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RAINWATER AND ECOLOGICAL ARCHITECTURE FOR THE CITY

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The idea that an urban system could be "a bit hydro-demanding" and "take part of the natural hydrologic cycle"[1] - in balance with his larger hydrologic context – goes through innovative views which does not necessarily mean expensive engineering technologies. For centuries and until the end of the twentieth century, the rainwater collection practice has been widespread in Italy as well as in other countries. The culture of water and a wise rainwater management have already been urban building issues in the settlements of the most ancient Mediterranean and Mesoamerican cultures. Modern practices of pumping, valorization and drinking water treatment and supply can be still placed side by side with long-standing methods such as the rainwater collection that provides a low-cost supply and remarkable environmental benefits. Nowadays the management of urban meteoric water could be assigned to unconventional models that use ecological architectures and infrastructures able to re-establish some natural processes that the present urbanization model tends to interrupt. The simplest supposable urban strategy for the collection and reuse of stormwater is the "stormwater eco-management strategy", in other words it is a capillary and localized rainwater harvesting: the collected water purification, stockpiling and reuse, would take place straight nearby the areas for harvest only. This strategy consists in the overlap of an ecological rainwater management through the public space - "stormwater features urban strategy" and through the buildings - "stormwater eco-building strategy".

RAINWATER AND GREEN ROOF

"The roof gardens. The flat roof demands in the first place systematic utilization for domestic purposes: roof terrace, roof garden. On the other hand, the reinforced concrete demands protection against changing temperatures. Over- activity on the part of the reinforced concrete is prevented by the maintenance of a constant humidity on the roof concrete. The roof terrace satisfies both demands (a rain-dampened layer of sand covered with concrete slabs with lawns in the interstices; the earth of the flowerbeds in direct contact with the layer of sand). In this way the rain water will flow off extremely slowly. Waste pipes in the interior of the building. Thus a latent humidity will remain continually on the roof skin. The roof gardens will display highly luxuriant vegetation. Shrubs and even small trees up to 3 or 4 metres tall can be planted. In this way the roof garden will become the most favoured place in the building. In general, roof gardens mean to a city the recovery of all the built-up area"[2]. LE CORBUSIER, *Vers une architecture*, Cres, Parigi, 1923.

That plants are good performers as building construction materials has already been well known in Modern Architecture, because of their architectural and urban benefits. Green roofs and walls contribute positively to the thermal insulation of buildings, reducing their demand for air-conditioning during warm and cold seasons; improving waterproof qualities and protecting building systems from atmospheric agents; increasing soundproof coefficients of covering and infilling. Green roofs and walls are here dealt with because they are closely related to urban regulation of rainwaters and they are also a useful tool for urban self-production of water. Going through the thin vegetation layer, gravel and soil, water is filtered and purified from pollutants typical of urban environment, reducing their phosphorus and nitrogen charge. Then water flux goes through metal filters with tight meshes which remove the remains of foliage and soil; the piped water, once have

[1] Tony Wong, Director of Centre for Water Sensitive Cities, Monash Sustainability Institute, Monash University; www.monash.edu.au; www.watersensitivecities.org.au
[2] LE CORBUSIER, Vers une architecture, Cres, Parigi, 1923.

