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Climate Change and Fish Farming: Venetian "Fish Valleys" as a Design Device for Coastal Adaptation and Mitigation

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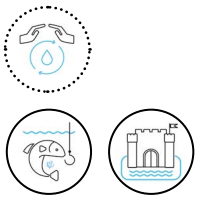
Beginning in the fourteenth century, along the northeastern Italian coastline, Venetians began to create a series of hydraulic structures called "fishing valleys," which combined aquaculture production with lagoon and seawater management. According to the current scenarios provided by the Intergovernmental Panel on Climate Change, the coastal areas, where many historic fish farms still stand, will inevitably be affected by the rise in sea level. To be preserved, coastlines will require some sort of water defense or possibly a managed retreat. Can we redesign traditional fish-farm systems as climate, economic and environmental adaptation devices? Through a series of design scenarios, this contribution explores how traditional fish farming can help redefine the territorial scale by addressing climate change and reviving existing production systems.

KEY THEMES



CLIMATE

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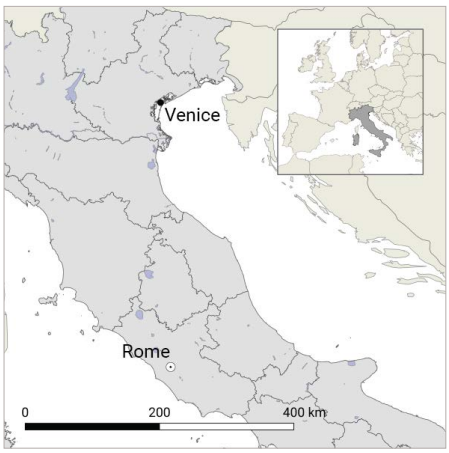


< Fig. 1 A fish valley in the northern Venetian Lagoon (Source: Alessandro Destro, 2017).

Introduction: Fish "Changes" Landscape Design

The northeastern Italian coast, which extends from the Po Delta toward the Venice Lagoon and finally the Grado Lagoon, features many historical landscape elements, including traditional aquaculture systems (fig. 2). From the Latin *vallum*, literally "wall," fish farms were created during the Venetian Republic, between the fourteenth and fifteenth centuries, as productive landscapes (Rallo 1997; Benà and Rallo 2011). Initially, the *valli da pesca* were developed for fishing with nets: in spring, the most fished species – sea bream, sea bass, goldfish, mullet and eel – need to leave the sea and look for brackish water to reproduce (Vatova 1962). The fish would then approach the mainland moving toward the large rivers that flow into the lagoon, and there, these species were captured with a system of reed trellises placed in the middle of the waters (D'Alpaos 2010). However, when the technique was refined and the Venetian Republic acquired greater institutional power, this fishing system was gradually replaced with one that involved earth embankments (D'Alpaos 2010). The valleys were transformed into stable dammed and semi-dammed structures (fig. 3), and the aquaculture practice transformed the hydraulic system into an industry that became an emblem of skillful interaction between humans and nature (fig. 4).

In spring, the fry are sown. The gates overlooking the lagoon or the sea are opened in autumn and winter. The fish pass through a channel called a *colauro*. Fishermen then close the grids (fig. 1) and harvest the fish. The mature ones are destined for sale, and the ones still too young to harvest are placed in fishponds to grow until the following spring (Vatova 1962; Fabris 1993).

