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Sustainable Post-Disaster Solutions—London 1666, Lisbon 1755 and Japan 2011—Learning from the Past

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Abstract: Natural disasters have impacted human settlements throughout the centuries, imparting lessons as new ways and strategies to avoid or minimize the damage inflicted by the natural processes. This on-going process has created new landscapes instrumental to man's balance of the use of the land by taking into account the probability of further natural disasters. This paper discusses the responses to disaster challenges taking past experiences on "after disaster decisions" in London 1666, in Lisbon 1755 as a framework to analyse the more recent Great East Japan Earthquake disaster. The concept of sustainability which adds a new perspective to the subject of more resistant solutions and strategies as the opportunity for a new design is presented by the destruction. Sustainable environmental, social and cultural issues improvements are important goals introduced in the 20th century and enrich long-term human adaptations to natural processes. They are also considered in this analysis as an evolving final product of the human adaptation that results in more durable cultural landscapes.

Key words: Baixa Pombalina, London fire, Great East Japan Earthquake, after disaster design, sustainable landscape design.

1. Introduction

To varying degrees, cities as cultural landscapes have evolved in response to on-going natural disasters. In the extreme, places regularly destroyed by floods, earthquakes, tornados or fires are simply rejected as viable sites for rebuilding. More often, however, a variety of reasons such as accumulated high investment in buildings and city infrastructures, long habitation patterns and traditions and the availability of resources (to name a few) mean that the population will not abandon these most historically at-risk places due to their potential for natural disasters. In contrast, the accumulated knowledge that results from cities responding to such events may be considered as the highest concentration of techniques and strategies for sustainability. In other words, every time a disaster strikes a high-density city, the result is a re-evaluation of established responses, as well as the opportunity to develop new strategies and techniques for addressing natural disasters. The human mind is called upon to observe and learn from the effects of imprudent land use, poor site selection and shoddy building techniques in order to create more sustainable solutions for subsequent generations with respect to land use, landscaping choices and building design.

Based on this "after-disaster creative process," it is important to look at prior solutions derived from catastrophic natural events and learn from the past. This paper, then, compares and contrasts the post-earthquake Lisbon reconstruction from the 18th century and the post-fire London reconstruction from the 17th century (Fig. 1). Both cases are then utilized as reference points for the on-going recovery and reconstruction associated with the 2011 Great East Japan Earthquake. Specifically, Lisbon presents a useful paradigm for city planning for change, while London is examined for its panoply of legal, regulatory and technical responses to a 350-year old disaster whose imprint can still be seen and felt in the modern city.

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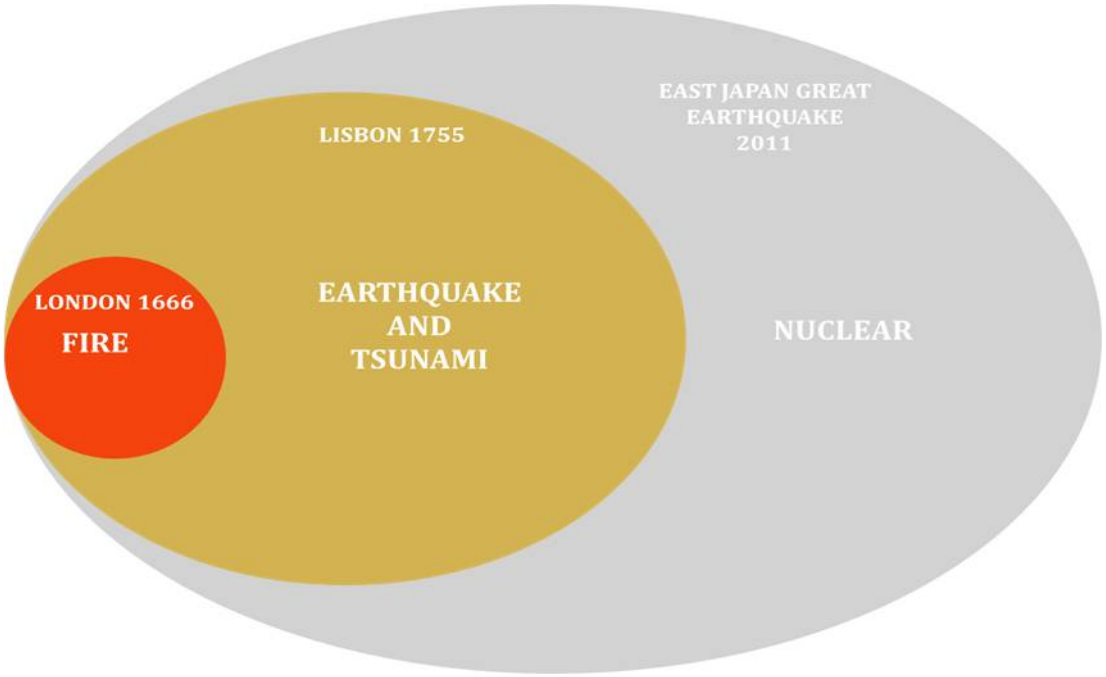

Fig. 1 Three examples of disasters separated by centuries that were taken to respond to a catastrophic event: London 1666, Lisbon 1755 and East Japan 2011 [1-3].

2. Materials: Three Cities Destroyed—Four Centuries of Accumulated Knowledge

2.1 A Compared Analyses

Three examples of disasters separated by centuries are illustrative in identifying specific actions that were taken to respond to a catastrophic event, each of which has contemporary implications for modern city planners: London 1666, Lisbon 1755 and East Japan 2011 [1-3]. For comparison, it is used the reconstruction of Lisbon following the earthquake of 1755 as a middle point in time, principally because it referred back to what had occurred in post-1666 London, although upgrading and modifying solutions based on new processes and planning decisions. Lisbon also reaches into the future as it can be analysed to identify strategies for future planning in areas suffering from immense natural disasters, such as what occurred in East Japan as a result of the great earthquake of 2011.

While these three examples have the destruction of cities in common, they differ in the cause and the extent of the disaster. One-third of Stuart-era London was destroyed by a great fire. Lisbon experienced an earthquake, a fire and a tsunami where “the entire city centre, the Baixa, ceased to exist” [4]. And the east coast of Japan was struck by an earthquake, a devastating tsunami and the spread of nuclear radiation throughout the region and beyond. These three historic events, while sharing some similarities, differ in each that had to respond to increasingly complex problems.

A common thread running through each of these case studies is that they all had an emergency “task force” (obviously, that modern nomenclature is liberally applied to the two older events) that responded very quickly to the needs of the population once disaster struck. Additionally, local inhabitants began relatively quickly to develop plans detailing the new spatial reality of each site, which entailed establishing safety regulations, identifying priorities for new projects and developments, and bringing the local population back to productive activities. In the case of both London and Lisbon, new building regulations and techniques were developed and implemented in response to the threat of a potential

repetition of the disaster. Moreover, despite the formidable challenge of rebuilding both cities, neither instance was relocating the city center seriously considered, although it was envisioned in one of the alternative plans. In contrast, after the Japan Earthquake and subsequent tsunami, at the time of writing only the village of Iwanuma in the Miyagi prefecture has been rebuilt and results cannot yet be measured. In other nearby areas, the reconstruction is slow, resulting in a high emigration rate and loss of families and the working class [3].

2.2 Lisbon 1755 Earthquake and the Transmission of London Solutions

On November 1, 1755 (ironically, the holiday of All Saints' Day), the old city of Lisbon suffered what subsequently became known as the Great Lisbon Earthquake, which was followed by fire and a tsunami (one of the largest and more destructive in recorded history (Fig. 2). Although the earthquake's magnitude cannot be known for certain, modern seismologists estimate its severity between 8.5 and 9.0 [5]. Buildings collapsed and Lisbon residents fled to the streets in terror. About 40 minutes after the earthquake, a tremendous wave moved into the lower part of the city and took the lives of thousands. In areas unaffected by the tsunami, fires raged for a number of days. The total number of casualties is believed to be about 50,000—with some estimates at twice that level.

Most of Lisbon's buildings (perhaps 85% of them) were destroyed or damaged, including most of Portugal's distinctive 16th-century Manueline architecture. In response, Lisbon's 18th-century post-disaster renovations were truly sweeping in scale: the implementation of more robust building solutions against earthquakes and fire, a new and more regularized city design plan with wider roads, a healthier and more hygienic sewage system, a compensation framework for property owners to allow building the same facilities in different locations, redesigning plazas for better commercial functions, and a public park [2]. This paper will present the ideas behind the planning and the results of the restoration that allowed Lisbon to become a new city, more resistant and more sustainable.

Fig. 2 Lisbon, Portugal, during the great earthquake of 1 November 1755, tsunami rush upon the shore, destroying the wharfs, Courtesy of Museu da Cidade, Lisbon.

