TeMA

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Land Use, Mobility and Environment

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THE RESILIENCE CITY / THE FRAGILE CITY. METHODS, TOOLS AND BEST PRACTICES.

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- the territorial risks and fragilities related to mobility of people, goods, knowledge, etc.;
- the housing issue and the need of urban regeneration of the built heritage;
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THE ADAPTING CITY

RESILIENCE THROUGH WATER DESIGN IN ROTTERDAM

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ABSTRACT

The Netherlands is a fragile and vulnerable land; spatial planning is very important, just as important is the resilience of the system and its adaptation to climate change. Rotterdam is a delta city and, in a period of heavy climate change, it will experiment more extreme weather conditions, such as heavier rainstorms, longer periods of drought and more heat waves, as well as higher water levels in the river Meuse; so is important to know that it is a deep vulnerable city and need right strategies to overcome the problem and to be adapted to conseguences of climate change. The results presented in these manuscript were developed through some academic course at TUDelft; the main aim is to arrive at shared ambitions for climate proof urban development and to make specific concrete agreements about this defining a strategy able to enforce urban beauty and absorb excess rainwater and improve urban resilience through the implementation of some adaptive measures linking this strategy to the whole urban governante of the city. There is the need to implement a conscious and smart urban governance and to undertake urban awareness actions that aim at the awareness of the communities, which becomes an active part in promoting urban resilience policies and in creating the sustainable city. The strategy is characterized by some main innovation that could be recreated in other countries, such as the inclusion of resilience's theme in all levels of government and in all urban planning instruments and in spatial and strategic development policies; the deep cooperation between all stakeholders and public administrations; and the role of urban design that is able to create a waterproof city, enhancing the quality of public space.

KEYWORDS:
Resilience; water management; waterproof city.

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适应城市

通过鹿特丹的水设计提高城市复原力

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摘要

荷兰是一个土地脆弱的国家，空间规划非常重要；但同时，系统的复原力及对气候变化的适应也非常重要。鹿特丹是一座三角洲城市，在气候变化严重的时期，它将经历更加极端的气候条件，如暴风雨加剧、干旱时间更长、热浪更多以及默兹河水位更高等情况；因此需要了解这座城市的脆弱性并需要制定正确的战略来解决这些问题，适应气候变化的影响。本文中的结果是通过 TUDelft 的学术课程获得的，主要目标是达成城市发展中对气候变化的共识并就这一战略达成具体协议，通过采取适应性措施美化城市并吸收多余的雨水，提高城市抗灾能力，将这一战略应用到整个城市管理中。有必要采取意识明确的智能城市治理，开展旨在提高意识的城市行动，这将成为促进城市复原力政策及打造持续发展城市的重要环节。该战略中的创新特点也可以实践应用到其它国家，如在各级政府和所有城市规划工具及空间和战略发展政策中纳入抵御能力的主题；在所有利益相关者和公共行政部门之间展开深入合作；以及城市设计的作用，打造防水城市，提升公共空间的质量。

关键词：
复原力、水管理、防水城市.

1 INTRODUCTION

Water has always played a key role in the dynamics of growth and in the development of a territory; the waters have always been at the center of the history of civilizations; the territories furrowed by the great "water infrastructures" were the first to be urbanized by man and marked the first human settlements; water has been at the center of the classical mythology of the gods and has been at the center of religious rituals that have exalted its sacred nature linked to its recognized healing abilities. The water space is a place of intense vitality, a space of relationships, of exchange, a connective tissue, a fluid environment in which flows of people, of goods and of knowledge are realized; the water space, the limit between land and water, is a strategic space, often protected, where a strong landscape and environmental value are recognized; but it is also a strategic space for the transformation of the city. Often this space is a place of comparisons; the water spaces are public spaces characterized by high recognizability and identity; they are places defined in a very clear way by the cognitive approach of mindscape; places of relationship in which social well-being is not only dictated by the urban project but also by its fluidity, by its becoming, by its being a territory in rapid and continuos evolution and transformation. The water, in its countless garments, is the center of the city and of the urban project and it is often precisely the element that qualifies it, making it sustainable and resilient; water has to be used but it is also the main component of a series of hydrogeological risks from which we need to protect ourselves. Climate change is taking place in a changing world; in the water cities, urban projects that are aware of the fragility and vulnerability of the territory must be promoted (Galderisi, 2012). It is necessary to implement urban resilience actions able to mitigate natural risks by converting territorial problems into territorial resources and opportunities. There is a need to implement a conscious and smart urban governance and to undertake urban awareness actions aimed at the awareness of the community; a community which becomes an active part in promoting urban resilience policies and in creating a sustainable city (Moraci & Fazia, 2013). The global population has grown exponentially over recent centuries (Eger, 2009); more than half of all people now live in towns and cities, most of which are vulnerable to climate change (Newman, Beatley & Boyer, 2009). In particular, the densely populated and economically prosperous cities in the large river deltas that open out into the sea will be directly affected by the consequences of climate change. It is necessary to promote the development of a sustainable city, a resilient city, able to adapt to climate change and to face its effects, trying to mitigate its risks and to develop its potential for development and urban use. Concerning climate change and resilient city (Sennet, 2014), flood safety is just one of the tasks confronting the city. Major effects of climate change will develop on water cities where is important the theme of flooding; but climate change will also lead to more frequent periods of high temperature with effetcs on citizens' health, on Energy consumption, on air quality, water quality and problems on biodiversity. The Netherlands is a fragile and vulnerable land because it is located at the delta of three european rivers: the Rhine that flows from Holland to the Alps, the Meuse, which arrives in France, and the belgian Scheldt; from the geological point of view the area is shaped by the presence of sandy banks that were deposited about twelve thousand years ago and have allowed the first human settlements that are currently the historical centers of the cities; the outskirts of the contemporary city rise on peat or heavy clay soils. The dutch landscape consists of a dense network of polders characterized by key elements such as dams, windmills and farms; it is a unique landscape but, at the same time, is very fragile and constantly changing, been characterized by a deep relationship between man and nature; the polders are in sharp contrast with the massive urbanization of recent years.

