

Cambridge University Press

0521840465 - Flooding and Environmental Challenges for Venice and its Lagoon: State of Knowledge

Edited by C. A. Fletcher and T. Spencer

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# Part I • Introduction

*Scientific paper*

# 1 • Venice and the Venice Lagoon: creating a forum for international debate

T. SPENCER, J. DA MOSTO, C. A. FLETCHER AND P. CAMPOSTRINI

## INTRODUCTION

'There really is no point in continuing to rescue and restore individual buildings in Venice if the city remains under increasing threat from flooding. Now what can be done about that wider issue?' With these words in late 2000, over lunch in the Master's Lodge at Churchill College, Cambridge, Anna Somers Cocks, the Chairman of Venice in Peril (The British Committee for the Preservation of Venice) set in train a broad series of research activities in Cambridge and Venice. One of several substantive outcomes of that process is this volume.

## HOW IS VENICE TO BE SAVED?

It is now nearly forty years since the disastrous storm surge of 3–4 November 1966 which flooded many parts of Venice to water depths of nearly 2 m above mean sea level. As Howard Moore notes in the preface to this book, that event was the catalyst for an international gathering of scientists to discuss the 'Venice problem' in 1969. Since that time a great volume of detailed research has been undertaken in Venice, elsewhere in Italy and around the world, on the geology, hydrology, ecology and biogeochemistry of the Venetian built environment and the Venice Lagoon, and the linkages of these habitats to the Adriatic Sea and the hinterland of the Veneto. There have been considerable technical developments, including, for example, the monitoring and mathematical modelling of tidal inlet and lagoon hydrodynamics. New problems have emerged, covering such diverse issues as the anoxic crises and algal blooms of the 1980s, the ecological and morphological impacts of hydraulic dredging for clams since the 1990s, and the recent identification in the lagoon of a range of

chemicals which affect biological systems at very low concentrations (the endocrine disrupters). Furthermore, there has been a growing realization of the spatial and temporal scale of sampling needed to effectively define the complex dynamics of both lagoon and watershed. Most recently, these issues have come to be seen against the backdrop, and uncertainties, provided by what global environmental change might mean for Venice. All these developments, amongst many others, are covered in detail in the chapters of this volume. However, the overarching problem of rising water levels and associated serious city flooding and what to do about it still remains the most apparent key issue facing Venice. And there are many indications that the problem is worsening. Whilst the 1966 event has not been repeated, of the ten highest floods between 1900 and 2004, 8 occurred after 1960. In the first decade of the twentieth century the lowest part of the city, St Mark's Square, flooded ten times per year or less. By the 1980s, flooding was occurring 40 times per year. In the winter of 2002, there were 10 'exceptional' floods (when nearly 4 per cent or more of the city is inundated) in one period of three weeks.

Within this context, this broad review of the 'state of knowledge' comes at a particularly timely point in the long history of flood protection measures for the city. The 1966 event concentrated minds. In 1971 a 'competition of ideas' was held and won by a design for an underwater mobile barrier to close off the three lagoon inlets at times of storm surge. A deciding factor was the importance of aesthetics; the barrier would lie on the seabed and only be raised, and thus visible, at times of high water. In 1984 the Special Law for Venice (see Appendix A2, this volume) created the Consorzio Venezia Nuova (CVN), a consortium of large Italian engineering and construction

companies, which was given sole responsibility for implementing the barrier solution, within a more general remit from the Ministry for Public Works for the planning, design and execution of all public works for the safeguarding of the lagoon. As part of a package of 'hard' and 'soft' engineering measures (now referred to singly as the 'MOSE system'), qualified approval for implementation of the mobile barrier system, and associated navigation locks, breakwaters and inlet modifications, was finally given in April 2003, at the halfway point of the Venice in Peril initiative that underpins this volume. These decisions have had a reinvigorating effect, both sharpening up some long-debated issues (the whole question of water, sediment and nutrient exchanges between the Adriatic Sea and the lagoon for instance) and generating some quite new questions (might the gates be used to control water circulation and thus water quality in the lagoon?) to which we have yet to apply existing knowledge or devise new, critical tests. Furthermore, one of the key questions concerning barrier impact, that of the frequency and duration of gate closures, and its seasonal variation, is crucially related to near-future changes in sea level and storminess consequent upon greenhouse-gas related environmental change.

