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Bio-Logic City. Ecological infrastructure and digital

The hydropoietic city - water infrastructures for ecological city

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Intro

The "Hydropoietic city - water infrastructures for ecological city" research suggests new generation infrastructures designed to achieve water sustainability goals in urban contexts. Water infrastructures are conceived as ecological management tools for water resources – visible, localized and qualitative - but also as an opportunity to redefine the quality of urban landscape in both well-established cities and new building areas. The infrastructures configuration - plurimodal and multi-function-is coherent with the - underground or surface, natural or artificial, never-ending or seasonal, apparently static or in convulsive motion - hydrographic support. The present research starting point is the concept of the autopoietic orientation of the ecological city: the hydropoietic functioning tends to satisfy the water demand of the system in which it operates through the continuous reproduction of those factors that control water production and preservation. The "Hydropoietic city" view is based on the potential self-production capacity of water expressed in an enduring way of managing urban water cycle for local water utilities.Water infrastructures for ecological city (WIEC) have been proposed as new design categories whose main purpose is to give an answer to urban water management and ecological preservation demands. WIEC overall logic is that the improvement of the quality of the whole integrated urban water cycle.

Autopoietic orientation of the ecological city

Cities' need for water supplies leads to a high exploitation system of natural resources and characterized by an increasing uptake of fresh water from natural water bodies and a return of low quality wastewater. The urban cycle of water conveyance and traditional disposal, is reducing water bodies self-regenerative skills and has produced a big disequilibrium between the urban settlements and their environmental framework. In addition to that there are evacuation systems of meteoric waters from urban soils that, including a constant city water drainage and evacuation process, have really altered the original hydrology. Inevitably consequences such as the urban functioning departure from the environmental genius loci and the obliteration of all-time links between man and water, city and hydrography follow. Nowadays hydraulic infrastructures are clearly disconnected from city spaces: waters are confined to the subsoil that is unknown to urban life and doesn't allow natural cycles to work properly. With the intubation and blockage of the natural hydrographic network the proper working of ecological processes is guaranteed and pervasive urban troubles such as: risk for urban salubrity due to anoxic phenomena which occur within closed channels; flood risk due to possible pipe occlusions; reduction of ground water recharging, ecological exchanges and biodiversity; loss of local identity and *"urbanalization"*(Muñoz 2008). Present-day ecological sensitivity focuses on the correct management of natural resources as the main tool to realize the ecological city, meant as an anthropic ecosystem in harmony with its landscape. We start from the assumption that: *"the key for the solution of global water crises and global cooling of the Earth is in keeping more rainwater within the country to get more evaporated water into the atmosphere, and in having more clouds and a saturated water cycle. It also means more water for people, foodstuffs, nature, smaller risks due to failures in weather, prevention against natural disasters and changing yellow, dried out landscapes into fertile greenery"*(Kravcik 1999). The evolutionary scenario of hydropotable demand, combined with climate change, suggests a global rethinking of the water management models in the cities.

The *"Hydropoietic city - water infrastructures for ecological city"* research suggests new generation infrastructures designed to achieve water sustainability goals in urban contexts: water infrastructures are conceived as ecological management tools for water resources but also as an opportunity to redefine the formal and landscape quality of built-up spaces in both well-established cities and new building areas. A design toolkit has been set up to allow urban conversion actors to look toward an infrastructuring qualitative synthesis ensued from city planning and hydraulic engineering. The present research starting point is the concept of the autopoietic orientation of the ecological city. The urban vision suggested is based on the autopoiesis concept and on the potential self-production capacity of resources of built-up areas. The organization of a big built-up area according to a model based on the autopoiesis improves urban metabolism and reduces the ecological footprint: increasing material and energy internal circulation, which decreases flows and exchanges with the outside environment. The hydropoietic functioning tends to satisfy the water demand of the system in which it operates through the continuous reproduction of those factors that control production and preservation. Just as an autopoietic ecosystem, the City will be able to go on *"creating and specifying his own organization, producing its own elements, with constant disturbances and compensating conditions"* (Varela & Maturana 1972).

