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On Atmosphere, Water and Soil

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The present investigation portrays an experimental line of design and relational thinking aimed at establishing critical design premises in relation with the present state of change and crisis (Goddard et al., 2015 and Maxmen 2018).

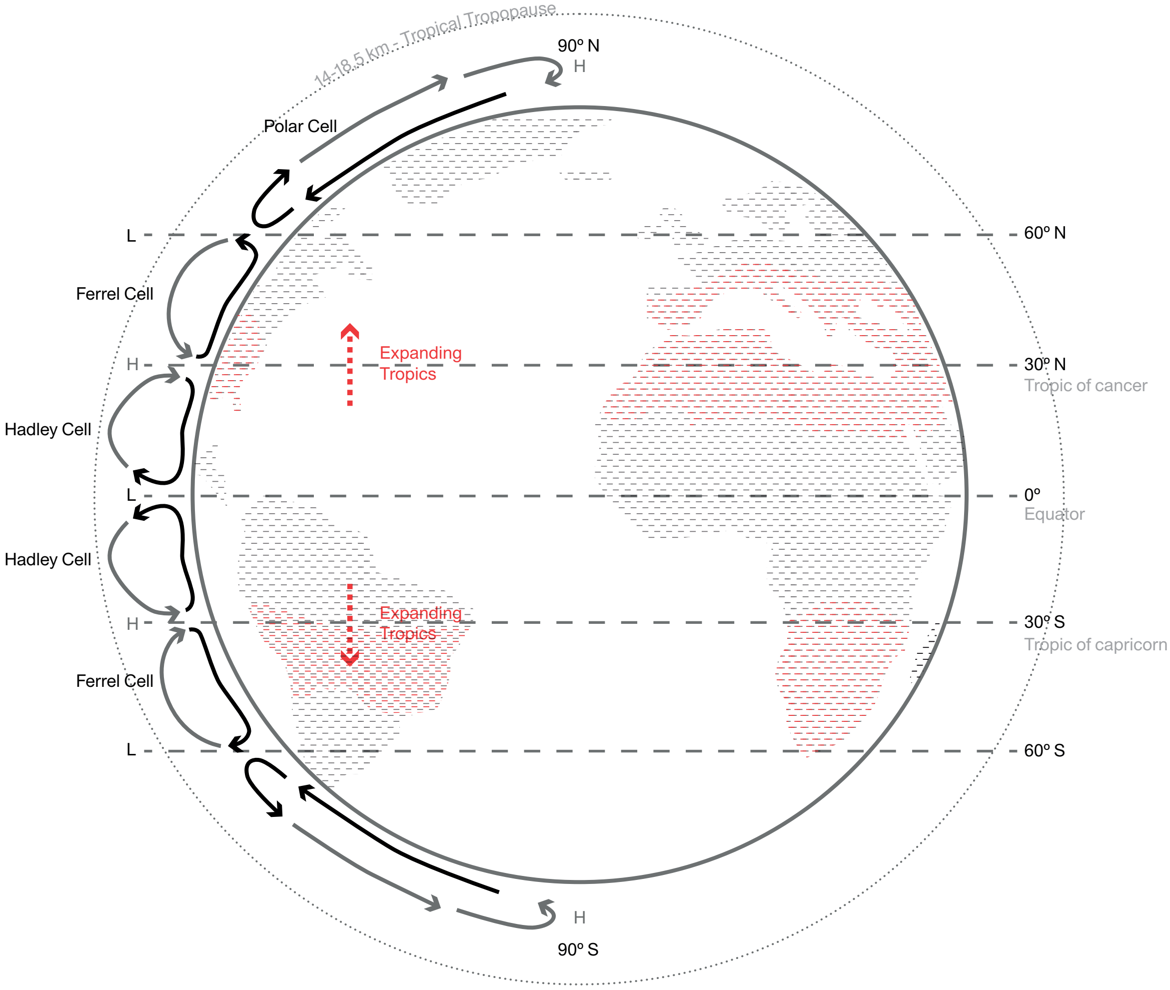
The description of abiotic and biotic shifts within the different realms -atmosphere, water and soil- inform the making of the urban / territorial project so it can contribute to the operationalisation and management of the new conditions of life:

Atmosphere talks about the importance of reading the new biophysical conditions of life through the establishment of a land use system of performances for carbon drawdown.

