



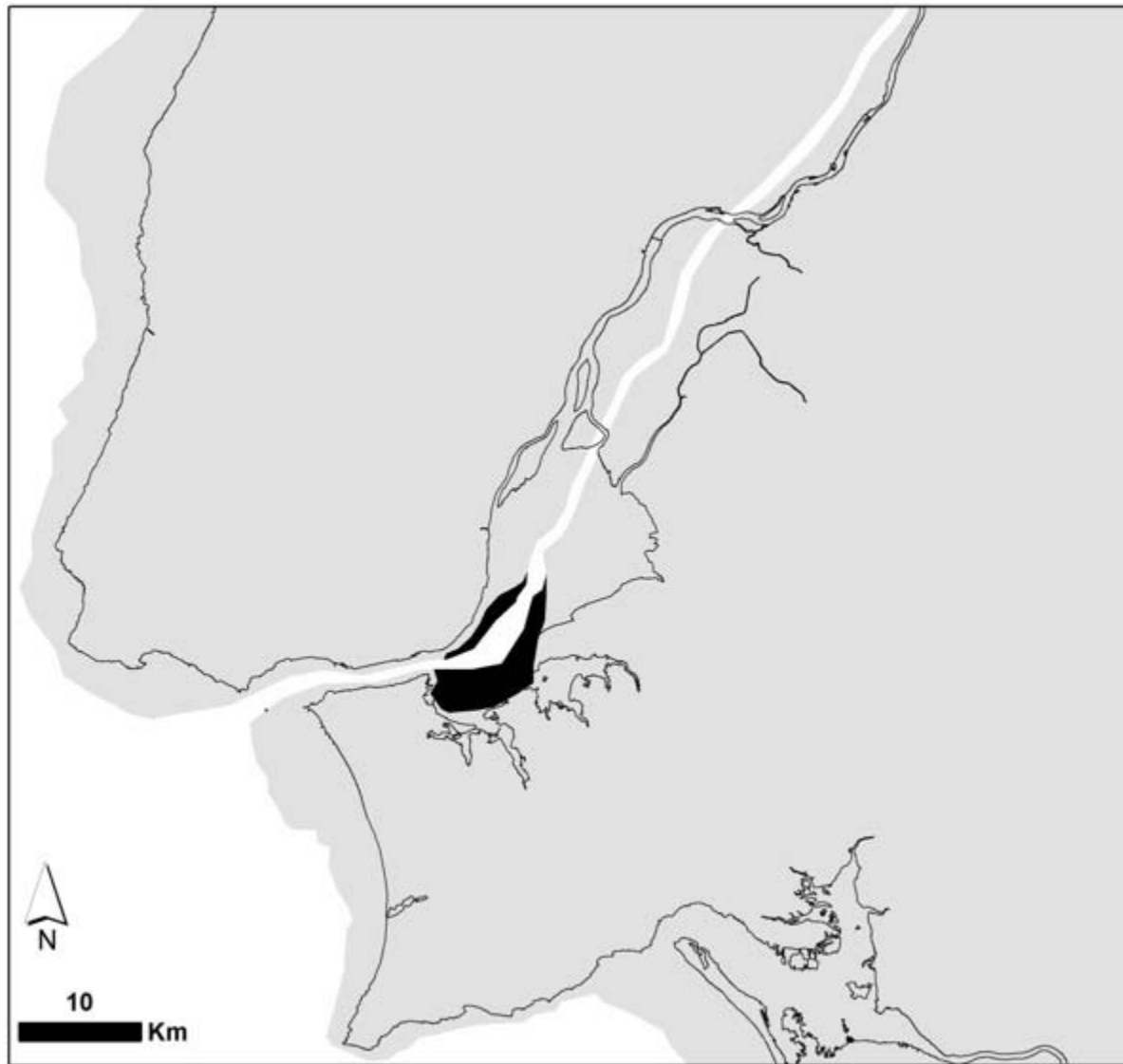
# Tagus Estuary

## Past, present and future

Pedro J Pinto | Instituto Superior Técnico

S.O.S. Climate Waterfront – Sustainable Open Solutions | March 12, 2019

**Past**



### **12,000 YBP**

Around Late Glacial Maximum, sea-level was about 60m lower than today.

The rapid deglaciation that followed marked the beginning of the Holocene and about 8 millennia of rapid sea-level rise

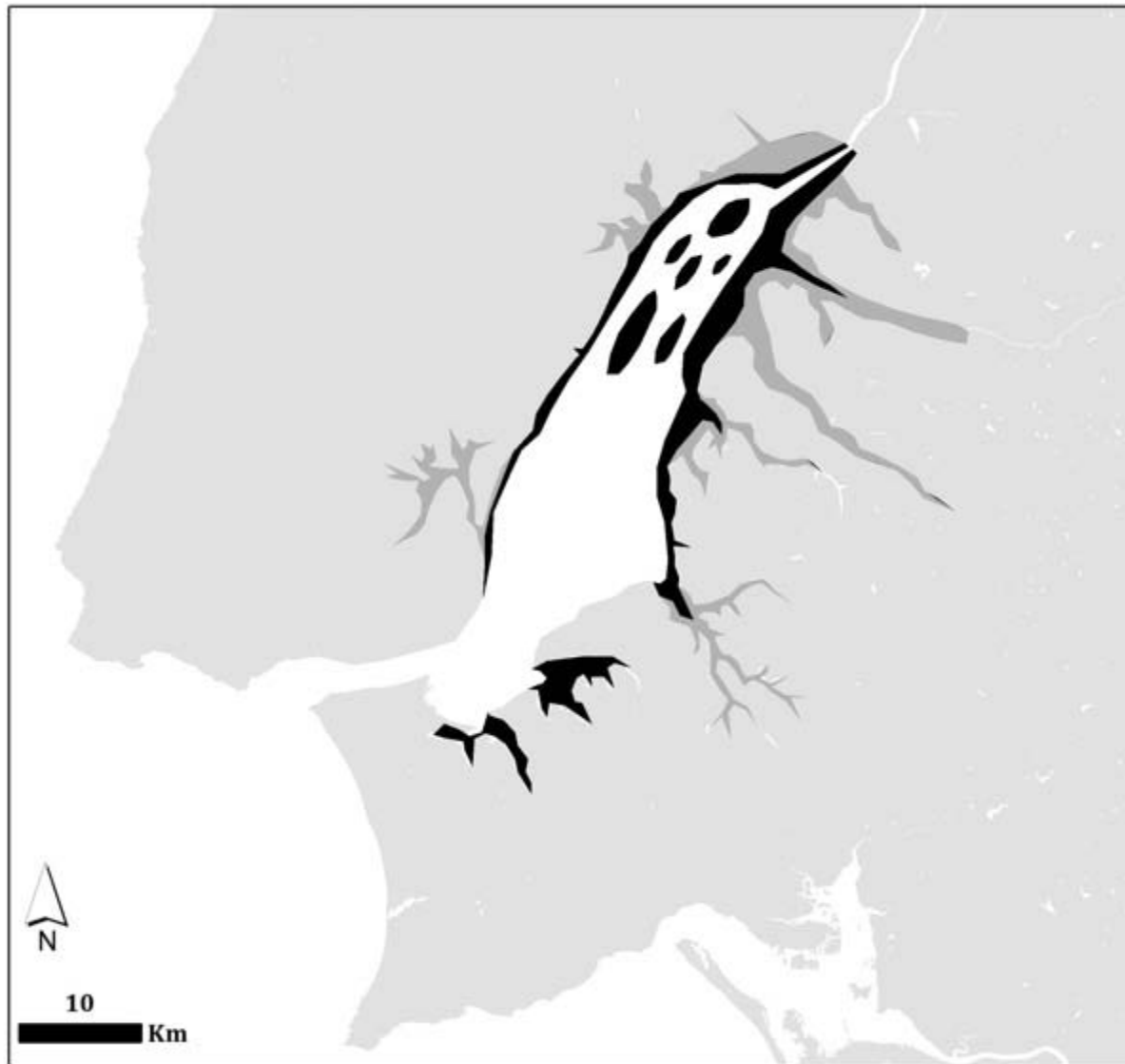


### **4,000 YBP**

Sea-level rise slowed down dramatically.

This allowed saltmarshes to colonize the sheltered shores.

The process of slow progradation of the delta was initiated.



