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12





ficha técnica

Título | Serial title

A OBRA NASCE
revista de Arquitetura e Urbanismo
da Universidade Fernando Pessoa
nº12, dezembro de 2017

Edição | Publisher

edições Universidade Fernando Pessoa
Praça 9 de Abril, 349 | 4249-004 Porto
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edicoes@ufp.pt | www.ufp.pt

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Oficina Gráfica da Universidade Fernando Pessoa

ISSN

2183-427X

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Reflexive City: use of rainwater to improve the technological quality of urban open spaces

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ABSTRACT

This contribution presents the results of a complex interdisciplinary research on the theme of the “reflexive city”, which interacts emotionally with its inhabitants and makes readable and understandable the archetypes of public space. It is a technological reading, aimed to offer a methodological approach for the meta-design phase of the transformation process in a historical context. Via Sopramuro in Pendino neighbourhood in Naples is the case of study. In this urban area, the eco-oriented analyses, carried out according to the RURDS method, show that it is a strategic place to preserve the historical market activities, improving environmental quality with an appropriate technological design as added value. It follows the sustainable design principles especially related to the water sources saving, as a part of a most complex urban design integrating strategies in order to improve the visual quality of this urban space. The expected result is not only the design response in a technological key, but the hypothesis of reproducibility and adaptability of this model to urban transformation process also to other sites in the Mediterranean area.

Keywords:

Technological design, Harvesting rainwater, Saving resources, Urban open spaces, RURDS method.

**1. INTRODUCTION: URBAN AND HUMAN
SCENARIOS** [ANTONELLA VIOLANO]

The Vitruvian conception of city as a “defined and circumscribed place” is overcome by the present urban situations that are scattered and decentralized, burdened by often antithetical and conflictual situations, with an urban pattern that shows signs of an invasive, intensive and at times disordered soil use, to the limits of legality. Security, well-being, living and environmental protection are the fundamental needs that the actual construction and urban redevelopment strategies seek to answer.

This paper presents the results of a complex interdisciplinary research on the theme of the “*reflexive city*”, which interacts emotionally with its inhabitants and makes readable and understandable the archetypes of public space, transforming the concept of usability into living.

The methodological approach is based on the link between constructed fabric shapes and daily human stories, analyzed according to three dimensional reference scales: space, time and users. Space is observed at the urban scale, the unit of measure is the Urban Quality and the goal is to re-convert the function in order to create positive self-generated growth processes. Time helps the design approach, giving a rhythm to alternating urban and human scenarios and recording the sequence of the process of transformation. Direct users, the citizens who live these places daily, are the true measure of metamorphosis of urban quality... from below, from within!

The technological design of a rainwater recovery infrastructure for road washing dynamically integrates the three variables: space, time and users and it has the purpose to meet specific social needs (urban area enhancement) through a technological project that has scientific foundations.

The design experimentation concerns Via Sopramuro (Pendino district in the south-east of Naples). The water resource has always been a peculiarity of this area because it defines the configuration of the historical road map coinciding with the natural flow of water from the



Fig.1. The three dimensional reference scales of the methodological approach. Source: A. Violano.

Capodimonte hills to the sea. In this project, rainfalls take the form of water ripples flowing along the facades of the buildings, giving a creative order to the visual image of the curtain road and collecting the volume of water coming from the roofs, conveying it into special tanks allocated to the underfloor. The collected water is enough for the washing of the road, which thanks to the double slope of the sidewalks, guarantees its outflow.

2. METHODOLOGY AND PHASES

From a methodological point of view, climate analysis is a prerequisite for assessing the comfort conditions of open spaces, here made using the scientific method "Redisco-

vering the Urban Realm and Open Spaces" (RUROS)¹; it highlights the propensity of public and semi-public spaces in order to create attraction sites. Social analysis, which simultaneously studies the typology of human activity in the area, focalizes dynamics of fruition and categories of users involved in the transformation, divided by type of users [direct and indirect] and time slots [day and night].

Research has shown that the intrinsic value of the area is indissolubly tied to the type of present commercial activity

¹ RUROS research published the results of an extended survey in seven European cities, Athens (GR), Thessaloniki (GR), Milan (IT), Friborg (CH), Kassel (D), Cambridge (UK) and Sheffield (UK), with the aim of identifying the relationship between climatic factors and comfort indices in open space, in terms of thermal user satisfaction (ASV), and providing the designer with simpler complex assessment models. Cfr. http://cordis.europa.eu/project/rcn/54204_it.html.

