magalhães

2019 collected cores from at 60 cm depth, while Stringer et al. 2016 extracted carbon data from 200 cm long cores; Table S1).

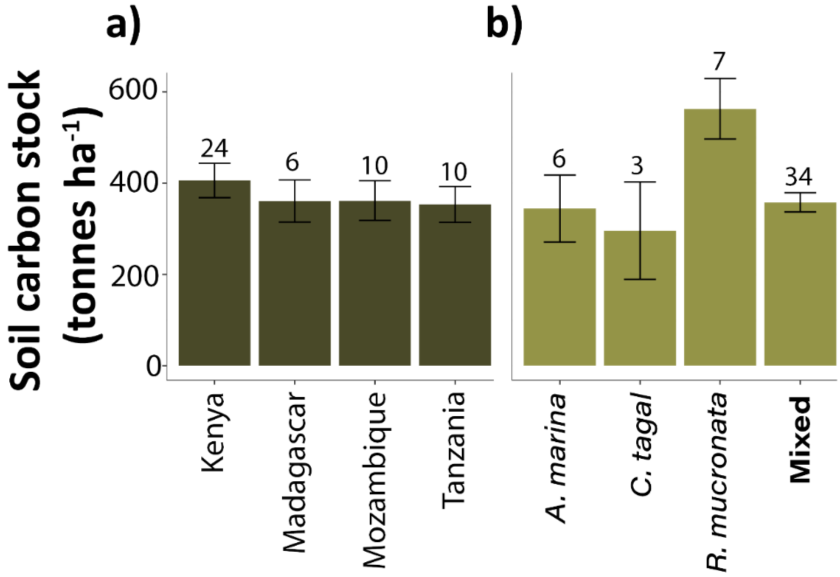

Figure 6. Mangrove SOC stocks (mean ± SE) within the tropical WIO region according to (a) country and (b) species. SOC values from cores ranging between 60 and 200 cm depth. Values above each bar indicate the number of datapoints used to calculate the mean. A single study can provide multiple datapoints.

Soil carbon stocks also varied according across country and species (Figure 6), with Kenya having the highest (405 ± 37.79 tonnes C ha^{-1}) and Tanzania the lowest mean carbon stocks (353.25 ± 39.30 tonnes C ha^{-1}; Figure 6). Furthermore, soil stocks were also different among species, with *R. mucronata* having the highest stocks (562.8 ± 66.02 tonnes C ha^{-1}; Figure 6) followed by mixed mangrove forests showing the second highest soil stocks (357.64 ± 21.05 tonnes C ha^{-1}; Figure 6). This corroborates the global soil stocks predicted by Atwood et al. (2017), who also found that *Rhizophora* and *Laguncularia* forests have the highest soil stocks (388 ± 277 tonnes C ha^{-1} and 424 ± 262 tonnes C ha^{-1}, respectively). The lowest mean soil stocks were found for *C. tagal*, which registered mean carbon stocks of 295.83 ± 106.39 tonnes C ha^{-1} (Figure 6).

SEAGRASS CARBON

SEAGRASS CARBON

TRENDS IN THE DATASETS

The capacity of seagrass meadows to serve as carbon sinks has received limited scientific attention in the tropical WIO. From the 49 seagrass studies reviewed, 41 papers included unique datasets and only six encompassed a complete assessment of the seagrass carbon stocks from both the plant and soil carbon pools (e.g., Githaiga 2017, Belshe et al. 2018, Gullström et al. 2018, Juma et al. 2020). The remaining studies report seagrass biomass or carbon stocks as complimentary datasets to ecological or environmental studies (e.g., Mariani 1999, Ndaro and Ólafsson 1999, Vaïtilingon et al. 2003). As highlighted by Bandeira and Björk (2001), seagrass research in the region has largely emphasised on diversity, ecology and ecophysiology.

Most of the seagrass blue carbon datasets (65.8%) have originated in Tanzania and Kenya thanks to the academic theses of Lyimo (2016), Dahl (2017), Githaiga (2017), and Juma (2019), which have led to more than 10 publications on the topic (e.g., Lyimo et al. 2006, Githaiga et al. 2016, 2017, Dahl et al. 2016, Gullström et al. 2018, Juma et al. 2020). Despite Madagascar holds most of the seagrass in the region, no studies have specifically quantified carbon stocks, and only two studies included relevant information on seagrass aboveground metrics or biomass (Vaïtilingon et al. 2003, Côté-Laurin et al. 2017). Our search only identified three relevant studies from Seychelles; all of them relating to seagrass shoot density or AGB (Aleem 1984, Kalugina-Gutnik et al. 1992, Ingram and Dawson 2001), and none to SOC stocks.

We found 40 studies that quantified the seagrass biomass pool (aboveground or belowground) within the tropical WIO. Only six of them directly focussed on carbon storage and estimated plant carbon stocks, with the rest limiting the datasets to seagrass biometrics or biomass (e.g., Gwada 2004, Daby 2003, Lyimo et al. 2006, Mamboya et al. 2009). All of the studies measured seagrass aboveground stocks (AGB or AGC), but less than half included belowground datasets (BGB or BGC). Considering that approximately two thirds of the seagrass' total carbon is stored belowground (Fourqurean et al. 2012), this pattern highlights that much of the research in the region is still primarily focussed on aboveground ecological processes (e.g., interaction with fish and invertebrates; Vaïtilingon et al. 2003, Gullström et al. 2008), instead of the carbon sink capacity of the system. Most of the seagrass biomass studies considered mixed stands, but *T. hemprichii* and *T. ciliatum* were the most widely studied individual species. A review by Githaiga et al. (2016) includes a comprehensive summary and analysis of the AGB and BGB reported for seagrasses in Africa.

Only ten studies have quantified seagrass SOC stocks in the tropical WIO, demonstrating a major knowledge gap in the region. Six of these studies follow the practical guidelines from Howard et al. (2014) and IPCC (2014) to provide SOC stocks (ton C ha^{-1}) and dry bulk densities from sediment cores of at least 30 cm depth (Belshe et al. 2018, Gullström et al. 2018, Juma et al. 2020). However, the remaining four simply report SOC *percentages* (SOC%) from shallow sediment cores (<10 cm depth; Ndaro and Ólafsson 1999, Paula et al. 2001, Eklöf et al. 2005). We did not find any study or dataset including sediment accretion rates from seagrass meadows.

PLANT CARBON

Seagrass AGC and BGC within the tropical WIO had a mean of 0.70 ± 0.03 tonnes C ha^{-1} and 2.21 ± 0.11 tonnes C ha^{-1}, respectively (Table S2). These values are similar to those found in the review by Githaiga et al. (2016), who discovered mean AGC stocks of 0.84 tonnes C ha^{-1} and BGC stocks of 1.85 tonnes C ha^{-1}. Furthermore, these values are also within the ranges of predicted global means reported by Fourqurean et al. (2012) of 0.755 ± 0.128 tonnes C ha^{-1} for AGC and 1.756 ± 0.375 tonnes C ha^{-1} for BGC. Similar to global trends (Fourqurean et al. 2012), approximately two-thirds of the living seagrass carbon is stored belowground. Datasets from the tropical WIO reveal that Kenya and Seychelles had the highest mean ABG stocks (0.89 ± 0.13 tonnes C ha^{-1} and 0.76 ± 0.04 tonnes C ha^{-1}, respectively), while Madagascar has the lowest mean ABG stocks (0.06 tonnes C ha^{-1}; Figure 7a). The dataset also showed that *T. ciliatum* had the highest AGC stocks, with mean carbon

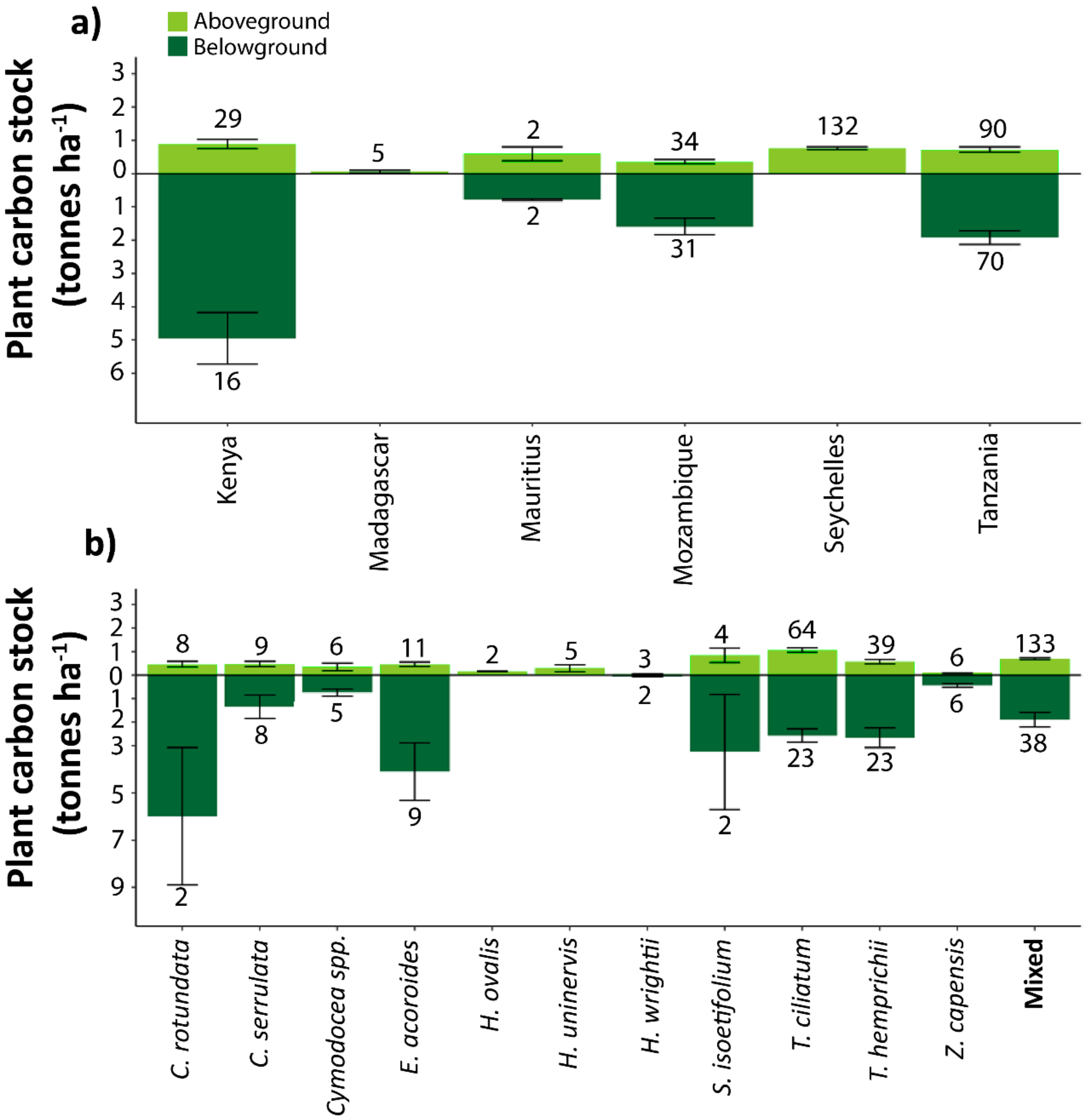

Figure 7. Seagrass plant carbon stocks (mean ± SE) within the tropical WIO region. Above- (AGC) and below- ground carbon stocks (BGC) according to (a) country and (b) seagrass species. Values on the bars indicate the number of datapoints used to calculate the mean. A single study can provide multiple datapoints. If required, biomass values (tonnes DW ha^{-1}) were transformed to carbon (tonnes C ha^{-1}) using a conversion factor of 0.35 (Fourqurean et al. 2012).

stocks at 1.06 ±0.09 tonnes C ha^{-1} followed by *S. isoetifolium* (0.84 ± 0.30 tonnes C ha^{-1}) and seagrass meadows composed of mixed species (0.69 ± 0.05 tonnes C ha^{-1}), reflecting the importance of species composition to the carbon accumulated in seagrass meadows (Figure 7a). The species with lowest mean ABG stocks were *H.*

ovalis (0.16 ± 0.02 tonnes C ha^{-1}), *Z. capensis* (0.08 ± 0.01 tonnes C ha^{-1}) and *H. wrightii* (0.03 ± 0.01 tonnes C ha^{-1}; Figure 7a).

