Quantifying changes in the extent of South African estuarine habitats to inform targets of the Global Biodiversity Framework (GBF)

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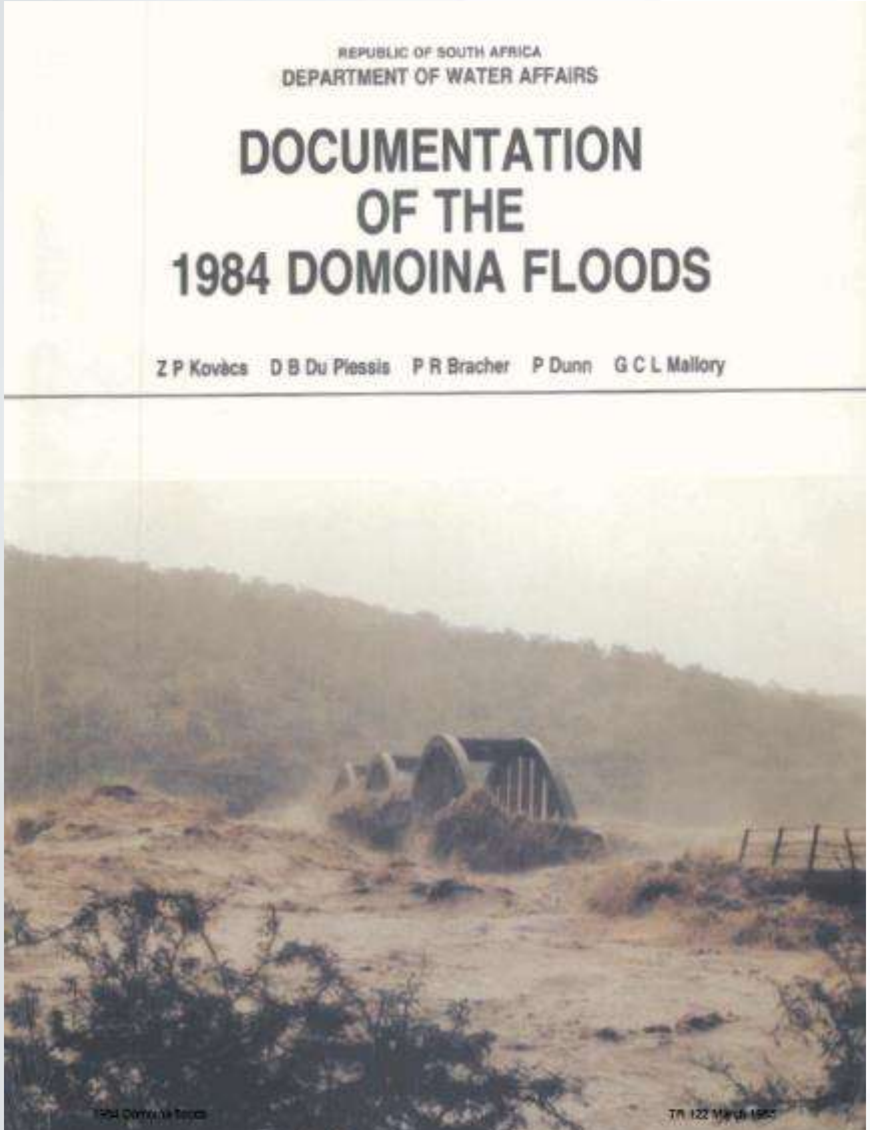
Touching lives through innovation

Changes in wetlands – natural or tipping points?


REPUBLIC OF SOUTH AFRICA
DEPARTMENT OF WATER AFFAIRS

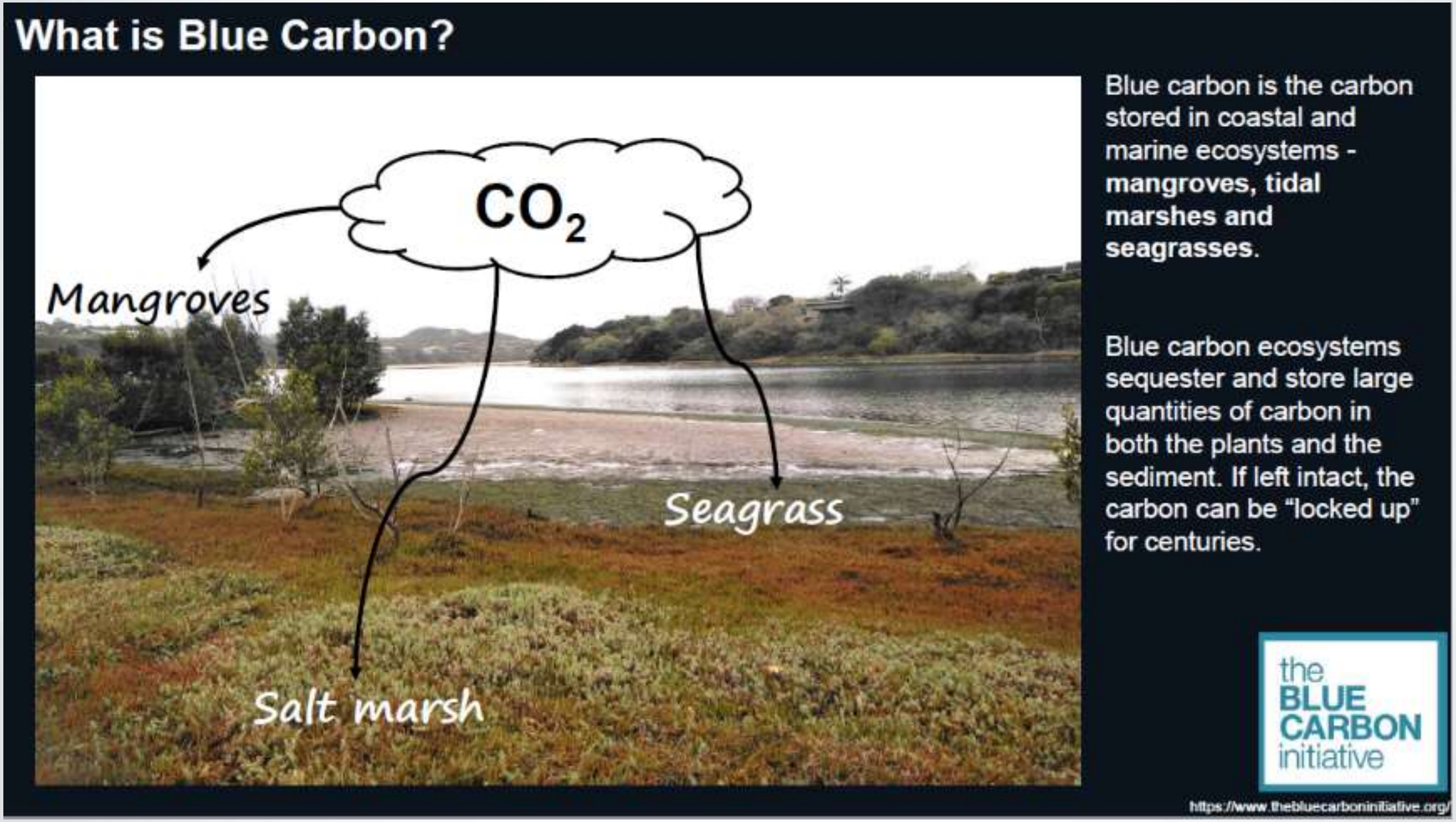
DOCUMENTATION OF THE 1984 DOMOINA FLOODS