The city-water relationship in the Netherlands is particularly important and strategic because 20% of the country is made up of water, whose presence affects every urban and architectural project; Netherland is, among the countries with the highest population density in the world, ranked 14th according to WorldAtlas[1], with a population of just over 17 million inhabitants on an area of 41.543 square kilometers and an average

1 www.worldatlas.com/aatlas/populations/ctypopls.htm

density of about 412 inh/sqkm. Spatial planning is very important, just as important is the resilience of the system and its adaptation to climate change; the relationship with water, as mentioned, is strategic and at the center of the policies of VROM, the Ministry of Home, Spatial Planning and the Environment. Aware of the fact that the existence and the survival of the territory itself depend on the infrastructures that determine it, dutch planners and designers have developed, especially in the twentieth century, policies and strategies to develop and maintain a "sustainable" balance between urbanization, landscape and infrastructures that have guaranteed the recognized leadership in the field of water management and defense, with a system of dams that is the largest in the world[2].

At the end of the eighteenth century, the dutch Parliament decided to introduce a more effective central organization for flood defense; on March 27th, 1798, an agency for public works and water management was established, which took the name of *Rijkswaterstaat*, which currently manages 3.260 kilometers of national roads and 1.686 kilometers of national waterways. On the whole of the national defense works, all the most important dunes and dams constitute the "primary water defenses", since they protect the country from the floods of the Ijsselmeer and Markermeer rivers, lakes and rivers. The "secondary" defenses are also important but if a dam of this system collapses no dramatic consequences will occur. In order to cope with the current climate change, in 2007 the national Government issued its "Vision" on the water policy entitled "Reclaiming the Netherlands from the future" (City of Rotterdam, 2008), which underlines the need for a sustainable management of the water resource in relation, above all, to climate change; in 2008 the Second Report of the Delta Commitee entitled "Working with water" was published (Delta Commissie, 2008), it contains twelve recommendations to guarantee national defense and security; in 2009 the "National Water Plan" (Ministry of Infrastructure and the Environment and Ministry of Economic Affairs, 2014), came into force whose slogan is "Move in accordance with natural processes where it is possible, offer resistance where necessary and seize opportunities to promote prosperity and well-being". To achieve these aims the theme of water will have a central importance in spatial planning.

