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NOTE

PROLOGUE

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ESSAYS AND VIEWPOINTS

RESEARCH AND EXPERIMENTATION

DIALOGUES edited by Ingrid Paoletti and Maria Pilar Vettori

Architecture and the "imaginary planet". Projects and technologies for an intermediate landscape in the city

ESSAYS AND VIEWPOINT

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Abstract. The traditional ecological and environmentalist thinking that theorised the 'return to nature' by contrasting cities and nature seems to be unable to remedy the destructive relationship between city and biosphere. For this reason, it is necessary to rethink the relationship between anthropised and biotic systems, in order to respect the objectives of the Paris Agreement. This rethinking process involves imagining a 'third space' with a positive environmental value, much like an intermediate landscape in which buildings and urban realities can be designed - in a backcasting process - as tools capable of incorporating different types of 'biospheric' capabilities. The essay investigates urban forestation technologies by evaluating their potential and long-term limitations in extreme climatic scenarios.

Keywords: Urban Forestation; NBS; Climatic Scenarios; Urban Regeneration; Intermediate Landscape.

Climate change scenarios and images of intermediate landscapes

Despite the evidence of the risks associated with an extreme rise in temperatures, reported by scientific reports (IPCC, 2018) and by the Press (New York Time, 2020), the fight against Climate Change (CC) seems to affect only part of the international community, as the recent failure of COP25 shows (UNFCCC, 2019). The absence of a global agreement for the reduction of greenhouse gas emissions (GHG) and their removal from the atmosphere, in fact, makes it almost impossible to respect the limit of +1.5°C, as established by the Paris Agreement (European Commission, 2015). In this context of uncertainty many studies, including Climate Action Tracker (CAT), prefigure different CC scenarios (Fig. 1), calculated on the real capacity of national policies to reduce climate-altering gas emissions in the atmosphere in 2020-25-30. CAT, for example, defines a CC range from a minimum of + 1.5°C (ideal scenario), to + <2°C (compatible with the Paris Agreement), to <3°C (insufficient), to <4°C (highly insufficient), up to >4°C (Critically insufficient) (Ritchie and Roser, 2019).

As global warming increases, the risks for urban areas, which are the most vulnerable to CC due to the high concentration of people (in 2050 two thirds of the world's population will live in cities), infrastructure and economic activities, will grow accordingly. For this reason, as Habitat III hopes in the New Urban Agenda roadmap, it seems to be necessary to rethink urban systems and their physical form by interpreting the urban settlement as a source of solutions and not as the cause of the problems that the planet is facing. The increase in the urban heat island, water management, loss of biodiversity and increase in air pollution, according to the CDP Disclosure Insight Action, are some of the risks to pay attention to (CDP Global, 2019). In fact, these risks could be potential causes of the non-habitability of many territories, including coastal and the Mediterranean areas, which are among the most populated regions today.

To cope with these environmental scenarios, numerous public administrations and private companies have decided to invest in the transformation of cities, proposing to transform the 'grey' spaces into green areas, vegetable gardens or urban farms. This presents numerous benefits (Fig 2, top): cost savings, flood risk mitigation, habitat creation for urban fauna, reduction of air and heat pollution, and food production.

Once the assumptions of the industrial revolution are exhausted and the progressive reduction of ecosystem services provided by the natural environment is evident, the image of the Garden City Tomorrow by Ebenezer Howard is replaced by new dystopian and utopian visions. Dystopian visions are like the ones already described in numerous apocalyptic films. Utopian visions are like the ones defined by the artist and activist Bert Theis or Vanessa Keith of Studio TEKA who, in The City After Climate Change, prefigures a city of 2100 (Fig. 2, in the centre). These images, as stated by the thesis of the sociologist Saskia Sassen, together with those elaborated by other well-known designers (Fig. 2, below), demonstrate the need for a 'third way' in which the contrast between artificial and natural - typical of contemporary settlement systems – has to be rethought, identifying a new model capable of overcoming this dichotomy and defining a third intermediate space, a bridge between the biosphere and the urban environment (Sassen, 2016). This would be a hybrid interstice where different positive articulations can be experienced, using innovative knowledge and technologies. The rethinking process is about imagining and building a 'thirdspace' with a positive environmental value, which can function as a reserve of capacity to draw on in order to improve the living conditions of the residents. An intermediate landscape (Desvigne, 2008), in which buildings and urban realities are imagined and designed - in a backcasting process - as tools capable of incorporating different 'biospheric' capabilities. Today, the ecological and environmentalist thinking, which prevailed decades ago and which theorised the 'return to nature' by contrasting cities and nature, is, in fact, proving no longer sufficient to remedy the city's destructive relationship with the biosphere. For this reason, it is necessary to use the urban built environment as a tool for incorporating and developing the biosphere's capabilities.