reached a good qualitative level, enters the storage tanks and from there gets into the distribution plant. The rainwater admissible in-door uses could cover until 30% of a flat water demand, while concerning industrial and commercial activities percentages would increase considerably.
City green roofs and walls do not have a purely aesthetic and landscape role, but they have ecological functions with an immediate fallout on the environment; urban metabolism itself can get decent benefits from "the recovery of all the built-up area". We can sum up the green roofs and walls' performances as follows: the reduction of urban outflow waters, the mitigation of the UHI (urban heat island) effect, the biodiversity increase and the decrease of the pollution load of urban outflow. Green roofs and walls give indeed the possibility of multiplying the available green surfaces, increasing the ecological and sanitary performances of the urban green networks, such as the carbon dioxide reduction within compact, high density urban tissues. The water collected and then kept by the green roof system is available for the environment, gets absorbed by vegetation or evapotranspires. The pollution load reduction of urban outflow waters is due to the passage of water through the planted surfaces' thickness with plant oils with great phytoextraction potentialities. Besides rainwater that is not collected into storage tanks, but falls to the ground, gets also partially purified from dust, acids and nutrients. The evaporation and evapotranspiration processes contribute to mitigate the UHI (urban heat island) effect, reducing the temperature and providing therefore benefits for the urban microclimate. Direct benefits for the water drainage are computable as the water load reduction imposed upon the urban drainage network.
Many North American cities are giving the green roof realization a boost in their high density areas since their use can provide ecological performances. In order to improve the city environmental quality, Toronto City Hall[3] has developed the "Eco Roof Strategy"[4], which consists in installing green roofs on public buildings, in setting up a set of laws, in starting an awareness campaign and a professional training all dedicated to green roofs. The "Eco-Roof Incentive Program" is the most incisive operating tool of the strategy: it is a direct economic incentive that the City Hall bids for the creation of particular kinds of green roofs on the existing commercial, institutional, industrial and residential buildings. Besides it has been made mandatory the use of green roofing for the 40% of the whole covered surface, for all types of just built buildings. Green roof strategies have been used in Mexico too; for instance in Ciudad de México they are planning the creation of 50.000 sq m of green roofs on the existing public buildings. The green roofs and wall' use is one of the actions suggested in the "Plan Ecológico" developed by the office of the "Jefe de Gobierno del Distrito Federal": their use is encouraged, in the case of private buildings, with tax cuts directly proportional to the green roof's building cost. In the US green roofs are very popular nowadays: it is a good reason of competition among urban institutions or local governments[5].

RAINWATER AND ECOLOGICAL ARCHITECTURE

The garden roof is the main tool of the "stormwater ecobuilding strategy", but many other architectural innovations can make rainwater collection, purification and reuse, useful and effective, giving their contribute to the formal and performance quality of the building tissue.
Opencast tanks called "roof ponds" or "hanging ponds", useful to refresh the urban microclimate and reduce the UHI (urban heat island) effect, can be built on buildings' roofs as well as on wide terraces, preferably within geographic areas not too wet. This technique offers great potentials. Besides providing a good water supply, a "roof pond" can considerably contribute to the thermoregulation inside the building. Once rainfall have ceased, some thermal insulating sliding panels can cover the stretch of water during winter nights, radiating heat collected during the day inside the building volume; in summertime this process is reversed, reducing the quantity of water which evaporates away[6]. The "roof spray" technique can join the rainwater hanging ponds, using forced ventilation systems to chill the pond, then putting cold water into the liquid cooling system of the building and bringing water back into the pond for a later cooling[7]. The combined use of water collection basins and green roof systems defines an "intensive green roof".
The "stormwater boxes" (SWBX) are rainwater collection systems which catch stormwater even before it falls to the ground and is canalized into the urban drainage system. The SWBX are waterproof basins which can be integrated into the building structures turning into the constituent architectural elements of overhangs, terraces, balconies and penthouses. They are the typical elements of the most advanced green roof generation, since their design is very flexible compared to the climatic circumstances and the spatial and formal requirements of the architectural structure. The SWBX's size are usually such as to allow the biopurification treatment of the first rainwater whose filtration cycle lasts four hours. The filtering SWBX are

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[3] B. A. CURRIE, Using Green Roofs to Enhance Biodiversity in the City of Toronto, Toronto City Planning Office, 2010.
[4] Info on the Eco Roof Strategy and the Toronto's Eco-Roof Incentive Program are available at Live Green Toronto, Eco-Roof Case Studies webpage: www.toronto.ca/livegreen/videoresources_resources.htm
[5] In 2006 the association "Green Roofs for Healthy Cities" reported significant data on the US cities with the largest green roofs built until 2005, the first five cities are: Chicago (27.461 sq m); Washington (19.221 sq m); Suitland (19044 sq m); Ashburn (11.148 sq m); New York (11.055 sq m).
[6] V. KEITH, "Clip-on Architecture: Reforesting Cities", in Urban Omnibus, Architectural League of New York, New York, 2010.
[7] B. STEIN, J. S. REYNOLDS, Mechanical and Electrical Equipment for Buildings, John Wiley & Sons, 2005.