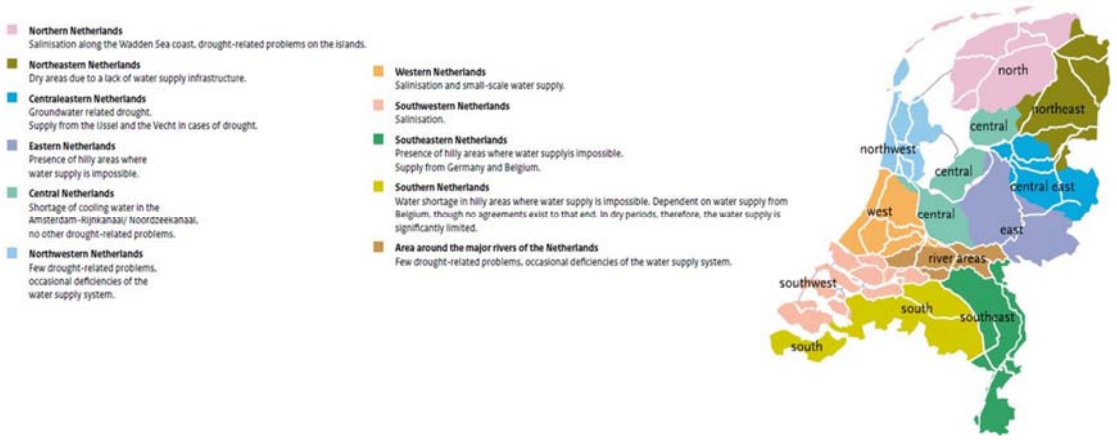

Fig. 1: Water in the Netherlands

The Netherlands is getting wetter, dryer and saltier. The sea level is rising. While rainfall is getting heavier at times, it may also at other times hold off much longer. Soil subsidence continues, due to both geological influences and human activities. Land use is changing as well, the economic sectors are continuously changing and, societally speaking, new demands are made on water. All this can hardly indicate anything else than the necessity for a change in water management and water use.

Adaptation involves solutions being found in all aspects of the urban environment that make it possible to alleviate the system and make it more resilient. Adaptation means that we must also focus on adapting the

2 In the Netherlands the dams are extended for 16.500 kilometers and panels about 300 structures.

city to make it less vulnerable and more resilient. Through the different experiences described in this manuscript, the authors want to contribute to the construction of an urban methodology that can allow the construction of a resilient urban system. This strategy also aims to contain storm water runoff in case of extreme rainfall, if possible in combination with measures to improve and enhance the green quality of open spaces in the city. The strategy combines sustainability efforts with resilience and urban transformations. The theme of resilience is included in all levels of government, in municipal plans and in spatial and strategic development policies, such as in some projects concerning public and private space.

Climate adaptation assumes the role of a real urban strategy that can innovate the city, making it more fascinating and modern. The approach pursued throughout the manuscript aims at fostering resilience and flood protection by means of the architectural and urban projects. Moreover, it considers the use of the public areas as strategic spaces where the resilient city can be developed, employing engineering technical climate defences as new public zones for citizens and communities. Urban governance (Deakin, 2013) is the best place to establish goals and objectives that must be pursued for the creation of a resilient city (Hollands, 2008); the city must be a unique, resilient project and every part of it, both public and private, must be seen as a potential space in which to pursue climate adaptation policies. To make smart planning implementable and equip it with the new paradigm of urban resilience, all levels of government and all the stakeholders must be involved. The resilient city is an urban challenge, but it is also a political and economic challenge. It is also important to link defense design with other spatial planning tools, to allow the better integration and implementation, a right cost reduction and an increased innovation. The challenge is to link climate adaptation to other urban measures, projects and initiatives such as the management and maintenance of roads and public spaces. It is also important to develop appropriate strategies to improve awareness within the population, to promote the active collaboration of the smallest “backyard actions.” To engage the community, it is necessary to ensure people are aware of the benefits they will have if they contribute to the pursuit of climate adaptation. It is necessary to implement urban resilience actions that are able to mitigate natural risks by converting territorial problems into territorial resources and opportunities. Implementing a conscious and smart urban governance and undertaking urban awareness actions are fundamental. The aim is to create a community actively participating in promoting urban resilience policies and in creating a sustainable city.

2 WATER MANAGEMENT IN THE NETHERLANDS

Water management in the Netherlands is a complicated issue (Rijkswaterstaat, 2011); the Netherlands could be considered as a gateway for water; all the water that is carried across its borders by streams and rivers must be discharged into the sea. The same applies for rainwater, which makes its way to the sea overland or underground. The Dutch model of water services management is entirely public; the tasks related to the integrated water service are not the responsibility of a single entity, but the aqueduct service is managed by water companies, companies with entirely public capital. The sewerage service is managed by the municipalities while the wastewater treatment is entrusted to waterschappen, functional public bodies that deal, on a regional scale, also with the management of water control works, fundamental for the very existence of the country. These subjects interact closely with each other and with other organizations that deal with the planning and management of the territory, given that the management of all water services (and not only that connected to civil and industrial uses) is strongly integrated in the Netherlands and, for historical and morphological reasons, it is also integrated with the planning and management of the territory. Responsibility for water management in the Netherlands is entrusted to the Rijkswaterstaat (the executive branch of the Ministry of Infrastructure and the Environment) and to the water control Committees; the Rijkswaterstaat (RWS) is responsible for the management of the main waters, such as the sea and rivers, and ensures that the responsible authorities are promptly warned in the event of floods or stormy seas.