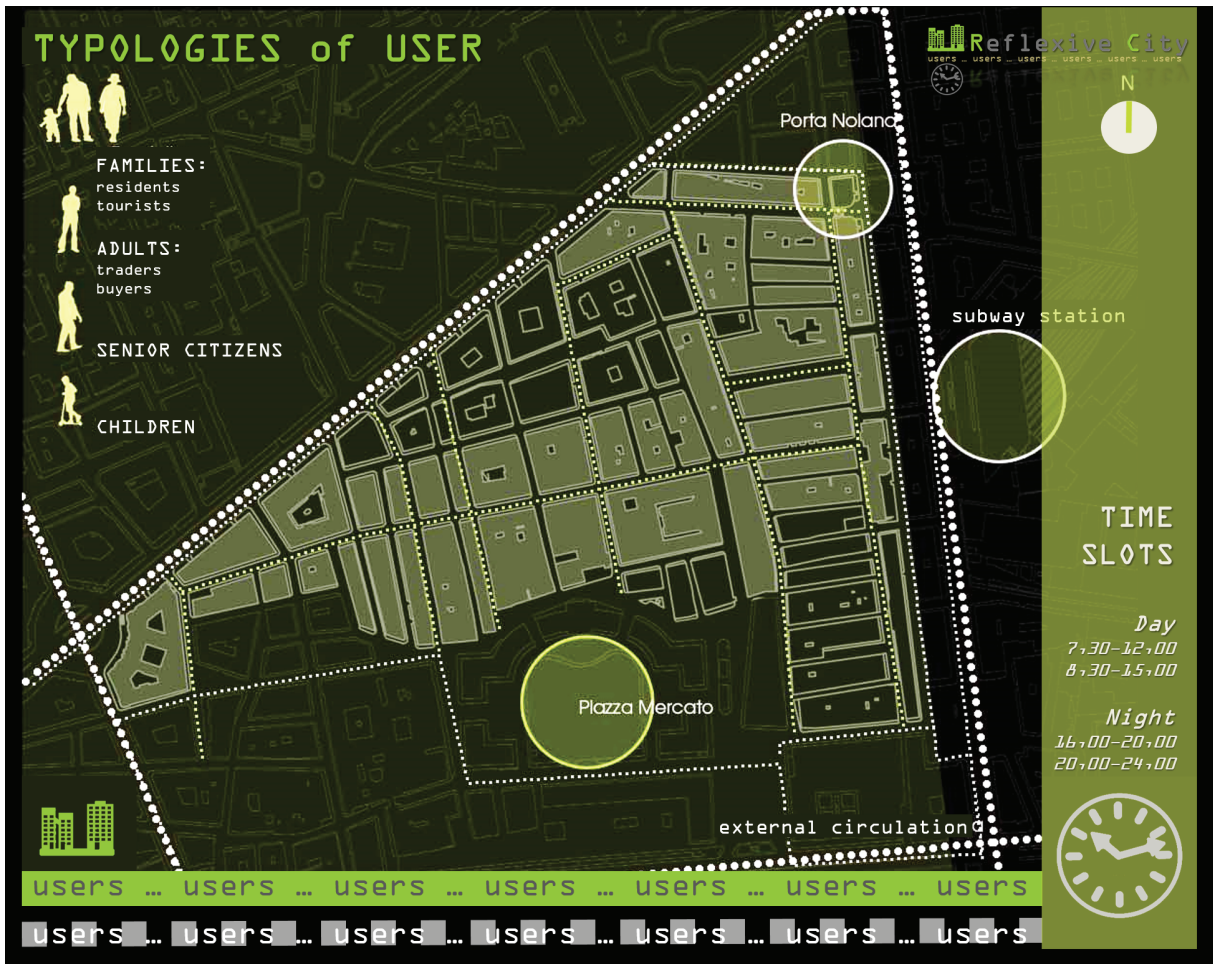


Fig.2: The Reflexive City. Source: A. Violano.

and less to the enjoyment of a specific type of user, as the carried out activities are an attraction for all types of users.

The approach to transformation, in a historically urban context, identifies in the first phase the peculiar features of the site in terms of potentialities and deficiencies. In the specific case, the relevant identified factors are *Complexity*, *Heterogeneity* and *Proximity*. The second phase has defined the assessment of comfort condition of open space and the most effective and shared transformation strategy, which maximizes the functional, perceptual and environmental integration of the intervention, already in the stages of implementation. In the third phase, the actions to be undertaken to accomplish the entire process of transformation are operationally structured: infrastructure realization, recovery of water resources, restitution of the perceptive

decorum of the curtain road, triggering processes of social identity and participation.

The expected result is not only the technological solution, but the hypothesis of reproducibility and adaptability of this model to urban transformation processes in other similar contexts.

Below, the outcomes of comfort evaluation of open spaces (second phase) with the RUIROS Method and design proposal (third phase), which interprets the needs through efficient performance, are described.



Fig.3: The urban context. Source: A. Violano & M. Buanne.

3. ASSESSMENT OF COMFORT PARAMETERS

[ANTONELLA VIOLANO]

The urban renewal process, driven by the development and improvement of socio-cultural, environmental and economic relations/synergies, requires refinement of data analysis and tools based on increasingly complex and transdisciplinary principles and methods. In fact, it is not possible to identify the eco-sustainability indicators of processing operations differently.

With the support of scientifically tested control tools, it is possible to verify the direct correlation between techniques, processes of transformation and environmental contexts, especially in areas characterized by increasing ecosystem and social degradation processes, in order to control the overall quality of urban transformation works.