Three key persons, the politian Marquis of Pombal, the engineer Manuel da Maia and the architect Eugénio dos Sanots can be credited with planning a safer and new city, which despite longstanding historical property lines and traditional land use, notably featured a new grid plan to replace the medieval labyrinth layout. Politically-motivated goals to move the city from its courtly and religious traditions into a new utilitarian productive commercial centre must also be considered in light of the unique circumstances [2]. Indeed, "the revitalization of a city following a calamitous event represents an unparalleled opportunity to reshape its form in accordance with new design standards and cultural ideals" [4].

The new segment of Lisbon known as the Baixa represents a highly successful achievement of a sustainable urban landscape (Fig. 3)—an example of astute planning that resulted in important social and architectural solutions to an unprecedented set of problems. As such, this event and its aftermath leads into a discussion of utopia and reality planning, public participation versus autocratic systems, which in the case of Lisbon was legitimated by enlightened decision makers, in particular, the prime minster Sebastiao de Melo, the powerful Marquis of Pombal (1699-1778) [4]. The King was so awestruck at Pombal's calm and rational response that he quickly directed Pombal to take charge of bringing order back to the city. With the King's approval and his powers of martial law, Pombal took immediate action. Within a matter of days, a food distribution system, the interment of the dead at sea (even with the cooperation of an often-reluctant Catholic clergy) and the establishment of law and order were all undertaken according to Pombal's directions. Additionally, the army was deployed to prevent people from fleeing the city, looters were summarily hanged, and pleas for special treatment from the nobles and clergy were ignored. Pombal quickly became a heroic figure among the Portuguese people [4]. So important was he in the reconstruction of Lisbon that Pombal's name is linked to the reconstruction of Baixa, which became known as Baixa Pombalina.

Important to this discussion is that Pombal had served as the Portuguese Ambassador to London for seven years (1738-1745). Even though most sources seem to reject the importance of the reconstruction of London as a precedent-setting example for Lisbon [2] (quoting the dissertations where the architect Manuel da Maia is clear about not having seen the plans for the reconstruction of London), it seems difficult to dismiss the fact that Pombal surely knew well the success of the rebuilt new city, despite the fact that he was living in London 70 years after the Great Fire. It can be assumed that he was familiar with the processes and legal systems "invented" by architects, lawyers and politicians to address a decimated London—many of the same problems that Lisbon would be facing just ten years after Pombal's return to Portugal.

As will be discussed in this paper, the rapidity with which Londoners responded to the destruction was instrumental in maintaining the city as the commercial hub of the country with active citizens producing wealth. The very same issue confronted the Marquis in formulating his vision for the Phoenix-like reconstruction of Lisbon. He understood that a swift response was essential to both maintain the economic importance of Lisbon, but also to make it safer and more resistant to earthquakes and tsunamis as an embodiment of a political change. He had a vision of all that could be achieved, bigger and with more benefits in political terms than had occurred with the London reconstruction.

2.3 The London Great Fire and Its Reconstruction: *A Useful Vision for the Portuguese Ambassador in London*

Despite the three and a half centuries that separate today from the London Fire, the planning and decision-making processes associated with the London

Fig. 3 Today's Lisbon traffic in the Baixa still uses the streets designed in 1756.

reconstruction can serve as a benchmark of a pioneer city rebuilding in democracy. In terms of its scale, the September 1666 fire burned for three days and destroyed some 13,000 homes in the old Medieval wooden city. The Great Fire also burned down dozens of churches and decimated the many slum areas of London. Surprisingly, relatively few deaths are linked to the conflagration. And despite the fact that the Lord Mayor of London is believed to have been slow in responding to the fire—which at that time was fought by creating firebreaks by demolishing buildings—the post-disaster response was quite different. In fact, with just a month after the fire, Christopher Wren's fully-sketched proposal for the reconstruction of London was submitted for consideration. "Christopher Wren's design for London sought to make all parts accessible by re-planning the streets, and while serving this end he kept in view four principal objects, correcting errors: (1) to let the Royal Exchange on its existing site stand free, "the nave or center of the town"; (2) to give to St. Paul's the significance which the metropolitan Cathedral required; (3) to improve the bad communications with London Bridge, upon which four important streets were to converge and (4) to clear the river bank from the Temple to the Tower, and construct thereon a public quay [1]. The Wren

plan is a very interesting document expressing the utopian qualities of a designer who in an incredibly short time delivers the dream of a perfect new city without any concern for the people's interest, rights or history. "It is above all things an architect's town" [1].

It had, nevertheless, the great advantage of triggering other plans from major architects of the time, including one from John Evelyn. In contrast to Wren, "John Evelyn's ideas were quite different (…). The greatest care has been taken to preserve a stately river front. The long quay does away with the irregularity and deformity of the old boat-stairs and wharves. (…) The Churchyard has been slightly enlarged into a regular oval, (…)" (Fig. 4) [1].

The third major model for rebuilding London was presented before the Common Council by Robert Hooke, then Reader of Mathematics at Gresham College [1]. "The chief streets, laid out east and west, were each to run in an exact straight line and, crossing these, other streets, equally straight, went north and south. All churches, public buildings, markets and the like were to be arranged in proper and convenient places." [1]. The final shape of London's reconstruction is close to Hooke's plan, which first and foremost had the safety and well-being of London's residents at its forefront. It recommended the construction of stronger, simpler and safer buildings within a grid of streets, allowing people to circulate in safety in going about their regular social and business activities, but escape quickly in case of emergency.

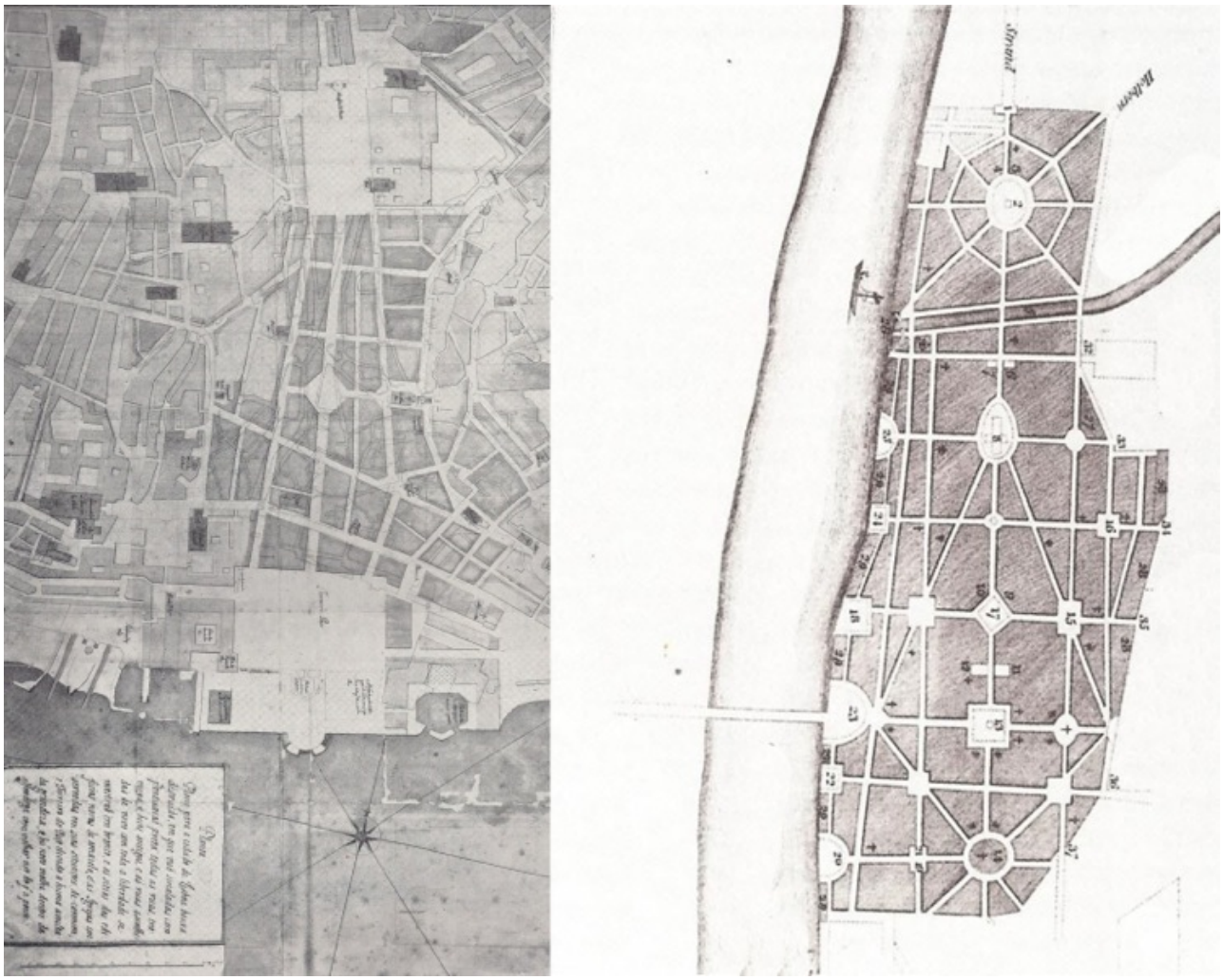

Fig. 4 With Eugenio dos Santos plan for Lisbon (1756) shows similarities with Evelyn's plan for London (1667) [1, 2].

