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Urban sprawl processes characterize the landscape of the areas surrounding cities. These landscapes show different features according to the geographical area that cities belong to, though some common factors can be identified: land consumption, indifference to the peculiarities of the context, homogeneity of activities and building typologies, mobility needs exasperatedly delegated to private cars.

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ENHANCING RESILIENCE

OF LONDON BY LEARNING FROM EXPERIENCES

ABSTRACT

The concept of resilience was introduced at the beginning of the 70s to indicate the capability of natural systems to absorb perturbations, preserving their structure and keeping the system functioning. The paper considers London as an example to a resilient city by focusing on some remarkable disasters in the history of London, such as the Great Fire in 1666, the Air Raids during the World War 2, 18 December 1987 King's Cross Fire, Terrorist Attack to the London Tube network on July 7, 2005, flooding in 1928 and 1953 Storm Surge. The paper starts by giving short descriptions of these disasters and continues by discussing the lessons learned. In this paper, the concept of resilience has been studied in three phases: prepare for, respond to and recover from a disaster. Besides, actions that have to be taken according to these three phases are going to be explored in detail. In conclusion, the notable effects of the mentioned disasters on structural and non-structural mitigation tools are revealed by considering resilience of London.

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KEYWORDS:
Resilience, flood risk, disaster risk management

London, which is one of the biggest cities in the world since the 19th century, has proved being resilient to natural and man-made disasters several times. Since London was settled in A.D. 50, the city had experienced many disasters (Withington 2010, 3), some of which destroyed almost the entire city and some other gave partial damage. Wars, invasions, terrorism, fires, floods, epidemics, wild weather, fog, accidents such as train crashes or explosions and also financial disasters occurred in the history of London. Following each disaster, London recovered and evolved according to the needs of its inhabitants and adapted to the changing environment.

In this paper, some of the notable disasters, which shape today's London's structural and non-structural mitigation measures to disasters, such as emergency management system, have been analysed by considering the lessons learned and their effects on the present system. The focus is on the Great Fire of 1666, the air raids during the World War 2, 18 December 1987 Kings Cross Fire, the terrorist attack to tube network on the 7th of July 2005, 1928 flooding and 1953 storm surge. The first two examples, the Great Fire 1666 and the blitz during World War 2 provided the opportunity to shape the London's physical structure again. On the other hand, Kings Cross Fire and July 2005 terrorist attacks revealed the strategic, operational and systemic problems encountered during a disaster on the transportation system. Moreover, 6 January 1928 flooding and 1953 East Coast Surge floods are chosen as they had noteworthy effects on the structural and non-structural defences to flooding in London. Campanella (2006, 143) states that a city is as resilient as its citizens, so it can be said that the common characteristic of all these examples is that each time both London and the citizens of London had proved their significant resilience.

1 1666 GREAT FIRE

In 1666, London was the biggest city in the UK with its estimated 500.000 population. Great fire of London lasted 5 days and destroyed more than 436 acres of urban land. Moreover, one in every three houses was destroyed by fire and around 70.000 people became homeless, which was the 14% of total population (Withington 2010, 71). The great fire of London led to improve fire regulations and "rebuilding of London Act 1666" had been issued. The 1666 act regulated the rebuilding and authorised to widen the roads, the types and organization of buildings by locating a Fire Court. Act helped to organise the density of buildings according to the width of the streets. According to the Act, all buildings must be in brick or stone. The act also grouped the buildings that are permitted in four categories:

- on the smaller streets: cellar, two floors high with an attic on by-lanes;
- on larger streets: one more storey than the first category;
- on main roads: two more storeys than the first category.

