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The cycle network as an environmental infrastructure

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Abstract

The topic intended to be investigated is the potential interdependence between the cycling network and the management of rainwater in the mid-Adriatic city of Abruzzo. Preliminarily, two observations. The first concerns cycling: in Italy it is constantly increasing, both in terms of territorial diffusion and in terms of turnover. The second: in recent years the frequency of urban flooding, resulting from extreme atmospheric phenomena, has been constantly increasing. Cycling and urban flooding are two issues addressed separately. The first is framed as a contribution to slow mobility. The second is treated as a continuing emergency. The goal is to overcome separateness. And imagine the cycle network as an environmental infrastructure that, in addition to supporting the transit of bicycles, is able to contribute to a better collection and management of rainwater as an alternative to the sewer system. Working on the hypothesis of the cycle network as an environmental infrastructure obliges us to broaden our gaze to those cities that have transformed water from an agent that generates dangerous conditions, into a strategic resource. Boston, San Rafael, Zwolle and Copenhagen went in this direction. Methodologically, the projects and intervention programs of the four cities will be compared with reference to: the network space (reserved for transit) and the materials used to build it (porous asphalt, underground channels for the flow of water); the space associated with the network with the Green Stormwater Infrastructures that contribute to drainage; the contexts crossed by the cycle network and the relationships it establishes with the public space. The comparison aims to bring out some lines of action useful for orienting the actions of the plan in the mid-Adriatic city of Abruzzo.

Keywords: Cycle network; Project; Environmental infrastructure; Urban flooding; Green Stormwater Infrastructures

1. Introduction

In the mid-Adriatic city of Abruzzo there are two phenomena which, in recent years, have assumed an ever-greater importance. The first concerns the spread of urban and territorial cycling that follows, and sometimes precedes, the national trend, both in the exponential increase in the volume of business linked to the bicycle economy (Il Sole 24

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Ore, 2019), and in the employment growth that the sector has shown, with reference to both the production of bicycles and the creation of new cycle paths (ISFORT, 2020). An example is sufficient to demonstrate the importance that slow mobility has assumed along the Abruzzo coast: from Martinsicuro to San Salvo there is an almost seamless route that crosses Vasto, Ortona, Francavilla, Pescara, Montesilvano, Pineto, Roseto, Giulianova, Tortoreto, Alba Adriatica: about 150 km in which the bicycle is a concrete alternative to crossing by car (FIAB Cycle Municipalities, 2021).

The second phenomenon concerns urban flooding, especially those deriving from extreme atmospheric events which, in recent years, have been constantly increasing in frequency and intensity (ISPRA, 2019). There are multiple causes. The main three are closely connected: the pervasive densification of the Abruzzo coast which "from above offers itself as an undifferentiated segment of the larger agglomeration that borders the entire western Adriatic area" (Bianchetti, 2003), the insufficient drainage capacity of the sewer network that fails to drain rainwater and the excessive waterproofing of the soil (Salvati and Bianchi, 2019).

However, in the Adriatic city of Abruzzo, cycling and urban flooding have always been treated as separate, unrelated phenomena, void of connections. On the one hand, the cycle network is seen as a contribution to sustainable mobility (Parkin, 2012; Vittadini, 2015; Calderón, 2012) which, when it manages to go beyond the quantitative perspective linked to the kilometers of paths built, focuses on topics of great importance such as technical functionality, safety and continuity of the route, horizontal and vertical signage, closure of the network and the search for intermodality, (Giuliani and Maternini, 2018; ECF, 2016; Fleury, 2012; Tira and Zazzi, 2007). On the other hand, urban floodings, despite the considerable damage caused to the city and the territory, continue to be addressed as a periodic emergency to which, time after time, an answer can be given to bring the situation back to normal in the shortest possible time. An answer that arrives, thanks to the intervention of the Fire Brigade and Civil Protection; with an increase, not negligible, on the municipal budget. And, above all, without a perspective of resolution to the problem. Which becomes increasingly unsustainable: from an environmental point of view, due to the pollution resulting from the flow of surface water into which not only the rain converges but also the return flow of the sewer system; from an economic point of view, for the damages to infrastructures, cultural heritage, residential fabric and production areas; socially due to the risks to which the population is subjected.

The separation between cycling and urban flooding, of course, is not accidental. The reasons are many. One of the most important is the Italian legislative framework.

