

Learning from Hydraulic Venice Landscape. Adaptive Strategies and Resilience

Giovanni Asmundo

IUAV University of Venice gasmundo@iuav.it

Abstract

Nel corso della propria storia millenaria, Venezia mise a punto strategie di adattamento a un habitat complesso, caratterizzato da un equilibrio delicatissimo e precario, inizialmente sviluppando una conoscenza empirica e in seguito rafforzando una scienza idraulica. Dapprima per rendere abitabile lo spazio della laguna, successivamente per non perdere la partita della storia, la città fu costretta a combattere per secoli – e infine soggiogò temporaneamente – alcune forze della natura. Per il raggiungimento dell'obiettivo, nel tempo definì un apparato giuridico in grado di gestire una pianificazione delle acque estremamente complessa a varie scale, aguzzò l'ingegno tecnico, pose i propri fondamenti su un forte interesse comune: la sopravvivenza della laguna. L'articolo propone un breve excursus su Venezia 'città idraulica' e le sue risoluzioni delle questioni ambientali. Tale lezione d'equilibrio tra necessità antropiche e salvaguardia del paesaggio potrebbe rappresentare un utile approccio nel guardare al futuro delle coste in una prospettiva storica e di resilienza.

Parole chiave

Venezia, laguna, paesaggio urbano, adattamento, resilienza

Abstract

The case of Venice and its Lagoon is emblematic: during its long history, the city had to learn to adapt to a complex habitat characterized by a really delicate and precarious balance, first developing an empirical knowledge, then strengthening a science of hydraulics. First to make the space in the lagoon area habitable, then not miss the game's history, Venice was forced to fight for centuries and finally subdued temporarily some forces of nature. Venice created a legal apparatus that could handle extremely complex water planning at various scales, sharpened the technical ingenuity, and founded itself on a strong common interest: the survival and preservation of the lagoon. The aim of the article is to propose a brief excursus about the 'Venice and waters' case study, with a problem-solving approach. This lesson about a balance between anthropic needs and landscape preservation could be a useful point of view to look at the future of our coastlines in a long-time frame and a resilience perspective.

Keywords

Venice, lagoon, urban landscape, adaptation, resilience

Received: July 2017 / Accepted: September 2017

© The Author(s) 2015. This article is published with Creative Commons license CC BY-SA 4.0 Firenze University Press.

DOI: 10.13128/RV-21998 - www.fupress.net/index.php/ri-vista/

Sea. Coastline erosion and defences

At the beginning of the nineteenth century, Giacomo Filiasi, a scholar and historian of the Venice Lagoon, wrote: “da Brondolo a Fiesolo, su di una linea di 32 miglia circa, un vespaio per così dire v’era di bocche e di foci, v’era l’uscita di uno sciame di fiumi tutti diversi”¹ (1820, p. 10). It is a complex drainage basin, with a very massive flow of water. There is a huge mass of debris that is pushed down across the mainland and put into the sea. Then it is pushed out the river mouths by a strong sea stream (called ‘moto radente’), which descends parallel to the Adriatic western coast. Driven by gale force winds, it will settle to the bottom of the sea at some distance from the shoreline, forming unstable coastal sand dunes, such as Sant’Erasmo island and afterwards the Lido island, thus creating the pools of closed marshy lagoons.

Any change undergone by this dynamic balance between the rivers and the sea water flows and outflows would have put in danger the very existence of the city of Venice, that had founded on the lagoon its own subsistence, military defence and, above all, commercial power (Archivio di Stato di Venezia, 1983).

Antonio Piscina, a chronicler of the seventeenth century, wrote that the Lagoon cannot naturally or accidentally be lost or saved without the help of

a special determination of who is master (Piscina, 1618). According to him, from the beginning of the *Civitas Rivoalti*, ancient Venetians clearly knew that the existence of their city was strictly related to a correct water management (Tentori, 1892, p. 228-9). In fact, the establishment of the first magistrates for the conservation of the lagoon has been attributed to the first Doge, Agnello Partecipazio. In 811 he elected a Tribune as a superintendent of the buildings, a second one about landfills and draining, and a third one about the good condition of the shores. He was supposed to maintain the environment against the fury of the sea and river waters flowing into the lagoon.

