Venice and the lagoon: interdisciplinary design for a sustainable future

The Perfect Lagoon and The Symbiotic System

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Publication date
2023

Document Version
Final published version

Citation (APA)
Buis, L. (Author), Draisma, M. (Author), van der Ent, N. (Author), van der Hagen, J. (Author), Hartmeyer, L. (Author), Kaletkina, A. (Author), Iuorio, L. (Author), Wüthrich, D. (Author), Hooimeijer, F. L. (Author), & More Authors (Author). (2023). Venice and the lagoon: interdisciplinary design for a sustainable future: The Perfect Lagoon and The Symbiotic System. Web publication/site, Flows. https://flowsplatform.nl/#/venice-and-the-lagoon--interdisciplinary-design-for-a-sustainable-future--the-perfect-lagoon-and-the-symbiotic-system-1677062523282_____

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Source: Buis, L. et al. (2023, February). *Venice and the lagoon: Interdisciplinary design for a sustainable future*. Flows Platform. Retrieved January 17, 2024, from https://flowsplatform.nl/#/venice-and-the-lagoon--interdisciplinary-design-for-a-sustainable-future--the-perfect-lagoon-and-the-symbiotic-system-1677062523282_____

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Venice and the lagoon: Interdisciplinary design for a sustainable future

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Venice is representative of the result of anthropocene acts on a vulnerable delta system. Therefore it is an excellent study case for a multidisciplinary team of TU students and tutors, to perform interdisciplinary research and design. Two visions were developed on the shared knowledge base to investigate 'how do flood defense systems influence the spatial aspects of the territory in the context of a high dynamic landscape in the Anthropocene?'

The plan for the *Perfect Lagoon* is focused on tackling all of the current and upcoming problems where the emphasis lies on preserving and perfecting the lagoon in its natural assets by introducing a new dike system that enforces the natural ecosystem. It makes smart use of the sediment flows and tackles erosion. The interdisciplinary design is especially worked out in the section of the dike, where dimensions and functionality are designed from a shared engineering and landscape perspective.

The plan *Symbiotic System* emphasizes the interconnectedness of the Veneto region in a sustainable way. The new transport/dam system will make the urban system more smart, it will be less burdensome, and give more space to the natural ecosystem of the lagoon.

Both visions are a testimony of how flood defense systems have a major influence in the spatial aspects of the territory. Using the multidisciplinary approach, an integral design can be made for the flood defense, in which the opportunities for the territory can be first explored and then designed together with hydraulic infrastructures.

1. Introduction

The city of Venice, Italy resides in the center of the Venetian lagoon which is connected to the Adriatic Sea by three constructed inlets: Chioggia, Malamocco and Lido (Martini et al., 2004). The water which once brought protection and prosperity to the city, has now become a major threat due to the effects of climate change inducing the sea level rise (Allan et al., 2021). Combined with the effect of the steady subsidence of Venice, the city now floods more frequently. As a measure, a storm surge barrier project MOSE was designed in 1984 for 60cm of sea level rise. While the MOSE forms a protection for the coming years, it only closes at very high tides and doesn't protect the city from the effects of storm surges. It also is not enough to save Venice and the lagoon from the upcoming sea level rise under the current projections, which show that it has just a couple of decades left to find a new solution (about 30 years, Allan et al., 2021).