City water autopoiesis represents an ideal state where there is a lasting self-production and self-management capacity of water that is necessary for the sustenance of the city itself. The wished scenario is going to be built gradually with subsequent approximations in order to orient a great number of urban water management files. The Hydropoietic City can be thought of as a guiding vision constantly aiming for urban implementation policies and actions. The Hydropoietic City is a conurbation where the water cycle management infrastructures are made following procedures inspired by the self-organization functioning of living systems and capable to start any regeneration process of the water resource. The idea that a urban system could be a bit hydro-demanding and take part of the natural hydrologic cycle - in balance with his larger hydrologic context – goes through innovative views which does not necessarily mean expensive engineering technologies. The suggested functioning model aims to lessen water taken from outside and the exported contamination, so that the urban hydrological footprint is reduced too. What characterizes city hydropoiesis is the high capacity of both outside water conservation (e.g. rivers, springs, groundwater aquifer) and further water resource self-production through the recursive reproduction of those elements which control water formation (e.g. groundwater recharge and stormwater detention basins building).

Urban water bioinfrastructures

Water infrastructures for ecological city (WIEC) have been proposed as new design categories whose main purpose is to give an answer to urban water management and ecological preservation demands. WIEC overall logic is that the improvement of the urban water cycles quality due to the introduction of efficient processes makes the city: healthy - with a lower level of soil, water and air contamination; light- with a reduced ecological footprint on the geographical reference context; florid – high natural elements quantity and landscape quality; valuable - high level of cultural heritage conservation. Such aims are naïve and ambitious, although readily communicable and suppose an ecological qualitative leap made by architectural, urban and landscape design, since: *"the overall project quality represents the outcome of the way it integrates the different varieties involved and the range of interventions planned, according to mutual reliance relations established from time to time and based on the participating actors strategies and context transformability conditions"* (Clementi 2010). The present research goal consists in reaching an interactive synthesis of two urban topics such as: water supply and drainage.

The WIEC can be considered useful infrastructures to deal with these topics and conceived as: "biological prosthesis of artificial naturality apt to replace environmental parts damaged by urban development or re-establish the functioning of those compromised" (Angrilli 2010). The WIEC network – plurimodal and multi-function – is coherent with the ecological and landscape matrix of urban environments and is made up of elements through which those of a new urban water cycle take shape with their formal and figurative qualities which contribute to urban open space and build-up space design. These bioinfrastructures establish a creative dialogue with the natural and anthropic water network, transforming the latter into a proactive net able to restore biological relations and functional connections among the urban parts.

The infrastructural network for the environmentally friendly management of urban meteoric water could be assigned to unconventional models and the simplest supposable urban strategy for the collection and reuse of stormwater is the "stormwater eco-management strategy", in other words 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 a "stormwater features urban strategy" and a "stormwater eco-building strategy".

Nowadays drinking water saving and valorization practices can be still placed side by side with long-standing methods such as water collection that provides a low-cost supply and remarkable environmental benefits. Within a residential building, rainwater admissible uses could cover 30% about of the water demand, and concerning industrial and commercial activities percentages increase considerably. Suitable elements for a proper architectural design able to exploit rain ecological potentiality, following the stormwater eco-building strategy are: green screen, green roof, roof pond, roof spray, rainwater wall, stormwater box, sequential-tiered cleansing systems, intensive green roof. The stormwater features urban strategy is a planning policy which tends to go over the traditional separation between rain management and public space design (public parks and gardens irrigation and water feature management by aqueduct water) through the urban drainage plan integrated in the public space. Stormwater is stored within the open space and used; the water features use rainwater (which has been bio-purified thanks to phytoextraction plants) and so turn into stormwater features; public parks and gardens are made of autochthonous vegetation which does not need an artificial irrigation. The primary elements of this model are commonly called green infrastructures, technical solutions supporting water cycle natural functions, whose approach aims to a “localized, qualitative and visible” management (Mazzotta, 2007).

The present research is based on a classification system both morphological and functional. The morphological classification aims to help the formal approach to the water infrastructures plan and divides them into: “linear infrastructures” (channels, trenches, belts); “punctual infrastructures” (filters, wells, tanks); “areal infrastructures” (lakes, basins, humid areas). The functional classification works according to the performance that the infrastructure offers: “water supply infrastructures” which collect the runoff, slow down the flow of water and canalize it; “water detention and retention infrastructures” to detain and retain water; “filtration and sedimentation infrastructures” to remove sediments and filter water”; “biopurification infrastructures” to remove polluting substances/pollutants through biotopes with herbal extraction properties; “percolation and infiltration infrastructures” which bring water back to ground waters, restoring a high level of soil permeability.

