NATURE-BASED SOLUTIONS (NBS): THE CASE OF KIYÚ BEACH, SAN JOSÉ, URUGUAY

Gustavo J Nagy

Dr en Oceanología
Profesor Agregado de Ciencias Ambientales
Experto en Estudios Climáticos Interdisciplinarios

Posgrado de Ciencias Ambientales
Grupo Integrador Ambiente-Clima-Sociedad
Instituto de Ecología y Ciencias Ambientales
Facultad de Ciencias, Universidad de la República,
Montevideo, Uruguay

Nature-Based Solutions (NbS)

Nature-based solutions (NbS) are becoming crucial for climate adaptation.

They use natural processes to strengthen climate resilience while addressing social and environmental challenges.

By combining environmental restoration with community benefits, NbS help reduce exposure and sensitivity and boost adaptive capacity, making them a key element in climate strategies [1].

NbS must be co-designed to ensure equitable distribution and cultural sensitivity of benefits, rather than imposed top-down [2].

The Rio de la Plata River Estuary

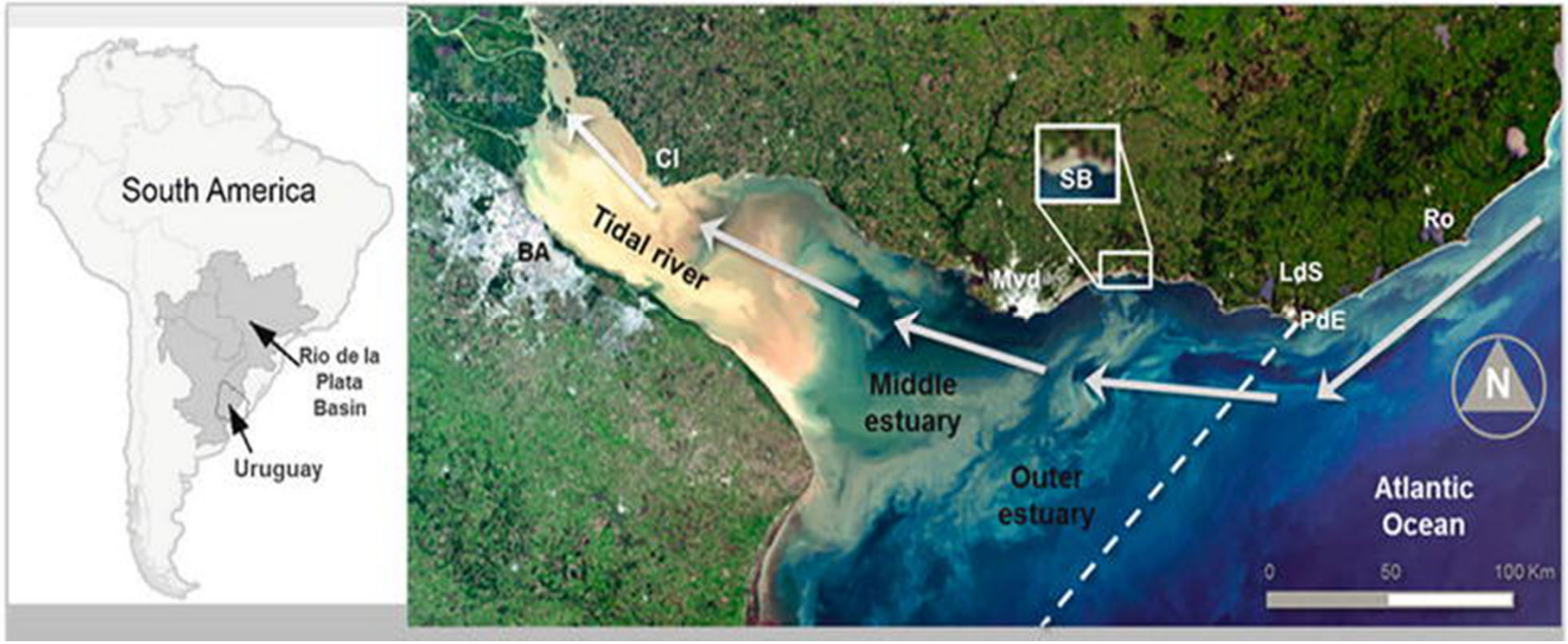


Figure 1. *The Rio de la Plata estuary. Source: The Copernicus Sentinel-3 satellites on 14 February 2022 (https://www. copernicus.eu/en/media/image-day-gallery/rio-de-la-plata-estuary). CL (Colonia); Mvd (Montevideo); LdS (Laguna del Sauce); Ro (Rocha); BA: Buenos Aires; SB: Sandy beaches. The arrows show the drift transport of sediments.* [3]

The Rio de la Plata: Uruguayan coast

The Rio de la Plata system is experiencing a continuous but moderate sea level rise and suffered an extraordinary rise in the flow of the main tributaries from the early 70s to the early 2000s.

Also, the frequency of extreme events, mainly wind-induced storm surges, has risen over the last three decades [3,4,5].

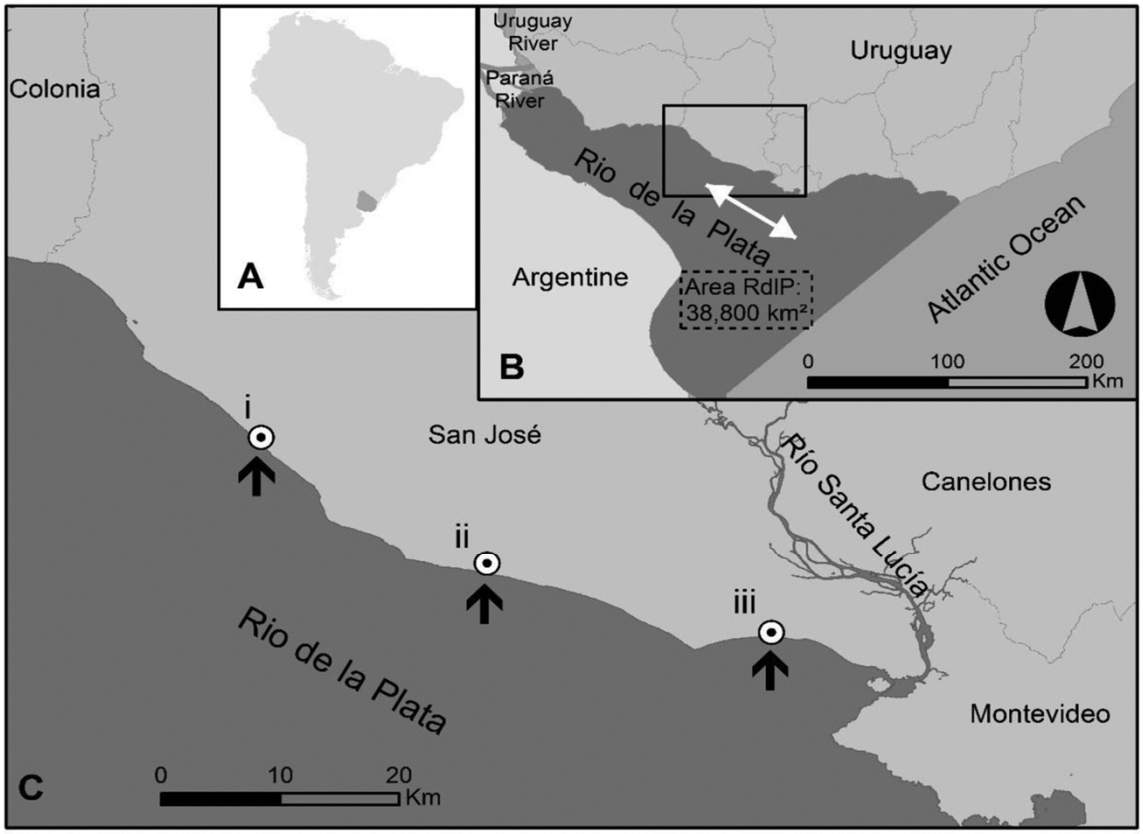
Kiyú (Información Intendencia Municipal de San José; alcaldía de Libertad) 60 km al W del centro de Montevideo; 120 km al E de Colonia.