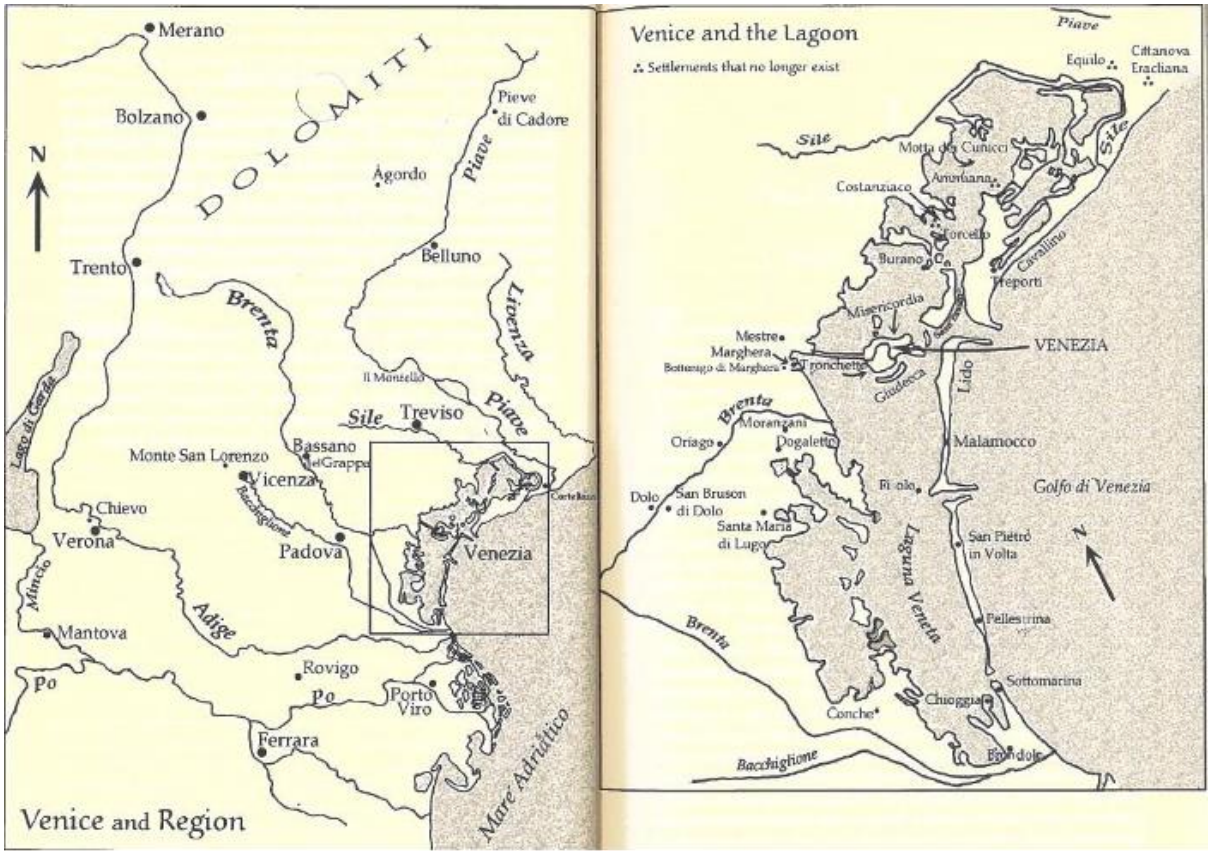

Figure 1. The Venice lagoon area represented by Ferguson (2009).

2. Territorial analysis

In the wake of industrialization of the 19th century, economic and infrastructural interests started to tip the scale on the fragile balance of the lagoon knowingly, by for example dredging lagoon inlets to allow for the passing of bigger ships, and unknowingly, by allowing motorboats in the lagoon that destroy both the building fabric of Venice as well as the barene around it or by employing aquifers, which amplify ground subsidence in the lagoon. This resulted in the ongoing destruction of a unique ecosystem. While some efforts have been made to preserve and restore the lagoon, no far reaching process, neither in planning nor actual projects, has been made as of today. The problem analysis presents a communicating set of impacts that affects the lagoon and Venice. Other issues besides the sea level rise are described in the table below.

Sediment Budget	Severe erosion of the lagoon, leading to degradation of salt marshals.
Salinity Problems	Following the Brenta diversion, the salinity in brackish water increased, affecting the current ecological system.
Sea Level Rise	Sea level rise drowns the lagoon as well as the city of Venice.
Subsidence	Subsidization of Venice accelerates the problem of sea level rise as these two factors work in opposite directions.

Canal and channel system	Dredging of canals led to massive erosion and a more turbid water column.
Pollution	Polluted sediment created by Porto Marghera and industry impacts ecology and public health.
Loss of ecology	Degradation of habitat, exotic species infiltrate and take over the area.
Heritage	Strong heritage which conflicts with many technical solutions.
Venetian inhabitants	Boat traffic creates waves which erode the salt marshes.
Tourism	Over-tourism exacerbates housing problems for residents.
Acqua alta	Storm surges flood lower lying parts of Venice causing damage to historical buildings and housing.

Table 1. The problems of Venice and the lagoon (Buis et al., 2021).

The shared territorial analysis of the group of students consisting of architecture, landscape architecture, construction management, hydraulic structures, coastal and riverine engineering resulted in two interdisciplinary design visions, forecasting the physical inheritance of Venice and its lagoon into the future (Buis et al., 2021).

3. Two visions for a sustainable future

The general challenge of both proposals is finding the balance between maintaining the lagoon as it is today and allowing it to change in order to cope with the climate change scenarios of the near future. Both visions present radical ideas on how to deal with landscape and the urban environment, with one leaning more towards controlling natural processes and the other more towards enabling them.

The perfect lagoon

The Perfect Lagoon proposes a paradigm shift from a world where we constantly fight and work against nature, to one where we live *with* and work *with* nature.

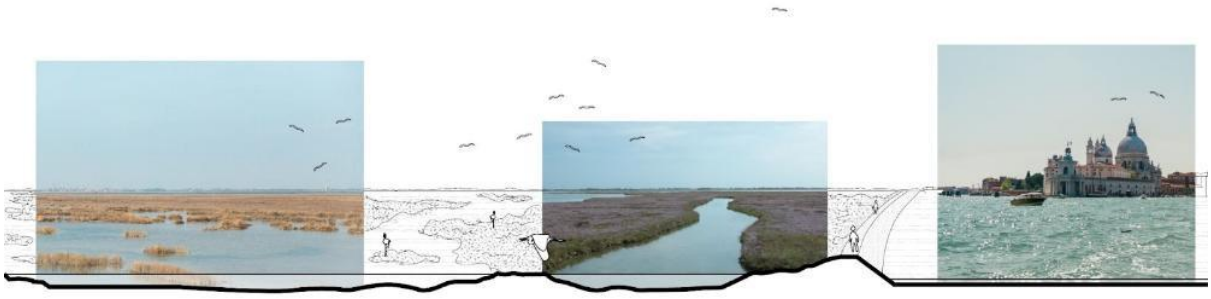

Figure 2. Vision diagram The Perfect Lagoon (Buis et al., 2021).

Figure 3: Impression of The Perfect Lagoon looking over the salt marshes onto the dike and the historic city of Venice (Buis et al., 2021).