Z P Kovàcs D B Du Plessis P R Bracher P Dunn G C L Mallory

Martin Bolton designed a spike branch spray for Working on Fire

https://journals.co.za/doi/epdf/10.10520/EJC-194fe9cf81

Blue carbon habitats



MFT1.2 Intertidal forests and shrubland

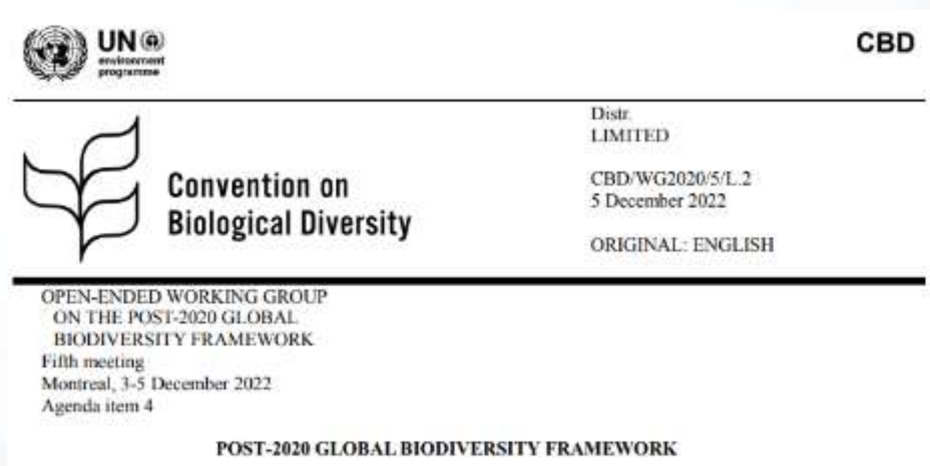
MFT1.3 Coastal saltmarshes and reedbeds

M1.1 Seagrass meadows

Post-2020 Global Biodiversity Framework

Goal Milestones, Components	
A1: Natural systems	Area
	Connectivity
	Integrity
A2: Species Populations	Extinction rate
	Extinction risk, Threat status
	Population abundance (size)
	Population Distribution
A3: Species Genetics	Genetic diversity

- Post-2020 GBF set new targets for measuring changes in the extent and condition of wetlands, reporting by 2030 and 2050
- Target 1: halt loss and facilitate effective management
- Target 2: 30% of the extent of degraded systems to be under restoration by 2030
- Target 3: Minimum 30% extent of each type to be conserved