### **Year 1000ce**

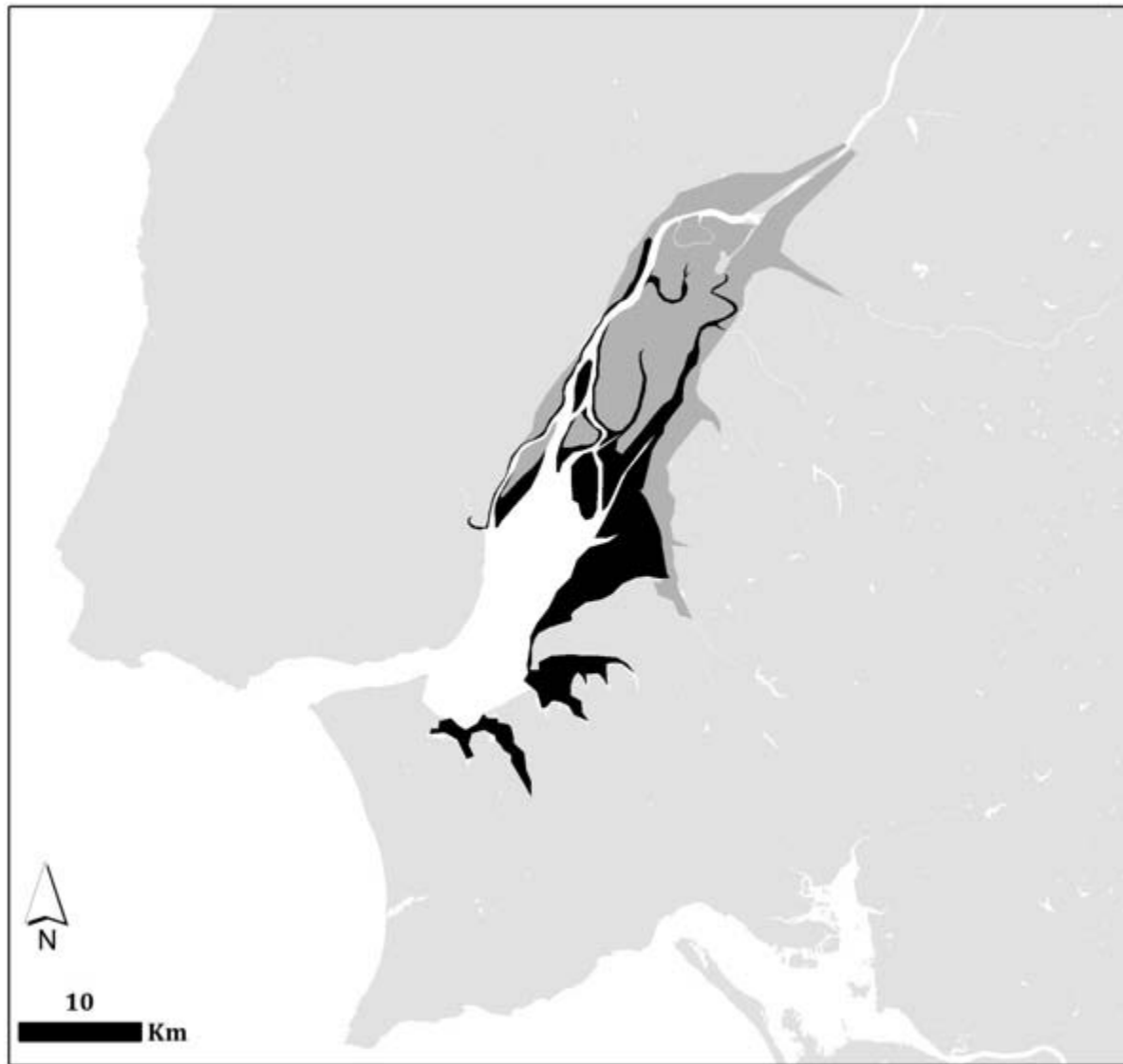
The natural process of progradation was much accelerated by human alteration of the land cover, which led to increased sediment yield

Starting with the Romans, a two-millennia long series of cycles of **transformation of high marsh and coastal scrubland to agricultural** land on alluvial soils – the *Lezíria*

According to Roman Law, then Visigothic Codes, Muslim Law upheld by the Moors, and on to the Medieval Portuguese Laws, **the beds and land subject to inundation were always the State's/King's land**

**Concession of the land and taxation** were major tools in the emergence of centralized power in Portugal

Around the Estuary, the standard for **public domain** was defined at the **Spring High Water** as early as the reign of King John I (1385-1433)



### **Year 1800ce**

Much of the upper delta had been transformed by successive pushes to drain upper marshes and convert them into alluvial farmland (the *Lezíria*).



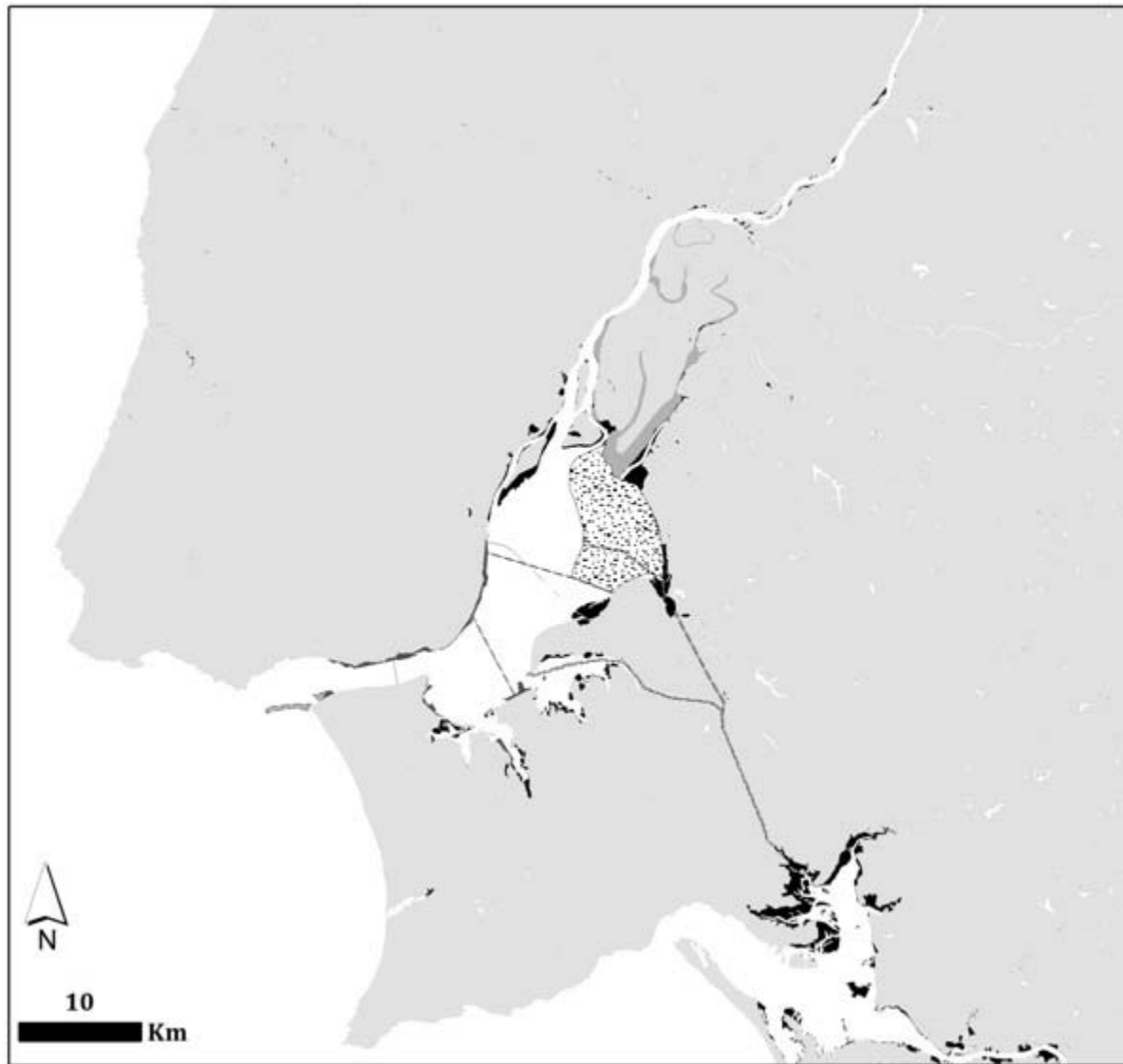
**Reclaimed land** on the Estuary was consolidated onto the Crown Prince's Estate (**Casa do Infantado**)

This Estate was sold to a private corporation in 1836 (the **Companhia das Lezírias**) which **manages most of the low-lying farmland** to this day. It was nationalized again in 1974

The riparian **Public Domain** was formalized in modern law code as early as **1864**

Revision of laws within a *Civil Law* system are frequent, and there have been **several expansions of mandates and jurisdictions**

Portugal's admission to the **European Union in 1986** saw a generalized **improvement of planning and environmental protection standards**