Methodological assumptions for the study of technologies for the intermediate landscape

If we consider the city as 'a type of socio-ecological system with a broad expanding spectrum of connections with nature's ecologies', these connections can be used to improve its sustainability by exploiting its systemic complexity and multi-scalar capacity (Sassen, 2012). Since, as is well known, cities incorporate a variety of nested scales in which a given ecological condition works, interventions at the micro-level can represent, in an upscaling process, effective interventions also on a global scale. In this sense, technological solutions to mitigate CC at the city scale also become a key element for implementing environmental policies.

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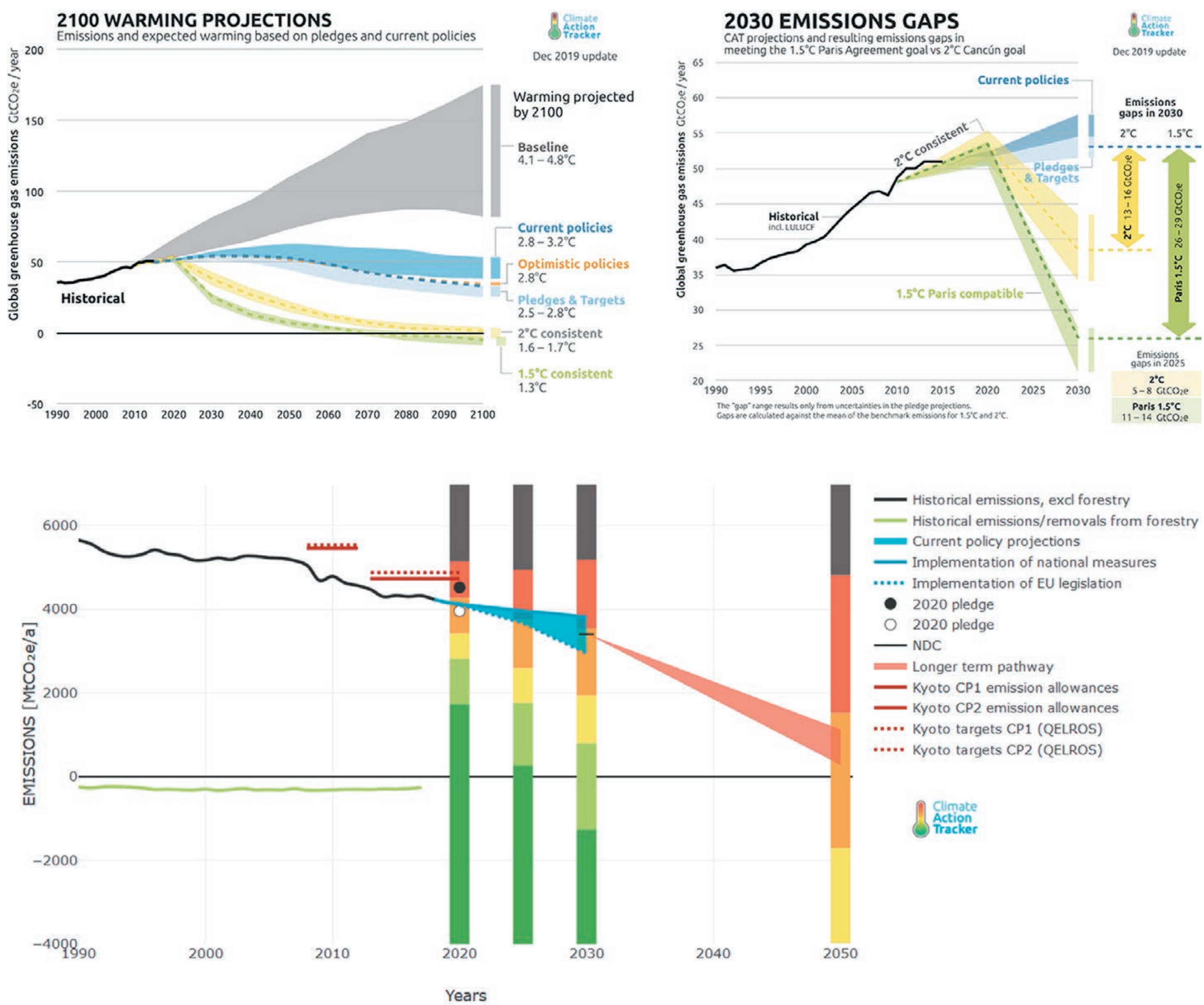