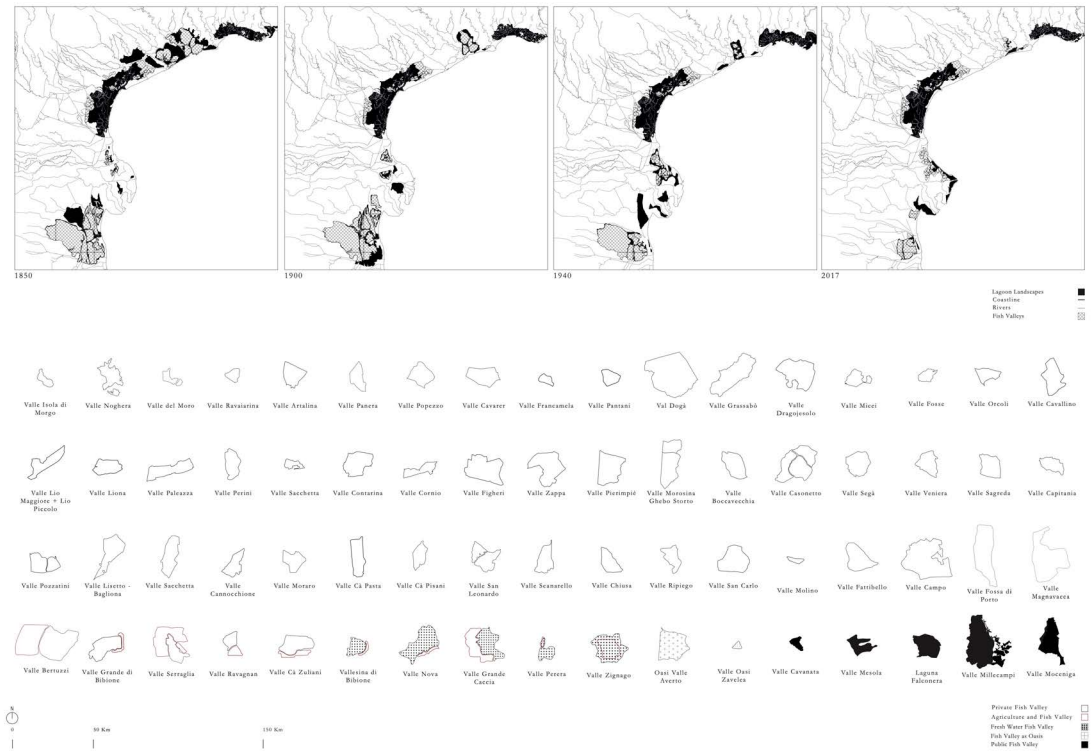
In addition to fishing, many other landscape practices have been taking place within these transitional areas between land and sea: breeding farm animals, cultivating cereals and producing rice fields and salt marshes (Provincia di Venezia 2009).

This historic aquaculture system has remained unchanged up to the present day. However, the economic crisis of fish farming at the end of the 1980s, the development of the global fish market and the growth of intensive farming have severely affected the economy of this traditional form of intensive fish farming (Cosolo et al. 2015; ICRAM 2007).

Methods

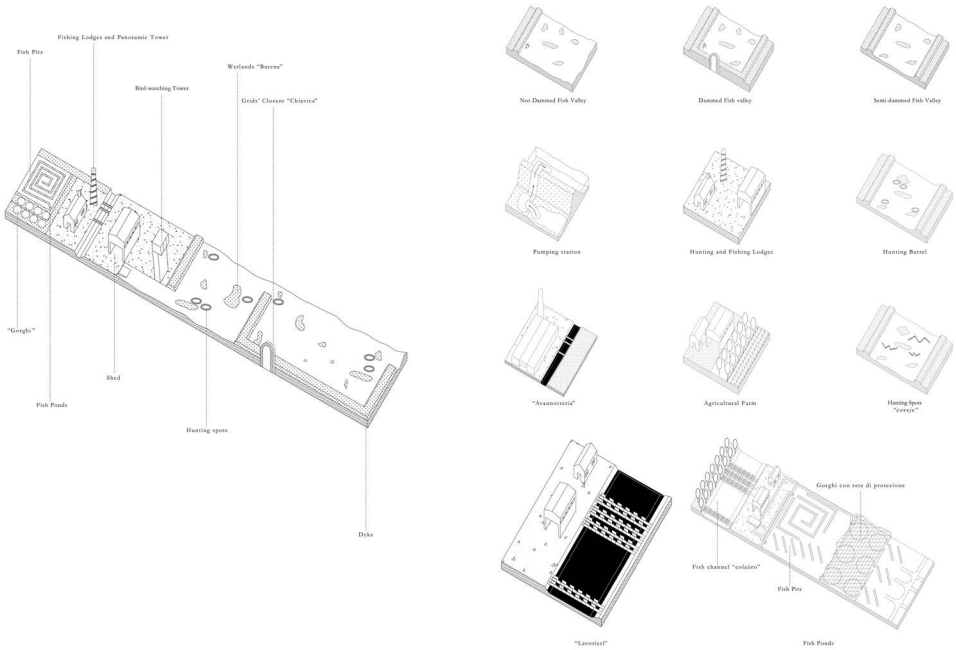
We have conducted research using multiple sources of information and methods. The "research through design" methodology involved mapping the landscape and urban systems. Ancient cartographies of northeast Italy and iconographic materials of former fish-farming systems were collected and carefully compared with the current systems. Geographic data collection and geographic information system analysis helped us investigate the landscape systems at multiple scales.