Water shows the regeneration of ecosystems at watershed level through vegetation density strategies -such as aforestation- to reverse desertification and enhance the water cycle via the Biotic Pump (Makarieva & Gorshkov, 2007).

Both *Water* and *Atmosphere* describe shifting conditions that land on *Soil*, the interface allowing for the interaction of systems, where abiotic conditions are translated and de-codified into biotic conditions. Therefore, Soil identifies the ground (surface-subsurface continuum) as the element of design, the sustaining infrastructure of all living systems, and proposes the transition from current mono-functional land use types to regenerative systems through the inclusion of vegetation diversity and intensity.

The design of the territory of the *new modernity*, as an inter - multi - disciplinary process, must comprehend and project across the whole gradient of urbanisation with the goal to regenerate urban landscapes, that is to say: to regulate atmospheric conditions, manage water patterns, sustain soil health and reconnect stronger culture and nature relations.



CHANGES AT ATMOSPHERIC LEVEL

The current climate crisis coming from the increasing warmth of the planet is technically characterised by an unprecedented amount of carbon in the air (Buis, 2020). This process is due to a particular land use change -from vegetated land cover to built up land cover-, through which carbon is being lost <u>from the ground to the atmosphere</u> more quickly over time (Wu et al., 2020).

The Hadley cell -a large-scale atmospheric convection cell in which warm air rises at the equator and sinks at medium latitudes in both hemispheres- defines tropical climate regions and is one of the major and global engines moving air around the planet. With the rapid increasing warmth of the planet and melting of ice, an increasing volume of water bodies is however shifting evaporation rates and patterns, changing the global moisture circulation patterns in a process coined as the Expansion of Hadley Cells (Hu et al., 2018).

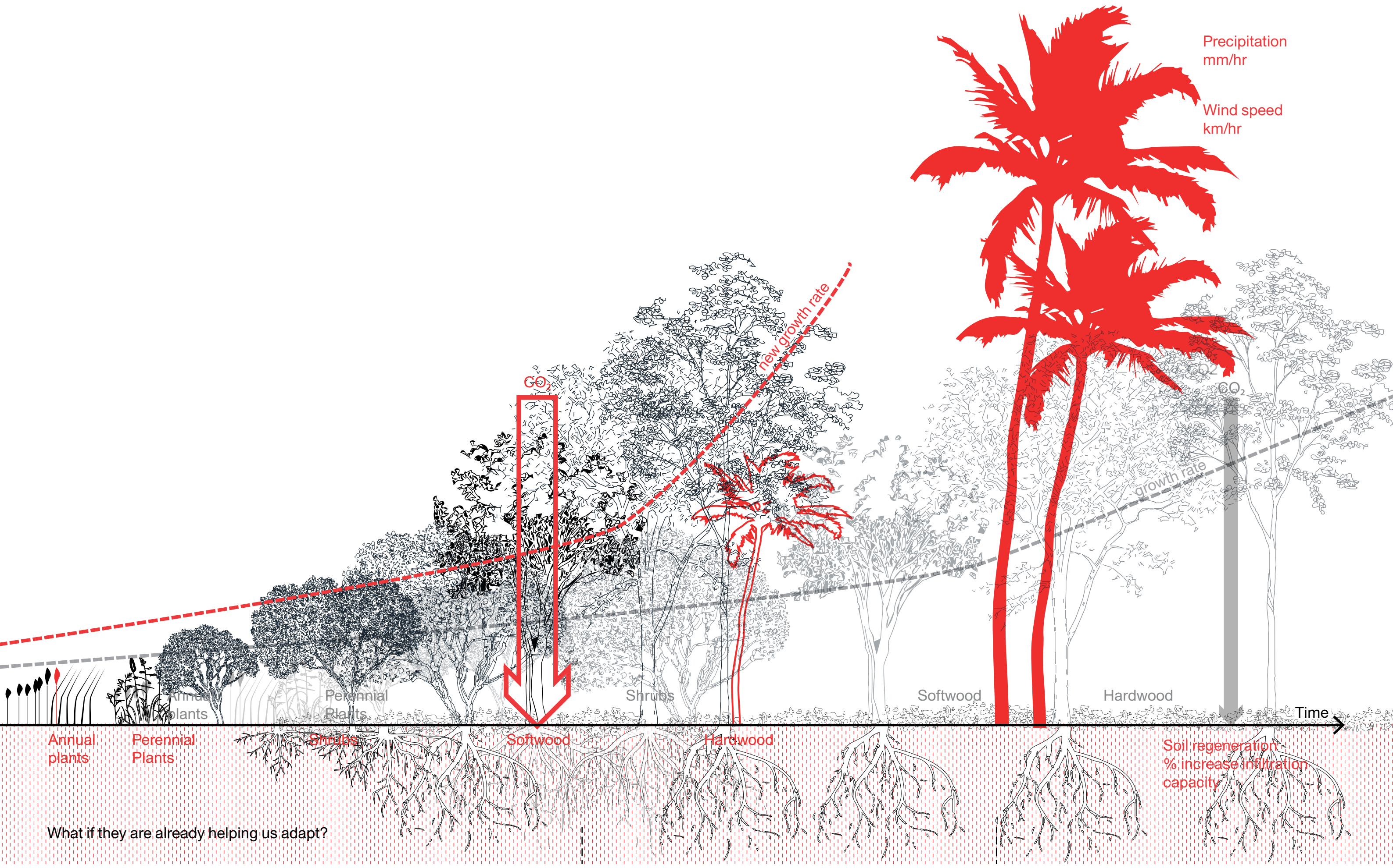
As a consequence, extratropical storms and higher winds are expected in typical 'non tropical' - mid latitude areas (Catto et al., 2019). The implications of these atmospheric shifts are landing in subtropical urbanised coasts such as the Liguria and Veneto region in Italy, where profound changes in the global climate system are being reported (Iannaccone and Valesini, 2015).

