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The "Serenissima" at hazard: the Historical Phenomenon of *Acqua Alta* in Venice

Abstract

In this paper we present ourselves as the "historical witnesses" of a problematic phenomenon which has afflicted Venice for centuries. The frequency of flooding in Venice has drastically increased over the last 50 years as a major consequence of natural and anthropogenic land subsidence, and a more active lagoon hydrodynamics induced partly by deepening of the largest navigation channels. Is Venice dying, a victim of its environment and of its own success? Many people fear so: the local residents who observe the decline of their beloved city, the Italian authorities, the millions of visitors. Beyond the splendour of restored churches and palaces, beyond the magnificent façades, the; reality is dramatic: the city is now often admired from gigantic ships in the Giudecca canal by cruisers of modern times. The survival of Venice as a living and vibrant city is at risk. The lagoon environment has always been characterized by a pronounced morphodynamics, inducing important morphological changes to the lagoon setting over the relatively short time of a few centuries. The aim of this paper is to analyse the history of the disasters which characterized this fascinating world surrounded by waters. In fact, the economic system and the existence of the "*Serenissima*" Republic itself was based on "water". Water meant refuge, safety, nourishment, wealth, military strength, and prospect for new developments.

Introduction

Venice was once the centre of a maritime republic. It was the greatest seaport in late medieval Europe and the continent's commercial and cultural link with Asia. Venice is unique environmentally, architecturally, and historically, and in its days as a republic the city was styled "*la Serenissima*" ("the most serene" or "sublime"). The visitor arriving in Venice is still transported into another world, one whose atmosphere and beauty remain incomparable. Every year Venice repeats the ceremony of her extraordinary "marriage to" the Sea. The sea is what Venice depends on and at the same time is threatened by. Venice and water, it's a story of

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love and hate. Love and death. The canals and the lagoon are the main characteristic of Venice and give the city its relaxed atmosphere. Rowing and regatas are part of the daily life of every Venetian. On the other hand, the destructive power of the water is also the biggest enemy of the infrastructure of the city. The frequency of flooding in Venice has drastically increased over the last 50 years as a major consequence of natural and anthropogenic land subsidence, and a more active lagoon hydrodynamics induced partly by deepening of the largest navigation channels. Is Venice dying, a victim of its environment and of its own success? Many people fear so: the local residents who observe the decline of their beloved city, the Italian authorities, the millions of visitors. Beyond the splendour of restored churches and palaces, beyond the magnificent façades the reality is dramatic: the city is now often admired from gigantic ships in the Giudecca canal by cruisers of modern times. The survival of Venice as a living and vibrant city is at risk. The lagoon environment has always been characterized by a pronounced morphodynamics, inducing important morphological changes to the lagoon setting over the relatively short time of a few centuries. The aim of this paper is to analyse the disasters history of this fascinating world surrounded by waters. In fact, the economic system and the existence of the "*Serenissima*" Republic itself was based on "water". Water meant refuge, safety, nourishment, wealth, military strength, and prospect for new developments.