- Ubicada sobre las Barrancas de San Gregorio, Kiyú – la casa de los grillos en lengua indígena – es una de las playas más hermosas del Uruguay en las costas del Río de la Plata.

- Las Barrancas de San Gregorio son formaciones geológicas de 50m de altura que se han producido como resultado de la erosión y junto a las blancas arenas, las playas mansas y la vegetación, hacen de Kiyú un lugar único.

- A lo largo de la costa, una serpenteante rambla une el Parador Grande, ubicado al este del balneario en la zona conocida como Kiyú Viejo, con el Parador Chico, el Kiyú Nuevo, donde se puede recorrer el Camino del Indio para acceder a la playa y disfrutar de las actividades deportiva que tienen lugar en la temporada.

- Entre ambos paradores se encuentra «la bajada del medio» una zona muy utilizada para vuelos en parapentes y alas delta.



Notes: (a) South America, (b) Rio de la Plata river estuary (area 38,800 km2) (the white arrow indicates the moving salt intrusion limit; SIL) (Nagy et al., HYPERLINK "file://\\chenas03\smartedit\Normalization\IN\INPROCESS\43" \o "43=Ref Nagy, G.J., Martínez, C.M., Caffera, R.M., Pedrosa, G., Forbes, E.A., Perdomo, A.C. and López Laborde, J. (1997), "1997), (c) black arrows indicate the three pilot coastal adaptation sites at San José: (i) Vulminot (up-river the SIL), (ii) Kiyú (at the upward boundary of the SIL), (iii) Ciudad Del Plata (at the mouth of Santa Lucia River estuary)

Figure 1. Kiyú Beach, San José, Uruguayan coast of the Rio de la Plata River Estuary Middle Region. [6]

Extreme weather (Storm Surges) impacted Kiyú Beach

Two successive extreme storm surges in September and October 2012 impacted Kiyú Beach, San José, Uruguay, on the coast of the Rio de la Plata's tidal river estuary (Figure 1).

These events highlighted the extent of coastal exposure to extreme weather.

The micro-tidal coastline (Amplitude: 30 cm) features erosive bluffs, sandy beaches, and dunes, all of which are vulnerable to **storm surges, sea-level rise (SLR), and El Niño-related riverine flooding**.

The storm surges resulted in erosion of the sandy beach, dunes, and bluffs; fallen trees contributed to bluff collapse. Infrastructure, including the "Parador Chico" Hostel and coastal roads, also sustained damage [6,7].