THE NEW CONDITION: FROM ABIOTIC TO BIOTIC SHIFTS

Under these atmospheric processes driving climate change the mean amount of water precipitation is, quantitatively, not changing but perhaps rising (Kappa et al., 2015). However, what is clearly changing is the distribution of water precipitation throughout the year: less rainy days and more intense events as 'extratropical' cyclones (Catto et al., 2019).

The new abiotic condition is interlinked with new biotic conditions as CO_2 is of central importance to plant metabolism affecting the growth, physiology, and chemistry of plants (Taub, 2010). Research based on Free-Air Carbon dioxide Enrichment (FACE) experiments, shows how this condition enables most plants to grow faster, shortening harvesting cycles for heat, rice and soybean (Ainsworth 2008; Long et al., 2006 in Taub, 2010). Also, as observed in mid latitudes in Europe the rise of palm trees indicate a shift in ecological succession, where plants are transitioning to other forms that better withstand stronger extratropical cyclones (Xi, 2015).

In an attempt to restore its own homeostasis, *Gaia* is already functioning and adapting to higher levels of CO_2 in the atmosphere.



HOW THIS NEW CONDITION INFORMS THE URBAN PROJECT

If tropical rain events are intense and short periods in which nature transfers back potential services to the land, territorial assets -land- must be designed in a way to retain, collect / store and distribute this potential in order to use it when needed (longer periods of drought). Reclaiming the permeability of our metropolis and the retention capacity of our agriculture becomes an essential modus operandi in the design and management of the urban areas and regions:

Learning from the abiotic shifts, the urban project should harness the potential of new thermodynamic patterns, informed by a revised territorial infrastructural project at watershed and basin scale.

Learning from the biotic shifts, the urban project should take this moment of change to design new co-existence and hybrids of transitioning species which will inform new cultures of the land (agricultures).