A glance at the origins

The Venice Lagoon was formed about 6000 years ago during the Flandrian transgression, when the rising Adriatic Sea flooded the eastern most part of the Po River Würmian paleoplain. The subsequent intensive depositional phase created an early lagoon that was supposedly smaller than the present one and that communicated with the sea through a larger number of inlets with respect to today. According to the reconstruction made in 1799 by the Venetian historian Teodoro Viero, the lagoon had nine inlets around 1000 A.D. compared to the three it has now. The lagoon environment has always been characterized by a pronounced and fast morphodynamics, inducing important morphological changes to the lagoon setting over the relatively short time of a few centuries. The lagoon's first inhabitants were fishermen and hunters. Legend says that the fugitives from Altino, a nearby inland town, found refuge inside the lagoon in 452 A.D. under the pressure of Attila's barbaric hordes. The history of Venice begins in the 5th century A.D. After the fall of the Western Roman Empire, barbarians from the north were raiding Rome's former territories. In order to escape these raids, the Venetian population on the mainland escaped to the nearby marshes, and found refuge on the sandy islands of Torcello, Iesolo and Malamocco. Although the settlements were initially temporary in nature, the Venetians gradually inhabited the islands on a permanent basis. In order to have their buildings on a solid foundation, the Venetians first drove wooden stakes into the sandy ground. Then, wooden platforms were constructed on top of these stakes. Finally, the buildings were constructed on these platforms. Although the Venetian Lagoon had long been inhabited and other historical accounts (or legends) exist, the foundation of Venice as a city is traditionally considered to have taken place at noon on the Feast of the Annunciation of the Archangel Gabriel to the Blessed Virgin Mary, 25 March, in 421 AD, when Venice's oldest church, *San Giacomo di Rialto*, was consecrated. In the following centuries Venetian people tried to face the threat of water's dangers using every kind of means. The religious one was one of the most experienced. In order to struggle the threat of flood they organized processions invoking the main saints of the *Serenissima*: Saint Mark and Saint George. The processions were held on a boat at sea: these moments represented the defense against sea dangers with the hope to save the Lagoon world, within its symbolic and geographic frontiers. It was the traditional marriage to the sea. The third saint who protected the Lagoon was Saint Nicholas, whose relics were brought in Venice during the First Crusade. The catastrophic events were very often considered as consequences of rage of God towards human mistakes and sins or, more often, they were due to the Devil. The Devil commanded winds and seas, according the medieval mentality. The medieval chronicles still evoked the dangers of a huge anthropization and the effects of the human intervention when those people decided to settle "*tra le fluttuose onde del mar*", "*in mezzo il vertice del pelago*", in this kind of environment. The Venetian basin in fact reprents the widest group of lagoons of the Adriatic northern coast. A 17th century book which explains in detail the construction procedure in Venice demonstrates the amount of wood required just for the stakes. According to this book, when the *Santa Maria Della Salute Church* was built, 1,106,657 wooden stakes, each measuring 4 metres, were driven underwater. This process took two years and two months to be completed. On top of that, the wood had to be obtained from the forests of Slovenia, Croatia and Montenegro, and not only of Veneto and transported to Venice via water. Thus, one can imagine the scale of this undertaking. The