01 | The images show (top) the changes in the climate scenarios compared to the possible worldwide policies adopted in order to reduce CO_2 emissions and (bottom) the climate scenario linked to the current policies adopted by the European Community (<3°C) (source: https://ourworldindata.org)

The paper fits into this cultural framework and analyses the contribution that some urban forestation technologies (UFT) can have in order to redefine future scenarios for architecture. The study limits the research field to the implications that CC may have in the short and long term on the performance of these technological systems.
In section 1, CC scenarios and main urban risk have been identified and described.
In section 2, methodology has been described.
In section 3, some case studies exemplify UFT and limit the research just to some of these.
In section 4, the performance variations of UFT with respect to the different climate scenarios are analysed, as well as the risks identified in section 1. To achieve this goal, an interdisciplinary literature review is developed based not only on research pertaining to the technology architectural design, but also on research related to other disciplines (i.e., urban ecology). The considered studies, mainly chosen among those reporting direct verifications of the performance of the technological systems, allowed to depict how the performance of UFT could vary in relation to the variant of the Climate Scenario and the identified risk.
Based on these data, the paper reconsiders the performance framework with respect to various environmental risks (heat island, rainwater cycle management, water consumption, biodiversity reduction, energy consumption, CO_2 reduction) in the five climate scenarios defined by the Climate Action Tracker. The performance study, which is carried out on a case study, is developed through a qualitative system analysis based on quantitative data derived from scientific research.
In section 5, UFT potential and limitations are discussed and, thanks to some innovative best practices, new research fields are identified in order to improve the performance of urban forestation technologies.

02 | The image shows scenarios of imaginary cities: at the top, Bert Theis' Utopia Island (source: Isola Art Center-ostra Aggloville, Turin 2015); centre, 2100: A Dystopian Utopia - The City After Climate Change (source: Studio Teka); below, Grand Site Tour Eiffel by Gustafson Porter + Bowman (source: Gustafson Porter + Bowman)

03 | The figure shows some examples of "external technologies" at the top (MOF Park and Oerliker Park, Zurich), "edge technologies" in the centre (NY roofs and detail of the green façade of the Musée du Quai Branly, Paris) and "internal technologies" below (vertical farming in the greenhouses of Ilimelgo)

03 |

| 02

Technologies for an intermediate landscape

Moving away from more consolidated approaches, some contemporary architecture experiments performed at different scales show innovative technological solutions for CC mitigation and adaptation. These solutions work on an intermediate landscape in which the artificial and the biotic systems relate, hybridise and complement each other (Raymond *et al.*, 2017).

These approaches to urban forestry find multiple applications, coded in this study, such as:

1. "external technologies", technologies that interact with the open space;
2. "edge technologies", technologies that interact with the building envelope;
3. "internal technologies", technologies inserted within volumes and buildings.

Examples of "external technologies" are the recent urban forest planning in Paris and Prato, the integration of greenery in Zurich, such as the MOF Park, characterised by a green infrastructure, and the Oerliker Park, defined by a real urban vivarium (Fig. 3, top), and the design of the Passeig Sant Joan by Lola Domenech.