UN environment programme

CBD

Convention on Biological Diversity

Distr.
LIMITED

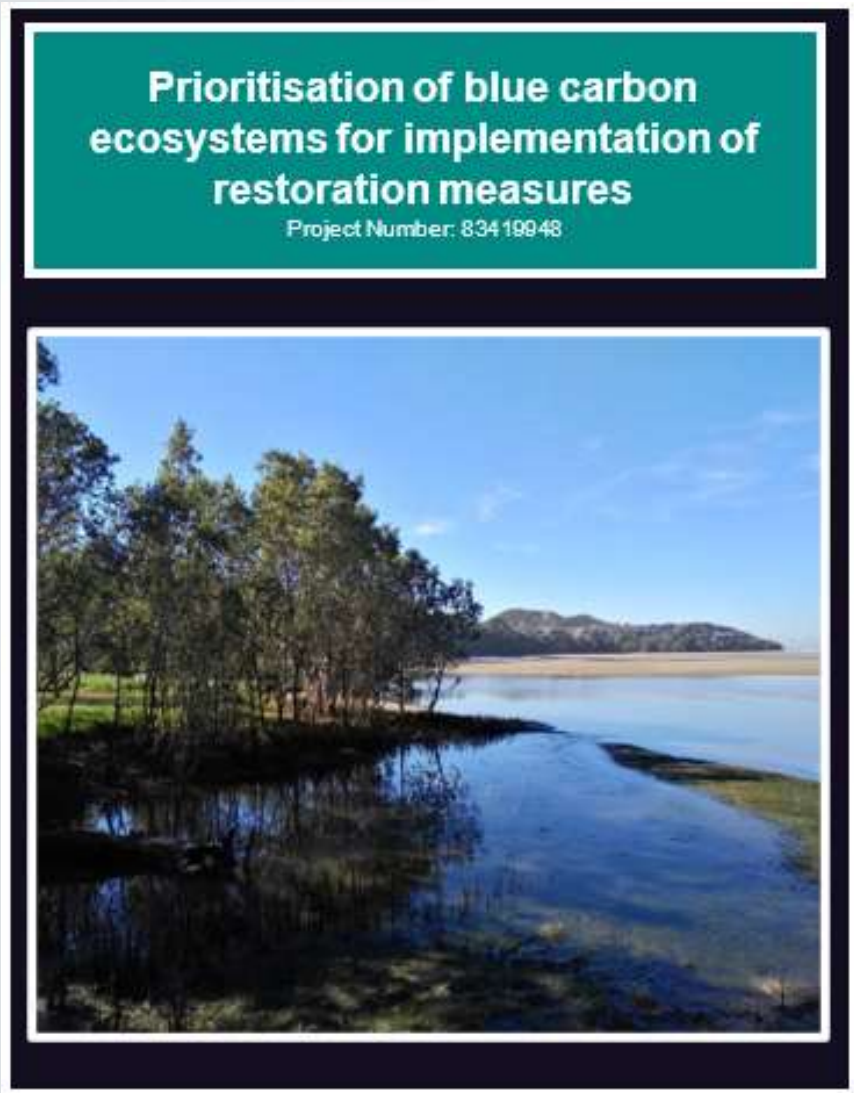
CBD/WG2020/5/L.2
5 December 2022

ORIGINAL: ENGLISH

OPEN-ENDED WORKING GROUP
ON THE POST-2020 GLOBAL
BIODIVERSITY FRAMEWORK
Fifth meeting
Montreal, 3-5 December 2022
Agenda item 4

POST-2020 GLOBAL BIODIVERSITY FRAMEWORK

Project initiated in 2023



- The project was funded through the GIZ implemented Climate Support Programme, which is part of the International Climate Initiative (IKI). The BMUV supports the IKI on the basis of a decision adopted by the German Bundestag
- Steering committee consisted of:
  - DFFE, Department of Forestry, Fisheries, and the Environment
  - GIZ, Deutsche Gesellschaft für Internationale Zusammenarbeit
- Lead by Prof. Janine Adams from the Nelson Mandela University (NMU)

Estuaries mapped in RSA

Manual mapping:

- 43% of 290 EFZs
- <10% of 42 micro-estuaries
- Random years
- Single layer

Remote sensing:

- Global datasets not mapping all
- Small area evidence available using Landsat, Spot, RapidEye & WV
- Varying accuracies
- Representivity?
- Random years

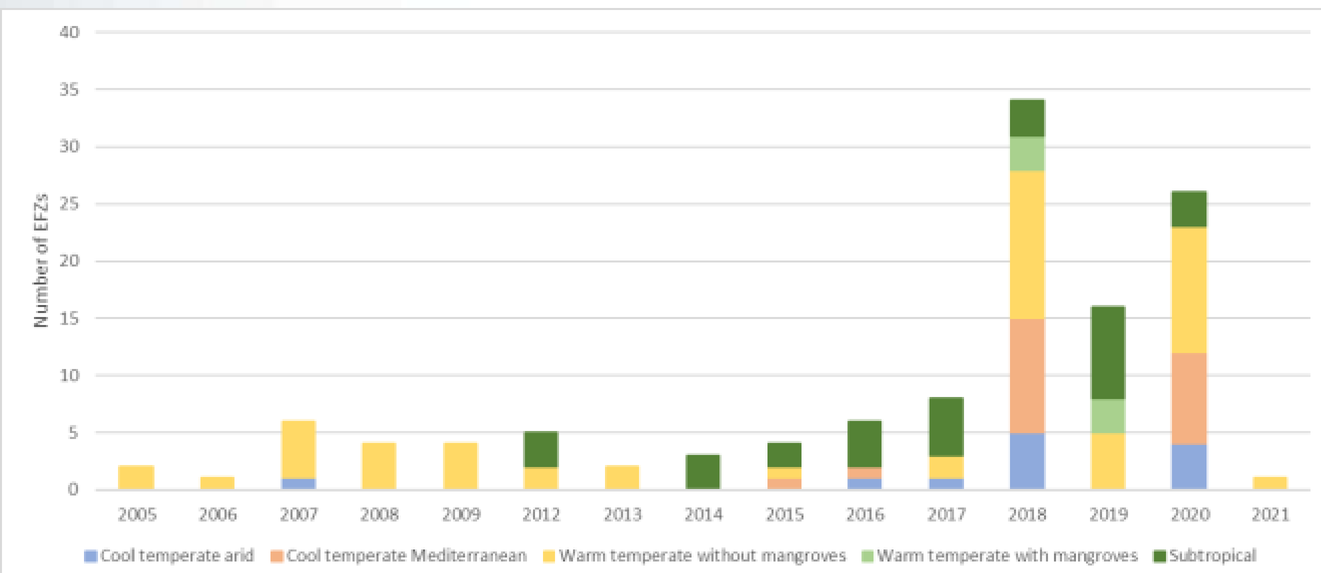


Figure 1. Number of EFZs for which estuarine habitats were mapped across five coastal regions and years.

