ENVISIONING RESILIENT CITIES for a POST-PANDEMIC ONE HEALTH FUTURE

REsilienceLAB

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CONTRIBUTIONS

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The book includes Scientific paper and reframing contribution stimulating challenges, highlighting crosscutting phenomena and providing perspectives envisioning resilient and sustainable cities futures.
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Photo Credit: Angela Colucci

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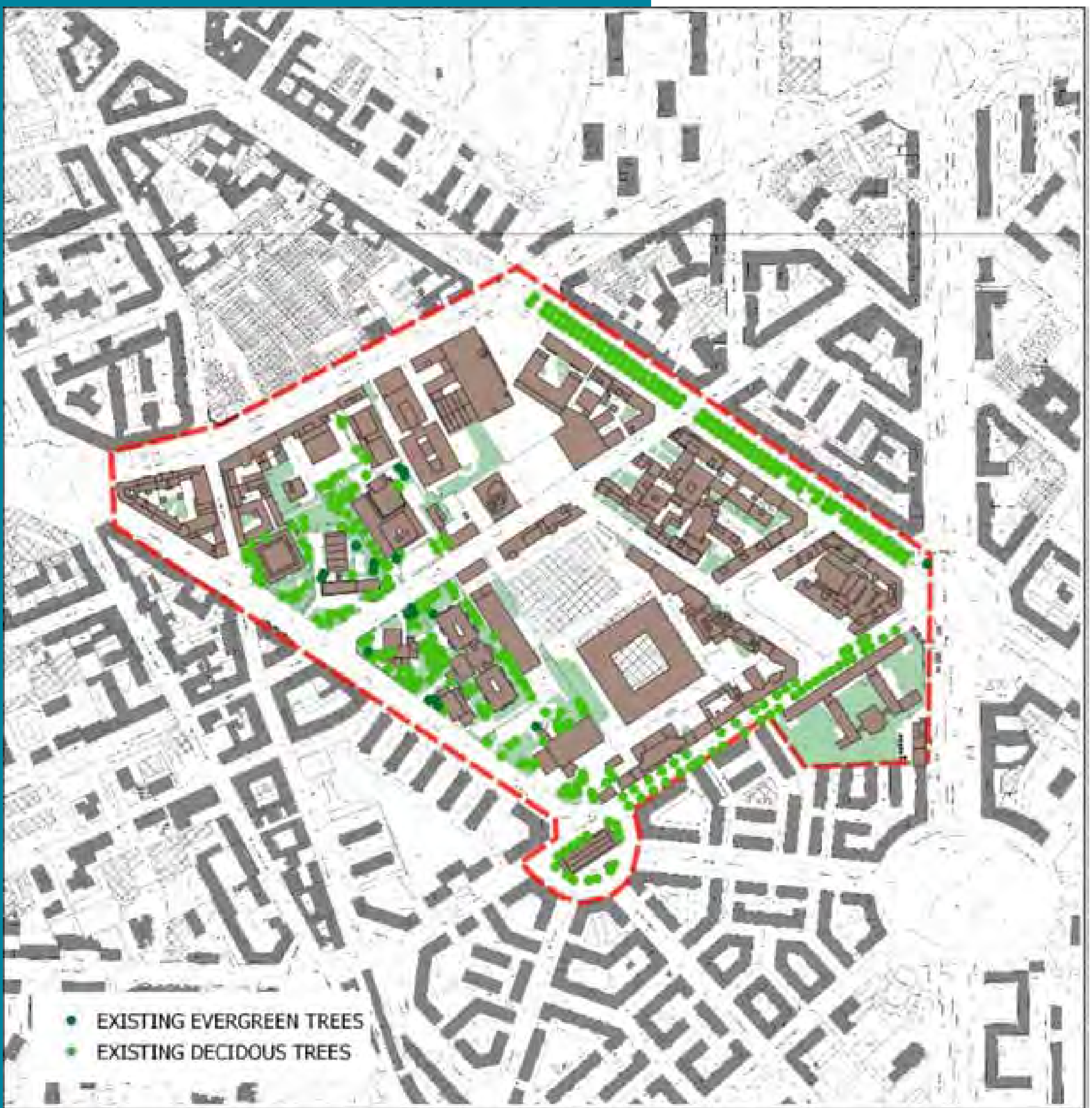

[SCh 1] Figure 6. Existing Deciduous and Evergreen Trees. Source: Authors' Elaboration based on the Comune di Milano Database

[SCh 1] Environmental Analysis and Design Anticipation for Urban Resilience and Human Health

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ABSTRACT

Relationship between human health and urban environment is nowadays well known. But, when we intervent locally, it is significant to have a site-specific approach in relation to the environmental and health local issues. In this scenario, it is very important to understand through predictive tools how the different design alternatives reflect on human health and well-being.

1. Premises

The built environment, conceived as the morpho-typology and the structure of cities, strongly influences the quality of life and the public health (Azzopardi-Muscat et al. 2020).
The worldwide climate change with the increasing of severe weather phenomena (IPCC 2013), such as heat waves and acute rainfalls as well as the concentrations of air pollutants represent relevant criticalities for the health and the psycho-physical well-being of people (Capolongo et al. 2018; Ministero della Salute 2015). Well-being, as defined by WHO, represents the essential element for fostering good livelihoods, building a productive workforce, creating resilient and vibrant communities, enabling mobility, promoting social interaction, and protecting vulnerable populations. Among the different factors of stress in the urban environment, those that have higher impacts on public health and psycho-physical well-being are the exposure to air and soil pollutants, to heat and noise and the loss of a sense of safety during acute rainy.
At the microscale of the neighborhood and the block, these factors of risk can be accentuated by the material composition of the surfaces (of the ground and buildings) as well as by the density of the building. In these terms, the climate and weather conditions directly affecting the human health can be conceived as barriers for the full accessibility and fruition of cities (Tartaglia et al. 2019)
The European strategy for GIs (European Commission 2013) has highlighted how ecosystem services (MEA 2005) provided by nature-based solutions (NBS) and Green Infrastructures (GI) represent an effective solution for the reduction of both environmental stress and for the promotion of healthy life. (Mussinelli et al. 2018; Tucci et al. 2019).

2. Objectives

The essay aims to outline the potentialities during the decisional and design process related to the predictive evaluation of benefits deriving from the application of NBS and GI in environmental design projects at the urban local scale (neighborhood), with the identification of the impacts on the health and on the psychophysical well-being of the population. In particular, the proposal is focused on the environmental improvement of the public space. In order to assess the benefits deriving from NBS and GI, place-based and site-specific analyses of a selected test-site (Study Area) were necessary to estimate the level of environmental quality existing in the current state. This site-specific approach appears particularly relevant in order to identify priorities and suitable solutions for the improvement of health and safety of population contrasting specific environmental criticalities.