Examples of "marginal technologies" are the pioneering experiences of Patrick Blanc and his thin vegetable facades, testified by the famous projects of the Caixa Forum in Madrid, the Musée du Quai Branly in Paris, and the thick green façade that grows on a special metal structure, tested by ENEA at Casaccia (RM). Green roofs are also examples of this typology, which is useful for new buildings, as shown by Renzo Piano's project for the California Academy of Science in San Francisco, or for implementation in modern cities, as supported by the legislation for green roofs introduced in 2018 by the New York City Council (Fig. 3, in the centre).

Examples of "internal technologies" are greenhouses integrated into buildings, like the garden designed by RPW in the NY Times building, or hydroponic systems, which find application, also from a production point of view, in London's underground urban framing experiments or in the hybrid buildings that integrate food production (SOA), intended to build urban vertical farming (Ilimelgo), or self-sufficient and sustainable neighbourhoods (Effect) (Fig. 3, below).

Despite being insufficient to describe an exhaustive picture, these examples, however, show how it is increasingly plausible to imagine extending greenery - where possible - in cities and to configure buildings and open spaces in order to recreate a new nature, a hybrid city. This scenario requires a non-traditional approach due to the requirement not only of specific skills (in the field of biology, materials science, agronomy, geography, physics and engineering) but, above all, of different figures assigned to the development of urban policies of public interest with the involvement of citizens. Numerous studies are evaluating the actual effectiveness of urban

04 | The image has been reworked by the authors on Climate Central data (CLIMATE CENTRAL, 2020)

05 | The image represents an example of the performance of the forestation technologies analysed with respect to six risks and to the five CC scenario (1-5). Effectiveness was assessed on a -2/0/2 scale, with the values indicating respectively a loss, constancy or an increase in performance, thus describing their potential effectiveness

to quantify, for example, the ecosystem effects (Wang *et al.*, 2014), to demonstrate a close correlation between their concentration and the reduction of pollutants (Irga *et al.*, 2015) , or to evaluate their benefits in terms of heat island reduction (Orsini and Marrone, 2018) and, again, to control the negative effects of gentrification processes (Haase *et al.*, 2017).

Even if the early results of these studies seem to support their effectiveness, little is known about the evolution of the performance of UFT in case of extreme or, at least, variable scenarios.

Performance of forestation technologies and climatic scenarios

Imagining backcasting scenarios or formulating dystopian scenarios would allow us to face the evaluation of a design and technological solution by imagining, backwards, both potential and limitations in the long term or in an extreme scenario. Five hypothetical climatic macro-scenarios, proposed by CAT were discussed to support a discussion on UFT. The analyses were conducted using the city of Bologna as a case study, for two main reasons: Bologna can represent, at a national level, the type of urban settlement of the Po Valley, and it is the most densely populated Italian natural region. Furthermore, due to its geomorphological conditions, Bologna represents an urban context extremely that is vulnerable to CC. In fact, in the most severe scenario, it would reach average temperatures similar to those of Port Said, in Egypt (Fig. 4). Hence the decision to analyse only some technological solutions of forestation, among the most widespread ones, easily implemented in urban contexts and representative of external, edge and internal technologies, particularly:

1. green roof;
2. rain garden;
3. green façade;
4. green structure;
5. trees.

The performance of the UFT, extracted from the data of the scientific literature, is analysed and elaborated in graphs that report their variation with respect to the climatic conditions analysed and to the risk considered. The effectiveness was assessed on a -2/0/2