city of Venice as we know it now is not a natural island (or group of 118 islands), but an artificial city built on the water. In the 8th and 9th century, Venice was only an archipelago of small islands separated by one large and many narrow canals. In fact such an environment was one of the most unsuitable to build a city on. Venice was really erected not on a solid foundation but on weak marshlands near a collection of 118 small muddy islands, the same ones that are today separated by many canals and connected by many bridges. The *Veneti*, the inhabitants of towns and villages along the Lagoon, found refuge on the islands and saved themselves from invasion. Despite the shallowness of the waters, the islets were impossible to reach by foot, and the raiders often had no ships. And anyway only the locals knew where the channels deep enough for seafaring vessels were located. Botanical remains of timber from constructions have revealed that the early builders of Venice carefully selected different types of wood for particular purposes. So, the vertical poles were overwhelmingly of alder, while the horizontal planking was of elm or oak. All three species withstand well repeated wetting and drying, hence their choice. Each wooden pole, or stake, measured about 4 metres. The secret of the longevity of Venice's wooden foundations is the fact that, being underwater, they are not exposed to oxygen, which is required by many bacteria and fungi responsible for the decay of wood. Furthermore, the effect of salt water around and through the wood petrifies the timber over time, so that it gets hardened and stone-like. These islands became inhabited from the 9th century onwards. When the population grew and houses became increasingly larger, they shored up the ground and created additional land. The *Fondamenta Nove* for instance was built in the late 16th century, whereas the *Riva degli Schiavoni* and the *Zattere* were added in the 19th century. One major problem in those old times was the preservation of the lagoon environment from silting up due to the incoming sediment flow of the major lagoon tributaries, namely the Adige, Bacchiglione, Brenta, Sile, and Piave Rivers. In fact, the economic system and the existence of the Republic itself was based on "water". Water meant refuge, safety, nourishment, wealth, military strength, and prospect for new developments. In 1399 a "*Commissione di Savi*" (Committee of Wise Men) was appointed by the Grand Council in order to address the issue of the lagoon protection and survival. They had huge power, and under their supervision the Republic of Venice (survived as an independent state until 1797) undertook impressive works, such as the diversion of the rivers to the Adriatic Sea and the construction of protective seawalls ("*Murazzi*"). Long jetties at the lagoon inlets and the excavation of internal navigation channels were completed in the 19th and 20th century, respectively. As a major consequence, a marine-type environment tended to dominate, with the number of high tides, the so-called "*acqua alta*" increasing. But it is important to remember that the earliest instrumental observations on atmospheric parameters were carried out by the Florentine "*Accademia del Cimento*" (Academy of Trials) along the tracks of the new interest for science coming from Galileo's findings. The first thermometer providing scientific records of air temperature was built in 1641; it was the first spirit-in-glass thermometer and was named the "Little Florentine thermometer". First regular records of air temperature measured at intervals of few hours started in 1654 and lasted to 1670, when an intervention by Inquisition stopped that practice. This implies that a serious gap exists in the time-series of air temperature until 1716, and recording of atmospheric parameters spread to many European sites.