Once verified the possible transformation of the drainage problem into a big urban and environmental resource, in order to assure an overall assessment of the urban cycle sustainability, it’s necessary to describe how to make environmentally friendly the city hydro-potable cycle. It’s supposed to be correct that a city whose samples are compatible with the sources and “whose drains are compatible with the water body which receives them” (Conte, 2009) is a sustainable city. In other words we can consider as “hydropoietic” a built-up area which reaches a stable balance with its environmental context in order to preserve for a long time the water bodies it has and makes use of. First of all it’s important to minimize water impermeable circulation, avoiding a downright production of artificial closed circuits which replace natural fluxes: if water is taken from a source and given back to the river mouth, considerable hydrologic malfunctions are produced. Long adduction infrastructures produce an impermeable and anoxic artificial cycle, which impoverishes the natural circulation and then, when the waste flux goes back into the natural cycle through the purifier, its capacity is often too high compared to the water cycle which receives it, so it can’t be correctly diluted. An important aspect is the hydrographic location and the distance between the sample and the return: taking samples from a water basin and giving them back to another is not recommended because the first gets poor (with the risk of draining the source), while the other one gets swelled(with the risk of eutrophication). If we take samples and make water drinkable from a source close to the users we will minimize losses and reduce the amount of waste; purifying and giving water back in a localized way will minimize the construction of large sewage systems, reducing high construction costs and dangerous infiltration risks of the wastewater not yet purified.

Decentralized wastewater collection and its biological treatment give the possibility of returning a basically purified water to its natural cycle, restoring the minimum vital flux of surface water bodies, impoverished by an excessive cycle anthropization. The best alternative to the current “conventional centralized purification” systems is likely the development of a “decentralized innovative bio-depuration strategy”, that is to say a reticular system for natural purification which allows to distinguish wastewater according to its pollution load, without a loss of both water and nutrients. The development of this strategy would bring advantages from different points of view: a safe capillary purification; local reuse of water and nutrients; slow and decentralized water return to its natural cycle. The innovative localized purification can take place through a capillary use of natural purification infrastructures such as: evapotranspiration and aerated lagoon infrastructures, constructed wetlands and *free water system, horizontal subsurface flow systems and vertical flow bed systems.*

Urban hydropoietic cycle

The WIEC (Water infrastructures for ecological city), providing several performances, aim to carry out five main tasks such as: to reduce the amount of forced water input in urban area; to improve the quality of water output put back into its natural cycle; to cushion flood and drought risks in built-up areas; to reduce the quantity of urban runoff waters and enhance their quality; to improve the ecological health of water bodies related to urbanized areas. The first water input cut takes place through the reductions of both aqueduct losses and end users consumptions. Besides the introduction of policies which allow alternative water sources retrieval - local and renewable – which do not exceed natural regeneration coefficients. A city can make use of alternative sources such as: rain - together with fog, humidity and snow - fallen on that urban area, and wastewater (through separate collection, reuse and recycle) ceaselessly produced by the city itself.

Wastewater employment as a renewable water source makes the waste a potential resource for the society which produced it; the strategy to achieve that is the “urban water recycle strategy”(infrastructural policy which allows the recycle of water before used and purified): through diverse networks aimed at the urban water transportation, recycle and reuse that will reduce water importation drastically, making real the accomplishment of the “ecological urban rehydration strategy” (policy which allows to turn water already used in an evolved and eco-compatible form, apt to water green areas and manage the trophic level of urban areas). Once the amount of natural resource go back to the anthropic water circulation, it will be much easier to improve the water output quality to give back to nature, even if we just consider the smaller effort of existing conventional purification system. The “decentralized innovative bio-depuration strategy”, in addition to the wastewater quality improvement, allows to manage the “ecological geometry” of urban water cycle (relational proportion of the artificial cycle with the natural one) more carefully. Management policies for rain considered as an alternative water source are going to reduce rainwater disposal, since part of this, once purified and stored, will become a reusable resource. Modern hydraulic engineering ejection techniques are going to be replaced by contemporary hydropoietic urban morphologies able to manage a great amount of water, increasing its quality. Spreading urban areas through ecological water supply infrastructures, the disposal, conversion, or integration of the inefficient traditional drainage network will be possible , as well as to manage the usage of alternative water sources, using linear bioinfrastructures both as a connective support and transportation network.