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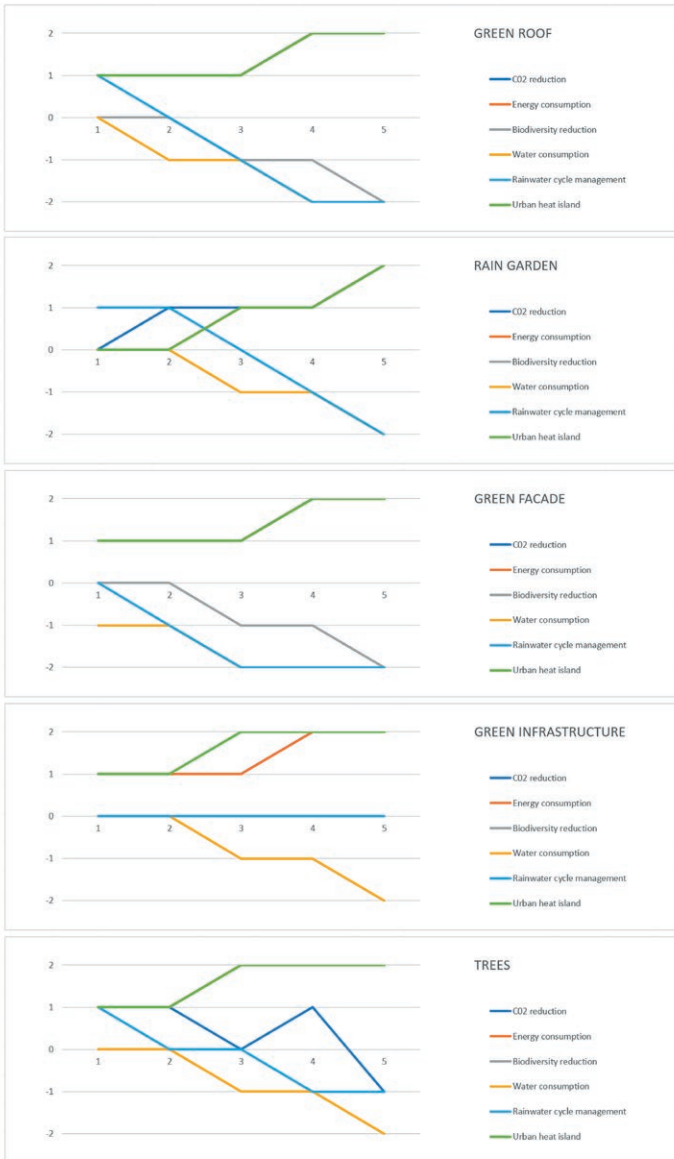


scale, with the values indicating a loss, constancy or an increase in performance, respectively, thus describing their potential effectiveness (Fig. 5).

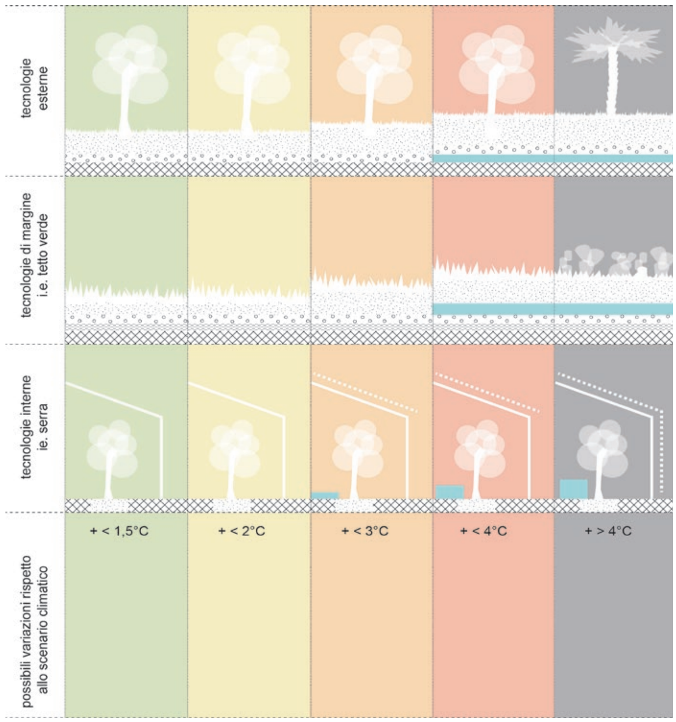
From the analysis, some considerations emerge on the potential, limitations and possible corrective actions of the forestation systems considered, which are shown in table 1.

In general, it can be observed how the UFT, with increasing temperatures, either maintain or increase their effectiveness allowing a reduction of: the energy consumption of buildings; the effects of the urban heat island; the air temperature, thanks to the effects of green cover, evapotranspiration, surface temperatures and, therefore, average radiant temperatures. At the same time, however, as temperatures rise, there is a loss of efficacy against risks, such as CO_2 absorption or water stress. Furthermore, scenarios with a strong increase in average temperatures could also correspond to alterations in the rain cycle (increase in intensity associated with a reduction in distribution over time) with consequent drought periods, harmful to some forestry technologies, such as the garden roof and the green façades.