These early embryonic forms acquired permanent status in 1282 with the establishment of a powerful special Magistrate at Water authority (*Magistrato alle Acque*), headed by three *Judices publicorum*, which were entrusted with the management and regulation of the whole lagoon domain, and whose laws were later collected in the famous Code of the Pievego.

For special needs it was possible to resort to the so-called *zonte* (literally ‘added’), those were subsidies of experts temporarily or permanently established in support of the Magistrates.

In a sonnet dedicated to Venice, Cristoforo Sabbadino wrote that Venice had the rivers, the sea and the



Fig. 1 – The Murazzi in Pellestrina island, 1904 (P. Molmenti, D. Mantovani).

Original bibliographic source: P. Molmenti, D. Mantovani 1904, *Le isole della laguna veneta*, Istituto Italiano d'Arti Grafiche, Bergamo, p. 53.
Online source: Internet Archive Book Images, digital archive.

man as enemies. He also wished that rivers could be moved far away and the men avidity moderated² (1540).

Indeed, the main threats to the preservation of the lagoon were the marine erosion of the beaches, the lagoon landfill due to river debris, as well as the anthropic pressures on the ecosystem. As a matter of fact, the risks connected to a mismanagement of the lagoon hydraulics were many and serious, making the system vulnerable to storms, high tides due to the sirocco wind and waterlogging of the *barene* (marshes). Those phenomena could have serious consequences, such as the pollution of wells, the unhealthiness of air and the loss of navigability, that was feared by the Venetians as the worst possible disaster (Bevilacqua, 1998).

Nowadays, centuries later, Venice has temporarily won some battles against the coastline erosion

and river flooding, through a complex landscape approach to urban and territorial planning. Now the main threats for the lagoon are the joint phenomena of eustasy and subsidence. They are principally caused by sea level rise due to climate change, excessive groundwater exploitation in the mainland and a regional geomorphological trend (Thetis, 2010).

The aim of the first interventions against the sea was to safeguard the shores and the banks from the erosive action of the Adriatic Sea, through public defence systems and planning. At least since 1275 the first Superintendents of the shores (*Soprastanti ai Lidi*) were elected as special superintendents, whose control function consisted in taking measures to preserve the ecosystem and designing specific infrastructures. Thus, in the Venetian regulations of the thirteenth and fourteenth century we can find



Fig. 2 – Venetie MD, 1500. Particular (J. de' Barbari). Online source: Google Arts and Cultures, digital archive. The original print is preserved in the Correr Museum of Venice.

a growing number of prohibitions as well as obligations with a landscape approach. For instance, it became forbidden to make fires or break down pine trees, uproot reeds, remove sand, collect oysters on the docks, make animals transit on the banks (Tiepolo, 1970). At the same time, it was required to plant tamarisks and reeds and to build docks to attenuate the action of salt wind and storms.

But the main work of defence since the XI century consisted of palisades made of tree trunks called *palade*, designed to protect the most exposed shores or vulnerable coast segments. The *Palade* could be made of single, double or triple rows of poles, usually reinforced by iron rods and tied together to form boxes then filled up with aggregates. However, this system was very expensive because of a substantial commitment of wooden resources and a really high cost of maintenance and renovation.

The so-called Murazzi was the first decisive permanent sea defence of the Venetian Republic. It was conceived and designed by Bernardino Zendrini, Magister in Water Authority (“Savio alle acque”), public mathematician and historian expert about the lagoon. He used the pozzolana, hitherto ignored by the Venetians, to create huge artificial reefs made of cemented Istrian stone. After his first experiment in 1738 in Ca’ Roman, near Malamocco, in 1740 the Senate authorized the extensive construction of the Murazzi, as large dams throughout the Lido and Pellestrina islands. The design was conceived in section and based on a site-specific technique (Grillo, 1989). Answering to a defined environmental issue, it became a monumental design that nowadays can be also considered able to shape an entire coastline at a landscape scale (Tiepolo, 1970). The construction lasted uninterrupted for thirty

years, until the fall of the Republic in 1797 and today still plays its fundamental role preventing the coastline from the erosion.