Mansions with fewer restrictions than the other three but still restricted to four storeys plus cellar and attic.[1]

Sir Christopher Wren prepared the new plan of London according to the act. In the new plan, central streets provide connections between main locations, while narrower streets divide residual areas in grid shape.[2] Organizing widths and orientation of the streets according to the facilities and density of the buildings had ensured effective mobility in the city. Moreover, dividing the city into four districts in accordance to the fire regulations was an attempt that improved resilience of the city in case of a fire incident. In each district, there were «800 buckets and 50 ladders, as well as shovels, pick axes and hand-held squirts». People also were informed about the fire-fighting equipment and how to quell a chimney fire etc. (Withington 2010, 75). Moreover, fire insurance concept aroused, as many businesspeople bankrupted due to the fire. First

[1] http://london.allinfo-about.com/features/rebuilding.html (Stephen Inwood, A History of London) (30.04.2012).

[2] RIBA Library Drawings and Archives Collections, http://www.architecture.com/LibraryDrawingsAndPhotographs/OnlineWorkshops/UrbanAdventures/01Wren.aspx (30.04.2012).

insurances were offered in 1680, by promising clients «the services of watermen as fire-fighters, or the rebuilding of their premises if these efforts failed to serve them», which is the way of emerging professional fire fighting in London (Withington 2010, 75-76).

The Great Fire of London is a significant disaster in London's history, because a much safer city was achieved by rebuilding according to the new rules defined by the "rebuilding of London act 1666" after the incident, which destroyed almost the entire city, and additionally, this disaster led to start professional fire fighting in London (Withington 2010, 76).

2 THE WORLD WAR 2 AND AIR RAIDS

In the Second World War, the causalities of air raids were more serious than the First World War. In the Second World War, in 1940, the transportation system was the main target and especially road network, the docks and railroads were bombed with an air raid. As fire engines were short in supply, different modes of transportation, such as taxis and private cars were used to carry mobile fire pumps to extinguish the fire (Withington 2010, 27). Furthermore, people were out of water, gas, electricity, food and basic services, even if their home stands. Moreover, sewage breached and contaminated water. Buses were used to evacuate people to rest centres in safer places. However, in the confusion, some of these buses could not find their way and could not arrive at safer places and rest centres. Regarding the tube network, people, who got stuck in London, used nearly 80 tube stations as shelters (Withington 2010, 27). Even though tube stations could seen as the best shelter place, they were actually hit by the bombs and hundreds of people died there. In the first six weeks of the air raids, more than 6.000 people were killed and 10.000 injured. 16.000 houses destroyed, 60.000 seriously damaged and 300.000 people needed re-housing (Withington 2010, 28).

The London blitz provided the reason to plan and reconstruct the city again, as it happened after the Great fire. Patrick Abercrombie prepared "the county of London plan in 1943", which states the deficiencies of London, such as «traffic congestion, depressed housing, inadequacy and maldistribution of open spaces» (Forshaw and Abercrombie 1943, 3) and provides ideas and plans for the development of the city. Due to the obsolete housing stock and declined quality of urban life, large numbers of Londoners migrated to the suburbs after the war. In the 40s, according to Abercrombie, London was just like a collection of villages and they need to be connected by new arterial and sub-arterial highways hierarchically. To solve the housing and traffic congestion problems, recover the population sprawl and define the edges of London (Hall 1989, 36), Patrick Abercrombie's plan for London's development was prepared between 1942 and 1944. The intention of this plan was to surround London with a green belt and regroup the population in the new or enlarged towns offering also workplaces (Parker 1999; Hall 1989; 1993). According to Hall (1989, 44), Abercrombie's plan was an interpretation of Howard's garden cities but in a bigger scale. By implementing the Abercrombie's plan, the population moved beyond the green belt successfully and the physical sprawl of the city stopped.