Kind of sources

Environmental historians can take advantage of various kind of sources. Some of these documents may be manuscript or printed press and can be classified according their character and purposes. The narrative sources for example include generic descriptions of events, such as chronicles, annals, diaries, correspondence, poems and compilations of remarkable events written for historical purposes, the pleasure of informing or disseminating news. There are also the ecclesiastic sources: registers noting liturgical services and rogation ceremonies commissioned by the local community or authority in the case of adverse conditions. The most relevant topics were: to beg for rain (*pro pluvia*) in view of the yield, or to stop precipitation (*pro serenitate*) especially in the case of rivers in flood, or in the occasion of famine, plague, locust invasions or any other challenge. Moreover we have to take into consideration the administrative sources: official documents (e.g. diplomatic letters, municipal registers, inspection reports) written by public officers to describe some local catastrophe happened, its impact on the society and the landscape and the remedy actions to undertake, e.g. repair and maintenance, temporary reduction of taxes. Among the different kinds of the aforementioned sources, such as climatic, dendroclimatic, documentary, administrative (both civic or ecclestiastical) sources, we normally use to reconstruct this phenomenon, we have to mention the "pictorial" ones. Even if the reconstruction of environmental data from pictorial sources is often subjective, an important exception is the monitoring of relative sea level rise in Venice, thanks to the use of the optical *camera obscura* for painting buildings. The optical *camera obscura* was used to outline the pictured buildings on their tables before adding colours. Indeed, this tool projects the figure on a surface; thus, if the artist accurately draws the lines, the oil paints are something like ancient "photos" taken before the development of this technique by Daguerre and others (1837). The pictures are, however, according to Dario Camuffo, to be compared with an independent index showing the sea level in order to estimate its change over time. A useful marker to monitor the average level of high tides is the presence of algae belt on the external lower surfaces of the Venetian buildings that was named "*comune marino*" and officially taken as reference of the sea level both for buildings and urban development. If the algae belt is accurately pictured on oil paints together with details of buildings, we can measure how much its level differs from the present one and therefore estimate the sea level changes due both to subsidence and eustatism. In fact the period before instrumental records is known after the fortunate combination of these two available factors: a biological marker constituted by green algae, and their precise reproduction in some particular paintings. The methodology is very simple. Buildings facing the canals have a green belt of algae living on walls at levels periodically reached by tides, and the belt front corresponds to the average of the high tides of the year. When the sea level changes, the green belt follows it by the same amount. Luckily the front of the algae on the Venice buildings was accurately reproduced by Paolo Caliari, nicknamed Veronese (in the 16th century 1528-1588), and especially by the painters of "*Vedutas*" (the so called *Vedutisti*) Giovan Antonio Canal, nicknamed Canaletto (1697-1768) and his nephew Bernardo Bellotto (1720-1780). In the 18th century, Venice lives, in the artistical and cultural field, a second "golden age". The city renovates, assuming the "face" that largely still preserves. During this century a new pictorial genre emerges, it had been rarely practiced by a few local artists: the *Vedutismo*. Painters draw some of the more or less known of the lagoon city in order to satisfy the needs of lots of noble, aristocratic families, above all of English and German origin, but also French people, who visited the city during their "*voyage d'Italie*" (Venice, Florence, Rome, Naples), and of those who even if had never been in Venice, decided to decorate their prestigious houses with festive or weekday views of the famous *Serenissima*. All of them used a *camera obscura* as a tool to obtain precise reproductions of the views and were extremely accurate in reporting the algae levels as it has been verified with historical and statistical tests. The first painting useful to these aims is by Veronese and is dated 1571. It accurately reproduces the *Coccina Palace*, facing the Grand Canal, with people standing on the staircase that has five steps clear from algae. Nowadays the algae infest all the steps of this staircase. The height of each step is 18 cm, so that the algae belt has displaced by 5×18 cm = 90 cm. We should, however, correct this finding for two factors that have caused an additional rise of the algae belt. The first factor is that modern motorboats generate waves higher than the rowboats in use at the XVIII century. The difference in wave height was assessed after wave gauge monitoring in the Grand Canal during normal business days and in the occasion of the famous "*Regatta*", i.e. the historical happening repeated every year, in which accurate replicas of rowboats and characters from the XVIII century rowing on the Grand Canal as in the times of the Venice Republic, ended 1797. The result was 5 cm additional wall wetting for motorboat waves. The second factor is the dynamic increase of the tidal wave for the excavation of deep and wide canals in the Lagoon and was evaluated to cause 3 cm additional wetting.