BGC stocks were only recorded in Kenya, Mauritius, Mozambique and Tanzania, with the highest stocks found in Kenya (4.95 ± 0.77 tonnes C ha^{-1}), followed by Tanzania (1.92 ± 0.20 tonnes C ha^{-1}), Mozambique (1.58 ± 0.24 tonnes C ha^{-1}) and Mauritius (0.78 ± 0.02 tonnes C ha^{-1}) (Figure 7a). Carbon stocks also varied according to species, where BGC stocks were higher in *C. rotundata* and *E. acoroides* meadows (5.99 ± 2.91 and 4.09 ± 1.23 tonnes C ha^{-1}, respectively). BGC stocks were lower than 1 tonne C ha^{-1} in *H. wrightii*, *Z. capensis* and *Cymodocea* spp. (Figure 7a).

SOIL CARBON

The only available estimates were recorded in Tanzania (Belshe et al. 2018, Gullström et al. 2018), Mozambique (Paula et al. 2001) and Kenya (Githaiga et al. 2017). Overall, seagrass soil showed a mean carbon concentration of 0.75 ± 0.06 %, and a SOC stock of 116 ± 24.1 tonnes C ha^{-1}. The soil carbon data compiled for this report included samples collected into intermediate (30-60 cm) and deep (> 60 cm) depths of the soil (Figure 8), with no register of soil samples at shallower depths (0-30 cm). These values are smaller than the global mean SOC stock of 139.7 tonnes C ha^{-1} found by Fourqurean et al. (2012). However, this could be explained by the relatively shallower cores included in this dataset, which were not extrapolated to 1 m depth of soil.

The carbon variation found among countries can possibly be explained by the sampling methodology. For example, Kenya registered the highest mean SOC stocks (294.03 ± 66.83 tonnes C ha^{-1}) with all carbon data being derived from samples in deeper depths of soil (Figure 8a). In contrast, Mozambique (28.99 ± 13.70 tonnes C ha^{-1}) and Tanzania (40.14 ± 3.45 tonnes C ha^{-1}) showed relatively smaller mean SOC stocks, with most of the data related to intermediate depths of the soils. Furthermore, seagrass SOC stocks can also vary significantly across species and mixed meadows (Figure 8b). In this case, *T. hemprichii* and *E. acoroides* showed the highest SOC stocks, with values of 362.34 ± 246.42 tonnes C ha^{-1} and 235 ± 117.24 tonnes C ha^{-1}, respectively. Seagrass meadows composed of mixed species showed a mean SOC stock of approximately 102.79 ± 52.19 tonnes C ha^{-1}, with the lowest SOC stocks were found for *Cymodocea* spp (29.67 tonnes C ha^{-1}).

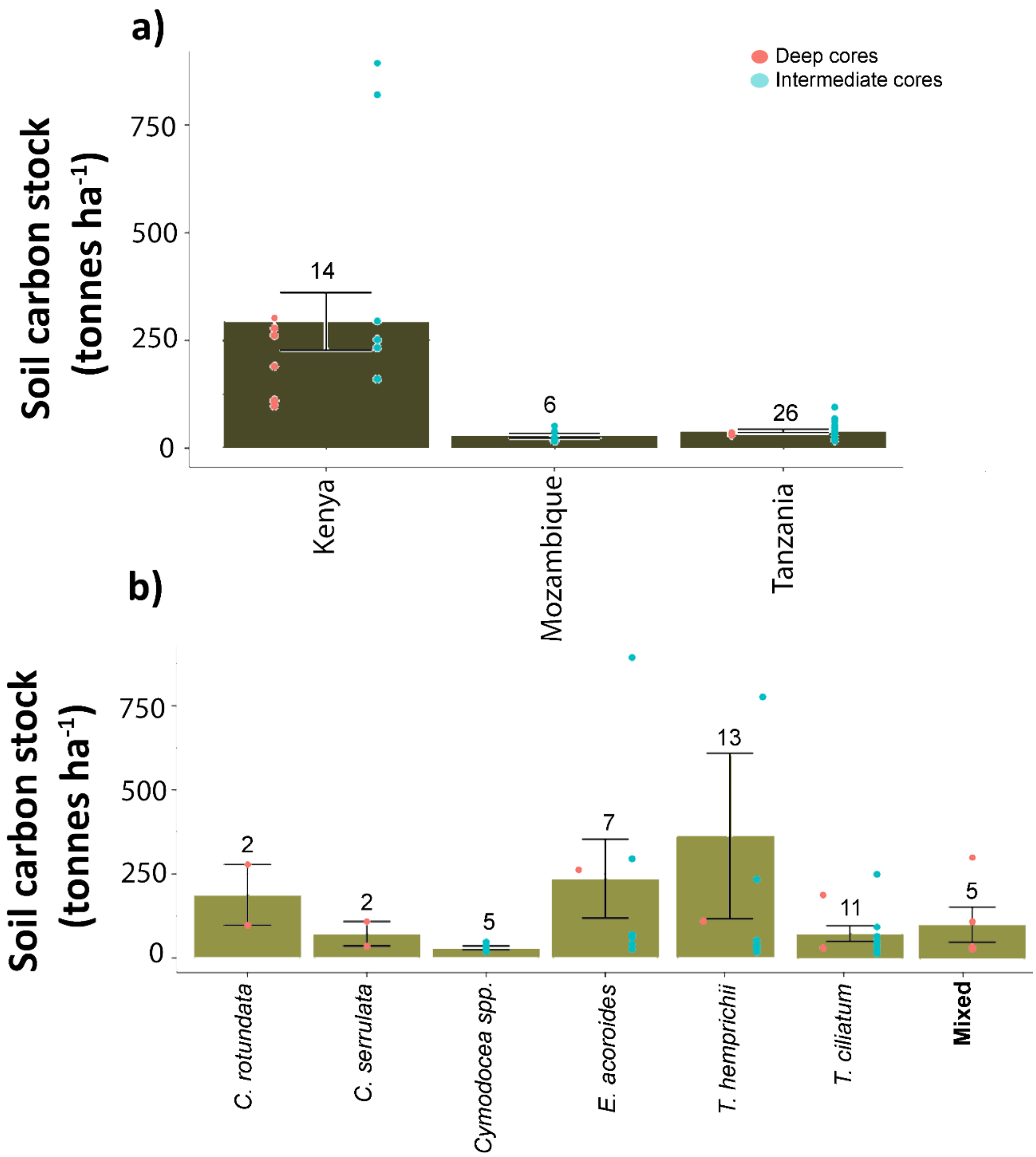

Figure 8. Seagrass SOC stocks (mean ± SE) across different (a) countries and (b) species in the tropical WIO region. SOC values were calculated from soil cores of intermediate (30 - 60 cm depth; blue dots) and deep length (> 60 cm depth; pink dots). Four papers reviewed provided SOC % for shallow cores (<10 cm depth), but not SOC stock values (Table S1). Values above each bar indicate the number of datapoints used to calculate the mean. A single study can provide multiple datapoints.

CONCLUSIONS

CONCLUSIONS

This literature review revealed the tropical WIO is a blue carbon hotspot with significant carbon stocks being stored in its diverse and extensive coastal ecosystems (i.e., mangroves and seagrass meadows). Further, despite the increasing regional interest on blue carbon research, we found that there are still important knowledge gaps to be addressed.

The key research gaps identified in this review were the lack of blue carbon datasets from seagrass ecosystems, specifically habitat distribution and belowground plant measures. Further, on both mangrove and seagrass ecosystems there is little information on soil carbon stocks and a significant lack of soil carbon sequestration rates (only 3 studies). Given that the majority of the blue carbon stocks are stored in the sediments (Duarte et al. 2005, Mcleod et al. 2011), soil data are critical to fully account for the annual carbon being sequestered by these ecosystems and, be able to incorporate blue carbon ecosystems in the NDCs. Finally, most research has been conducted in the mainland coast of East Africa, leaving a major geographical gap of blue carbon datasets in Small Island Developing States (SIDS) such as Seychelles and Mauritius. The main reason for this may be due to the fact that 'blue carbon' is a fairly new concept, especially within these areas of the tropical WIO. Considering the knowledge gaps identified above, we propose the following recommendations to efficiently advance blue carbon research in Seychelles and the tropical WIO:

- The education, and the promotion of the 'blue carbon' concept to the general local populous. Specifically, within schools, scientific communities, governmental and non-governmental organisations.
- Invest in seagrass research, particularly projects that improve seagrass mapping (i.e., remote sensing, species distribution modelling) and solve uncertainties in its distribution extent.
- Target the collection of mangrove and seagrass cores along a deep soil profile (>1 m deep), to enable the accurate quantification of soil carbon stocks and soil carbon sequestration rates.