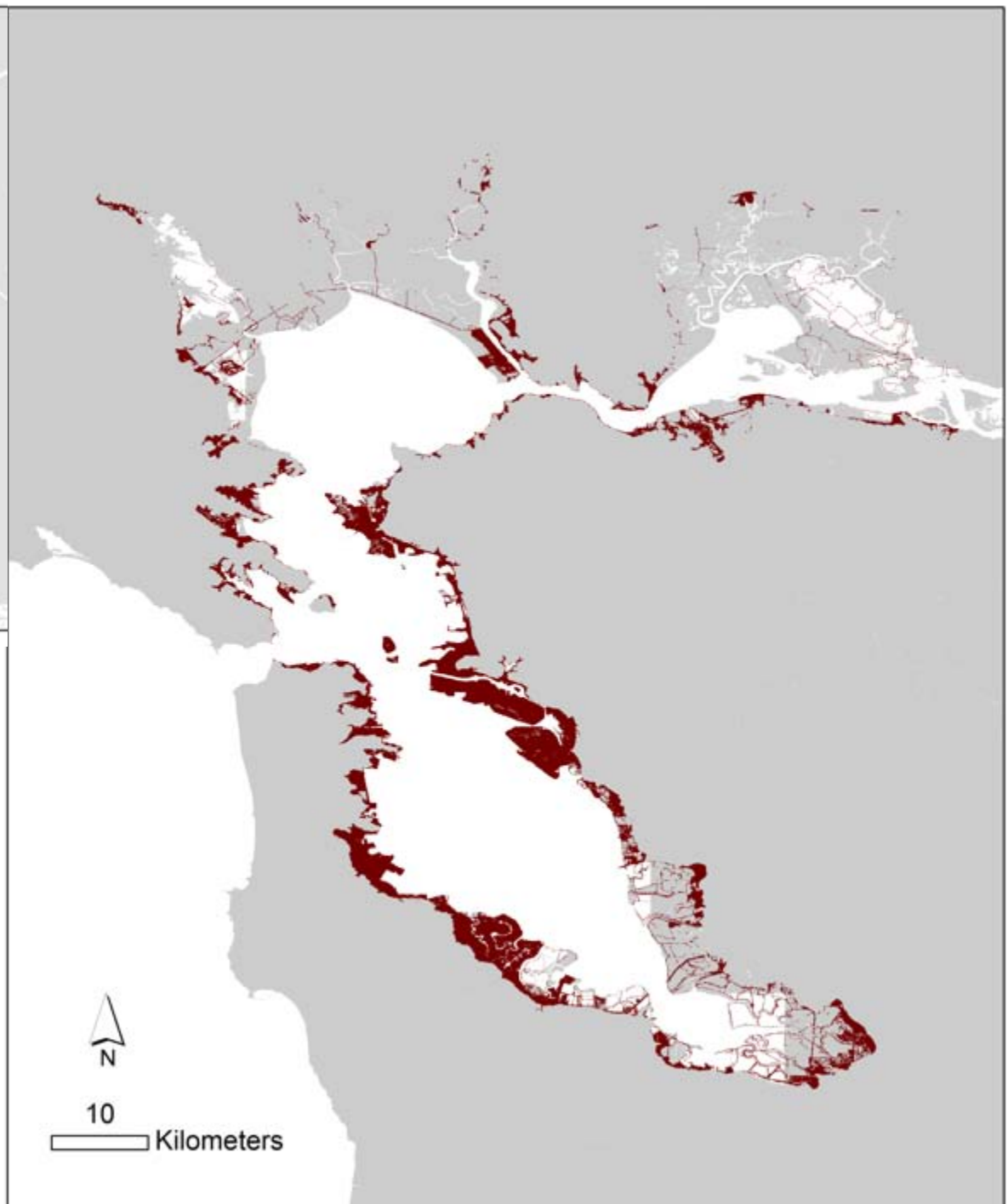


### **Unrealized mid-20th century projects**

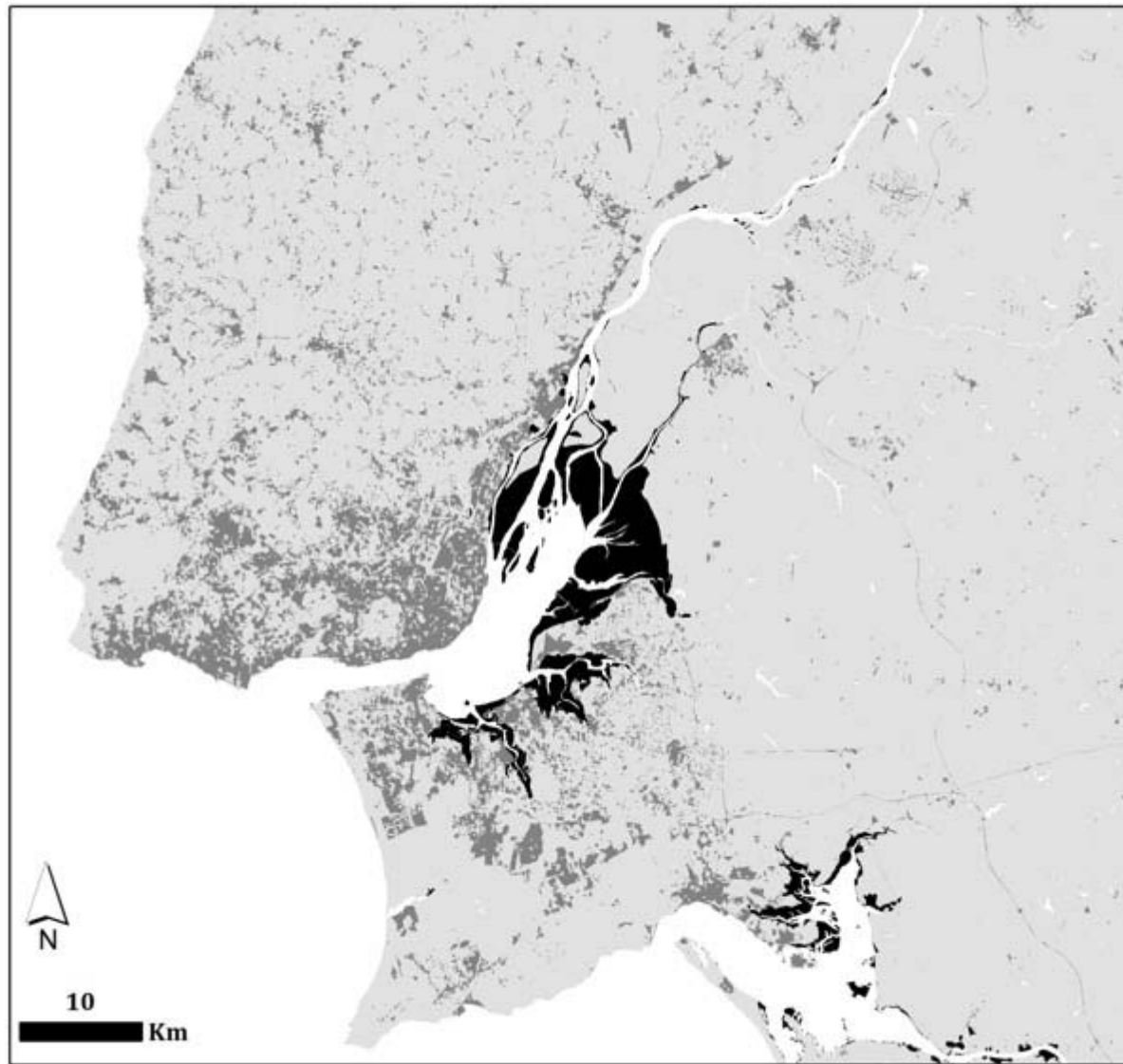
Technological advances made it possible to dam, drain, channelize or landfill entire estuaries. Only the emergence of environmental concerns in the later half of the century halted these processes.



**Urban and infrastructure development over landfill was much less extensive than in other metropolitan regions, such as the San Francisco Bay Area.**



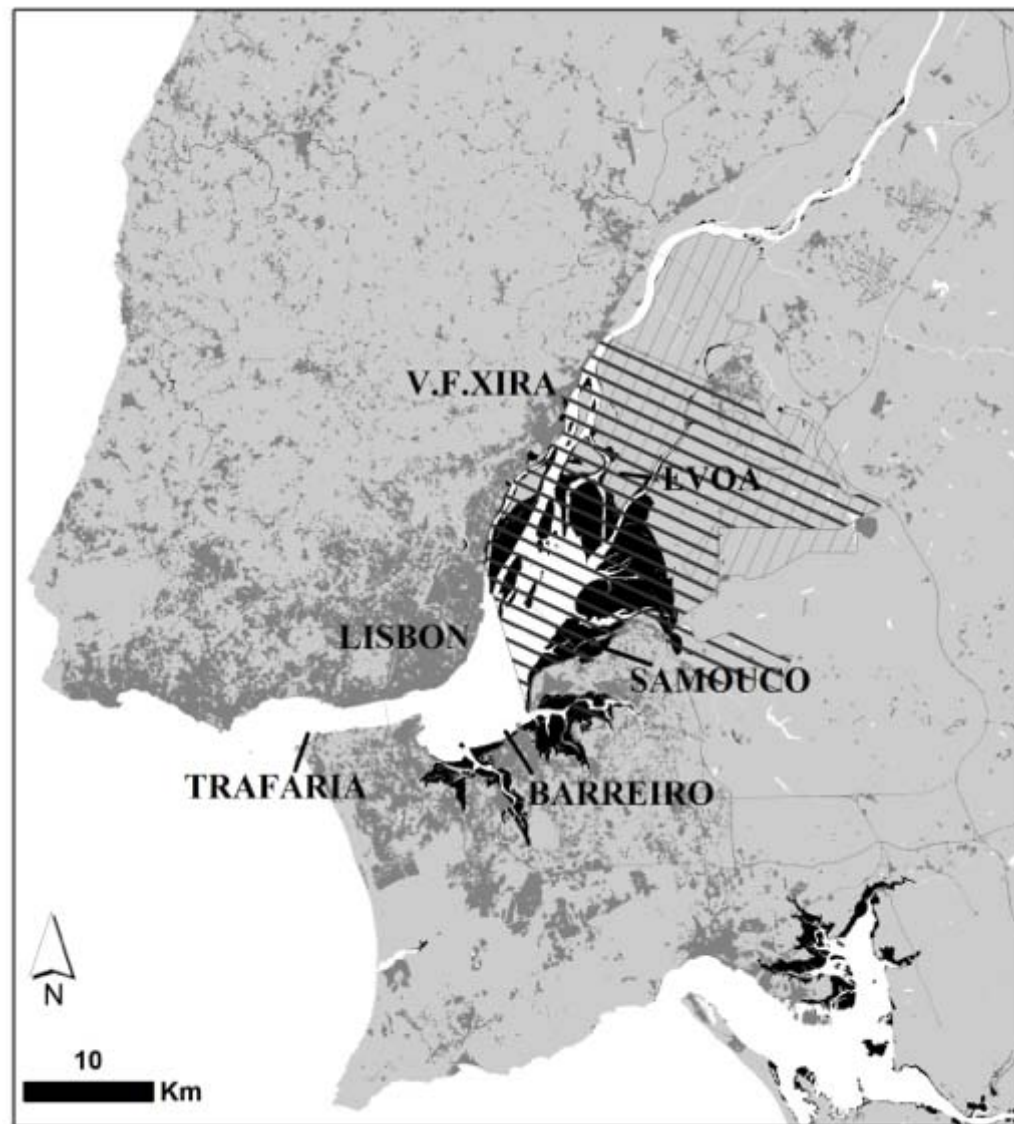
**Present**



### Today

The estuary is now composed of a narrow upper section, bordering farmland, and a much wider lower section, ringed by urban development, especially in the northern shore, and wetlands around its northeastern edge and southern inlets.