3 18 NOVEMBER 1987 KING'S CROSS FIRE

The fire at the King's Cross was initially a minor accident which turned into a disaster. It could have had different results, if the employees had known how to distinguish a fire, and how to evacuate people. A small fire has noticed under one of the escalators by one of the staff. However, staff did not know the evacuation procedure, he could not handle the situation, so they called first the Police, and when the Police arrived at the station and saw the situation, they decided to call the fire brigade. Additional time has been lost due to communication problems, as the radio did not work in the underground. When Police decided to evacuate the station, they were sending customers up by escalators, where the fire is, because they thought that it was the only way to go out. When the fire brigades arrived, together with the staff and Police, they stopped the people coming up from the escalators, put them back onto the trains, and did not let the following trains stop at the platforms. Just three minutes after the fire brigades arrived at the station, a huge explosion occurred at the station (Withington 2010, 100-103).

This chain of events indicates some vital points. First of all, un-trained underground staff was a shortcoming in this event, as only four of the staff on twenty-three staff on duty received training in evacuation/fire drills (Withington 2010, 104-106). Even though there were fire-fighting equipment all over the station, the staff was not able to use them. Secondly, communication was one of the main problems as radio did not work in the underground and the only way to communicate was landline or word of mouth. The supervisor of the station was in his room that was far from the fire and the only way to communicate with him was his internal phone, and he was informed about the fire twelve minutes after its first discovery. Although, fire brigades and British Police officers had radios, they were working only on the surface level (Withington 2010, 104-106).

In this accident, more than 200 fire brigades were involved, 31 people died and more than 50 people were injured. Although, there had been about 400 fires in the London underground between 1956 and 1987 (Withington 2010, 98), the obligation of doing drills was introduced after this terrific fire at the King's Cross tube station to make sure people knew what to do in times of emergency[3].

4 TERRORIST ATTACK TO THE TUBE NETWORK ON 7 JULY 2005

In 2005, the terrorist bombs hitting the tube indicated what worked effectively and revealed the defects to be improved for better performance. When the bomb exploded at 8:51am, it took time for the officers to understand what had happened. The first thing that was seen was a massive loss of electrical power on the northern side of the Circle line. Two years before this event, there was power lost on the underground and a dramatic incident occurred as a result on the 23rd of August 2003 when many people were trapped in the tunnels and trains. Due to this accident anytime a new problem occurred, people tended to perceive that problem, similar to the one they experienced before. Therefore, as the reports were saying that there was no electrical power, the initial assumption of the authorities was that one of the electric providers blew causing all this noise. Within about ten minutes, further reports showed that the situation was more serious and different from the first assumption. By 9:15 am, it was decided to evacuate the tube network and the code amber[4] was ordered to re-ensure employees, public and further trains from any risk.

The employees were out of the network between 8:51 and 9:15, as there was a drivers' stop next to the scene. Many people went to help the people stuck on trains and charged right into the tunnels where the bomb exploded. It took the emergency services a while to arrive at the scene. The employees of the underground went to those tunnels immediately and used what they had learned in previous training to do what they could.

Some important lessons were learned from these incidents that need to be pointed out. First, management cannot intervene fast enough, as it takes too long to understand what is happening. Therefore, the most important thing is to train people ready to respond, as they are the most valuable resource and immediate response. Therefore, it is crucial to train people and make sure that they know what to do. Just two weeks before the terrorist attack, the London Underground had run a drill at Tower of Hill station. As they had trained, people did response very well. Additionally, they run table-top exercises with the emergency service

[3] The information gathered by conducting an interview with the former boss of London Underground, July 2011.
[4] Code amber is the code to evacuate network and control under circumstances.

a couple of times a year. All these exercises paid off, because employees of the London Underground were already in the incident scene and they were the first responders.

There was one thing about the reaction of people at the bombsites. When the code amber was ordered, which was to evacuate the network by taking each train into a platform and getting people out, it was happening in the middle of the morning peak and there were people on trains all over the network. Thus, customers did not know what is going on. Trains were stopped, and people were made to get out of stations. They might never have been in that station before and those people were out on the street. 250.000 people were in the network in that time, and hundreds and thousands of people evacuated within an hour.