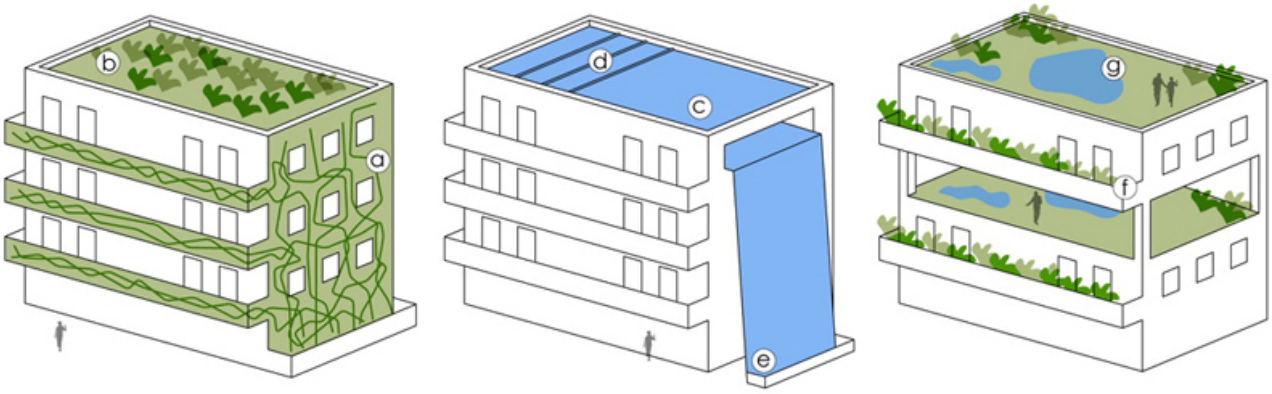
filled with planted fertile soil ("stormwater grass filter box" or "planter box") or with sand and gravel ("stormwater sand filter box"). A technique often used consists into the "sequential-tiered cleansing systems" planning; each of them works at a lower level in a temporal sequence: a vertical sequence of stormwater boxes, that are usually defined as "tiered stormwater planter boxes", that being multilevel, need small planimetric surfaces. Rainwater is collected and purified in sequence through filtering biotopes prearranged in the boxes, in order to get an high qualitative level of the resource, making it ready to be used.
During heavy rainfall, the hanging gardens keep some water, while another part of it will be stored in tanks or soil basins; anyway the water that falls on the buildings will quickly slip on the ground, where will be held into artificial basins for a later use. The construction of a "rainwater wall" is a matter for conjecture to profit from the very short phase of the rainwater cycle during which the water runs from the roof to the soil. The "rainwater wall" is a waterproof surface that joins a traditional building wall, on which the water flux can run regulated by valves outfitted on the roof and activate micro-turbines which produce electric energy. The "rainwater wall" can also function as a second layer of building cladding, creating a ventilated wall whose liquid cooling system increases the thermal insulating characteristics of the building (Stein & Reynolds 2005).
There are many techniques to create green walls or vertical gardens, whose contribution to the urban water regulation depends above all on the high coefficient of water retention that these walls can reach. Simpler techniques can provide good results too: the "green screen" for instance is a metallic structure fixed to the existing walls or self-supporting, that bears the vertical growth of different kinds of plants.