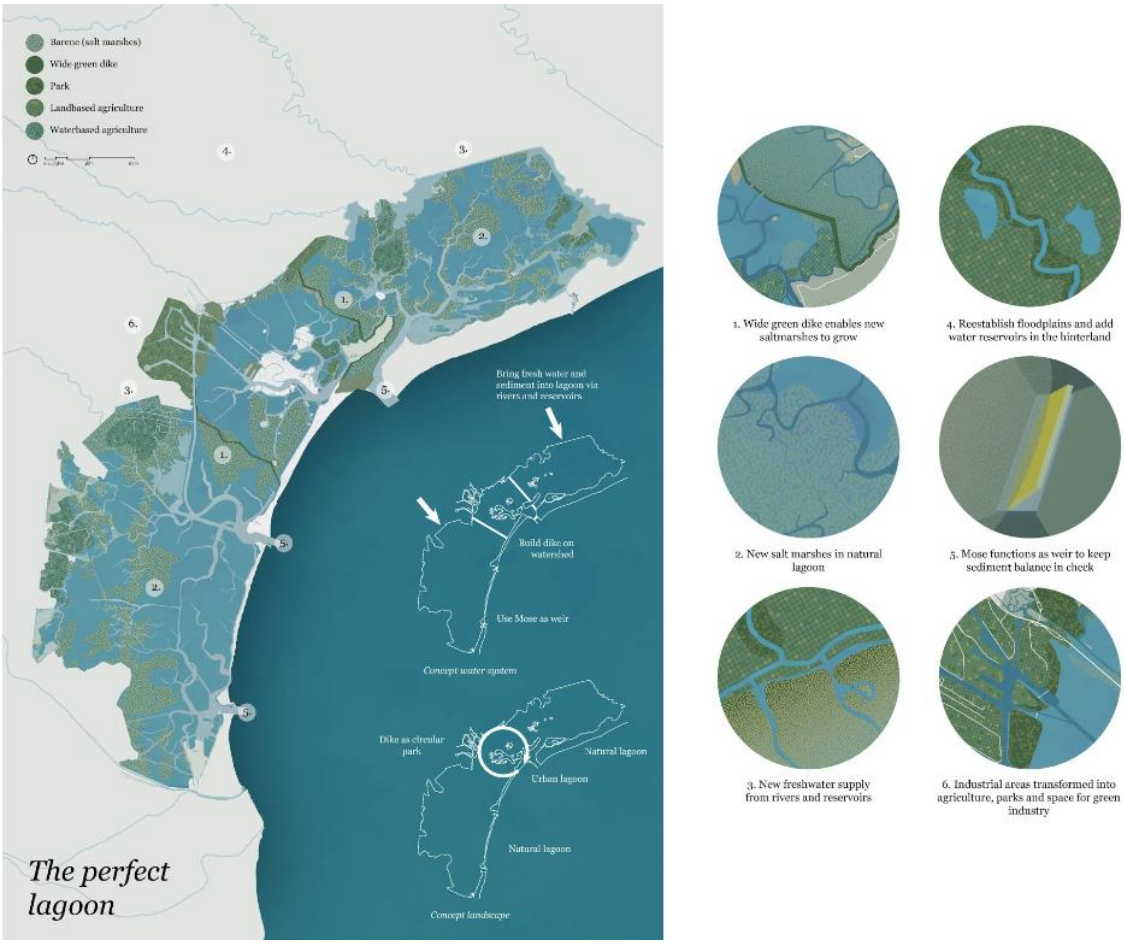

Figure 4. Overview map perfect lagoon depicting most important interventions (Buis et al., 2021).

The lagoon is divided in three parts by a dike protecting the central part around Venice from sea level rise, while leaving the more natural Northern and Southern parts exposed to the sea. This is necessary to preserve and enhance the characteristic landscape of the lagoon, the *barena* or salt marsh, and harness its potential for flood protection and nature development.

While the overall emphasis of the Perfect Lagoon lays on nature development, the further detailing of the plan also suggests three strategies to allow for human development, mostly located in and around the dike: allocate spaces for nature-inclusive farming and fishing (*productive lagoon*), establish spaces for slow tourism, recreation and nature education (*liveable lagoon*) and create a self sufficient drinking water system as well as swim water quality in the lagoon (*cleansing lagoon*).