2. Sector legislative framework

The current Italian legislation does not contemplate the possibility of an interdependence between the cycle path and the management and collection of water. The Traffic Laws (*Codice della strada*, Dlgs 285/92), its Implementing Regulation, (*Regolamento attuativo*, DPR 495/92), the Main criteria and design standards of cycle paths (*Principali criteri e standard progettuali delle piste ciclabili*, Circolare Ministero delle aree urbane 432/93), define the types of tracks, the dimensional and plano-altimetric characteristics of the route, its intersections with ordinary roads, project speed and the requirements of horizontal and vertical signs. The Regulation laying down rules for the definition of the technical characteristics of cycle paths (*Regolamento recante norme per la definizione delle caratteristiche tecniche delle piste ciclabili*, DM 557/99) defines cycle routes in descending order with respect to the safety they offer for cycling users, such as: cycle paths in their lane; cycle lanes on reserved lanes; mixed pedestrian and cycle paths; mixed cycling and vehicular routes. The purpose of the decree is to promote and encourage a high degree of cycling and pedestrian mobility, an alternative to the use of motor vehicles in urban areas; aim at the attractiveness, continuity and recognizability of the cycle route; assess the profitability of the investment with reference to real and potential users and in relation to the objective of reducing the risk of accidents and the levels of air and noise pollution; verify the objective feasibility and the actual use of cycle routes by users. And with regards to surface water drainage there are only two hints. The first is in art. 8, which states that a cross slope of 2% is sufficient, with reference to road paving with a bituminous conglomerate wear layer that favors the discharge in the existing sewerage network. The other in art. 12 which clarifies how on the cycle paths the presence of grids for the collection of water is not allowed with main elements parallel to the axis of the tracks themselves, nor with transverse elements such as to cause difficulties for transit for cyclists. Nor is it possible to find anything on this subject in the Provisions for the development of bicycle mobility and the creation of the national cycling network (*Disposizioni per lo sviluppo della mobilità in bicicletta e la realizzazione della rete nazionale di percorribilità ciclistica*, L. 2/2018): art. 6 provides for the preparation of the

Biciplan as sector plans of sustainable mobility urban plans. Just as there is no mention in the Guidelines for the preparation and implementation of the "Biciplan" (*Linee guida per la redazione e l'attuazione del "Biciplan"*, 2019), nor is there any in the Experimental guidelines for the development of cycle mobility (*Linee Guida sperimentali per lo sviluppo della mobilità ciclabile*, 2020), both written by the Ministry of Infrastructure and Transport. This brief examination of the sector legislation shows that the cycle network not only does not contribute to combating urban flooding but, even, facilitates it. The cycle network is a work of waterproofing the territory. And considering that in 2017, the length of cycle paths in the provincial capitals is 4,541 km, with a growth (2011-2017) of 4.1% per year (Confartigianato, 2020). It is immediately obvious that this is a significant quantity of waterproofed soil. From the point of view of the contribution to sustainable development there is a paradoxical situation: if the economic and social pillars are perfectly verified, as mentioned in the introduction, the environmental one, on the other hand, is only partly verified due to a pervasive use of waterproofing materials that could almost always be avoided, especially in the case of bicycle lanes on own premises. Furthermore, a mono-functionality emerges aimed at guaranteeing the movement from one place to another, in which the network space is, exclusively, the support for cycling traffic. These findings introduce some questions. Does the cycle network only have to be this? Or is a form of interdependence with rainwater management possible? A form that can guarantee full sustainability and contribute to urban resilience? The answer to these questions is the most important challenge: to overcome separateness. And imagine the cycle network as an environmental infrastructure that can contribute to urban resilience, through a project that, in addition to supporting the transit of bicycles, is able to contribute to a better collection and management of rainwater, as an alternative to the sewer system. It is evident that such a hypothesis of work has no ambition to be a resolutive one. Rather, it intends to delimit the field of investigation in the context of a topic of great importance: to counteract the negative effects deriving from urban flooding, urban planning must transform water from an agent generating dangerous conditions, into a strategic resource for rethinking ecological regeneration; it must rethink open spaces according to their ability to provide adequate environmental performance; and again, it must go in the direction of de-waterproofing all those surfaces that allow it. Boston, San Rafael, Zwolle and Copenhagen are going in this direction.