- Fieldwork studies should follow the international guidelines for blue carbon assessments by Howard et al. (2014) and IPCC (2014) to allow accurate estimates and enable comparisons.
- Sampling should systematically consider different species and locations throughout the region (e.g., the different species occurring within the Seychelles' archipelago).
- Carbon stock analyses and soil age-dating should be conducted with the most accurate and robust methodology given the characteristics of the samples.
- Blue carbon research in the region could rapidly advance by aligning research goals between national, regional and international stakeholders (e.g., academia, government and industry).
- SIDS could benefit from collaborating with regional blue carbon experts, including those from the mainland East African coast (e.g., Kenya, Tanzania), to fulfil the knowledge gaps highlighted in this report.
- Invest in local training and capacity building (e.g., supporting PhD and Masters' projects in blue carbon research, citizen science programs and land managers technical training workshops) to help build a critical group of researchers, practitioners, and educators based in Seychelles for the continued on-going monitoring of blue carbon ecosystems.
- Considering that the majority of blue carbon habitats of the Seychelles lie within the outer islands of the archipelago; making these islands more accessible to scientists, educators and related stakeholders (e.g., through scientific subsidies), could help facilitate and empower research activities in these areas.

As highlighted in the report, mangroves and seagrass beds in the tropical WIO have a great potential for carbon offsetting programs given their high sequestration potential (mangroves) and large extents (seagrasses). Accounting for the carbon being captured or loss (via deforestation/degradation) by these ecosystems, could guide the inclusion of these ecosystems in the NDCs of the country. For example, blue carbon related actions under the NDCs include: 1) mitigation actions (e.g., land use, land-use change and forestry; general mitigation, co-benefits) and 2) adaptation actions (e.g., conservation, protection and restoration efforts; coastal zone management for climate adaptation; and adaptation in the fisheries sector) (Herr and

Landis 2016). Further, blue carbon projects have the potential to generate income for local communities, while also helping to mitigate climate change. Such projects are required to follow the principle of ‘additionality’, in which carbon credits could only be generated by management actions that would not occur under business-as-usual actions (Needelman et al. 2018, Michaelowa et al. 2019). Several studies already suggest great economic opportunities can be available through programs like the REDD+, given the success of mangrove reforestation projects and the significant amounts of carbon being sequestered in planted forests (Tamooh et al. 2008, Stringer et al. 2014, Musyoka 2015).

The blue carbon dataset compiled in this report (see Table S1 and S2) is instrumental to develop first-pass estimates of blue carbon stocks in locations of the tropical WIO where data are lacking (e.g., Seychelles). However, it is important to highlight that the plant and soil estimates we report may have significant uncertainties associated with the diversity of sampling methods, analytical techniques, and spatial scales used across studies. Before using any of these values it is critical to access the original sources to understand the context of the research (e.g., sampling procedure, analytical techniques) and the biogeographical characteristics of ecosystem where the data originated (e.g., species diversity, mangrove tree height, etc.). Despite this, the dataset compiled within this literature review is a first step towards advancing blue carbon research in Seychelles, which can guide future investments in on-ground research and facilitate future management and conservation of blue carbon ecosystems.

There are several institutions (e.g., the World Bank and the Seychelles Climate Change Adaptation Trust), that are currently facilitating and promoting blue carbon research within the Seychelles archipelago through financing initiatives that were created under the debt for nature swap, and the sovereign blue bonds. As a result, this has sparked local, as well as international, scientific interest to the region. By having a clear vision of research and development for better decision making, and sustainable growth, such institutions should be recognised and supported fully by the local government to enable its longevity in Seychelles.

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SUPPLEMENTARY MATERIAL

Table S1. Mangrove carbon pools (AGC, BGC and SOC) reported within the tropical WIO. Values denote mean ± SE, unless otherwise stated.

*Values transformed from AGB or BGB (tonnes DW ha^{-1}) to carbon (tonnes C ha^{-1}) using a carbon fraction of 0.47 and 0.39, respectively (Kauffman and Donato, 2012).

**Several studies include radiocarbon age-dating from mangrove sediments from which soil accretion could potentially be inferred (Andreeta et al. 2014; Massuanganhe et al. 2018; Punwong et al. 2013a, 2013b, 2013c; Woodoffre et al. 2015a, 2015b; Zinke et al. 2003, Zinke2005).

Reference	Country	Location	Forest Type	Species	Height (m)	DBH (cm)	Tree Density	AGC (Mg ha^{-1})	BGC (Mg ha^{-1})	SOC (Mg ha^{-1})	Core depth (cm)	Soil Accretion** (mm yr^{-1})
Alavaisha and Mangora (2016)	Tanzania	Geza	Lower	Mixed				62.74±11.76	19.61±2.94	349.75±5.83	100	
			Mid					103.92±15.69	31.37±8.82	400.5±15.95	100	
			Upper					64.70±6.82	21.57±4.90	183±7.73	100	
		Mtimbwani	Lower					111.76±34.31	33.33±4.90	470±10.64	100	
			Mid					303.92±49.02	78.43±11.76	497±24.45	100	
			Upper					109.80±25.49	33.33±5.88	418.25±28.25	100	
Andreeta et al. (2014)	Kenya	Gazi Bay	Natural	*A.marina*						161.5	80	
			Natural	*A.marina*						213.3	80	
			Natural	*A.marina*						167.9	80	
			Natural	*C.tagal*						87.5	80	
			Natural	*R.mucronata*						297.2	80	
Arias-Ortiz et al. (2020)	Madagascar	Tsimipaika Bay	Closed Canopy	Mixed	9±0.41	12±1.64	2740±623.37	133±21.58 (SD)	43.8±6.65 (SD)	200±40	100	3.4±1.4
Bandeira et al. (2009)	Mozambique & Tanzania	Saco	Natural	Mixed	3.88±0.2	16.8±1.46	1966±0.03					
		Sangala			2.48±0.1	7.84±0.38	3680±7451					
		Mecu´ fi			3.23±0.1		2180±7352					
		Pemba			3.41±0.11	11.7±1.13	2753±7439					
		Ibo			2.98±0.1	10.6±1.01	2080±7269					
		Luchete			2.19±0.11	11.4±70.9	2260±7438					
		Ulo			2.71±70.6	7.73±0.43	3120±7629					
		Mngoji 1			5.16±0.26	10±0.39	1480±7136					
		Mngoji 2			3.77±0.12	8.17	2286±7220					
Benson et al. (2017)	Madagascar		Closed-canopy	Mixed	6.1±0.27	8.03±0.37	3927±244	46.15	30.77	381±27.11	100	
	Madagascar		Open-Canopy	Mixed	5.89±0.45	8.78±0.91	3564±478	28.2	17.95	294.63±36.41	100	
Bosire et al. (2003)	Kenya	Gazi Bay	Natural	*A.marina*	6.1±0.1					25±11(SOM%)	5	
				R.mucronata	7.5±0.2					40±2(SOM%)	5	
				S.alba	8.3±0.6					5±1(SOM%)	5	
			Reforested	*A.marina*	4.5±0.1					19±8(SOM%)	5	
				R.mucronata	2.9±0.1					4±0.1(SOM%)	5	
				S.alba	2.6±0.04					11±2(SOM%)	5	
Bosire et al. (2012)	Kenya	NhaimboII	Natural	Mixed				207±45.38*	67.1±14.65*	373.91±19.92	100	
		Nhaimbo						111.24±24.81*	37.83±7.43*	376.75±26.98	100	
		Temane						155.38±41.91*	48.40±11.84*			
		Mwandua						46.95±21.09*	16.54±7.07*	112.42±25.76	100	
		Nhamacara						278.65±49.90*	88.31±12.95*	306.3±15.12	100	
		General						162.13±20.35*	52.62±6.27*	321±20.15	100	
Bosire et al. (2014)	Kenya	Mwache Creek	Peri-urban/degraded	Mixed	5.3±2.4	6±1.06	1701±105					
		Tudor Creek	Peri-urban/degraded		4.31±0.42	6.35±0.1	1304±118					

Cohen et al. (2013)	Kenya	Mtwapa Creek	Natural	Mixed			18.66*			
		Mida Creek					22.12*			
		Mwache Creek					49.07*			
		Gazi Bay					49.76*			
		South Coast					66.35*			
		Vanga					78.79*			
		South Lamu					79.48*			
		Kiunga					151.37*			
Cohen (2014)	Kenya	Gazi Bay	Natural	Mixed	6.55±0.6	10.5±1.3	36.89±14.24*			
		Mida Creek			7.60±1	14.3±2.6	35.06±10.62*			
		South Lamu			7.5±1.6	11.2±2.2	46.86±14.62*			
		Kiunga			8.8±2	13.8±3.1	51.23±13.54*			
de Boer (2000)	Mozambique	Inhaca Is	Natural	Mixed	2±1.5 (SD)	6.4±7.3 (SD)	78.49*			
Fatoyinbo et al. (2008)	Mozambique	Maputo Province	Natural	Mixed	3.7		33.84*			
		Gaza Province			15.9		97.29*			
		Inhambane Province			4		31.49*			
		Sofala Province			4.8		39.48*			
		Zambezia Province			5.8		45.59*			
		Nampula Province			4.7		39.48*			
		Cabo Delgado Province			6.3		47.94*			
		Country-wide			5.8		38.07*			
Gang and Agatsiva (1992)	Kenya	Mida Creek	Natural	*R.mucronata*				11.83		
				B.gymnorrhiza				1.029		
				C.tagal				14.17		
				X.granatum				0.514		
Gress et al. (2017)	Kenya	Gazi Bay	Natural	*R.mucronata*					653.13	100
			Natural	Mixed					503.13	100
			Natural	*A.marina*					496.88	100
			Natural	Mixed					309.38	100
			Natural	*C.tagal*					362.50	100
		Vanga	Natural	*R.mucronata*					534.38	100
			Natural	Mixed					509.38	100
			Natural	*A.marina*					509.38	100
			Natural	Mixed					553.13	100
			Natural	*C.tagal*					437.50	100
		Inhaca Is (MIM/I)	*A. marina* with *Saccostrea cucullata* on the roots	*A.marina*					234 (TOM; g m^2)	5
		Inhaca Is (MIM/I)	*A. marina*	*A.marina*					258 (TOM; g m^2)	5