06 | The figure outlines possible adaptation processes of forestry technologies to varying climatic conditions, highlighting that, as temperatures increase, it is necessary to increase the thickness of natural substrates, to introduce rainwater management and accumulation systems, and to adopt suitable plant types to extreme climatic scenarios

07 | The figure shows some examples of innovative technologies. Top, the Air Factory of PNAT; centre, the BIUP House of ARUP; below that, the tent with algae from EcoLogicStudio; bottom, the American Pavilion of Expo 2015

06 |



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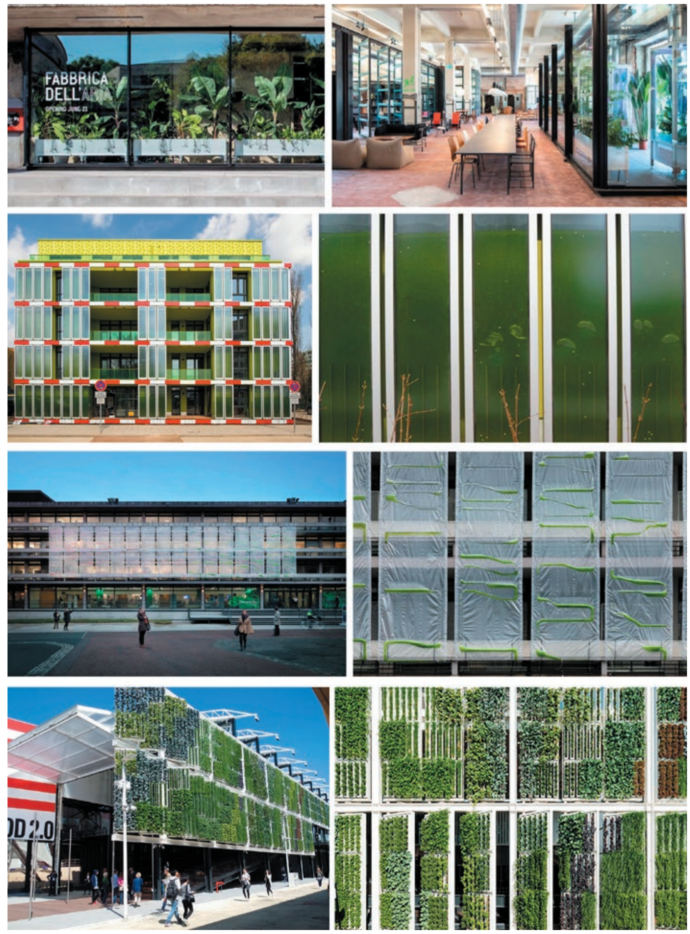

Beyond urban forestation technologies: innovation scenarios

UFT offers interesting solutions to increase the performance of eco-systemic services in urban settlements and, thus, contribute to the reduction of environmental risks due to CC. The increasing spread of these strategies, highlighted by numerous recent urban forestation plans, is tracing a third way for urban development, characterised by an intermediate landscape in which the biotic and anthropic systems coexist, overcoming the artificial/natural dichotomy that has characterised human history. In this context UFT can improve the mitigation of the negative effects imposed by CC, on the one side, but can be strongly affected by it, on the other.

This essay investigates the performance variation of UFT in five climatic scenarios characterised by an increment in average temperatures. From this study, in general, it emerges that a sharp increment in temperatures, with a consequent environmental alteration, may compromise the performance of some forestry technologies with respect to certain risks, such as the absorption of climate-changing gases or the management of the water cycle, reducing their absorption capacity during heavy rains and requiring greater quantities of water during periods of prolonged drought (Fig. 6).

Today, the possible loss of effectiveness of some UFT, compared to particular extreme climatic scenarios, becomes an interesting area for new research fields with the aim of developing new systems or components that, as plug-ins, are able to make the various technological systems adaptable to changing climatic conditions, either maintaining or increasing efficiency. In support of this thought, some forestry experiments (Fig. 7) are moving in this direction, hybridising technology with nature in order to produce energy, purify the air and improve urban food production.