3. Water strategies for Greater Boston

Developing resilience. Living with water strategies for Greater Boston, represents the policy of the metropolitan area of Boston to counter flood risks. The starting point was to realise that the lack of a public debate on the social and economic implications of floods has led to a general underestimation of the risks to be faced. That is why raising the awareness of the population and stakeholders as regards the fact that the effects of climate change are the most important challenge for the future of cities was such a fundamental step.

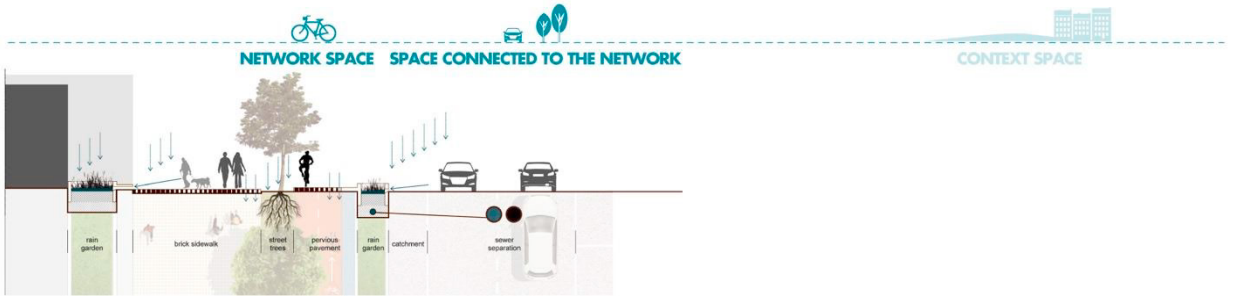

Fig. 1. Greater Boston (Cambridge), section of Western Avenue. *Source: original drawing by arch. Massimo Padrone*.

Developing resilience is a systematic set of measures on a supra-municipal scale the overall aim of which is to improve the sustainability and resilience of the urban system. From a programmatic point of view, a series of projects are planned in the residential sector to improve the environmental performance of buildings; in the infrastructural sector in order to reduce the vulnerability of the electricity, natural gas, drinking water and sewage networks; in the transport sector in order to make public and private mobility more sustainable. And this is precisely the sector into which the redevelopment of Western Avenue falls. A road that plays a major role in linking Central Square and the

Charles River in Cambridge. The project has two main objectives: to moderate car traffic flows and to improve rainwater treatment. The first of these objectives was pursued by reducing the carriageway and expanding the cycle/pedestrian section. The second resulted in the construction of a cycling path out of permeable material while the part immediately adjacent to it consists of green stormwater infrastructures. Both these solutions allow the water to flow towards a pipeline completely separate from wastewaters. From the hydraulic point of view, this pipeline dedicated to filtered water, both from the permeable floor and from the vegetation, has a double positive effect: it increases rainwater drainage capacity and reduces the pressure on the sewage system.

4. Elevate San Rafael

San Rafael is the city most exposed to flood risk in the whole of San Francisco Bay. In the face of this problem, more traditional solutions no longer seem sufficient, *Elevate San Rafael* is a new paradigm to respond to the complexity of environmental change. We propose that the city evolve by employing time-tested approaches to coastal adaptation in combination with a moral, financial, and infrastructural agenda for large scale preparedness. In this process of strategic change and redefining the relationship to the bay, we see the singular opportunity to elevate all aspects of life.

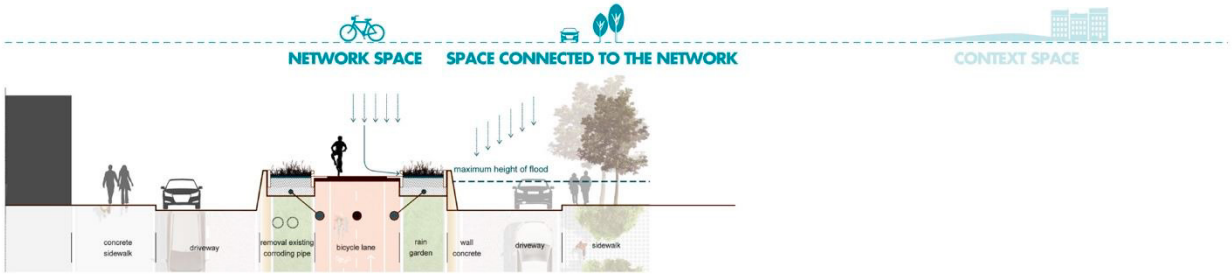

Fig. 2. San Rafael, section of Canal Street. *Source: original drawing by arch. Massimo Padrone*.