Acqua alta

The phenomenon of *acqua alta* (high water) is very well known, even to people who have never visited Venice. *Acqua alta* generally takes place in winter time, when a combination of astronomical tides, strong south wind (*scirocco*) and sea waves cause a larger inflow of water into the Venetian lagoon. The consequences are that part of the city is flooded, bulkheads have to be put in front of the doors and the heightened walkways have to be set up. Most of the times, the flooding is limited to a rather small area around the *San Marco* square and it only lasts a couple of hours, until the tide changes again. Exceptional high tides (140 cm above sea level), which correspond with a flooding of approximately 50% of the city, have happened only 8 times since 2000. The early Venetians would have never expected that one day in the future, water was to become their most dangerous enemy and a most severe threat to the city's existence. In fact, the first mention of *acqua alta* dates back to 589 A.D., but the frequency of Venice flooding has grown significantly with time, especially in the second half of the 20th century. A number of factors may account for this increase: land subsidence, both natural and anthropogenic due to groundwater overdraft, sea level rise due to global warming, and deepening of existing canals for internal navigation. The average relative elevation loss of the city can be estimated at 23 cm over the last century, with sea level rise and land settlement contributing 11 and 12 cm, respectively. The whole city is supported by millions of wooden piles, each about 14 cm thick and up to 3 metre long. To be more precise: 12,000 tree trunks were used to support the weight of the *Rialto* bridge, 100,000 for the campanile on the *San Marco* square and more than a million for the *Santa Maria della Salute* Church. Not only the woods of Venice's Italian hinterland were almost completely cleared for the construction of Venice, but also the coasts of Istria and Dalmatia, on the opposite side of the Adriatic. The barren landscapes of the eastern Adriatic coastline still bear witness to this deforestation. These piles are driven deep into the soil, until they reach hard clay which could hold the weight of the buildings. The wooden piles have been (more or less) intact for more than 500 years and kept the city above the water, thanks to a combination of reasons. First of all, the type of wood used (oak or larch) is very water resistant. Secondly, wood only rots when both air and water are present. Hence, the wooden piles were protected due to the lack of oxygen in the water underneath the buildings. Thirdly, the extremely large amount of silt and soil blasted the wood, which turned it into stone at an accelerated pace. Finally, the piles were placed as closely together as the soil of the ground would permit and stone and rock were thrown in between to keep the silt from rising up. Also the houses needed and need to be constructed in a special way, as they have to stay upright on an unstable soil and resist the forces of the water. You might for instance have noticed that most buildings in Venice have marble floors. The rationale behind this is not only related to aesthetics, but mainly due to the fact that marble is impermeable to water. Other examples of specific Venetian construction requirements are the outer walls which are wider than inner walls and which have larger and deeper foundations or the 'paratie' that you find in front of the doors to avoid water entering the house at *acqua alta*. Mencini writes in the conclusions of his recent E-book: "*l'acqua alta è vissuta dalla popolazione con grande disagio e con una insofferenza maggiore rispetto al passato, probabilmente anche per il cambiamento del tessuto sociale della città sempre meno "giovane" e più "vecchia" con esigenze pertanto di vita diverse. Situazioni sociali mutate, attività economiche sempre più legate allo sviluppo turistico, diminuzione dei finanziamenti per la tutela e il restauro dei monumenti storico-architettonici e delle stesse abitazioni dei residenti, i cambiamenti climatici in atto, rendono sempre più indispensabile fermare le acque alte a Venezia*". Even though *acqua alta* is something 'common' for Venetians, it always gets a lot of attention from the world media, who seem to worry much more about it than the residents. Venice is often referred to as the "sinking city", and unfortunately there is some element of truth in it. The city is now 25 cm lower compared to the sea level than at the beginning of the 20th century. One of the underlying reasons is the use of the ground water from the subsoil under the city for the daily life. As a result, and as you can see on the graph from the "Centro Previsioni e Segnalazioni Maree", the frequency of reaching a water level of 110 cm is increasing over time. The current problem of the climate change and the rising sea level adds another level of complexity to it. Jay Griffin, an architecture student from the Technology University of Sydney, looked into this topic and compared Venice to other regions in the world with the same problem. There is also the opposite phenomenon, i.e. ***acqua bassa***. When this happens, the water in some canals is so low (from -50 cm, even down to -70 cm) that boats get stuck and the waterways cannot be used. The destructive impact from the water on the houses is also visible at that time below the waterline. *Acqua bassa* happens less often than *acqua alta*, but it has been occurring more frequently in the last years due to the fact that many canals haven't been dredged and cleaned for a long time. Due to changes in the law (*Legge Speciale*), all financing went primarily to the Mose project instead. As with *acqua alta*, it's a matter of patience (of a couple of hours) until the water flows again normally.