It must be noted that Wren's plan had appealing ideas that were later used in the reconstruction process without any reference to him. These included a large plaza in front of the river, and the use of stone rubble to overcome "the worst declivities of the ground have gone in a process of general leveling," with the intent of avoiding future inundations [1]. "The obvious criticism of Wren's model, all questions of cost apart is that it made no provision for growth, and that his riverside quay, if perpetuated, would have shut out the enormous shipping and warehousing business (…)" [1]. All the plans—those selected and those not—represented an important intellectual addition to the discussion on the matter of reconstruction, which was democratically considered within the Parliament and the Common Council. Nonetheless, competing interests and the urgency in putting the city back on its feet created some discord. "Parliament was divided upon the method of procedure in rebuilding London. There were three parties in the House of Commons, one of which favored an entirely new arrangement of the streets as proposed by Wren, Evelyn and Hooke, but made no choice of plans. Another desired to restore the city as before, but with brick, and the third advocated a fusion of the two projects by raising a quay along the river (…)" [1].

It is recognized here that suggested plans had to be contextualized within a legal framework prepared by Parliament, where the status of owner and tenant became instrumental to the rapid reconstruction and fairness of the solutions. "The impracticability of rebuilding the city (…) was soon manifest, and when the Act of Parliament was framed the models were quietly set aside. (…) The greatest aid in the rebuilding of London was unquestionably that given by an Act of Parliament—the Statute 18 & 19 Charles II, chap. 7, which set up the Court of Fire Judges. It was drafted to meet a situation that called for drastic measures." [1]. In essence, a new court system created that relied upon a methodical analysis and survey of each case, and while no design was needed, the survey was supervised by Hooke.

An unquestionable man of high experience headed the court: "Sir Mathew Hale, the Lord Chief Baron, drafted the Act and was largely employed in its application. He enjoyed the public confidence, and rightly, in a remarkable degree. A man of immense industry, knowledge, and sagacity (…)." [1]. This unparalleled situation is still an example today, let alone in the time of Pombal, who lived within the *spatial product* of this regulation system a few decades later. "London after the Fire was built upon compromise" [1]. In contrast, Lisbon was rebuilt according to Pombal's uncompromising, albeit enlightened, vision of a successful mercantile Lisbon—even if it meant going against the traditional power of the church and the Nobles. Pombal was a despotic ruler who did not learn the full lesson from London—namely, compromise in rebuilding. The reader will see in Lisbon how the rebuilding process was set in a non-democratic atmosphere. "The indecision of the Parliament (in London) was met by the obstinate averseness of the citizens to accept any scheme for the transfer of property" [1]. In fact, knowing that Lisbon residents were digging in their heels, Pombal took things into his own hands. Within days, he ensured that all remains of standing properties were leveled to the ground so that the hopes of the people to rebuild with the same materials and in the same spot were reduced to nothing. This strong will of the people to maintain their property in the exact same location is a recurrent problem that can be witnessed through the centuries—until the Great East Japan Earthquake, which will be detailed later in this article.

However, the legal structure created in London thereafter fostered a most important device of the reconstruction—the institution of building regulations that by themselves are the proof of a sustainable future for the city. On the one hand, no longer were wooden structures permitted. London moved to a more fire-resistant material: brick. On the other hand,

limiting the height of the buildings, controlling their alignment and redesigning the width of the streets further reduced the risk for fire damage. “The (Rebuilding) Act gave to London for the first time a complete code of building regulations, and so doing, did that which no Building Act before or since had attempted” [1]. These various regulations were later adapted for use in Lisbon in the form of new building codes, such as the mandated use of stone and the regularization of building height.

The regulatory framework for rebuilding in London was unambiguous, yet manageable, which allowed for a swift rebuilding of the city. “For each type of house the thickness of brick walls, heights from floor to ceiling, depth of cellars and sufficiency of party walls, scantlings of timber and much other detail were set out in scheduled tables, to which builders were required to conform.” [1]. Similarly, in Lisbon, it can be found details of a building system invented to be more resistant to earthquakes. The specifications of this system featured the use of cage structures, which were rigorously enforced in the rebuilt area [6]. These are still standing in Lisbon after more than 250 years.

As in any reconstruction effort—especially one taking place in historically multi-layered city needing wider streets, a sewage system, new homes and more public spaces—such improvements are costly. Thus, the rebuilding process required innovative funding solutions as well. “As drafted, the Rebuilding Act made no financial provision. To meet the cost of public works, the city proposed tax upon all coal brought into London (…). Instead, a clause was at the last moment added to the Rebuilding Act, imposing a tax of one shilling upon each chaldron or ton, the first proceeds to be devoted to compensation for land taken and passages, restoring the river wharves and quays, and rebuilding the city prisons.” [6]. The experience of London shows that the capacity to find quick solutions for each problem, even financial ones, facilitated rapid reconstruction. Indeed, the urgent need to bring the city back required both a multidisciplinary approach involving many professional areas, as well as agreement between all parts involved.

When viewed from a distance, the sequence of steps following the Great Fire of 1666—starting with the submission of alternative plans, deciding on the “no-specific plan” reconstruction, using a legal system for decisions while assuring a public participation for the invention of a model, and requiring a multidisciplinary team for the decision making—represents a pioneering response to an unprecedented calamity and no doubt hastened the reconstruction of London.

2.4 The Lisbon Reconstruction Process

As noted earlier, the intensity of the Lisbon disaster was significantly greater than what had occurred in London some 89 years earlier. Consider that Lisbon’s fire was precipitated by a massive earthquake, which then created a tsunami the likes of which residents had never experienced.

King Joseph I was so traumatized by the disaster that he developed a lifelong case of claustrophobia, never wanted to live again in stone buildings—nor did he ever return to his Lisbon palace. Instead, he gave full power for the reconstruction to the Marquis of Pombal, who appointed Manuel da Maia, the wise old military engineer of Lisbon, as master of the reconstruction. The latter was about 80 years old and highly capable and experienced with engineering and construction, as evidenced by the fact that he designed, a most impressive 30 km long stone aqueduct that brought water to the city of Lisbon, and which remained intact even after the earthquake. “Royal Engineer-in-chief, Maia had a wealth of experiences that made him a logical designee. Trained in the Vaubanesque style of military fortification, architecture and engineering of the late seventeenth century/early eighteenth century, director of the Academy of Fortification (Aula de Fortificacao), extensively experienced in developing projects

through the reigns of three kings, and author of a previously unimplemented plan of Lisbon, he was well-grounded in the problems that were facing the city." [4].

One month after the earthquake, "on December 4th of 1755, master Manuel da Maia (…) sent to the Justice Minister the first part of a long memorial (the "Dissertation") in which he studies some problems pertaining the reconstruction of Lisbon" [2]. Two other parts were delivered in February and March 1756 and Maia's texts states "the discussion of urban planning alternatives, a proposal of architectural models and original observations on construction details pertaining to the safety and resistance of the buildings as to the hygienic road system." [2]. Four alternative planning options suggested the following options:

(1) Rebuilding the city as it was, a medieval organic layout with high, unfortified buildings;

(2) Reconstructing the city with minimal improvements to the street pattern, but reducing the height of buildings;

(3) Rebuilding with a 100% new design;

(4) Relocating the city on a new site near Belem and beginning a new.

Maia was opposed to the first option, claiming that "this way of building in height supposes that the past earthquake is not a prognostic of another (…) and that the authors should not expect a subsequent one." [7]. He knew full well the probability of such an occurrence since Lisbon had experienced six major earthquakes in the 14th and 16th centuries. This "no-change option" was rejected due to the magnitude of the disaster and the opportunities it presented to a city in need of significant urban improvements.

The fourth suggested solution of relocating the capital—although representing an intelligent approach to city planning, quite ahead of his time—was dismissed by Pombal but preferred by Maia. The experienced master of reconstruction suggested that the city be relocated west of the center in the area of Ajuda and Belem, where buildings had been less damaged. In the absence of modern geospatial analysis tools, Maia's proposal bordered on prophetic. Almost 150 years after Pombal's survey documenting the most and least destroyed areas of the city, and based on it, a data treatment was made that commented on the stability of each part of the city of Lisbon and confirmed Maia's perception of the ground [8]. Later in the 20th century, geological maps of Lisbon (Fig. 5) showed a clear difference between the western part of Lisbon where little damage occurred (Ajuda and Belem) and which were composed of hard basalt and limestone, and the eastern part where the city was rebuilt on mostly alluvial soils and less stable limestone [9].

In short, without "hard" scientific data and only by direct analyses of the effects of the tremor on the site, Maia was able to identify a more robust area resilient to both earthquakes and tsunamis. He was able to read the landscape capacities and propose a more geographically appropriate site for the relocation of the city. However, despite the long-term sustainability and prudence of Maia's advice, Pombal rejected the move and selected the third option—rebuilding in Baixa. Note the distinctly different decision-making process in comparison to what had occurred in London in 1666, which basically evolved via democratic consensus.