Kiyú study site

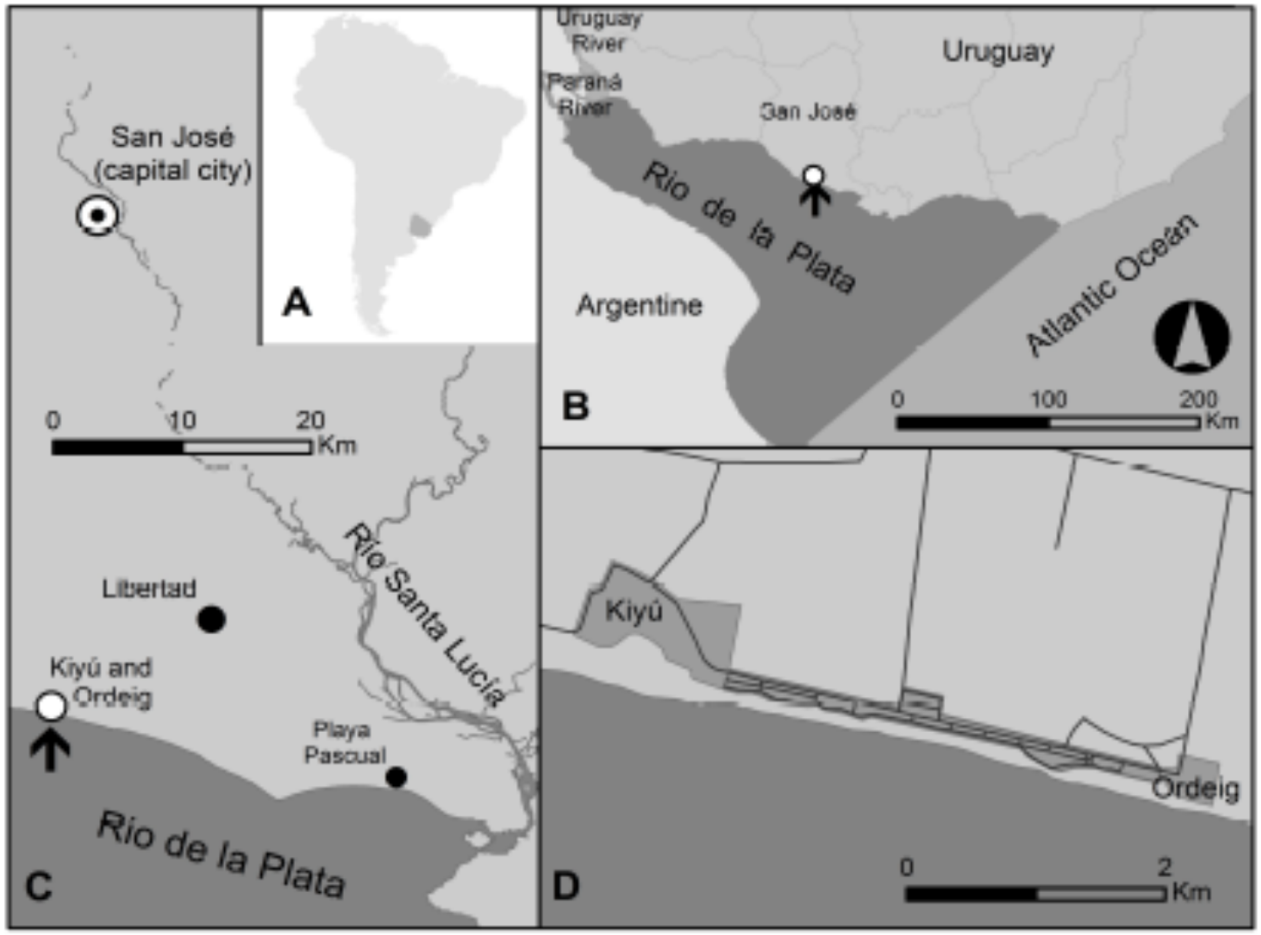


Figure 2: Study site. A) South America. B) Rio de la Plata river estuary. The black arrow indicates the pilot coastal adaptation site at San José: Kiyú. C) Kiyú and its surroundings. D) Kiyú - Ordeig in detail. [8]

Uruguay's Climate Adaptation, Vulnerability Reduction Assessment (VRA) and Ecosystem-Based Adaptation (EbA). (Coasts)

- Uruguay's Climate Adaptation (CA) model highlights the value of integrating participatory processes, scientific input, and capacity building into local knowledge.

- This approach embeds NbS as a core adaptation strategy. The case of Kiyú Beach on the Rio de la Plata coast (Figure 2) demonstrates why these steps are critical, given that sandy beaches and infrastructure are highly vulnerable to extreme events, such as storm surges and flooding, heavy rainfall, and sea-level rise (SLR).

- Within Uruguay's CA model, vulnerability reduction assessment (VRA), ecosystem-based adaptation (EbA), and beach profiling [6] show that NbS support community-led interventions.

- This targeted approach speeds up ecological recovery and institutional learning, helping cement NbS in national adaptation planning [7].

- Local adaptation efforts focused on green infrastructure and sustainable drainage, reducing erosion, improving adaptive capacity, and encouraging local innovation [6,7].

- The Kiyú small town example shows that using EbA increases coastal resilience to both extreme weather and SLR [8].