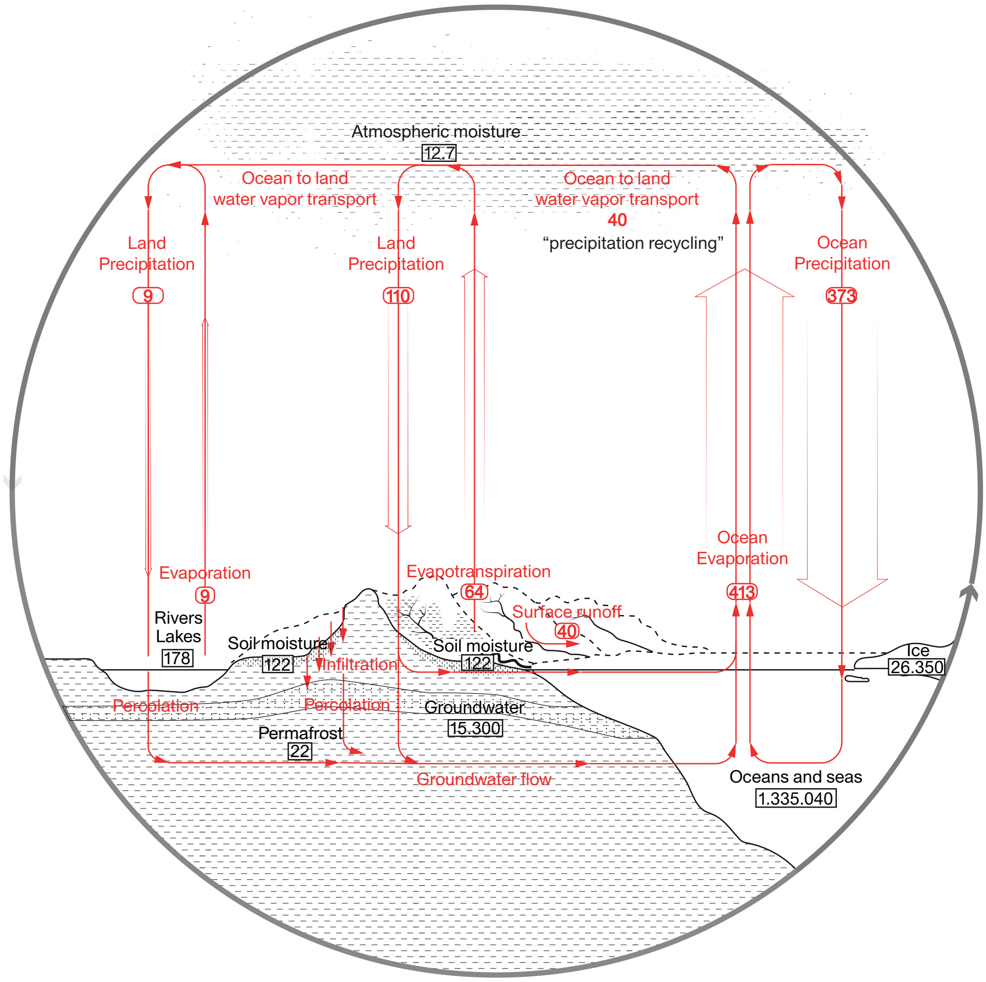
DESIGN PRINCIPLE: QUANTITATIVE PERFORMANCE

The shifts in the Atmosphere realm ask for the projection of new biophysical conditions of living that could inform land use systems of performances for carbon drawdown.

ROLE OF REGENERATIVE SEA/LAND PRACTICES TO MANAGE THIS CONDITION

Regenerative practices that aim at increasing the forested land cover will harness the capacity to produce and re-balance rain patterns as explained with the biotic pump notion (Gorshkov & Makarieva, 2007): mitigating extremes -due to the capacity of forests to allow for latent heat to escape the trap of greenhouse gases and be released into space-, and raising the water retention capacity of our territories.

Atmosphere, water, and soil are extremely interlinked and intertwined. In order to tackle atmospheric issues, we need to shift our perspective on earth and design with the systems of life that both mitigate and adapt to the new abiotic and biotic conditions.



TRANSBOUNDARY HYDROLOGIC SPACE

"Livelihoods depend upon our recognition of the transboundary nature of hydrologic space. Water and energy cycles should be placed at the core of water and land use management and planning strategies." (Gorshkov & Makarieva, 2007)

The earth's rotation together with convection processes are responsible for the lateral circulation of atmospheric moisture known as the "large water cycle" transporting oceanic evaporation and evapotranspiration -from vegetation and soil surfaces- across planetary surfaces from oceans to land. However, on a catchment level, precipitation is recycled by forests and other forms of vegetation and transported across terrestrial surfaces towards continental interiors due to forest-driven air pressure, a process known as "small water cycle" (Ellison et al., 2017). Gorshkov & Makarieva (2007) also describe this process with the notion of the biotic pump of atmospheric moisture, a concept that explains how forests secure moisture flow inland, irrigating territories that, in the case of primary forests -such as the boreal forest in Russia-, can reach up to 7.000km (Makarieva, 2007).