Aim and process

- Map BCE for 1990, 2014, 2018 and 2020 in GEE

Table 5. Number of Estuarine Functional Zone (EFZ) and micro-estuaries per Earth Observation (EO) remote sensing classification region

(a) Mangrove EO region: 207 estuaries		
	With submerged macrophytes	**Without submerged macrophytes**
EFZ	19	159
Micro-estuary	1	28
(b) Non-mangrove EO region: 125 estuaries		
	With submerged macrophytes	**Without submerged macrophytes**
EFZ	19	93
Micro-estuary	0	13

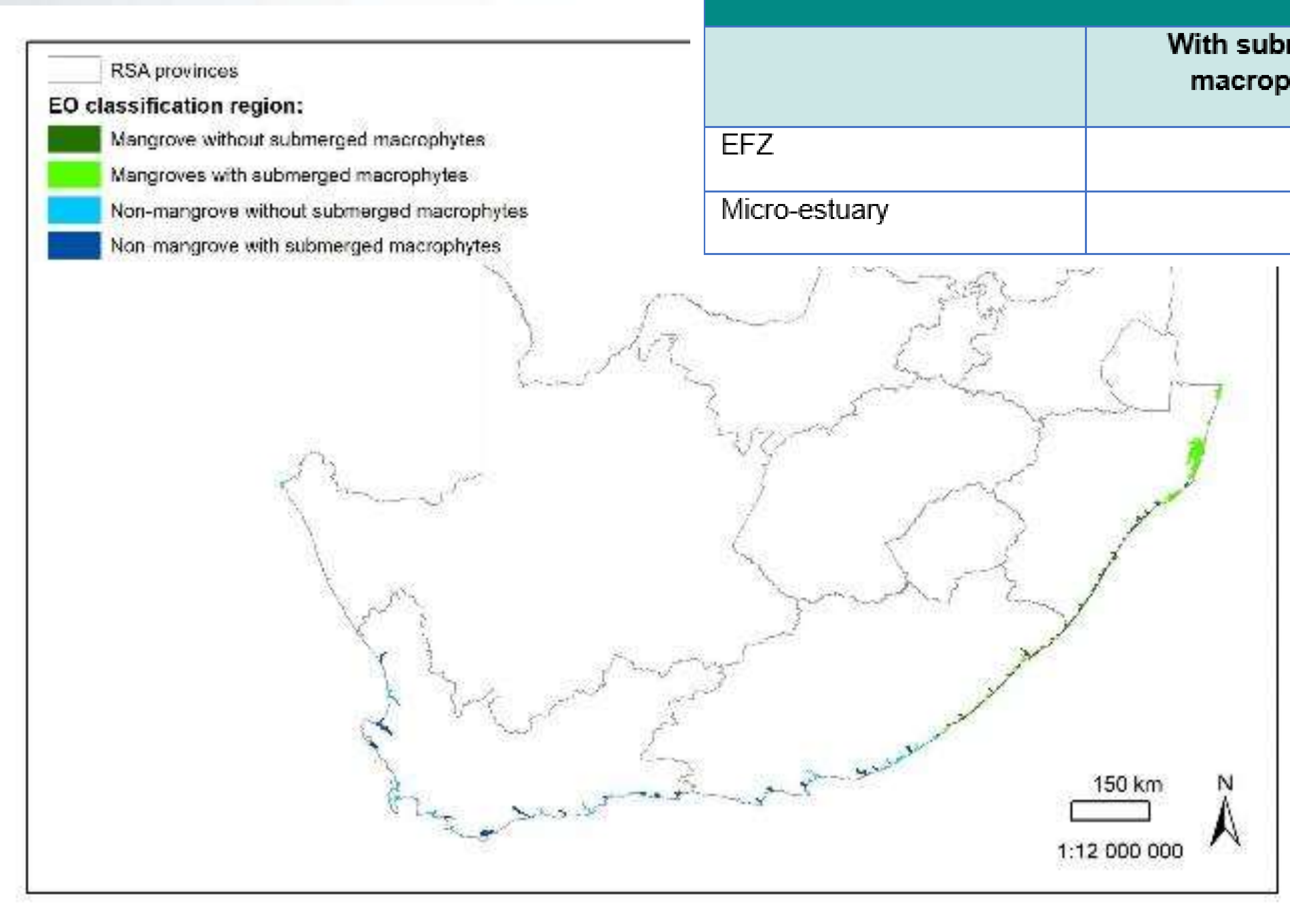


Figure 2. Four Earth Observation (EO) regions used for the remote sensing classification