3. Methodology

In order to achieve the objective, the essay adopts a design-based approach consisting in: definition of a study area in the city of Milano; place-based and site-specific analysis of the site; development of project based on the adoption of NBS aimed at the improvement of the local environmental conditions; predictive evaluation of the benefits. More precisely, from a methodological point of view, the work was structured following these steps:

- Definition of the Study Area and context analysis;
- Definition of indicators and indices for the measurement and mitigation of environmental criticalities with impacts on health;
- Site analysis according to the selected indicators;
- Design proposal based on the adoption of NBS and GI to improve the environmental quality of public space and predictive quantification and assessment of the benefits generated;
- Evaluation of the results.

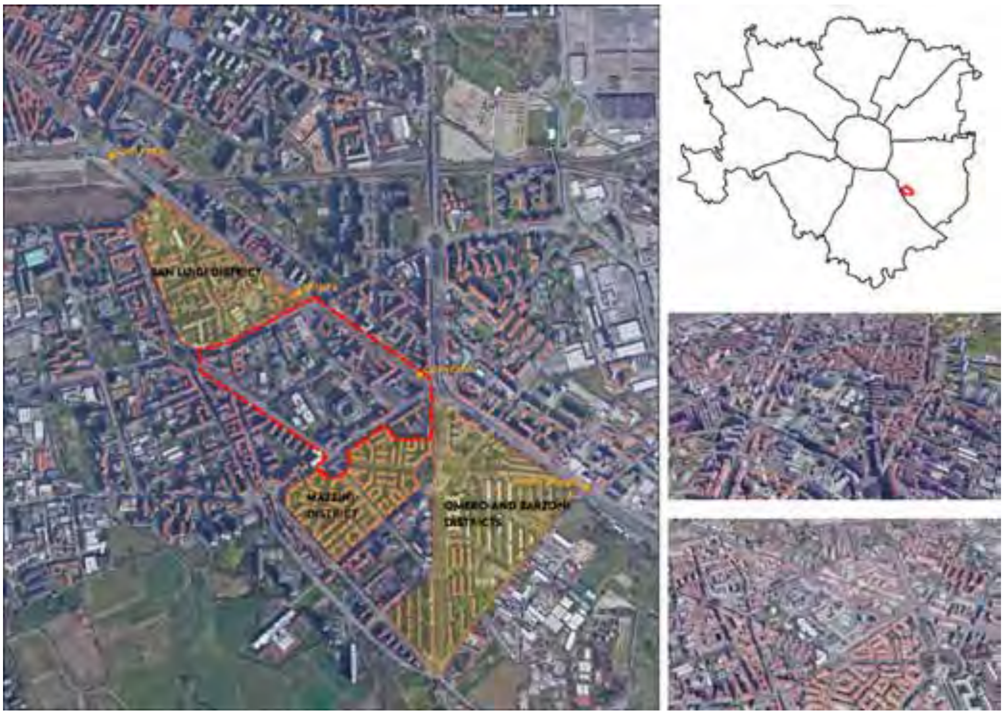
4. Definition of the Study Area and context analysis

For the definition of the Study Area, the Research Group has assumed the following criteria:

- Dimensional characteristics: coherency with the neighborhood scale;
- Morpho-typological characteristics: homogeneity of the urban fabric; presence of transformation areas;
- Functional characteristics: high prevalence of public functions (eg. services open to citizens, sport facilities, green areas, etc.); high accessibility to the area through public and private transport; presence of Systems of Public Spaces (SPS)[1].

Based on these general criteria and in coherence with other studies developed by the Research Group on the wider urban sector[2], the Study Area is identified in the context of Milan, more precisely in the South-East sector of the city (Figure 1). Furthermore, the Study Area is also a context where the Municipality of Milan intends to develop a series of interventions on public spaces[3]. The site is defined by four major streets (viale Brenta, corso Lodi, via Polesine and via Mincio) and within the Study Area there are five blocks.

With reference to the morpho-typological aspects, the identified site results clearly discernible from the neighboring districts. Thus, both from the San Luigi District localized on the North and the Mazzini District on the South. Similarly, Via Mincio on the West and Corso Lodi on the East represent borders between the identified area and other neighborhoods with different morpho-typological and functional characteristics. Through the historical cartography of Milan and historical urban planning tools (Prg 1953 and Prg 1980), it is visible that the development of the Study Area started during the second post-war period. With an initial mixed settlement (productive, commercial, and residential) and a further progressive replacement of the production destination with buildings for public services and for tertiary activities since the Sixties (Figure 3).



[SCh 1] Figure 1. Land Albedo and Permeability classification – Current State. Source: Authors' Elaboration.

[SCh 1] Figure 2. Localization of Public Buildings. Source: Authors' Elaboration

[SCh 1] Figure 3.. Main building destinations. Source: Authors' Elaboration on Comune di Milano Database

In the current configuration, a significant concentration of public services characterizes the area with the presence in contiguous blocks of schools, municipal offices, and sports facilities. In fact, in the area the following public services area localized: the headquarters of the Municipality 4, Headquarter of the Municipality of Milan, the Civic Theater "Della Quattordicesima", the Schools Marcello Candia, the Lombardini Middle School, the Regional School Office for Lombardy, the municipal swimming pool, the multifunctional structure Polo Ferrara are located (Figure 2). The forecasts for a new student housing of the Politecnico di Milano and the requalification of the municipal market (Mercato Piazza Ferrara) through the "Made in Corvetto" initiative (collaboration between Fondazione Cariplo, Comune di Milano, Fondazione Snam and other institutions) are also significant.
The Study Area covers a surface of about 23 ha (229.841 sqm). With respect to this surface, a taxonomy of the morpho-typological composition of the surfaces has been drawn up.
The applied taxonomy was derived from the Regional Territorial Database (DBTR, 2019) used for the classification of the territory of the Municipality of Milan. Since the database for the Municipality of Milan refers to the year 2012, changes have been made to the classification of the recently transformed/under transformation.

5. Definition of indicators and indices for the measurement and mitigation of environmental criticalities

5.1. Indicators and indices for the identification of environmental criticalities with impacts on Health

Among the several indicators for the measurement of the potential level of environmental stress of open spaces, this study has taken into consideration those that have directly referable to health and safety of local population (Table 1). In particular, the following indicators have been identified:

a) definition of the albedo values of the ground surfaces and of the building envelopes (vertical and horizontal surfaces);
b) qualification and quantification of the permeable and impermeable surfaces of open spaces;
c) shading provided by buildings;
d) air temperature and ground surfaces temperature;
e) soil permeability index;