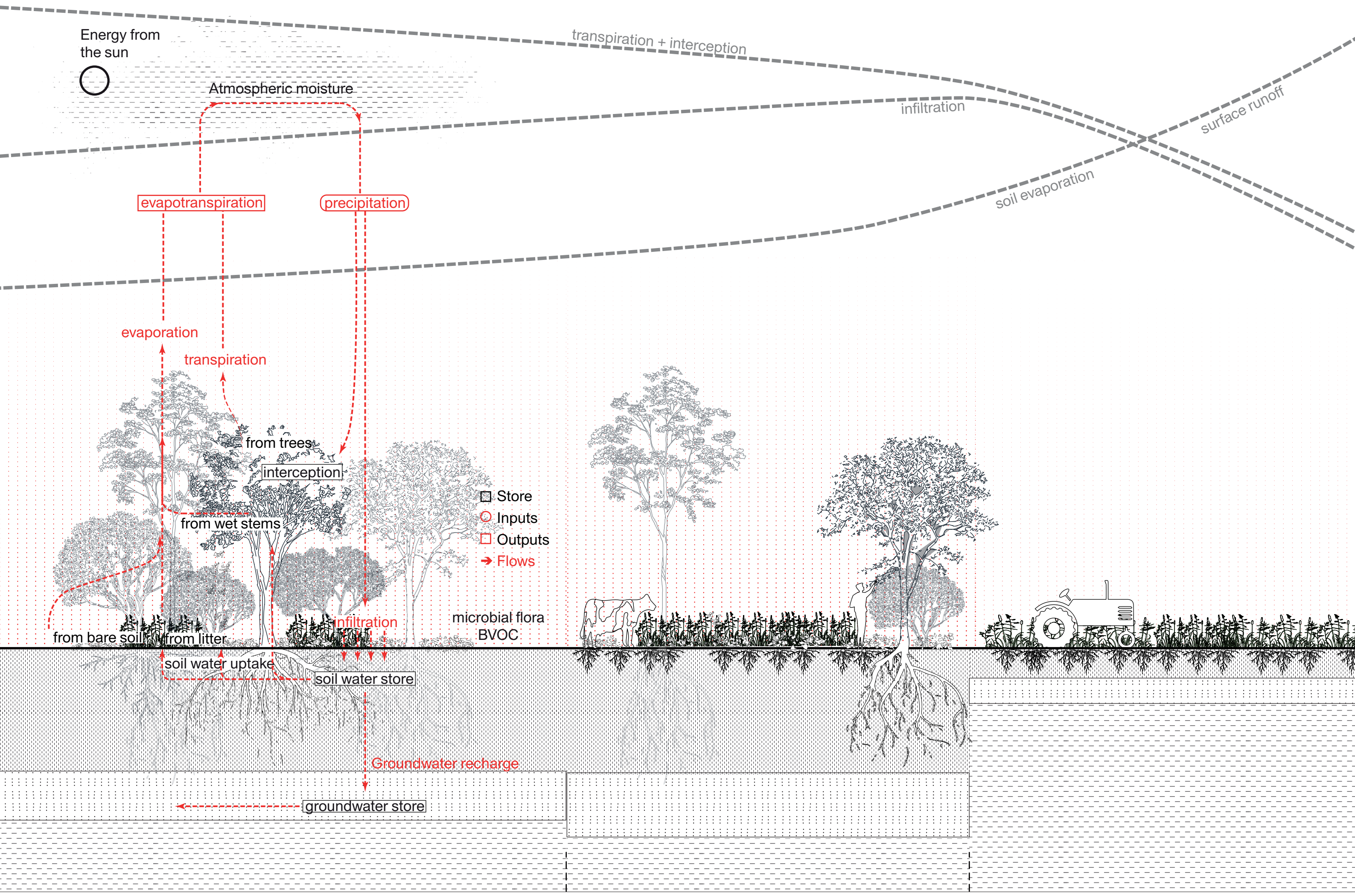
In this sense, evapotranspiration coming primarily from trees is depicted as a syntrophic exchange of water among forms of life. From the macro to the nano scale, the water cycle is greatly influenced by evapotranspiration happening in trees and specifically in leafs. In this sense, forests create, move and spread rain (Gorshkov & Makarieva, 2007).

