Historic Salt Marsh Decline in the Venice Lagoon

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Digital Archaeological and Historic Landscapes | Information, Society, & Culture

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Project summary: Investigating and visualizing the spatial distribution of salt marsh decay in the Venetian lagoon through geo-rectified historical maps and a 0D analytical model

BACKGROUND

The area of interest of this project is located in the north of the Venice lagoon. Among the several human interventions that deeply modified the lagoon morphology since the XIII century, the diversion of the main rivers and the construction of the jetties at the inlets had the most impacting consequences, transforming the lagoon in a much saltier environment with an extremely low input of sediments and increased depth. The consequences of these actions are particularly evident if we analyze the salt marsh areas in the available historical maps, that have been eroded over time and have extensively disappeared. Salt marshes are intertidal coastal morphological structures that develop along estuaries and lagoons, and are characterized by the presence of halophytic vegetation.
Exploring the spatial distribution of the marsh decay, we found that it has not been homogeneous over the lagoon but fairly concentrated in specific areas. In this work we will quantitatively describe the spatial distribution of the marsh decay and we will then show under what environmental conditions the decay might have happened using a 0D analytical model.

GEOSPATIAL ANALYSIS

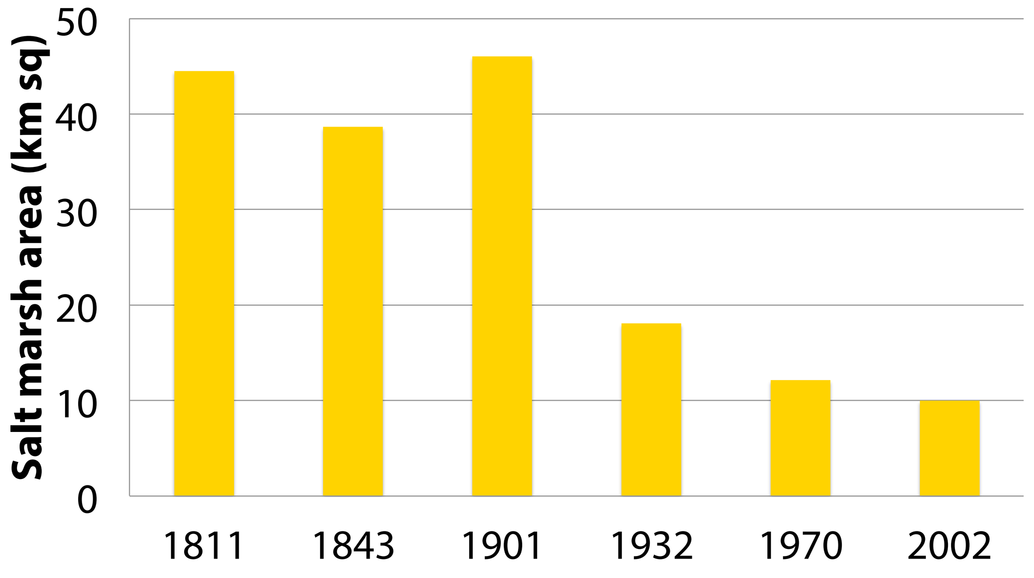


Figure 1

Methods: Analysis of this region of salt marsh is derived from five historic maps (provided by the Italian Ministry of Infrastructure and Transportation) that were geo-rectified and digitized using ArcGIS.

Results: The total area of the salt marsh decreased approximately 34 square kilometers in two centuries (Figure 1). This change did not occur homogenously neither temporally or spatially. The period that experienced the most intense decay was between 1901 and 1932.