A considerable part of the whole ecological urban re generation will take place through the reduction of the pollution load thanks to a continuous movement of the purification bioinfrastructures waters, in fact they follow in circular succession: retention, filtration, sedimentation, purification and biopurification. The Hydropoietic City exploits the natural process of *biological uptake* to contrast damages caused by pollution spread in the area; such process can remove a great amount of nitrate and phosphate (that once into water bodies produce their eutrophication), reusable nutrients then to improve urban rehydration quality. The reduction of the Hydropoietic City pollution load and the spread of phytoextraction organisms, will develop a virtuous circle that we can define as “*trophic rebalancing”* process of the natural water network, that is to say the natural phenomenon of water bodies ecological self-regeneration, now induced by anthropic proactive and focused actions.

The only long lasting strategy apt to mitigate any phenomena connected with the lack of resources seems to be the achievement of perfect ecological water bodies condition. Rivers, lakes and ground waters in good health will be necessary during dry periods. Ecological water supply infrastructures, increasing surfaces roughness and widening the river or channel bed section, will reduce the runoff speed and avoid fast and violent water entrance into the bed of primary water bodies, producing their overflow. The Hydropoietic City realization will bring water parameters (surface infiltration, surface flow speed, evapotranspiration, evaporation, retention, percolation speed and deep infiltration) back to their natural values. The restored water parameters balance will reduce considerably hydraulic risks due both to excessive water input into the river basin, and to the drastic fall of ground water levels, phenomena caused by soils’ waterproof qualities and traditional hydraulic engineering. It will be essential to keep the ground water level in the urban area in balance, in order to renew and regenerate the local resource and to reduce water importation from far-off sources.

The hydropoietic city morphology

Introducing *“bioregionalism & biourbanism”* concepts, we can say that the approach to the environmental *genius loci* will take place following a relational stratigraphic logic (Williams, 2007). Urban ecologies will be read through the relations between the principal layers surrounding the earth which are populated: troposphere, earth surface and crust. Soil usage planning will follow the relational logic of geographical conformations. Orographic and hydrographic figures and all those elements connected to water basins, landscape figures, ecological figures, could constitute the elements. Winds, rainfall, temperatures and air quality will be other variables necessary in urban planning. Subsoil dynamic studies - aimed at understanding the processes which bear on tectonic stability and affect underground water fluxes (essential for water autopoietic regeneration) - will integrate traditional studies on the geological soil composition.

WIEC will contribute to modify a built-up area morphology and functioning, increasing its quality, “actually considered as a tangible value, since it is perceptible - in experiencing it personally – by all those who live or use a certain space” (Clementi, 2010). Bioinfrastructures can provide a surplus value to the city connected with different urban regeneration components that we can sum up as follows: biodiversity increase; mitigation of the UHI (urban heat island) effect; soil and air quality improvement; cultural, symbolic and hypogeum renewal of urban landscape; redevelopment of building fabric and open space; reduction of energy consumption; climate change adaptability increase.

Urban water infrastructure network could represent a decisive element in the city configuration quality and identity, once conceived according to the criteria linked to: a sustainable usage of available resources, a crossbreeding between artifice and nature, and the (IC) Intelligent City’s digital technology implementation. Water flow daily management - into and from renewable sources supply networks as well as from many small and big basins for meteoric water urban detention and treatment – will take place thanks to digital technologies supported by satellite instruments for weather forecasts. Thanks to the remote monitoring, bioinfrastructures will be used as a public space prolongation - with recreational and cultural functions - which follows the same logic often used for the mobility infrastructures: the *“shared urban space strategy”*.

The bioinfrastructural network could produce permeable morphologies, according to Stevin’s communicating vessels principle, becoming highly connecting, pervasive and tendentially not hierarchic, following a rhyzomatic logic. The system rhyzomatic structure will be made up of dots, lines and water surfaces, organized in a water circle, virtually with neither entries nor exits, beginning or end, coherent with the ecological context of natural hydrographic paths. The Hydropoietic City Network (water supply, detention, retention, filtration, sedimentation, purification, storage, transpiration, expansion, biopurification, aerated lagoon treatment, percolation, infiltration) will have a multiform and rhyzomatic nature, due to water masses which will find their set-up reading the natural hydrogeological functioning of the territory.