## WIDENING THE REMIT

The long delay between the original concept, completion of testing of the prototype mobile barrier in 1992 and the final decision to implement the 'MOSE' storm protection system reflects the intensity of scientific, social and political debate over what approach is best for Venice and its lagoon. Apart from the issue of cost (currently budgeted at €4bn or £2.7bn) and whether this expenditure should be a priority, serious and sustained challenges to this scheme have come from the engineering arena, when considering the risks associated with such an innovative barrier system and irreversibility of the structure, especially in the light of adaptations to the possible effects of climate change. Ecological concerns have also been repeatedly highlighted – when the floodgates are closed, the lagoon will become cut off from the benefits of tidal flooding. This has implications for both sediment exchange and water quality, the

former with consequences for the maintenance of lagoonal saltmarsh accretion in the face of sea level rise and the latter raising the spectre of a return to the algal blooms seen in the lagoon in the 1980s.

Over time numerous debates over the merits and demerits of a mobile barrier scheme have become highly polarized, resulting in oversimplification of the key issues governing the 'health' of the lagoon and safety of the city, notably lagoon ecosystem characterization, functional dynamics and evolutionary trends and the relations between the lagoon, the city and the large watershed of the Veneto that feeds into the lagoon. Tackling this level of questions requires a more sympathetic and more holistic view of Venice and its lagoon and a willingness to listen to, and draw information from, a wide range of specialist scientific disciplines into a more thorough synthesis.

## CREATING AN INTERNATIONAL FORUM: PROCESS AND PRODUCT

With generous financial backing from Venice in Peril and its supporters in place, a research plan was formulated in 2001 by a group of scientists, engineers, architects and geographers, largely drawn from Cambridge University's Centre for Sustainable Engineering, Centre for Risk in the Built Environment and the Cambridge Coastal Research Unit, and developed in association with CORILA, the Venetian consortium for the coordination of research activities concerning Venice and the lagoon system. Within the broad aim of promoting the objective study and review of information concerning the 'Venice problem', it was agreed to develop a three-stranded collaborative research programme. This consisted of an information gathering process; the promulgation of a series of workshops; and the organization of an international discussion meeting.

By September 2002, the project was in a position to mount the scientific and technical workshops in a number of Cambridge Colleges. The workshops, each attended by 12-15 participants, covered the following five themes: urban flooding – architectural and structural issues; engineering solutions to storm surge flooding of Venice; physical and ecological processes of the Venice Lagoon; modelling the hydrodynamics, morphology and water quality of the Venice Lagoon;

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and global environmental change, uncertainty, risk and sea-level rise in the North Adriatic Sea. The aim of the workshops was to identify and outline the key flooding and environmental issues; identify research requirements (in both the mid- and long-term); highlight areas of information need where current understanding of the complex Venice system requires further elaboration; raise matters concerning communication of science and data availability; and, not least, in a relatively informal setting with no formal recording of proceedings, allow the exploration of less mainstream and more innovative solutions to Venice's environmental issues. Participants at each workshop were a mixture of researchers working specifically in Venice and internationally recognised experts on the issues under consideration.

A prime aim of the workshops was to act as a sounding board and pump-priming operation for planning of the international discussion meeting to be held in Cambridge 12 months afterwards. This meeting duly took place in Churchill College, Cambridge in September 2003, under the title 'Flooding and Environmental Challenges for Venice and its Lagoon: State of Knowledge'. The papers given at that meeting, attended by 130 scientists and engineers from Italy, the UK, The Netherlands, Denmark, Germany, Spain, Lithuania, Russia and the USA, subsequently developed and revised, and with additional invited contributions and commentaries, are presented here. The aim of the collection is to show what is currently known about the city and lagoon; where debate remains; and where critical information and tests of key hypotheses are still lacking. The text reports the wide spectrum of scientific archival, field, laboratory and modelling studies on Venice and its lagoon; shows the considerable intellectual challenges involved in trying to understand the workings of a complex, highly managed and altered, and highly stressed set of ecological habitats (in the widest sense, from buildings to plants, both predominantly rooted in salty water); and identifies the need to overcome past shortcomings in research co-ordination and effective dissemination of research results in order to deliver key understandings of city and lagoon dynamics to opinion makers and decision takers.