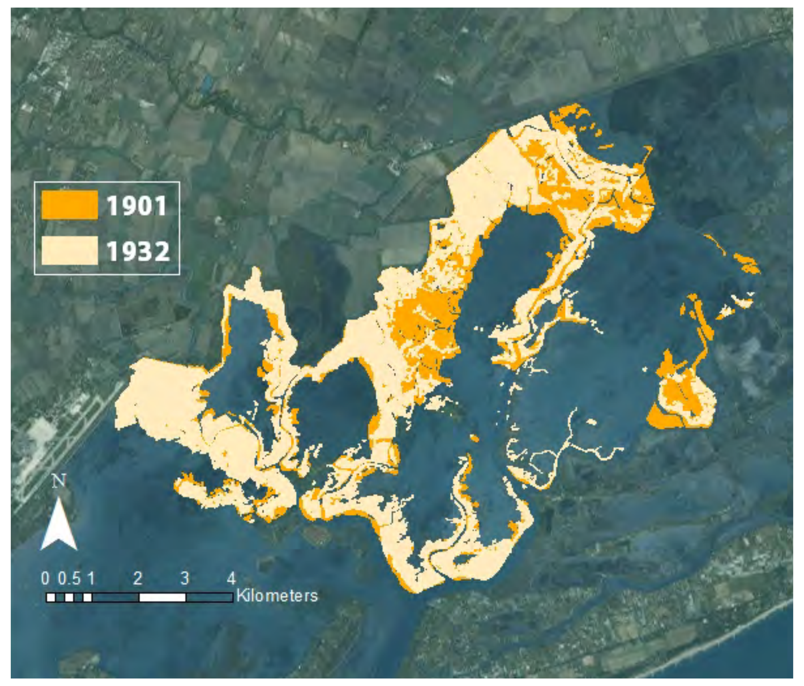


Figure 2: Decline in salt marsh area between 1901 and 1932. The region of interest is noted in orange in the northern region of the Venice Lagoon .

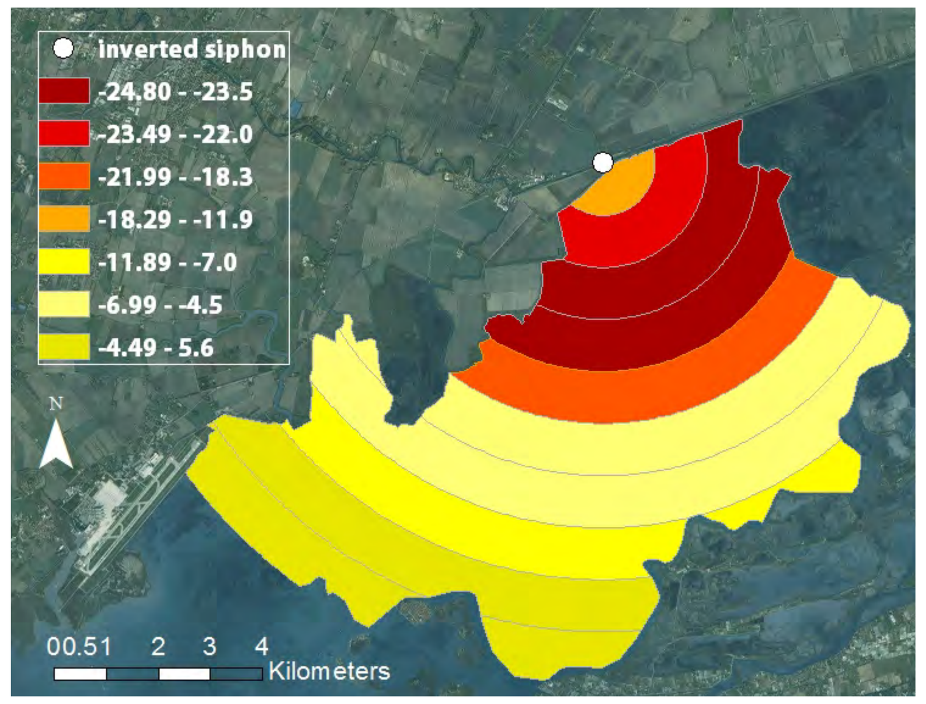


Figure 3: Ten buffer zones set in one kilometer increments from the inverted siphon's location indicate the difference in the percentage of marsh area between 1901 and 1932. All calculations were completed on ArcGIS. The output was found using a combination of "Tabulate Intersect" and "Multiple Ring Buffer".