On-site investigations and fieldwork constituted the cornerstone of our knowledge acquisition and helped us adopt a "place-based approach" to the design process. An in-depth survey was conducted in the 2017–2018 academic year and partly originated from a year-long design process in northeast Italy. We traveled along the coast, observing the places of probable future climate transformation and getting to know the local people and cultures related to aquaculture systems. Our methodology included observing and studying from different scales as starting points for understanding. The survey included



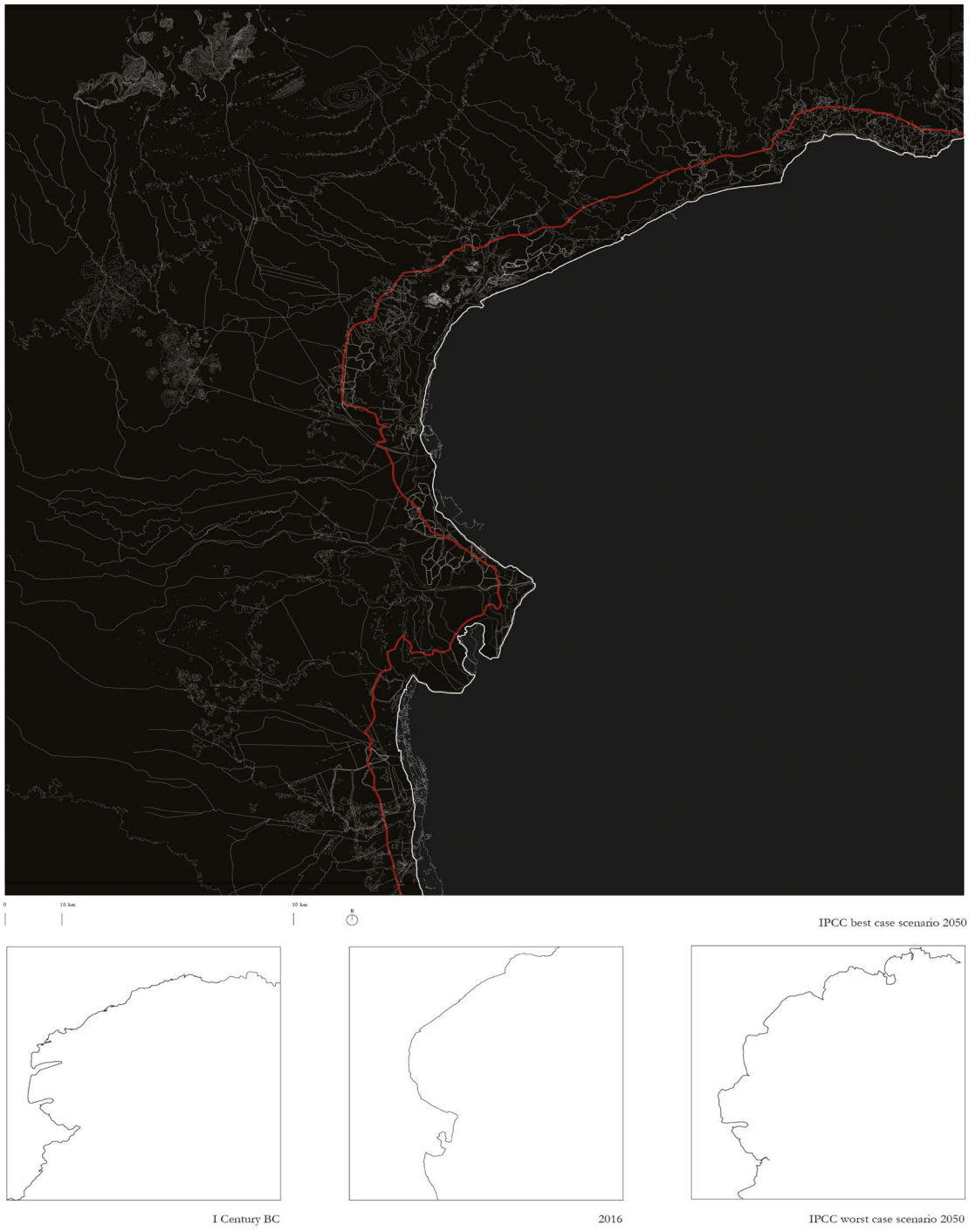
^ Fig. 2 On top, fish valleys' geographical distribution and evolution in the last 150 years (1850-1900-1940-2017) on the northeastern Italian coast. Below is the taxonomy of *valli da pesca* fish farms: today's existing fish valleys according to their different types and peculiarities (private and public fish valleys, fish valleys with agriculture, freshwater fish valleys, and fish valley oasis). (Source: Alessandro Destro, 2018. Supervised by Laura Cipriani, 2018. Edited by Laura Cipriani, 2023).