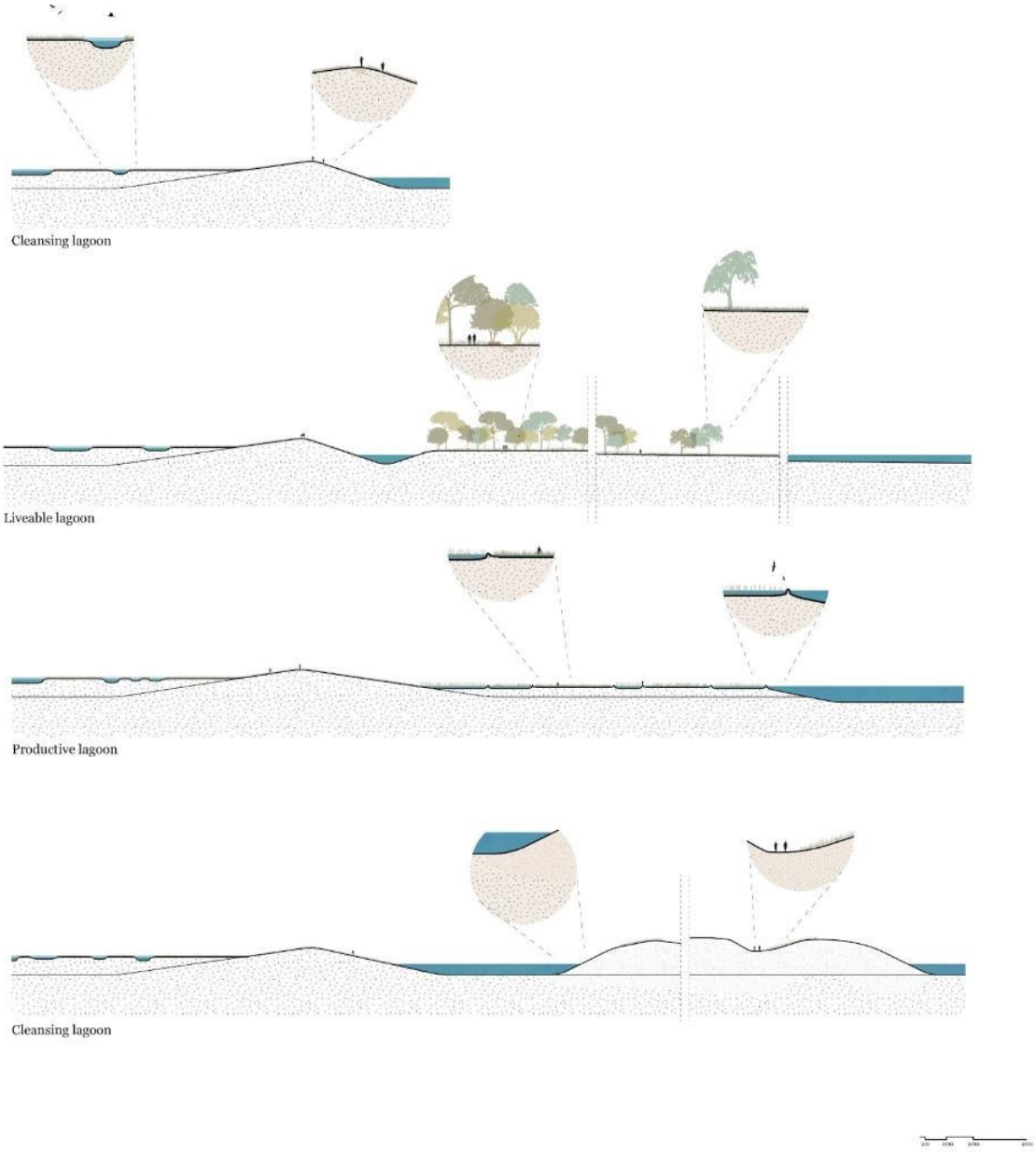

Figure 5. Sections depicting the dike with its various functions embedded (Buis et al., 2021).

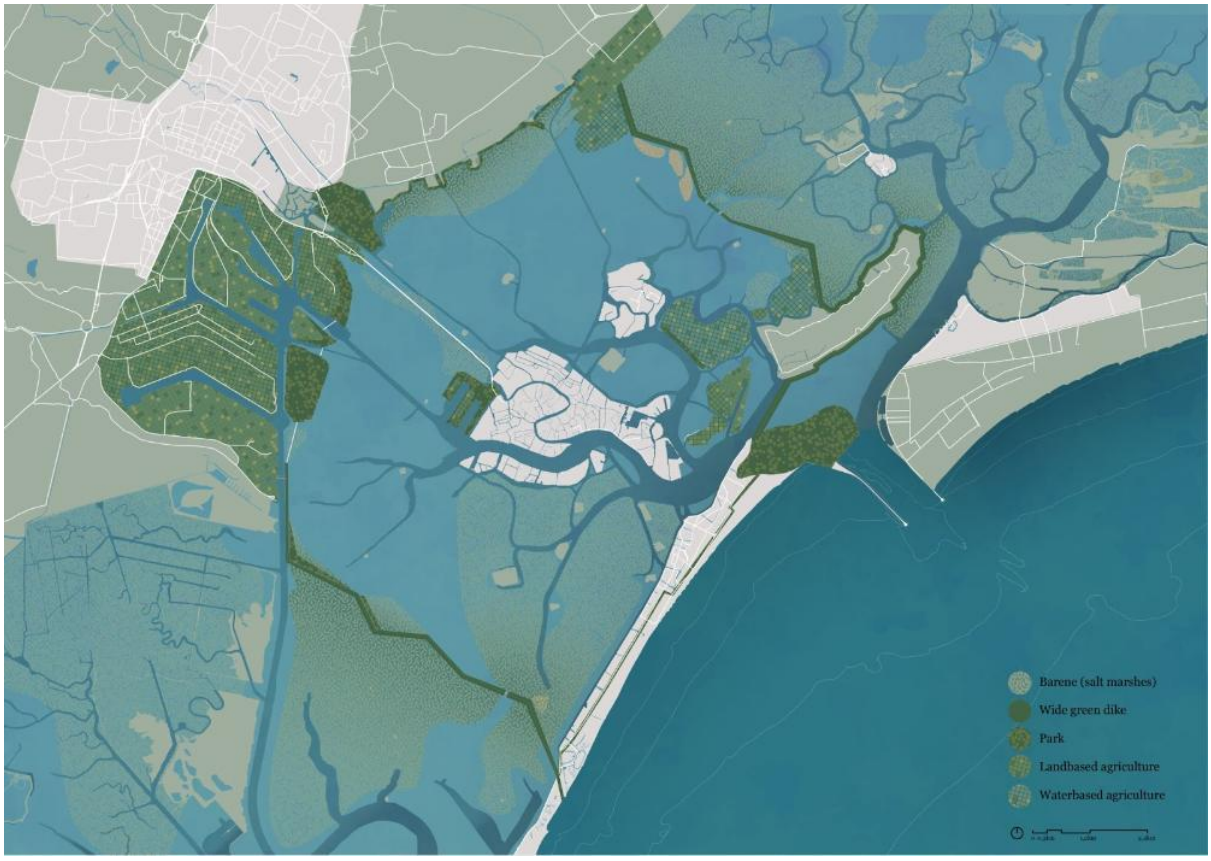

Figure 6. Plan depicting dike around Venice with various functions embedded (Buis et al., 2021).

Salt marsh preservation and growing new salt marshes in the Northern and Southern part of the lagoon are essential to the plan. Specific salt-tolerant plants within the *barene* can trap sediment, which means that the marshland can grow with sea level rise and restore itself over and over again. For this the current negative sediment budget needs to be balanced especially in the Southern part of the lagoon, which will be achieved by reconnecting the rivers Brenta and Piave to the lagoon, as well as repurposing the MOSE as a submerged weir.

Reconnecting the rivers will also improve the fresh water supply to the lagoon and with that the quality of the brackish water, which is critical for providing a healthy habitat for the diverse plants and animals of the *barene*.