The current need is to promote actions aimed at not only mitigating negative impacts, but also enhancing the

adaptive capacity of systems, which must be self-balanced, with least risk and cost, without ever exceeding the intrinsic resilience threshold.

The scientific work conducted on the topic of "reflexive city" has guided design towards the reconquest of areas that are rich of identitarian characteristics, where the designer needs to know, in order to be able to manage/govern the conversion without compromising the essence, the intrinsic value. *"Nothing old is ever reborn, but it never really disappears either. And anything that has ever been always re-emerges in a new form."* (Aalto, 1921, p.69)

The elements characterizing and narrating urban life, frequencies, flows, rates of use, are all typical of the urban landscape with its colors, its typical atmosphere, its "ambiance". Therefore, Harvey's point of view is strongly shared when he says:

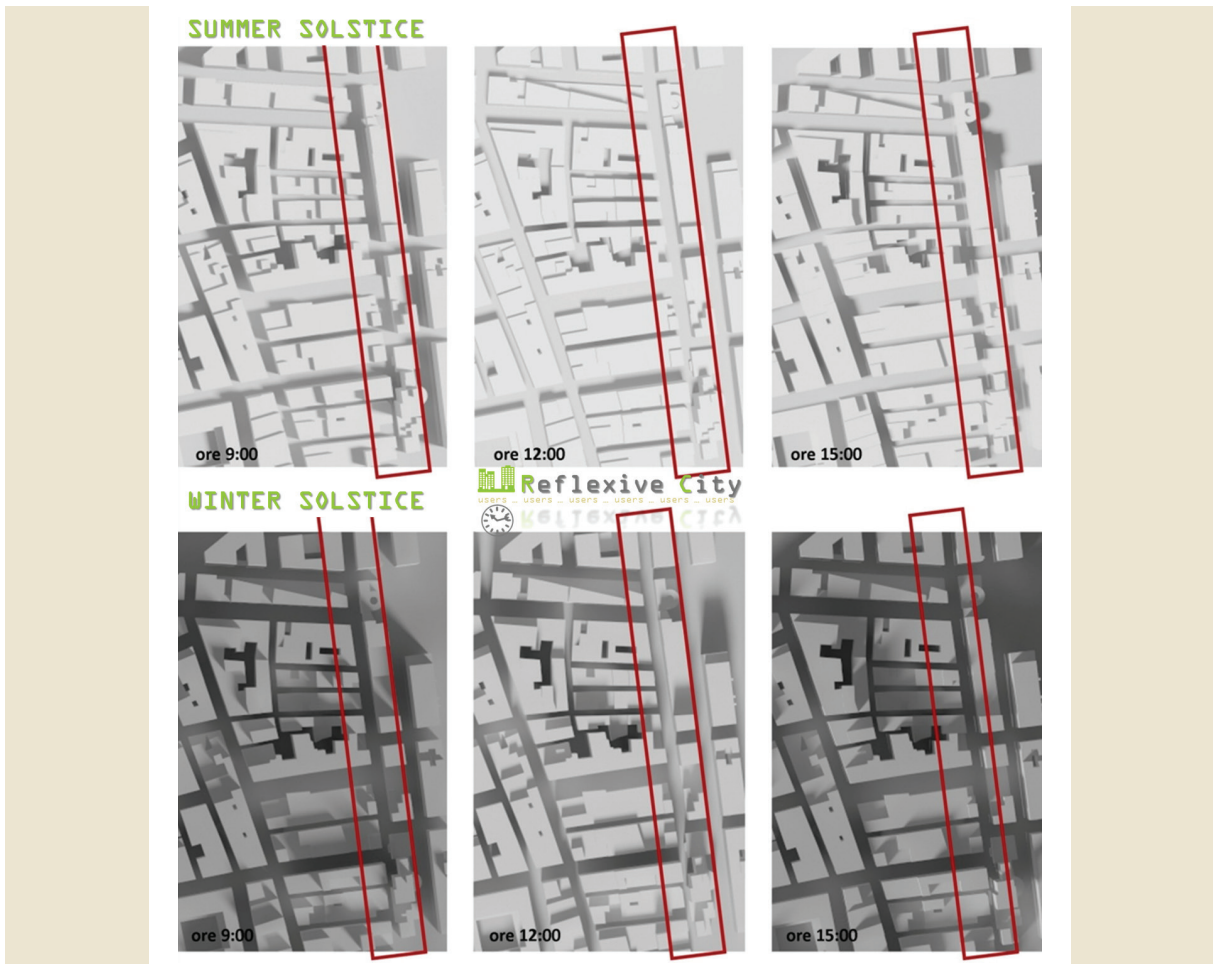


Fig.4: Shadows on Via Sopramuro on the days of the summer and winter solstice. Source: A. Violano & M. Buanne.

[...] a complex, labyrinthic and ever-transforming text as an urban space can not be read without ambiguity. It is susceptible to all interpretations and misunderstandings because the rules with which it is written can not be learned a priori but must be learned from the experience” (Harvey, 1989, p.233).