## ACKNOWLEDGEMENTS

This project is a contribution to the Cambridge Environmental Initiative of Cambridge University (formerly the Cambridge Committee for Interdisciplinary Environmental Studies). We are grateful to Peter Guthrie, Paul Richens and Robin Spence for their participation in the Project team, along with Frances Clarke and Anna Somers Cocks, distinguished by their vision and tenacity, and to Sir John Boyd and Janet Milne of Churchill College, who hosted and helped with the organization of the International Meeting. Venice in Peril, the Save Venice Boston Chapter, the UNESCO Office in Venice – Regional Bureau for Science in Europe (ROSTE) and the Regione Veneto provided material support for the Meeting. And above all, we recognize the many scientists who have applied, and continue to apply, their talents and energies to improving our understanding of this most remarkable of ecosystems and home to a unique cultural heritage.

*Scientific paper*

## 2 • Between salt and fresh waters

G. CANIATO

Venice built her fortunes on the sea: a huge emporium of trade between the Orient and the West. A connecting point between the Middle East, the Mediterranean coasts and continental Europe, that reached the peak of its political and commercial power, between the fifteenth and sixteenth centuries, thanks to the control of maritime routes. But – this is the first question – was Venice (and is Venice) a city on the sea?

In fact Venice is not – as one would normally think – a maritime city provided with docks or waterfronts facing the sea, like Marseille, Genoa, Naples, Istanbul or most of the other major and minor sea ports on the Mediterranean and Atlantic coasts. Venice is in fact an island (or rather a series of islands, a crowded ‘archipelago’), well inside a protected lagoon, capital of an independent Republic until 1797: the main island, amongst the dozens scattered all around the lagoon, the heart of a complex productive and residential environment densely populated until a few decades ago.

Today many parts of the lagoon are wastelands full of abandoned settlements formerly used for centuries, and even in the recent past, by fishermen, sailors, boatmen and people living on local agriculture and trade. More or less as in the twelfth century, when the ancient Rialto archipelago became definitively the capital of the Commune Venetiarum, cradle of the new-born Republic which developed as an international power after the Fourth Crusade, but was still located in a narrow marshy area spreading along the Adriatic coasts, compressed between the Adige and Isonzo river mouths.

Even today Venice and its lagoon should be seen as a single entity (as it used to be) and the ancient capital as the centre of a wider productive, commercial and residential system, in which water can be compared to the green belt commonly found in other

major metropolitan areas. Not a liquid desert, but an essential part of a ‘diffuse city’, with the canals acting as boulevards and the lagoons as ‘fields’, to be frequented like Hyde Park in London or Central Park in New York. But the vast, shallow and placid water surface of the lagoon is today considered more as an obstacle, that can be criss-crossed by fast, and often huge, destructive motorboats racing from land to sea and back. Or maybe bypassed with rapid underground connections, as some local planners propose.

On the other hand, the lagoon is often simply considered as the natural ‘frame’ and background for the former amphibian ‘Queen of the Sea’, an ecosystem to be preserved – together with the stones of Venice – for its beauty and uniqueness. An ecosystem that should still be considered (as it was) a life-giving territory for the survival of the diffused city as a living organism and as a capital of European culture populated not only by hurried masses of day-trippers.

Comparisons between the present and the situation of the lagoon centuries ago is probably impossible, but Venetians were not interested in such ‘aesthetic’ questions concerning the lagoon where they lived: their primary, if not their only, concern, as we shall see, was with strategic security, maritime navigation and sanitary matters. The lagoon was modified over the centuries as the permanent site for a once Mediterranean-wide civilization. Individual needs were not allowed to prevail and always had to be subordinated to the general interest: full private property of water surfaces was not admitted and our forefathers managed to guarantee a precarious but lasting balance between land and sea, adapting and somehow taming an unstable environment, threatened both by freshwater floods and by sea-sand and river-silt deposits.