# Tagus Estuary: Past, present and future



## Legend



Built-up area



Non-built-up area



Permanently flooded



Wetlands.



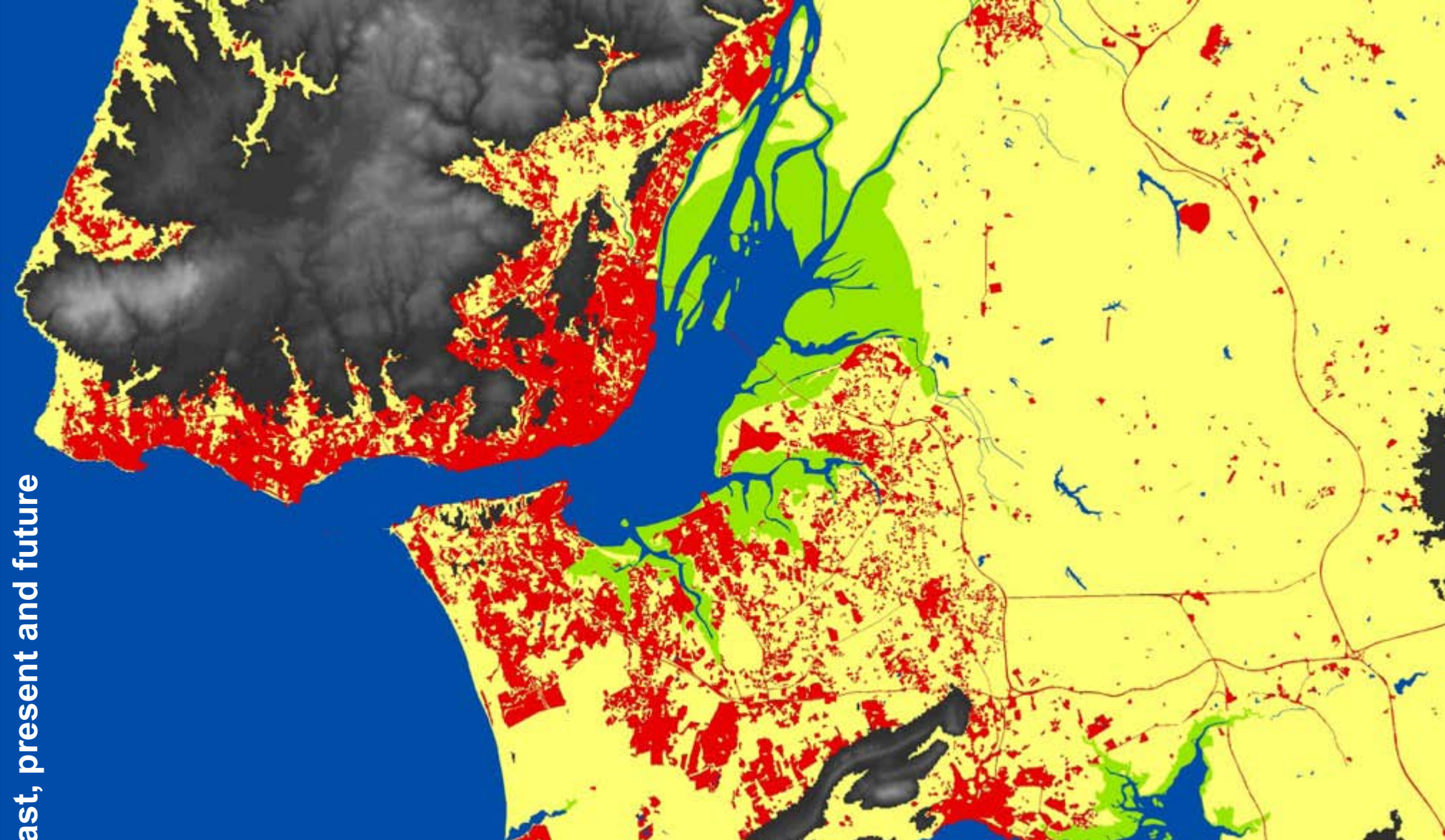
Natural Reserve



Companhia das Lezírias



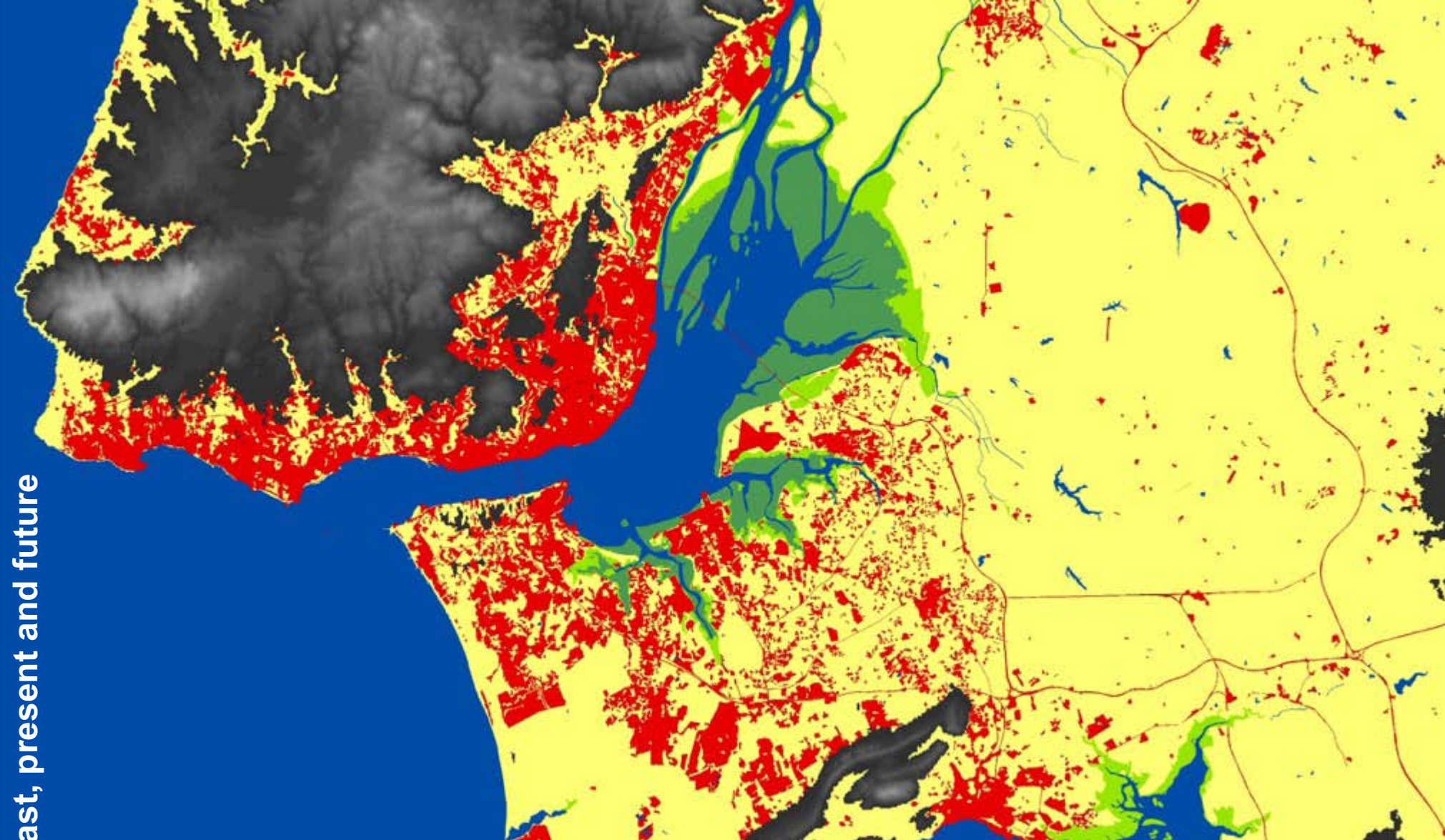
Tagus Estuary: Past, present and future



Current sea-level, low tide



Tagus Estuary: Past, present and future



Current sea-level, high tide

**Future**

# SLR: how much by when?

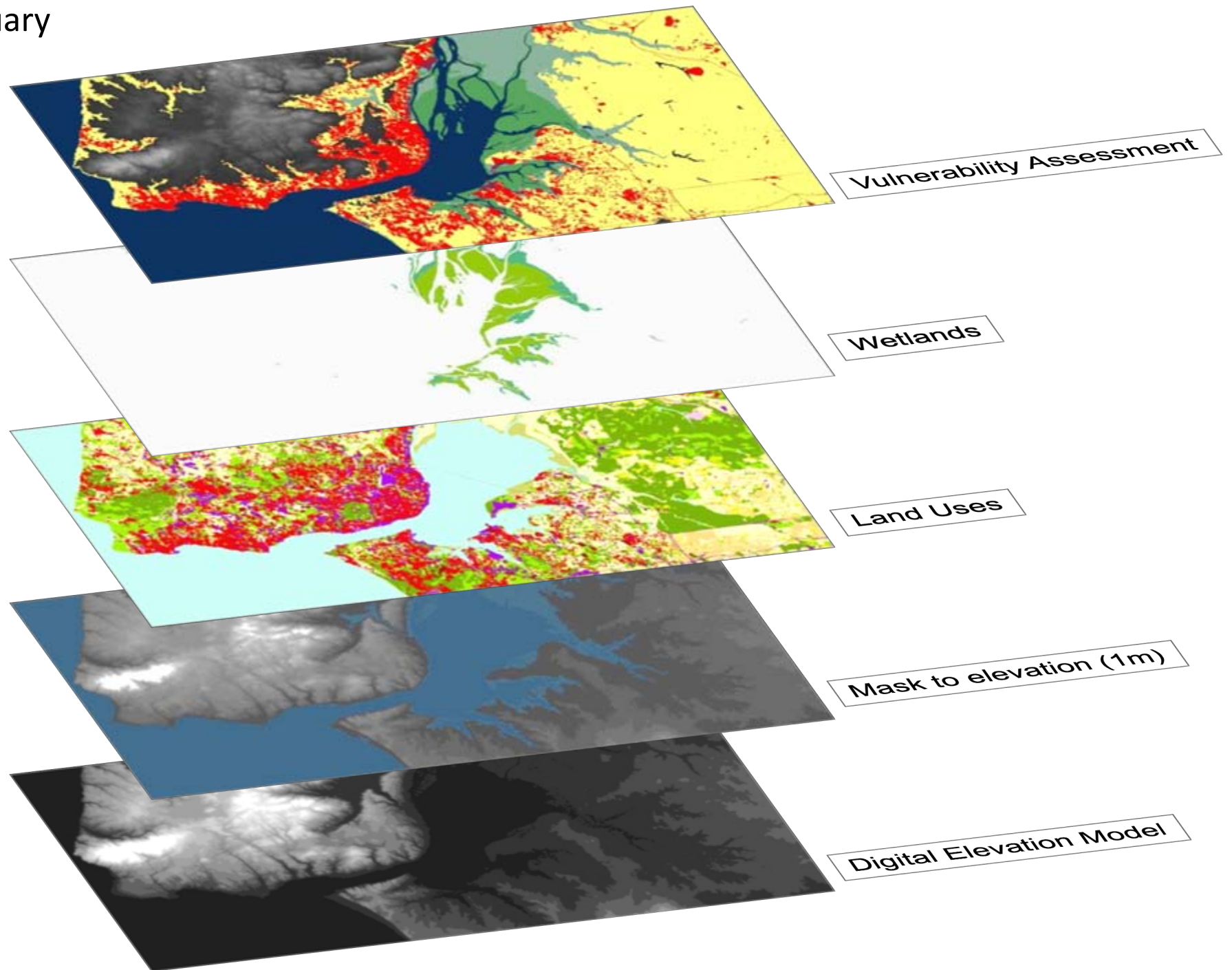
