The concept of a 'regenerative city': How to turn cities into regenerative systems

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Abstract   During the COVID-19 pandemic, the world has been going through a veritable global 'vulnerability experience', ultimately revealing the interconnectedness of both global and local challenges such as health, pollution and climate change, biodiversity, and food and energy supply. The pandemic has prompted us to rethink the way our cities are designed in order to promote future-proof models that are in harmony with the local conditions and our planet's boundaries. Any visionary role model of a city, however, is only as successful as it suggests clear transition pathways. This paper intends to show that the concept of a 'regenerative city' is such a model. Furthermore, it seeks to encourage to look at transitional trajectories ahead, be it in the food, energy, transport or health sector, from the implementational level of a city government. The regenerative city not only preserves the capacities and capabilities of ecosystems, but actively restores them by establishing closed, efficient and consistent material cycles between the city and the surrounding area. At the same time, the regenerative city is not only aimed at the regeneration of resources and the efficiency of ecosystems, it also has to regenerate its public spaces and built environments in a human-centred fashion, rather than centred on individual car use. One of the determining factors of a regenerative city aiming for greater resilience will be whether or not it is able to establish a restorative relationship with its environment, its hinterlands, and build a circular metabolism of goods.

Keywords: *regenerative city, health, climate change, urban transition, sustainability, local action*

INTRODUCTION

'Think Globally – Act Locally' is a slogan invented some decades ago, but it has never been more true than today when the world is fighting a global pandemic. This global threat requires a comprehensive action plan, including global exchange about knowledge, scientific research, measures and policy tools and local implementation based on spatial conditions. Existing technology provided us with the opportunity to connect globally via social networks or videoconferencing at an unprecedented scale and reach, while national 'lockdowns' including travel restrictions and curfews forced people to rediscover their immediate neighbourhoods and, above all, their own place of living. The global and the local represent two opposing but yet dramatically maturing trends. Still, this 'vulnerability experience' which took hold across the globe is urging every government to first and foremost act locally. What can be learnt from the global health crisis in the years 2020 and 2021 is the interconnectedness of global and local challenges, interdependencies of health, food and energy, and the hugely important role cities and communities play in fighting a crisis.

When it comes to increasing urban resilience, the importance of local leadership and local institutions cannot and must not be underestimated. Accounting for around 70 per cent of energy consumption and greenhouse gas emissions worldwide,[1] cities and communities are at the forefront to act not just on global health, but on the global climate crisis as a whole. There is no doubt that cities are the local landing place for national and global decision making and have to be considered accordingly.

This paper will make the argument that the concept of the regenerative city offers a paradigm shift from a car-dependent city planning towards a people-centred model by embracing innovative approaches that put nature at the heart. For this purpose, the paper will first give a historical outline of the development of cities in order to make the case for the regenerative city model. In the second part, the main features of the concept will be elaborated while putting emphasis on some practical examples of how cities have addressed regeneration in their urban planning approaches.

It is important to stress that the ideas to be discussed for embarking on a journey towards a regenerative city can merely serve as a toolbox, since there is no one-size-fits-all approach and every future development plan of any city has to closely correspond with its local characteristics. All actors, ranging from policy makers to local activists, must build on the distinctive local features and potential that are engrained in each particular urban setting. In essence, effective and lasting change can only be made by first developing a thorough understanding of the local DNA of a place.

A FIRST WORD ON THE SPECIFICATION OF EVERY LOCAL STRATEGY: DEFINING THE LOCAL DNA OF A PLACE

To begin with, the category of 'cities' includes not only metropolises such as Istanbul, Mumbai, São Paulo or Shanghai, but also all centralised and demarcated urban settlements with their own administrative and supply structure and at least (depending on the country) 2,000–10,000 inhabitants. On a general note, a 'place' can be defined as a location in which unique relationships emerge between individuals, communities and their natural surroundings. Like any living organism, each place has native attributes encoded in its individual DNA. In line with this analogy, localities, communities and cities bear their unique set of

characteristics. This inevitably includes the constantly changing nature of locally relevant circumstances. Just as the DNA of any living organism changes with time and responds to variations in environment, the local DNA of a place continuously responds to external inputs.

Advancing existing systems towards a viable future requires the understanding of this local DNA, such as carefully assessing the unique individual traits of a place. Accordingly, any sustainability action plan will need to correspond with the local DNA, allowing the community to continuously evolve towards a more optimal form. Hereby, planning for systemic, future and just change must acknowledge that individuals and communities are indigenous to a particular place, and need to incorporate these native attributes into urban planning processes.