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Venetians knew perfectly well – if they wanted to survive as an independent Nation – that they had to preserve a permanent balance between land and water: they understood that a coastal lagoon – left on its own – will naturally be transformed into open sea (if tides and currents prevail) or into land (if sediments brought by rivers prevail). Thus, water management slowly changed the first marshy location into an ‘artificial’ (or rather, ‘anthropic-shaped’) environment, permanently suitable for the safe settlement of a human community in constant expansion.

In fact, winding your way through the canals of the lagoon – far from the centre of Venice and beyond the major islands of Burano and Torcello – you will find yourself immersed in a flat landscape that can be fully understood only from the air, with little scattered islands emerging just a few inches above water

level. A peculiar environment that – especially at low tide – often becomes a muddy plain: the only protection for the only capital in the world that never had walls. And truly the vast, shallow lagoon surfaces were – as our forefathers knew – the walls of Venice that enemy armies could not scale or destroy. A sort of dogma, recalled by the Renaissance humanist Giovan Battista Cipelli, better known as Egnatius:

Venetorum urbs divina disponente providentia aquis fundata, aquarum ambitu circumsepta, aquis pro muro munitur. Quisquid igitur, quoque modo, detrimentum publicis aquis inferre ausus fuerit, ut hostis patriae iudicetur, nec minori plectatur poena quam qui sanctos muros patriae violasset. Huius edicti ius ratum perpetuumque esto.



Fig. 2.1 Traditional fishing in the shallow waters of the lagoon near Sant'Erasmo sea port (photograph by Catullo and Lagomarsino: Venice, 1990).



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Fig. 2.2 Late eighteenth-century engraving of the island of San Giorgio in Alga, along the canal connecting Venice with the Brenta river mouth.

The city of Venice, founded by divine providence on the waters, is surrounded by water and has water for its walls. Therefore, if anyone in any way should damage these waters, he shall be judged an enemy of the state and shall receive no less punishment than if he had violated the holy walls of the homeland. This ruling is given in perpetuity.

A muddy landscape, criss-crossed by a network of major channels and minor tortuous canals ramifying from the sea ports to the river deltas of the mainland. The 'veins and arteries of a living organism' as our forefathers used to say, the lagoon being the natural extension and indispensable support of the main island: Venice, fulcrum of a vast 'diffuse city' whose waterways were carefully maintained and used daily, giving vitality to the minor islands that provided important support for fishing (Fig. 2.1), transport,

trade, agriculture and all those activities that used to make the lagoon a lively and populous environment.

The end of the Venetian Republic (and the widespread use of the islands for 'military' purposes during the following twenty or so years of recurrent warfare) marked the end of this ancient and well balanced interconnection between Venice and its liquid surroundings. A powerful 'protective belt' with massive fortifications – of which Venetians had never felt the need – was built well inside the lagoon and on the edge of the nearby mainland; insular convents and monasteries were abandoned or destroyed and the nearby canals gradually started to lose their importance (Figs. 2.2., 2.3). In more recent times people began to reach Venice across the railway bridge (built in 1846), followed in 1933 by a parallel road bridge, with adverse affects on the old waterways that used to serve the city linking it both to the mainland and the sea ports.

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Fig. 2.3 Aerial photograph of San Giorgio in Alga. Still visible are the recently collapsed remains of the ancient monastery, used from 1810 until the Second World War as a military base (photograph by Giacomelli: Venice, 1960).

When examining how ancient Venetians acted in order to preserve their lagoon we can perceive apparent discrepancies. Sometimes, when the government finally decided to realize important hydraulic enterprises, such as massive excavations or river diversions, from the moment of the decision to the final execution a very short time elapsed. Just think – for example – of the diversion of the lower branch of the Po, the greatest of Italian rivers. Once it became clear that the easterly flows from the delta contributed to the silting of the southern portion of the lagoon, it was quickly decided to divert it to the south. The Senate took the final decision in the year 1600 and a huge excavation was completed in 1604, in spite of the delicate diplomatic problems that arose, the lower portion of the Po river being a political boundary between the Republic and the still powerful and

certainly not always friendly State of the Roman Church.