SLR in the 20<sup>th</sup> century: 0.19m

**IPCC** (2013) maintains a conservative estimate of between **0.26** and 0.55m SLR before 2100 with strong mitigation actions and 0.52 to **0.98m** for the worst emissions pathway.

Many of the effects will persist for several centuries. This includes SLR, which might top 5 to 7m above present msl.

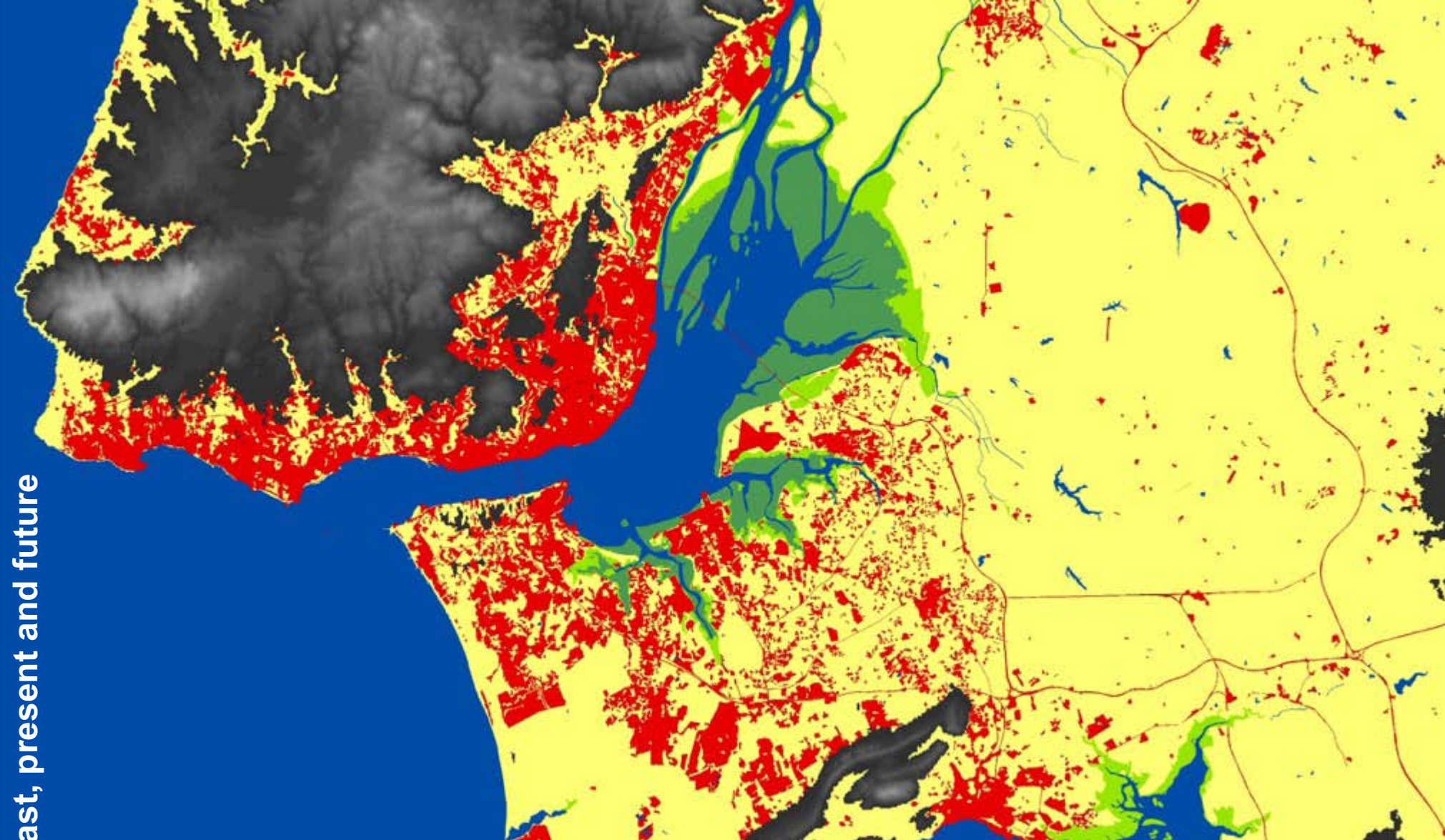
# Rapid assessment of vulnerability to SLR