Communication in the underground system has improved after the terrorist attack. Before that, there was no inner operability and the existing communication system had failed in previous accidents. After this event, efficient means of communication were put in place. Today, there is a radio system, by which one can talk to anyone else both in the tunnels and the various underground levels. Moreover, the emergency services have channels on this radio system and they can talk to their own people.

Another lesson learned regards the shortcoming of exaggerated focus of protocols. According to the previous arrangements, once an accident occurs, the Metropolitan police get the “gold control.” The London underground is under their authority. The Metropolitan police are responsible also for communicating with the public. Informing people was not the responsibility of the underground authority. However, the Underground Authority realized that it was a mistake, as their employees were looking for information about the incident. The Underground Authority thought that not giving the information to their employees would create distrust in the network. So, the Underground Authority shared the available information with their employee, thinking that otherwise employee would think authorities hide some information while their life are at stake. After the attack, to keep the trust of their employees, the London Underground Authority changed this protocol and decided that in case of accident, no information will be withhold to the employees and tell everything that they know and not know, taking the risk that the information might become public.

Another limitation was that, there were no storage of medical supplies in the underground to deal with the situation and it took long for the emergency services to bring it there. One of the changes applied after the attack was putting more storage of medical supplies across the underground system, and very large supplies at strategic locations in the zone one, where it is most likely that an emergency may happen.

One other lesson that is learned from this experience was the importance of drills for multiple incidents at the same time. The London underground used to do drills, but both the strategic planning and the emergency planning of drill scenarios were always about dealing with a single incident. A drill was never planned for multiple incidents at the same time. London Underground personnel could deal with an incident but dealing with three of them at the same time was quite challenging, especially when their knowledge was deficient. As a result, having multiple attacks changed the scenario planning for future training.

At the incident scene, the employees of underground were grouped in three and the tasks had divided in these teams. The first team continued focusing on getting relief and dealing with the immediate incident. Another team was put together to deal with the planning and create new service patterns, like shuttle systems on both sides. Besides, there was a third team to focus on the immediate restoration of services at the bomb side, which was heavily engineering based. In this respect, the tunnels were inspected and blown up trains extracted. The primary aim was to bring the system back and organize the services again to continue functioning. The underground system started operating the next day in the morning.

A customer service program to informing people about any situation had been started before the terrorist attack and was accelerated after the incident. Now, drivers are talking on the P.A. constantly to inform public about any problem. For example, when there is a delay, drivers inform about the reason of delay.

5 6 JANUARY 1928 FLOODING

1928 flooding along the Thames and its branches was a combination of melting snow, deep depression, heavy rain and spring tide (Holford 1976, 97). The 6th of January, the height of the water at the Southend was 1.5 meters more than forecasted, and in the central London, 1.8 meters higher than predicted and 0.3 meters more than formerly recorded level. The areas flooded were Battersea, Poplar, Greenwich, embankments at Temple station, Old Palace Yard, Westminster, Tate Gallery, Lots Power station, Wandsworth Gas Works, Blackwall Tunnel (Holford 1976, 97-98). Flooding made homeless more than 4000 people (Holford 1976, 99). This event showed the insufficiency of the walls along the Thames and their height has risen after the event. Increasing the height of the walls cannot be an efficient and effective solution, and it cannot be done constantly. Should the wall be raised, this has to be done along the entire length of the wall. This operation is getting more costly and less efficient each time, because it involves also alteration of wharves, approaching roads and sometimes demolishing properties (Holford 1976, 100).

The 1928 flooding led to improvements in the forecasting and warning systems for flooding. In terms of forecasting, a research program was started by the Meteorological Office and the Liverpool Observatory and Tidal Institute for studying storm surges. Regarding to alerts, a warning system for London was installed by using the danger level at Southend as a threshold. Lastly, the idea of building a barrier on the Thames River had discussed again after a similar storm in 1897 (Holford 1976, 100).