To physically elevate habitation, and the bonds of community and dignity. To elevate ones social and financial position in life, and policy for urban change. To lift infrastructure to new elevations and purposes and allow for ecology to persist and expand (Bionic Team, 2018). The strategy is based on an immediate response which includes a series of measures called pilot and catalyst projects with the aim of protecting San Rafael now, to better prepare for the future, and a longer-term response consisting in the re-elaboration of the entire urban structure, its mobility, its infrastructure and its residential and productive areas. As part of the pilot and catalyst projects, a new elevated cycling path is planned along Canal Street and Francisco Boulevard, which, on the one hand, would complete the Bay Trail route and, on the other hand, would protect the city closest to the sea from flooding. Such solution envisages the Bay Trail being raised by 30 cm to about 130 cm in all its parts to ensure the community is protected until the middle of the century and reduce the need for additional short-term protection measures along the coast. This is a special case for a cycling path: it is not only a bike path but also a project that, through soil modelling, relates to the needs of the urban context because it links the coast with the downtown areas and becomes a tool for sustainable local development. The prerogatives of this bike path do not however stop there. The track is, in fact, a new environmental infrastructure for the drainage of water that works in two directions: it provides for the replacement of existing metal pipes, now corroded, with new materials and increases the dispersion of water in the landfill used for the elevation. A real stormwater infrastructure that contributes to the greater resilience of the urban system.

5. Zwolle and Plastic Road

The Plastic Road is a prefabricated road structure with which a section of the cycle network in Zwolle in the Netherlands was built. Beyond its modest planimetric extension, it is important to emphasize its degree of innovation. Three fundamental characteristics. The first concerns a fact of extraordinary interest from the point of view of sustainability: be made with entirely recycled plastic materials and, above all, recyclable even after its disposal.

Another important aspect is the prefabricated production and the design realized in light modules that makes the installation very fast, to the point that the times for its realization are reduced by about 70%. All this is combined with much higher resistance and durability than traditional cycle paths. Although these two peculiarities are very relevant from an environmental, social, and economic point of view, what matters most with respect to the issue of treatment and management of rainwater is the hollow modular structure inside. This third characteristic was imagined to counteract rain flooding even in the presence of extreme atmospheric phenomena, thus avoiding overloading the sewage system.

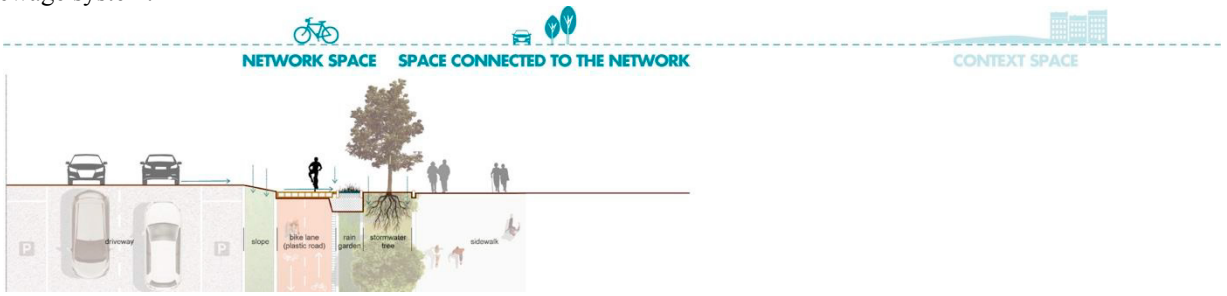

Fig. 3. Zwolle, section of the Plastic Road in Deventerstraatweg. *Source: original drawing by arch. Massimo Padrone*.

Considering that the surface of the Plastic Road is completely waterproof, the water collection system consists of a storm drain located at a lower level than the road. This storm drain runs parallel to the hedge which helps to manage the flow of water due to the slope, since the ground level is at a lower level than the cycle path. This allows you to manage rainwater allowing storage, infiltration, and evapotranspiration. An effect that is amplified by the system of trees adjacent to the hedge (PlasticRoad, 2018).