Three other architects were selected to produce alternative urban designs for the Baixa (Fig. 6). "Below Maia in rank were Captain Eugénio dos Santos (1711-1760) and Lieutenant Colonel Carlos Mardel (1695-1763). These two military engineers were responsible for overseeing the creation of the plan and its implementation." [4]. Eugénio dos Santos, became the most famous because he was responsible for the final drawings of the Baixa and followed its construction during the next decade. "Santos, aged 45 at the time of the earthquake. Pragmatic and fully committed to the need for efficiency and speed, Santos must be most credited with understanding

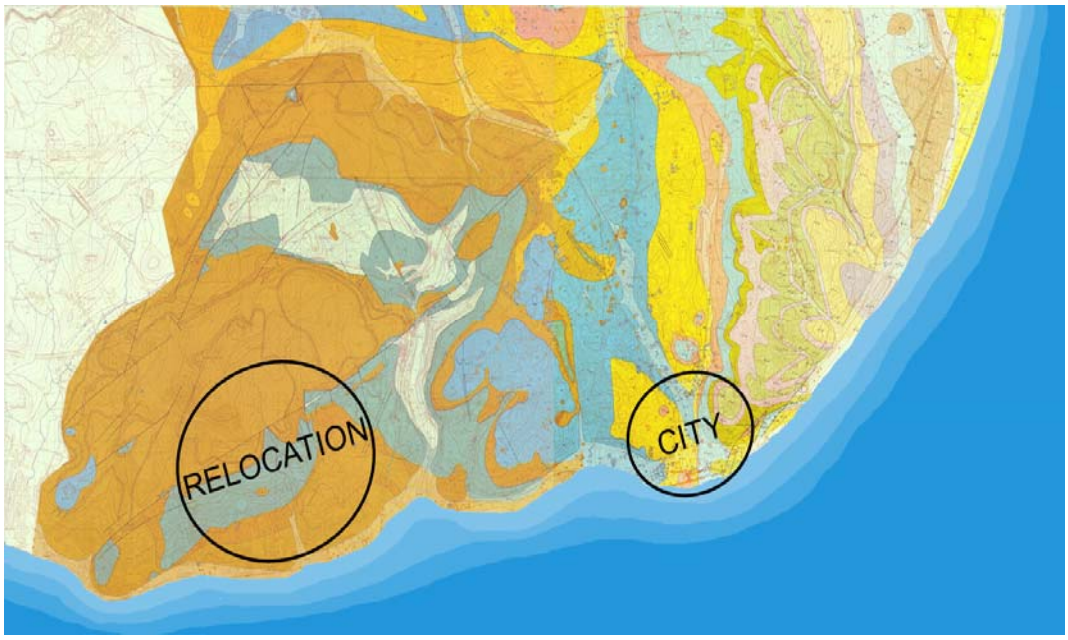

Fig. 5 The proposed Re–location of Lisbon to Ajuda, the area least affected by the disasters, which was Maia's, 4th proposal, a good site, confirmed later by 20th century geological maps.

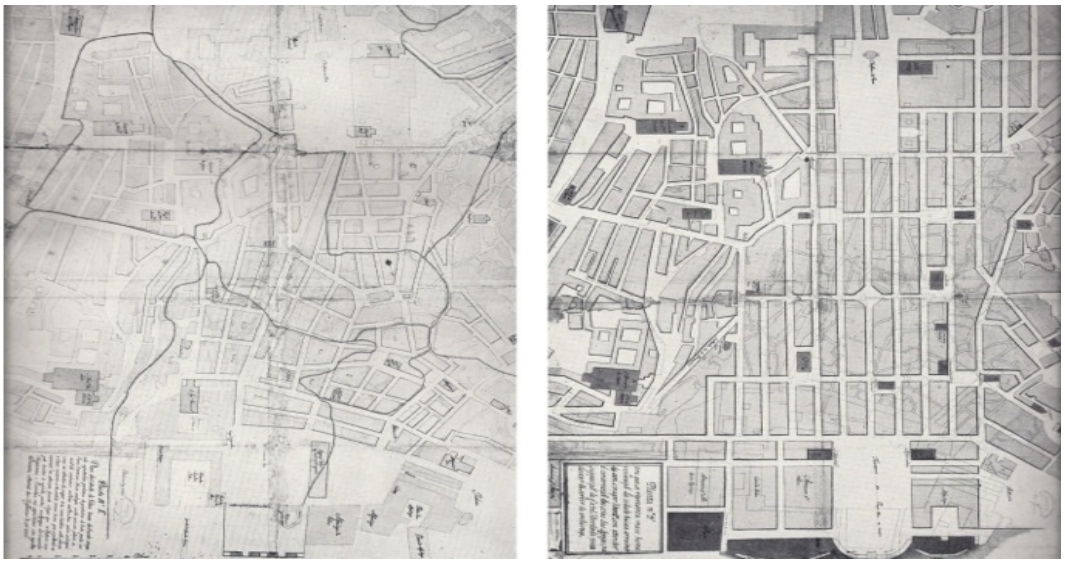

Fig. 6 Two of the alternative urban designs for the Baixa presented to the Marquis of Pombal in 1756.

Pombal's visions of a new society in a physical sense. It is through Santos' work, with its emphasis on utility, simplicity and repetition that people can see the most extensive and sophisticated adaptation of "plain architecture" undertaken in any Portuguese city [4].

It should also be noted that the three guiding architects commissioned their junior colleagues—Gualter da Fonseca, Elias Sebastião Poppe, Eugénio dos Santos and Carlos Mardel—to produce plans that focused on three differing goals: (1) keep the road alignment and the churches; (2) open new roads while maintaining the location of churches and (3) create a whole new street pattern. The teams worked collaboratively in proposing the most advantageous layout for the new city, each a distinct emphasis. For example, the Poppe Plan represented a significant departure from Fonseca's Plan. It was at once utilitarian with its repetitious row on row of

blocks and an abstract step toward the enlightened city with its emphasis on ease of movement, sunlight and airflow. Above all, it was a dramatic announcement that it was possible to create a new community based upon the standards of the time within the heart of an old city (Fig. 7) [4]. The third plan included three large avenues connecting the inland plaza, known as the Rossio (laid on approximately the same space as it had been before), geometrizing it into a rectangle parallel to a new riverfront plaza that was given a new name—the Terreiro do Paço (the King's palace grounds) became Praça do Comércio. Importantly, the name "Commercial Plaza" represents a distinct departure in terms of land use. Pombal chose to deemphasize the area's courtly association and stress its new mercantile destiny [10].

Ultimately, Pompal selected the fifth plan proposed by Eugenio dos Santos and Mardel to guide Lisbon's renewal. This proposal connected the two plazas, adjusted well to the east and west hills, and deviated the squares and streets by a 13º angle improving the parallelism between the two squares. This winning plan was quite revolutionary. "A radically different urban dynamic was at work that included unique block patterns, variation in road widths, lengths and end points, in addition to a redesigned Terreiro do Paço. (…) With ease of movement, standardized lots, easy parcelization, only minimal church relocation and opportunities for monumentality, Santos' plan met all of the basic conceptual objectives set by Maia and became the basis for the "Baixa Pombalina" (Fig. 8) [4].

With this new plan approved, the city could be rebuilt and it soon became instrumental in Pombal's