[1] The public space is recognized as a key-factor in urban regeneration processes (Battisti, Mussinelli & Rigillo, 2020). Starting from this assumption, the research focuses on the analysis and the design proposal regarding systems of public spaces (SPS). SPS refers to a taxonomy of public spaces based on spatial and material characteristics (urban axis - streets, elevated roads, etc.; green spaces - gardens, parks and agricultural fringe areas).
[2] In particular, research PRIN 2015 "Adaptive design e innovazioni tecnologiche per la rigenerazione resiliente dei distretti urbani in regime di cambiamento climatico / Adaptive Design and Technological Innovations for the Resilient Regeneration of Urban Districts in Climate Change Regime". The scientific work was conducted by the following Research Units: Università degli Studi di Napoli Federico II (Principal Investigator and local coordinator Mario Losasso), Politecnico di Milano (local coordinator Elena Mussinelli), Sapienza Università di Roma (local coordinator Fabrizio Tucci), Università degli Studi della Campania Luigi Vanvitelli (local coordinator Renata Valente), Università degli Studi di Firenze (local coordinator Roberto Bologna), Università degli Studi Mediterranea di Reggio Calabria (local coordinator Maria Teresa Lucarelli).
[3] The Municipality of Milan, in occasion of the construction of the new Municipal Office in via Sile, has launched a program of interventions for the improvement of urban quality of public spaces. For more information, see: https://www.comune.milano.it/-/via-sile.-aprono-i-nuovi-uffici-comunali-al-corvetto

f) vehicular flows per hour;
g) pedestrian flows per hour;
h) average concentration of pollutants;
i) type and the age of tree species.

The measurement of indicators a), b), c) and d) is necessary for the definition of the indices related to the so-called "perceived temperature" during summer. The reduction of the values of these indices implies greater well-being for the population. In particular, the indicator c) is relevant to understand which portions of public space are shaded during the hottest hours in the summer. The measurement of the indicator e) is not particularly relevant for the Study Area, due to the fact that the South-East sector of Milan, where the Study Area is located, is usually not affected by flooding and other problems related to the management of rain water during acute wheatear phenomena. Indicators f) and g) evaluate potential negative mixtures between vehicular and pedestrian paths (Table 2). The measurement of the indicator h), together with the analysis of the data on air pollutants concentrations by the Regional Environment Agency, was necessary to assess the quality of the air at the local level (neighborhood, blocks, and streets). The measurement of the indicator i) allow verifying the potential emission of Volatile Organic Compounds (VOC) by the existing trees. This study did not take into consideration the plant species (grasses and small shrubs) existing in the meadows, potentially allergenic for the human and animal population. With reference to the measurement of the perceived temperature indices, since the operation required complex processing, they have been calculated, in the current and project state, only for a portion of the Study Area.

[SCh 1] Table 1. Indicators/Indexes and Health and Safety Impacts. Source: Authors' Elaboration

Analysis	Indicators	Index	Health and Safety Impacts
Materic Surface Quantification and Qualification, Building Heights	Albedo values quantification	PMV - UTCI-HUMIDEX INDEX	Health Diseases due to Exposure to Extreme Heat
	Measured facade Temperature		
	Shadow casted on public surfaces (streets, square, etc.)		
Data derived from Existing DB	Land Surface Temperature		
	Permeability Quantification and Qualification	Run-off index	safety during severe Stormwater
Vehicular flows, Streets dimensions	number of vehicles per hour	AIR QUALITY INDEX	Health Diseases due to Air Pollutants Exposure, Noise Pollutants Exposure
Pedestrian flows, Walksides dimensions and accessibility	number of pedestrians per hour		
Green Areas Quantification and Qualification	Trees VOC Emission	-	Health Diseases due to VOC Exposure
	Surface of Graminaceous plants and grasses	-	Diseases due to Graminaceous plants and grasses

[SCh 1] Table 2. Dangerous admixture between pedestrians and vehicular traffic in viale Brenta. Source: data collected by Authors through direct surveys on viale Brenta on the 29.04.2019

Time	Pedestrian		Vehicles	
7:30 AM to 9:30 AM	1697		2100	
	North side	South side	North side	South side
	85%	15%	50%	50%
5:30 PM to 7:30 PM	1845		2350	
	North side	South side	North side	South side
	80%	20%	60%	40%

[SCh 1] Table 3. Ecosystem Services Provided by NBS and SNE and Impacts on Health and Safety. Source: Authors' Elaboration

NBS Typologies	Regulation ES provided	Wellbeing ES provided	Socio-Cultural ES provided	Health and Safety impacts
Green Areas (meadows)	Albedo reduction, runoff reduction, air pollutants reduction, Land Surface Temperature, PMV-UTCI HI reduction, AIR QUALITY improvement	physical outdoor activity, reduced depression and anxiety, recovery from stress, positive emotions, enhance of sense of safety		HEALTHY AND SAFETY ENVIRONMENTS
Number and Trees Classification				
Biobasin and Bioswales				
Seminatural Solutions				
High-reflective Pavements	Albedo reduction, runoff reduction, air pollutants reduction, Land Surface Temperature, PMV-UTCI HI reduction	community cohesion and increase of visitors	quality of path, connectivity and linkage with other modes, walking and cycling increase	
Permeable Pavements				

With regard to the design choices for green infrastructure of public space using NBS and semi natural elements (SNE), the considered indicators/indices, mainly related to the measurement of the regulation ecosystem services (ES) (Table 3), are:

A. Increase of albedo values through the replacement of pavement materials;
B. Increase of shaded surfaces through tree planting (tree crowns);
C. Increase in the permeability index;
D. Reduction in absolute value of air pollutants.

6. Site analysis according to the selected indicators

1.a Built environment

The building footprint on the ground is almost 31% of the Study Area overall surface, while the open space is under 69% of the overall surface (Figure 4).

1.b Open spaces – taxonomy and quantification

The open space was also classified according to public and private ownership. The surface of open spaces in the Study Area consists of 15 hectares, of which the 78% publicly owned.With reference to the public spaces, almost half (55%) is devoted to the road and pedestrian system, the 17% to green areas and the 21% to access systems and courtyard areas serving the existing public buildings. The remaining 9% of public spaces is represented by a free area, still without a definitive destination (Figure 5)

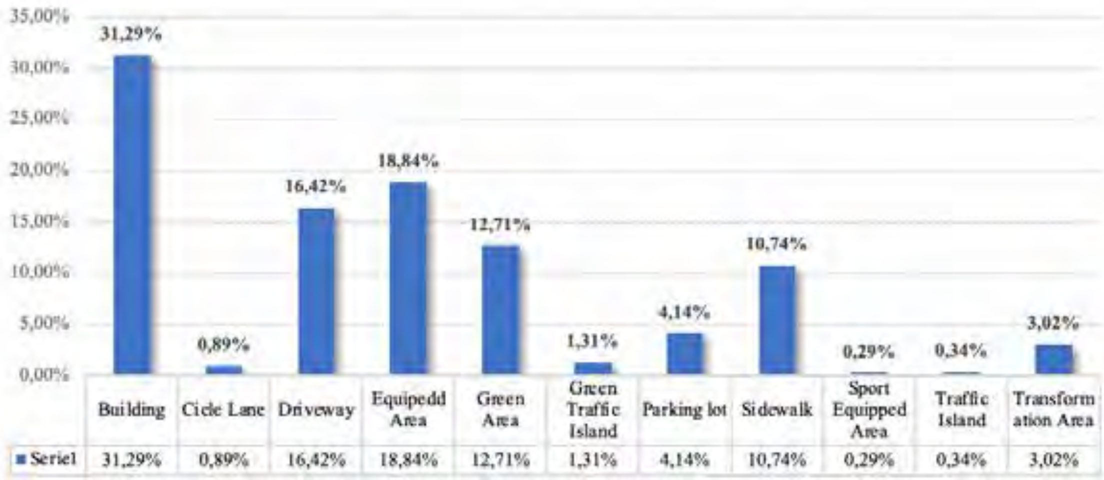
1.c Open space - Spatial and environmental analysis