From the point of view of climate stabilisation, the hydrologic space plays a key role: while the absorption interval of CO_2 molecules covers less than 20 % of the spectrum of thermal radiation of the Earth's surface, atmospheric moisture absorbs thermal radiation rather uniformly over the entire spectrum (Makarieva, 2007). Such climate stabilisation can be performed by natural forests that control the hydrological cycle on land and the adjacent ocean, helping latent heat escape the tropopause.

Conversely, destruction of forests leads to disruption of the hydrological cycle, which expectedly causes significant fluctuations on the magnitude of the global greenhouse effect, leading to complete loss of climatic stability and transition of Earth's climate to a state incompatible with life (Makarieva, 2007).

HOW THE HYDROLOGIC SPACE INFORMS THE DESIGN SPACE

"If you destroy the biotic pump upstream, moisture from ocean will condensate right on the coastline and provoke catastrophic floods" (Gorshkov & Makarieva, 2007)



The biotic pump concept (and more generally the theory of the biotic regulation of the environment of which the former is a part of) for the first time quantifies the stabilising environmental function of ecosystems with respect to the hydrological cycle and pinpoints the physical mechanism that is responsible for this function.

We must elevate the status of ecosystem conservation from a side issue in global environmental talks and treaties (that are exclusively focused on carbon) to an urgent high priority issue.

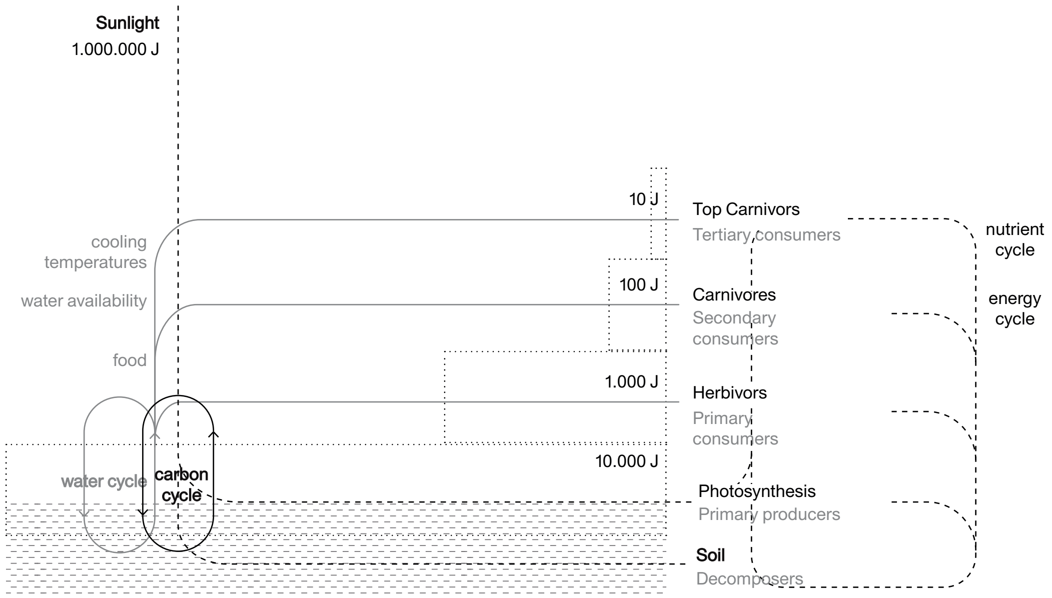
The destruction of local ecosystems -due to urbanisation and intensive land use change such as industrial agriculture and monocropping-, dries out the soil interface, reduces evaporation, condensation and moisture, and causes higher temperature. This albedo effect increases sensible heat and temperature divergence, which in turn, increases the intensity of extreme rainfall events.

Local ecosystems restoration, has therefore a major role on a local level but also, and specially, on a catchment level.

Following this systemic understanding, the importance of the bio-region (Geddes, 1901 & Forman, 2008) becomes crucial in any form of territorial project, land use management and governance programme.

DESIGN PRINCIPLE:
RETAIN, STORE AND DISTRIBUTE

If trees become water, the territorial project calls for the hybridisation of land use patterns through vegetation density strategies. This will result in different forms of vegetation cover and vegetal - mineral mixes that seek ecosystem regeneration. In this sense, this research on water casts light on the re-making of territories following watershed regeneration as strategies to increase watershed biological potential.