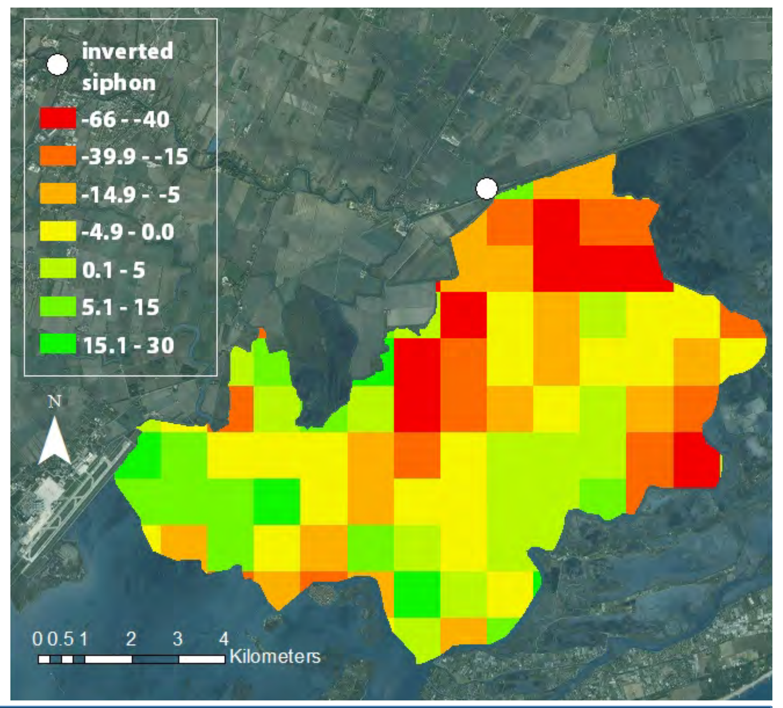


Figure 4: On ArcGIS the "Fishnet" and "Tabulate Intersect" were used to visualize the data using a grid with cells of 1 by 1 km.

METHODS

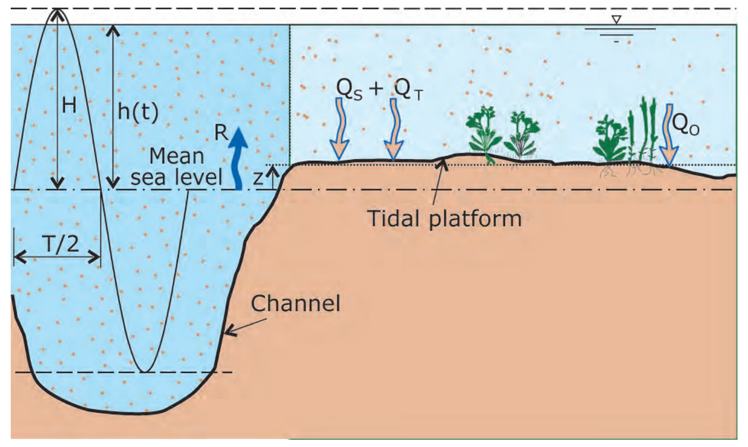
Salt marshes are resilient. Small perturbations of the system, as for example a small change in the rate of sea level rise, lead to feedback mechanisms that work to re-establish the stable state. However when the rate of sea level changes very fast with respect to the inorganic and organic accretion rates, the marsh state cannot persist and the system shifts to a different stable state, i.e. the tidal flat or the sub-tidal platform (Marani et al., 2007; D'Alpaos et al., 2011). In the timeframe considered within the scope of this project (1811-2002), we considered two main factors that have probably influenced the disomogeneous marsh decay.

1) The presence of salt increases the rate of flocculation and the overall floc sizes and hence the settling velocity (Kumar et al., 2010; Mietta et al., 2009). Christiansen et al. (2000) found that 70-80% of the sediments deposited in salt marshes are deposited in flocculated form. In the 1887 an inverted siphon "*Botte delle Trezze*" was created to drain the fresh water of an inland swamp into the lagoon. The drainage of fresh water continued till 1927, decreasing the salinity of the lagoon water near the location of the *Botte*. The lower salinity has probably decreased the flocculation processes and hence the sediment settling velocity.
2) The hydrodynamic has certainly played a central role since the lagoon depth has increased over the years due to the construction of the jetties at the north inlet (completed in the 1890). A 2D hydrodynamic model specifically developed to simulate the water flow in the historic framework of the Venice lagoon (D'Alpaos, 2010) is used here to calculate the tidal amplitude and the local mean sea level in the study area. The outputs are then used in a 0D analytical model of the salt marsh evolution (Marani et al., 2007; D'Alpaos et al., 2011) to describe the dynamic of the marsh elevation over time.

Relative Sea Level Rise

$$\frac{dz}{dt} = Q_D - Q_E - R$$

Deposition — Erosion



To simulate the Venice lagoon case, we consider a salt marsh platform subject to micro-tidal conditions, with a sinusoidal tide with semi-amplitude H lower than 0.5 m, and elevation z with respect to the local MSL (Mean Sea Level).

