The value of green infrastructures in urbanized areas

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Introduction

Climate change theme is one of the most discussed in the contemporary scientific debate: in fact some phenomena such as deforestation, use of fossil fuels and unsustainable growth and consumption model are the main causes of toxic emissions, which are themselves responsible for greenhouse gases increase, global warming and natural resources exploitation.

The topic of natural resources protection starts to be relevant in Europe during the middle of last century. The first approved directives in environmental subjects (“Birds Directive” 79/409/EEC, “Habitat Directive” 92/43/EEC) provided several shared criteria for community heritage conservation, maintenance and restoration of natural habitats. In particular, the “Habitat Directive” defined the construction of “Natura 2000” network that consists in special conservation areas and recognized the importance of certain landscape elements that played a key role in net connections for flora and fauna. Later the European Institute for Environmental Policies developed the construction of a European Ecological Network as police for rural areas protection and as conceptual and operational framework to pursued at all planning levels. Species and sites protection was not sufficient to ensure an effective contrast to human pressures and to reduce the effects of habitat fragmentation: so it was necessary to construct ecological corridors. These green elements are able to allow the dispersion of plants and animals through natural paths between protected areas. Member States are urged to maintain or, if necessary develop, these elements to improve the ecological coherence of the “Natura 2000” network and to incorporate into their legislation the main aspects of European Directives. Italy involves the National Ecological Network construction through an approach based on the principles of subsidiarity, participation, shared responsibility and integration of environmental policy with others. The ecological network, despite predictions at the national level, taking shape at the regional scale, which has the role to mediate between general abstractness of larger scales and specificities of smaller ones. These issues recognize the importance of green infrastructures in the Regional Development Plan and constitute a guideline for strategic and operational planning (provincial and municipal).

In order to contribute to climate change mitigation and protection of natural resources and biodiversity, it is necessary a strategic solution able to enhance eco-systemic forces and simultaneously to start up urban regeneration mechanisms.

Green Infrastructures as a possible solution

A possible strategy is the realization of green infrastructures, “networks of multi-functional green spaces, both newly identified and existing, both rural and urban, that supports natural and ecological processes. They are fundamental component for community health and quality of life” (Planning Policy Statement, Policy 12, Local Spatial Planning).

The concept of green infrastructure refers to ecological network but it assumes a broader meaning: in fact it combines both eco-systemic and functional aspects (recreation, open space, mobility, etc.) becoming territory project between cities and small settlements. Multifunctionality, integration of functions, is a basic characteristic of green infrastructure. Other key components are connectivity (not necessarily physical and direct but also visual) and the transcalarity (urban and suburban landscapes connection in order to create a unified and integrated view with margins and gates system).

In particular there are two types of green infrastructures: the natural ones (such as ecological corridors) and those consisting of artificial elements with ecological value (for example green and multifunctional areas, green roofs and walls, cycling routes with environmental functions).

These networks, if properly implemented and management, brings several environmental, social and economic benefits.

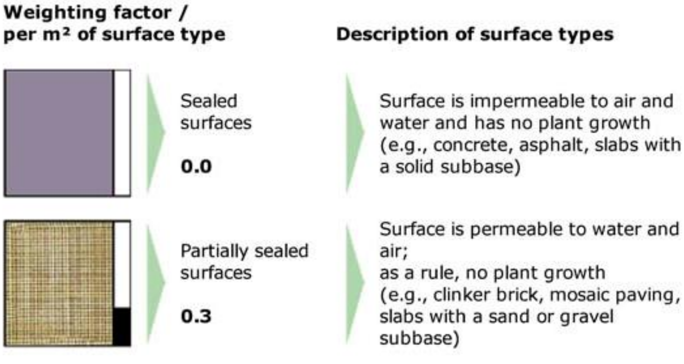
From the environmental point of view, they contribute to biodiversity conservation by maintaining existing habitats and offering new natural one for animal plant and species. Moreover, they contribute to climate mitigation and environmental quality improvement.
From the social point of view, they provide new services by creating a more pleasant place for city users. Finally, they influence positively the local economy by increasing attractiveness. Green infrastructures solve simultaneously several aspects through functional integration principle contrary to traditional gray ones that perform single functions such as drainage or transportation. Theirs role is crucial for sustainable territorial development: for this reason, European policies support the strategic planning of green infrastructures in order to preserve and enhance ecosystems.