ON COOPERATION

As a free deal that arises from the same functioning of earth for millions of years, plants are the sole organisms able to assimilate and translate for us, the main source of life and energy, the sun (Bill Mollison in Murakami, 1991). As Coccia (2019) articulates, "photosynthesis is a great atmospheric laboratory in which solar energy is transformed into living matter" (p. 37).

From abiotic to biotic processes, soil is the interface of around 2m depth, in which geosphere, atmosphere, biosphere and hydrosphere come together. As these spheres interact, providing water, carbon, nitrogen and nutrients, the ground acts as a temporary reservoir –of water and carbon– but also as the media where transformation and assimilation of nitrogen and nutrients takes place. In this sense, the soil is here defined as the crucial mediator, the most essential infrastructure supporting life on Earth.

The formation of soil and, with it, life as we know it, tells a history of cooperation of mutually beneficial relationships -from lichens 700 million years old- to mycorrhizae -500 million years old-, that ultimately provided the fertile conditions for plants to colonise land (Asher, 2015).

This moment of colonisation entailed, for the plants, the possibility to develop extensive vasculature, leaves and rooting systems; and for the soil, the enhancement of sufficient organic matter and structure that, eventually, enabled stability against erosion (Asher, 2015).

"Thanks to roots, the vascular plant, alone among all living organisms, inhabits simultaneously two environments that are radically different in their texture, structure, and organisation and in the nature of the life that inhabits them: earth, air, sun and sky." Coccia (2019, p.80).

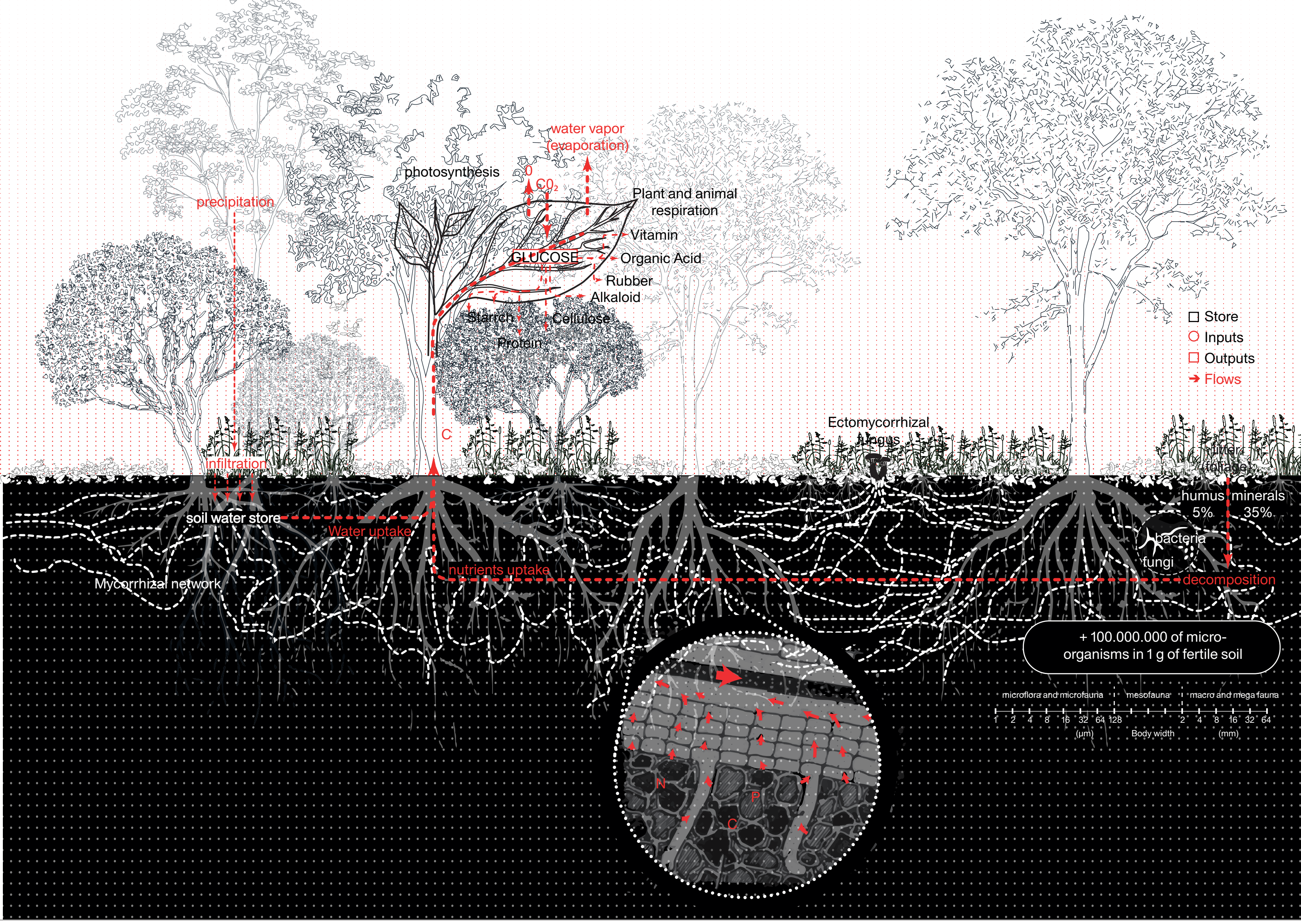
As cosmic mediators (Coccia, 2019), roots are therefore hybrid beings with a double character, between biotic and abiotic, between two radically different environment conditions and spaces.