Or just think of the huge sea-walls of Istrian stone along the shores of the Lido: the work was begun in 1740 and continued throughout the century with an enormous financial effort, in years considered, even by recent historians, to be ones of political and economic decadence. The two opposing parties, active in Venice even in the past, of those who wanted to reclaim land along the borders of the lagoon and those who wanted to leave the saltwater free to expand as far as possible on the mainland, were in perfect agreement instead about the need for adequate protection along the seaward side of the lagoon.

But – this is the next question – have we ever thought why it took centuries for the Venetians to complete not only other important hydraulic works



(such as the diversion of the rivers Brenta, Sile and Piave outside the lagoon, directly into the Adriatic Sea) but also quite a simple operation such as the definition of the fiscal and judicial boundaries of the lagoon? The so called *conterminazione* ('boundary line') was planned in the late sixteenth century and finally concluded only in 1791, with different laws, regulations and prescriptions effective inside the line. Maybe one of the ancestral psychological reasons for the delay was that the early borders – facing often hostile rulers on the nearby mainland – were along the uncertain line, varying with the tide, that divided salt lagoons (first home to the Venetians) from the mainland and from the fresh water marshes occupied by the new barbarians after the fall of the Roman Empire. So the lagoons had to be maintained as wide as possible in order to keep the political and military boundaries far from the main inhabited islands. Yet at the same time ensuring that the tide could penetrate deep inside the lagoon, in and out twice a day, to wash sewage away, keep the waterways healthy and the canals and channels deep. Diseases such as malaria flourished in areas of prevailing fresh water – such as the surroundings of Torcello – that had to be abandoned. This long continued effort of the Venetians was encapsulated in the mid sixteenth century in a sonnet attributed to Cristoforo Sabbadino, the chief hydraulic engineer of the time:

Quanto fur grandi le tue mura il sai,  
Venetia, hor come le s'attrova vedi,  
e s'al periglio lor tu non provvedi  
deserta e senza mura rimarai.

I fiumi e 'l mar e gli huomini tu hai  
per inimici, e 'l provi e non lo credi,  
non tardar, apri gli occhi e muovi i piedi,  
che volendolo poi far tu nol potrai.

Scaccia i fiumi da te, le voglie ingorde  
de gl'huomini raffrena e poscia il mare,  
restato sol, sempre t'harà obedita.

(...)

How great your walls were, you know  
Venice, now see how you find them.

and, if you don't provide against their ruin,  
deserted and wall-less you will remain.

The rivers, the sea, and men you have  
as enemies, and for proof and belief  
don't delay, open your eyes and get moving,  
(otherwise) what you wish to do, you will find  
impossible.

Drive the rivers away from you, and check the greedy  
desires of men and then, only the sea  
remaining, it has always obeyed you.

(...)

But why – this is the next question – were many other projects concerning the safeguarding of the lagoon proposed, discussed, analysed, sometimes experimentally started, but finally abandoned or never realized? Projects, that became numerous especially in the sixteenth and seventeenth centuries, such as those presented in 1672 to the Senate and to the Magistrato alle Acque by Agostino Martinelli (*Prodromus ad revocandam lacunam inclytae civitatis Venetiarum ad primam profunditatem*), who proposed building a stone wall across the sea-mouths of the lagoon, provided with huge sluice gates (...*per le quali a compiacenza si potessero aprire e serare, hora per introdurre il mare et hora per negarli l'ingresso*) (which could be opened and closed at will, to let the sea in or to keep it out) and in 1673 by Alfonso Moscatelli who proposed closing two of the major port mouths (Chioggia and Sant'Erasmo) and separating with embankments the central lagoon from the marshes facing the mainland, in order to strengthen the vital natural action of the tides.

So our ancient patrician rulers and water management technicians planned, studied, proposed and discussed dozens and dozens of projects, often made mistakes, tried to correct them by learning from nature's reactions, or just changed their minds over time. Planning artificial diversions on the lower course of the Brenta river – as an example – went on for centuries, starting long before Venice achieved direct control of the nearby mainland. Padua ruled the whole area through which the river ran until the beginning of the fifteenth century but even in the