Rivers. Flooding, landfill, *imago urbis* and diversion of the rivers

Not only the sea and the anthropic issues were enemies of the health of the lagoon, but, as Sabbadino (1540) wrote in the sixteenth century, the 'inner waters' were stressed by the rivers, those according to him were the most powerful and disorderly forces of nature). Marco Cornaro had already wrote that failures products from the sea, they were nothing compared to the damages that rivers do (Pavanello et al., 1919, p. 144). This danger became an increasingly evident threat since the early fifteenth century, because of the deforesting of the mainland due to wood exploitation and, above all, new extensive agricultural activities. This strong anthropic modification of the landscape was linked with economic, political and cultural issues strickly related to the expansion of the 'Stato da terra' (the mainland dominion) of the Venetian Republic. As a secondary effect, this challenge caused the leaching of the plain and the dragging of huge masses of debris into the lagoon (Cessi, 1960).

The main strategies developed by the Venetians to cope with this danger gradually developed on

two levels, one local and one regional: on one hand the daily work so that the lagoon basin were daily gouged with manual industry, as Alvise Zorzi wrote (Zorzi, 1589, cited in Bevilacqua, 1998). On the other hand, struggled and grandiose interventions were planned at a regional scale, whose most remarkable achievement was the secular work of the diversion of the rivers ('bando dei fiumi').

The periodic excavation of the sludge was practiced since the ancient medieval Venice. "Se io volessi tessere la serie storica di tutte le escavazioni eseguite in laguna e Canali dell'Estuario mi converrebbe formare un grosso volume"³, Cristofaro Tentori wrote (1892, p. 74).

Moreover, the excavation of the sludge was always linked to the growth of the same city. The works of drainage, land reclamation, creation of soil between the waters are instruments on what the birth and development of Venice civilization historically based on (Crouzet-Pavan, 1992).

A fourteenth century source mentioned by Filiassi said "siccaverunt paludes, manufecerunt solum et quasi ex abyssi aedifitia sustulerunt"⁴ (1829, p. 98). As Tentori wrote, the excavated sludge was used "in the amplification of the islands, in the formation of new ones, and the expansion of the city" (1892, p. 74). The same excavations were financed by the state with transit duties on the canals and fees of own-

ers of lands chosen for redeposit of sludge (expropriation instruments were also applied with not favourable owners). During the fifteenth century, it was forbidden to deposit sludge in not appropriated spaces, in order to avoid uncontrolled extensions of private properties.

Since the sixteenth century, the planning of the city exploited the programmed deposition of recycled sludge coming from the so-called 'general excavations' (1546, 1658, 1677). The sludges were used for islands extensions and buildings construction (with profits going to the Treasury). This process went also in parallel with the definition of the modern and consolidated *forma urbis* of Venice.

Moreover, artificial canals were created to improve water flow and circulation (for example the Zuccarina, Osellin and Cavallin canals) thanks to these new excavations.

So once again the tireless workings of the Venetians turned the environmental conditions and natural processes into advantage.

Nevertheless, the work of excavation was not sufficient to cope with the increasing silting of the lagoon. So, it was equally necessary to intervene at the root of the problem, directly on the major rivers. On May 28th, 1412 "si dichiaravano tutti gli argini dei fiumi dello Stato, e quelli d'intorno della laguna del regio fisco e di pubblica ragione, cosicch  in verun

modo non potessero n  esser venduti o affittati o livellati da chi che sia"⁵ (Crouzet-Pavan, p. 89).

This legislation updated in a modern way the Code of Piovego. Thus, the public control was no longer limited to the lagoon areas, but included also any external territorial space (at any distance) that could be considered related to the dynamics of the inner waters.

The conservation of river beds and banks had a large impact not only on the lagoon, but also on the interests of the entire mainland. It was felt as a fundamental value, so that anyone who had caused some ruins to water systems would incur in the capital punishment (Cacciavillani, 1984, p. 192).

Marco Cornaro, in the mid-fifteenth century, was the first to understand in a modern way the necessity of a large territorial framework of all the new domains of the Republic, in order to safeguard the lagoon.

The control of the main hydrographic systems became very relevant to face challenges such as the formation of unhealthful swamps, the floods and the lagoon silting.

For instance, the Sile river carried a large amount of freshwater, releasing it into the northern lagoon. This had as a consequence on the formation of reeds and swamps. The Piave was also a serious threat because of the frequent and dangerous flooding and variations of its course. But the main concern

was represented by the Brenta, which caused the greatest dangers of silting because of flowing into the central lagoon. Originally, it didn't flow into the lagoon, but Paduan had diverted it in order to protect themselves from flooding. Four centuries of efforts and talents were spent to solve the Brenta problem, contributing significantly to the founding of the modern science of hydraulics, through the development of a vast literature on the subject (Vacani, 1867; Miozzi, 1974).