Particular attention was paid to the accessibility and usability of the public green areas, which represent the outdoor places where commonly physical activity is mostly carried out.
According to the conducted analysis, it emerged that all the gardens belonging to public buildings are fenced and not usable for outdoor activities. Furthermore, two thirds of these are pertinent to sensitive public functions (e.g., schools and elderly house). With reference to the additional public open spaces such as by the driveways and sidewalks, three types of analyzes were developed.

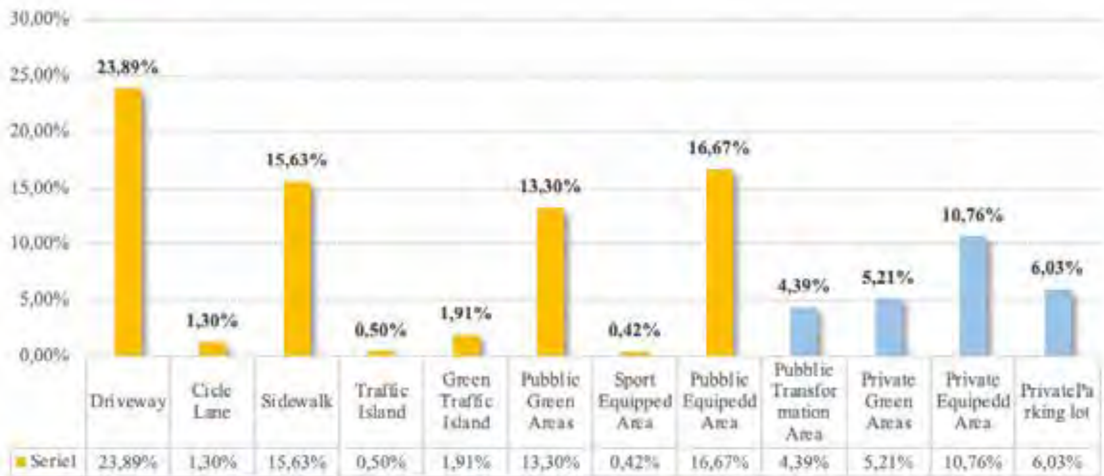
The first concerned the material consistency (albedo) and the permeability of the surfaces. The outcome of this analysis highlighted that the surfaces with albedo included in the value ranges between 0.04-0.12 represent the 68%, those between 0.13-0.25 the 27% and those between 0.26-0.55 the 4% of the total surface[4]. Moreover the 83% of the surfaces is not permeable[5].

[4] The albedo analysis was conducted elaborating Comune di Milano Database with a classification of the ground surfaces according to three thresholds of albedo values related to the superficial materials.
[5] The permeability was conducted elaborating Comune di Milano Database with a classification of the ground surfaces according to the three levels: not permeable, semi-permeable, permeable.

[SCh 1] Figure 4. Land use Classification and Quantification. Source: Authors' Elaboration based on the Comune di Milano Database



[SCh 1] Figure 5. Quantification and Qualification of the Public and Private Surfaces. Source: Authors' Elaboration based on the Comune di Milano Database



[SCh 1] Figure 6. Existing Deciduous and Evergreen Trees. Source: Authors' Elaboration based on the Comune di Milano Database

The second analysis concerned the vehicular capacity of the roads[6]. The data by the PUMS were also corroborated by on-site surveys carried out in 2019 that for example in the street that defines the North limit of the area stressed the passage during the rush hours of approximately 2.100 vehicles and 1.700 pedestrians per hour. The pedestrian traffic flows to the public transport hubs in the Study Area were also analyzed.
The third concerned the amount of shading on the surfaces of public open spaces during the summer period[7].

Environmental analysis - trees
Trees were surveyed on all public open spaces (map of the green heritage of the Municipality of Milan, 2019). In Study Area, about 43% of the trees are localized along two major streets that define the East and South sides of the area. The remaining trees (including the 19 evergreen species) are planted in green areas located near public buildings (Figure 6 and Table 4). The conducted analyzes on the public open spaces enhanced the construction of the cognitive framework of the potential critical issues regarding the urban microclimate, air quality and rainwater management.

7. Design Proposal based on the adoption of NBSs and GIs to improve the environmental quality of public space and predictive assessment of the benefits generated

The proposed green infrastructure of the Study Area, in coherence with the first hypothesis pointed out by the municipality, involved most of the streets and the large municipal area, located in the central block, through the planting of new trees.
Two internal streets have been redesigned for mainly pedestrian functionality. Two parking lots guarantee the possibility of parking cars: one private for public use (a market parking at the North East of the area, the other public, located at the South East. The new trees are planted between the driveways and the walkways. Moreover, the new trees along the roads are protected at the base with cast iron closures (tree pits). In the street on the North side (viale Brenta), in addition to the planting of trees, a hedge system is planned to protect the cycle lane located between the roadways. As regards the vacant area, a high-density tree plant system is forecasted, in line with planting practices already present in other parks in the city of Milan.
In total, the pilot project envisaged the planting of about 370 new trees, of which about 270 on public roads and about 100 for the construction of the park.

The projects doubles the arboreal heritage of the Study Area.
In addition to tree planting, bio-basins for infiltration and retention of rainwater coming from walkways and driveways (feature areas) were planned. The planting of shrubs able to withstand both long periods of drought and submersion during acute rainy phenomena has also made it possible to improve the interception of air pollutants at road level, to increase the flora and fauna biodiversity, to increase the quantity of CO2 absorbed and sequestrated as well as to improve the aesthetic quality of the streets.
Furthermore, other technological solutions were used to improve the environmental quality of the Study Area. With references to the paved surfaces of public streets, materials with high reflectance and permeability index (pervious concrete) have been designed. In addition, in the buffer area between the new headquarters of the Comune di Milano, a water blade has been provided with the function of a misting fountain capable of mitigate temperatures during the hottest hours of the summer.
The measurements of the benefits deriving from the use of NBS and GI were developed with respect to the main regulation ES (Tables 5 and 6). Of course, for better understanding and predictive ability further additional indicators and index could be implemented.

[6] Data deriving from PUMS 2019.
[7] Analysis conducted with Archicad software set on 21 July at 4:00 pm.