Guerreiro et al. (1996)	Mozambique	Ponta Rasa (MIM/II)	*R. mucronata* with *Uca annulipes* and *Terebralia palustris*	*R.mucronata*						329.4 (TOM; g m^2)	5
		Ponta Rasa (MIM/II)	muddy area with *R. mucronata*	*R.mucronata*						919.8 (TOM; g m^2)	5
		Ponta Rasa (MIM/II)	dense association of *R. mucronata* and *A. marina*	Mixed						928.8 (TOM; g m^2)	5
Hatton and Couto (1992)	Mozambique	Portuguese Island	Flooded	*C.tagal*			22444±3230				
				B.gymnorrhiza			5933±1869				
				A.marina			133±95				
				R.mucronata			622±327				
			Non-Flooded	*C.tagal*			19777±6387				
				B.gymnorrhiza			4022±1126				
				A.marina			555±385				
				R.mucronata			311±311				
Hemminga et al. (1994)	Kenya	Gazi Bay	Natural	*R.mucronata*						15.37±2.9 (SOC%)	7
				C.tagal						1.71±0.14 (SOC%)	7
Jones et al. (2014)	Madagascar	Ambanja & Ambaro bays	Closed-canopy	Mixed	6.67±6.82	10.8	3553.17	88.77±7.14	544.12±39.21	446.2±36.9	150
		Ambanja & Ambaro bays	Open-canopy I	Mixed	4.36±4.36	7.9	2312	25.51±3.06	377.45±34.31	324±36.5	150
		Ambanja & Ambaro bays	Open-canopy II	*A.marina*	1.7±0.25	4.6±0.1	1306±277	13.26±2.04	598.04±73.53	517.1±76	150
Jones et al. (2015)	Madagascar	Mahajamba Bay	Closed-canopy I	Mixed	9.43±0.82	11.86±1.42	3169.75	104.54±11.23 (SD)	50.07±5.56 (SD)		
			Closed-canopy II	Mixed	7.71±0.3	12.7±0.67	1153.5	88.5±9.77 (SD)	38.82±4.07 (SD)		
			Open-canopy I	Mixed	4.067±0.64	7.67±0.64	1525.5	22.45±3.45 (SD)	13.69±2.51 (SD)		
			Open-canopy II	Mixed	4.01±0.89	7.01±0.89	1175.5	17.66±6.53 (SD)	12.9±4.14 (SD)		
			Open-canopy III	*A.marina*	2.31±0.17	3.96±0.18	1089±134	9.68±2.72 (SD)	4.87±1.38 (SD)		
de Jong Cleyndert et al. (2020)	Tanzania	Lindi	Shore distance (4.3km)	Mixed	5.53	8.83		12.75	13.71	485.11	100
			Shore distance (8.1km)		7.62	12.53		28.85	24.3	329.79	100
			Shore distance (11km)		4.39	10.52		10.86	10.35	242.55	100
			Shore distance (13.5km)		7.37	13.59		54.9	43.3	155.32	100
Kairo et al. (2008)	Kenya	Gazi Bay	Reforested (12yrs)	*R.mucronata*	8.5±0.15	6.3±0.25	4864	106.7±24(SD)	24.9±11.4(SD)	17.38±0.78 (SOC%)	6
Kairo et al. (2009)	Kenya	Gazi Bay	Planted	*R.mucronata*				9.52*			
				A.marina				5.5*			
				S.alba				3.15*			
				C.tagal				1.74*			
Kamau et al.	Kenya	Mikindani	3k before-sewage	*R.mucronata*						9.75±0.23 (TOM%)	16

(2015)	Kenya	Mikindani	6k before sewage	*R.mucronata*						4.34±0.15 (TOM%)	16	
Kirue et al.2007	Kenya	Gazi Bay	Natural	*R.mucronata*				212.45*				
Kristensen et al. (2008)	Tanzania	Ras Dege	Pristine	*A.marina*						6.12 (SOM%)	16	
				Mixed						12.44 (SOM%)	16	
Kyalo (2016)	Kenya	Gazi Bay	Natural	*R.mucronata*						48.25±0.15 (TOM%)	10	
			Reforested (10yrs)	*R.mucronata*						33±0.9 (TOM%)	10	
Lang'at et al. (2013)	Kenya	Gazi Bay	Planted (4yrs)	*A.marina*				300.93±51.75*	263.74±27.20*			
				B.gymnorrhiza				40.57±10.35*	148.70±48.67*			
				C.tagal				108.20±6.90*	64.53±5.73*			
				Mixed				290.79±50.02*	291.80±34.36*			
Lang'at et al. (2014)	Kenya	Gazi Bay	Control	*R.mucronata*						524.1±45.31	100	4.2±1.4
Lupembe (2014)	Tanzania	Rufiji River Delta	Natural (Secondary forest)	Mixed			729±34	40.5	21.08	100.86	60	
Lyimo et al. (2002)	Tanzania	Dar es Salaam	Natural (Station A)	Mixed						18.33±2.87	30	
Macamo et al. (2015)	Mozambique	Maputo Bay	Remote Sensing	*A.marina*	2.85±0.03	6.85±0.29						
				B.gymnorrhiza	1.82±0.09	6.29±1.31						
				C.tagal	1.63±0.04	5.23±0.27						
				L.racemosa	1.71±0.11	14.54±1.66						
				R.mucronata	1.95±0.09	13.62±0.94						
				X.granatum	2.49±0.2	10.47±1.94						
Macamo et al. (2016)	Mozambique	Save River Delta	Creek forest	Mixed	4.2±2.7 (SD)	12.8±0.9 (SD)	101±63 (SD)					
					3.7±1.5 (SD)	8.6±1.3 (SD)	289±89 (SD)					
					4.3±1.5 (SD)	5.9±1.3 (SD)	488±111 (SD)					
			Seaward forest		3.2±1.1 (SD)	4.5±1.1 (SD)	413±68 (SD)					
					3.6±0.8 (SD)	5.6±1.7 (SD)	817.7±130 (SD)					
Machiwa (1998)	Tanzania	Zanzibar	Marine fringe (MF)	*S.alba*						2.59±0.12 (SOC%)	25	
			Shoreline (SL)	Mixed						5.86±0.95 (SOC%)	25	
			Landward extending (LE)	Mixed						10.21±0.61 (SOC%)	25	
			Terrestrial fringe (TF)	*A.marina*						8.43±1.88 (SOC%)	25	
Magalhães (2019)	Mozambique	Maputo Bay	Secondary forest	*A.marina*	1.35±0.03			4.59±0.53 (SD)		43.08±2.49	30	
			Avicennia river-fringing	*A.marina*						13.71 (SOC%)	40	
			Avicennia saline basin-type	*A.marina*						0.79 (SOC%)	40	
			Bruguiera station X	*B.gymnorrhiza*						4.69 (SOC%)	40	
			Ceriops station A	*C.tagal*						5.32 (SOC%)	40	
			Ceriops station B	*C.tagal*						3.42 (SOC%)	40	
			Ceriops station C	*C.tagal*						4.57 (SOC%)	40	
			Rhizophora station J	*R.mucronata*						3.37 (SOC%)	40	
			Rhizophora station K	*R.mucronata*						7.08 (SOC%)	40	

Middelburg et al. (1996)	Kenya	Gazi Bay	Rhizophora station L	*R.mucronata*		11.33 (SOC%)	40	
			Rhizophora station M	*R.mucronata*		5.83 (SOC%)	40	
			Sonneratia station I	*S.alba*		0.35 (SOC%)	40	
			Sonneratia station II	*S.alba*		0.64 (SOC%)	40	
			Sonneratia station III	*S.alba*		0.38 (SOC%)	40	
			Sonneratia station IV	*S.alba*		2.01 (SOC%)	40	
			Sonneratia station V	*S.alba*		1.74 (SOC%)	40	
			Sonneratia station VI	*S.alba*		2.20 (SOC%)	40	
Minu et al. (2018)	Tanzania	Rufiji River Delta	NR1	*R.mucronata*		1.8±0.23 (SOM%)	200	1.4
			NR2	Mixed			200	
			NR3	*A.marina*		1.08±0.30 (SOM%)	200	0.5
			NR4	*H.littoralis*			200	0.4
			CR1	*R.mucronata*		1.69±0.34 (SOM%)	200	1
			SR1	Mixed		2.04±0.24 (SOM%)	200	2.8
Msangameno et al. (2017)	Tanzania	Zanzibar (Maruhubi)	Peri-urban	*A.marina*	4.26±0.11			
			Peri-urban	*S.alba*	5.71±0.13			
			Peri-urban	*C.tagal*	2.76±0.12			
			Peri-urban	*B.gymnorrhiza*	3.14±0.13			
			Peri-urban	*R.mucronata*	4.34±0.45			
		Zanzibar (Makoba)		*A.marina*	2.72±0.09			
				S.alba	5.63±0.25			
				C.tagal	2.59±0.34			
				B.gymnorrhiza	0.26±2.59			
				R.mucronata	3.9±0.14			
		Zanzibar (Mkokotoni)		*A.marina*	5.53±0.12			
				S.alba	7.14±0.28			
				C.tagal	4.31±0.3			
				B.gymnorrhiza	4.1±0.26			
				R.mucronata	4.7±0.12			
				X.moluccensis	3±0			
		Zanzibar (Tumbatu)	Rural	*A.marina*	3.48±0.2			
			Rural	*S.alba*	4.74±0.98			
			Rural	*C.tagal*	3.58±0.19			
			Rural	*B.gymnorrhiza*	5.36±0.33			
			Rural	*R.mucronata*	5.48±0.22			

			Rural	*X.moluccensis*	3.5±0.59						
Musyoka (2015)	Kenya	Kinondo	Natural	*R.mucronata*	5.3±0.1	7.2±0.2		167.9±35.5 (SD)	83.8±4.5 (SD)	442.1±46.5	100
		Gazi Bay (El Niño)	Plantation (13 yrs)	*R.mucronata*	5.2±1.2	4.5±0.8		37.2±5.8 (SD)	56.2±2.5 (SD)	848±176.2	100
		Kinondo	Plantation (19 yrs)	*R.mucronata*	11.6±1.7	10.05±2.5		98.2±7.1 (SD)	66.3±2.5 (SD)	640.5±27.6	100
Mutua et al. (2011)	Kenya	Gazi Bay	Natural	*R.mucronata*						54±6 (TOM%)	10
			Reforested (5yrs)	*R.mucronata*						29±6 (TOM%)	10
			Reforested (10yrs)	*R.mucronata*						18±8 (TOM%)	10
Muzuka and Shunula (2006)	Tanzania	Bagamoyo	Natural, partly cleared for construction	*A.marina*						2.11 (SOC%)	5
				B.gymnorrhiza						0.77 (SOC%)	5
				C.tagal						2.88 (SOC%)	5
				L.racemosa							5
				R.mucronata						2.11 (SOC%)	5
				S.alba						2.11 (SOC%)	5
				X.moluccensis							5
		Kisakasaka	Natural	*A.marina*						6.73 (SOC%)	5
				B.gymnorrhiza							5
				C.tagal							5
				L.racemosa						5.96 (SOC%)	5
				R.mucronata							5
				S.alba						9.04 (SOC%)	5
				H.littoralis						1.92 (SOC%)	5
				P.acidula							5
				X.granatum						6.73 (SOC%)	5
Nehemia et al. (2019)	Tanzania	Tanga	Natural	*A.marina*						0.90 (SOC%)	5
		Bagamoyo		*A.marina*						1.89 (SOC%)	5
		Kilwa		*A.marina*						0.78 (SOC%)	5
		Mtwara		*A.marina*						1.46 (SOC%)	5
		Pemba		*A.marina*						2.47 (SOC%)	5
		Unguja		*A.marina*						1.47 (SOC%)	5
Njana et al. (2018)	Tanzania	Country-wide	Natural	Mixed				33.5±2.96 (SD)	30±2.31 (SD)		
Njana (2020)	Tanzania	Rufiji River Delta	Natural	Mixed	11.9±0.21	16.5±0.15	2120±191.73	44.3±2.12 (SD)	29.3±1.21 (SD)		
		Kilwa		Mixed	8.6±0.24	13.7±0.16	3417±411.77	42.5±2.09 (SD)	40.2±1.96 (SD)		
Penha-Lopes et al. (2009)	Mozambique	Inhaca Island	Lower	*A.marina*						1.6±0.1 (SOM%)	2
			Mid	*A.marina*						3.4±1.1 (SOM%)	2
			Upper	*A.marina*						3.1±0.5 (SOM%)	2
			Canopy	*A.marina*						5±0.5 (SOM%)	2