A City in danger

The precariousness of the Venice setting and the risk for her survival received universal recognition after the catastrophic inundation of 4th November 1966, when water attained the unprecedented elevation of 194 cm above datum and with the city below 100 cm of water for 15 hours. A tide of 194 cm completely flooded Venice, as well as Chioggia and other islands and villages in the lagoon. At that time, UNESCO launched an international request for funding to repair the damages to the city. Several international committees were created, of which many still exist to preserve the history of Venice. Fifty years after the 1966 Venice flood, the "*Fondazione Giorgio Cini*" held an international workshop devoted to the theme 'Sustainability of local commons with a global value: Venice and its lagoon'. The theme was addressed by international experts from various disciplines: economics, ecology, political science, sociology, tourism, urban planning, and cultural heritage. These experts decided to assemble the main ideas and proposals raised during the meeting in a document, which is meant as a sort of '*manifesto*' addressed to public opinion and politicians. At that time in fact an endless debate started about the most appropriate solution to the *acqua alta* problem, which seems to have come to a final conclusion with the official approval of the *Modulo Sperimentale Elettromeccanico* (MOSE) project. MOSE consists of 79 mobile barriers made from hollow steel boxes 20 m wide and 20 m long. Normally, the barriers are filled with water and rest horizontally hinged on the bottom of the three lagoon inlets. They are rotated up to an angle of 45 to prevent seawater from entering the lagoon any time the elevation in the Adriatic achieves 110 cm above the official Italian datum. The Mose project is not only focusing on the problem of the increase in high tides and floods, but it is an integrated project that intends to restore and protect the ecosystem in the lagoon as well. The erosion of the littorals resulted in the gradual disappearance of beaches, while the environmental deterioration led to a loss of typical habitats such as salt marshes and shallows. The Mose project is therefore much more than an installation of mobile barriers as it also implements solutions for these environmental issues. The following actions have already been taken and/or are ongoing: Recreation and protection of salt marshes to safeguard the natural habitats and to guarantee the essential ecological biodiversity in the lagoon. Reconstruction of (new) beaches and coastal dunes and construction of outer breakwaters to defend from sea storms and stop the erosion. Raising of quaysides and public paved zones in the lowest parts to defend urban centres from floods. Improving the water and sediment quality by isolating polluted land from the canal shores in *Porto Marghera* and from dumps and by creating special wetlands between the mainland and the lagoon to filter the water. Installation of mobile barriers at lagoon inlets to protect against floods. The installation of the mobile barriers is a technically challenging project. There will be 4 barriers of approx. 200 metres wide at the inlets of Lido (2 barriers), Malamocco and Chioggia. Each barrier consists of approx. 20 gates, which can be manipulated individually. The barriers should protect Venice and the other lagoon islands up to a sea level of 300 cm, way above the historical level of 194 cm. The control and management of the system takes place from the control room at *Arsenale Nord*. So far, the barrier in the *Lido-Treporti* inlet is already finalized, while the foundations of the other 3 are in place and they will be fully installed in the coming two years. The system will only be used once all 4 barriers are complete. The barriers will be raised to separate the lagoon from the sea when a high tide of 110 cm or more is forecasted (although this could change in the future depending on the requirements). In such an event, the barriers are filled with compressed air to rise up out of the sea. Once the danger is gone (usually a 4 hour period), the barriers are filled with water to lower them below the sea level. Depending on the tide, they might be used simultaneously, separately or even partially with only a limited number of gates. To avoid interference with the normal port activities, locks have been installed next to the barriers of Malamocco (merchant ships), Chioggia and Lido (fishing boats, emergency vessels and pleasure craft) to ensure that ships can enter or exit the lagoon when the barriers are up. The only ones who will be stuck are the large cruise ships. A few authors have expressed severe criticism of MOSE [Umgiesser, 1999; Ammerman and McClennen, 2000; Pirazzoli, 2002]. According to those authors, MOSE, in the first place, does not protect Venice from floods between 80 and 110 cm (at 80 cm, San Marco square is flooded) when a significant (up to 12%) fraction of the city is submerged, and this situation can occur a sizable number of times. Thus in a season such as the 2002 fall, with the city experiencing several ‘‘acqua alta’’ below but close to the limiting 110 cm value, a strong pressure by the Venetians to have MOSE work for these floods might be anticipated. In this case the frequency of MOSE operation would increase, causing reduced renewal of lagoon water with potential