Vulnerability Assessment Reduction (VRA): The Kiyú case study: 2011-2018

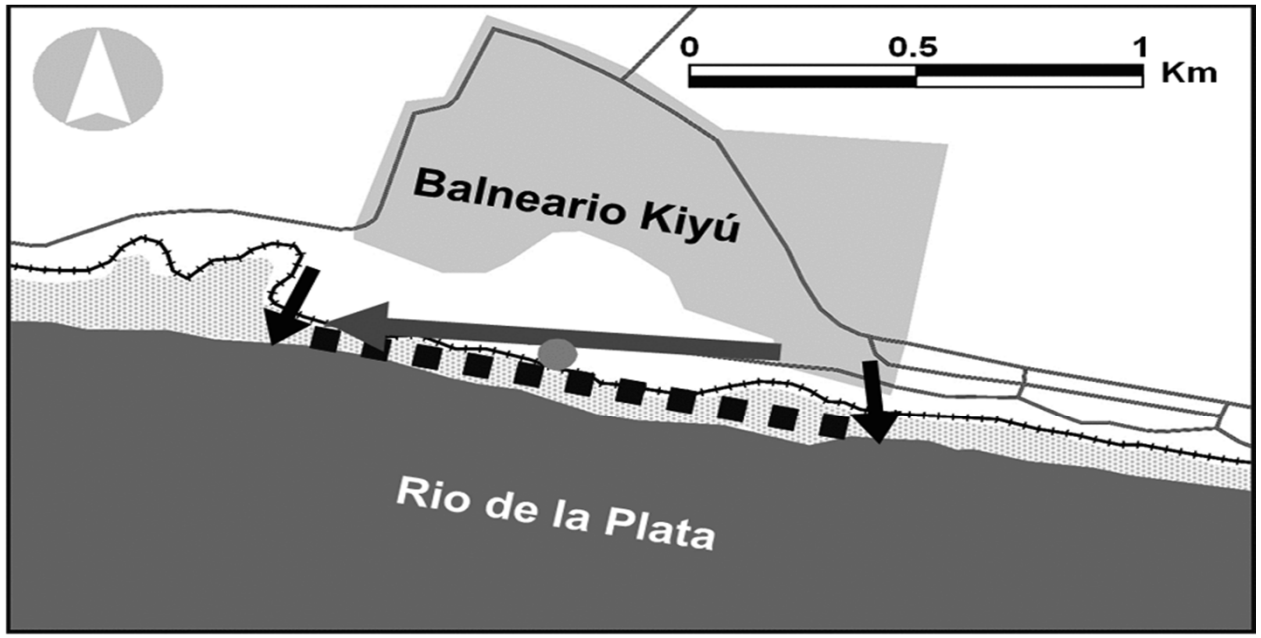
The VRA [9] is designed to measure community-level adaptive capacity to climate change and variability in Community-Based Adaptation (CBA) monitoring and evaluation activities.

It is a relative measure of change from a pre-project baseline (before-after implementation of measures).

VRA evaluates both the vulnerability and risk perceptions of decision-makers and stakeholders, as well as the barriers and opportunities related to adaptation. The process comprises four stages [3,6,10]:

- 1) Semi-structured and in-depth interviews with different groups of stakeholders;
- 2) Focus group discussions;
- 3) Complete a multiple-question matrix that includes qualitative comments and a numerical assessment using a Likert 1-5 scale, based on open-ended, perception-based questions. This matrix aggregates responses as indicators of adaptive capacity and combines qualitative insights with numerical scores to evaluate adaptation.
- 4) A dialogue between participants and experts was held to achieve a collectively agreed value for each question and oral comments.

Kiyú Beach.
Sketch of the placement of EbA interventions.



Notes: The reprofiled roads (dark grey arrow) and the sites of storm drains entrances to the beach area (black arrows) are shown

Figure 3. Sketch of the placement of sand captor fences and planting of coastal forest species (black dotted line: ≈1,200 linear m), which in turn is the zone used for beach profiling, where the starting point reference is the base of "Parador Chico" hostel (grey point). [6]

VRA of the NBS and CbA Results from 2011-2018 [6,7]

Table 1: Stakeholders' perceptions of threats and impacts, vulnerability and adaptive capacity (V and AC).