## Tagus Estuary





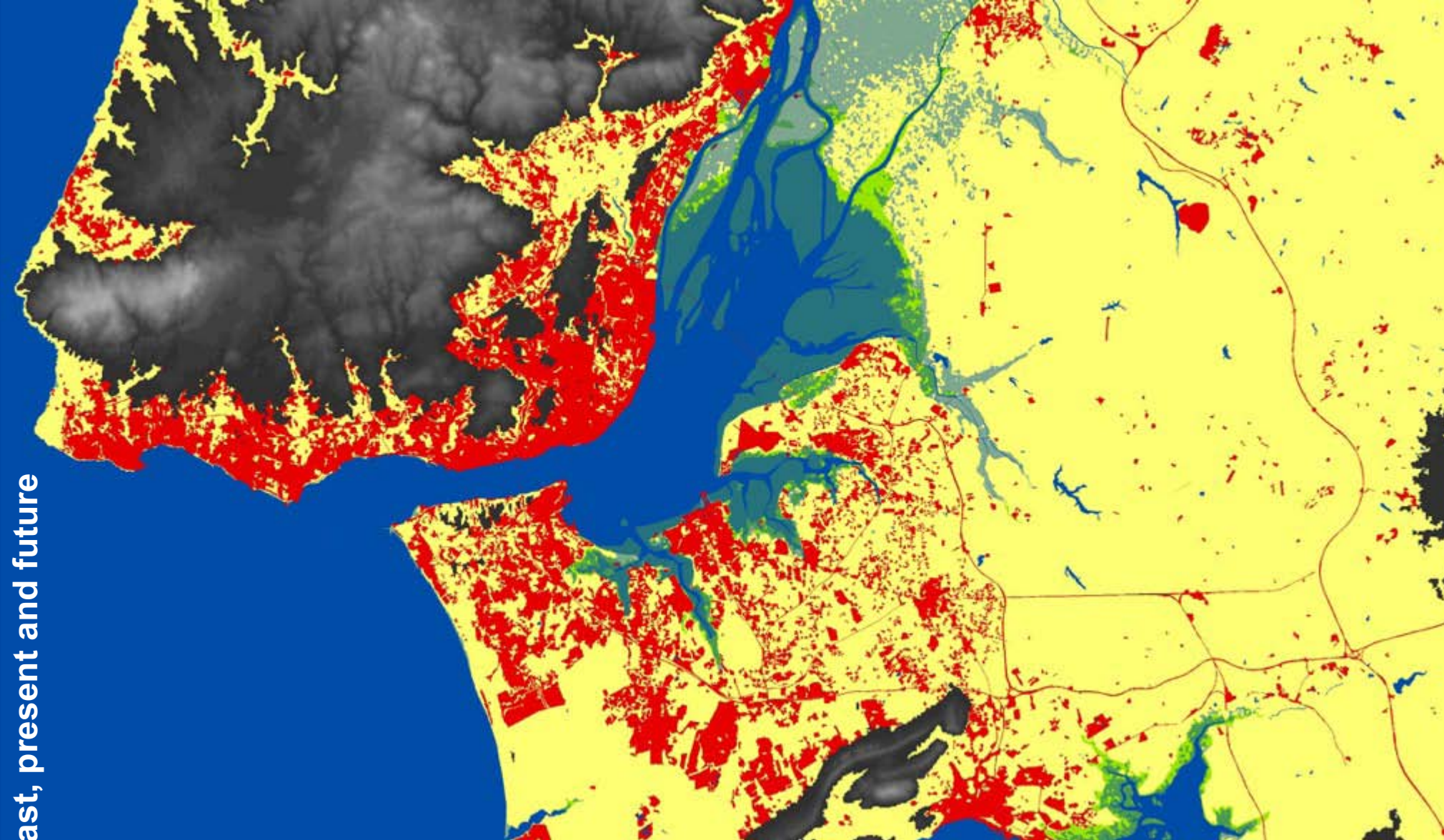
Tagus Estuary: Past, present and future



Current sea-level, high tide



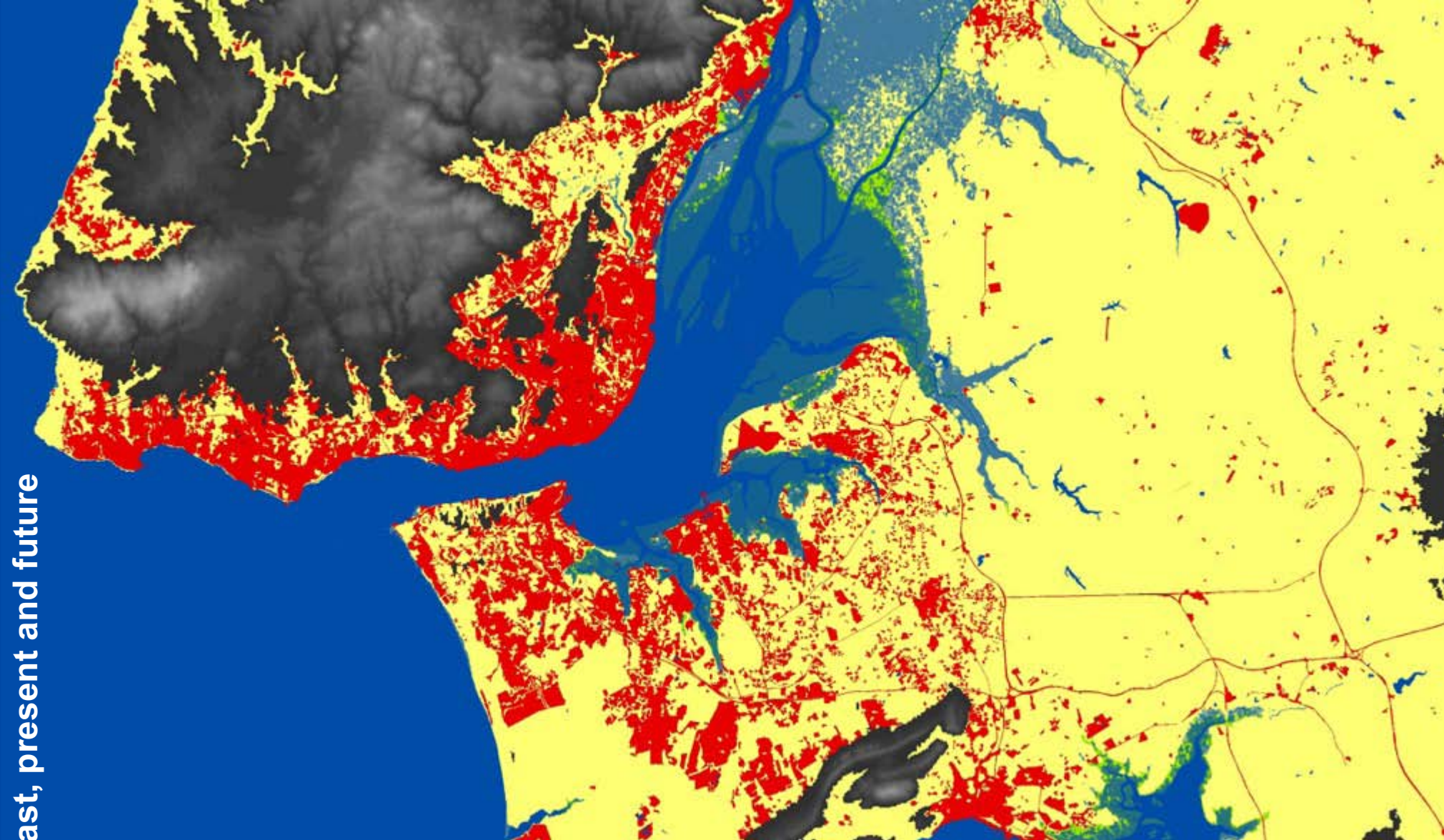
Tagus Estuary: Past, present and future



1m sea-level rise



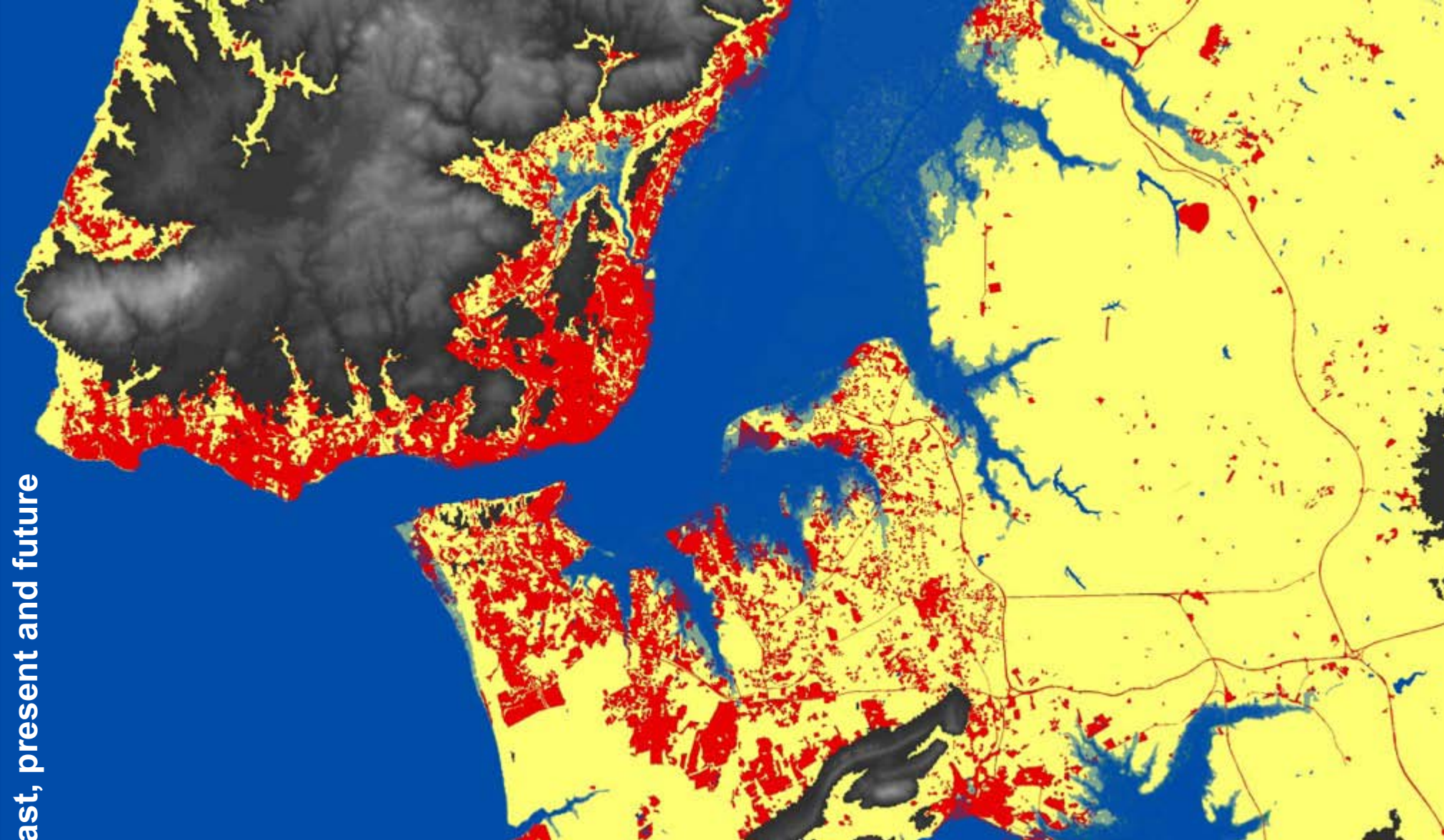
Tagus Estuary: Past, present and future



2m sea-level rise



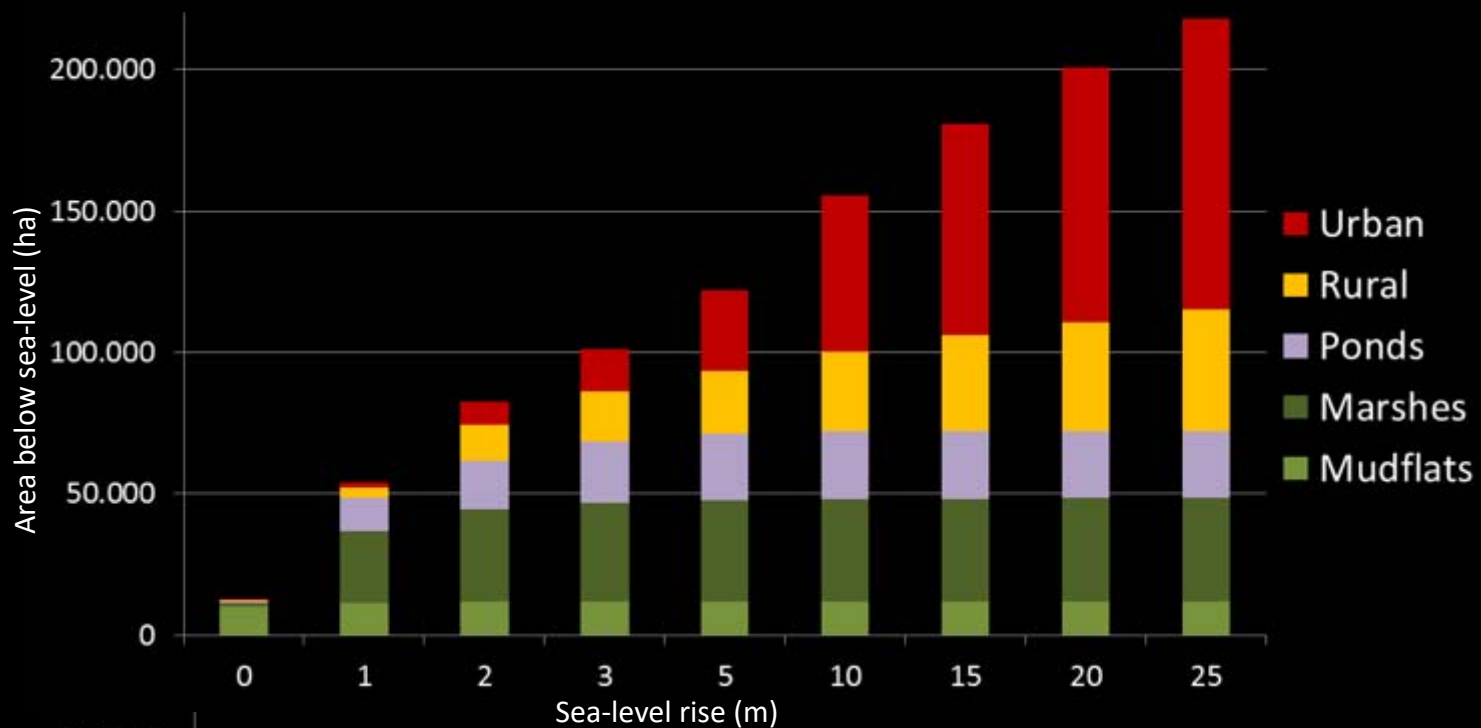