The “Urban Walking Tool” has been chosen in order to define the method of space experiential observation. It is a sensitive and sensory approach, made of smells, sounds, sensations, visual perceptions, emotional stimuli. Along Via Sopramuro, in the various hours of the day, urban rhythms, practical activities, space quality, rituals have been observed and recorded.

Experimental observations have been crossed with other technical parameters of the RUR05 Method. It assesses the comfort conditions of the open spaces with a multisensory

approach: not only limited to the bio-climatic control of the thermo-hygrometer factor, but oriented to assess the visual, acoustic, olfactory and tactile quality of the urban space.

The bioclimatic analysis of shading and natural ventilation, in the two seasons (summer and winter) and the two conditions (day and night), is the initial phase of the mapping. The morphology of the site determines thermo-hygrometric well-being conditions: air flow data [evaluated according to direction, frequency and speed] are crossed with data on direct sunlight [depending on the direction of the roads, but also from the relationship between the height of the buildings and their distance].

Cross-reading of the two factors allows us to assess the living conditions and the propensity to use the area,

analyzed on a seasonal and daily cycle. In this way, the risk that functional choices are incorrect is minimized, and the suitability/appropriateness of technology choices can be carefully evaluated by making the necessary changes before the project is implemented. The methodology is easily and effectively applicable to any urban site.

Relative to the perceived comfort, the bioclimatic Actual Sensation Vote (ASV) Index has combined four parameters: sky opening, continuity of the facade, visual complexity and number of buildings. The evaluation of the formal complexity of Via Sopramuro is aimed to identify the parameters: aspect, fruition and structure of the environmental system, by highlighting the peculiarities of the urban environment.

The first factor is the Visual Complexity that is *the measure of the abundance of formal elements present in the urban environment*, described by the multiplicity of components of which roads (insignia of various types, umbrellas, curtains, tubes, pumps, stalls, ...), facades of buildings (colors, materials, constructive elements, ...) and flooring (scheme, texture, materials) are made.

The second factor analyzed is the Sky View Factor (SVF) that is *the amount of sky visible in every significant*

urban perspective. Geometrically, it is defined by the three-dimensional measurement of the solid angle of the sky view from an urban space and determines the amount of solar (thermal and luminous) energy transmitted, absorbed and reflected, determining the radiative/thermal behavior of the urban environment. In Via Sopramuro, the view of the sky is quite small, being a small road (just over 6 meters, including sidewalks) flanked by tall buildings (on average 15 meters).

The third factor analyzes the Number of Buildings that is *the dimensional relationship between road width and height of buildings*.

It represents the apparent amount of visible buildings in a photograph. It is a simplified measure of the scale of the city and establishes the morphological relationship between horizontal and vertical boundaries that also determines in addition to physical flows (people, vehicles, etc.) all the radiative flows and convective (Rogora and Dessi, 2005, p.52).

According to this parameter, Via Sopramuro reflects the high density of housing that characterizes most of Naples' historic city center. The stratifications over the years have contributed to the degradation of this road, whose ratio of road width to average building height is 40% ($6/15 = 0,40$).



Fig.5: Visual Complexity and Sky View Factor. Source: R. Violano & M. Buanne.



Fig.6: Number of buildings and Continuity of the façade. Source: R. Violano & M. Buanne.

The fifth and last factor investigated is the Continuity of the façade: from the perceptual point of view it provides information on *the level of closure/opening of the urban space*; from the energy point of view, it indicates *the radiant exchange with the built* (parterre and facades), which can be considered a complementary parameter to the SVF.

Through the suggestions that came out during the research (inspired by bioclimatic principles) it is possible to modify the urban microclimate according to the morphology of the space and its activities. The identified criticalities can be corrected with appropriate and integrated design solutions.

In particular, Naples ("C" climatic zone) enjoys a typically Mediterranean climate, with mild and rainy winters and hot and dry summers, refreshed by the sea breeze. Because of its particular geomorphological conformation, the city records different local microclimate, with significant relative temperature and humidity variations. For this reason, the comfort analysis of Via Sopramuro was carried out with the data of the Military Air Force Military Service of Naples Capodichino Meteorological Station, which are most compatible with the real conditions of the study area.

The ASV calculation² (Tab. 1) shows that the comfort conditions of the area are discrete in all seasons except for the winter time where most users are in non-comfort conditions. (Tab. 2)

Tab.1: Average seasonal weather data for Naples Capodichino, useful for calculating the ASV.

SEASON	AIR TEMPERATURE Tair_met [°C]	SOLAR RADIATION Sol_met [W·m ⁻²]	WIND SPEED V_met [m·s ⁻¹]	RELATIVE HUMIDITY RH_met [%]	ASV
SPRING	14	211,3	2,9	71	-0.34
SUMMER	23	282,5	2,9	70	0.16
AUTUMN	18	138,3	2,2	74	-0.13
WINTER	19	78,1	2,2	75	-0.62
AVERAGE	16	177,55	2,55	73	

Source: M. Buanne.