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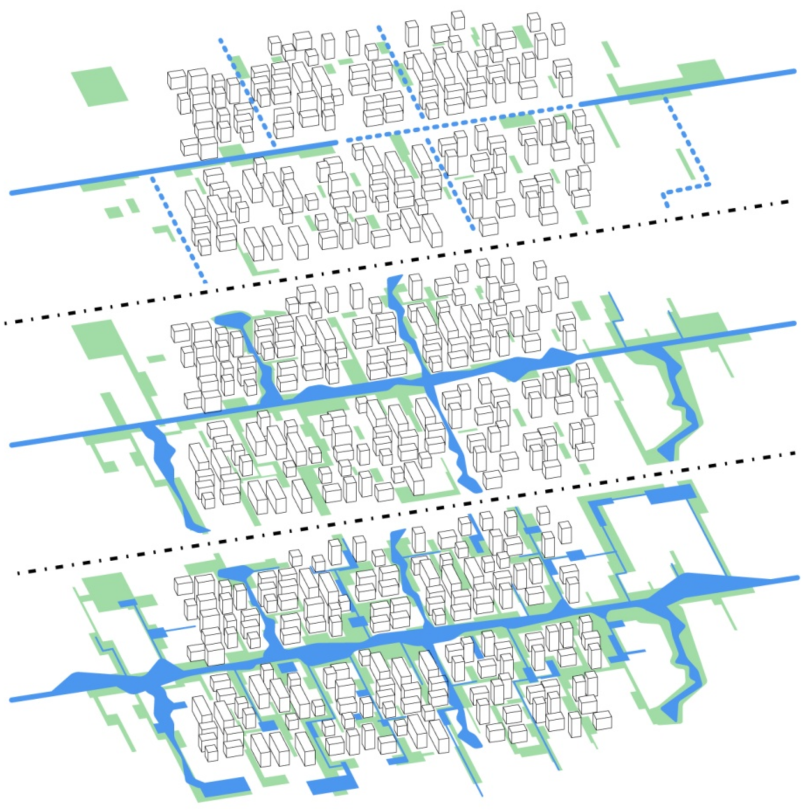
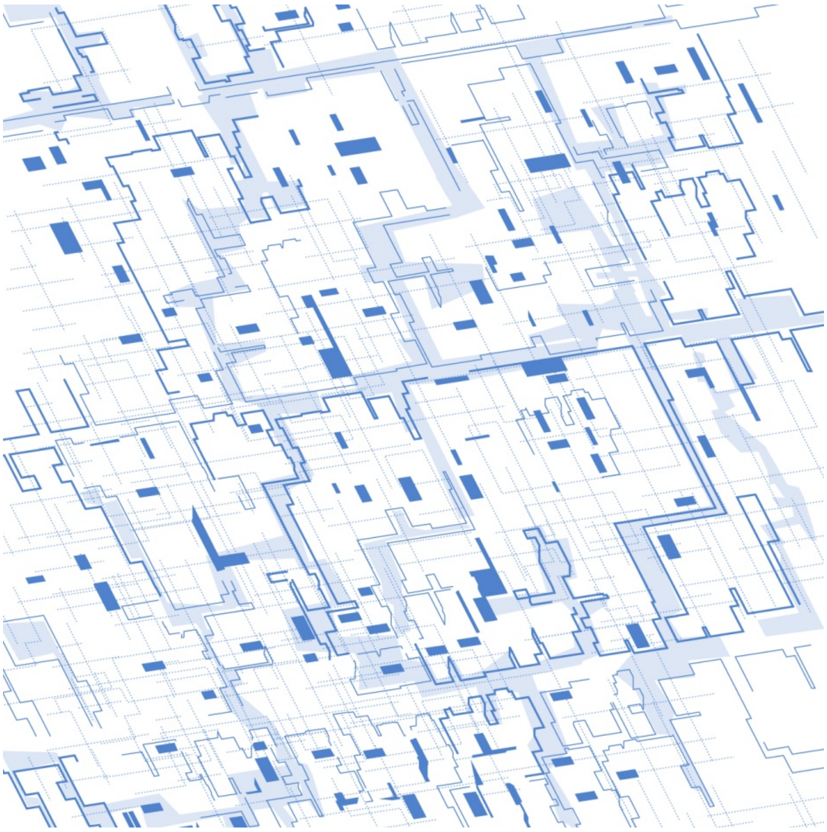
IMAGES