The identification and appraisal of the urban DNA in terms of social, cultural and geopolitical contexts can help communities share good practices and develop transition plans more efficiently and effectively. In this light, it seems recommendable that a number of attributes of a city or a community are understood as the particular resources and impediments embedded in a community's DNA. Examples of local attributes could include (but are not necessarily limited to) the following:

- Climate;
- Geography;
- Ecology;
- Cultural values;
- Economy;
- Social capital;
- Human resources;
- Public awareness;
- Education.

It is worth mentioning that all attributes are closely interlinked and should not be seen in isolation. Equally, the definition of the attributes of a local DNA as suggested in this paper may not be exhaustive for every city or region. While each local entity is encouraged to define the distinguishing attributes of its city or region, the proposed attributes may provide guidance for a better assessment of the local DNA.

Likewise, particular climatic conditions can largely differ from place to place. Temperatures, solar irradiation values, humidity, wind speeds or seasonal climate variations will therefore provide key guidance on specific energy needs, building design conditions, local renewable energy potential, space heating or cooling requirements. A regenerative city corresponds closely with the conditions in which the city is embedded — not just with regard to the resources flow, but also with regard to its urban shape, its architecture or its public space. While this may sound obvious, it certainly has not been the case in recent decades, with many cities following a 'global' stereotype of urban design and infrastructure paradigm.

CITIES IN THE AGE OF CLIMATE CHANGE

Climate change will shape future cities as much as industrialisation has. In other words, with the dawn of the industrial age based on the combustion of coal, gas and oil, humans began to relocate carbon dioxide stored over millions of years in fossil reserves into the atmosphere within a few decades. Today, cities are already and will be subject to heavy climate impacts while at the same time they seek to increase their resilience and reduce their ecological footprint. When it comes to the global climate crisis, cities are one of the main causes of human-induced climate change — and yet exposed to the highest risks from climate-related hazards. Coastal cities, for instance, may face the most

severe threat as sea-level rise may convert today's land into inhabitable regions already within this century.

The way we build, run and further shape our cities will resolve the pressing question of whether the world will manage to keep the global average temperature increase below the dangerous benchmark of 1.5 degrees,[2] as reinforced at the recent COP 26 climate summit in Glasgow (the Glasgow Climate Pact). Residential and commercial buildings account for more than 30 per cent of global final energy use[3] and additional energy demand is induced by transport and industrial activities in and around cities. Most cities also see the various environmental and economic benefits that are associated with a transition, namely less pollution, the creation of jobs, energy and data sovereignty, much less resource depletion, greener urban spaces, and so forth. One of the most important rate limiting factors for any city authority on embarking on a low carbon and sustainability trajectory, however, is the lack of information about which measures would work with regard to the individual context and what the actual implications are.

Cities do not only concentrate residents and economic activities in a small area but are also hotspots for resource consumption and emissions. In the wake of industrialisation and the expansion of cities, economic activity has increased steadily over past generations. With industrialisation, specifically, the urban hunger for energy has been satisfied primarily by constantly increasing burning fossil raw materials. Food, building materials and consumer goods are imported, resulting in accumulated waste which is ultimately exported in the form of pollutants in the air, soil and water. Simply put, cities contribute not only to climate change but also to soil erosion, the extinction of species and other environmental problems, and thus

need to be designed within a closed-cycle approach to be resilient and well-equipped for the future.

At the same time, humanity and its economy are dependent on planetary ecosystems and so-called ecosystem services. Nonetheless, these have been overstrained for several decades and the planetary boundaries[4] have been exceeded into all directions. And yet, this ecological footprint is expected to grow for residents of larger and richer cities: if the entire population lived like the people in the UK, nearly three earths would be needed to maintain the ecosystem services necessary for human existence.[5] According to the classic definition, 'sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future'.[6] In view of the planetary boundaries that have already been exceeded in the last decade, as stated by the Stockholm Resilience Center, it will hardly be possible for future generations to meet their own needs.[7]

While acknowledging these challenges, this paper makes the case that the regenerative city not only preserves the capacities and capabilities of ecosystems, but actively restores them by establishing closed, efficient and consistent material cycles between the city and the surrounding area. At the same time, the regenerative city is not only aimed at the regeneration of resources and the above-described efficiency of the ecosystems, it also has to regenerate its public spaces and built environments in a human-centred fashion, rather than centred on individual car use.