^ Fig. 3 A fish valley in the northern Venetian Lagoon (Source: Alessandro Destro, 2017).



^ Fig. 4 *Valli da pesca* typologies and elements (Source: Alessandro Destro, 2018. Supervised by Laura Cipriani, 2018. Edited by Laura Cipriani, 2023).

^ Fig. 5 Fishermen at work in a canal of the fish valley (Source: Alessandro Destro, 2017).



^ Fig. 6 On top, in red, is the 2050 coastline assuming a one-meter sea-level rise. Below are the palimpsests of the past and future (Sources: Laura Cipriani, 2018 and Alessandro Destro, 2017).

photographic investigations and sampling, and a study of water quality and plant species to comprehend the phenomena associated with the *vallicoltura* systems – this peculiar type of extensive fish farming practiced in the upper Adriatic Sea in brackish water basins and enclosed by embankments.

Another source of knowledge was interviews with local people involved in the fish farm industry: fishermen (fig. 5), workers, owners, concessionaires, public authorities and local economic players such as restaurateurs and historians of the "Museo del Territorio delle Valli e della Laguna di Venezia" fish farms museum.

Our literature review considered multiple sources of information, including non-academic sources, such as newspapers and documents, which helped us understand the mechanisms underlying the current crisis facing the aquaculture system and the opportunities that may exist for it.

Who Owns the Landscape between Water and Land?