Tagus Estuary: Past, present and future



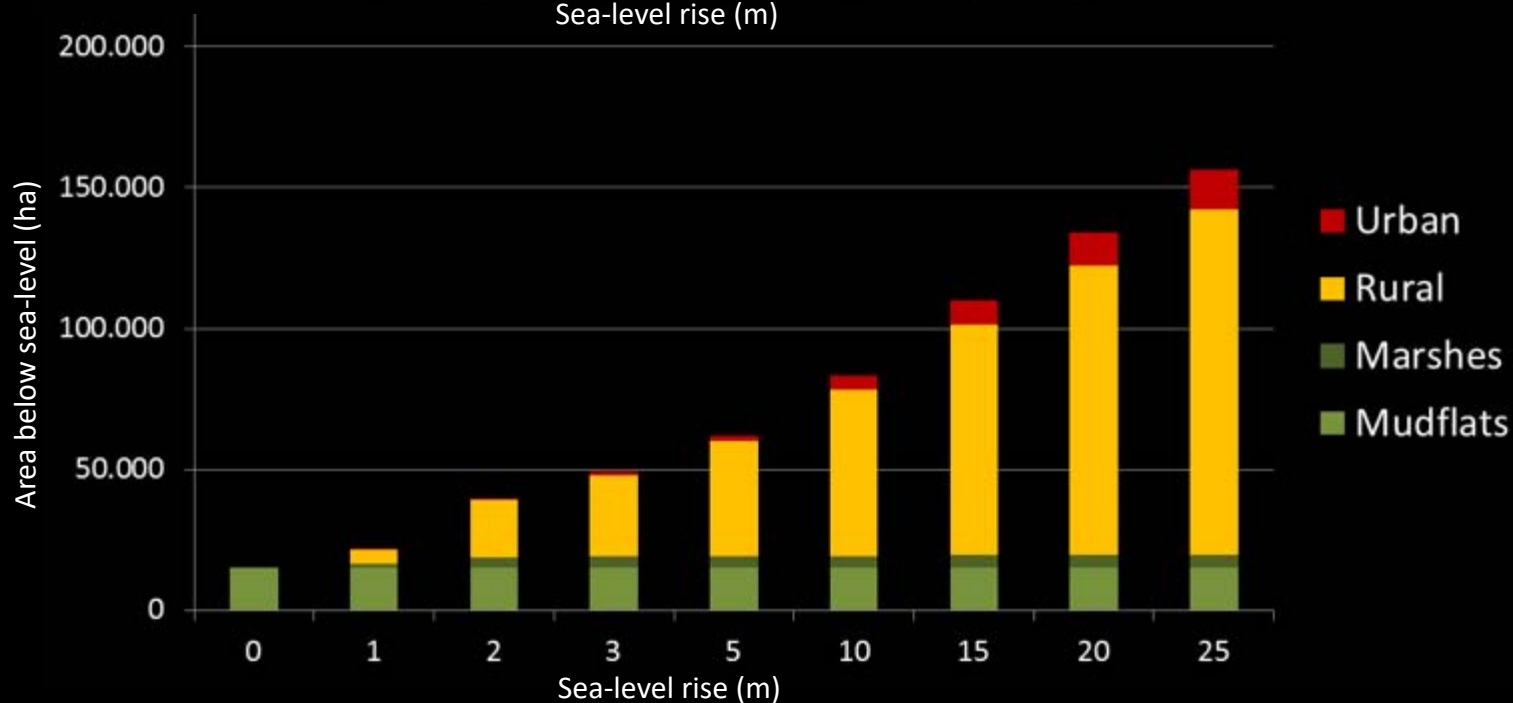
10m sea-level rise



# SAN FRANCISCO



# LISBON



Area below  
sea-level (ha)

150.000  
100.000  
50.000  
0

# SAN FRANCISCO

- Non-artificial
- Artificial areas
- Wetlands

Sea-level rise (m)

Area below  
sea-level (ha)

150.000  
100.000  
50.000  
0

# LISBON

- Artificial areas
- Wetlands
- Non-artificial

Sea-level rise (m)