² The calculation of the ASV, done by M. Buanne, develops the relationship between: mean value of the air temperature [Tair_met], mean value of the solar radiation [Sol_met], mean value of the wind speed [V_met] and average relative humidity [RH_met].

Tab.2: Percentage Values of Users in Comfort (ASV).

SEASON	ASV	COMFORT	PERCENTAGE
SPRING	-0.34	0.65	65%
SUMMER	0.16	0.78	78%
AUTUMN	-0.13	0.70	70%
WINTER	-0.62	0.49	49%

Source: M. Buanne.

In addition, Via Sopramuro's analysis showed a strong need for reuse of water resource for road cleaning, maintaining the area's characteristic feature of fish sales.

Starting from critical evaluations of the application of the RUIOS method to this urban space, the meta-design bases of the "Reflexive City" Project have been defined. Numerous socio-environmental needs have emerged as critical:

- > to reduce the promiscuity of activities, essentially distinguishing themselves in three categories: clothing, grocery stores and coffee;
- > to improve the visual quality of this urban space, eliminating visual and functional disturbance factors;
- > to increase cleansing of the area after the mercatious activities;
- > to assure continued use to reduce the security risk.

Below, a part of the most complex "Reflexive City" Project is described. It enhances the water resource, meeting the most significant needs emerging during the analysis phases, through the design of an integrated rainfall recovery and collection system.

4. A DESIGN EXPERIMENTATION FOR VIA SOPRAMURO (MARIANGELA BUANNE)

Water is a qualifying element of urban space, both in micro-climatic terms and in psycho-physical well-being. The core principle for proper management of this resource is the recovery of rainwater, which statistically reduces the waste of potable water resources for inappropriate purposes by 50%, and consequently halts management and supply costs. This is the most effective and shared transformation strategy that oriented the design experimentation. However, before describing the project, a reflection should be made about the traditional business vocation of this area.

The market place of Porta Nolana, in Via Sopramuro (Pendino neighborhood), is historically linked to the sale of food, mainly fish. In fact, starting from 1438, Ferrante d'Aragona promoted the expansion of the city walls and the development of a market-dedicated area near to the new city walls. This was possible thanks mostly to the proximity to the sea and to Porta Nolana, one of the gateways to the city.



Fig.7: Via Sopramuro pictures. Source: M. Buanne.

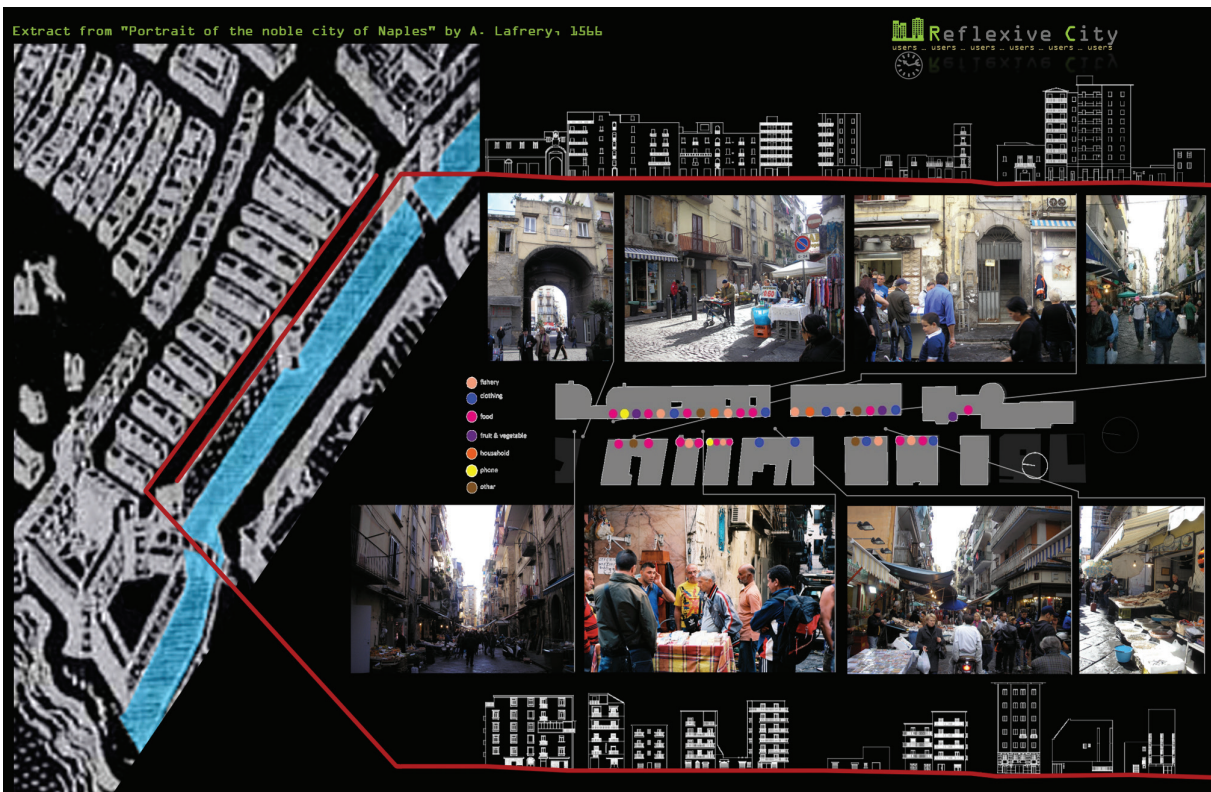


Fig.8: Via Sopramuro evaluation of market activities. Source: M. Buanne.