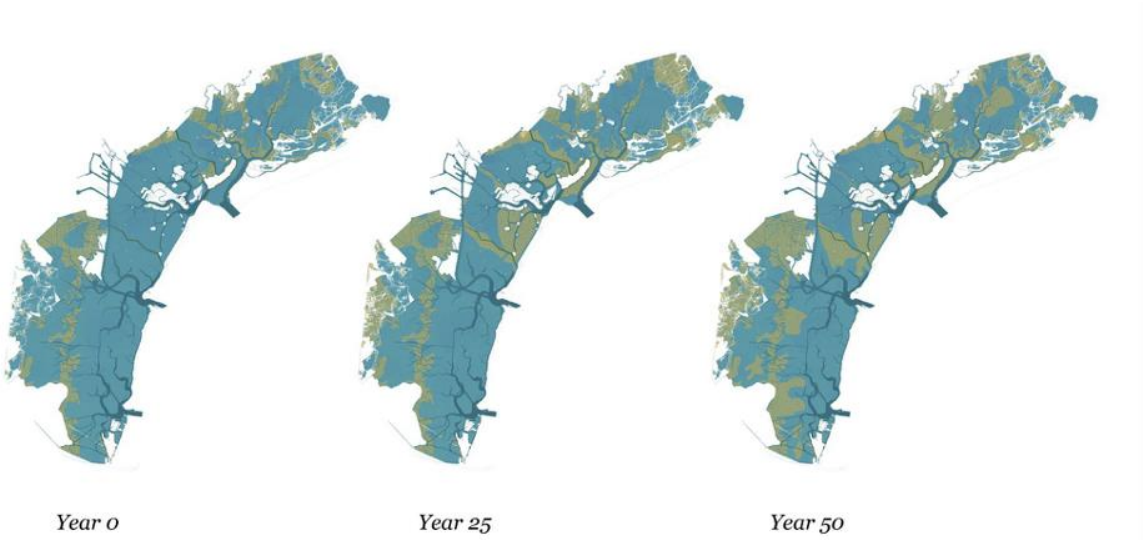

Figure 7. Scheme for regeneration of salt marshes over the first 50 years (Buis et al., 2021).

Figure 8. Impression of the wide green dike with agriculture (water-based farming) and recreation (hiking path) embedded in it (Buis et al., 2021).

For this proposal it is essential to move the Porto Marghera to another location. The former port can be reused for high-tech food production, reducing the need to farm in the lagoon. The Lido furthermore plays a role as a barrier island essential for the dike system. The expectation is that the dune face in the

south of the island will provide enough protection against sea level rise, while the back of the island will be protected with a double-dike.

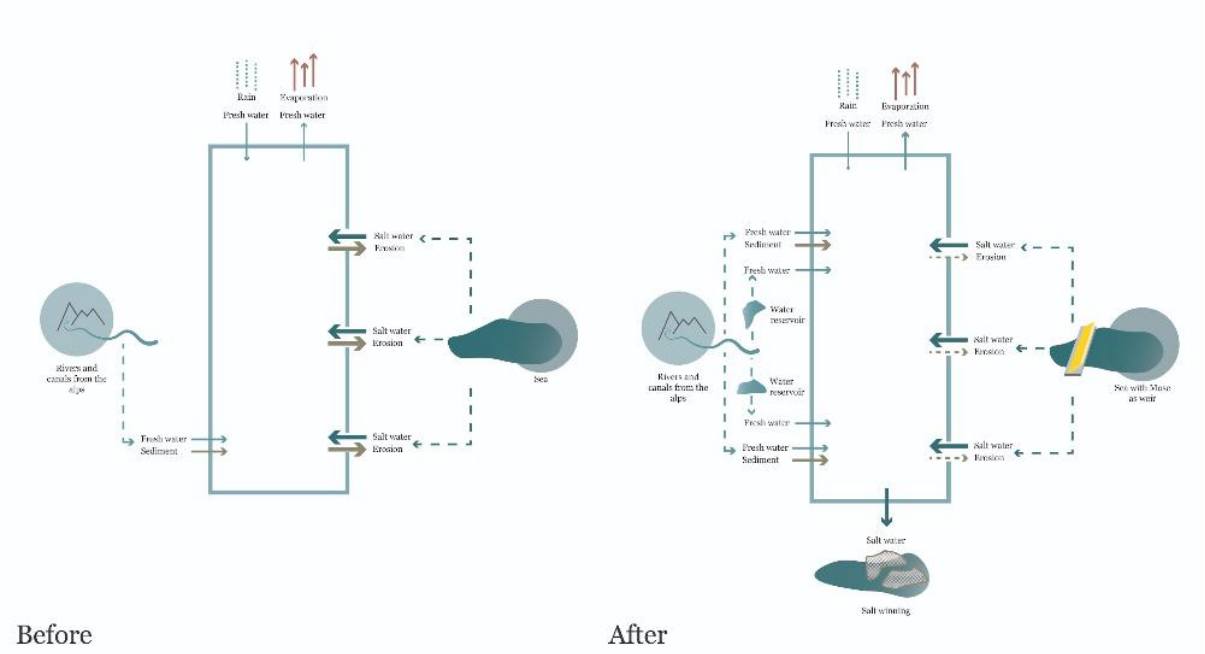

Figure 9. Conceptual before and after diagram restoration sediment and freshwater balance (Buis et al., 2021).

The symbiotic system

The Symbiotic System preserves the historical traditions and aesthetics as much as possible while creating a sustainable and modern metropolitan area by placing a dam and better connections between the islands and with the hinterland. The existing boat routes are preserved as much as possible and new bridges are added. This way, mass tourism can be managed better by zoning, easier distribution and adding functions to surrounding islands. This will increase the quality of life of the locals as they will literally and figuratively have more space.