[SCh 1] Table 5. Tree Planting. Indicators and values for ES quantification. Source: Authors' Elaboration

Project site Location					ES Regulation Indicators									
					Energy Saving		Pollutants Removal					Climate change effects reduction	Rainwater Management	
	Project Location	Number	Tree feature	VOC emission	Energy Saving KWh (*)		Pollutants Removal (**)					CO2 (***)	Rainwater Canopy Interception (****)	
U.M.		Nr.	m		KWh/ tree *year	KWh/tree *year	KWh/tree*year				Kg CO2eq.* tree/year	Kg CO2eq.* tree/ year	l/* tree/ year	KgCO2eq./ mc* year
			Tree height when planted				O3	PM10	SO2	NO2	Co2eq	assimilated		
Celtis Australis	Viale brenta-	36	8/10	Low	136	66,4904	0,13	0,143	0,265	0,186	55,428	325	2150	0,5418
Liquidambar styraciflua	Via Oglio	89	8/10	Low-medium	136	66,4904	0,13	0,127	0,35	0,11	32,78	320	1450	0,3654
Tilia cordata	Parco Comunale	98	4-6	Low	136	66,4904	0,3	0,152	0,32	0,11	32,78	231	2000	0,504
Pyrus calleryana	Via Sile-GamboloParkingMarket viale Brenta corso Lodi	111	4-6	Low-medium	67	32,7563	0,05	0,05	0,1	0,05	14,9	84	200	0,0504
Prunus CerasiFERA Pissardil	Parking via Sile	39	4-6	Low	67	32,7563	0,05	0,05	0,1	0,05	14,9	77	200	0,0504
Photinia red Robin	Viale Brenta	80	1,8	Low			0,08	0,05	0,1	0,09	26,82	23		
(*)	Values defined from Scientific Leterature (CNT, 2010, McPherson E., et Al., 2006).CO2eq production value. per KWh produced it is assumed to be 0.4889 Kg (ISPRA 2017)													
(**)	The unit values were taken from the qualiviva database and from the simulation made with the I-Tree eco v.6 software on the project area. For the determination of the CO2 equivalent, the assumed value is 298 Kg of CO2 eq. per kg of NO2 removed (IPCC, 2007)													
(***)	The unit values of CO2eq per year were taken from the qualiviva database and averaged from past simulations made with the I-Tree eco v.6 software on the project area													
(****)	The unit values were taken from the simulation made with the I-Tree eco v.6 software on the project area and reported to the average ten-year rainfall (1086 mm of rain / year) measured by the ARPA control unit via Juvara, Milan station ID 502 . For the calculation of the CO2 equivalent, the value of 0.252 Kg / mc * year was taken from the analysis of the carbon footprint of the company CAP Holding SPA for the years 2016 and 2017 (CAP Holding, environmental balance), referring to the activity rainwater treatment (networks and purifiers).													

[SCh 1] Table 6. Bioswales-Grass-Meadows and Semi-permeable surface. Indicators and values for ES quantification. Source: Authors' Elaboration

Project site Location				ES Regulation Indicators							
	Surface	Location	Typology	Pollutants Removal					Climate change effects reduction	Rainwater Management	
U.M.	mq			KWh/tree*year				Kg CO2eq.* tree/year	Kg CO2eq.* tree/year	l/* mq/year	KgCO2eq./ mc*year
				O3	PM10	SO2	NO2	CO2eq avoided	CO2 Assimilated	average rainfall * coeff. runoff	CO2eq avoided
Bioswales	2550	Viale Brenta- Vie Oglio-Sile-Gambolota-Polesine	depression consisting of grassing and planting of small and medium-sized carpeting shrubs resistant to periods of drought and temporary flooding	0,004492	0,0006490	0,001982	0,002329	0,694042	0,25	1016	0,256032
Grass and meadow	6785	New designed Park	Grass and Meadow	0,002871	0,0005570	0,001118	0,001465	0,43657	0,16	1016	0,256032
Semi-permeable Surface	24327	Viale Brenta- Vie Oglio-Sile-Gambolota-Polesine	Streets-Walkside							304,8	0,0768096
(*)	Values taken from scientific literature (CNT, 2010; McPherson et al., 2005) for the type of bio-basin planted with small and medium-sized shrubs. For the determination of the CO2 equivalent, the assumed value is 298 Kg of CO2 eq. per kg of NO2 removed (IPCC,2007)										
(**)	The unit values were deduced with respect to the average ten-year rainfall (1086 mm of rain / year) measured by the ARPA control unit via Juvara, Milan station ID 502 and a prudentially set runoff coefficient equal to 0.8. For the calculation of the CO2 equivalent, the value of 0.252 Kg / mc * year was taken from the analysis of the carbon footprint of the company CAP Holding SPA for the years 2016 and 2017 (CAP Holding, environmental balance), referring to the rainwater treatment (networks and purifiers).										

8. Evaluation of the results

8.1 Improvement of urban microclimate - Reduction of the effects of albedo - Increase in permeability and shading of surfaces

With respect to the pilot project, the surfaces subject to material replacement and albedo variation were measured. In the current state, the surfaces with albedo included in the value ranges between 0.04-0.12 represent the 68%, those between 0.13-0.25 the 27% and those between 0.26-0.55 the 4% of the total surface of the Study Area. The use of high-reflectance surfaces (albedo between 0.26-0.55) for the reconstruction of the pavement and roads (viale Brenta, via Oglio, Via Sile and via Polesine) and of the two parking lots has resulted in a greater reflective surface (+13%) (Figures 7, 9 and 10).
The replacement of these surfaces with semi-permeable pavements (sidewalks, roads and parking lots), new trees and grassy areas (new park and bio-basins) has considerably increased the percentage of rainwater drainage on the Study Area (Figure 8, Tables 7 and 8). The study included the quantification of the number of liters infiltrated into the soil and the amount of avoided CO2 emissions (CO2eq) into the atmosphere due to minor use of the sewage and rainwater purification system on the basis of the annual precipitation media. (Table 8).

The planting of tree species on the selected streets, as well as the forestation of the municipal area included in the block made it possible to implement the amount of shade produced by the trees during the summer phase. The ability to mitigate the temperature of the air and of the surfaces due to shading was considered in the time interval of 25 years (Figure 11), the time necessary for the trees to reach maturity.