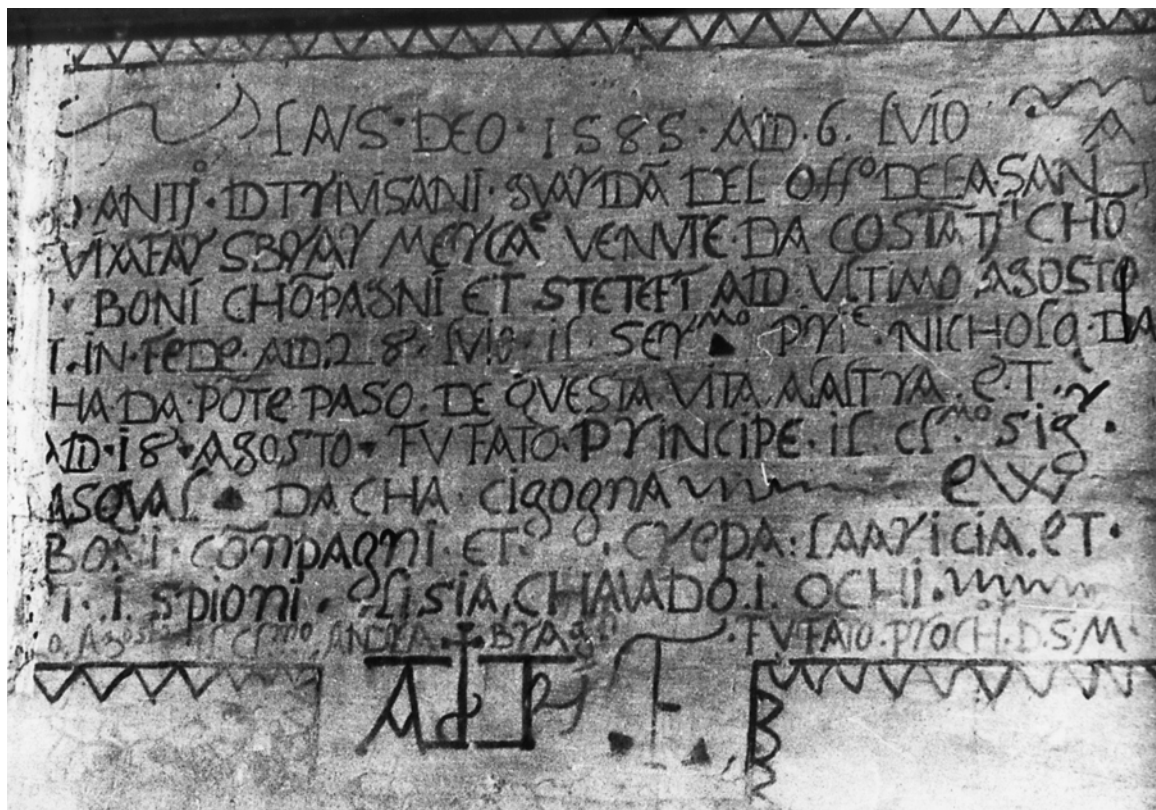


Fig. 2.4 A 1585 text painted on the inside wall of an ancient warehouse on the Lazzaretto Novo island. Here wool and other goods were kept in quarantine (photograph by G. Caniato, 1978).

twelfth century rivers had been diverted, mainly for strategic reasons and not far from the boundaries of Venice. Here swamps and marshes, scattered amongst fields and agricultural land, were often compromised by river flooding. The river delta was important not only for trade between the sea, the lagoon and the densely populated plains of northern Italy, but also for fishing, hunting, brush-wood gathering, heating and mill-grinding. All these activities were needed for the survival of the thousands that could make a living from the lagoon and from the nearby mainland and marshes.

Health problems caused by natural or anthropic changes in the local environment forced the Venetians to act. In 1324, they decided to build a long earth bank in front of the Brenta lagoon delta,

in order to divert the river to the south-west, as far as possible from the site of the capital. This enterprise soon caused serious environmental problems, both to the nearby mainland, where fresh water lakes and marshes expanded and forced peasants to abandon their lands and houses, and to the main sea-channels, which shallowed with the loss of the previously adequate and continuous river flow that had kept them naturally deep. At the beginning of the following century the 'filling up' of the lagoon (today we know it was probably caused by a general lowering of the average sea level, but our forefathers did not have such scientific data) and the reduced depth of the main canals and harbours – so vital for maritime navigation – forced Venetians to plan possible solutions.