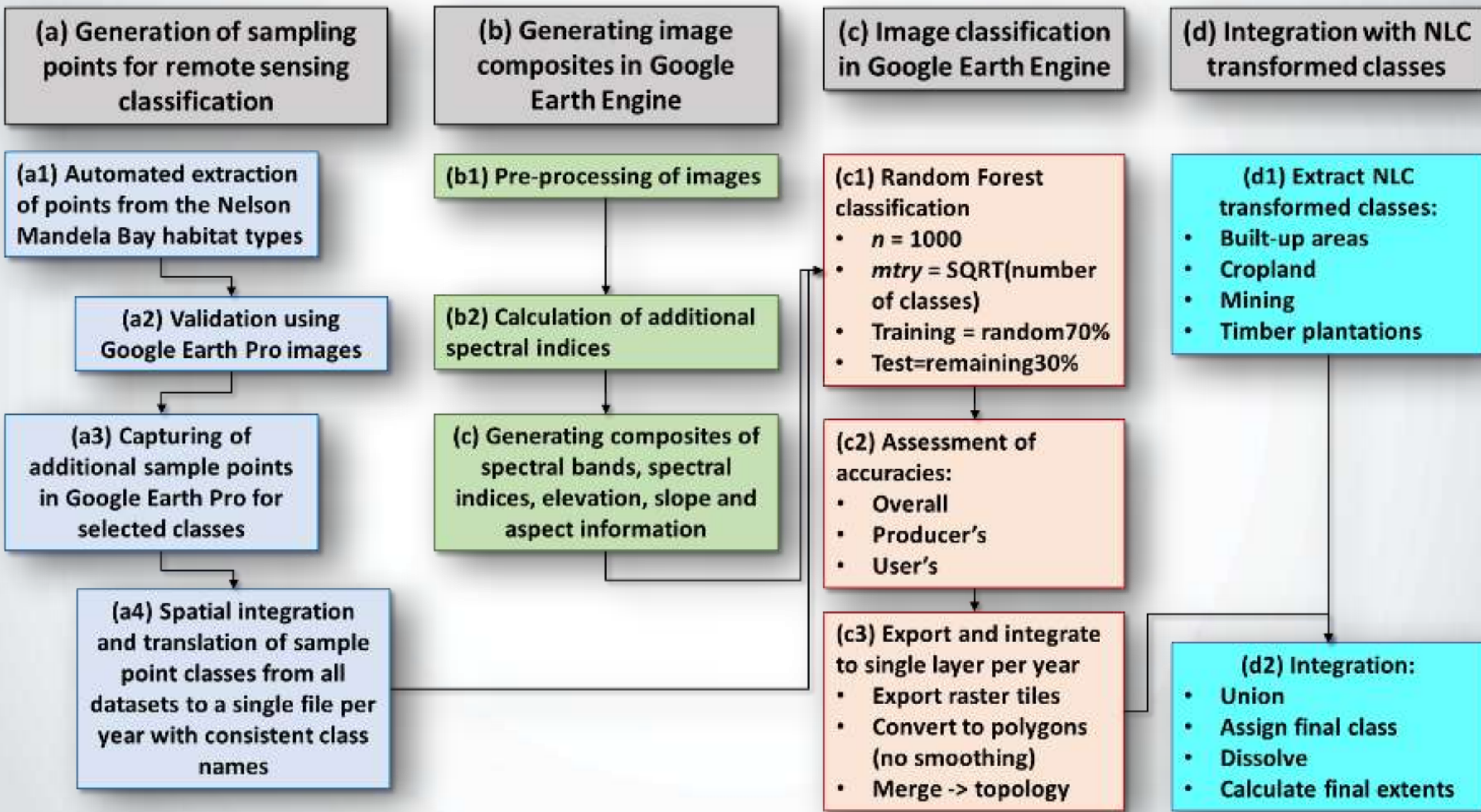
- Compare outputs to the Nelson Mandela University habitat map (2020)

Inclusion of multi-seasons to optimise accuracies

Table 6. Phenological phases used for the classification of blue carbon ecosystems in South Africa. Landsat 4 (L4) was operational 16 July 1982 – 14 December 1993; Landsat 5 (L5): 1 March 1984 – 5 June 2013; Landsat 7 (L7): 15 April 1999 – 6 April 2022; Landsat 8 (L8): 11 February 2013 to date; Sentinel-1A (S1): 3 April 2014; Sentinel-1B (S1): 25 April 2014; Sentinel-2A (S2): 23 June 2015; Sentinel-2B: 7 March 2017

Sensors	Landsat				Sentinel	
	L4	L5	L7	L8	S1	S2
1 September 1989- 28 February 1991	✓	✓				
1 September 2013- 28 February 2015		✓	✓	✓		
1 September 2017- 28 February 2019					✓	✓
1 September 2019- 28 February 2021					✓	✓

Overall workflow



Detailed results of BCE per region, year and class

Table A.10: Percentage of overall and user's accuracies (%) attained from the remote sensing classification reported per class across the four Earth Observation (EO) regions and year. Cells showing the resulted percentage of accuracy marked green indicates that the class attained the idealised target of > 70% for the user's accuracy (see Table A.7 in for number of ROIs per class). Yellow cells indicate that the user's accuracies were between 50 – 70%, whereas orange cells had user's accuracies < 50%. Grey cells indicate an absence of that class in the respective EO region. = EO region has no submerged macrophytes; SM = EO region has submerged macrophytes.