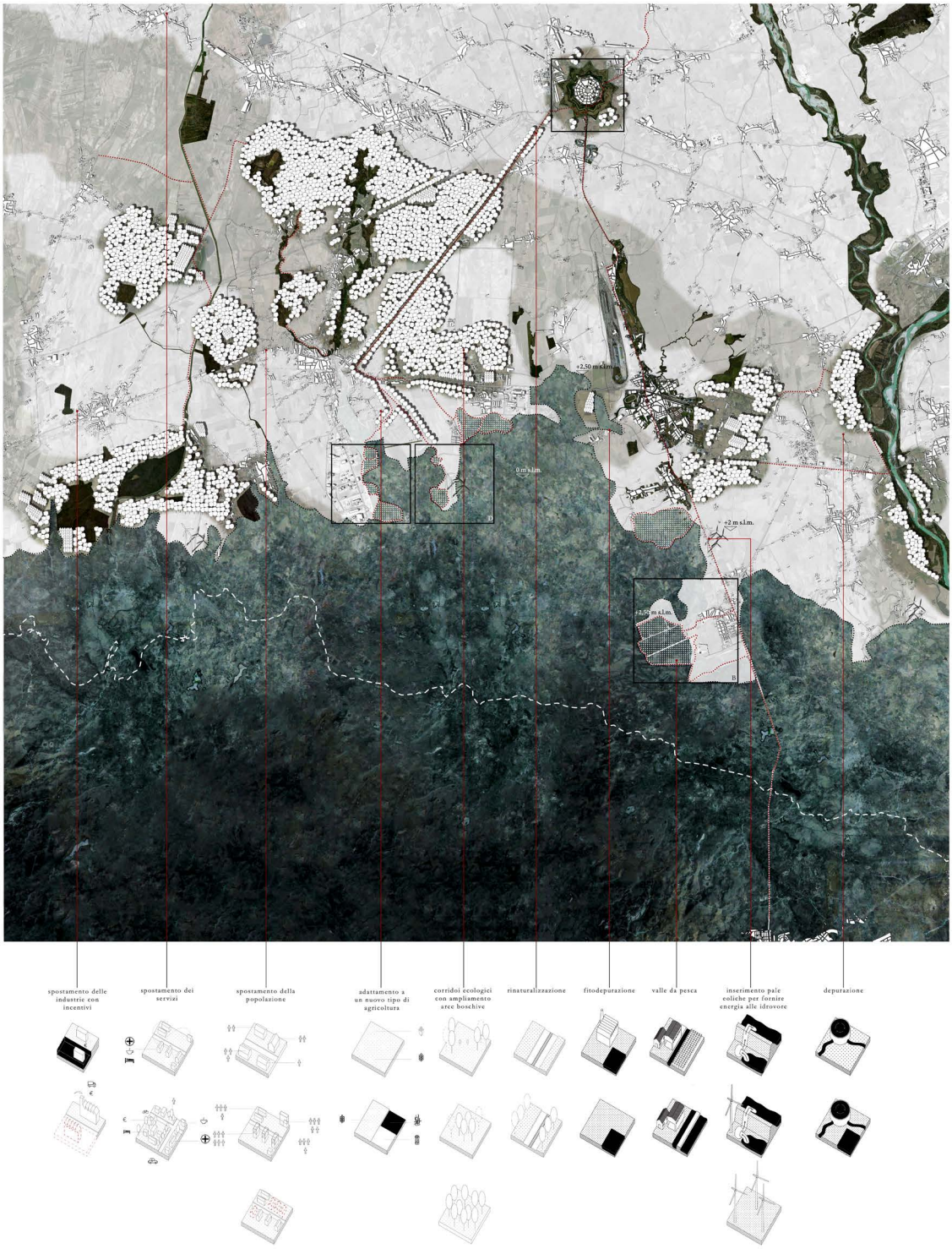
The ownership, hydrology, ecology, conservation and management of fish farms are highly debated. Who owns the landscape between water and land?

Initially, fish farms were lagoon parcels temporarily delimited by reed fences that prevented the expansion of the tide. The hydraulic resistance of the structures reduced sea-lagoon exchanges (D'Alpaos 2010). The Serenissima Republic soon regimented the valley areas, partly as state property and only to a small extent as private property (Rallo 1994, Fortibuoni et al. 2014, Rivoal 2021). Most structures are today private (Alpa et al. 2010), creating conflicts between the public and private sectors that also underlie significant hydraulic problems. The progressive embankment of the fish farms has effectively privatized and modified the hydraulic regimes of the lagoons and transition zones subjected to the action of the tides. The stable embankments of the fish farms limit the expansion of the waters coming from the hinterland upstream as well as of the brackish tidal waters coming from the sea. In addition, ongoing climatic changes necessarily require giving progressively more room to upstream and downstream waters (D'Alpaos 2010).