Year	Threats	V/AC	Comments
2011: Baseline	Extreme Events and erosion	4.2/1.5	Lack of local adaptive capacity
2013: Before EbA implementation	Windstroms, flooding, and beach and bluff erosion.	2.5/2.1	Lack of adaptive capacity and information regarding impacts and possible adaptation measures / Confidence in local commitment and local authorities.
2014: After EbA implementation	Windstors, rainstorms, SLR, increased extremes.	1.8/3.3	Increased perception of threats after the damaging rainstorm in early 2014. Increased confidence in adaptive capacity.
2018: Monitoring and Evaluation	Windstorms; erosive rainstorms.	1.8/3.3	Decreased perception of threats and vulnerability; similar adaptive capacity (compared with 2014). Future scenarios and adaptation processes are understood. Increased need for new storm-drains.

Beach profile evolution before-after the soft EbA intervention and of the desired near-future state.

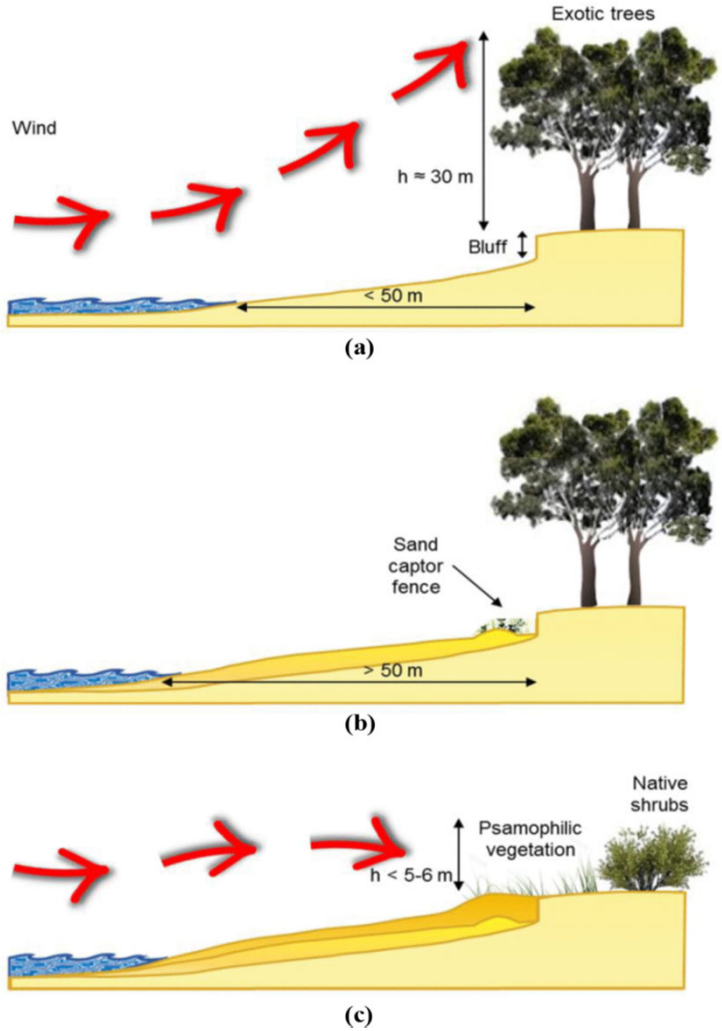


Figure 4. Schematic representation of the beach profile before (a) and after (b) the soft intervention in 2013 (inspired by Kim et al., 2014); the desired near-future state (c) shows an ideal rebuilding of both beach profile and ridge of dunes. [6]

NbS and EbA: Climate Adaptation approaches

- Success in small-town adaptation depends on coordination among governments, NGOs, businesses, and researchers, as well as effective knowledge sharing through international networks [8].
- Evaluating adaptation also requires looking beyond just population size [7,8].
- The Kiyú case shows that prioritising NbS, primarily through participatory EbA, is vital for building resilient social-ecological systems and ensuring long-term sustainability [6].
- However, evidence suggests that top-down approaches providing data, models, and, **mainly, political will** are crucial for informing stakeholders and achieving consensus and results [3,7].

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