This city block was shaped in alleys and squares, which formed a system of the urban market that is still present today.

The market place of Porta Nolana flourished so that it became a traditional mark of characteristic language where its direct and indirect users still identify themselves.

Nowadays, most of these markets gather together in many places; among these, Via Sopramuro (literally "street above the walls", meaning just outside the perimeter) is characterized by fish market.

Here the sale happens everyday, drawing people with colors, vibrant sounds, folkloristic atmosphere and prime quality products.

Exhibiting shop stands are opened on the road from early morning until late evening and they occupy the sidewalk and part of the carriageway. The consumers crowd, walk,

watch and bargain in the middle of the road. All the noises, the colours and the smells that this lively reality engages, represent its local code. The perceptual wealth gives this place a strong identity, a feeling shared by all the citizens and lived by its users. However, the neighbourhood has been for decades in a state of social degradation, and often reported in the parthenopean crime news.

When the sale ends, the unsold merchandise is placed into small spaces on the ground floor with stands and market umbrellas, leaving Via Sopramuro not cleaned out and desolate. In addition, the street cleaning is a recurring problem that increases urban and environmental degradation.

The key components for urban regeneration are:

- > linear development of the road, that allows the consumers to have a clear perspective of available path;
- > existence of monuments such as Porta Nolana and two side towers, that comes back to local history;

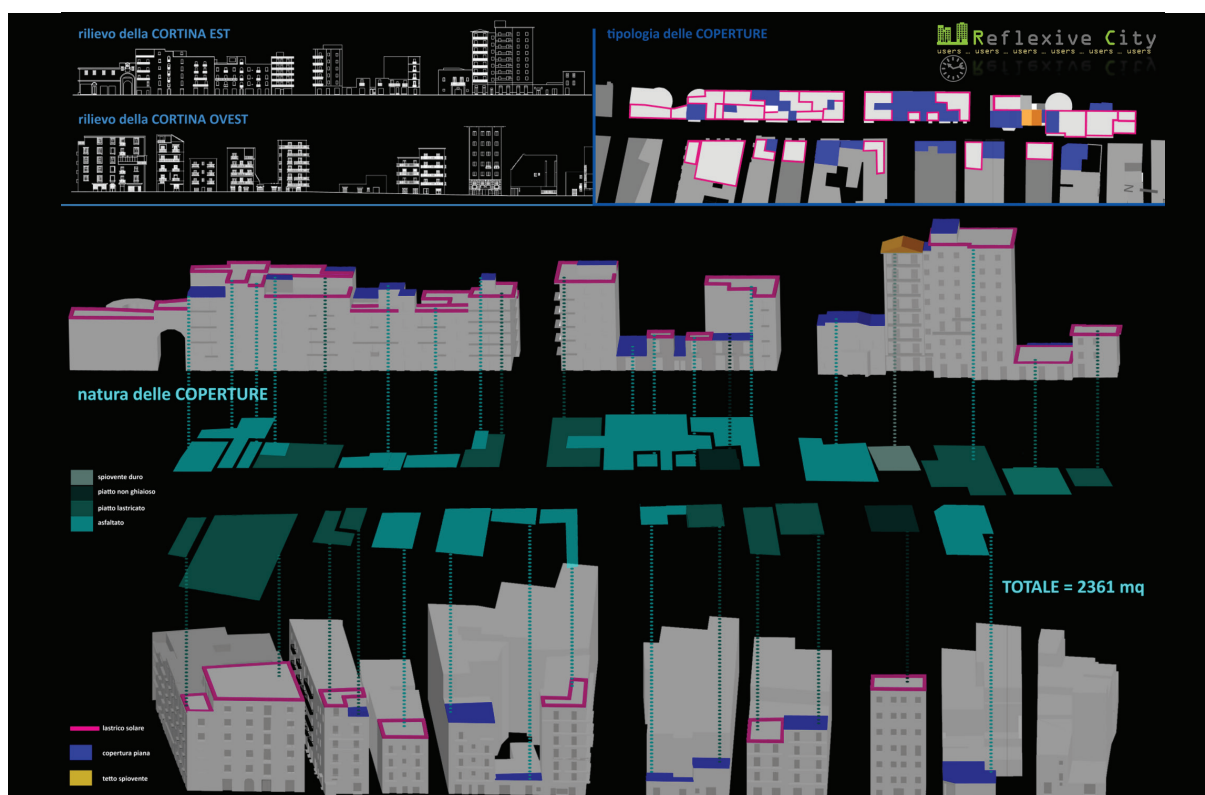


Fig.9: Kind of roofing surfaces in Via Sopramuro buildings. Source: M. Buanne.