Ralison et al. (2008)	Madagascar	Betsiboka	Natural, estuary	Mixed						0.86±0.03 (SOC%)	10
				Mixed						0.9±0.08 (SOC%)	10
				Mixed						0.83±0.34 (SOC%)	10
				Mixed						0.84±0.06 (SOC%)	10
Rönnbäck et al. (2002)	Mozambique	Inhaca Island	Fringe Mud	*A.marina*						11.8±0.6 (SOM%)	5
			Fringe Sand	*A.marina*						3±0.2 (SOM%)	5
			Interior	*A.marina*						3.1±0.6 (SOM%)	5
Schrijvers et al. (1995)	Kenya	Gazi Bay	Natural (G1)	*C.tagal*						19.41 (SOM%)	20
			Natural (G2)	*R.mucronata*						22.47 (SOM%)	20
Sitoe et al. (2014)	Mozambique	Sofala Bay	Natural	Mixed				28.02±1.24 (SD)	25.22±0.71 (SD)	159.98	100
Sjöling et al. (2005)	Tanzania	Kisakasaka	Protected	Mixed						20±2.88 (SOM%)	5
Slim et al. (1996)	Kenya	Gazi Bay	Natural	*C.tagal*				18.52±0.39 (SD)			
				R.mucronata				118.32±9.51 (SD)			
Stringer et al. (2015)	Mozambique	Zambezi River Delta	Height1	Mixed				75.4±12.6 (SD)	23.8±3.1 (SD)	278.76	200
			Height2	Mixed				115.9±16.8 (SD)	36±5 (SD)	285.72	200
			Height3	Mixed				152.5±17.7 (SD)	46.9±5.1 (SD)	299.79	200
			Height4	Mixed				206±20.5 (SD)	59.7±5.2 (SD)	276.40	200
			Height5	Mixed				268.5±36.6 (SD)	72.8±9.4 (SD)	280.70	200
Stringer et al. (2016)	Mozambique	Zambezi River Delta	Seaward fringe	Mixed	5.53±0.51	9.37±0.3				419.04	200
			Creek	Mixed	7.96±0.99	9.2±0.68				558.32	200
			Riverine	Mixed	12.35±1.72	15.06±1.44				499.59	200
			Interior	Mixed	11.9±0.68	10.78±0.94				557.48	200
Tamooh et al. (2008)	Kenya	Gazi Bay	Planted (6yrs)	*R.mucronata*		2.4±0.3	4650±177		3.75±0.2 (SD)		
			Planted (12yrs)	*R.mucronata*		7.9±0.4	3800±212		12.45±0.3 (SD)		
			Natural	*R.mucronata*		6.5±0.2	3567±398		17.9±0.55 (SD)		
			Planted (9yrs)	*S.alba*		7.7±0.9	2300±174		26.7±0.85 (SD)		
			Planted (12yrs)	*S.alba*			7900±141		37.75±1 (SD)		
			Natural	*S.alba*		7.4±0.5	3067±283		24.2±0.35 (SD)		
			Planted (12yrs)	*A.marina*		5.6±0.4	4300±919		21.85±0.85 (SD)		
			Natural	*A.marina*		7.9±0.7	3133±501		19.55±0.35 (SD)		
			Height Class 1	*C.tagal*	6.8±0.5	7.2±0.1	285±224	4.65±3.67*	1.87±1.49*		
			Height Class 2	*C.tagal*	6.4±0.6	7.6±0.11	724±184	13.72±3.38*	5.38±1.33*		
			Height Class 3	*C.tagal*	9.2±1.4	7.8±1.1	930±411	26.84±10.06*	9.36±3.24*		
			Height Class 4	*C.tagal*	10.2±0.7	9±0.3	165±86	4.79±2.40*	1.79±90*		
			Height Class 5	*C.tagal*	11±3.3	15.8±8.1	19±12	5.45±4.23*	1.48±1.05*		
			Height Class 1	*B.gymnorrhiza*	6.2±0.4	8±0.5	116±91	2.91±2.68*	1.05±0.94*		
			Height Class 2	*B.gymnorrhiza*	8.2±1.1	10.8±2.2	85±46	5.87±3.38*	1.87±1.01*		
			Height Class 3	*B.gymnorrhiza*	12.1±0.7	16±1.8	219±86	28.39±12.50*	9.01±3.9*		
			Height Class 4	*B.gymnorrhiza*	12.8±1.1	15.9±1.1	274±131	37.79±17.67*	11.82±5.50*		
			Height Class 5	*B.gymnorrhiza*	14.3±0.5	16.2±2.1	219±118	36.33±18.47*	10.80±5.42*		
			Height Class 1	*X.granatum*	7.6±1.1	10.1±0.7	601±337	20.1±11.33*	7.25±4.09*		
			Height Class 2	*X.granatum*	8.7±0.9	11.5±0.8	371±90	17.81±5.40*	6.20±1.79*		
			Height Class 3	*X.granatum*	9.3±0.5	11.4±0.6	278±132	13.02±5.87*	4.46±2.07*		

			Height Class 4	*X.granatum*	11±1	13.8±1.2	114±39	8.46±3.00*	2.85±0.97*
			Height Class 5	*X.granatum*	11±1.1	12.6±1.5	275±158	18.85±9.31*	6.12±3.00*
			Height Class 1	*S.alba*	6.4±0	6.4±0.1	39±36	0.37±3.38*	0.16±0.16*
			Height Class 2	*S.alba*		14.9±0	8±8	1.03±3.38*	0.31±0.31*
			Height Class 3	*S.alba*					
			Height Class 4	*S.alba*	18.7±0	22.5±1.3	166±115	39.62±29.28*	12.09±8.85*
			Height Class 5	*S.alba*	15.1±1.8	15.9±1.9	591±268	87.84±43.10*	26.79±13.69*
Trettin et al. (2016)	Mozambique	Zambezi River delta	Height Class 1	*A.marina*	7.1±0.5	8.9±0.9	631±200	19.55±0*	6.94±2.96*
			Height Class 2	*A.marina*	7.2±0.9	11.1±1	326±70	19.03±0*	6.32±1.91*
			Height Class 3	*A.marina*	13±0.1	11.1±1	208±126	8.93±5.87*	3.24±2.11*
			Height Class 4	*A.marina*	10.6±0	10.3±0.2	418±288	15.93±0*	5.73±3.70*
			Height Class 5	*A.marina*	12.6±0.9	14.8±1.3	229±185	21.99±15.27*	7.21±0*
			Height Class 1	*R.mucronata*	6.1±1.3	7.7±0.2	132±115	2.63±2.16*	1.05±0.86*
			Height Class 2	*R.mucronata*	7.3±1.4	9.2±0.8	334±119	12.22±6.02*	4.41±2.11*
			Height Class 3	*R.mucronata*	10.3±0.3	11.2±1.3	464±230	31.07±18.61*	10.45±6.16*
			Height Class 4	*R.mucronata*	11.1±0.2	12±0.9	679±253	51.09±22.37*	17.12±7.41*
			Height Class 5	*R.mucronata*	14.3±2.2	14.4±2.7	132±73	16.83±14.71*	5.30±4.52*
			Height Class 1	*H.littoralis*					
			Height Class 2	*H.littoralis*	9.5±0.1	11.1±0.2	348±274	21.06±16.78*	7.18±5.73*
			Height Class 3	*H.littoralis*	11.8±1.4	13.2±0.7	96±65	9.49±6.39*	3.08±2.07*
			Height Class 4	*H.littoralis*	10.9±0.4	10.9±0.6	214±138	13.35±7.75*	4.48±2.61*
			Height Class 5	*H.littoralis*	10.5±0.9	11.6±1.3	366±232	34.22±18.85*	10.53±5.65*
			Height Class 1	*L.racemosa*	5.1±0	6.3±0	2±2	0.05±0.05*	0.008±0*
			Height Class 2	*L.racemosa*					
			Height Class 3	*L.racemosa*	9.7±0.2	11.7±0.2	29±28	1.74±1.64*	0.58±0.55*
			Height Class 4	*L.racemosa*					
			Height Class 5	*L.racemosa*	11.9±0	15.1±0	17±18	5.26±5.54*	1.36±1.44*

Table S2. Seagrass carbon pools (AGC, BGC and SOC) reported within the tropical WIO. Values denote mean ± SE, unless otherwise stated.
*Values transformed from AGB or BGB (g DW m^{-2}) to carbon (tonnes C ha^{-1}) using a carbon fraction of 0.35 (Fourqurean et al. 2012).

Reference	Country	Location	Species	Root Density (m^2)	Height (m)	AGC (Mg ha^{-1})	BGC (Mg ha^{-1})	SOC (Mg ha^{-1})	Down To Depth (cm)
Aboud and Kannah (2017)	Kenya	Kanami	*C.rotundata*		7.38±1.84 (SD)				
		Vipingo	*C.rotundata*		11.23±2.41 (SD)				
		Nyali	*C.rotundata*		10.73±3.68 (SD)				
		Diani	*C.rotundata*		11.78±0.8 (SD)				
		Kanami	*C.serrulata*						
		Vipingo	*C.serrulata*						
		Nyali	*C.serrulata*		14.18±4.35 (SD)				
		Diani	*C.serrulata*		12.07±1.26 (SD)				
		Kanami	*H.ovalis*						
		Vipingo	*H.ovalis*		3.65±0.92 (SD)				
		Nyali	*H.ovalis*		2.47±1.5 (SD)				
		Diani	*H.ovalis*		2.48±1.33 (SD)				
		Kanami	*H.stipulacea*						
		Vipingo	*H.stipulacea*						
		Nyali	*H.stipulacea*		4.05±1.05 (SD)				
		Diani	*H.stipulacea*		3.16±1.29 (SD)				
		Kanami	*H.wrightii*		6.51±1.06 (SD)				
		Vipingo	*H.wrightii*		7.57±2.43 (SD)				
		Nyali	*H.wrightii*		7.18±2.49 (SD)				
		Diani	*H.wrightii*		6.21±1.08 (SD)				
		Kanami	*S.isoetifolium*						
		Vipingo	*S.isoetifolium*						
		Nyali	*S.isoetifolium*		19.48±3.78 (SD)				
		Diani	*S.isoetifolium*		18.68±0.46 (SD)				
		Kanami	*T.ciliatum*						
		Vipingo	*T.ciliatum*		12.43±5.58 (SD)				
		Nyali	*T.ciliatum*		49.66±13.13 (SD)				
		Diani	*T.ciliatum*						
		Kanami	*T.hemprichii*		9.98±4.07 (SD)				
		Vipingo	*T.hemprichii*		15.2±4.67 (SD)				
		Nyali	*T.hemprichii*		15.62±4.51 (SD)				
		Diani	*T.hemprichii*		17.17±0.56 (SD)				
Aleem (1984)	Seychelles	Aldabra	*H.uninervis*			0.85*			
		Aldabra	*H.ovalis*			0.14*			
		Mahe	*H.ovalis*			0.18*			
		Aldabra	Mixed			1.37*			
		Mahe	Mixed			1.73*			
		Aldabra	Mixed			1.21*			
		Aldabra	*T.hemprichii*			1.16*			