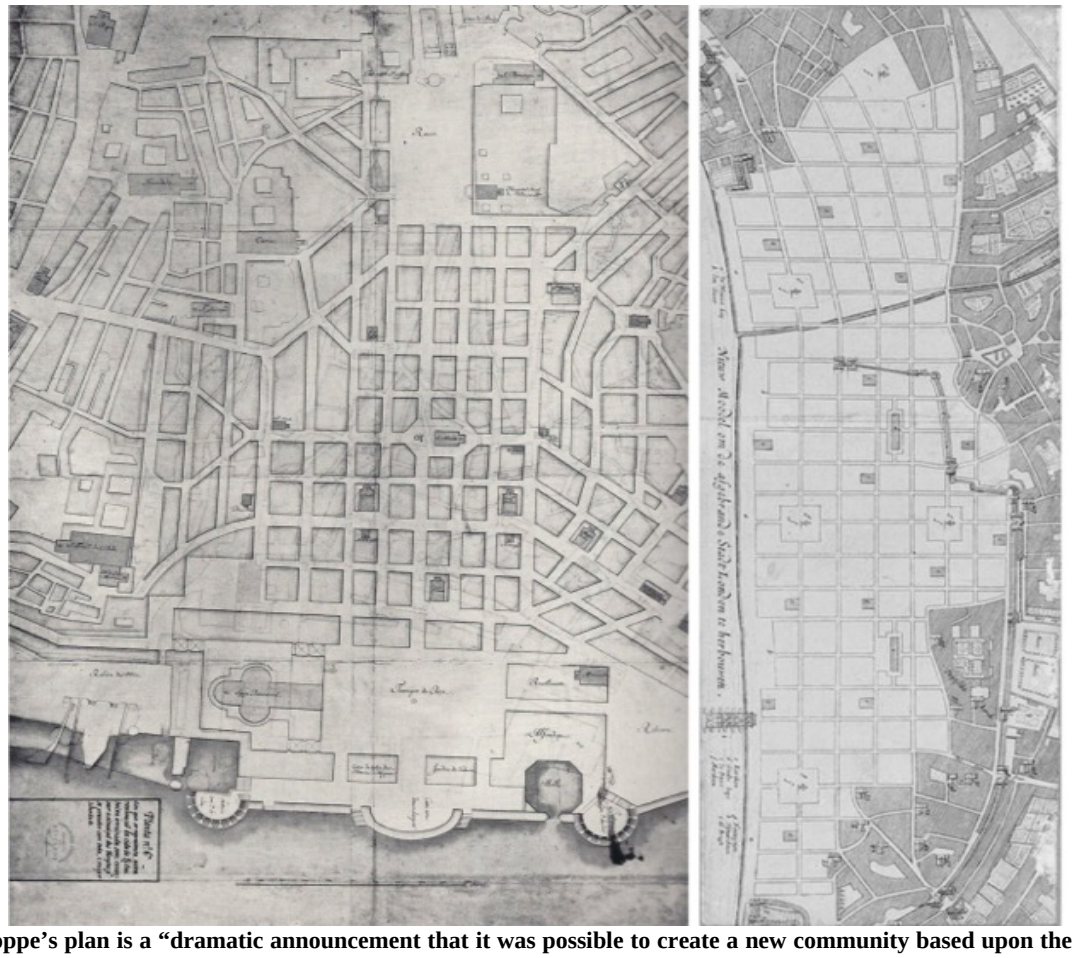

Fig. 7 Poppe's plan is a "dramatic announcement that it was possible to create a new community based upon the standards of the time within the heart of an old city" (Mullin, J.), this grid plan is similar to Hook's proposal.

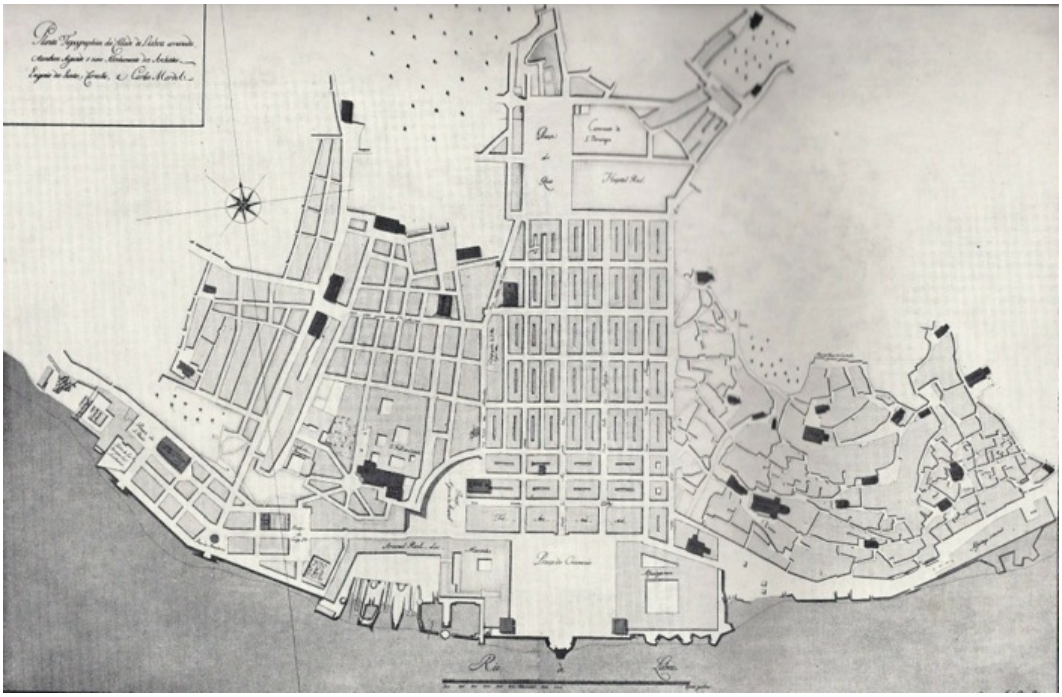

Fig. 8 Final approved plan, by Eugénio dos Santos and Carlos Mardel for the reconstruction of Lisbon 1756.

political ideals of a dynamic and enlightened center of a productive country. The large Royal plaza facing the river became an impressive entrance for the far distant commercial routes maintained between Portugal and her many colonial settlements in China, India, Indonesia, Africa and Brazil [10]. Simultaneously, however, the rise of Marquis of Pombal as an all-powered minister created many enemies in the clergy—but mainly among the powerful Jesuits and the high noblemen of Lisbon and beyond. For instance, the selection of the new layout of Lisbon also implied changing the ownership of the 14 existing churches' area and their "sacred" location, which had financial implications in terms of the real estate potential each parish owned. Essentially, Lisbon was no longer the city of the King, the Cardinal Patriarch and the noblemen. The altered post-disaster layout emphasized the role of the people's government, the merchant class and the increasing middle class. "Commerce and exchange processes were the main goal of Lisbon and these activities had precedent over the religious activities, the royal presence and settlement and all the court palatial movement." [4].

It must be noted, however, that although it is known that Pombal's dream of an efficient mercantile (i.e., wealthy) city started with his grid plan and an emphasis on linking the older lower portions to the upper parts of the city, the Marquis' plans were not fully realized in his lifetime [10]. The construction on Praça do Comércio had not yet been completed when the King died. Without his royal supporter, Pombal was dismissed and send to exile by all the enemies he had created. The plaza was only finished in the 19th century and was never really embraced as a People's Plaza by Lisbon residents and symbolically it has kept the two names.

As approved by Pombal, the new Lisbon grid design featured two larger streets linking the two major plazas, crisscrossed by a clear system of adjoining streets at right angles, which imposed homogeneous spaces, created unity and strength that is unique and inspiring in its plain utilitarian design. Similar to what had been mandated in London, Eugénio dos Santos led the project construction where three-story high blocks featuring standardized stone defining the windows, doors and verandas, all

originating from the same quarry were built. Most importantly, the new buildings in Lisbon complied with advanced structural requirements for seismic resilience, as evidenced by the imposition of the cage structure (Fig. 9).

Lisbon has been criticized for the monotony of its façades, the repetitious use of building materials, as well as the lost opportunity for designing and building a more ornamented baroque city. Nonetheless, it is exactly the imposing homogeneous volume of the reconstructed city, creating unity and strength, that is unique and inspiring—especially in light of the magnitude of the human, economic and material loss from which it had to recover. Today, going through the city by car or strolling along on its sidewalks, Lisbon presents a very comfortable and colorful ambiance. Inside, banking and commercial activities, services, and a few residences keep it alive. The "monotony" of its 18th century form has been overcomed by time. Owners have added azulejos or ornamented façades, lively colors and verandas. And the Baixa is undergoing a new restoration of the major Plaza over the Tagus estuary, imparting a new vibrancy to Lisbon as a Place Royale.

2.5 Great East Japan Earthquake: The Case of Iwanuma City in Miyagi Prefecture

The Great East Japan Earthquake on 11 March 2011 captured the attention of the world—indeed, its impact was felt as far away as Antarctica in the form of broken icebergs associated with the devastating 8-20 m tsunami that swept inland after the quake. Similar in magnitude to what had taken place in Lisbon (an estimated 9.0 on the Richter scale), the earthquake unleashed a range of "modern" problems that the country continues to address—not the least of which is loss of life. In 2016, a survey estimated that the disaster resulted in 15,894 dead and 2,563 missing. Moreover, the number of survivors living in temporary and borrowed houses stands at 174,000 with almost all communities still waiting for landscape rehabilitation and house reconstruction [3].