A first example is the 'Air Factory', developed by the Start Up PNAT of the University of Florence. This system is based on a glass box containing several plants with huge leaves. The system works by purifying indoor air by using the soil and the huge leaves of the plants. It can filter 5,000 cubic metres of air per hour, reducing atmospheric pollutants by 98%. This technological device develops a controlled environment for the plants in order to protect them from the possible extreme effect of CC and guarantees their performance, integrating them into building spaces.

The use of algae application on the façade, tested for example by ARUP in the "BIQ House" or by EcoLogicStudio during the Climate Innovation Summit (Dublin, 2018), is another example. ARUP's idea is based on a new stable façade with glass panels incorporating algae. The solution allows the implementation of these green technologies even when the climatic conditions vary. Furthermore, growing the algae into the panels allows different uses, like biomass production and hot water for heat exchange (solar collector), achieving around 30 kWh/m^2 energy for each system (ARUP 2020). The prototype of EcoLogicStudio is based on the same principles as ARUP's prototype but with simpler and lighter technologies that can be used for rapid and inexpensive retrofit strategies. Each panel, with a surface

Tab. 01 | The table shows the scientific references of the study and a synoptic picture of the potential, limitations and possible corrective actions that can be introduced

| Tab. 01

Risk		Effects of climate change on forestation technologies	Reference
Heat island	+	The increment of temperatures increases the differential between outside and inside, and therefore the effectiveness of green technologies, compared to traditional technologies.	(Berardi, GhaffarianHoseini and GhaffarianHoseini, 2014) (Zhang *et al.*, 2019)
	-	Thermal stress of plants, especially in systems with little plant substrate, could be a problem that can be solved with an increase in irrigation or with the selection of species with reduced water requirements.	
Rainwater cycle management	+	Water absorption capacity with strong reduction of the sewer load. Water purification.	(Klein and Coffman, 2015) (Moghadas *et al.*, 2011) (Debele *et al.*, 2019) (Vanuytrecht *et al.*, 2014) (Liu, Li and Yu, 2019)
	-	With extreme phenomena, the positive impact is reduced. To remedy this problem, systems for the accumulation of water (storage tanks) or systems that allow greater infiltration of water into the subsoil (canals) could be integrated.	
Water consumption	+		(Szota et al., 2017) (Menzel et al., 1995)
	-	An increase in temperatures corresponds to an increase in arid periods, with consequent water stress. The problem can be solved by using plants suitable for scarce rains or by increasing the thickness of the substrates in order to retain greater soil moisture.	
Biodiversity reduction	+		(Madre et al., 2013) (Radić, Dodig and Auer, 2019) (Zhang *et al.*, 2019)
	-	Risk of biodiversity reduction with increasing climate, also due to possible non-native predatory species.	
Energy consumption	+	The effect of green roofs allows to reduce energy consumption for cooling, as temperatures increase, their effectiveness increases.	(Chan and Chow, 2013) (Talaei, Mahdavinejad and Azari, 2020) (Campiotti, Giagnacovo and Nencini, 2020)
	-	Thermal stress of plants, especially in systems with little plant substrate, could be a problem that can be solved with an increase in irrigation or with the selection of species with reduced water requirements.	
C02 reduction	+	Green technologies generally prove to be useful systems for reducing the CO_2 present in the urban atmosphere.	(Bastin et al., 2019) (Foster, Lowe and Winkelman, 2011) (Wang *et al.*, 2014)
	-	Drought reduces plants' ability to absorb CO_2. The problem can be solved by increasing the areas planted and using plants resistant to hot climates.	

area of 2 m^2 and 50 kg of weight, is able to absorb 22 kg CO_2/year, the same quantity as a 5,000 kg mature tree (Photosynthetica, 2020). The production of vegetables, in addition to the aforementioned urban greenhouses, has also recently been released in the "American Food 2.0" pavilion for expo 2015 by architect James Biber. Developed by the startup Bright Agrotech, the structure is a particular façade that integrates hydroponic systems for growing vegetables and producing food every two weeks in an urban centre.

These innovative experiences show possible interesting scenarios to develop new technologies capable of dealing with CC that will affect our cities, and to define new models in which the anthropic system and the biosphere merge into an "imagined" rather than an "imaginary" planet.

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