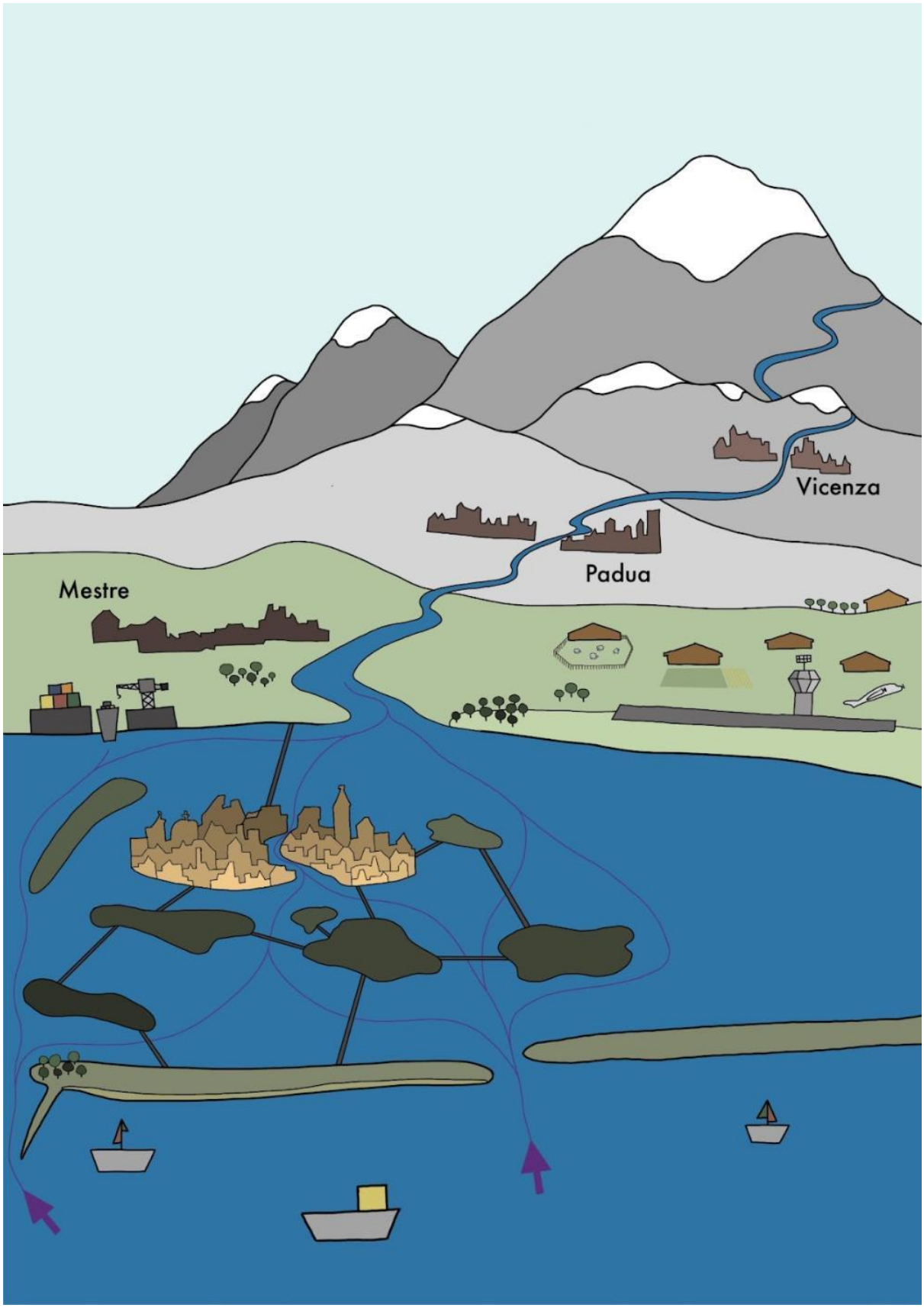

Figure 10. Territorial vision of the Symbiotic System (Buis et al., 2021).

An important goal of this modernization is to create new sustainable systems that are independent from the rest of the lagoon which will enable it to restore itself and find a new balance. This might mean that eventually the lagoon will be swallowed by the Adriatic sea.