The diversion of the rivers went in parallel with large programs of land reclamation, based on complex social and economic processes and dynamics. For instance, the considerably rich Benedictine Abbey in Correzzola, in the Paduan territory, was the most important agricultural and administrative centre on the Bacchiglione river; in the XV-XVI century, it had a social hierarchical system inherited in part from medieval customs, but it also developed a modern and efficient land reclamation management, in terms of organization, accounting, maintenance of fields and channels: these were organised in a large system of canalizations and underground ducts connected to the Bacchiglione. The Abbey consolidated also a 'typological' form of settling and colonization of the reclaimed territory, which would also inspire in some way the land reclamation plans by Alvise Cornaro, for example in Codevigo (Coppa, 1990, pp. 218-220).

At the same time, a wide territorial vision was gradually created in function of Venice city centre and its internal waters, defining progressively around the lagoon an area bounded by precise borders. This *conterminazione*⁶ was a legislative border, marked by cairns of Istrian stone with the effigy of Saint Mark. This limit was considered to be defended at any cost, even in disadvantage of the interests of the mainland or submitted territories, those were considered subordinated to the ultimate goal of preserving the *status quo* of the Lagoon (Tentori, 1892; Miozzi, 1974). Thus, water management and designs in the mainland were increasingly connected with urban planning in Venice as well as landscape conservation in the lagoon.

In fact, the proposals for land reclamation and general reorganisation of the waters in the lagoon – or flowing towards it – were linked to specific necessities in the planning of the city. For example, the design about a complete embankment of the lagoon basin proposed by Cornaro in its *Trattato di acque* (1560, cited in Coppa, 1990) modified the intended use of some city 'zones': Sant'Erasmo, Tre Porti and Malamocco would have lost their portual function, that would have been moved to the new area of Brondolo, strengthening the Chioggia port and creating there new waterways thanks to the diverted rivers (Coppa, 1990, p. 228).

However, these intervention policies were not always free of conflicts. Focusing on water resources management we remember, among the cases, that the diversion of the Brenta towards Conche, between the end of the XV and the beginning of the XVI century, was defined as 'the ruination of the paduan territory' (*ruina del padoan*), but at the same time it was also interesting as a hydraulic system based on metal doors to help the outflow and prevent the flow due to the lagoon tides, linking a small scale regulation with a regional scale water planning (Coppa, 1990, p. 226).

The idea of the protection at any cost of the particular *status quo* concerning Venice and its Lagoon was a result of a wide debate among the supporters of a maritime or land-based economy, that followed the commercial crisis of the Mediterranean routes in the early sixteenth century. This conservation instance was reinforced in parallel with a political and cultural idea of Venice. We could also find some representation of this idea of Venice in significant contemporary visual documents, such as the famous perspective plan by Jacopo de' Barbari (1500 A.C.). In this 'portrait of the city' (De Seta, 2011), we could see Venice caught in a bird's eye view (taken from the sea towards the mainland), where the fabric of the city is inseparable from the lagoon as a single landscape made of urban fabric and water, closed by

the mountain range of the Alpes. This view contributed also to determine the *imago urbis* of the modern Venice, establishing a canon that was continued with many perspective plans during the following centuries (Baso et al., 2003).

This representation of a new Venice, still maritime but also oriented towards the mainland, is linked to an economic and ideological vision of a territory colonized by villas and ennobled by the idea of a 'holy agriculture' ('*santa agricoltura*'), a concept that was strongly supported, above all, by Alvise Cornaro. He also promoted and established in 1545 a Magistrate of Uncultivated Properties (*Magistrato dei Beni Inculti*) with the aim of mapping all the potentially productive areas in the Lagoon as well as in the mainland under the Venetian domain and transforming them in 2000 fields ruled by 250 villas. Thus, once again, the city, the lagoon and the mainland were considered as a whole, and the urban and regional scale were connected (Coppa, 1990, p. 226-27).