RAINWATER AND PUBLIC SPACE

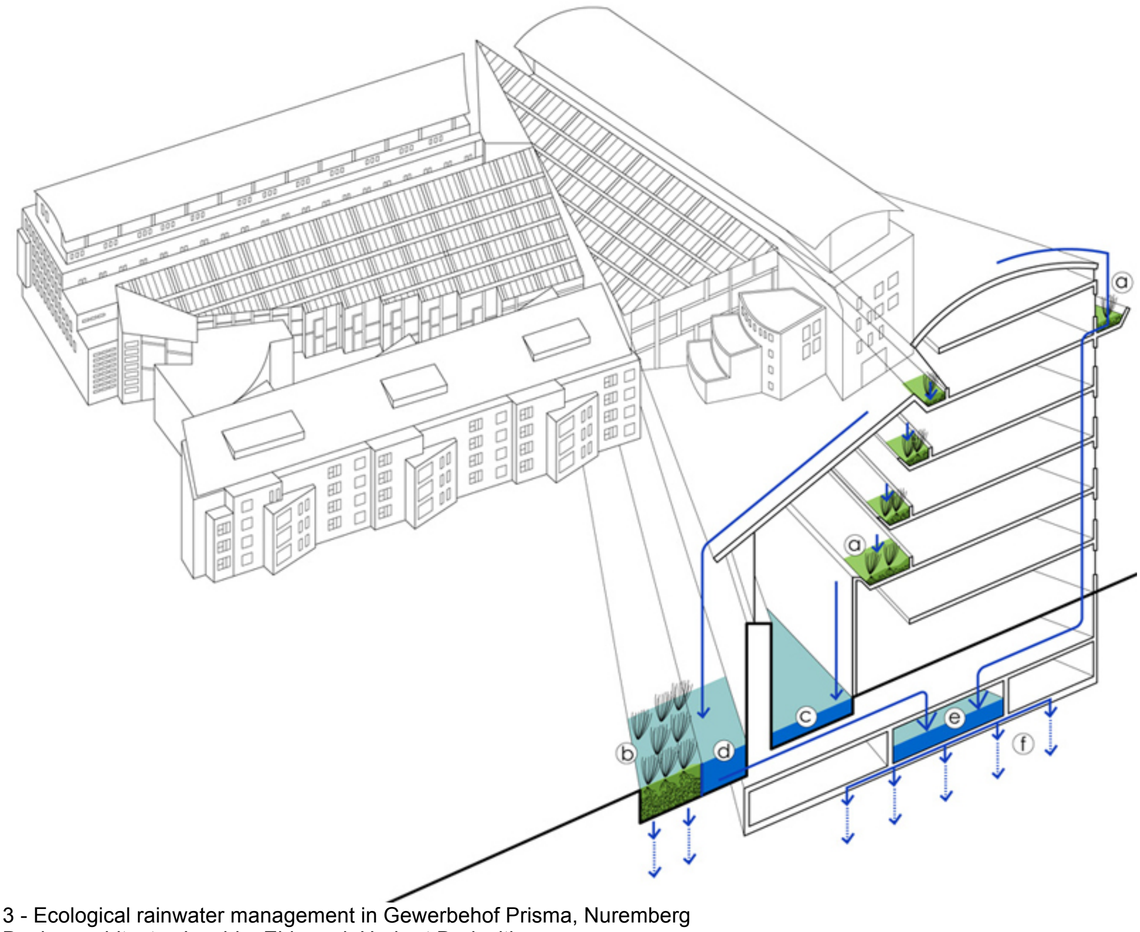
City open spaces such as streets, squares and gardens are usually objects of requalification and renewal projects, but often such projects do not affect the capacities of these spaces to contribute to a better functioning of the urban ecological system, not to mention the local water cycle. Traditionally the urbanization project tends to separate the functioning of open spaces and public parks from the management of the runoff waters and the urban microhydrography's ones. Once the so-called "water features"[8] enter the public space, they tend to the self-reference and dissipation of resources, since they come from a hydraulic cycle that draws on from waterworks and they are not involved into the rainwater drainage process. Despite the high quality of the resource employed in these water features, in most cases, mechanical filters and chemical additives make them unusable for drinking purposes, because the reasons why they have been historically built in dense urban tissue have got lost. In the Italian urban landscape, the water features, identifiable as fountains or stretches of water, decorate squares, gardens or roundabouts: they are made mainly of cement or stone and they have no connection with urban vegetation, being purely aesthetic elements, put into small reservoirs unconnected to each other from a hydraulic point of view.
Here a new role for urban ecological water figures, which use water to feed themselves, is suggested. If rains were recycled through the innovative projects of requalification of the urban open spaces, using therefore "stormwater features urban strategy" too, the role of ecological architecture towards rainwater could be very effective within the urban tissue. Building, into the public space, active green areas such as the "cleansing biotopes" and the figures produced by the rainwater, has both an ecological and a symbolic value: the suggested design aesthetically embodies the urban sustainability values, creating an urban landscape that changes with the seasons, aware of its climatic context and flexible to ongoing changes. The "stormwater features urban strategy" tries to build a dynamic urban ambient, where crossing and parking can go with the basic elements of the natural hydrography- being significant elements of urban contemporary design. The infrastructures of the ecological urban drainage – the "stormwater features" – that is to say elements necessary to the integration between the public space design and the runoff water management – can have several forms and functions. The water supply infrastructures collect the runoff, slow down the flow of water and canalize it; the water detention and retention infrastructures detain and retain water; the filtration and sedimentation infrastructures remove sediments and filter water; the biopurification infrastructures remove pollutants through biotopes with herbal extraction properties; the percolation and infiltration infrastructures bring the water back to the ground waters, restoring a high level of soil permeability.
The integrated project of the ecological infrastructures and architectures could make possible a real implementation of the supposed "stormwater ecomanagement strategy" and an intersection and overlap of the stormwater ecobuilding strategy and the stormwater features urban strategy in a symbiotic ecological phenomenology of the built-up space.