- > water resource, that is constantly present in the history of Via Sopramuro.

Thanks to their integration, the quality of usability could be improved in the architectural redesign of the area, increasing their environmental value and setting up as an integration process between present-day lifestyle and historical background.

5. THE ADAPTIVE PROJECT THAT QUALIFIES THE URBAN SPACE (MARIANGELA BUANNE)

Based on the analysis carried out, the technological project, that was designed for specific conditions of fish sale, consists in the integration of water saving, aimed for the street cleaning when daily activity will be finished.

Water is the most important resource to preserve, for this reason avoiding waste is a priority. Water changed its role

for Naples city walls: in the past it lapped them as a natural protection; today it floods them to ensure cleanliness and health. The project allows to convert the water in a distinctive characteristic for the site regeneration, improved with the added value of the recycling. It shall be pursued through the achievement of three phases:

- > **step 1:** evaluation of feasibility of the system according to rainwater resources;
- > **step 2:** preparation of underground storage into place of use;
- > **step 3:** efficient allocation of resources for the street cleaning.

In order to verify the feasibility of the technological system, the determination of the need for water resource for the street cleaning was compared with that of the recoverable amount of the rainwater [water requirements].

Tab.3: Schedule: The maximum volume of rainwater that has accumulated on rooftops [VSC].

	SLOPED ROOF [e=0.90]	NO GRAVEL [e=0.80]	GRAVEL [e=0.60]	PAVED [e=0.50]	TAR [e=0.80]
west side	0	0	43'589	332'243	301'441
east side	36'614	21'697	0	176'292	601'332
TOTAL	36'614	21'697	43'589	508'535	902'773
VMC	1 513 258 litres/year				

Source: M. Buanne

The established water needs is 4600 litres in a day and the rainwater supply is determined by monthly precipitation (the data are from the nearest weather station of Napoli Capodichino) and from rainwater that has accumulated on the rooftops of Via Sopramuro's buildings. The report sets out that it is possible to retrieve about 4200 litres a day from rainwater, therefore producing savings by more than 90% of resource.

The technological project provides a new road arrangement: nowadays Via Sopramuro is not opened to traffic and also in the project it is so, reducing the actual dimensions from 6 metres each to 3 metres, in order to make it easier for the public to access to the market. The project provides

also a diversification of the inclination paving's percentage: in the first section it has a standard inclination with a 2% slope and 1,20 metres long; the second one is 1,80 metres long with a 8% slope, in order to facilitate the trade show products and the water flowing towards the sewage system for the street cleaning.

Therefore, the rainwater is collected by roofings and it is stored in a series of underground storage tanks, placed a few metres under the street. They collect and accumulate the rainwater and a system of pumps bring it up when needed. The street is washed in a natural way following the street slope to flow, through the street concavity, into the drain-trap and at last into the sewer.

This harvesting rainwater cycle may be divided into three phases:

- > The first stage consists in *collecting* rainwater on the rooftops; the water is *filtered* of residues and smells by the drain-trap, then it runs into the basin to be stored;
- > The second stage consists in pumping up the water into the tubes sited in the kerbstone of the sidewalk; water is further filtered into a collection sump that is stored on the street;
- > The third stage consists in *washing*, following the slope of the road and in the end, water is channelled into the sewers.

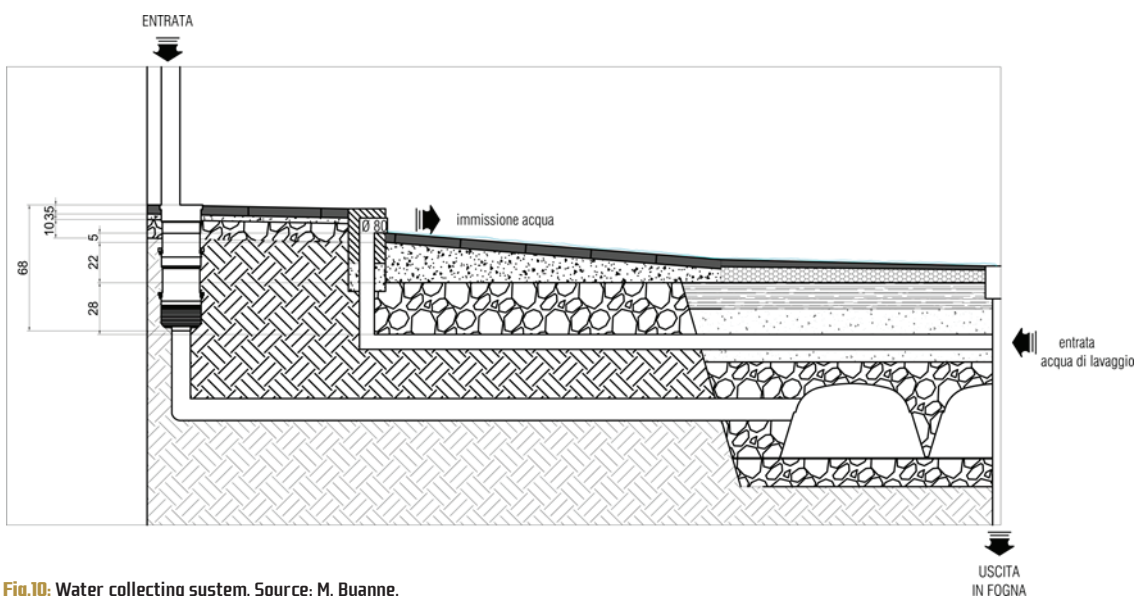


Fig.10: Water collecting system. Source: M. Buanne.