2D VISUALIZATION OF MARSH DECAY

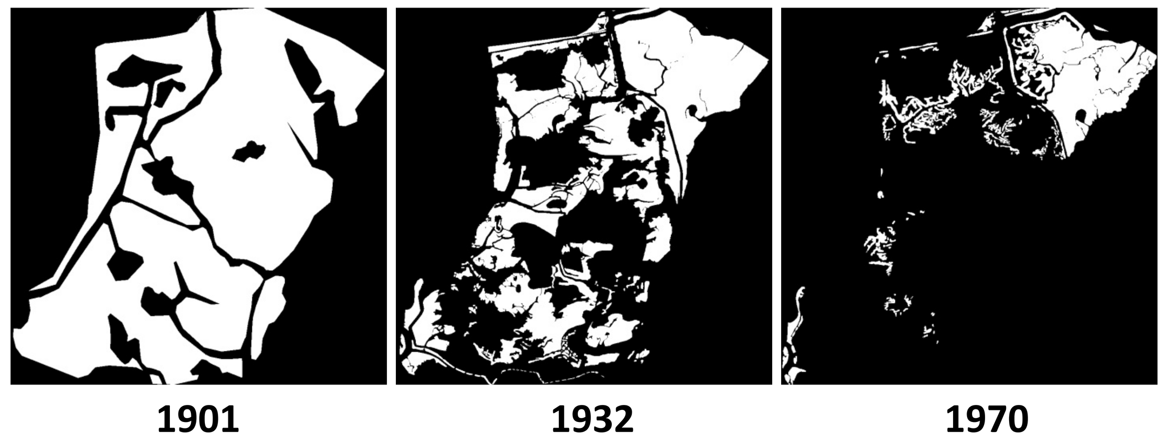


Figure 5: Comparison of the salt marsh near Valle di Ca' Zane across 1901, 1932 and 1970. The marsh decay affected the inner marsh areas excluding a lateral erosion mechanism.

3D VISUALIZATION

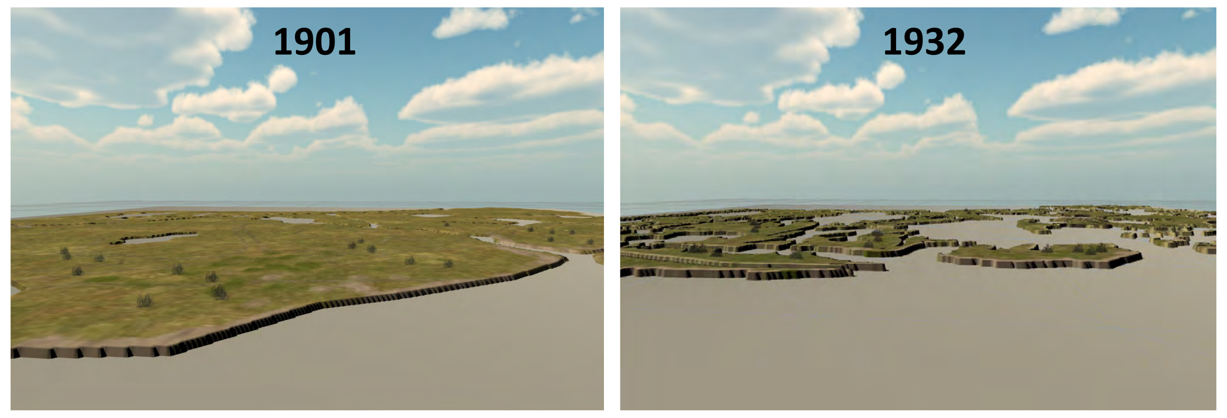


Figure 6: Comparison across 1932 and 1901: Using the spatial information from the geo-rectified historical maps, the surface levels . Differences between the marsh area across time was considered to estimate the z (or elevation) values necessary to develop a 3D reconstruction. These values were utilized in Unity 3D to generate a virtual environment of the salt marsh area (Figure 5).

REFERENCES

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Kumar, R., Strom, K., & Keyvani, A. (2010). Floc properties and settling velocity of San Jacinto estuary mud under variable shear and salinity conditions. Continental Shelf Research, 30, 2067-2081.
D'Alpaos, A., S. M. Mudd, and L. Carniello (2011), Dynamic response of marshes to perturbations in suspended sediment concentrations and rates of relative sea level rise, J. Geophys. Res., 116, F04020, doi:10.1029/2011JF002093

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