EO region (across)		Not mangroves EO region								Mangrove EO region							
Year (across)		1990		2014		2018		2020		1990		2014		2018		2020	
Class (down) accuracies (across)	Class #	no S M	SM	no S M	SM	no S M	SM	no S M	SM	no S M	SM	no S M	SM	no S M	SM	no S M	SM
Overall accuracies (%, across)		72.6	57.5	74.5	61.3	78.8	67.1	78.4	68.0	63.4	64.2	73.6	71.2	78.6	76.1	82.5	78.7
Bare soil	1	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beach sand	2	64.3	20.0	100.0	100.0	84.6	100.0	50.0	100.0	61.9	0.0	65.2	66.7	81.8	0.0	75.0	100.0
Built-up areas	3	85.2	69.2	79.2	61.9	85.2	60.0	90.0	56.3	0.0	0.0	0.0	94.1	0.0	95.8	0.0	100.0
Cleared land	4	0.0	50.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cropland	5	0.0	45.5	0.0	62.1	0.0	65.6	0.0	42.1	57.1	0.0	62.5	0.0	75.0	0.0	66.0	0.0
Cultivated wetland	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.9	0.0	69.3	0.0	87.7
Forested wetland	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	70.5	55.6	60.8	62.5	72.4	78.6	77.2
Freshwater marsh	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	60.8	42.9	67.2	25.0	61.2	85.7	70.1
Intertidal salt marsh (Other)	9	33.0	100	0.0	100	0.0	0.0	0.0	50	67.0	0.0	86	0.0	78	0.0	100.0	0.0
Intertidal salt marsh (*Spartina maritima*)	10	0.0	38	0.0	63	0.0	85	0.0	85	0.0	0.0	100	0.0	100	0.0	66.7	0.0
Intertidal salt marsh (Succulent)	11	0.0	54	0.0	39	0.0	75	0.0	63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large macrophytes	12	58.8	71.4	46.5	59.2	66.7	66.0	76.2	85.2	41.7	53.2	43.4	59.2	52.7	64.3	63.3	64.4
Mangroves	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.1	65.9	81.7	84.9	85.4	80.6	86.5	82.7
Mining	14	100.0	69.2	85.7	82.9	100.0	93.8	100.0	87.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nymphaea spp.	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	83.3	0.0	50.0
Open water	16	82.8	65.1	89.9	68.2	89.2	72.9	88.2	81.2	60.4	74.0	74.7	73.1	97.5	81.9	91.3	80.8
Relic gardens	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.7	0.0	68.8	0.0	84.0	0.0	88.6
Salt marsh	18	47.4	57.7	66.7	63.3	75.0	55.2	54.2	65.9	39.1	100.0	55.0	100.0	100.0	100.0	84.0	50.0
Sand/mudbanks	19	0.0	60.0	0.0	62.1	0.0	63.6	0.0	70.4	0.0	12.5	0.0	50.0	0.0	77.8	0.0	100.0
Submerged macrophytes (intertidal Zostera)	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	85.0	0.0	98.1	0.0	89.6	0.0	90.1
Submerged macrophytes (subtidal Zostera)	21	0.0	55.6	0.0	63.4	0.0	67.9	0.0	64.1	0.0	65.1	0.0	74.3	0.0	76.5	0.0	78.0
Supratidal salt marsh (*Juncus kraussii*)	22	0.0	100.0	0.0	75.0	0.0	75.0	0.0	60.0	82.4	62.8	66.7	60.7	78.6	78.7	42.9	70.4
Supratidal salt marsh (Other)	23	53.6	55.8	62.7	62.9	67.6	62.4	67.1	62.1	33.3	100.0	66.7	75.0	27.3	73.3	100.0	71.4
Supratidal salt marsh (Saline grasses)	24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.9	0.0	100.0	100.0	44.4	0.0	75.0
Terrestrial grasses	25	0.0	28.6	0.0	75.0	0.0	20.0	0.0	50.0	76.9	52.4	78.6	57.7	72.0	73.5	93.8	73.5
Terrestrial shrubs	26	0.0	33.3	0.0	33.3	0.0	59.3	0.0	47.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terrestrial trees	27	0.0	51.7	0.0	73.0	0.0	75.0	0.0	78.8	70.4	67.9	76.8	76.3	79.3	80.3	82.8	81.8
Terrestrial vegetation	28	78.4	57.1	74.7	40.5	74.0	44.8	77.5	55.6	0.0	88.9	0.0	50.0	0.0	85.7	0.0	57.1
Timber plantations	29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.9	100.0	88.8	81.8	82.1	75.0	96.4	83.3
Waves	30	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0

- 30 classes
- Overall Accuracies (OA)
- User's accuracies (UA)
- Visual comparison