6 EAST COAST SURGE FLOODS, 1 FEBRUARY 1953

East Coast Surge flood is called also as North Sea Storm Surge and affected not only in England but also in the Netherlands and Belgium. The effects of this storm surge was more serious in the Netherlands than in the other two countries. The economic damage (1953 values) of this event was 1.5 billion guilders in the Netherlands and 50 million pounds in the UK (Jonkman and Kelman 2005, 2). Moreover, in the Netherlands 200.000 hectares area inundated, in the UK 40.000 hectares and in Belgium 10.000 hectares (Jonkman and Kelman 2005, 2). Because of this incident, nowadays, the Netherlands has the most effective and efficient structural and non-structural mechanisms for flooding in Europe.

The causalities in the UK mainly depended on being not able to forecast the event. The event occurred unexpectedly and without warning. Fatalities were higher in the sea towns in Canvey Island, Jaywick and Lynn where the buildings were of low quality, as, people started living in those kind of temporary and low quality buildings shortly after the war (Jonkman and Kelman 2005, 6). Main causalities were among elderly people. At Canvey Island 42 out of 58, at Jaywick 28 out of 34, and at Lynn all 14 fatalities were older than 60 (Jonkman and Kelman 2005, 5-6).

Met Office indicated that the surge expanded from Tilbury to Docklands and caused damages on Docks, oil refineries, factories, cement works, gas works and electricity generating stations. Additionally, 100 metres sea walls were destroyed, and, more than 1000 houses were flooded[5].

The shortcomings the forecasting and warning systems in the UK became evident during this disaster. People were unaware of their own vulnerability to storm surges and being without electricity and communication systems increased the number of causalities. Sea defences collapsed, and this situation led

[5] Met Office: Great weather events: the UK east coast floods of 1953, http://www.metlink.org/pdf/teachers/1953_east_coast_floods.pdf.

to question the maintenance degree of the structural defences and their reliability (Jonkman and Kelman 2005, 8-9).

7 LESSONS LEARNED

EVENT	DESCRIPTION	DEFICIENCIES SHORTCOMINGS	EFFECTS ON STRUCTURAL PATTERN	EFFECTS ON NON-STRUCTURAL PATTERN
1666 Great Fire	Lasted 5 days and 436 acres burned. 70.000 people became homeless (14% of London's total population).	Timber houses, narrow streets, not having sufficient equipment to extinguish fire.	A grid plan prepared for rebuilding the city of London. "Rebuilding of London Act" issued, and all the buildings rebuild by brick or stone. Moreover, the act grouped the buildings in four categories and height of the buildings had arranged according to the width of the street.	Fire regulations had improved, and the event led to initiate professional fire fighting. The rebuilding act divide the city into four districts and sufficient fire fighting equipment had provided for each district. People had informed about how to use the equipment to extinguish fire.
Air Raids during the World War 2	More than 6.000 people were killed, 10.000 people injured, 16.000 houses damaged, 60.000 houses seriously damaged, 300.000 people needed re-housing.	Fire engines were short in supply. Evacuation of people was not successful. Shelters were in shortage.	The plan of Abercrombie was prepared to reconstruct the city again. Docks were never fully repaired after the blitz and they were the regeneration areas during 80s.	
1987 King's Cross Fire	31 people died, 50 people were injured, 200 fire brigades had been involved.	Not having trained underground staff and communication problem.	Timber escalators were removed.	Doing drills has become obligatory for the employees of the Tfl.
2005 Terrorist Attack to the Tube Network	Multiple attacks on the tube network.	It took time to understand the real issue, as communication was a problem. Being disciplined about following the protocol. Not having medical supplies in the underground. Employees knew what to do, because they were doing drills twice a year, however they never practiced a drill for multiple accidents.	Stores of medical supplies were put across the system and very large supplies at the strategic locations in the zone one. Inner operable radio system had built, know it is possible to talk to anyone no matter in the tunnel or not.	To keep the trust with their employees, underground has changed their protocol and decided to communicate their employees and tell everything they know and do not know. Having multiple attacks changed the scenario planning for drills.
January 1928, Flood	The water was 1.8 meters higher than predicted in the central London and 0.3 meters more than formerly recorded level.	Not having a proper forecasting and warning system. Not having sufficient structural tools to prevent flooding.	The height of the walls along the Thames had risen.	Improvements on the forecasting and warning system: a research program for forecasting was started, and a warning system for London was established.
East Coast Surge Flood 1953	More than 420 people died, 32.000 people were affected, and economic damage was 50.000 million pounds (1953 values).	The forecasting and warning systems were the shortcomings of this event. The maintenance degree and reliability of structural defences were other problems.	Thames Barrier had been built. Structural defences had been improved.	Flood forecasting, monitoring and warning systems have been improved. Emergency management system has come to today's level.