It is interesting to mention that the strategy of the diversion of the rivers was widely debated. In the middle of the sixteenth century, Alvise Cornaro (1560) reported that the sea level average had risen three feet (1.05 m) compared with ancient levels and proposed as a solution the embankment of Venice and the central lagoon. The design of a canal

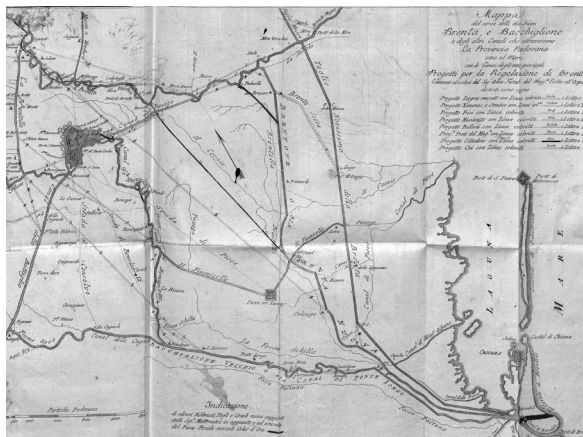


Fig. 3 – Map of the Brenta and Bacchiglione rivers, 1789 (Anonymous)
Online source: BEIC Biblioteca Europea di Informazione e Cultura, digital library.

opposite page

Fig. 4 – Design for Sile river, 1684 (Anonymous). Original bibliographic source: Zendrini B. 1726, *Memorie storiche dello stato antico e moderno delle lagune di Venezia e di que' fiumi che restarono divertiti per la conservazione delle medesime*, Archivio di Stato ('Savi ed Esecutori alle Acque' fund), Venice. Online source: Wikipedia.

around the lagoon intended to allow the water flow, as well as the waterways for navigation towards the mainland. Furthermore, noting a rise of half a foot in tides, caused by the narrowing of Malamocco sea mouth, he proposed to close the other mouths leaving just one of them open.

The veronese scholar Girolamo Fracastoro (1815) proposed in addition to dig in the lagoon some parallel canals in a east-west direction, recycling the excavated mud for the reclamation of many arable hills. He also proposed the embankment of the Lizza Fusina canal, to allow the direct transport of drinking freshwater, with a brilliant anticipatory idea of the aqueduct that was designed three centuries later, in 1811, following the same path.

Bitter opponents of the rivers removal were patrician di Zorzi and doctor Francesco Giusto (1676, cited in Bevilacqua, 1998) who, worried about the confused movements of water as a cause of stagnation and malaria, proposed embankments and sluices as used in the Flanders.

Only Cristofaro Sabbadino (1540, cited in Cessi, 1930), engineer and technical superintendent at waters (Ingegnier e protho de l'officio delle Acque), understood that the salvation of Venice would have been inseparable from its lagoon. He preached throughout all his life the radical solution of the diversion of the rivers. Although antagonizing many

contemporaries, the Magistrates finally evaluated forward-looking his grandiose plan, whose work continued until the fall of the Republic in 1797.

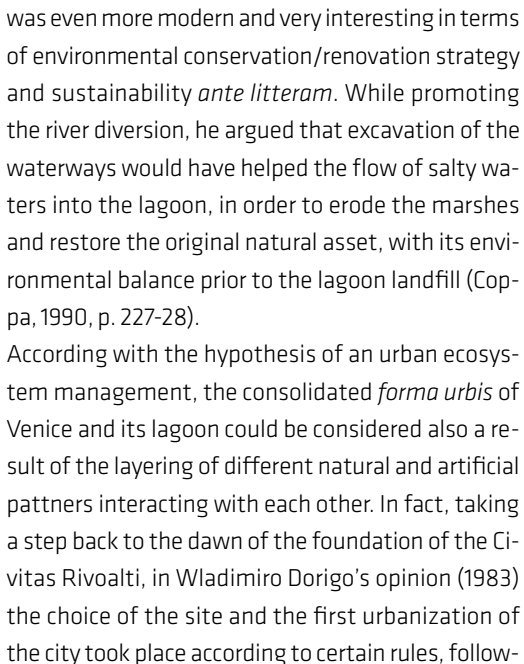
Canals. Hydraulics, urban landscape and resilience

As already mentioned, the great works of protection of the entire lagoon corresponded to a daily maintenance effort at the smallest scale, even within the same fabric of the city, watered and structured by rivers and tidal streams.

Venice and its waters have a really complex urban landscape, as a result of a stratification of signs and traces those have been sedimented during one thousand years of history (Zucchetta, 1998).