Results of BCE extent and OA

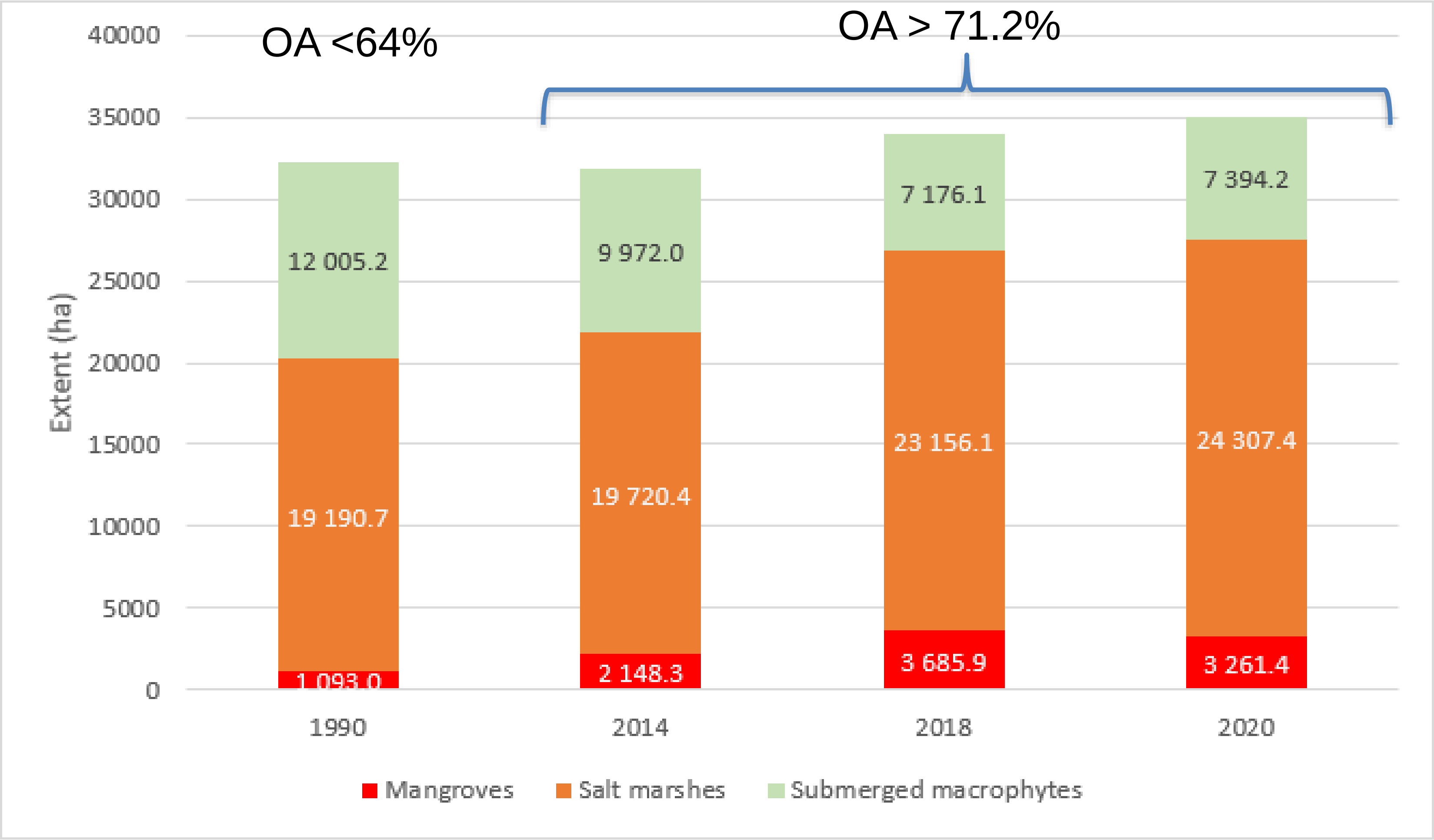


Figure A.5: *Changes in the extent of estuarine Ecosystem Functional Groups (EFGs) or Blue Carbon Ecosystems (BCEs) between 1990 and 2020 for South Africa.*

User's accuracies

BCE	# of (sub) classes	1990	2014	2018	2020
Mangroves	1	53%, 66% - Underestimation of extent	82%, 85%	85%, 81%	87%, 83% - **151%** of habitats mapped by NMU
Salt marshes	6	M: >78% NM: 33%	M: >78% NM: 38-85%	M>78% NM:38-85%	M>78% NM:38-85% - **200%** of habitats mapped by NMU
Seagrasses	3	M: 65%, 85% NM: 56%	M: 74%, 98% NM: 63%	M: 77%, 90% NM: 68%	M: >78%, 90% NM: 64% - Overpredicted by **232%** of habitats mapped by NMU