[8] *A* "water feature" *is a small recreational area where water is the decisive element, in continuous motion: there we can find pools, fountains, ponds, basins, created to make the place more fascinating from an aesthetic point of view.*

1 - Ecological urban architecture and Stormwater Ecomanagement Strategy
Project: Romainmotier Eco-Dynamic Nozon Valley, Lausanne.
Design architects: Cesare Corfone, Luciana De Girolamo, Marianna Di Lauro, Patrizia Toscano.
Open spaces and buildings embody a design philosophy which tends to reduce the ecological footprint of the traditional urbanization. Building porosity and permeability together with the qualitative and surface management of rainwater contribute to preserve biodiversity, water resources and local ecological functioning.



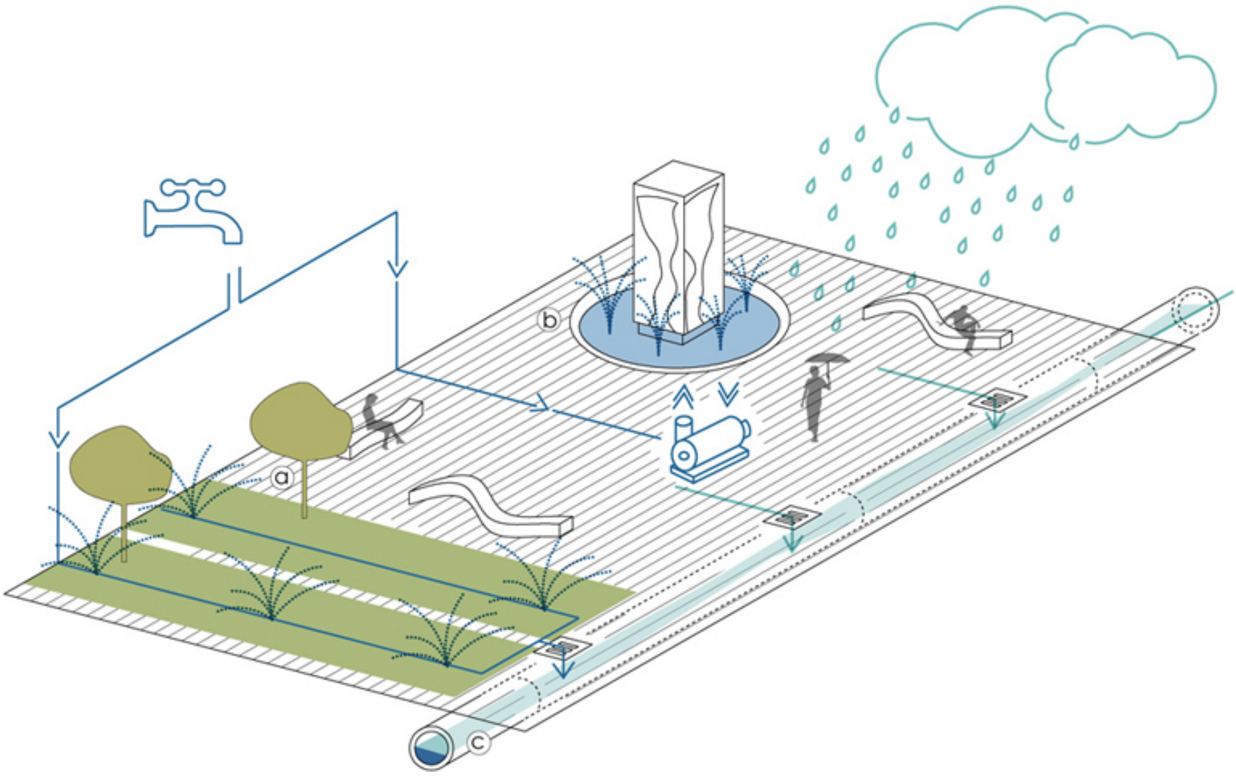
2 - Stormwater Ecobuilding Strategy
Design by Cesare Corfone.
Graphic design by Valeria Miele.
The buildings project is the expression of old techniques and new technologies which allow to reduce the buildings' ecological footprint, improving their technical performances and formal characteristics.
a) green screen;
b) green roof;
c) roof pond;
d) roof spray;
e) rainwater wall;
f) stormwater box;
g) intensive green roof.