PROCESSES DRIVING THE DEGRADATION OF THE SOIL

In a lapse of a couple of hundred years, man-steered changes on land-use and land-cover, and particularly, industrial agricultural practices are threatening the 500 million years history of soil formation and its performance to support life.

Due to the increasing pressures exerted on the soil, below-ground life is under threat. Among all the pressures, intensive human exploitation through industrial agricultural practices is threatening the soil microorganisms, soil fauna and soil functions (Orgiazzi et al., 2016).

In particular monocultures and their need for industrial fertilizers, nitrogen / potassium / phosphorus, deplete the soil, which transforms from carbon sink to carbon source. According to Murakami (1991), in comparison with holistic and regenerative agricultures which imitate



the productivity model of food forests, conventional land management and industrial agriculture lead to soils with: less ground cover, fewer roots, less carbon stored in soil, less water retention in topsoil, depleting groundwater, more erosion, less bioproductivity, less diversity, more carbon in the atmosphere.

The urban project -as it unfolds today- is in direct correlation with the degradation of the soil infrastructural space, compromising its performance as a temporary reservoir -of water and carbon- but also compromising its capacity to assimilate nitrogen and nutrients. These degrading processes come together with increasing erosion and imperviousness of open spaces, setting the ground for floods in the events of extreme rainfall.

THE URBAN PROJECT AS AN INFRASTRUCTURAL PROJECT

The understanding of the unseen, through the representation of abiotic-biotic processes, asks for the redirecting of the role of urban landscape practices. As part of a super-organism, land transformations -that enable urban life- should seek to regenerate the relationships among the rest of the living systems.

The research calls for an infrastructural project that restores the biological capacity of soils along with water retention, carbon absorption, nitrogen and nutrients assimilation and recycling.

ROLE OF REGENERATIVE SEA/LAND PRACTICES TO RESTORE THE SUPPORTING CAPACITY OF SOILS

According to Murakami (1991), in agricultural systems, the hybridisation (increased of ecological density) is associated with holistic land management and other techniques of regenerative agriculture.

These systems mimic the systemic relations happening in ecosystems: continuous soil formation, maximization of soil organic matter, diversification of actors (species) resistance to pathogens and insects, nutrients retention, high functioning of soil microbiome, high precipitation use efficiency, and no fossil fuel dependence.

The urban project should design, plan and manage the hybridisation of the open space-built up gradient including a range of ways in which forested systems, vegetation diversity, and material practices can be implemented in order to regenerate the biological capacity of soils.

DESIGN PRINCIPLE: COOPERATION

The research *On Soil* describes the importance of cooperation, a strategy that can be translated into a design principle as the seeking for alignments, synergies, and diversification. In this space of cooperation, different land cultures shall arise and define new interspecies dependencies, temporal dynamics, postindustrial and post-anthropocentric cultures.

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