Furthermore, RWS maintains dams, dunes, cages and overvoltage barriers and protects the coast by regimenting and expanding the floodplains and building secondary canals.
Dutch have started to use modern wastewater treatment techniques since the 1970s; currently all homes have access to drinking and chlorine-free water, while 99.4% are connected to the sewage system; moreover, the level of recycling of industrial wastewater is high and the water is of sufficient quality to be used in the food and beverage industry. The regulatory framework of the Dutch water management legislation consists of a 2011 law ("Drinkwaterwet") which prevents the private sector from directly managing water resources. In relation to current climate change, the national government, since the early years of the 21st century, is trying to promote the formation of a resilient city, able to cope with the ongoing natural transformations and to create a less vulnerable and more resilient city. For dutch people is possible to link the adaptive measures to other spatial development projects in the city and to intelligently combine them with existing management and maintenance programmes with an intensive cooperation with other partners who are active in the city. The general aim is to promote the creation of a waterproof city through joint responsibilities and smart management and urban governance. In 2007, the government published its vision on water policy, entitled 'Reclaiming the Netherlands from the Future', a document in which the government wanted to operate in the field of National water policy, encouraging the formation of sustainable water management. The Water Vision specifies five spearheads for which the cabinet would like to intensive its policies. One is resilience to climate change. The Delta Committee, in 2008 published its report 'Working with Water' (Delta Commissie, 2008) containing twelve raccomendations to help to face the threat of an excess of sea and river water and to safeguard freshwater supply in the long term; this study anticipated the National Water Plan that was published in 2009 (Ministry of Infrastructure and the Environment and Ministry of Economic Affairs, 2014); with the aim to enforce the National Water Policy stressing the importance of the pursuing of sustainable water management and giving to the water greater significance in spatial development; for this reason this plan is considered as a frame work vision based on the Spatial Planning Act. This Water Plan has integrated eight previous sectorial water acts of the Netherlands, addressing all relationships within water systems. For example, the relationship between the quality and quantity of water, between surface water and groundwater, but also the relationship between water, land use and water users. Integrated water management is also characterised by its relationship with other policy areas such as nature, environment and spatial planning.

3 A RESILIENT PROJECT: THE DELTA METROPOLIS

As we have already highlighted, the territory of the Netherlands is very fragile and vulnerable, placed on average 5 meters below sea level; for this reason about 75% of the Dutch coast is protected by sandy dunes that vary their length from 100 meters to several kilometers; 15% of the coast is made up of "hard" man-made constructions such as dams and artificial reefs, while the remaining 10% is characterized by flat and very wide beaches. Dikes and dunes ensure that Netherlands and its inhabitants could feel safe. All the dunes and the most important dikes are called primary water defences, because they protect mainly from flooding by the sea, the main rivers or Lake IJsselmeer and Lake Markermeer. The secondary defences are also important, but if a dike in this category collapses, the consequences are not as dramatic. If the primary water defences were breached, the consequences would be considerably greater. The Flood Defences Act indicates the safety standards for every dike ring area. The standard is higher if more economic activities take place within the ring and if the number of inhabitants is high. Other important factors are the size of the area liable to flooding; the height to which the water may rise and whether the flood water will be fresh or saline. Flooding occurs when water levels are so high that the streams, lakes or waterways bursts their banks. In the main water system, floods are deemed to occur if national waterways are not sufficiently capable of storing or discharging regional water discharges. In the field of hydraulic works and

hydrogeological management, the most famous flood protection projects are the Afsluitdijk dam and the Delta Works, a system of dams, sluices and mobile barriers in the two Zeeland and Zuid-Holland provinces. The two most important works of the Deltaworks are the Oosterscheldekering dam, inaugurated in 1986 between two islands, in the Zeeland Province, and the Afsluitdijk dam, a 32-kilometer dam, designed as early as the seventeenth century, but completed only in 1932, which separates the inland sea from the North Sea and connects the Friesland and Noord-Holland provinces. This dam protects the coasts of four provinces from maritime floods, and creates the large inland lake IJsselmeer, a freshwater basin that is used in periods of drought. The Delta Project is impressive and was designed and built in response to the catastrophe that struck the Western Netherlands in 1953. The area devastated by the storm was that on the southern coast, called Zeeland, affected by the mouths of three major European rivers, the Rhine, the Scheldt and the Meuse; the project, which involved the construction of eleven dams that blocked the main estuaries of the Delta, had the ambition to increase the safety of the topographically most depressed areas of the delta of the Rhine, the Meuse and the Scheldt, defending them from the most violent storms and floods. This impressive project, also considered one of the seven wonders of the world, demonstrates the ability of the Dutch to dominate the immense power of water. The main element of the Delta Plan is the Oosterscheldekering dam, a unique 8-kilometer-long storm barrier that isolates the entire Eastern Scheldt in just 75 minutes; this ingenious system consists of 62 huge sliding gates that can close quickly protecting the Netherlands from flooding. Given that more than a third of the country is below sea level, the goal was very complex; to achieve the goal of hydraulic protection, the coastal dunes were raised more than 5 meters and the islands of Zeeland were connected by dams and other masterpieces of high engineering. Under normal circumstances, dutch water system works well. Problems such as safety, water shortages, flooding, waterlogging and salinisation usually only occur under extreme circumstances.