The coexistence of environmental and anthropic dynamics and their transformation in time produced a unique ecosystem (Tiezzi and Marchettini, 1997) and landscape, regulated by laws and plans ables to manage resources and fluxes, in ways that could be compared with the current concept of urban ecosystem management (Nicoletti, 1978; Bevilacqua, 1998; Van Bueren et al., 2012).

Concerning this, for example, the mentioned design by Cornaro (1545) about the diversion of the major rivers proposed a large reclamation of the higher marshes through the utilisation of the previous riverbeds for the drainage. But the Sabbadino's view



ing the paths of existing agricultural ancient Roman *centuriationes* here crossing (Patavina III Mestrina, Altinum III Equilense, Patavium IV Marciana). Studying the first venetian urbanization, articulated on a church-field-river system, Dorigo concluded that among 66 existing systems in the twelfth century there were 109 rivers, including 59 with a north-south and 50 with east-west direction, all adhering to the prior plan of the centuriation. Without going into further details, according to Dorigo all the other *rivi* in the city were originally rather small canals and pre-existing natural small canals called *ghebi* between the *barene* (marshes).

Though probably at the beginning the venetian canals were similar to ditches on the mainland, as they assumed a waterway function it became increasingly important to preserve their course from obstructing, maintaining optimal morphology,



depth, flows and outflows. Thus, Venetians began to build up the banks with *palade* (palisades) and *grisiolo* (fences). Privates were entrusted with their implementation, but the systems were placed under public control and regulations. For example, dryers were forbidden to wash cloths in the canals not to slow the currents, and for the same reason the mooring of boats was prohibited along some canals. At the same time, a constant maintenance of the *rivi* with dredging and excavation was clearly needed (Caniato et al., 1999).

In fact, the river canals in the city of Venice represent a really complex system, with delicate hydrodynamics, where the natural tidal system has been exploited and artificially shaped (Zucchetta, 1985).

In 1900, the hygienist Paluello (1900) studied the direction and distribution of tidal currents in the rivers and canals which are entrusted with the drainage of the city, thus making a survey so accurate that it's still valid.

He distinguished a predominant direction of flow

from the San Nicolò port westward, with very few exceptions. The Grand Canal behaves in both phases of flow and outflow as a supplier and a recipient of water for about twenty canals, and the lagoon works as a sort of inclined plan toward the harbor mouth.

Fabris (1937) instead classified the canals into three groups: primary canals joining two main points (i.e. Grand Canal, Giudecca Canal, Fondamente Nove Canal), secondary canals connecting two distant points of the Grand Canal; tertiary canals originating and ending in points near the Grand Canal.

The canals of the first order show the operation of 'tide anticipation' as they flow from the Grand Canal towards the lagoon and then they outflow in the opposite direction, always with a strong current velocity. So this is a hierarchical system until the third-order streams, characterized by a low current movement.

Thus, the fabric of the city itself and its streams are a complex system, that has been shaped and

opposite page

Fig. 5 – Saint Mark's Square in Venice during the 4th november 1966 flooding (Unknown Author).
Online Source: Wikimose.

well-finished for centuries through the constant maintenance of precise channel sections (Zucchetta, 1998).

Thanks to this delicate mechanism based on the balance between the flows of sweet and salty waters, the currents are always in motion to prevent stagnation and epidemics. This way, urban fabric and water channels are a complex network designed as a uniform operation, also related to a territorial scale and planning (Zucchetta, 1985 and 1998; Coppa, 1990).

Nowadays, the high tides problem highlights that one of the main threats for Venice lagoon conservation and identity is linked to climate change (Theitis, 2010). Even though the recent years interventions were not addressed in this article, according to a methodological approach to analysis of the safeguarding measures in a historical perspective, it is necessary to mention the Mo.S.E. (Experimental Electromechanical Module), a sophisticated hydraulic engineering project under construction, which, once completed, in theory should protect Venice from exceptional high tides (Scotti, 1993; Solinas, 1994; Mose, 2017).

However, many interesting programs and designs have recently been realised. For example it is possible to mention, among the others, the LIFE Vimine project, which proposed an integrated approach for

the conservation of the lagoon intertidal marshes from erosion and a sustainable landscape management (LIFE Vimine, 2017).