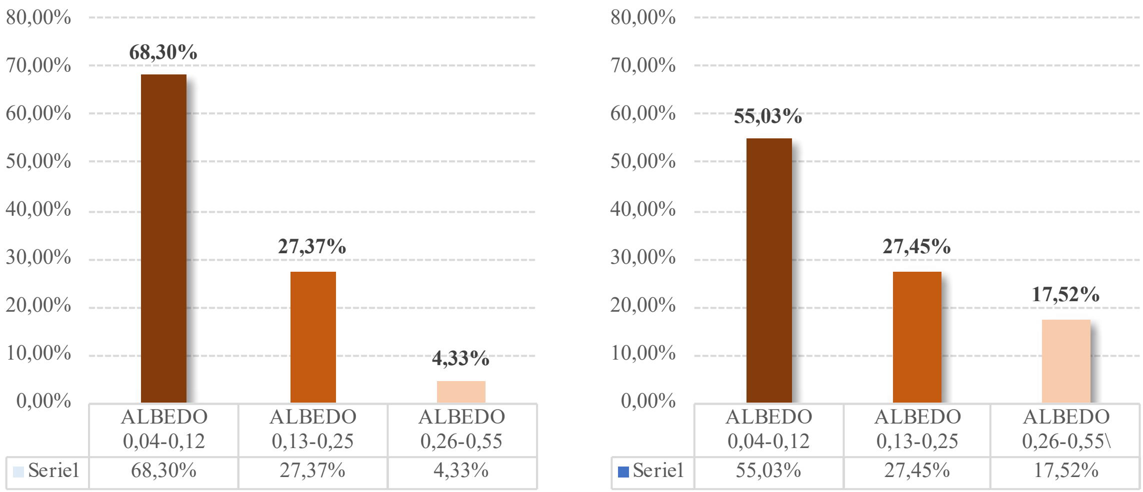
8.2 Improvement of the urban microclimate - Measurement of perceived temperature indices

The evaluation of this environmental aspect concerned only an in-depth study on one East West street (viale Brenta).
The first adopted methodology aimed at the simulation of the urban microclimate was used to understand the effects of the urban heat island on this axis.
The methodology for determining the benefits generated by the green infrastructure with reference to the actions aimed at facing the UHI, was based on the different measurements between the current state and the project state of the Ta (Air temperature), Hr (Humidity ratio) indicators and the thermal comfort Universal Climate Thermal Index (UCTI).
The ENVI-Met software (version 4.4) was used for the elaboration of the modeling of the area (current and project status) as well as for the measurement of the indicators and indices described above.
The measurement of the PMV (Predicted Mean Vote) and UTCI indices was carried out by setting, as input data, the biophysical parameters of the people as follows: age 65, male sex, weight 75 Kg, height 1.75 m, static isolation of the clothes (Static Clothing Insulation, CLO): 0.20, walking speed 1.0 m/s. The indicators and indices were calculated and measured in the hottest hours of the day 21.06.2018 (from 14:00 to 18:00) (Figures 12 and 13).

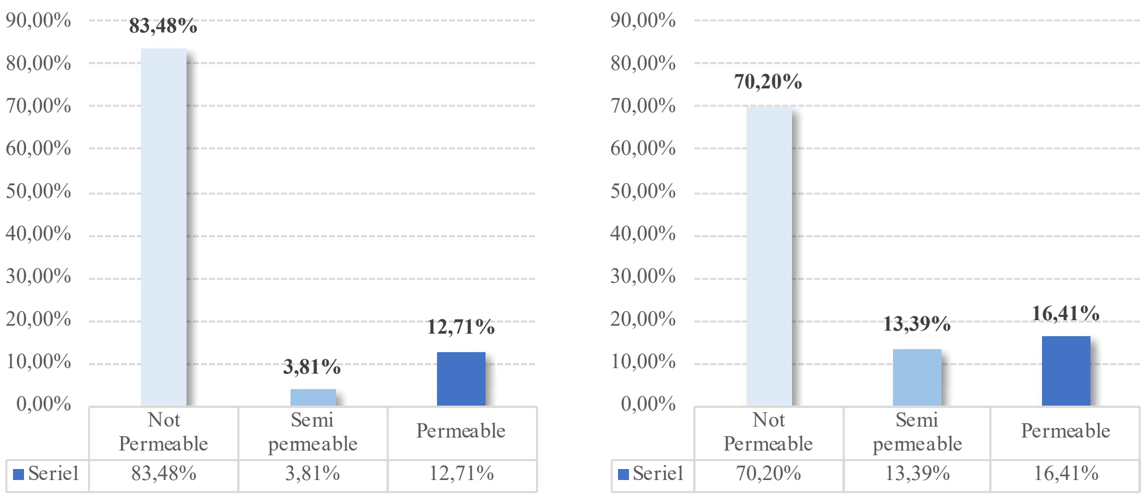
8.3 Air pollutants removal

The quantification of air pollutants removed was calculated by applying the UFORE (Urban Forest Effects) model to the new plantations planned on the Study Area.
Through the use of the I-Tree software (I-Tree Version 6.1.37) and of the table information (Qualiviva Database, 2015) it was possible to define, with respect to the planned NBS, the removal (kg/year) of the major air pollutants (Table 9) generally investigated as causes of disease.

[SCh 1] Figure 7. Albedo Classification and Quantification in Current State (Left) and in the Project State (Right). Source: Authors' Elaboration



[SCh 1] Figure 8. Permeability Classification and Quantification in the Current State (Left) and Project State (Right). Source: Authors' Elaboration



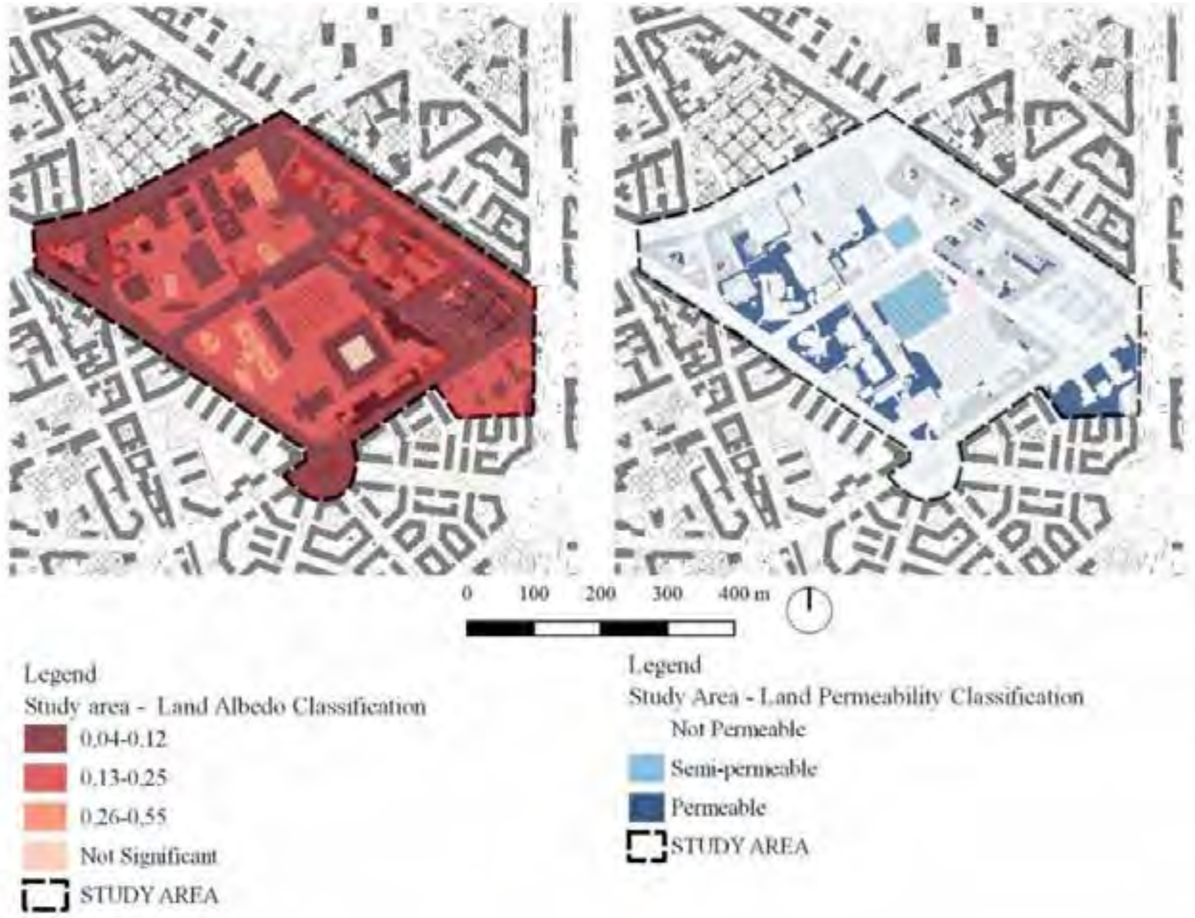
[SCh 1] Table 7. Run-off Calculation related to Tree Planting. Source: Authors' Elaboration