The value of green infrastructures in urbanized areas

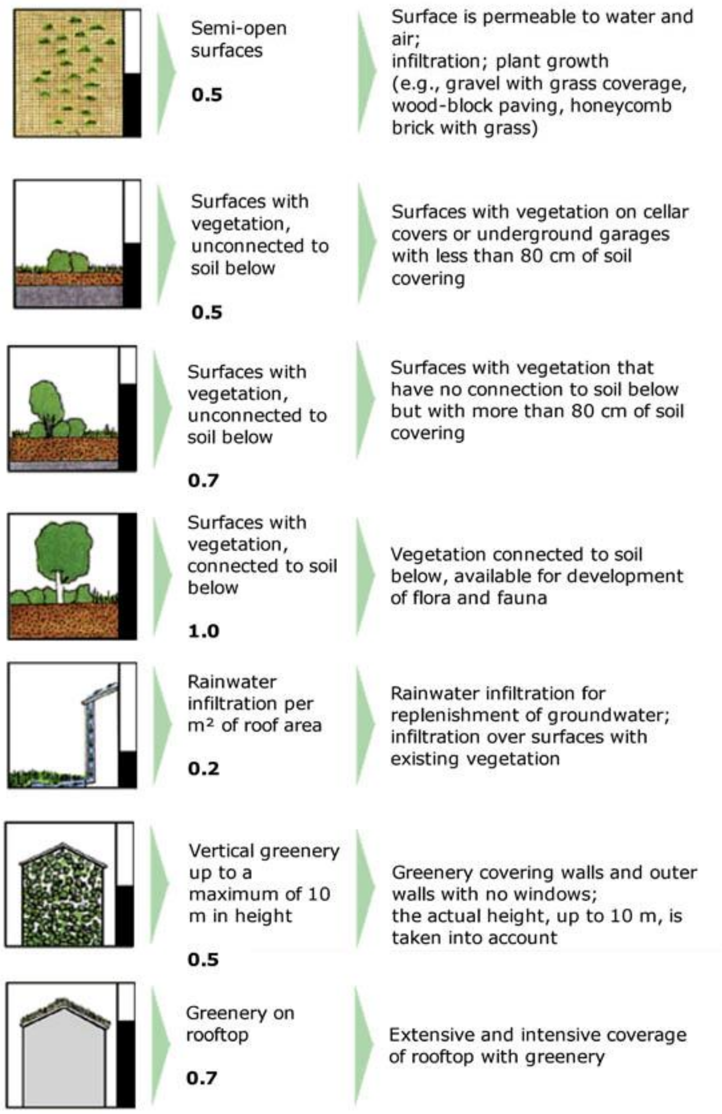
In highly urbanized contexts (high density, high soil sealing and high covered surface) it is essential to insert artificial green elements able to increase the ecological quality of the ecosystems and to remove rigidities and inefficiencies. Often, the percentage of urban permeable and green areas is not capable of perform ecosystem functions: in this case, light and widespread green infrastructure may become fundamental and unique elements of the municipal ecological network.
In fact, from ecological point of view, these green elements act on urbanized fabrics such as stepping stones, support points for transfer of organisms from large natural basins in the absence of continuous natural corridors. These units are located in urbanized areas and, if properly aligned, they can replace to a certain extent a continuous corridor (Peraboni, 2010). In the last decades methods have been studied for uniquely express the ecological value of an area. In scientific literature, experimentation of new ecological indices were numerous and the parameters synthesized different environmental criteria bringing a unique undeniable value.
For the easy application, they were integrated with the standards of most innovative plans in order to improve environmental quality.
The first index that was applied in an urban areas for improve the ecological value and the microclimate is Biotope Area Factor (BAF). It expresses the relationship between ecologically effective surface area and total area as shown in the following formula:

$$\mathrm{BAF} = \frac{\text{Ecologically effective surface area}}{\text{Total land area}}$$

In this calculation, the individual parts of a plot of land are weighted according to their ecological value (Berlin municipality’s website). Weighting factors of several surface are shown in the following table:



Weighting factor / per m² of surface type	Description of surface types
Sealed surfaces 0.0	Surface is impermeable to air and water and has no plant growth (e.g., concrete, asphalt, slabs with a solid subbase)
Partially sealed surfaces 0.3	Surface is permeable to water and air; as a rule, no plant growth (e.g., clinker brick, mosaic paving, slabs with a sand or gravel subbase)



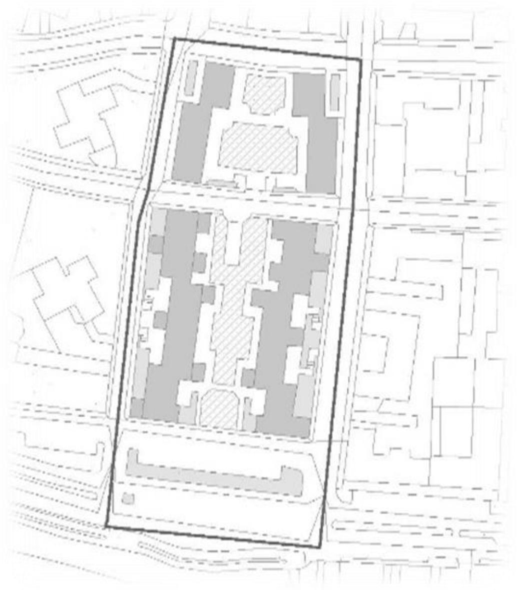
From the formula shown, it is clear that the ecologically effective surface is directly proportional to the value of the Biotope Area Factor. To increase the ecological value of an urban portion it is necessary to enhance the value of BAF and consequently the ecologically effective surface. For example replacements of existing traditional roofs with green ones would increase this index.
Through the use of Biotope Area Factor, it is possible to verify that set of artificial intervention within an urbanized area are comparable, in ecological terms, to a natural green infrastructure.

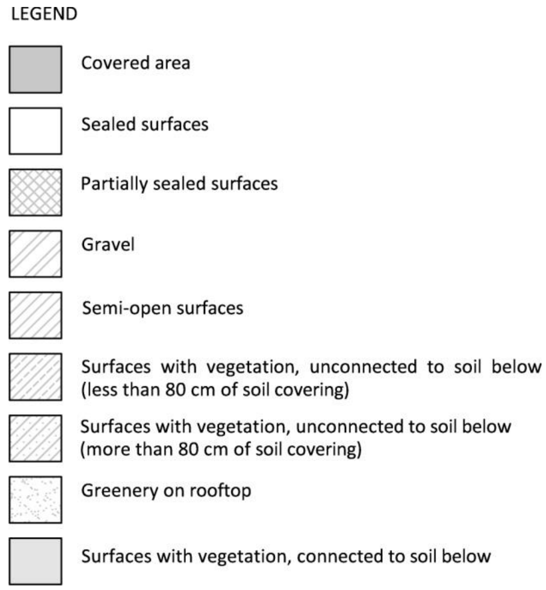
Application case

The application case analyzes Pavia's blocks with high, medium and low density, in particular:

- High density block: Montebello street, Vittadini street, Depretis street , Franchi street
- Medium density block: Ludovico il Moro street, Cattaneo Street, Bona di Savoia street, Verri street
- Low density block: Paiola street, Pensa street, Maciachini street, Don Gnocchi street

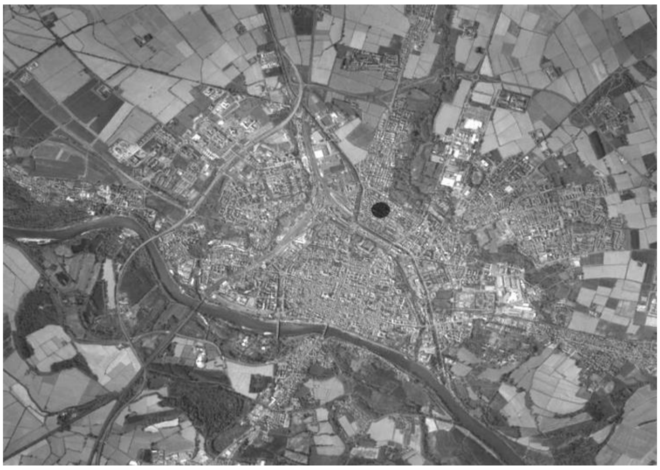
High density block: Montebello street, Depretis street , Vittadini street, Franchi street