The reconstruction plan followed a "temporary" schedule that was instituted in March 2012 until March 2013, when municipalities established their fundamental reconstruction plan for five years. The Ministry of Land, Infrastructure, Transportation and Tourism (MLIT) organized the reconstruction projects in three types: Community Relocation Project (CRP Land Readjustment Project (LRP) and the Tsunami Reconstruction Core Area Project (TRCP), issuing thereafter in May 2015 in Miyagi Pref. 195 CRP, 34LRP and 12 TRCP [12]. Although official statistics confirm that each of these thrust areas has begun, none have completed the reconstruction and the relocation of people. This section focuses on the Iwanuma city

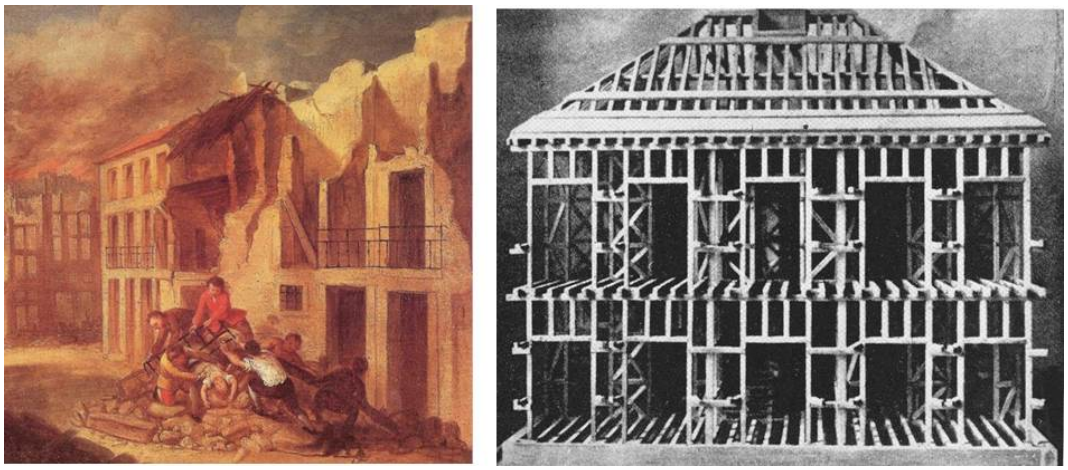

Fig. 9 Stone construction before 1755, no change since the roman times-2nd century (left), "The cage": model of a building obligatory in the new regulation building system in Lisbon after 1755 (right).

as a case study, which was successfully implemented as a CRP, with subsequent comparisons to the reconstruction processes that occurred in London and Lisbon to analyse the causes of its success.

At the time of the earthquake, the city of Iwanuma had a population of 44,000 and spread over 60 km^2 of alluvial plains created by the Abukuma River. Its six villages located along the coastal zone were almost completely destroyed by the tsunami with the loss of 181 people and the destruction of 5,426 buildings (Fig. 10). The tsunami overran extensive paddy fields, eventually leading to salt damage in large rural soil areas.

In the case of Great East Japan Earthquake Disaster, the national government did not officially release any adequate policies for community-based reconstruction efforts until March 2012. Not content to wait, the city of Iwanuma established its own reconstruction committee (the IRC) in April 2011, which consisted of survivors, scholars, agricultural and industrial leaders and the mayor. Just four months later in August, the IRC devised a recovery plan that comprised seven goals [13].

Goal 1: Setting up temporary housing for survivors;

Goal 2: Finding a suitable location to re-establish the six villages and create a safe city;

Goal 3: Revitalizing agriculture as a first priority;

Goal 4: Creating new employment using the advantages of the city's airport;

Goal 5: Promoting natural energy projects;

Goal 6: Developing a multiple defense system against tsunamis by creating and "Hill of Hopes for Thousand Years";

Goal 7: Revitalizing the cultural landscape as the city's identity.

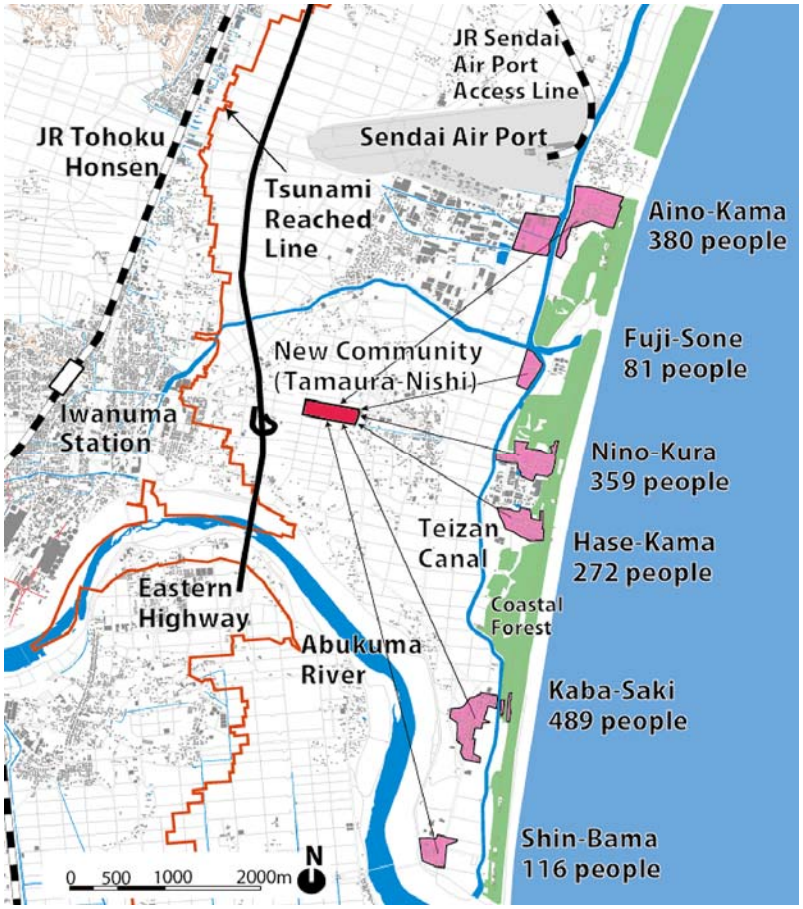

Fig. 10 Location of 6 devasted villages in Iwanuma city.

Additionally, the community started its work eight months after the disaster with a workshop organized by a University of Tokyo-led team [14]. Their goal was to engage the participation of Iwanuma city survivors in order to develop a clear image of what their reconstructed town should look like. The first workshop for the reconstruction planning was held on 12 November 2011, with subsequent meetings held over the ensuing six months. Prior to sitting down, the people involved started their work by walking the devastated area and sharing their fears and experiences of the disaster. Using a map, each participant then geo-referenced through a drawing the dangerous area, the evacuation routes, and the places of higher destruction. At this stage, it became clear to all that some areas had been more resistant to the tsunami. These regions included the Igune Sacred Forest in the rear of the temples, which were then surveyed before the trees all died of excessive salt concentration in the soil as a result of being inundated with the water from the Pacific. The workshop organizers also sent 611 questionnaires to local households. A significant number urged that the reconstruction efforts include saving the Igune Forest as a wind break and an important aspect for daily life (Figs. 11 and 12) [15].

Based on reports from individual experiences (obtained through a series of participatory meetings and surveys), the university-led team evaluated the recovery efforts and associated problems and eventually developed a Master Plan for the new Iwanuma community. This collaborative survey process can be compared to what had occurred in Lisbon and was recorded right after the disaster in order to understand what areas were more prone to earthquake and tsunami effects, thereby aiding reconstruction decisions. Similarly, the authors can establish a parallel with what happened in London during parliamentary discussion where cross-sectional representatives could defend their ideas to improve the new city design.

A key issue during the Iwanuma city workshop was to achieve a broad-based consensus. To achieve that goal, three simple rules were established: (a) to listen to what others had to say; (b) to avoid criticizing other people and (c) to summarize and relate succinct summaries of each groups' findings. From the workshop to the eventual relocation of the community, which occurred in June 2015, the team went through a planning process that compassed four stages.

Fig. 11 Protected house from Tsunami by Igune (agricultural forest) May, 2011.

The first stage resulted in the formulation of a "Grand Design" which represented the long-term vision developed by the Reconstruction Committee between April and September 2011 that identified major problems and common goals. The second stage involved public participation and became known as the "Citizen Workshops" which lasted from October 2011 to June 2012 and responded to the needs of survivors. Important to note is that these workshops essentially evolved in the absence of a national government release of an appropriate method for developing a community-based reconstruction plan for the most devastated communities. With the help of the University of Tokyo team and the contributions of the local government, the refugees started to think about their future community through their participation in these citizen workshops (Fig. 13).

The third stage started by designating a Formal Reconstruction Committee, which worked from June 2012 to November 2013. Its members consisted of representatives of each community. They subsequently gathered in 28 separate meetings to establish a reconstruction plan. The fourth and final stage involved the creation of a mixed council—the Machizukuri Council—which was created by survivors who began to work on common projects for the new community. The Council was envisioned as an aggregation of the six old villages whose residents could share equipment, combine local infrastructures and plan community-building social activities. The Machizukuri Council started its work in January 2014 and is still working toward the good of its community members.

When one compares the seven goals of Iwanuma 2011 and those of Lisbon 1755, the five that target the rebuilding of devastated cities are very similar:

Goal 1: To quickly create temporary housing for survivors. This occurred in both Iwanuma and Lisbon in areas that were less ravaged by the disasters;

Goal 2: To create of a safer city via the identification of a suitable location for the long-term reestablishment of communities. In Lisbon, this goal was realized by establishing a successful grid city that is still active as a commercial centre;

Goal 3: To restart economic activities impacted by the disaster. This involved a revitalization of agriculture as a first priority in Iwanuma, and the revitalization of commercial activities in Lisbon;

Fig. 12 All trees have died by the tsunami salt damage May 2012.