Tab.1 Retrospective view of risk

After the Great Fire, a plan was prepared to rebuild the city by considering mitigation of fire risk first time in London's history. Moreover, after the WW2, a plan had been prepared by the team of Sir Patrick Abercrombie to rebuild the city and to improve the existing deficiencies lasted since the beginning of the 19th century. This plan has given London its current shape. In addition, the Docks, which were severely damaged during the blitz, was subject to regeneration and economic revival in the 80s, and today the area consists of residential and financial activities.

Furthermore, the fire at the King's Cross underground station revealed the deficiencies of communication and un-trained underground staff in case of an emergency. After this event, getting involved in drills has become obligatory for the underground staff. However, communication system had not improved until the terrorist attack in 2005. Terrorist attacks on the 7th of July 2005, revealed the strategic, operational and systemic problems encountered during a disaster on the transportation system. Foremost problem in this example was communication between the staff in the tunnels and the people who were outside and trying to understand the real issue. As, employees of Tfl were doing drills since the King's Cross fire, they knew what to do in case of an emergency, and this was one of the biggest advantages in this event. After the incident, a radio system has been installed and communication is not a problem anymore.

Regarding to flooding, after the flood event in 1928 the focus was on the deficiency of structural mitigation tools. Besides, attention was given also to building forecasting and warning systems by conducting a research program for forecasting and by establishing a warning system for London. However, in 1953, a surge flood hit the southern part of the country including London, and this event showed that the forecasting and warning systems, which were established more than two decades ago, were not successful. After the event, having a barrier on the Thames had been considered again, and the construction of the barrier started in the 70s forecasting and warning systems have been improved and reached to today's level.

Table 1 indicates that each incident helped to improve structural and/or non-structural risk mitigation and/or management tools in the aftermath of the event. It also proved that seeing deficiencies of a system was not enough to improve it, sufficient resources must be provided as well. For example, the consequences of not having a proper communication system during an incident were seen in the King's Cross Fire. However, the communication system has improved only after the terrorist attack in 2005, 18 years after the King's Cross Fire. There is the similar situation for the construction of the Thames barrier. Since the 19th century, the need of having a barrier on the Thames was known, however the construction started only in the 70s.

8 ENHANCING RESILIENCE OF LONDON

The concept of resilience was introduced at the beginning of the 70s to indicate the capability of natural systems to absorb perturbations, preserve their structure and keep the system functioning. The characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural hazard (Blakie et al. 2004). In ARMONIA project (2006; Walker at al. 2011, 17) 'resilience' is defined as «the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to restore or maintain an expectable level of functioning and structure». Godschalk (2005, 58) indicates «acting beforehand to mitigate the impact of a natural hazard is far more effective than picking up the pieces afterwards». Godschalk suggests investing in mitigation before the next disaster (2005, 58), however, in some of the examples in the case of London, such as Great Fire or King's Cross Fire the strategy was to invest in mitigation after the last but before the next disaster.