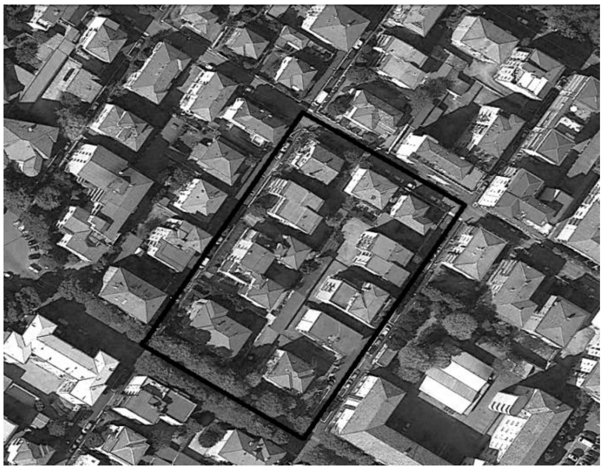


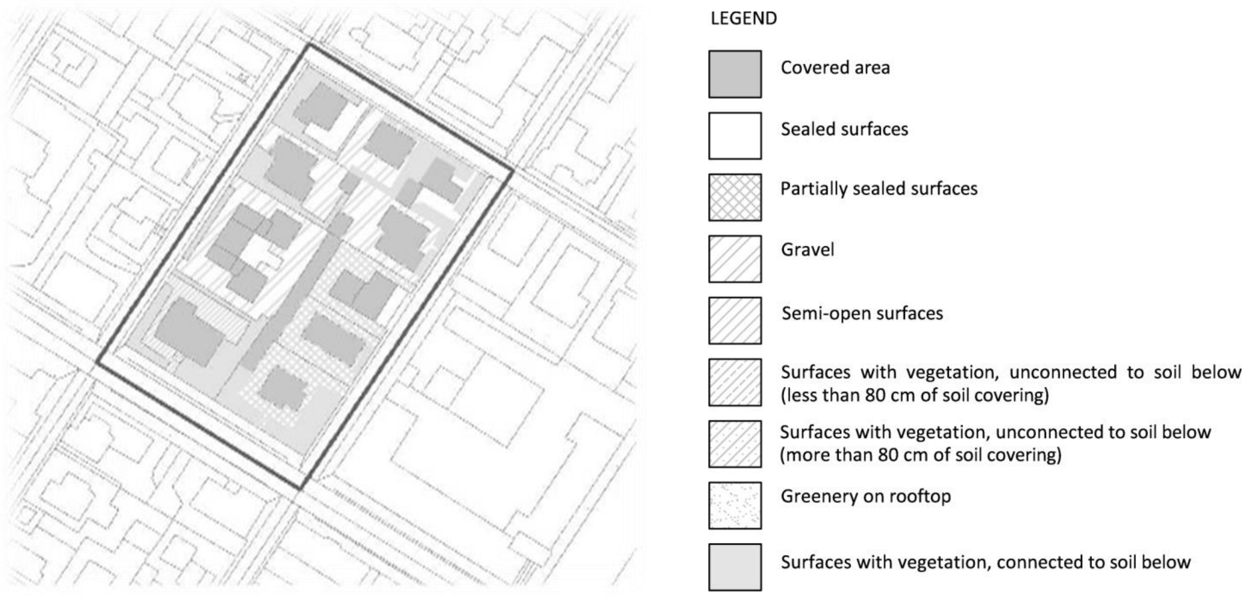


Description of surface types	m² of surface type	Weighting factor	Ecologically effective surface area (m²)
Covered area	3597,42	0	0
Sealed surfaces	8528,28	0	0
Partially sealed surfaces	0	0,3	0
Gravel	0	0,4	0
Semi-open surfaces	0	0,5	0
Surfaces with vegetation, unconnected to soil below (less than 80 cm of soil covering)	0	0,5	0
Surfaces with vegetation, unconnected to soil below (more than 80 cm of soil covering)	1747,00	0,7	1222,90
Greenery on rooftop	0	0,7	0
Surfaces with vegetation, connected to soil below	1298,30	1	1298,30
Total land area (m²)		15171,00	
Total ecologically effective surface area (m²)		2521,20	
BAF		**0,17**	