The recent efforts for safeguarding are remarkable (Cacciari, 1995; Amorosino, 2002), but it would be necessary to think about the lagoon problem by enlarging again design and planning to a wider scale. In the past, Venice took advantage even of short periods of occupation of a conquered territory to carry out large scale projects related to the preservation of its lagoon. For example, in the case of the Comacchio valleys, in 1604 the Venetians made some great interventions on the Po river delta to avoid flooding and landfill in the port of Brondolo and Chioggia, even though the territory was occupied for a short period (Coppa, 1990, p. 284).

The main processes we've seen in this brief *excur-sus* had a relevant role in making Venice and its lagoon to represent an extraordinary cultural landscape. It preserves distinctive and stratified signs of how the natural and artificial environment have shaped each other during the centuries (UNESCO, 2017), with a high awareness of the interrelation between the anthropic and landscape dynamics. From this point of view, Venice could be still a 'planetary metaphor' and a useful case study for a landscape approach to a future-oriented sustainable planning (Bevilacqua, 1998).



opposite page

Fig. 6 – Formation of a *ghebo* morphology during the renovation of the Campalto's marshes, 2010. (G. Asmundo).

Conclusions

During its evolution, Venice built a resilient system able to develop different mitigation or adaptation strategies in front of the natural or man-induced environmental challenges, understanding that its prosperity or salvation was strictly related to the balance with its land-water landscape. Although they are modern categories, it could be possible to say that in some way Venice developed an integrated landscape management, a holistic urban and regional planning, an accurate resources recycling, as it has emerged from the preceding arguments (Coppa, 1990; Bevilacqua, 1998 ecc.).

Many natural dynamics or interests of others were bent, such as the case of the Paduan territory mentioned above. But with a new consciousness about ecology and sustainable development we can update the Venice lagoon historical experience. Today we have to face new challenges, such as the sea level rise due to climate change or the erosion of the marshes, but others such as the coastline erosion of the flooding risk have already been dealt with (sometimes successfully), although the conditions and instruments were different. We could take some lessons from a civilization that was able to really adapt to not succumb to the forces of nature, managing a precarious balance between landscape preservation and planning (Tiepolo, 1970; Cessi, 1930; Coppa, 1990; Bevilacqua, 1998).

Endnotes

¹ Trad. "From Brondolo to Fiesolo, on a line approximately 32 miles long, there was a kind of wasps' nest of mouths and estuaries, there was the release of a swarm of many different rivers".

² Original quote: "Li fiumi, e'l mar, e gl'huomeni tu hai / Per inimici [...] Scaccia i fiumi da te, le voglie ingorde / De gl'huomeni raffrena [...]"

³ Trad. "if I wanted to plot here all the historical series of excavations carried out in the Lagoon and Estuary Canals, this would led me to form another large volume".

⁴ Trad. "they dried out the swamps, manufactured the soil and supported the buildings almost from the abyss".

⁵ Trad. "all the banks and rivers were declared to the State property, and those around the lagoon to the Treasury and public domain, so that they could not be sold or rented or leveled by anybody".

⁶ In Italian in the text.

Bibliographical references

Archivio di Stato di Venezia 1983, *Lagune, lidi, fiumi, cinque secoli di gestione delle acque*, Helvetia, Venice.

Amorosino S. 2002, *Il governo delle acque. La salvaguardia a Venezia: una storia amministrativa italiana*, Donzelli, Rome.

Baso G., Scarso M., Tonini C. (eds) 2003, *La Laguna di Venezia nella cartografia a stampa del Museo Correr*, Musei Civici Veneziani, luav Circe e Marsilio Editori, Venice.

Bevilacqua P. 1998, *Venezia e le acque. Una metafora planetaria*, Donzelli Editore, Rome.

Cacciari P. 1995, *La salvaguardia di Venezia. Dieci anni di battaglie*, ARC, Venice.

Cacciavillani I., 1984, *Le leggi veneziane sul territorio 1471-1789. Boschi fiumi irrigazioni*, Signum, Limena (Padua).

Caniato G., Carrera F., Gianotti V., Pypaert P. 1999, *Venezia la città dei rii*, Unesco-Insula S.p.A., Venice.

Cessi R. (eds) 1930, *Discorsi sopra la laguna. Cristoforo Sabbadino*, Premiate officine grafiche C. Ferrari, Venice (original ed. 1540, *Discorsi di Cristoforo Sabbadino sopra la laguna*, Ms 399 Biblioteca Un. di Padova, Padua).

Cessi R. 1960, *Evoluzione storica del problema lagunare*, Officine Grafiche C. Ferrari, Venice.