		Aldabra	*T.ciliatum*			1.85*			
		Mahe	*S.isoetifolium*			1.50*			
Bandeira (1997)	Tanzania	Inhaca Is (Portinho and Estação de Biologia Marinha)	*T.ciliatum*			1.09*	1.83*		
		Inhaca Is (Banco Sidzanye)	*T.ciliatum*			0.48*	0.64*		
		Inhaca Is (Barreira Vermelha -BVE)	*T.ciliatum*			2.26*	3.78*		
		Inhaca Is (Portinho and Estação de Biologia Marinha)	*T.ciliatum*			1.48*	2.39*		
		Inhaca Is (Banco Sidzanye)	*T.ciliatum*			0.90*	0.97*		
Bandeira (2002)	Mozambique	Rocky habitat	*T.ciliatum*	4561±529		1.68±0.13*	2.07±0.22*		
		Sandy Habitat	*T.ciliatum*	888±103		1.07±0.09*	1.95±0.18*		
Belshe et al. (2018)	Tanzania	Tanzania	*C.serrulata*	1023±800.5		0.44±0.11*	0.90±0.23*		100
			C.serrulata	622±512		0.44±0.11*	0.90±0.23*	35.1	100
			C.serrulata	1112±912		0.44±0.11*	0.90±0.23*		100
			T.ciliatum	1201±1156.5		3.40±0.26*	2.39±1.37*		100
			T.ciliatum	667±556.5		3.40±0.26*	2.39±1.37*	32.2±7.9	100
			T.ciliatum			3.40±0.26*	2.39±1.37*		100
		Zanibar	Mixed	5312.5		0.13±0.06*	0.81±0.29*		100
			Mixed	2098.21		0.13±0.06*	0.81±0.29*	30.8	100
			Mixed	5714.29		0.13±0.06*	0.81±0.29*		100
			Mixed	714.29		0.24±0.17*	1.06±0.36*		100
			Mixed	758.93		0.24±0.17*	1.06±0.36*	36.5	100
			Mixed	2053.57		0.24±0.17*	1.06±0.36*		100
			Mixed	1160.71		0.23±0.11*	1.37±0.50*		100
			Mixed	1696.43		0.23±0.11*	1.37±0.50*	32.4	100
			Mixed	669.64		0.23±0.11*	1.37±0.50*		100
de Boer (2000)	Mozambique	Inhaca Is (Saco, Banco)	*Z.capensis*	2540±427		0.055±0.01*	0.61±0.17*		
			C.serrulata	257±117		0.12±0.06*	0.13±0.05*		
			H.wrightii	662±102		0.06±0.08*	0.06±0.05*		
			Z.capensis	2992±517		0.09±0.03*	0.70±0.26*		
			C.serrulata	148±98		0.09±0.03*	0.09±0.05*		
			H.wrightii	424±203		0.02±0.02*	0.06±0.02*		
Côté-Laurin et al. (2017)	Madagascar	Andavoadoaka (before cyclone)	Mixed		24.79±1.51				
		Turtle Beach (before cyclone)	Mixed		19.94±1.41				
		Antsargnasoa (before cyclone)	Mixed		17.65±1.14				
Daby (2003)	Mauritius	Mon Choisy–Trou aux Biches	*H.uninervis*	2876±843.3		0.38±0.07*	0.76±0.03*		
			S.isoetifolium	2676.1±110.1		0.81±0.11*	0.81±0.06*		
Dahl et al. (2016)	Tanzania	Tanzania (Chwaka Bay)	*T.hemprichii*			0.52±0.13 (SD)	1.11±0.19 (SD)	1.36±0.23 (SD; SOC%)	30
Deyanova2017	Tanzania	Tanzania (Chwaka Bay)	*T.hemprichii*	432.2±33.90		0.54±0.05*	1±0.08*		
Duarte1998	Kenya	Chale Lagoon	*T.ciliatum*	800			0.85*		
Eklöf et al. (2005)	Tanzania	Tanzania (Chwaka Bay)	*T.hemprichii*	1069.23±138.46	14.53±1.13	0.31±0.07*		5.12±0.58 (SD; SOM%)	5
			Mixed	761.54±265.38	21.32±3.78	0.34±0.17*		4.06±0.35 (SD; SOM%)	5
			Mixed	276.92±61.54	48.68±4.15	0.37±0.13*		4.42±0.39 (SD; SOM%)	5
Eklöf et al. (2006)	Tanzania	Tanzania (Chwaka Bay)	*T.hemprichii*	111.51±27.63		0.07±0.02*		3.5 (SOM%)	2
			E.acoroides	153.95±17.76		0.43±0.06*		3.5 (SOM%)	2

			Mixed	266.94±22.20		0.50±0.05*		3.5 (SOM%)	2
Githaiga et al. (2017)	Kenya	Gazi Bay	*T.hemprichii*	996±47.96	18.4±1.4	0.7±0.3	4.6±3.2	233.77±85.96	50
			E.acoroides	248±14.28	55.1±4.1	1±0	6±1	295.74±125.66	50
			T.ciliatum	531±34.18	36.7±3.9	1±0	4±2	252.10±105.16	50
			S.isoetifolium	4351±255.10	23.3±2.7	1±0.3	5.7±1.9*	160.65±79.71	50
Githaiga et al. (2019)	Kenya	Gazi Bay	*E.acoroides*	248±28		0.42±0.06*	1.68±0.07*	893.86±65.35	50
			T.hemprichii	997±94				820.56±47.43	50
Gullström et al. (2008)	Tanzania	Tanzania (Chwaka Bay)	*E.acoroides*	378.8±27.5	39.17±1.33	0.97±0.22*			
			T.hemprichii	1063.73±71.47	14.9±0.77	0.29±0.03*			
			Mixed	422.8±44.2	33.8±2.8	0.33±0.05*			
Gullström et al. (2018)	Tanzania	Pongwe	*T.hemprichii*	1003.6±109.29	10.3±0.54	0.33±0.08*	1.21±0.16*	52.5	50
		Chwaka	*E.acoroides*	277.3±6.58	68±1.86	0.21±0.05*	6.87±0.96*	68.85	50
			T.ciliatum	611.6±68.31	58±1.65	1.71±0.37*	5.56±0.58*	95.04	50
			T.hemprichii	275.8±6.71	11±0.71	0.03±0.00*	3.70±0.53*	51.68	50
		Fumba	*E.acoroides*	114.7±4.83	34.9±1.40	0.09±0.02*	2.49±0.15*	61.965	50
			T.ciliatum	390±47.11	21.8±0.82	0.29±0.06*	3.31±0.61*	45.725	50
			T.hemprichii	918.2±23.92	12.1±0.66	0.20±0.04*	1.91±0.19*	34.04	50
		ZanMbweni	*T.ciliatum*	629.3±59.42	43±0.87	0.32±0.06*	2.96±0.21*	34.78	50
			T.hemprichii	780.2±36.58	10.4±0.49	0.08±0.02*	1.30±0.13*	37.365	50
			Cymodocea.spp	538.7±20.62	12.7±0.66	0.20±0.04*	0.88±0.06*	47.79	50
		Mbegani	*E.acoroides*	181.3±5.37	73.9±2.47	0.17±0.04*	2.44±0.09*	26.74	50
			T.ciliatum	702.2±21.26	41.2±1.11	0.32±0.06*	3.43±0.22*	24.22	50
			T.hemprichii	735.1±21.12	15.4±0.54	0.04±0.01*	1.82±0.15*	26.74	50
			Cymodocea.spp	472±22.20	20.5±0.33	0.08±0.02*	0.69±0.02*	24.84	50
		MainMbweni	*T.ciliatum*	507±26.59	41.0.54	0.44±0.08*	1.77±0.08*	18.48	50
			T.hemprichii	560.9±9.99	16.6±0.23	0.10±0.02*	0.41±0.04*	32.2	50
			Cymodocea.spp	536±7.82	22.9±0.45	0.12±0.02*	0.71±0.05*	35.4	50
		Ocean Road	*E.acoroides*	256±13.53	75.9±1.93	0.09±0.02*	1.76±0.07*	40.29	50
			T.ciliatum	454.2±18.70	26±0.94	0.18±0.03*	1.28±0.07*	67.635	50
			T.hemprichii	496±13.76	24.6±0.61	0.13±0.03*	0.78±0.07*	18	50
	Mozambique	Saco	*T.ciliatum*	784.6±68.73	26.9±0.61	0.76±0.17*	2.67±0.21*	16.8	50
			T.hemprichii	1537.4±79.43	10.3±0.19	0.89±0.23	1.66±0.18*	39.2	50
			Cymodocea.spp	2666.4±197.02	7.5±0.21	1.11±0.08*	1.17±0.44*	18.81	50
		Sangala	*T.ciliatum*	568±23.50	15.3±0.71	0.16±0.03*	1.97±0.20*	51.74	50
			T.hemprichii	818.4±89.05	10.5±0.18	0.06±0.04*	2.91±0.22*	25.885	50
			Cymodocea.spp	623.6±30.71	11.6±0.40	0.13±0.07*	0.24±0.09*	21.5	50
Gwada (2004)	Kenya	Nyali Lagoon	*T.ciliatum*	914±48.64		1.30±0.07*	2.22±0*		
			T.ciliatum	881.8±45.81		1.40±0*	2.13±0*		
Hamisi et al. (2009)	Tanzania	Mjimwema (Nov)	*H.uninervis*			0.13±0.04*			
		Mjimwema (Feb)	*H.uninervis*			0.08±0.03*			
		Mjimwema (Nov)	*C.rotundata*			0.47±0.05*			
		Mjimwema (Feb)	*C.rotundata*			0.14±0.03*			
		Mjimwema (Nov)	*T.hemprichii*			2.37±0.17*			
		Mjimwema (Feb)	*T.hemprichii*			0.60±0.07*			
		Mjimwema (Nov)	*C.rotundata*			0.95±0.11*			
		Mjimwema (Feb)	*C.rotundata*			1.07±0.09*			
Ingram and Dawson (2001)	Seychelles	Anse Aux Pins, Mahe	*T.hemprichii*	627.17±407.65					
			S.isoetifolium	1122.73±573.61					
			C.serrulata	1107.18±660.82					
			T.hemprichii	539.46±478.12					
			S.isoetifolium	1760.71±1092.01					
			C.serrulata	1093.54±736.3					
		Gazi Bay (estuarine-west)	*C.rotundata*	686.4±70.73	28.65±1.10	0.40±0.03	8.90±0.03	278.41±9.84	100
			E.acoroides	204.8±33.25	62.26±4.21	0.51±0.03	12.35±0.03	261.98±22.10	100
			Mixed	469.6±67.85	44±4	0.73±0.09	9.56±0.09	302.45±43.23	100