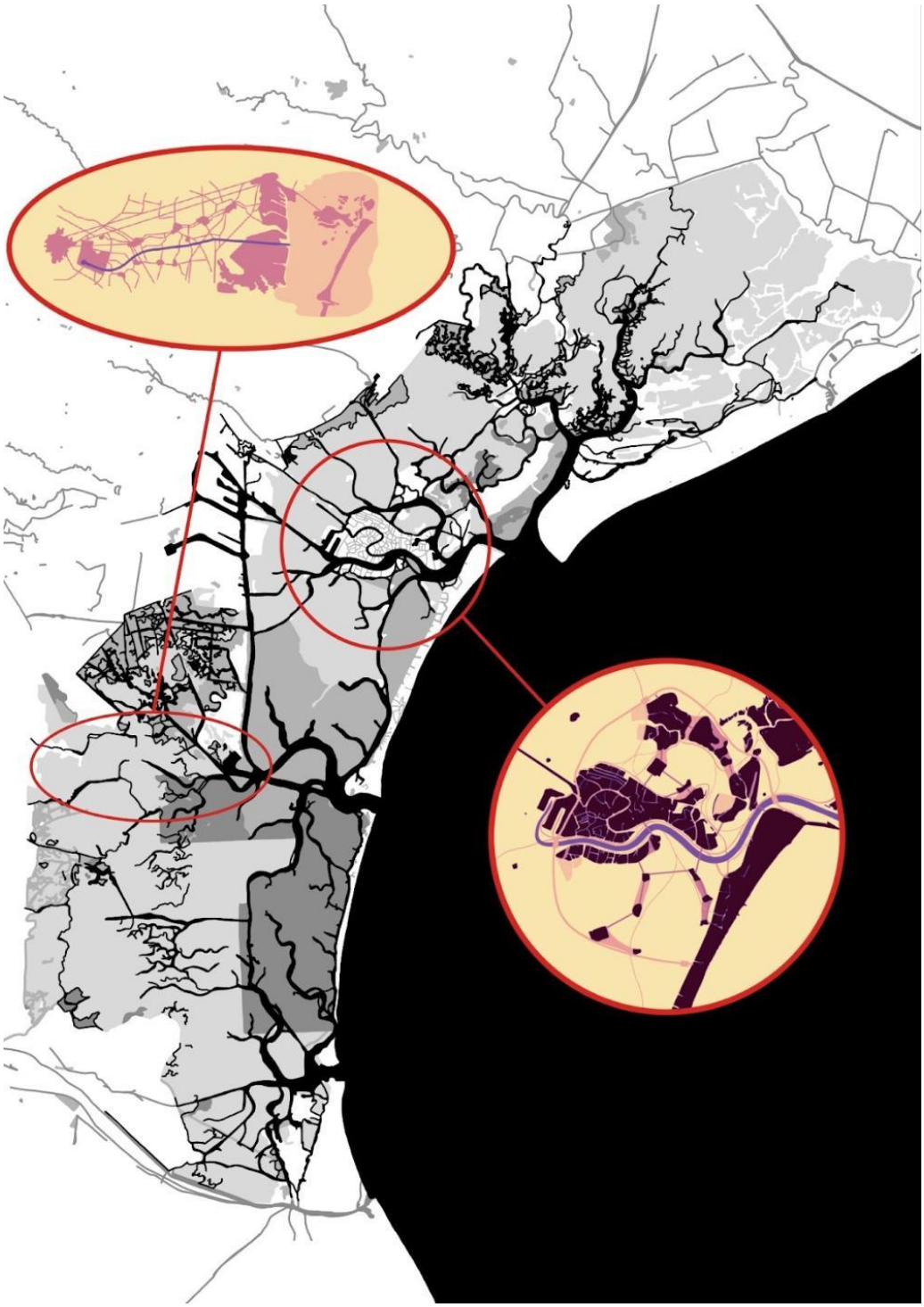

Figure 11. Overview Symbiotic System (Buis et al., 2021).

The main intervention of this vision is placing an encircling dam to control the water levels around Venice. This dam is multifunctional and offers new infrastructure: a metro system, promenades and new space for housing. Walking bridges are added to connect the islands and create a future proof

metropolitan network. Lido functions as a barrier island and is included in the dam-network. To allow ships to navigate towards Porto Marghera the MOSE is without a purpose. When sea level rise renders the MOSE unable to function as a storm surge barrier it should be heightened to use as a secondary storm surge barrier for the next 100 years. This way, during extreme storm surges combined with the effect of sea level rise, MOSE could protect the primary coastal defense, preventing possible overflow/failure from happening.

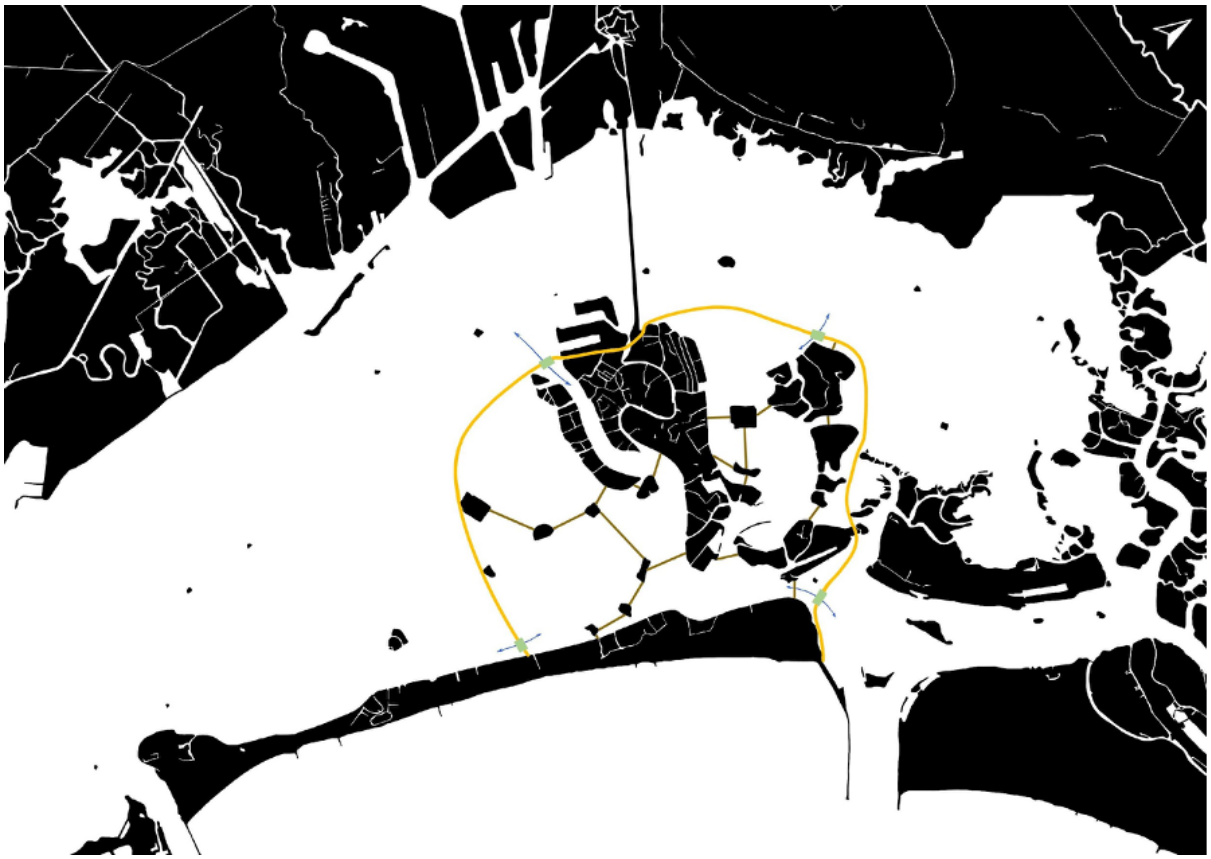

Figure 12. New dam (orange) and bridges (brown) network (Buis et al., 2021).