Tree planting. Sustainable Rainwater Management - Run-off Calculation					
		Run-off through crowns of trees		Avoided emission of CO2 (CO2 eq.)	
		l/ anno*tree	l/year	KgCO2eq./ tree*year	KgCO2eq./year
Celtis Australis	36	2150	77400	0,5418	19,5048
Liquidambar styraciflua	89	1450	129050	0,3654	32,5206
Tilia Cordata	98	2000	196000	0,1575	15,435
Pyrus calleryana	111	200	22200	0,0504	5,5944
Prunus Cerasifera Pissardii	39	200	7800	0,504	19,656
TOTAL	**373**		**432.450**		**92,7108**

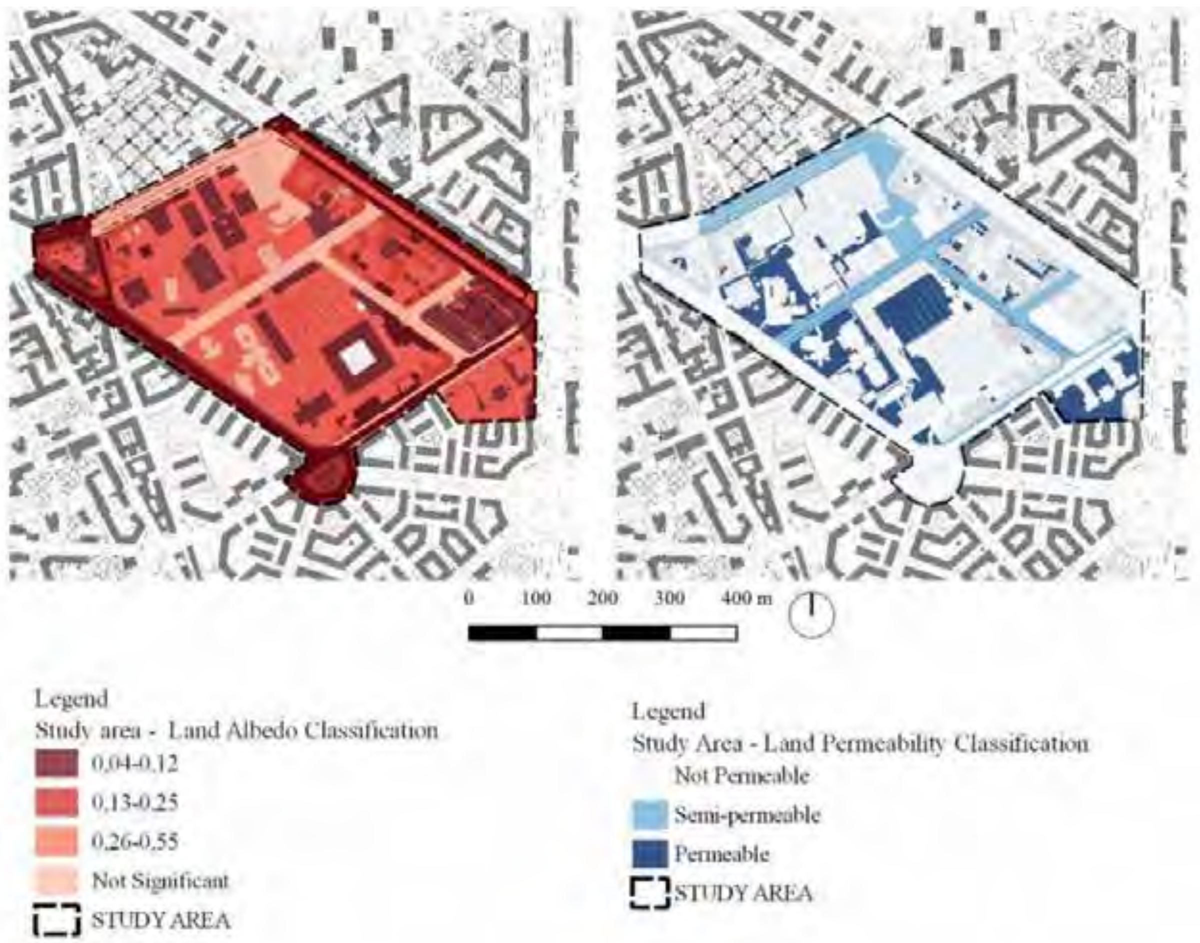
[SCh 1] Table 8. Run-off Calculation related to Rainwater Sustainable Management. Source: Authors' Elaboration

Sustainable Rainwater Management - Run-off Calculation					
			mm/year	l/year	KgCO2eq
		run-off index (*)	Mean Annual Rainfall	l/intercepted	CO2eq avoided
Bioswales	2550	1	1013	2583150	650,9538
Grass and meadow	6785	1	1013	6873205	1732,04766
Semi permeable surface streets	13269	0,3	1013	4032449,1	1016,177173
Semi permeable surface walkside	11058	0,3	1013	3360526,2	846,8526024
Tot surface in study area	**33.662**			**16.849.330,3**	**4.246,031236**