6. Copenhagen

"Climate change challenges are clearly defined in Copenhagen and in Denmark. 1000 km of dikes protect many parts of the country from the sea, but the new threat is the water from within and from above. Our fate has become being inundated with torrential rain that floods entire neighborhoods. The existing sewer system is completely inadequate to tackle the volume of water from cloudbursts" (Colville-Andersen, 2015). The *Climate Adaptation Plan* includes a range of actions to contrast urban flooding. However, it was in the wake of the July 4, 2011 flood that the problem created by heavy rainfall during extreme weather events became one of the principal points for rethinking the entire city. This rethinking began in 2012 with the *Cloudburst Management Plan* and evolved with the hypothesis of the cloudburst streets (Ramboll, 2016), in other words, proposals to transform streets into infrastructures for storing and draining stormwater. However, these infrastructures require a certain road section that is not always available. This is precisely the reason for the creation of *The Copenhagenize Current – Stormwater Management and Cycle Tracks*: thanks to this design solution even the narrowest streets can help contrast urban flooding.

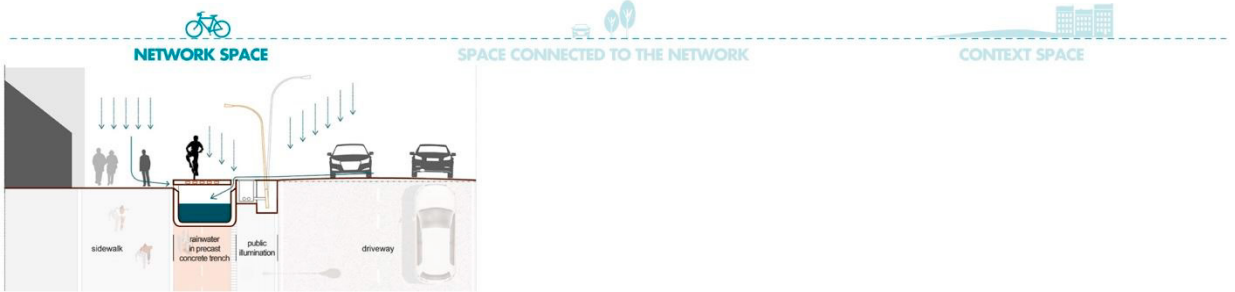

Fig. 4. *The Copenhagenize Current* is a project for a prefabricated canal beneath a bicycle path by M. Colville-Andersen and S. Montebello. *Source: original drawing by arch. Massimo Padrone.*

The strong idea is to use the space beneath bicycle paths with the twofold objective of creating a diffuse stormwater drainage system, separate from the city's sewer network, and to improve the infrastructures offered to cyclists. These objectives are pursued using prefabricated concrete channels covered by concrete slabs, also prefabricated, that form the base of the bicycle path. The slabs can support the weight of thousands of cyclists as well as the weight of automobiles crossing at street intersections. Additionally, the slabs feature integrated led lights to improve visibility and heating coils that melt ice during the winter. Other elements of the project include storm drains flanking the sidewalk and street to drain stormwater from both sides, while simultaneously blocking the flow of detritus. The entire system is easy to install and maintain. What is more, it also provides for the possibility to reserve space, when necessary, for the insertion of underground urban utilities. *The Copenhagenize Current* integrates the drainage capacity of the existing sewer network, accelerating drainage of water that is channeled toward the river, the sea and Saint George's Lake.

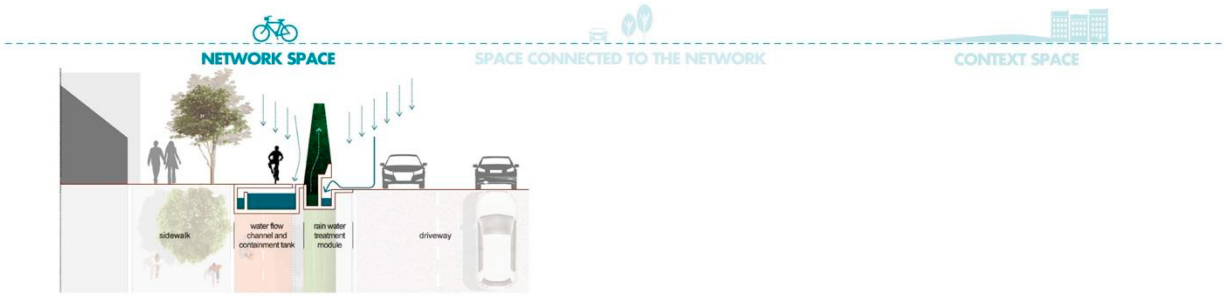

Fig. 5. Copenhagen, section of the the project idea by Marina Bergen Jensen. *Source: original drawing by arch. Massimo Padrone.*