Medium density block: Ludovico il Moro street, Cattaneo Street, Bona di Savoia street, Verri street

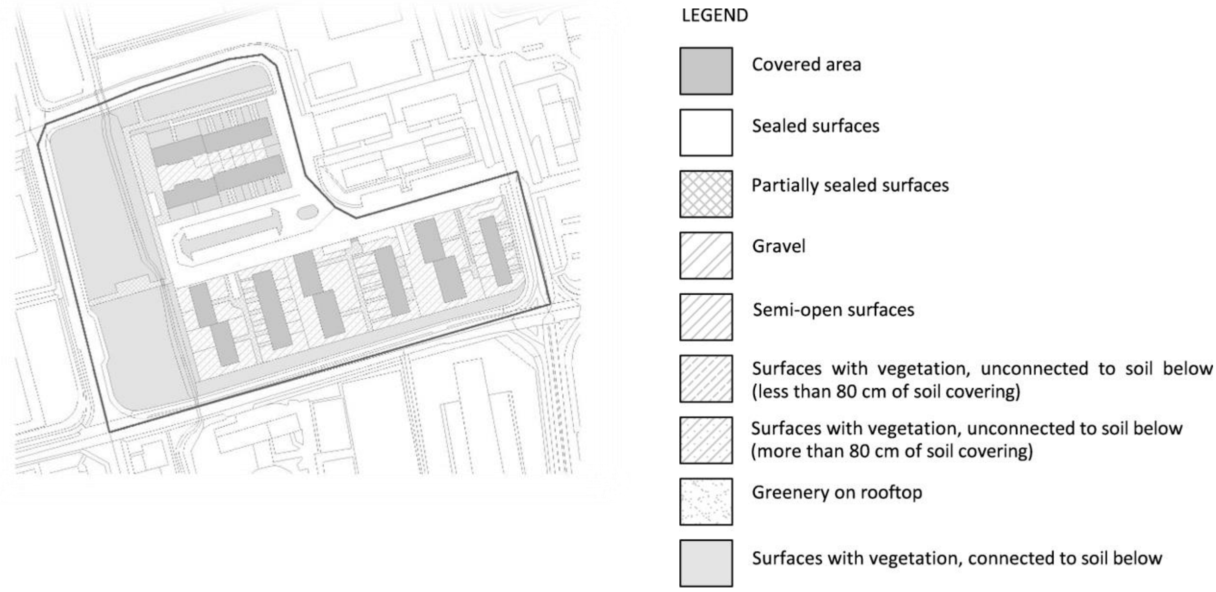






Description of surface types	m² of surface type	Weighting factor	Ecologically effective surface area (m²)
Covered area	1992,80	0	0
Sealed surfaces	2241,75	0	0
Partially sealed surfaces	802,60	0,3	240,78
Gravel	1328,61	0,4	531,44
Semi-open surfaces	244,64	0,5	122,32
Surfaces with vegetation, unconnected to soil below (less than 80 cm of soil covering)	0	0,5	0
Surfaces with vegetation, unconnected to soil below (more than 80 cm of soil covering)	0	0,7	0
Greenery on rooftop	0	0,7	0
Surfaces with vegetation, connected to soil below	1344,20	1	1344,20
Total land area (m²)		7954,60	
Total ecologically effective surface area (m²)		2238,74	
BAF		**0,28**	

Low density block: Paiola street, Pensa street, Maciachini street, Don Gnocchi street



Description of surface types	m² of surface type	Weighting factor	Ecologically effective surface area (m²)
Covered area	4703,65	0	0
Sealed surfaces	10674,55	0	0
Partially sealed surfaces	2819,70	0,3	845,91
Gravel	0	0,4	0
Semi-open surfaces	0	0,5	0
Surfaces with vegetation, unconnected to soil below (less than 80 cm of soil covering)	7124,00	0,5	3562,00
Surfaces with vegetation, unconnected to soil below (more than 80 cm of soil covering)	0	0,7	0
Greenery on rooftop	0	0,7	0
Surfaces with vegetation, connected to soil below	12415,00	1	12415,00
Total land area (m²)		37736,90	
Total ecologically effective surface area (m²)		16822,91	
BAF		**0,45**	

For each selected block was estimated the current ecological value through BAF index: in particular, this value decreases with the increase of density, because in these fabrics the percentage of green or semi-permeable surfaces is lower. The following tables show the values of analyzed blocks after green interventions (such as replacement of traditional roofs with green ones).