4 ROTTERDAM RESILIENT CITY: STRATEGIE AND ACTIONS FOR A WATERPROOF CITY

Rotterdam has been protecting itself from the threat of the water from the rivers and especially from the sea for centuries. The dams and dikes, belonging to primary and secondary defenses, have managed the risk of flooding and have helped the drainage of urban land. For this reason Rotterdam is considered one of the safest delta cities in the world altought Rotterdam iso ne of the most vulnerable city in the world (Meyer, 2003). Rotterdam is located in the delta of the rivers Rhine and Meuse; the city, for the resilience strategy, is divided in different zone but the main importance is to be in the inner city or in the outer-dike areas; The outer-dike areas of Rotterdam are not protected by dikes while the inner part is protected by dikes and is less vulnerable. Within the dikes, the inner-dike city of Rotterdam is mostly well below sea level, with the lowest point being as much as 6.67 metres below NAP[3]. The Rotterdam Programme on Sustainability and Climate Change (City of Rotterdam, 2014) focus on some priority, on some urban topic such as enhancing sustainability, producing a greener and more Energy saving environment, reducing CO2 emissions and working with polpe and communities to promote awareness for the best management of natural hazards and resources. Rotterdam is a delta city and in a period of heavy climate change is will experiment more extreme weather conditions, such as heavier rainstorms, longer periods of drought and more heat waves, as well as higher water levels in the river Meuse; so is important to know that it is a deep vulnerable city and need right strategies to overcome the problem and to be adapted to conseguences of climate change *Rotterdammer*[4] have been adapting their city to the ever-changing delta for centuries. Rotterdam has a strong relationship with water, the whole city is surrounded by water that comes from the sea, from the river, from precipitation and from groundwater.

3 NAP, the National Amsterdam Level, is an agreed ordnance measurement that is almost equal to mean sea level.

4 Rotterdam's citizens.

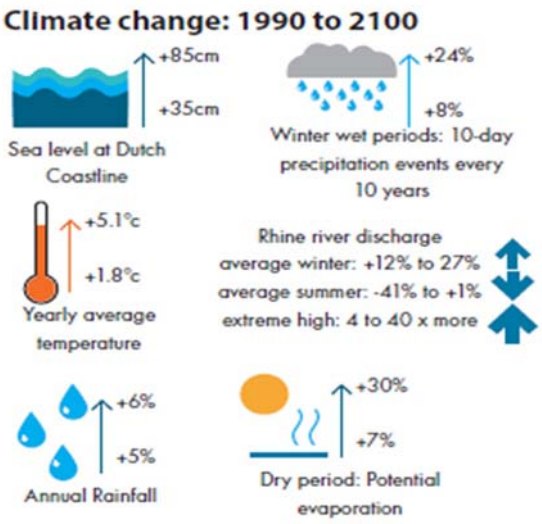

Fig. 2: Climate Change 1990-2100

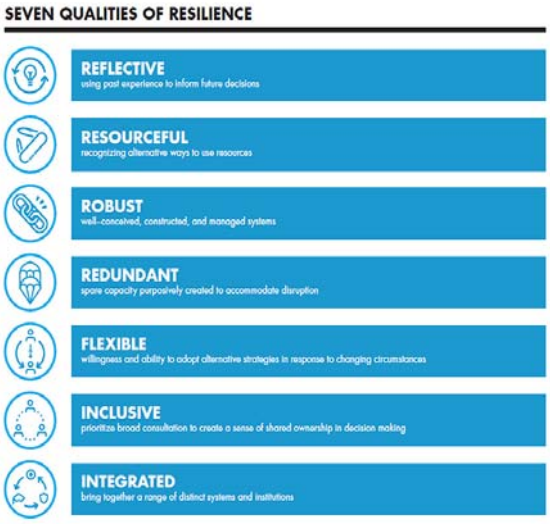

Fig. 3: Quality of resilience

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This is the main reason because the city is one of the more vulnerable to the consequences of climate change. The rise in sea levels and increase in water levels directly influence the city's flood risks. During periods of estreme rainfall, it is very difficult for the water to drain away. Drought manifests itself for example by low water tables and low river levels. Furthermore, the negative effects of a heat wave are more apparent in a highly populated, compact city such as Rotterdam than in the surrounding countryside.