Goal 4: To create new employment opportunities. In Japan, this targeted utilizing the advantages of the city's airport in Miyagi prefecture; while in Lisbon, Pombal concentrated on the advantages of the large natural harbour;

Goal 5: To establish a tsunami defense system. In Iwanuma, the tsunami threat was addressed by creating a topographic change with the "Hill of Hopes for Thousand Years" along the seashore. In the case of Lisbon, the rubble that resulted from destroyed buildings enabled architects to build the new city at a level almost 2 m higher than prior to the earthquake;

Goal 6: To revitalize the cultural landscape as a community identity;

Goal 7: To promote natural energy projects. This last goal is specific to the 21st century and has no parallel in either 17th century London or 18th century Lisbon.

Inherent in achieving some or all of these goals is intense survey work. With layers of geographic information, geology, vegetation, soil and historical land use to consider, the University of Tokyo team created the Natural Land Use Units Map [16] which was utilized as a scientific roadmap for identifying the safest areas for new settlements. For example, survey data from areas destroyed by the tsunami revealed that shrines had remained almost intact, thanks to mounds of little height, an almost micro topography that had played an important role in reducing the energy of the water in movement. This finding was a key issue in formulating the reconstruction plan. Additionally, the locations of sand banks, riverbanks and distribution of soils for agricultural use were clearly identified. Such information was essential in determining where the six villages could be safely relocated.

The creation of a multiple defense system along coastal areas was of prime importance for survivors. Indeed, this represents a common concern when building on alluvial flats. Accordingly, the survey identified that in Sendai's alluvial flats, several small hills for recreation had allowed people to escape from the moving waters. In fact, experts believe that the existence of many islands weakened the power of the tsunami, thereby minimizing the damage to Matsushima and Shiogama city. Considering this strong evidence, the reconstruction plan included the construction of several strategically positioned hills to weaken the power of future tsunamis. Based on these diverse findings, Iwanuma city was able to assemble its "Master Plan for Reconstruction" as early as 27 September 2011—a little more than six months after Great East Japan Earthquake Disaster [17].

To varying degrees, the participation of citizens in the process of post-disaster planning and reconstruction connects these three cities across the centuries. In London, parliamentary discussions facilitated the participation of all impacted constituencies, where solutions were weighted for the interest of many. In Lisbon, an enlightened group of leaders and architects evaluated the reconstruction options and made reconstruction decisions that stood the test of time. In Iwanuma city and environs, a formal Reconstruction Committee was established to represent the interests of the six impacted villages. The committee included 18 from each village, 3 from adjacent communities and 3 advisers. Committee meetings were held 28 times and the final plan was submitted to the mayor on 25 November 2012 (Fig. 13).

All three case studies presented possibilities to correct past errors and introduce new design innovations. In both London and Lisbon, generous public space was incorporated in the new designs, which included public parks. In Miyagi prefecture, the common spaces refer to the parks, the Igune and the assembly halls, which were to be shared by the six villages. The dilemma for Miyagi prefecture, however, had to do with the Igune. Due to lack of funds, the city informed the survivors that it would be impossible to repopulate the Igune forest, which survivors regarded not only as windbreak, but also as an important cultural landmark. Following several meetings held by the new Machizukuri Council, local residents finally

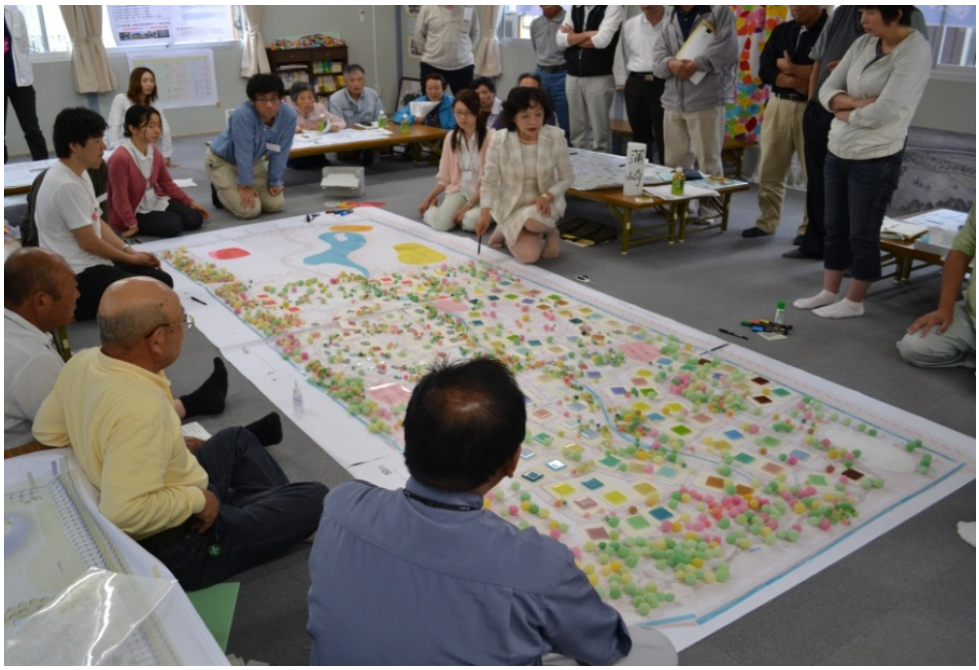

Fig. 13 Survivors' Workshop at the temporary house in Iwanuma city June 2012.

decided to plant Igune themselves, collecting money and soliciting design plans for replanting.

The characteristics of the reconstruction planning of Iwanuma city can be summarized from the point of view of social, environmental, and cultural sustainability. In terms of social sustainability, the speed of the reconstruction process is very important. In Iwanuma, the second stage of the workshop served to build consensus for the design of the future community, whereby survivors could express their opinions and come to understood what others were thinking. The importance of consensus building following a natural disaster cannot be overstated. In the case of case Iwanuma city, the rapid introduction of the workshop served as an effective support for survivors and municipalities.

The importance of environmental sustainability was, of course, of paramount importance in the community-based rebulding Master Plan. The essential components of the reconstruction—including the establishment of safe places, the multi-defense system, the Hill of Hopes for a Thousand Years—all featured prominently in discussions and execution. Moreover, the municipality as a whole shared responsibility for the implementation. Finally, with respect to cultural sustainability, Igune was planted as a cultural landscape. Equally important, the park system introduced in the community is now acting as a commons where festivals, events and daily community gatherings are taking place. The creation of this public green space gives pride of place and hope to survivors.

3. Results: The Lessons from the Past When Compared with the Present

Based on the London and Lisbon analyses, a lesson was given on efficiency, simplicity and sustainability. Table 1—presenting the issues, actions and examples synthetize from results of this comparison is provided. It will hopefully facilitate further discussion on sustainable solutions following natural (or man-made) disaster.

4. Conclusions

This paper examined the disaster responses of local leaders and population to three distinct historical events, the most recent of which took place nearly 350 years after the first. An overall conclusion based on

Table 1 Results presenting the issues, actions and examples synthetize from the comparisons.

Concepts	Actions		Examples		
		Goals	London Great Fire of 1666.	Lisbon Earthquake, Tsunami & Fire 1755. 11	Japan (Iwanuma City, Miyagi) Earthquake & Tsunami 2011.03.11
Speed	Temporarily relocate survivors to safer areas, feed them, and formulate immediate response plans.	First priority for preventing abandonment of impacted areas. Only by speedy rebuilding could the trade of London and Lisbon be prevented from migrating elsewhere.	Act of Parliament set up the Court of Fire Judges, which facilitated speedy restoration of the city.	Immediate response from the Marquis of Alegrete: kept survivors fed, prevented food prices from escalating, and abolished taxes for one year. Marquis of Pombal actions: buried the dead and destroyed all damaged building.	The mayor declared that the city's first priority for the reconstruction would be "Community" and "Speed".
	Create a government-sanctioned body with financial support and authority for rapid reconstruction.	Create financial provision for reconstruction and trade rights. Recuperate economic activities and avoid abandonment of city.	Rebuilding Act: no detailed financial provisions, but the city proposed tax upon coal in the form of one shilling per ton brought into London.	Marquis of Pombal created a compensation scheme for landowners—not on their land but within the reconstructed new designed areas controlled by *Tombo e Mapas das Adjudicações.*	First Law for the budget for Great East Japan Earthquake Disaster established on May 2, 2011. The second was on July 25, 2011, the third was on Nov. 21. However, the financial supports for the community-based reconstruction were very slow and municipalities had to wait until March 2012.
Vision	Create grand design (Master Plan) as an ideal plan for the future.	Correct past errors in order to create a safer city; promulgate a vision for a more attractive and richer city that is better equipped to mitigate the damage from future disasters.	C. Wren's design plan to straighten King and Queen Streets. A set-aside of public land along river. Areas beyond the water were raised 1.5 m.	Manuel da Maia, summoned to lead the reconstruction, wrote the dissertation with city reconstruction plan goals. Four alternative plans were submitted by four architects: Gualter da Fonseca, S. Poppe, Eugénio dos Santos and C. Mardel.	Grand design was established in August 2011, as an ideal goal of the city.
Opportunity for renewal	Precise survey and documentation of damage.	Diminish potential disaster damage by selecting a safer reconstruction design, location and new post-disaster infrastructures.	R. Hook, London's chief surveyor, was responsible for measuring, adjusting and setting grounds for building.	Lisbon learned from London and on Nov 29th the survey was launched by decree-law "*Tombo das praças, Ruas, casa e Edifícios Publicos*"	The University of Tokyo led team carried out an intensive geospatial survey.
	Gather past experience	Incorporate the many factors and knowledge of past and introduce safer reconstruction techniques, safer location and new resistant infrastructures.	Court of Fire Judges, headed by Sir M. Hale (a man of immense experience and knowledge) spearheaded the renewal.	Marquis of Pombal, who knew of London's successful reconstruction strategies, called upon Manuel da Maia (a highly respected military and engineering figurehead) to lead.	Survivors were brought into the renewal efforts, hearings were held, and digital archives detailing the activities of former villages were created.