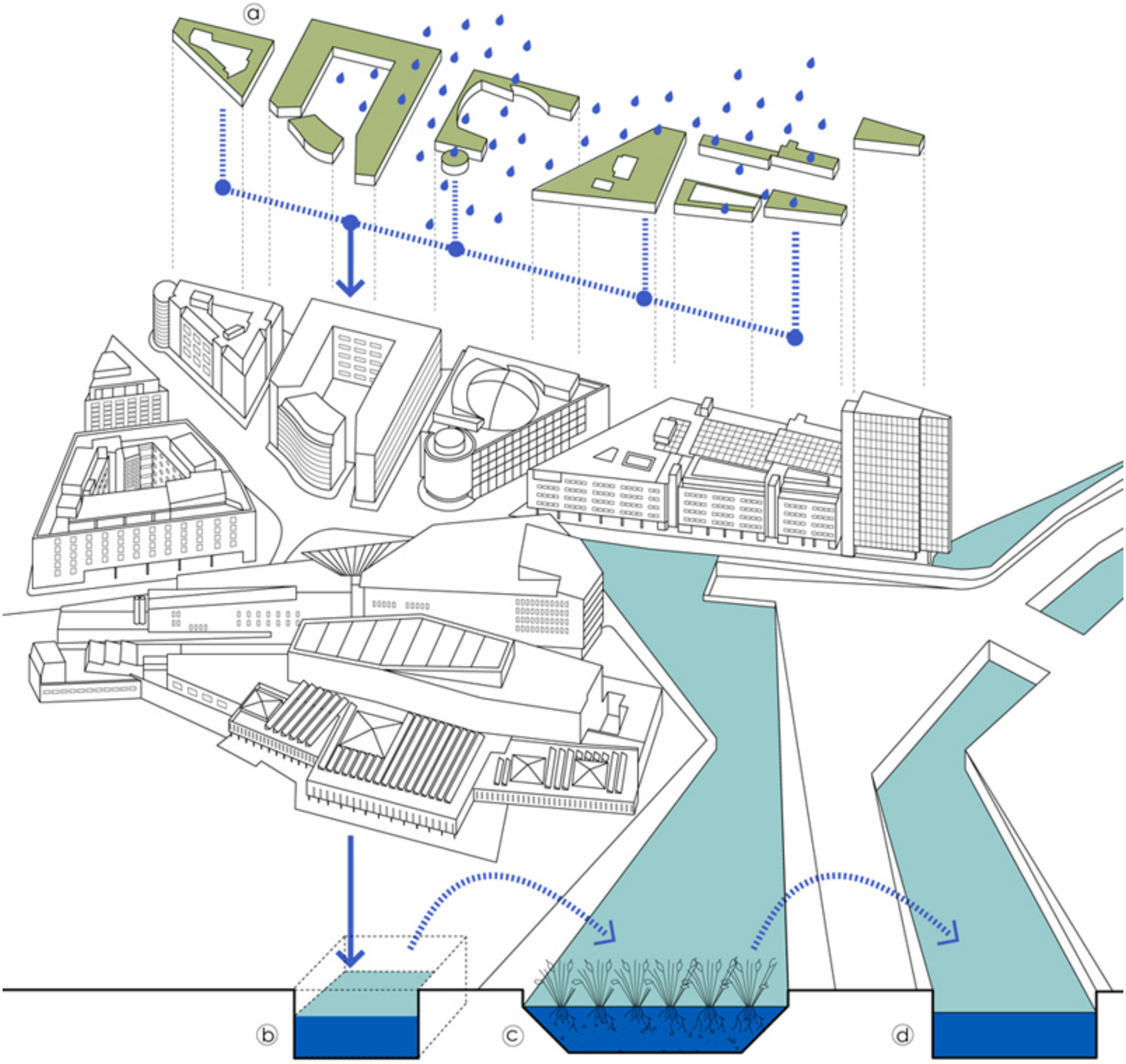
3 - Ecological rainwater management in Gewerbehof Prisma, Nuremberg
Design architects: Joachim Eble and Herbert Dreiseitl.
Graphic design by Cesare Corfone and Valeria Miele.
The collected rainwater, before entering the main tank, is filtered through a series of "stormwater boxes" situated inside and outside the building; then going down through the gargoyles along the terraces, water is purified by the "cleansing biotopes" and evapotranspires, refreshing the air inside the building hall.
a) stormwater boxes;
b) cleansing biotopes;
c) water collection inner basin;
d) water collection outer basin;
e) underground rainwater storage tank ;
f) underground drainage system.