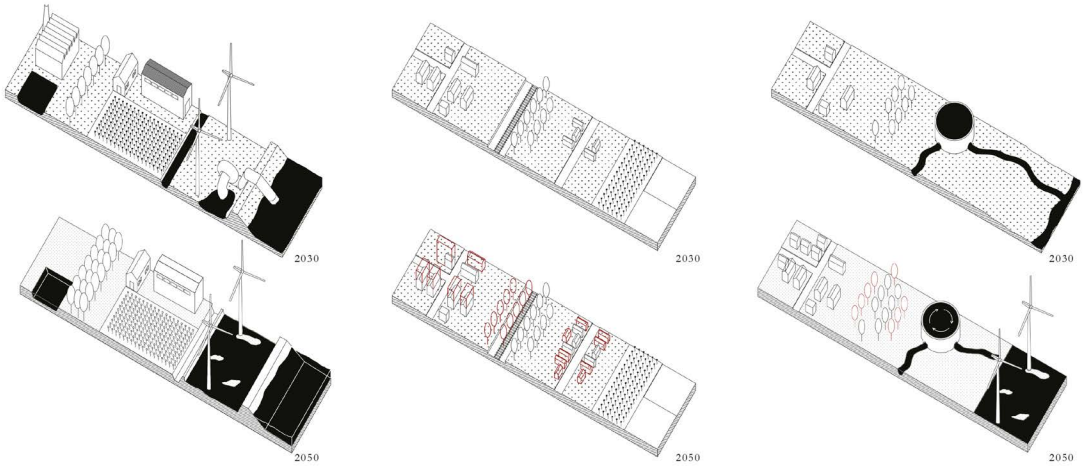
A further conflict is ecological. Today, the economy of the fishing valleys is mainly based on the income deriving from the rental of the valleys for hunting, which because of its frequency and intensity causes many ecological and environmental problems for birds and causes excessive lead pollution of the waters (Arpa 2023). This activity runs counter to European biodiversity conservation regulations since the fish farms in northeast Italy are in Sites of Community Importance and Special Areas of Conservation as part of the Habitat Directive, forming a network of protected sites called Natura 2000 (Regione Veneto 2020; Regione Friuli Venezia Giulia 2018; Regione Emilia-Romagna 1993). Furthermore, some of the fish farms are located near industrial or otherwise polluting areas. The farms near the Porto Marghera industrial area in the Venice Lagoon are examples. Finally, there is a regulatory conflict since the regional and local urban and landscape plans often overlap and differ in their protections for fish farms and their systems.

Fish Farming in Future Scenarios

What other management approach can be considered for the future? Should fishfarms be preserved or transformed? Can we redesign traditional fish-farming systems to make them ways



^ Fig. 7 Retreat scenario in the Marano Lagoon and the fish farms' transformation (Source: Benedetta Bertellini, Roberta Bertoglio, Alessandro Destro, Francesco Fagotto, Francesco Moretton and Matteo Tosoni, 2017. Supervised by Laura Cipriani, 2017).

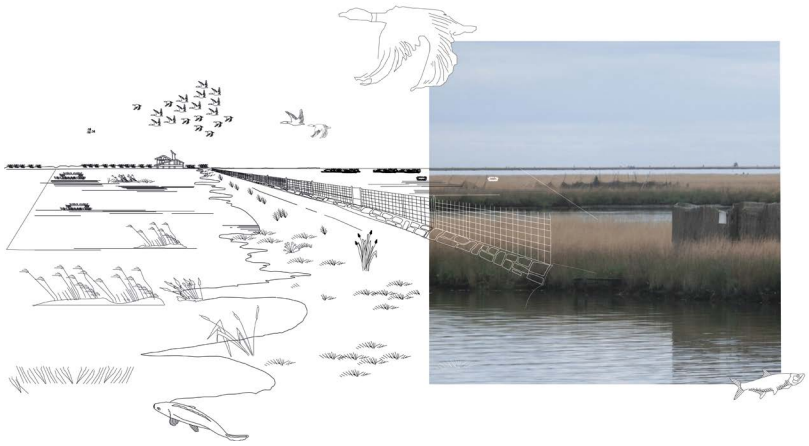


^ Fig. 8 Transformation of a fish valley in the Venetian lagoon (Source: Alessandro Destro, 2018. Supervised by Laura Cipriani, 2018).