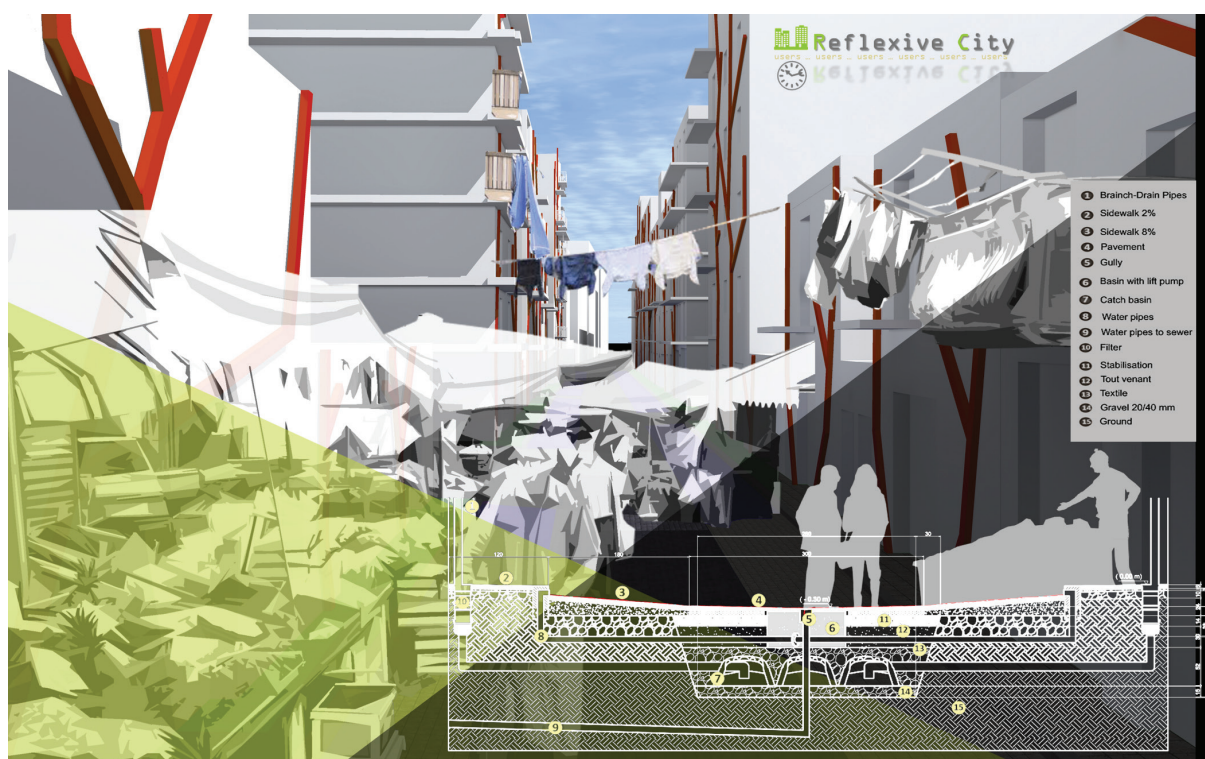


Fig.11: Via Sopramuro section with drain pipes plants. Source: M. Buanne.

Therefore, this project, through rainwater rescuing and re-using, allows via Sopramuro to self-wash from the market's remains and developing its economic activity. At the same time, the project restores the ancient street dignity and unity, highlighting the living and users' relation with the neighbourhood and its activities.

Once the market activity is over, the road can be used for other initiatives or events of different types. Therefore, the eco-oriented technological project, following the principles of sustainable design, has achieved the objective of reducing degradation, providing quality to urban spaces and using appropriate technologies that give added value.

6. CONCLUSIONS

Operating in an historic urban neighbourhood means to act in a complex context where the transformations cause significant impacts on living quality. It is not possible to draw a dividing line between urban and human scenarios because,

especially in consolidated historical contexts, man has to define, configure, perform the spaces in which he daily lives. For these reasons, urban redevelopment is a complex process that can be effective only if it is based on sound analysis of specific social factors and if it evaluates needs, valorises strength points (identity, comfort, usability) and mitigates criticality (order, safety, health).

This study shows a technological project model, an eco-oriented design that allows to operate in this typology of context in order to increase the value of cultural, social and economic features. According to this approach the very site's features become the key elements of urban transformation, both in the design and in operational phase.

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