Juma et al. (2020)	Kenya	Gazi Bay (marine-east)	*T.ciliatum*	571.2±43.40	55.13±5.65	2.38±0.28	5.88±0.28	190.01±16.87	100
			C.rotundata	780.4±93.79	24.79±1.52	0.35±0.04	3.07±0.04	97.57±7.74	100
			C.serrulata	600±33.16	23.55±0.93	0.57±0.05	4.23±0.05	108.23±6.54	100
			Mixed	610.4±47.01	24.81±1.41	0.48±0.05	4.47±0.05	111.82±8.40	100
			T.hemprichii	584±33.07	28.86±1.55	0.53±0.07	3.60±0.07	109.27±2.76	100
		NW, station2, middle intertidal, Coetivy Island	*Thalassia hemprichii*	1308	15	0.47*			
		NW, station3, middle intertidal, Coetivy Island	mixture	1768	10	0.15*			
		NW, station4, middle intertidal, Coetivy island	mixture	1332	6	0.23*			
		NW, station5, lower intertidal, Coetivy Island	mixture	720	15	0.57*			
		NW, station6, lower intertidal, Coetivy Island	mixture	3532	20	2.32*			
		S, station7, middle intertidal, Coetivy Island	*Thalassodendron ciliatum*	1872	20	1.16*			
		S, station8, middle intertidal, Coetivy Island	mixture	524	15	0.16*			
		S, station10, middle intertidal, Coetivy Island	mixture	692	15	0.20*			
		S, station11, middle intertidal, Coetivy Island	mixture	408	20	1.15*			
		N, station12, Coetivy Island	mixture	1040	25	0.87*			
		NE, station13, Coetivy Island	mixture	1396	25	1.14*			
		W, station14, Coetivy Island	mixture	1564	30	1.25*			
		W, station17, Coetivy Island	mixture	84	20	0.59*			
		W, station21, Coetivy Island	*Thalassodendron ciliatum*	1060	21	1.10*			
		W, station22, Coetivy Island	mixture	336	22	0.51*			
		W, station23, Coetivy Island	*Thalassodendron ciliatum*	188	25	0.36*			
		E, station24, middle intertidal, Coetivy Island	*Thalassia hemprichii*	668	80	0.13*			
		E, station25, middle intertidal, Coetivy Island	mixture	1516	25	0.64*			
		E, station26, lower intertidal, Coetivy Island	mixture	2532	25	1.02*			
		E, station27, Coetivy Island	mixture	1416	20	0.92*			
		E, station28, Coetivy Island	mixture	792	20	0.54*			
		E, station29, Coetivy Island	mixture	28	12	0.20*			
		NE, station30, Coetivy Island	mixture	788	18	0.59*			
		NE, station32, Coetivy Island	mixture	74	23	0.63*			
		NE, station33, Coetivy Island	mixture	468		0.57*			
		NE, station34, Coetivy Island	mixture	832	27	0.82*			
		NE, station35, middle intertidal, Coetivy Island	*Thalassia hemprichii*	1096	15	0.37*			
		NE, station36, middle intertidal, Coetivy Island	mixture	492	16	0.87*			
		NE, station37, lower intertidal, Coetivy Island	mixture	3004	17	1.18*			
		S, station39, Coetivy Island	*Thalassodendron ciliatum*	868	20	0.73*			
		S, station40, Coetivy Island	*Thalassodendron ciliatum*	684	21	0.41*			
		S, station41, Coetivy Island	mixture	28	18	0.15*			

W, station42, middle intertidal, Coetivy Island	mixture	1840	23	0.49*
W, station43, middle intertidal, Coetivy Island	mixture	3240	40	1.77*
W, station44, middle intertidal, Coetivy Island	mixture	3336	30	0.91*
W, station45, lower intertidal, Coetivy Island	*Thalassodendron ciliatum*	1960	20	1.40*
W, station46, Coetivy Island	*Thalassodendron ciliatum*	732	24	0.71*
W, station47, Coetivy Island	*Thalassodendron ciliatum*	692	25	0.61*
W, station48, Coetivy Island	*Thalassodendron ciliatum*	1088	27	0.86*
W, station49, Coetivy Island	*Thalassodendron ciliatum*	376	24	0.23*
W, station50, Coetivy Island	mixture	120	21	0.24*
W, station51, Coetivy Island	*Thalassodendron ciliatum*	1080	18	0.81*
S, station52, middle intertidal, Farquhar Island	mixture	732	15	0.19*
S, station53, lower intertidal, Farquhar Island	*Thalassodendron ciliatum*	888	13	0.31*
S, station55, lower intertidal, Farquhar Island	mixture	128	15	0.25*
N, station59, middle intertidal, Farquhar Island	mixture	1068	8	0.35*
Lagoon, station68, Farquhar Island	*Thalassodendron ciliatum*	472	28	0.45*
Lagoon, station71, Farquhar Island	mixture	918	35	1.60*
Lagoon, station72, Farquhar Island	mixture	664	24	0.93*
Lagoon, station73, Farquhar Island	mixture	1004	28	0.91*
Lagoon, station78, Farquhar Island	mixture	446	30	0.79*
Lagoon, station79, Farquhar Island	mixture	868	126	0.96*
Lagoon, station80, Farquhar Island	mixture	848	20	0.51*
N, station81, middle intertidal, Farquhar Island	mixture	584	14	0.42*
N, station82, lower intertidal, Farquhar Island	mixture	1352	12	0.65*
N, station83, lower intertidal, Farquhar Island	mixture	1160	12	0.55*
S, station84, Farquhar Island	*Thalassodendron ciliatum*		25	
Lagoon, station89, lower intertidal, Aldabra Island	mixture	518	18	0.44*
Lagoon, station90, lower intertidal, Aldabra Island	mixture	376	12	0.20*
Lagoon, station91, lower intertidal, Aldabra Island	mixture	284	25	1.91*
Lagoon, station92, middle intertidal, Aldabra Island	mixture	584	17	0.51*
Lagoon, station93, Aldabra Island	*Thalassia hemprichii*	960	24	0.72*
W, station94, Aldabra Island	*Thalassodendron ciliatum*	1004	24	0.95*
W, station95, lower intertidal, Aldabra Island	mixture	960	15	0.69*

		W, station96, lower intertidal, Aldabra Island	mixture	768	17	0.73*
		W, station97, lower intertidal, Aldabra Island	mixture		20	
		NW, station98, middle intertidal, Desroches Island	mixture	788	20	0.23*
		NW, station99, middle intertidal, Desroches Island	mixture	1476	30	0.84*
		NW, station100, lower intertidal, Desroches Island	*Thalassodendron ciliatum*	1456	42	1.35*
Kalugina-Gutnik et al. (1992)	Seychelles	NW, station101, Desroches Island	*Thalassodendron ciliatum*		40	
		NW, station102, Desroches Island	*Thalassodendron ciliatum*	648	42	0.76*
		NW, station103, Desroches Island	mixture	408	25	0.55*
		NW, station105, Desroches Island	mixture		20	
		NW, station106, middle intertidal, Desroches Island	mixture	1526	20	0.50*
		NW, station107, middle intertidal, Desroches Island	mixture	1324	20	0.86*
		NW, station108, lower intertidal, Desroches Island	mixture	1232	30	1.55*
		NW, station109, lower intertidal, Desroches Island	*Thalassodendron ciliatum*	2600	40	1.78*
		SW, station110, Desroches Island	mixture		40	
		W, station112, Desroches Island	*Thalassodendron ciliatum*	1282	38	1.44*
		W, station114, Desroches Island	*Thalassodendron ciliatum*	1468	40	1.32*
		S, station116, middle intertidal, Desroches Island	mixture	1396	6	0.21*
		S, station117, middle intertidal, Desroches Island	mixture	1432	6	0.20*
		S, station118, lower intertidal, Desroches Island	mixture	1672	15	0.40*
		S, station119, lower intertidal, Desroches Island	mixture	1732	25	0.78*
		S, station120, Desroches Island	*Thalassodendron ciliatum*	1780	33	1.14*
		SE, station124, Desroches Island	*Thalassodendron ciliatum*	764	30	0.70*
		SE, station125, Desroches Island	*Thalassodendron ciliatum*	1192	30	0.72*
		SE, station130, Desroches Island	mixture		30	
		S, station133, middle intertidal, Desroches Island	mixture	2312	20	0.78
		S, station134, lower intertidal, Desroches Island	*Thalassodendron ciliatum*	1776	30	1.50*
		S, station135, lower intertidal, Desroches Island	*Thalassodendron ciliatum*	2184	40	1.43*
		SW, station140, middle intertidal, Desroches Island	mixture	784	16	0.44*
		SW, station141, lower intertidal, Desroches Island	mixture	2448	30	1.01*
		SW, station142, lower intertidal, Desroches Island	mixture	1356	30	0.75*
		SE, station146, Desroches Island	mixture		30	