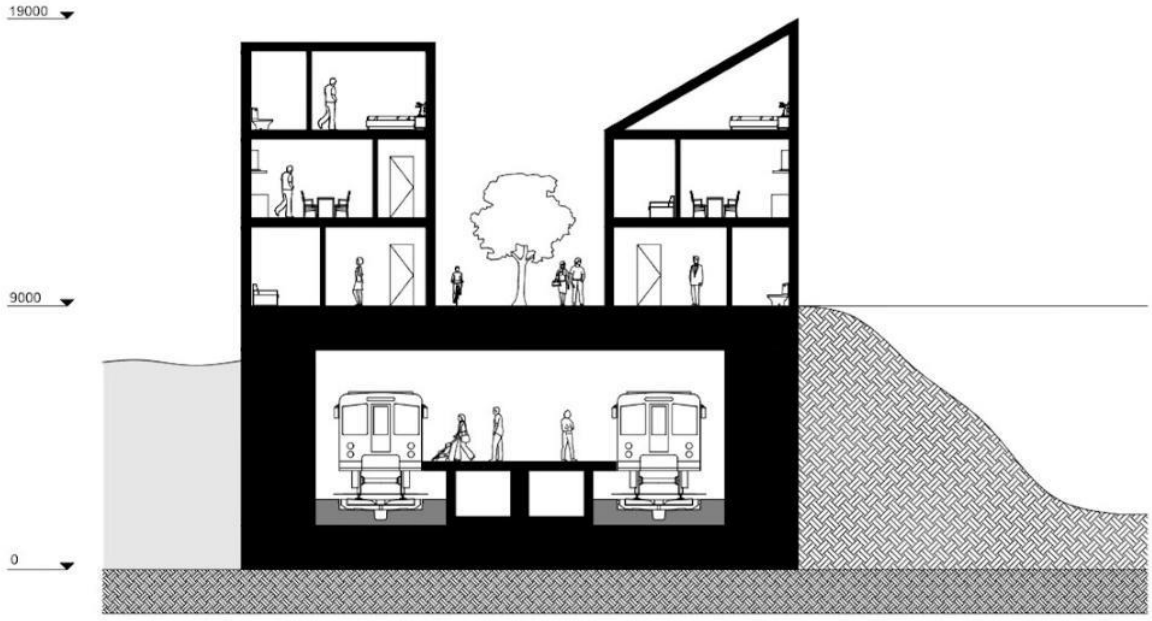

Figure 13. Section 1: metro line inside the dam, buildings on top of the dam, park connection to the island (Buis et al., 2021).

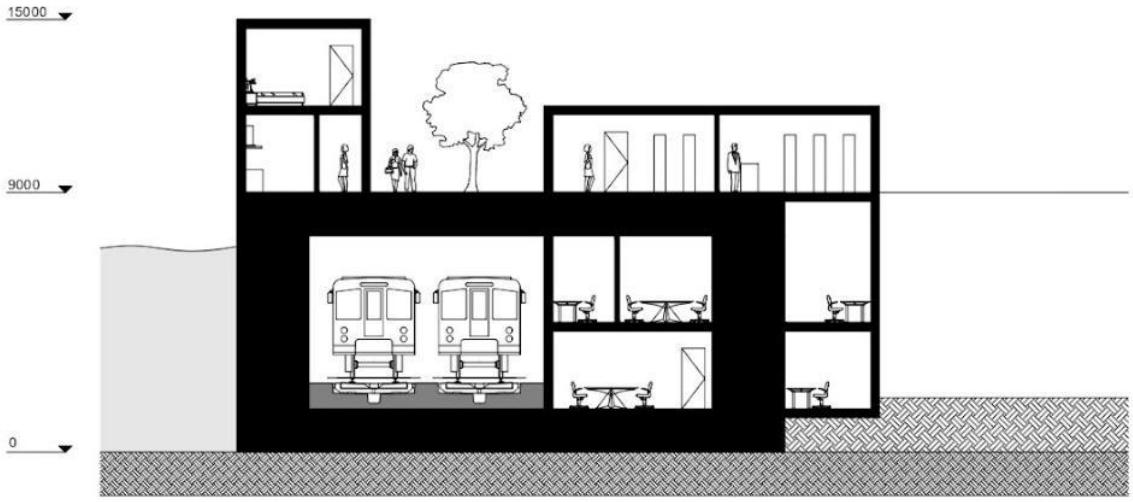

Figure 14. Section 2: metro line inside the dam, buildings on top, partially inside and over the dam, building connection to the island (Buis et al., 2021).

An important aspect of the modernization is connectivity and expansion of islands with dredged materials from the lagoon. The first island expansion can be done with soils coming out of the building of the dam. The second expansion can be done after 25 years when enough sand is collected from the dredging in the lagoon. The main advantage of this is that the exact expansion and location of these islands can always be revised in the future when the climate change is developing differently than expected or when the needs of the Venetian peoples are changing.

Figure 15. Growth of artificial islands in three steps represented in red (Buis et al., 2021).

The Symbiotic System allows better distribution of tourists over the (artificial) islands. By locating more hotels on the other islands which are well connected to the old city center more room for the residents in the old city center is made.

4. Reflection

Flood defense systems have a major influence in the spatial aspects of the territory. Rather than minimizing the spatial impact of the flood defense infrastructure and thinking of it as a line dividing two landscapes, it should be considered a landscape itself and given the appropriate amount of space according to that. The two proposals show that primary flood defense systems not only reduce the risk of flood but increase the spatial value and functioning of the urban landscape in which they are situated. The presented visions may seem far from realistic. But with the current challenges that society is faced with, radical intervention should be made in the near future to save Venice and/or its Lagoon.

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