This experience was also accompanied by another. Marina Bergen Jensen, professor in Design and Construction of Urban Landscapes Adapted to Climate Change at the University of Copenhagen, has developed a project to create a vegetal wall that functions as both an acoustic barrier separating bicycle and automobile traffic and as an element for the capillary rising of stormwater that accumulates in the channel beneath the path (Bergen Jensen, 2015).

It is once again a perspective of resilience that presides over the requalification of public spaces such as Skt. Kjelds District, referred to as the first climate district in which the professional practice Tredje Natur transforms the neighborhood through de-waterproofing of entire areas. This way the urban space gains the value of environmental infrastructure for the collection and outflow of meteoric waters towards the harbor (Tredje Natur, 2016).

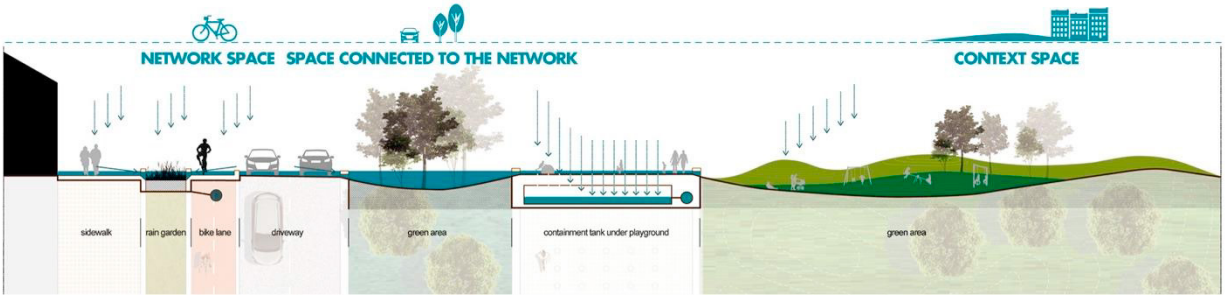

Fig. 6. Copenhagen, section of the Skt. Kjelds District. *Source: original drawing by arch. Massimo Padrone.*

Another example is The Soul of nørrebro by Stig Lennart Andersson for Hans Tavsen's Park. It is an integrated urban design and climate adaption project in which rainwater is collected and used locally, whereas the water in excess from storms is carried from the park to the lake Peblinge Sø, which is purified by the natural biotopes of the city along Korsgade (Andersson, 2016).

Thanks to different architectural solutions, during extreme weather events the urban landscaping of these public spaces drains heavy flows of water and, when they are truly excessive, channels them into underground reservoirs. In

this landscape, bicycle paths participate in achieving these objectives thanks to their necessary slopes, which channel water toward these stormwater infrastructures.

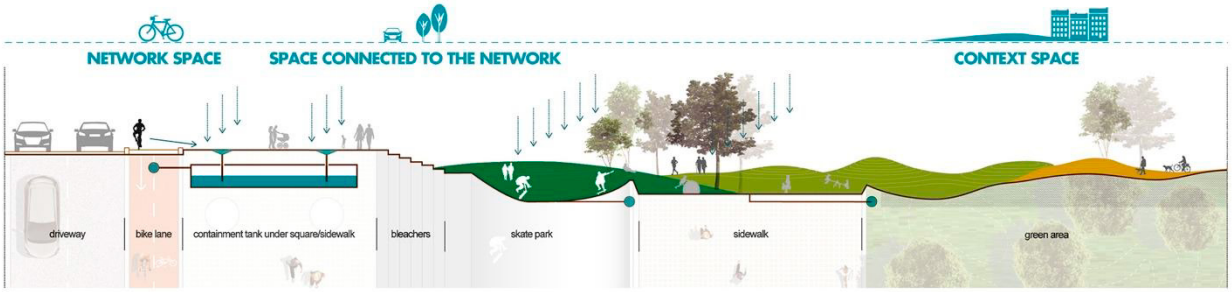

Fig. 7. Copenhagen, section of the Hans Tavsen's Park. *Source: original drawing by arch. Massimo Padrone.*