Furthermore, in this paper enhancing resilience capacities of a community in general can be considered in three phases. These phases are: "prepare for a disaster", "respond to a disaster" and "recovery and reconstruction after a disaster" (Table 2).

PREPARE FOR A DISASTER		RESPOND TO A DISASTER		RECOVERY AND RECONSTRUCTION AFTER A DISASTER	
	MITIGATION MEASURES	EARLY WARNING	DURING EMERGENCY		
Limiting exposure to hazard	Restricting development within hazard zone	Forecasting flood	Defining first respondents and training them	Physical	Assessment of loss and damages
	Selecting development areas outside the hazard zone	Monitoring flood	An integrated system		Repairing and reconstructing the built environment
	Land acquisition	Disseminating warning to public by translation of scientific information coming from forecasting & monitoring	Emergency drills with large public involvement		Availability of partial relocation programs during reconstruction for the most critical situations
	Land use ordinances	Training public on how to respond to warnings and how to act during emergencies	Maintaining and mobilizing stand by people, materials and financial resources		Building codes and retrofitting for new construction
	Density restrictions	Establishing a community network	Continuing long-term training of both emergency personnel and also public		Availability to incorporate recovery/resilience measures in future urban redevelopment plans
	Community relocation	Defining responsibilities and capabilities of institutions clearly			Sharing reconstruction plans among stakeholders
	Having disaster management plans	Warning industries, plants and hazardous facilities			Existence of skilled workers for reconstruction activities
					Geographical and economic importance of potentially affected settlements
Dimi-nishing direct and indirect impacts of hazard	Sea walls	Evacuation of public		Infra-structure	Mapping damage
	Leaves	Mobilizing material and emergency personnel			Quick survey on damaged parts
	Dams				Using spare materials for repair
	Fire breaks				Availability of personnel for repair work
	Quarantine				Existence of protocols to proceed with repairs requiring interlifelines intervention
	Strongly built environment to resists physical forces of hazards				
Sharing the losses	Insurances			Eco-nomic	Insurance coverage
	Relief funds				Dependence of economic actors on loss of environmental perils
	Personal savings				Access to funds
	Restoring pre-disaster situation, financial and medical services				Degree of diversification and capacity to spread risk
	Facilitating permanent return of residents				Providing work for those who lost their work
				Social	Healing injured and traumatized community
					Bringing together separated families
					Identifying dead
				Institu-tions	Liability
					Transparency in funds
					Ability to learn from past events

Tab. 2 Enhancing resilience capacity of communities for flood hazard risk in London

First phase, “prepare for a disaster” includes mitigation measures, such as limiting the exposure to hazard and diminishing direct, indirect impacts of hazard and sharing the losses. First, as for limiting the exposure to hazard, the development within hazard zone has to be restricted, and new development areas must be selected outside the hazard zone. Moreover, land acquisition, land use ordinances, density restriction, community relocation and having disaster management plans are the other measures to limit the exposure in the hazard zone. Second, to mitigate the risk of hazard both direct and indirect impacts of a possible hazard have to be diminished by developing strongly built environment to resist physical forces of hazard and by building sea walls, leaves, fire breaks, quarantine, dams or barriers as in the London case. The third issue as for mitigating measures is sharing the losses by insurances, relief funds, personal savings, financial and medical services and indeed facilitating permanent return of residents who left the city shortly after occurrence a disaster.

Moreover, in the respond phase to a disaster there are early warning and emergency management aspects. The success of early warning depends on the success of the procedures coming before disseminating the early warning, such as forecasting and monitoring hazard. Monitoring hazard is a continuous activity to forecast possible hazards and understand its severity and duration. The quality of monitoring and forecasting could help to increase the warning lead-time. Therefore, people can be warned and informed about the existing risk to take the essential precautions before the occurrence of a hazard. While disseminating warning, the language of warning has to be transformed from scientific language which consists technical terms to the one that can be understood clearly by public.