Rotterdam is an example of resilience and adaptation to climate change; the theme of urban resilience has been under the attention of the municipality for about fifteen years and Legambiente has included the Dutch city as one of the examples to follow in the 2017 "Cities to the challenge of climate" dossier (Legambiente, 2016); moreover, in the central districts of Rotterdam, urban retrofitting actions are experimented through new technologies and new functions applied to existing structures, and in line with the climatic changes taking place. Rotterdam is also experimenting with some innovative building technologies; for example, is adopting architectural technology solutions that adapt to the fluctuation of water levels with the introduction of the obligation, by 2025, to create sustainable constructions with floating quarters, in areas outside the banks; the urban water system is also being resilient with the creation of tanks for the storage of excess rainwater. Through some programs, including the "Rotterdam Climate Initiative" (City of Rotterdam, 2013), Rotterdam is seeking, with the help of the government and organizations, research centers and citizens (van Oostrom, 2001), to reduce pollutant emissions by 50% by 2025, trying to adapt the city to climate change in progress and promoting five main initiatives focusing on the concept of resilience: 1) floating houses; 2) the water squares; 3) enhanced water collection systems; 4) green roofs; 5) the sustainable port. Rotterdam is the inspiring example to other delta cities around the world going through a sustainability approach; as a green city is an attractive and resilient city where people love to live, work and relax; sustainability is an integral part of all area development projects in Rotterdam; sustainable areas are future-proof areas with good living conditions. The Rotterdam City Council is committed to making Rotterdam a leader in sustainable urban living. The original core of Rotterdam was along the Rotte river (now largely reduced to an underground but navigable canal); in the expansion of 1626 the city assumed the shape of a triangle with the river Maas as a southern limit and limited by Goudsche Singel and Coolsingel and Schiedamsche Singel. Rotterdam is formed by some district: the *Oude Binnenstad*, the most ancient urban nucleus, almost entirely razed to the ground in 1940 by bombing and rebuilt with a new, extensive urban and functional structure; from the *buitenstad*, the predominantly commercial suburbs; from the *polderstad*, the most modern residential district, and finally, on the left of the river, from the *port* and *industrial quarters*, where economic

life is thriving and one third of the population. Refering to the city form, concerning climate change there is a clear distinction between the outer-dike and the inner-dike areas of Rotterdam; the outer-dike regions are not protected by dikes and are directly affected by the water levels of the river and by the tide so they are more likely to flood than the inner-dike areas. The outer-dike areas are protected by the Maeslant storm surge barrier. This barrier closes when water levels reach 3 metres above NAP; it is expected that by 2080 the barrier will have to close once a year on average, rather than the current average of once every twelve years. Inner-dike Rotterdam is extremely well-protected from flooding; prevention is the key factor in the flood protection of inner-dike Rotterdam. Outer-dike Rotterdam is the least vulnerable area. The 19th century urban districts are the most vulnerable areas. These are densely built-up, generally paved over, have relatively little open water and green. The inner-city centre of Rotterdam is especially vulnerable to extreme rainfall because it is densely built-up, the public areas are used intensively and there is very little vegetation The main difference between these six zones is if they are defended by the dykes (inner dyke) or if, on the contrary, they are lacking (outer dyke); in other areas the main difference is in the presence and availability of potential public spaces or, on the contrary, in the compactness of the fabric that precludes or limits the sustainable project of public space.

5 RESILIENT STRATEGY AND CLIMATE URBAN ADAPTATION

A definition of urban climate resilience is provided by the Environmental Protection Agency (United States Environmental Protection Agency, EPA, 2017): it is a city's ability to reduce exposure and sensitivity to, and recover and learn from, gradual climatic changes or extreme climate events. This ability comes from a city's risk reduction and response capacity, and includes retaining or improving physical, social, institutional, environmental, and governance structures within a city.

Resilience thinking has attracted attention since the Katrina disaster in 2005. Indeed, it is the ability to function, survive and thrive to any stress, according to the Disaster Risk Reduction Hyogo Protocol in 2005 (International Strategy for Disaster Reduction, 2007) and to the UN conference on Disaster Risk Reduction.

The European Commission has adopted the *European Adaptation Strategy* with the obligation for all the Member States to implement national plans to cope with the inevitable Climate Change impacts by 2017. Many EU members have already developed national strategies, among those: The Netherlands, Denmark, Finland, Spain and United Kingdom (Swart; Singh, 2013). Additionally, in 2012, the European Commission presented *The EU Approach to Resilience: Learning from food crises*, which provided policy principles for action to help vulnerable communities in areas facing crisis. Some countries, such as the UK, developed separate national resilience plans, whereas others, as The Netherlands and Denmark, included resilience in their national adaptation strategies. Rotterdam is considered one of the lowest-lying cities in Europe; a city safe and well protected but still vulnerable to flooding, in estreme weather conditions. For this reason, in the last yeas, a lot of urban and enviromental strategies were adepte to face climate change and environmental hazards; in 2014 the national Delta Programme was adepte and become part of the Rotterdam Adaptation Strategy (Ministry of Infrastructure and Environment, 2017).