7. Conclusions

Compared to this review of projects and intervention programs, the mid-Adriatic city of Abruzzo is going in another direction. One of the main reasons is related to the fact that all the realizations comply with the legislation, without trying to experiment. An emblematic example is the Biciplan of Pescara which remains a sector plan of the Urban Traffic Plan. And which is divided into two levels: infrastructural and promotional. The first relates to the network of cycle routes with its four perimeter circuits, the three crossing ridges and the cycle parks. The promotional level refers to strategies aimed at encouraging the use of bicycles. However, the Biciplan makes no contribution to what clearly emerges from the meteorological data: the most frequent problem in Pescara concerns flooding due to heavy rains that paralyze almost the entire city, making it difficult for citizens to move around, for the functioning of services, often causing problems in lower floors of public and private buildings" (Legambiente, 2020).

The perspective of intervention must be reversed. And bring the relationship between the cycle network, collection and management of rainwater within the ordinary themes of the urban plan. This is what Boston, San Rafael, Zwolle and Copenhagen have done, transforming the cycle network into an environmental infrastructure through a multiplicity of strategic choices. There are three main ones.

The first concerns the fact that the cycle path is not a strip of asphalt but a much larger and more complex system. From the comparison of the case studies, the system is mainly made up of three types of spaces. The network space: this concerns the area on which cycle traffic passes and which can be used for technological devices, placed under the track, to allow the collection and management of water. The space connected to the network: the ideal place for green stormwater infrastructures that contribute to increasing the permeability of the soil on one or both sides of the cycle path. And finally, the space of the context within which the cycle network is a work that relates to the places it crosses; which establishes privileged relationships with the public space; which opens up the interdependence between infrastructure and context. Deciding how to make the network space, associated space and context interact, concerns the geomorphological conditions, the width of the road section, the possibility of integrating the underground system or not and, more generally, the possibility of creating alternative solutions to the sewer network for the collection and management of rainwater.

The second strategic choice concerns the need to focus on smaller networks and, in particular, on those of slow mobility. For the medium-Adriatic city of Abruzzo it would be a historic reversal of the trend: the perspective of transport engineering would be overturned which, from the second post-war period, imposed the idea that to solve the problems of mobility and accessibility one should invest only in large infrastructure. Pescara is an undisputed icon of this method. Its construction was strongly influenced by the railway along the coast, by the State Road 16, by the A 14 Motorway, by the Asse Attrezzato and by the junctions connecting with the urban road network. Changing direction is possible, as Copenhagen demonstrates. The capital of Denmark, after the flood of 2011, was able to innovate the practices of urban planning and design. The innovation also involved the cycle network and was conceived as an opportunity to guide the morphological quality of the interventions. The district of Sankt Kjelds and the park of Hans Tavsen are the clearest evidence of this.

Finally, the apparently more paradoxical choice: the cycle network must work even in the absence of traffic when atmospheric events occur, especially extreme ones. In this case the network loses its function of support for the transit of bicycles to acquire that of a permeable body which has the purpose of reducing the recovery times of the area affected by the negative effects of a flood. To achieve this result, the project can go towards the permeability of the cycle path (Boston, San Rafael), or provide for the installation of underlying prefabricated canals (Copenhagen), or grids for rainwater collection (Zwolle). This creates an alternative to the urban drainage system which, in the presence of extreme atmospheric phenomena, almost never manages to dispose of the enormous amount of water that is poured into the city in a limited time. Respecting this condition means going in the direction of full sustainability because it would remedy the paradox of the cycle path as a work of ground waterproofing.

The cycle network as an environmental infrastructure is not just a vision for the future of the mid-Adriatic city. In Abruzzo, it can be so much more. The technical-architectural devices used in the case studies, although not explicitly provided by Italian legislation (national and regional), are not even prohibited. This means that it is necessary to innovate. And this is precisely the responsibility that, ultimately, who plans a cycle network must assume: making it become a part of a wider territorial project capable of triggering not only sustainable development processes but also urban resilience.

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