Recovery after a disaster can be studied by considering the city in physical, infrastructural, economic, social and institutional systems. To recover the physical structure, first loss and damages have to be assessed before starting and reconstructing the built environment. In some cases, assessment and repairing works are done simultaneously to start operating the system as soon as possible. This can be possible in small and close systems, as it has seen in the example of terrorist attack to the London tube network in June 2005. However, it cannot be feasible in large-scale disasters. Before repairing also new building codes for new construction of the built environment has issued by the authorities.

If the previously mentioned disasters are considered within the structure of Table 2, the Great Fire in 1666 and reconstruction after air raids are good examples to increase resilience of a city by improving the physical conditions and taking precautions in the pre-disaster phase. In the latter example, after the World War 2, the physical deficiencies and unhealthy structure of the city healed by restricting density in the central London, controlling urban sprawl and traffic congestion and improving the quality of the physical environment. Furthermore, after the Great Fire, the city planned again by taking into account land-use ordinances, restricting the density and development, organizing height of the buildings according to the width of the streets and preparing disaster management plans in case of fire. Private insurance companies have established first time in the history to insure especially businesses in case of a fire incident. In addition, there are also two issues, which corresponded to the response phase of a disaster. First, public were trained on how to behave during a fire incident, how to extinguish fire and how to clean their chimneys. Second, in addition to improving fire regulations, professional fire brigade units were initiated with the name of watermen.

Moreover, after the 1987 King's Cross Fire, doing drills became obligatory for the entire underground staff and as it was seen in the 2005 Terrorist attacks, the underground personnel knew what to do and dealt with the situation very well as being the first respondents to the incident. However, communication has been improved after the 2005 terrorist attacks. 2005 Terrorist attacks also proved that the underground system is also resilient to such a multiple attack in terms of recovering after the incident. Regarding to the infrastructure, first, the damage has mapped by a quick survey on the damaged parts of the network. The resources and existing personnel were available for conducting repairing work, while some of the staff were still responding to the incident.

1928 flooding and 1953 Storm Surge event are the two examples which led to improve resilience by focusing on preparation and respond phases. As for the preparation, height of the see walls have increased, barriers such as Thames and Barking were constructed. For being able to respond to disaster, forecasting, monitoring and warning systems have been improved and warning networks have been established.

To sum, in the London case the ability to learn from failures and improving the system according to lessons learnt definitely increase resilience of the system. In addition, in the course of the time structural and non-structural mitigation have been improved reaching today's advanced level. In general, on one hand, the city is becoming more resilient by improving the system in all three phases, on the other hand, the exposure was increasing and formerly floodplain areas were becoming the attraction point for development after the construction of the Thames Barrier. Today, the barriers and embankments have protected the area according to the 1 in 1000 year flood event. However, during the construction of these defences, climate change and sea level rise have not been considered. Although flood hazard probability is changing due to climate change and sea level rise, the main reason of increasing flood risk in London is the *post-defence development* (Parker 1995, 341) and increased ownership of goods and property in the floodplain (Parker et al. 1987; Green and Penning-Rowsell 1989, cited in Parker 1995, 342). The post-defence development after the construction of the Thames Barrier in the 80s, such as increasing number of population, buildings, companies and firms, and extended infrastructure in the floodplain, led to increase exposure to hazards. Moreover, more businesses have been established and more infrastructures have been constructed in the area. By developments in the area, investment on transportation has also increased to connect the area both to London (DLR-Docklands Light Rail) and to the rest of the world (City Airport). Although the area is well connected to London, because of lack of redundancy of rail and road networks, any disruption on the existing transportation system in the area could lead to isolate the area from the rest of the city. Furthermore, having any disruption on these infrastructures in case of an incident could create not only direct damages but also indirect damages have increased due to increasing number of businesses, infrastructure and demand on traffic in the area (Parker 1995, 342). Though the probability of risk is low, due to increasing exposure and investments in the area, the consequences of an incident would be very high and costly.

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