Description of surface types	m² of surface type	Weighting factor	Ecologically effective surface area (m²)
Covered area	3597,42	0	0
Sealed surfaces	8528,28	0	0
Partially sealed surfaces	0	0,3	0
Gravel	0	0,4	0
Semi-open surfaces	0	0,5	0
Surfaces with vegetation, unconnected to soil below (less than 80 cm of soil covering)	0	0,5	0
Surfaces with vegetation, unconnected to soil below (more than 80 cm of soil covering)	1747,00	0,7	1222,90
Greenery on rooftop	3597,42	0,7	2518,19
Surfaces with vegetation, connected to soil below	1298,30	1	1298,30
Total land area (m²)		15171,00	
Total ecologically effective surface area (m²)		5039,39	
BAF		**0,33**	

High density block: calculation of BAF after interventions

Description of surface types	m² of surface type	Weighting factor	Ecologically effective surface area (m²)
Covered area	1992,8	0	0
Sealed surfaces	2241,75	0	0
Partially sealed surfaces	802,60	0,3	240,78
Gravel	1328,61	0,4	531,44
Semi-open surfaces	244,64	0,5	122,32
Surfaces with vegetation, unconnected to soil below (less than 80 cm of soil covering)	0	0,5	0
Surfaces with vegetation, unconnected to soil below (more than 80 cm of soil covering)	0	0,7	0
Greenery on rooftop	1992,80	0,7	1394,96
Surfaces with vegetation, connected to soil below	1344,20	1	1344,20
Total land area (m²)		7954,60	
Total ecologically effective surface area (m²)		3633,70	
BAF		**0,46**	

Medium density block: calculation of BAF after interventions

Description of surface types	m² of surface type	Weighting factor	Ecologically effective surface area (m²)
Covered area	4703,65	0	0
Sealed surfaces	10674,55	0	0
Partially sealed surfaces	2819,70	0,3	845,91
Gravel	0	0,4	0
Semi-open surfaces	0	0,5	0
Surfaces with vegetation, unconnected to soil below (less than 80 cm of soil covering)	7124,00	0,5	3562,00
Surfaces with vegetation, unconnected to soil below (more than 80 cm of soil covering)	0	0,7	0
Greenery on rooftop	4703,65	0,7	3292,55
Surfaces with vegetation, connected to soil below	12415,00	1	12415,00
Total land area (m²)		37736,90	
Total ecologically effective surface area (m²)		20115,47	
BAF		**0,53**	

Low density block: calculation of BAF after interventions

The tables show that the construction of artificial green infrastructure such as green roofs increases the value of BAF. In particular, these interventions are more effective in high and medium density fabrics, where the coverage ratio is greater.
In high density block, interventions doubled the ecologically effective surface (from 2521 mq to 5039 mq) and that increase of green surface is equivalent to the creation of a natural green infrastructure, such as a neighborhood park (2500 square meters).

Observations and conclusions

The application case shows how in urbanized fabrics, especially with high density and high soil sealing, the inclusion of widespread artificial elements can help to improve the ecological value. The total area of the intervention is comparable, in ecological way, to an urban park.
The artificial infrastructures act on urbanized contexts as stepping stones which bring several benefits especially from the environmental point of view. In fact they regulate the urban microclimate moderating the heat island effect: different from impermeable surfaces, the green ones absorb heat and reduce the temperatures thanks to their evapotranspiration ability. Green interventions contribute to air quality improvement through two mechanisms: the absorption of pollutants (such as CO_2) and the energy savings due to the presence of trees, which also guarantee insulating function. Moreover they hold a central role in surface water management by absorbing excess ones and by reducing floods risk.
From the comfort point of view, the presence (in example) of green roofs and walls improves the thermal and acoustic insulation, greatly increasing performance and welfare of buildings.
Moreover, diffuse private interventions help to optimize the quality of urban landscape increasing both ecological and entertainment value.
All these aspects involve health improvement and the socio-economic well-being by increasing the real value and making the city more attractive for tourists and potential investors.
Artificial green infrastructures improve territory ecological functions and these interventions, if well designed, built and operated, fall within urban regeneration actions.

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