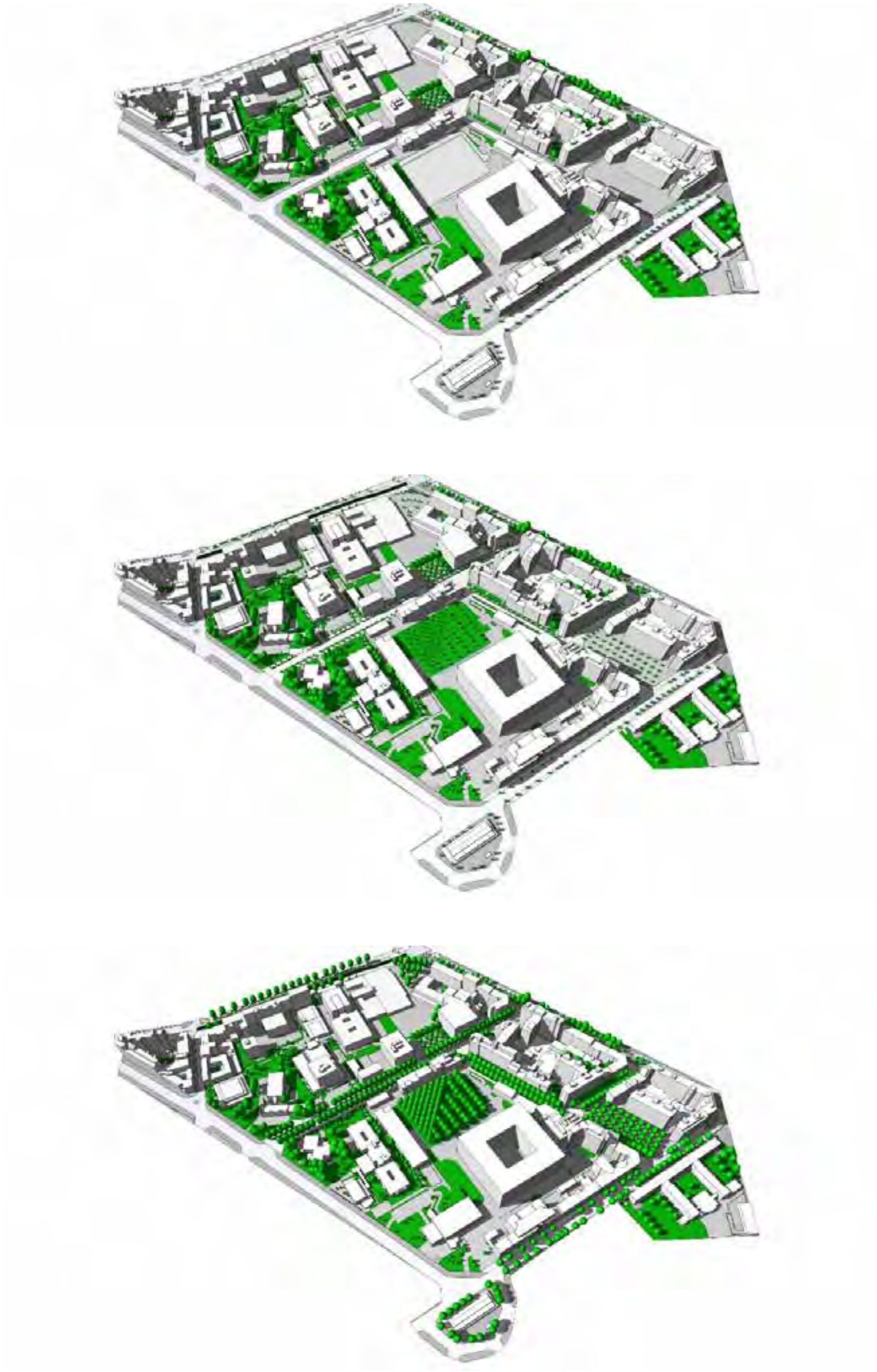
[SCh 1] Figure 9. Land Albedo and Permeability classification – Current State. Source: Authors' Elaboration



[SCh 1] Figure 10. Land Albedo and Permeability classification – Project State. Source: Authors' Elaboration



[SCh 1] Figure 11. Arboreal Heritage in the Study Area in the Current Status (A), in the Project Status at T=0 years (B) and in the Project Status at T=25 years (C). Source: Authors' Elaboration



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The measurement of the PMV (Predicted Mean Vote) and UTCI indices was carried out by setting, as input data, the biophysical parameters of the people as follows: age 65, male sex, weight 75 Kg, height 1.75 m, static isolation of the clothes (Static Clothing Insulation, CLO): 0.20, walking speed 1.0 m/s. The indicators and indices were calculated and measured in the hottest hours of the day 21.06.2018 (from 14:00 to 18:00) (Figures 12 and 13).

[SCh 1] Figure 12. UTCI Simulation of the Current Status at 16.00 pm of 21.06.2018. Source: Authors' Elaboration – ENVIMET Simulation

[SCh 1] Figure 13. UTCI Simulation of the Project Status at 16.00 pm of 21.06.2018. Source: Authors' Elaboration – ENVIMET Simulation

[SCh 1] Table 9. Removal of Air Pollutants through Tree Planting. Source: Authors' Elaboration

Tree planting. Removal of Air Pollutants										
	Nr.	Pollutant removed per unit								CO2eq
		O3		PM10		SO2		NO2		298 Kg CO2/Kg NO2
		Kg/tree*year	Kg/year	Kg/tree*year	Kg/year	Kg/tree*year	Kg/year	Kg/tree*year	Kg/year	Kg CO2eq/year
Celtis Australis	36	0,130	4,68	0,143	5,148	0,265	9,540	0,186	6,696	1995,408
Liquidambar styraciflua	89	0,13	11,57	0,127	11,303	0,35	31,150	0,11	9,790	2917,420
Tilia Cordata	98	0,3	4,9	0,152	14,896	0,32	31,360	0,11	10,780	3212,440
Pyrus calleryana	111	0,05	14,43	0,05	5,550	0,1	11,100	0,05	5,550	1653,900
Prunus Cerasifera Pissardii	39	0,05	11,7	0,05	1,950	0,1	3,900	0,05	1,950	581,100
TOTAL	373		47,280		38,847		87,050		34,766	10.360,268

9. Conclusions

The paper presents the first outcomes of applied research consisting in a design-based experimentation, investigating the relationship between some solutions for the implementation of urban resilience and the health and safety of population. Each NBS provide specific Ecosystem services (regulation, socio-cultural, etc.) that impact on urban environment and thus on health. The applied methodology reveals the importance of site-specific analysis and site-specific design solutions. Indeed, it should be noted that the impact of design solutions on environment and health can significantly vary, due to specific local conditions, at the micro-scale. It is therefore necessary to integrate predictive tools in the design process in order to optimize the impacts of transformations with respect to the real problems encountered not only at the territorial level where policies pay more attentions. The predictive tools that implies simulations at the micro-scale are in these terms particularly important, helping designers and decision-makers in optimizing the solutions, overpassing only quantitative approach and supporting site-specific approaches. Therefore, guidelines promoted by local authorities for interventions on urban open spaces, based on a site-specific design approach that include predictive assessments, would be particularly important in order to foster a virtuous process of regeneration of urban contexts.

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