Table 1 continued

Concepts	Actions		Examples		
		Goals	London Great Fire of 1666.	Lisbon Earthquake, Tsunami & Fire 1755. 11	Japan (Iwanuma City, Miyagi) Earthquake & Tsunami 2011.03.11
Opportunity for renewal	Create building regulations for sustainability	Improve resistance to disaster and introduce new technologies to support that goal—especially in architecture. More cautious land use and topographic improvement to resist disaster.	The Act provided London with a complete code of building regulations for "better uniformity and gracefulness" with four types of brick-constructed houses.	Lisbon created specific building regulations that imposed a homogenous plan and volume for all Baixa buildings, same window/door design and same stone from same quarry. Structural system of "*gaiola*" for seismic resilience was obligatory.	District planning was established for the new community and Tsunami-prone areas were designated as off-limits for future settlements.
	Economic Opportunity	Utilizing the city's building and landscape "talents" and local opportunities.	Planners encouraged real estate development in London with an emphasis on trade and shipyard activities along the river Thames.	Pombal developed the four-hectare riverfront *Praça do Comércio* to become the maritime trading center and cultural area, and relocated elsewhere the Royal Palace and many churches. Emphasis on commercial prosperity.	Instituted efforts to recover salted agricultural field, and provided subsidies for rebuilding green houses. Encouraged industrial development utilizing the city's location adjacent to the airport.
Continuity	Location control, maintenance and essential adaptations, including improved disaster defense (e.g. creation of barriers and altering topography). Public participation and consensus for rebuilding.	Maintain real estate values; consider and incorporate traditional practices and values in reconstruction efforts. Reduce risk of future disaster. Secure "buy-in" in redevelopment efforts by engaging residents in the new city design.	London's city limits were strictly controlled. To reduce danger of further fires, the use of brick construction (instead of wood) was obligatory. Trade guilds were consulted and played a role in reconstruction efforts. The Fire Judges' Court considered each owner's problems/suggestions to optimize rebuilding possibilities.	Lisbon learned from London to control city limits; the city instituted a law to prohibit buildings outside city to avoid migration (the Nov. 29 "Aviso"). Maia proposed a relocation alternative from Alcantara to Algés for a safer city location (but not ultimately accepted). Pombal did not engage public participation in planning decision. Lisbon's Baixa reconstruction represents a combination of technical, functional and political autocratic planning.	Location control was accomplished utilizing the new City Planning Law. A multi-defense system was created with the collaboration of the Divisions of Seashore Management, Forest Management and River Management. Public participation was an essential factor in consensus-building.
New 21st century elements responding to disaster areas					
Environmental sustainability	Energy source alternative	Increase durable city design solutions	Raise London waterfront to allow better drainage	Lisbon learned from London and Baixa and the Plaza were raised about 1.5 m by in-filling with rubble. Introduced and improved sewage system.	Safer land use system was established based on Natural Land Use Method.

Table 1 continued

Concepts	Actions		Examples		
		Goals	London Great Fire of 1666.	Lisbon Earthquake, Tsunami & Fire 1755. 11	Japan (Iwanuma City, Miyagi) Earthquake & Tsunami 2011.03.11
Social sustainability	Heritage preservation. Multidisciplinary Planning.	Improve cultural recognition of a common city and landscape. Stimulate community practices for survivors and new residents to encourage greater social connections.	Wren's single plan lacked public support, but Act of Parliament included the opinions of trade guilds and other designers/architects through the House of Commons (1667).	No public participation and legal enforcement of Pombal's decisions upon clergy and nobles. No direct social input and much controversy. "Passeio public" (a public park) was built under Pombal, but was unused and unsuccessful. Two large plazas were created for social interactions and trading.	Strong community ties were observed and reinforced throughout the reconstruction process. Multidisciplinary planning was introduced.
Cultural sustainability	Create commons and public spaces. Reconstruction of cultural landscapes.	Foster greater community ties through all traditions in common areas. Emphasize community recognition of a common past.	C. Wren's plan emphasized the rebuilding of St Paul's Cathedral. J. Evelyn's plans included St. Paul's school and a public library. R. Hook stressed the building of churches, public buildings, and markets in easily-accessible locations.	The design and implementation of a public park, "Passeio public," was a failure at the time and not used until the 19th century.	Park system was created as common area for festivals and other cultural/social gatherings. Igune was planted as a symbol of cultural landscape in Tohoku, northern Japan.

this comparative analysis is the fact that after great unexpected disasters—no matter the culture, the century and the technological or scientific advancements in place at the time—the actions that constitute a successful response are largely similar and are based on four main issues: efficiency, vision, public participation and continuity in renewal.

The speed of the disaster response is a critical priority for preventing abandonment of impacted areas. In the case of both London and Lisbon, it was only through rapid rebuilding that commerce and trade were able to remain in the city. However, such actions require the institution of certain financial provisions for reconstruction and trade rights that encourage the reestablishment of economic activities and curtail the abandonment of the city.

Within this demanding fast pace, the vision to create a Grand Design (Master Plan) as an ideal plan for the future is a key issue in urban and landscape planning. Such a vision seeks to correct past errors by creating a safer city that is more resilient to natural disasters, as well as promulgates a vision for a more attractive and richer city.

Despite the many horrific aspects of a natural disaster—and depending on the extent of the damage—events such as those that took place in London, Lisbon and eastern Japan do provide urban planners with the opportunity to enact urban renewal projects. The ability to conduct a comprehensive survey of damaged areas is essential for learning from the past and formulating a reconstruction plan that will minimize the destruction from unanticipated future events. Some issues were replicated in all three case studies: selecting a safer location, identifying advanced reconstruction design plans and implementing new post-disaster infrastructures. These renewal efforts demand the input of those with a variety of experiential knowledge who will incorporate solutions

that address multi-level concerns so as to ensure the sustainability of new urban renewal projects and infrastructures. For example, spatial renewal must be accompanied by new advanced building regulations that improve disaster resistance and introduce new technologies to support that goal—especially in architecture. In landscape renewal, a different approach is required that typically involves more cautious land use (e.g. the creation of plant barriers and in extreme cases actually altering the topography), which will enhance an area's ability to resist disaster events. Whether addressing structural improvements or landscape solutions, such urban renewal efforts offer an economic opportunity to utilize a city's "talents" in order to optimize adaptive responses.

The concept of "continuity in renewal" is based on the need to control locations for human habitation—in other words, maintaining real estate values and ownership in the same place as much as possible, while avoiding future investments in areas that are especially prone to disasters. Indeed, this issue was very much at the forefront of disaster response in all three cases. Although residents are likely to want to continue to live in the same place, continuing to invest in an area prone to disaster events is often economically untenable, not to mention reckless in terms of preserving the health and welfare of residents. Alternatively, if relocation is simply impossible, how do urban and landscape planners defend a place from disaster? This issue is very much at the nucleus of a successful new city.

To promote continuity in achieving essential adaptations, planners must consider how to incorporate traditional practices and values in reconstruction efforts. The main goal is to reduce the risk of future disasters, while at the same time engaging surviving residents in the new city design because they are the holders of disaster memories. Reconstruction efforts should secure inclusive "buy-in" in redevelopment efforts through public participation and consensus for rebuilding.

This comparative analysis also brings to the forefront a relatively new issue for disaster responders that emerged as a result of the tsunami in Japan—the nuclear disaster in Fukushima prefecture that captured the attention of the world. Thus, certain "21st century conclusions" must be noted in thinking about disaster response and reconstruction. The results of data collected for this paper highlight the importance of environmental, social and cultural sustainability as important factors for reconstruction efforts. Energy source alternatives, heritage preservation and multidisciplinary planning emerged as essential requirements for increasing durable city design solutions and improving cultural recognition of a common city and landscape.

The experience of the prior disaster reconstruction efforts that the Tokyo University team had gathered pointed to a critical component that in order to stimulate enduring social and economic practices among both survivors and new residents, it would be essential to encourage greater social connections. This goal was achieved through fostering stronger community ties and emphasizing existing traditions in common areas (e.g. land use, religious, agricultural and fishery related). The trauma of the physical destruction of the area could not destroy the community's need to perpetuate a common heritage. Nonetheless, the incorporation of contemporary urban and landscape solutions would serve to both heal the wounds and point the way to an enduring and more sustainable presence in a region.

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