severe impact on the preservation of the lagoon ecosystem equilibrium. Secondly, MOSE might become rapidly obsolete because of the expected sea level rise due to global climate change. Other proposals, such as raising the pavements or increasing the resistance to water flooding at the three inlets are also controversial. Some of these solutions are currently being implemented. For example, in the lowest suburbs, the sidewalks and the channel banks have been raised up by 50 cm, while works at the inlets are undergoing. Complementary to the raising of street pavements, which is being implemented wherever possible in the city, they study the possibility offered by deep fluid injection to raise the entire lagoon bottom below the Venice area. The basic idea is concerned with injecting seawater into a brackish geological formation located 600–800 m below the city and raising the lagoon bottom as a consequence of the rock swelling caused by the pore pressure increase in the injected formation. Injection technology is currently available from the petroleum industry and has been used worldwide over the last 40–50 years, with facilities across the United States discharging a variety of fluids into more than 400,000 injection wells [U.S. Environmental Protection Agency (USEPA), 2002]. Water injection is performed for different purposes. Reinjection of salty formation water has also been accomplished in the northern Adriatic basin (the same basin that underlies Venice) by ENI-E&P, the Italian national oil company. The water extracted along with gas from the Malossa field, located about 200 km west of the Venice Lagoon, has been pumped at a rate of 1000–3000 m3 d_1 for a number of years through two injection wells into a 1100- to 1350-m-deep sandy formation characterized by average porosity and permeability of 23% and 3_10_7ms_1, respectively. The increasing challenge posed by flooding may be solved, at least for a few decades, by completion of the MOSE system in 2018-2019. Yet in the meantime residents are fleeing the historic city. The frequency of floods, the pressure of tourists, the high price of property, and the opportunities created by extending the hospitality industry into private homes are all contributing to the exodus. Corrosion by salty water menaces houses and historic monuments, like the *Basilica of San Marco*. Moreover, the designation of Venice as a World Heritage site has immensely increased the attraction of the historical city, whilst cheap mass transportation and the diversification and growth of tourist accommodation in the historic center have triggered a massive influx of people that the fabric of this fragile city is unable to absorb. 50 years after the 1966 disastrous flood, the works supposed to better control the tides and "acqua alta" are not yet completed in spite of the huge amount of financial resources put in that venture. And more financial resources will be needed for its very costly maintenance. Yet there is no indication which authority will be in charge of managing and funding its operations. Even worse, the system of governance of the complex eco-system (the historical city and its lagoon, the "*terraferma*", the port and airport and their related activities) is completely inadequate and does not encompass the entire set of interrelated problems facing this unique city. Too many different authorities locally, regionally and nationally are involved in managing the city and the lagoon. They have differing priorities and the coordination costs are huge with everyone able to veto decisions to address the vital issues. In a scene reminiscent of those in the movie *Water World*, the Nova documentary *Sinking City of Venice* contains a dramatic computer-simulation of a future flooded Venice with only the top third of the *Campanile* and the Dome of *San Marco* peeking out among the waves. The sea level around the world is predicted to rise anywhere from 8 to 88 cm by the start of the next century. Venice is therefore the first city to face sea level rise as a consequence of climate warming due to being flush at sea level. In this respect, the present conditions in Venice are a presage for what the future might bring elsewhere. Or as Tomasin dramatically worded it in 2004: “Sea level rise is like a rope that is tightening around the neck of Venice”.

Conclusions

In conclusion, time may be running out for Venice. The problem has been in converting all the research into action. With rising average water levels, the frequency of city flooding is increasing and the threat of a repeat of the November 1966 event, when the aforementioned violent storm surge took water levels nearly two metres higher than usual, remains. Surrounding the city is a severely degraded lagoon ecosystem. Venice should draw inspiration from other cities around the world, such as Amsterdam, Bruges or Barcelona that are facing similar challenges of excessive tourism growth and environmental degradation to varying degrees. Money and regulations are important but they are not enough. Protection is a necessity, revival is a duty. The city has always been the meeting point between East and West, South and North and it should aim to recover this vocation through education, research and innovation.

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Humanities, Anno VI(2017), numero 2
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