4 - Green roof and ecological architecture, Mulhouse
Design architect: Duncan Lewis.
Photography by Cesare Corfone.
The social housing complex realized by Lewis in Mulhouse used abundant green materials which contribute to improve the ecological and formal performances of the new buildings. The water collected and then kept by the green roof system is available for the environment, gets absorbed by vegetation or evapotranspires.

5 - Traditional project for public space and not not integrated water management
Design by Cesare Corfone.
Graphic design by Valeria Miele.
The traditional project of open spaces, public parks, fountains and recreational areas needs water from aqueduct and refuses the rainwater use.
a) public parks irrigation with water from aqueducts;
b) management of fountains and water features with water from aqueducts;
c) quick rainwater evacuation through sewer systems.



6 - Stormwater Feature Urban Strategy
Design by Cesare Corfone.
Graphic design by Valeria Miele.
The public space project includes innovative ecological techniques for the rainwater urban management.
a) the rainwater is kept inside the public space and used;
b) the stormwater features use the rainwater biopurified thanks to the water plants' herbal extraction properties;
a) public parks are made of autochthonous vegetation that doesn't need any artificial irrigation.



7 - Rainwater and public space in Potsdamer Platz, Berlin
Design architect: Herbert Dreiseitl
Graphic design by Cesare Corfone and Valeria Miele.
The building complex has covers made of green roofs from which meteoric water is collected and stored in underground tanks. The stored resource once filtrated is reused in the bathrooms' flushes of executive, commercial and tourist buildings. The redundant water is then used for the public park irrigation and as a proper element of the urban public space we can find it in ponds, canals and fountains. This system reuses water after its purification through infrastructures of natural purification of water.
a) green roofing for water filtration;
b) underground tanks for rainwater collection and storage;
c) main rainwater harvesting pond;
d) main waterbody: Kanal Landwehr.