Examples of results

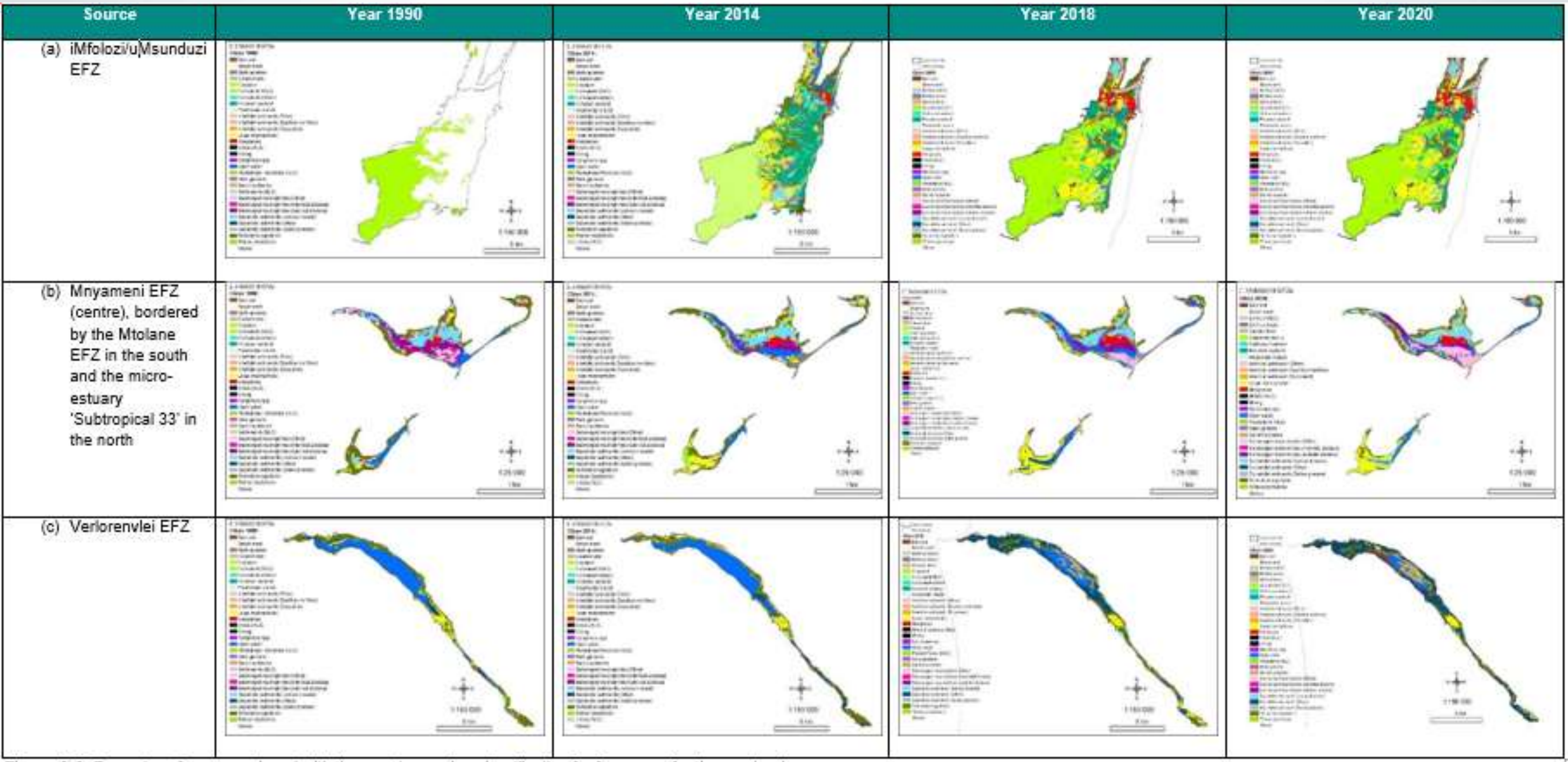


Figure A.6: Examples of maps produced with the remote sensing classification for four years for three estuaries.

Limitations and future work

- 13 of the 332 (4%) estuaries had no results (11 EFZs, 2 micro-estuaries)
- Cloud cover for the iMfolozi/uMsunduzi/St Lucia estuary in 1990 obscured part of the habitats
- Overprediction higher than the 5 and 10 m a.m.s.l. contour lines visible, and underestimation in other areas
- Narrow extents, degraded and fragmented areas poorly detected and mapped

➡ **We require a finer spatial resolution (<10 m) images to monitor our blue carbon ecosystems**

- NASA Bioscape aerial campaign 2023:
  - NASA Bioreach (Groot Berg, Knysna, Keurbooms, Langebaan, Wilderness), under leadership of Dr Anthony Campbell

Co-authors / team

Ms Yolokazi Galada

CBD definition of “Inland waters”

“Inland waters” are aquatic-influenced environments located within land boundaries. This includes those located in coastal areas, even where adjacent to marine environments. Inland water systems can be fresh, saline or a mix of the two (brackishwater). …

- **Estuaries are transitional zones between rivers and the sea**. In practice, “inland waters” considerations tend to focus on fresh water – partly because freshwater environments dominate inland waters – but mainly because of the important of fresh water globally. The programme of work on inland waters and that for marine and coastal biodiversity collaborate for relevant coastal areas.
- The CBD has adopted the **Ramsar Convention's definition of “wetland**." The Ramsar Convention takes a broad approach in determining the wetlands that come under its aegis. Under the text of the Convention (Article 1.1), wetlands are defined as:
- *"Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."*

Table 9. Vegetation and water indices included in the classification of the estuarine Ecosystem Functional Groups (EFGs) to enhance the separability of the remote sensing classes. NIR = near infrared; SWIR = Shortwave infrared

Spectral index	Equation	Wetland property enhanced
Difference Vegetation Index (DVI) (Tuker, 1979)	$DVI = \mathrm{NIR} - \mathrm{Red}$	Soil Moisture
Enhanced Vegetation Index (EVI) (Huete et al., 2002)	$EVI = 2.5 \times \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + (6 \times \mathrm{Red} - 7.5 \times \mathrm{Blue}) + 1}$	Chlorophyll
Green Difference Vegetation Index (GDVI) (Tucker et al., 1979)	$GDVI = \mathrm{NIR} - \mathrm{Green}$	Chlorophyll and nitrogen
Green Normalized Difference Vegetation Index (gNDVI) (Gitelson et al., 1996)	$gNDVI = \frac{(\mathrm{NIR} - \mathrm{Green})}{(\mathrm{NIR} + \mathrm{Green})}$	Chlorophyll
Green Soil Adjusted Vegetation Index (GSAVI) (Mahdianpari et al., 2020)	$gSAVI = \frac{(\mathrm{NIR} - \mathrm{Green})}{(\mathrm{NIR} + \mathrm{Green})} \times 1.5$	Chlorophyll
Modified Normalised Difference Water Index (MNDWI) (Xu, 2006)	$MNDWI = \frac{(Green - \mathrm{SWIR})}{(Green + \mathrm{SWIR})}$	Leaf water content
Modified Soil Adjusted Vegetation Index (MSAVI) (Qi et al. 1994)	$MSAVI = \frac{2\mathrm{NIR} + 1 - \sqrt{(2\mathrm{NIR} + 1)^2} - 8(NIR}{2}$	Chlorophyll
Normalized Difference Vegetation Index (NDVI); (Rouse et al., 1973; Tucker, 1979)	$NDVI = \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red})}$	Chlorophyll
Normalized Difference Water Index (NDWI) (Gao, 1996)	$NDWI = \frac{(R\mathrm{NIR} - R\mathrm{SWIR})}{(R\mathrm{NIR} + R\mathrm{SWIR})}$	Leaf & water content
Optimized Soil Adjusted Vegetation Index (OSAVI) (Rondeaux et al., 1996)	$OSAVI = \frac{(\mathrm{NIR} - \mathrm{Green})}{(\mathrm{NIR} + \mathrm{Red}) + 0.16}$	Chlorophyll and leaf area index
Red Edge Normalized Difference Vegetation Index (NDVIre); (Gitelson and Merzlyak, 1994)	$NDVIre = \frac{(\mathrm{NIR} - \mathrm{Red\ Edge})}{(\mathrm{NIR} + \mathrm{Red\ Edge})}$	Chlorophyll, leaf area/biomass and nitrogen
Sentinel-1 ratio	$Sratio = \frac{\mathrm{VV}}{\mathrm{VH}}$	Vegetation structure