The aim of the Rotterdam Adaptation Strategy (City of Rotterdam, 2016) is to maintain and optimise the existing strong defence system, to improve urban resilience through the implementation of some adaptive measures, to involve citizens and community, and to link this strategy to the whole urban governance of the city. The final aim is to take advantage of the opportunities that climate change adaptation provides making city more attractive and forming new multifunctional public space. This strategy also aims to contain storm water runoff in case of extreme rainfall, if possible in combination with measures to improve and enhance the green quality of open spaces in the city. It includes measures at neighbourhood, street and building level to minimise the consequences of extreme precipitation that will, at the same time, result in a more beautiful, green city for the people of Rotterdam. The strategy combines sustainability efforts with resilience and urban

transformations, making Rotterdam more able to clear the panorama of the different hazards that could interest it; and in this way the right action to face the situation could be undertaken, a smart and comprehensive solutions able to realize a waterproof and resilient city. Rotterdam has joined also the Resilient City programme for the best 100's city promoted by the Rockefeller Foundation (Rockefeller Foundation, 2015); this programme can provide very useful support for the other pillars and ambitions of the Rotterdam Programme on Sustainability and Climate Change, not least by linking the various themes and intelligently anticipating future trends (Kimmelmann, 2017). The Rotterdam Climate Change Adaptation Strategy indicates which measures can be implemented in the various parts of the city in order to face the effects of climate change. The main priority in outer dyke areas is based on prevention and adaptation; the main defense system based on the storm surge barrier will continue to be the first strong measure for flood protection but, according to this, the protection will be augmented with adaptive measures aimed at increasing resilience and evolving with climate change; for example with the creation of adaptive building, with the construction of floating buildings and the adaptive design of outdoor areas including roadways, utility infrastructure, wilderness areas and parks.

In the area within the dykes will be promoted urban design action able to reinforce the sponge function of this part of the city; will be implemented actions able to store rainwater and to delay drainage, will be realized green roofs and sustainable green infrastructure and will be promoted the permeability of private and public space. In the highly populate areas, with little open space, will be developed measures on existing buildings while, in those part of the city where there is more space, robust measures such as increasing the water storage capacity of canals and lakes and constructing green-blue corridors will significantly contribute to making the city climate proof. The activities promoted in the strategy, and that has to be achieved within 2018 regarding the planting of trees, plants and flowers in the district of Oude Noorden, Nieuwe Westen/Middelland, Tarwewijk, Bloemhof and Hillesluis, combining, where is possible, this with measures to contain storm water runoff in incidences of extreme rainfall; encouraging the residents to plant more flowers, shrubs and trees near their homes removing tiles from the garden enforcing the private space's permeability; encouraging the introduction of lush greenery and a healthy cover of vegetation along the river banks of the New Meuse River, along the New Waterway, the River Rotte and the River Schie, creating an attractive and pleasant green corridor; encouraging the addition of green alements to existing facilities, such as green car parking sites; stressing the importance to develop Wall gardens, or vertical gardens, not only brighten up the streets but also prevent the wall from warming up too much during extremely hot days. Making green roofs has a double meaning: enforcing urban beauty and absorb excess rainwater, they are necessary especially in this district dominated by brick, such as the city center and the old urban districts. Green roofs save energy (keeping homes cooler in summertime) and double the life of the roof. Furthermore, they enhance the city's biodiversity. The target is to install 40.000 sq of green roofs every year. Private initiatives include measures such as green roofs and façades and green inner courtyards and gardens. In public areas there are a wide range of potential measures, from incorporating more green in the streets and along the infrastructure (boulevards, quays, cycle and walking routes) to good management and extension of parks and greenbelts. The 'waterproof city' is robust and resilient (grey and green-blue) with a mix of paving and vegetation. The focus is on adaptive measures whereby the rainwater is captured and drainage is delayed. Public areas become a strategical space where store the rainwater; this could be realized along the infrastructures (through the street profile) and along the surface of the square, realizing multilevel public space that, in case of particular weather, could be used as a store for rainwater. Additional areas of water storage are included in the projects currently being implemented in Rotterdam, for example in Centraal Station or in Kruisplein and also in urban vision in 2030 or 2050 as "Rotterdam child friendly city" (City of Rotterdam, 2010) or "Wilderness school playgrounds" . The group of architects "De Urbanisten" has defined several projects (Bokern, 2014) concerning the management of urban water in Rotterdam and in neighboring polders, realizing many water squares. Is interesting, for example, the project for the

Benthemplein water square, a large multifunctional water square that combines rainwater collection with the creation of an outdoor public area; the project was defined after three preparatory workshops in which the natural elements and the form of public space were discussed. Green and blue roofs, removing paving and planting trees and bushes in the streets and open areas and waterproof design all contribute to increased resilience. The core of the strategy is to incorporate more flora in the city, especially in its paved, densely built-up areas. This is being done at all levels in the city, from pavements to city parks.