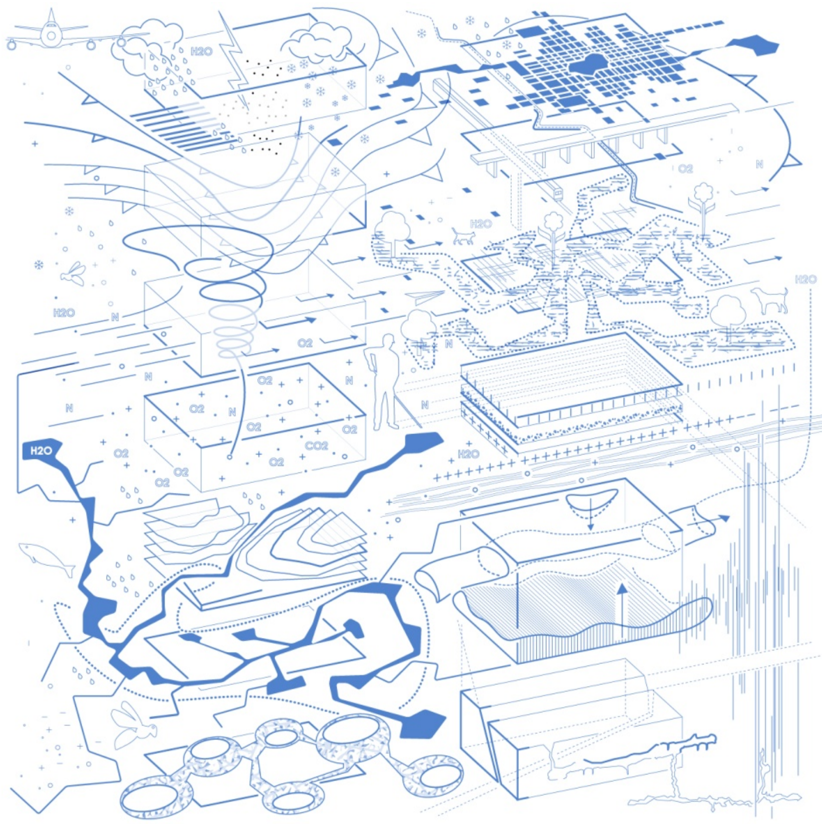
1. Primary elements of Hydropoietic City



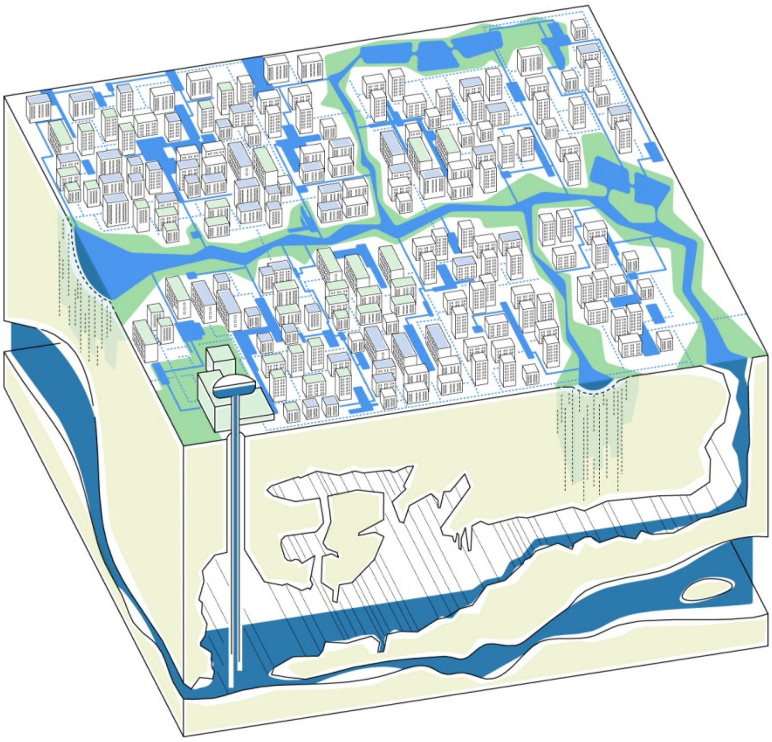
2. Incremental logic of Hydropoietic City



3. Rhyzomatic morphology of Hydropoietic City



4. Morphostratigraphy of Hydropoietic City



5. Water cycle in Hydropoietic City