Coppa M. 1990, *Piccola storia dell'urbanistica. Paesaggio e ambiente*, UTET Libreria, Turin.

Cornaro A. 1560, *Trattato di Acque*, Padova, Perchacino.

Crouzet-Pavan E. 1992, *Sopra le acque salse*, Ecole Française de Rome, Rome.

De Seta C. 2011, *Ritratti di città*, Einaudi, Turin.

Dorigo W. 1983, *Venezia origini: fondamenti, ipotesi, metodi*, Electa, Milan.

Fabris G. 1937, *In marea nei canali di Venezia*, Ateneo Veneto XII riunione, XV, Venice.

Filiassi G. 1820, *Osservazioni sulle cause che possono aver fatto ritrovare nel secolo XIV in parte pregiudicata la Laguna rispetto alla posizione di Venezia*, Opuscoli due, Francesco Andreola, Venezia.

Giusto F. 1676-1725, *Discorso sopra la laguna*, s.d. Ms 384 cc 308, Biblioteca Un. di Padova, Padua.

Grillo S. 1989, *Venezia le difese a mare. Profilo architettonico delle opere di difesa idraulica dei litorali di Venezia*, Arsenale Editrice, Venice.

LIFE Vimine, <<http://www.lifevimine.eu/en/index.php>> (09/17).

Miozzi E. 1957, *Venezia nei secoli, III, La Laguna*, Libeccio, Venice.

MOSE, Mose Venezia <<https://www.mosevenezia.eu>> (09/17).

Nicoletti M. 1978, *L'Ecosistema Urbano*, Dedalo, Bari.

Paluello C. 1900, *Note igieniche sul progettato ponte lagunare con particolare riguardo alla malaria*, «Rivista veneta di scienze mediche», XVII year, n. IX, Venice.

Pavanello G. (eds) 1919, *Della laguna*, in *Antichi scrittori d'idraulica veneta, 1, Marco Cornaro (1414-1464)*, Officine Grafiche Ferraresi, Venice.

Piscina A. 1618, *Pratica Universale del Magistrato alle Acque*, Ms n. 399 cc 204 Biblioteca Un. di Padova, Padova.

Scotti A. 1993 and 1994, *Progettazione delle opere di difesa dalle acque alte*, «Quaderni trimestrali del Consorzio Venezia Nuova», 3 and 1, pp. 9-29.

Solinas L. 1994 and 1995, *Modulo sperimentale elettrimeccanico-Mo.S.E.: i risultati di quattro anni di sperimentazioni*, «Quaderni trimestrali del Consorzio Venezia Nuova», 4 and 1, pp. 74-93.

Stratico S. (eds) 1815, *Lettera di G. Fracastoro sulla laguna di Venezia ad Alvise Cornaro*, Alvisopoli, Venice.

Tentori C. 1892, *Della Legislazione veneziana sulla preservazione della laguna. Dissertazione storica-filosofica-critica del Sign. Abate Cristoforo Tentori*, at Giuseppe Rosa, Venice.

Thetis 2010, *Strumenti del Magistrato alle Acque di Venezia. Stato dell'ecosistema lagunare veneziano*, Marsilio, Venice.

Tiepolo M. F., *Difese a mare*, in UNESCO et al. 1970, *Mostra storica della laguna di Venezia*, Stamperia di Venezia, Venice.

Tiezzi E., Marchettini N. 1997, *Cambiamenti climatici e comparazione evolutiva degli ecosistemi antropizzati e degli ecosistemi naturali. Le implicazioni per la laguna di Venezia*, in «Quaderni trimestrali del Consorzio Venezia Nuova», 2.

UNESCO, *Venice and its Lagoon. Outstanding Universal Value*, <<http://whc.unesco.org/en/list/394>> (07/17).

Vacani C. 1867, *Della Laguna di Venezia e delle attigue province. Memoria*, Litografia degli Ingegneri, Florence

Van Bueren E., Van Bohemen H., Itard L., Visscher H. (eds) 2012, *Sustainable Urban Environments. An Ecosystem Approach*, Springer, Dordrecht.

Zucchetto G. 1985, *I rii di Venezia. La storia degli ultimi tre secoli*, Edizioni Helvetia/Foligraf, Venice.

Zucchetto G. 1998, *Venezia e i suoi canali*, Marsilio, Venice.