Tagus Estuary: Past,  
present and future

# Habitat restoration

Tagus Estuary: Past, present and future

## EVOA

70ha

€200K

~€2,900/ha

3 managers/  
3 partners

2 donors

## Samouco

360ha

€500K

~€1,400/ha

3 managers

1 donor

## South Bay

6.111ha

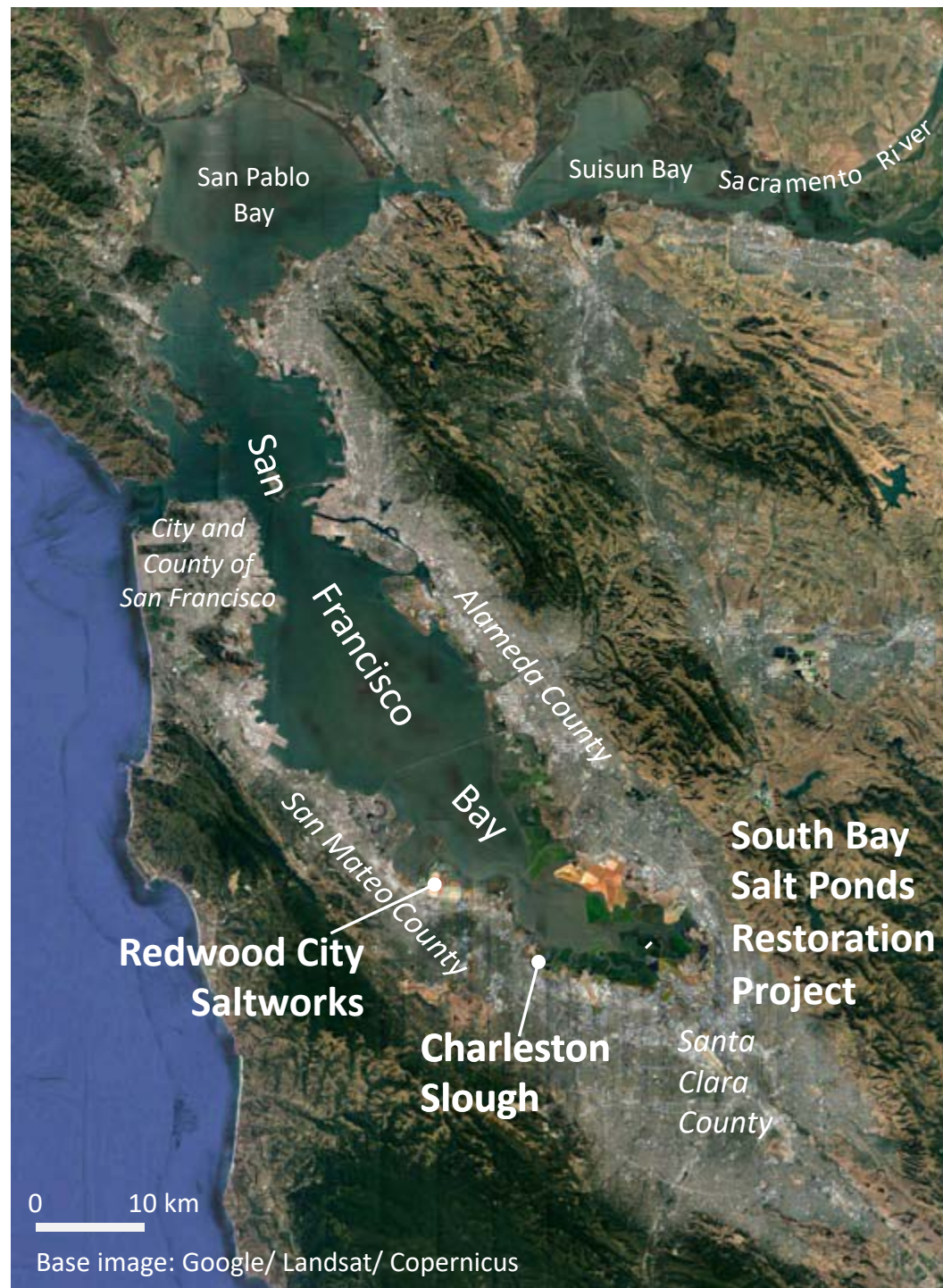
>€200.000K

>\$32,700/ha

11 managers

15 donors

# Tagus Estuary: Past, present and future

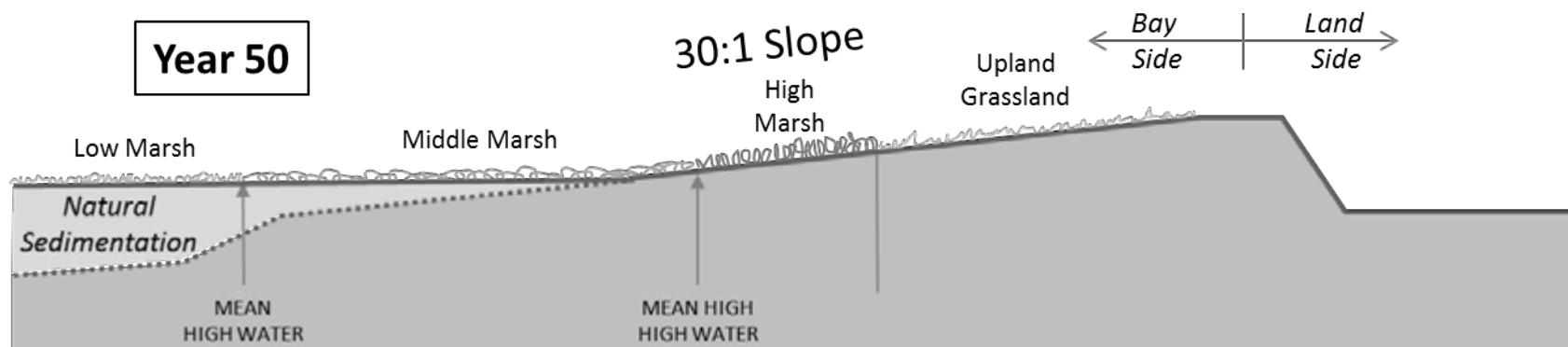
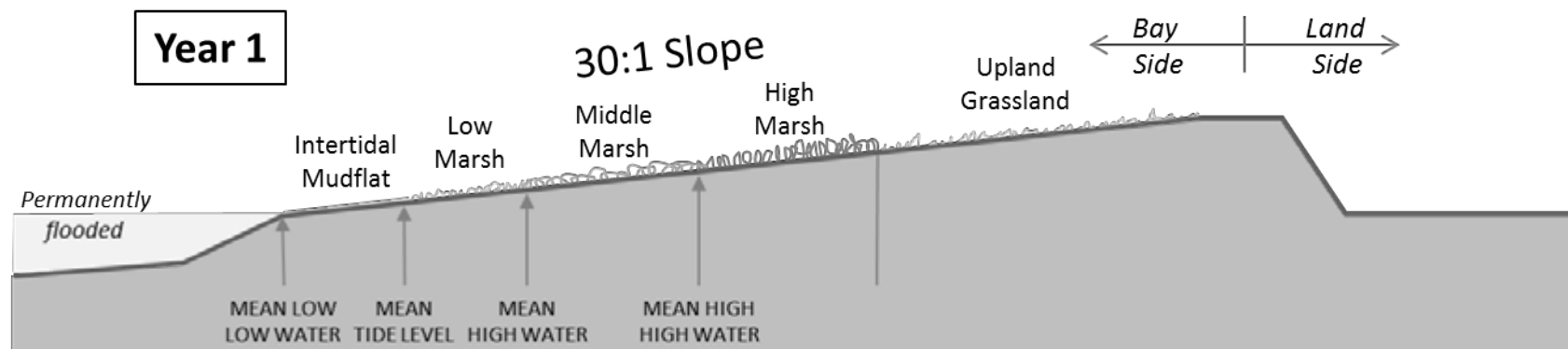




# Tagus Estuary: Past, present and future







				Cost		Scale		Time horizon		Regrets		
				Low	High	Small	Large	Short	Long	No/Low	High	
Structural	Hard	H1	Equip vulnerable dwellings with removable, fixed, or automatic <b>flood gates for doors</b> , windows, airholes and garage doors	X		X		X		X		
		H2	Implement formal system of <b>road signs</b> providing warning of flooded roadways and sidewalks	X		X		X		X		
		H3	<b>Waterpumps</b> must be installed on all basements, underground garages, or ground floors below flood stage		X	X			X	X		
		H4	Transfer <b>machinery</b> , generators, elevator shafts to <b>higher floors</b>		X	X			X		X	
		H5	Improve <b>stormwater drainage</b> systems by replacing pipes, introducing tidal vales, pumping stations or reservoirs		X		X		X	X		
		H6	<b>Transfer</b> schools, health <b>facilities</b> , firehouses, and other civil protection agencies located on vulnerable areas		X		X		X	X		
		H7	Raise waterfront parapets/guards to increase protection against low flood levels or wave spill-over		X		X		X		X	
		H8	Raise waterfront <b>public spaces</b> and/or <b>design</b> them so as to double as barriers against flooding		X		X		X		X	
		H9	<b>Rebuild</b> with <b>raised</b> ground floors or <b>on stilts</b> , with elevated pathways and driveways, above flood stage			X	X			X	X	
		H10	<b>Abandon most vulnerable areas</b> , moving buildings, people and functions to safe locations			X		X		X		X
		H11	Create or <b>upgrade</b> dykes and <b>levees</b> protecting vulnerable shorelines			X		X		X		X
		H12	Create <b>flood barrier/dam</b> across river's mouth			X		X		X		X



					Cost		Scale		Time horizon		Regrets	
					Low	High	Small	Large	Short	Long	No/Low	High
Structural	Green	G1	Actively manage existing <b>wetlands</b> so as to <b>increase their resilience</b> and promote their expansion		X			X		X	X	
		G2	<b>Reduce</b> peak surface <b>runoff</b> by introducing <b>green infrastructure</b> and improving infiltration and detention			X		X		X		X
		G3	Maintain <b>beach nourishment</b> projects to reduce the impacts of coastal erosion			X			X	X		X
		G4	Create new <b>artificial wetlands</b> , namely by reconverting underused reclaimed landfill areas				X	X		X		X
	Soft	G5	----- <b>Protect existing wetlands</b> , beaches and dune systems	X				X	X		X	
		S1	Identify <b>safe routes</b> alternative to flood-vulnerable roadways and transit lines		X			X	X		X	
		S2	<b>Forbid</b> the construction of <b>basements</b> in flood-prone areas	X			X			X		X
		S3	<b>Remove</b> valuable or perishable <b>items</b> and sensitive infrastructure from basements and <b>flood-prone</b> ground floors		X		X			X		X
		S4	<b>Map risks, highlight vulnerable areas, and increase awareness</b>		X			X		X	X	
		S5	<b>Forbid new construction</b> in vulnerable areas through local planning instruments	X				X		X		X
		S6	<b>Raise awareness</b> of politicians, civil protection agents, and populations to the impacts of coastal flooding and sea-level rise		X				X	X	X	
		S7	<b>Revise building standards</b> so as to require higher ground floor clearance on new buildings or reconstructions	X				X			X	X
		S8	Implement <b>early flood warning</b> and monitoring systems (SMS, Media alerts, Sirens...)			X			X	X		X
		S9	Enact changes to <b>flood risk insurance policies</b> so as to increase accountability for "risky" location choices				X		X		X	X

# A tale of two estuaries

## Comparison of environmental planning frameworks

- **SF:** Strong **participative** process
- **LX:** Limited public **participation**
- **SF:** Participation is highly organized and dominated by **interest groups**: environmental NGOs, developers, agencies defending jurisdiction...
- **LX:** Active participation mostly dominated by **public agencies** with jurisdiction

# A tale of two estuaries

## Comparison of environmental planning frameworks

- **SF:** Expansion of mandates very difficult
- **LX:** Great leeway in the reinforcement of mandates **by the legislators**
- **SF:** Tradition of **public-private partnerships** for specific initiatives
- **LX:** Short tradition of collaboration and near **absence of private** partners

# A tale of two estuaries

## Comparison of environmental planning frameworks

- **SF:** Chain-of-command conditioned by a mix of ***bottom-up*** influences and a **limited *top-down* coordination capacity**
- **LX:** Very strong ***top-down*** coordination and decision-making but with challenges as to the balance of interests, especially among public agencies
- **SF:** Financing from the **public sector** and through **private sponsors**
- **LX:** Financing almost exclusively **public**

# A tale of two estuaries

## Comparison of environmental planning frameworks

- **SF:** Strong emphasis on preservation of **private property and rights** – protection through land acquisition
- **LX:** Respect for **common interest/ public trust** – protection through limitation of rights
- **SF:** Great **economic capacity** for environmental restoration, coastal defense and land acquisition
- **LX:** Environmental protection based on building **restrictions** and control of urban expansion



Thank you.

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