of adapting to changes in climate, economy and environment? All cultural landscapes are products of progressive adaptation. Looking at the past teaches us that the Venetian fish farms have never been static systems but rather have evolved to meet the needs and technical-technological refinements that have taken place over time.

Sea-level rise will change the coastline and transform the territories and legislative and administrative systems of the areas concerned. According to the Intergovernmental Panel on Climate Change (IPCC 2014, IPCC 2022), northeast Italy will be one of the places most affected by climate change and sea-level rise. Assuming an increase in temperature of 1.5 °C, the coastline of 2050 will move to a position corresponding to the geo-morphological palimpsest of the first century BC, when the marine waters of the Upper Adriatic were at a much higher altitude than the current mean sea level (fig. 6). Just as in the past the great hydraulic engineers of the Venetian Republic diverted the main rivers that carried sediments into the lagoon to preserve Venice from silting up, so today, some areas of the coast of northeast Italy might reinterpret and adapt the historical tradition.

The project we have presented (Destro 2018; Cipriani 2019) proposes a series of scenarios for the medium to long term for the Venice Lagoon, the Marano Lagoon and the Po Delta to try to take advantage of the new environmental conditions by welcoming or rejecting the water that will come. Many agricultural lands in the water–land transitional areas can be made into fish farms because of the dikes present and the water adaptability and productivity of the area (fig. 7). Farms could be transformed into fishing valleys; this would involve raising their embankments, allowing coastal protection (fig. 8), and activating economies already present in the area (fig. 9). Extending the fish valleys into a territorial system can be a valid climate adaptation tool for coastal protection and a crucial climate mitigation tool for carbon sequestration and storage. Finally, aquaculture's traditional hydraulic, agro-pastoral and economic functions are expected to be transformed with new technological processes such as integrated multi-trophic aquaculture systems (Neori et al.



^ Fig. 9 Fish Valley and its adaptation (Source: Alessandro Destro, 2018. Supervised by Laura Cipriani, 2018. Edited by Laura Cipriani, 2023).

2004; Nesar and Marion 2016) for water purification, biomass (algae) growth and energy production. From their humble origins as small landscape devices, fish farms could ultimately help redraw the coastline on a territorial scale.

Conclusion: Select the "Active Part" of the Past

The projects presented concerning the fishing valleys of northeast Italy induce a series of reflections that transcend the single case study with regard to the themes of water and heritage.

First, all cultural landscapes are the product of progressive adaptation led by social, economic, and technical-technological needs. Preserving does not mean leaving the past unchanged, but rather innovating tradition with an eye to the future. The designer's task is to know how to *select the "active part" of the past*. That means understanding and deciding what are the dynamic parts of the landscape's past and how and if they can be preserved while embracing the transformation according to new uses, forms, and scales of the present. Heritage also extends to all of a landscape's living and non-living systems: plants and fishes can be considered the heritage of an ever-evolving cyclical process. The cultural value lies in adapting site-based landscape devices to meet future challenges in the short, medium and long term.

Second, a close-scale landscape micro-device can change the territorial scale and, in this case, suggest a possible climatic adaptation.

Third, the economic sustainability of a landscape device is an essential element of adapting the past for the future. In plans aimed at mitigating and adapting to the climate crisis, protection from damage must be combined with the production of economic value. Only a plan to generate new economies and innovations can ultimately be effective.

Finally, to respond effectively to climate urgencies, administrators, institutions, planners, associations, communities, individuals and living entities must design and collaborate with the landscape. This implies the need for new governmental and legislative tools for the future.

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