W, station154, middle intertidal, Mahé (Cerf)	*Cymodocea*	111	10	0.49*
E, station159, middle intertidal, Mahé (Saint Anne) Island	mixture	624	10	0.12*
NW, station180, lower intertidal, Mahé Island	mixture	992	20	0.59*
SE, station187, African Banks	*Thalassodendron ciliatum*	324	32	0.42*
SE, station188, African Banks	*Thalassodendron ciliatum*	248	30	0.15*
SE, station189, African Banks	*Thalassodendron ciliatum*	540	27	0.49*
SE, station189a, African Banks	*Thalassodendron ciliatum*	570	26	0.77*
SE, station194, African Banks	*Thalassodendron ciliatum*	448	42	0.78*
SE, station195, African Banks	*Thalassodendron ciliatum*	1412	18	0.88*
SE, station196, African Banks	mixture	716	20	0.72*
SE, station197, African Banks	mixture	1096	25	0.74*
SE, station198, African Banks	*Thalassodendron ciliatum*	1268	25	0.91*
S, station201, middle intertidal, Saint Joseph Islands			10	0.35*
S, station202, middle intertidal, Saint Joseph Islands	mixture	1312	11	0.36*
S, station203, lower intertidal, Saint Joseph Islands	mixture	608	10	0.15*
S, station208, Saint Joseph Islands	*Thalassodendron ciliatum*		20	
S, station212, Saint Joseph Islands	*Thalassodendron ciliatum*	1264	30	0.57*
S, station213, lower intertidal, Saint Joseph Islands	mixture	1148	20	0.35*
S, station214, lower intertidal, Saint Joseph Islands	*Thalassodendron ciliatum*	1416	30	0.79*
S, station215, Saint Joseph Islands	*Thalassodendron ciliatum*	1384	30	1.03*
E, station219, Saint Joseph Islands	mixture	6		
NE, station220, Saint Joseph Islands	*Thalassodendron ciliatum*	740	40	0.59*
S, station224, Providence Atoll	*Thalassodendron ciliatum*	924	30	1.38*
S, station225, Providence Atoll	*Thalassodendron ciliatum*	784	30	0.80*
S, station226, Providence Atoll	*Thalassodendron ciliatum*	2876	30	1.37*
W, station227, Providence Atoll	mixture		30	
W, station228, Providence Atoll	mixture		20	
Lagoon, station231, Cosmoledo Islands	mixture	392	20	0.50*
Lagoon, station232, Cosmoledo Islands	mixture	916	25	0.91*
Lagoon, station233, Cosmoledo Islands	mixture	716	35	1.94*

		Lagoon, station234, Cosmoledo Islands	mixture	688	30	0.70*	
		Lagoon, station235, Cosmoledo Islands	mixture	172	10	0.10*	
		Lagoon, station236, Cosmoledo Islands	*Halodule uniervis*	2592	6	0.07*	
		Lagoon, station244, Cosmoledo Islands	mixture	1644	20	1.35*	
		Lagoon, station245, Cosmoledo Islands	mixture	980	20	0.53*	
		S, station246, lower intertidal, Astove Islands	mixture	604	25	0.90*	
		S, station247, lower intertidal, Astove Islands	mixture	1360	30	0.85*	
		S, station248, lower intertidal, Astove Islands	mixture	1540	30	0.57*	
		S, station249, lower intertidal, Astove Islands	mixture	2100	20	1.13*	
		Lagoon, station250, Astove Islands	mixture		15		
Kamermans et al. (2002)	Kenya	Watamu	Mixed			1.60±0.21*	
		Diani	Mixed			1.50±0.23*	
		Roka	Mixed			2.25±0.15*	
		Nyali	Mixed			2.11±0.15*	
	Tanzania	Kiwengwa	Mixed			0.40±0.15*	
	Kenya	Kenyatta	Mixed			0.78±0.22*	
	Tanzania	Dongwe	Mixed			0.78±0.36*	
		Tumbatu	Mixed			0.78±0.32*	
Larsson (2009)	Mozambique	Portuguese Island	*T.hemprichii*	475±17		0.20±0.00*	
		Banco	*T.hemprichii*	234±10		0.16±0.00*	
		Saco	*T.hemprichii*	248±15		0.16±0.01*	
Lyimo et al. (2006)	Tanzania	Marumbi (NSW)	*T.hemprichii*	134±17.89	11.6±0.92	1.05±0.01*	1.55±0.10*
		Marumbi (NSW)	*E.acoroides*	301±14.88	34.9±3.28	0.50±0.01*	1.79±0.26*
		Chwaka Bay (NSW)	*T.hemprichii*	128±11.98	15.8±1.07	0.61±0.01*	0.77±0.00*
		Chwaka Bay (NSW)	*E.acoroides*	175±6.72	47±1.20	0.70±0.01*	1.45±0.14*
		Jambiani (NSW)	*T.hemprichii*	1090±127.63	9.38±1.11	2.13±0.01*	8.59±1.14*
		Jambiani (NSW)	*E.acoroides*	NA			
Lyimo et al. (2008)	Tanzania	CAM -Chwaka Bay; NonSeaWeed, Middle tidal zone	Mixed			1.4±1.75*	1.75*
		CAL -Chwaka Bay; NonSeaWeed, Low tidal zone	Mixed			2.68±2.45*	2.45*
		CAM -Chwaka Bay; NonSeaWeed, Middle tidal zone	Mixed			0.7±0.93*	0.93*
		CAL -Chwaka Bay; NonSeaWeed, Low tidal zone	Mixed			2.92±2.45*	2.45*
		JAM -Jambiani; NonSeaWeed, Middle tidal zone	Mixed			1±5.5*	5.50*
		JAL Jambiani; NonSeaWeed, Low tidal zone	*T.hemprichii*			1.5±5.12*	5.12*
		JAM -Jambiani; NonSeaWeed, Middle tidal zone	Mixed			1.12±6.5*	6.5*
		JAL Jambiani; NonSeaWeed, Low tidal zone	*T.hemprichii*			1.75±3.37*	3.37*
Lyimo et al. (2018)	Tanzania	Tanzania (Chwaka Bay)	*T.hemprichii*			0.53±0.08*	1.8±0.18*
		Mijimwema (Mid)		537.14	6.58	0.24±0.08* (SD)	0.40±0.34* (SD)
		Mijimwema (Low)		594.29	7.63	0.42±0.23* (SD)	0.32±0.09* (SD)
		Mijimwema (Sub)		651.43	8.68	0.26±0.15* (SD)	0.40±0.35* (SD)
		Bongoyo (Low)		365.71	10.53	0.34±0.13* (SD)	0.94±0.68* (SD)

Mamboya et al. (2009)	Tanzania	Bongoyo (Sub)	Mixed	434.29	15.53	0.24±0.17* (SD)	0.24±0.23* (SD)		
		Mbweni (Mid)		525.71	24.21	0.37±0.19* (SD)	0.50±0.05* (SD)		
		Mbewni (Low)		491.43	7.63	0.61±0.42* (SD)	0.54±0.32* (SD)		
		Mbewni (Sub)		388.57	11.84	1.08±0.76* (SD)	0.28±0.15* (SD)		
		Mbundya (Low)		754.29	11.32	0.52±0.20* (SD)	0.35±0.14* (SD)		
		Mbundya (Sub)		662.86	18.95	0.87±0.58* (SD)	0.98±0.58* (SD)		
Martins and Bandeira (2001)	Mozambique	Inhaca Island (North Bay)	*T.hemprichii*			0.54±0.08*	2.21±0.79*		
		Inhaca Island (South Bay)				0.51± 0.08*	6.05±1.40*		
Mvungi (2011)	Tanzania	Mijimwema	*T.hemprichii*	1038.1±288.4 (SD)	14.8±2.1 (SD)	0.93±0.15* (SD)	4.12±0.93* (SD)		
			C.serrulata	1622.7±304.5 (SD)	16.7±1.8 (SD)	1.23±0.51* (SD)	2.58±0.91* (SD)		
		Ocean Road	*T.hemprichii*	792±17.6 (SD)	17.6±2.7 (SD)	1.07±0.26* (SD)	1.44±0.33* (SD)		
			C.serrulata	819±14.1 (SD)	14.1±2 (SD)	0.71±0.24* (SD)	0.94±0.52* (SD)		
Ndaro and Ólafsson (	Tanzania	Tanzania	Mixed					7±0.52 (SOC%)	5
Nordlund and Gullström (2013)	Mozambique	Inhaca Island (Portected)	Mixed	612.04±140.47	10.29±0.76	0.43±0.12*	3.66*		
		Inhaca Island (Harvest)		848.3±143	12.35±1.08	0.48±0.09*	3.44*		
		Inhaca Island (Harbour)		479.6±56.19	23.4±2.48	0.62±0.09*	2.1*		
Ochieng and Erftemeijer (1999)	Kenya	Mombasa Marine National Park	*T.ciliatum*			2.66±0.34* (SD)			
Paula et al. (2001)	Mozambique	Inhaca Is 1	Mixed			0.33±0.05*	1.99±0.69*	8.3±1.7 (SOM%)	25
		Inhaca Is 2	Mixed			0.30±0.03*	1.51±0.50*	11.47±2.03 (SOM%)	25
		Inhaca Is 1	Mixed			0.23±0.04*	0.57±0.16*	9.04±2.26 (SOM%)	25
		Inhaca Is 2	Mixed			0.32±0.06*	1.54±0.26*	9.92±1.77 (SOM%)	25
		Inhaca Is 1	*Z.capensis*			0.07±0.01*	0.35±0.06*	4.26±0.94 (SOM%)	25
		Inhaca Is 2	*Z.capensis*			0.06±0.01*	0.38±0.04*	11.98±3.02 (SOM%)	25
		Inhaca Is 1	Mixed			0.43±0.06*	2.30±0.28*	7.27±0.89 (SOM%)	25
		Inhaca Is 2	Mixed			0.38±0.03*	3.40±0.23*	6.6±0.2 (SOM%)	25
		Inhaca Is 1	Mixed			0.20±0.01*	1.29±0.20*	5.95±4.19 (SOM%)	25
		Inhaca Is 2	Mixed			0.21±0.03*	1.48±0.20*	3.6±1.25 (SOM%)	25
		Inhaca Is 1	*Z.capensis*			0.10±0.02*	0.28±0.05*	4.41±0.44 (SOM%)	25
		Inhaca Is 2	*Z.capensis*			0.08±0.00*	0.28±0.02*	4.55±0.59 (SOM%)	25
Uku (1995)	Kenya	Diani Beach	Mixed			0.18*			
		Galu	Mixed			0.10*			
Uku and Björk (2001)	Kenya	Nyali	*T.ciliatum*	21.9±9.26 (SD)					
		Vipingo	*T.ciliatum*	28.4±10.6 (SD)					
		Nyali	*T.hemprichii*	39.4±10.25 (SD)					
		Vipingo	*T.hemprichii*	36.25±13.70 (SD)					
		Nyali	*C.rotundata*	60.95±11.40 (SD)					
		Vipingo	*C.rotundata*	38.15±11.68 (SD)					
Uku and Björk (2005)	Kenya	Nyali	*T.ciliatum*	982.95±107.9 (SD)		0.58*			
		Vipingo	*T.ciliatum*	790.45±141.1 (SD)		0.36*			
		Nyali	*T.hemprichii*	974.60±256.85 (SD)		0.43*			
		Vipingo	*T.hemprichii*	1091.05±167.30 (SD)		0.22*			
		Nyali	*C.rotundata*	1903.50±278.25 (SD)		0.18*			
		Vipingo	*C.rotundata*	1976.05±483.80 (SD)		0.13*			
Vaïtilingon et al. (2003)	Madagascar	Toliara	*S.isoetifolium*	694		0.06*			
			C.serrulata	566		0.20*			
			H.uninervis	314		0.02*			
			H.wrightii			0.04*			
			T.hemprichii	2		0.001*			

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