6 CONCLUSION

In the manuscript is underlined the Rotterdam strategy for the creation of a resilient city; the whole strategy is developed promoting an intensive cooperation between the water boards, urban developers, the City of Rotterdam and spatial administrators; other parties such as housing corporations, project developers and the inhabitants has an active role in trasforming the city.

Creating a waterproof city, as Rotterdam best practice shows, requires intensive cooperation, public awareness and citizens involvement; everyone is deeply involved in making the city waterproof.

The Rotterdam Adaptation Strategy (City of Rotterdam, 2013) charts the course by which Rotterdam plans to adapt to the consequences of climate change and shows how residents, businesses and the city can gain maximum benefit. This strategy offers the framework and the guiding principles for a future-proof development of Rotterdam and ensures that every future (spatial) development will include subjects such as flood management, accessibility and robustness of the city as basic principles from the very outset of the process. It is also important to link defense design with other spatial planning tools, to allow the better integration and implementation, a right cost reduction and an increased innovation.

These actions will not only contribute to making Rotterdam more resilient but will contribute to the creation of a more pleasant and attractive urban environment¸rotterdam's climate adaptation strategy provided opportunities for reinforcing its image as an attractive city; resilient urban design experimented in Rotterdam was well integrated and multifunctional, making space for water storage gave to the city the opportunity to create an high quality and pleasant public space. The main added value for the city is the creation of an attractive and green-blue environment with sustainable solutions for coping with rainwater. Experiments with 'water in the city' reinforce the Rotterdam's international image as a progressive, ambitious delta city. Rotterdam's water squares are exemplary.

Rotterdam, in its adaptation strategy, wants to anticipate climate change; the main innovations are that:

- the strategy encourages flood protection through the architectural and urban project;
- resilience theme are included in all levels of government and in all urban planning instruments and spatial and strategic development policies;
- additional areas of water storage are included in the projects currently being implemented in Rotterdam, for example in Centraal Station or in Kruisplein and also in urban vision 2030 or 2050 as "Rotterdam child friendly city" or "Wilderness school playgrounds";
- as *waterproof city*, Rotterdam has involved in its strategy, individual actions and cooperation between water boards, ministreries and municipalities, urban developers and private firms, the housing corporations and, over all, the citizens;
- the defense works become spaces for the city and new high quality public space because "blue and green" strategy which will also contribute to making the urban environment more attractive and enjoyable.

In Rotterdam, Architects and urban designers are finally responding to the threats of rising sea levels by "welcoming the water" into city, so the waterscape is becoming a new paradigm of spatial planning; Rotterdam is striving to become a climate proof city that will be safe and attractive to inhabitants, visitors

and businesses, and will remain so in the future. A healthy delta city in which it is pleasant to live, work and spend leisure time.

Fig. 4: Water squares in Rotterdam. (City of Rotterdam, 2013)

The approach devised in the Rotterdam water plan will be extended to all areas that are important in a climate proof city. The adaptation strategy provides the framework and basis for discussions. The aim is to arrive at shared ambitions for climate proof urban development and to make specific concrete agreements about this. The Rotterdam's experience shows that there is the need to implement a conscious and smart urban governance and to undertake urban awareness actions that aim at the awareness of the communities, which becomes an active part in promoting urban resilience policies and in creating the sustainable city. The involvement of private is also crucial, taking place in two ways: firstly, individuals are involved in the thematic awareness process and become aware of the environmental risks associated with climate change; secondly, precisely because of this mature awareness, they become an active part of the adaptation policy by implementing some strategic actions in the areas they own or by encouraging participation in the case of interventions in public areas through forms of associationism and smart communities. Spaces and resources are shared and the strategy becomes more implementable and successful (EU, 2011). In addition, the Dutch are deeply aware of the environmental problems, because at school, from an early age, training courses are provided that update them on the risks and the main techniques to preserve their nation, as for example, that of the polders. The education system, in this case, is one of the best in the world and aims to raise children's awareness so that they can refine their behavior with growth and be examples of best practices and smart communities. Furthermore, there is a strong convergence of interests between the central government and the individual municipalities, a union that is difficult to implement, but desirable, in countries such as Italy due to the excessive size and the normative and administrative organization. Rotterdam is becoming resilient not just by fortifying its defences to a changing climate and rising seas, but also by building a more cohesive and inclusive society. Resilience thinking is being incorporated in the policymaking and initiatives across all domains of city government, including across social, physical and economic programmes.

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Fig. 2 - Fig. 3: City of Rotterdam (2016). Rotterdam resilient strategy. Ready for the 21st Century. Available at www.100resilientcities.org/wp.../strategy-resilient-rotterdam.pdf.

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