The challenges and opportunities of urban densification and future urban planning

With more than half of the world's population living in urban settlements, cities urgently need to transform their

urban core and be responsive to the specific needs of their residents. As the urban population is expected to grow by 2.5bn over the next three decades,[8] both public authorities and urban planners need to adopt efficient planning policies to accommodate new households, increase economic activities and expand urban infrastructure while preventing land take and its concomitant repercussions.[9]

Distinct factors can be considered either macro- or micro-drivers of urban densification including demography, economy and transport and not only have an impact on the local microclimate but equally exert pressure on biodiversity and urban green spaces if not managed properly.[10] From an economic perspective, city dwellers generate around 80 per cent of the global gross domestic product, as the high urban population density enables intensive trade and the efficient provision of goods and services.[11] Given these distinct challenges, future-proof role models suggesting different development trajectories based on the local conditions are indispensable.

Historical development: From the Agropolis to the Petropolis

Historically, cities closely corresponded with their geographical surroundings and relied on this for the provision of food, raw materials and other goods. Using organic waste from the urban core to fertilise the surrounding ecosystems, cities with such a symbiotic relationship to their surrounding area can therefore be described as the original state of the *polis* — the Agropolis (agros-land; polis-city), as first described by Herbert Girardet and the World Future Council.[12] Already in the 19th century, the economist Johann Heinrich von Thünen[13] described the functioning of this classic city system. According to von Thünen, two geographical factors determine the type

of use of the urban surroundings: the transport costs between the production site and the marketplace, and the price and quality of the agricultural land.

In 1826, at the time when von Thünen published his analysis, the Industrial Revolution in England was already picking up speed. With the invention and spread of the steam engine, a paramount economic leap in performance was made possible. Industrialisation went hand in hand with rapid urban growth as farmers moved to cities to find work in newly emerging industries whose steam engines in factories and locomotives ran on coal. The combustion of fossil fuels such as crude oil (as a fuel for the internal combustion engine which was invented later) and natural gas followed. It goes without saying that this fast-paced industrialisation entailing energy-related emissions marked a self-perpetuating vicious circle. With the rise in energy demand and a considerable increase in petrochemical fuels, the Agropolis which had existed for thousands of years ultimately evolved into a Petropolis (petroleum; polis-city) in the 20th century. In this model, central urban functions ranging from production and transport to consumption are based on the combustion of fossil fuels.

In terms of the urban setting, the expansion of cities along navigable rivers and the construction of overseas ports enabled the goods produced in the cities to be exported efficiently to all parts of the world. With the new energy sources, the transport of goods and people was significantly accelerated and less expensive: first by railways and shipping, later by automobiles and airplanes. It goes without saying that urban planning was highly influenced by industrialisation and later by individual motorised transport. In particular, the car became the determining factor in the organisation of the urban context. As a result, public urban spaces

were converted into car-friendly places. Streets, parking lots and highways were built within and between cities. The central influence of geographical factors for the Agropolis therefore became almost insignificant in the Petropolis. Thus, the initial links between the city and its surrounding ecosystem were almost cut. Food, fuel and essential goods were imported from all over the world and vice versa. From an environmental perspective, this economic globalisation equally yields an increase in waste accumulation and emissions of greenhouse gases and air pollutants.

In order to manage imminent challenges such as environmental pollution, climate change and sustainable resource management, it can be assumed that the Petropolis will no longer work as the future model of the city. A new model should therefore aim to combine the positive characteristics of the Petropolis with those of the Agropolis, especially those that have an economic and ecological added value. This model can be understood as an Ecopolis (ecology; polis–city), the basis of which is a city that is constantly 'regenerating' — the regenerative city — an ongoing process rather than any fixed status which does not fit any description of how a city works.

From a circular to a linear and back to a circular metabolism

Nature is the result of a circular metabolism, a system in which waste is raw material that fuels growth. This circular system can be found in the Agropolis, which extracts resources from the direct surrounding area and spreads organic 'waste' in its environs as fertiliser in a reasonable amount. By contrast, the Petropolis follows a linear pattern by taking a large amount of resources from nature outside the city, metabolising them and leaving their waste elsewhere. This linear system can be best illustrated by the increasing build–up of carbon dioxide in the atmosphere or the steadily growing amount of plastic waste in the ocean. The rate at which mankind takes resources from ecosystems and introduces waste into them is higher today than the natural capacity for regeneration. The Petropolis therefore builds on the depletion of natural capital rather than regenerating it.

Climate stability is also an elementary biophysical function that is already approaching a critical limit. Even though global climate changes have occurred over millennia and are not an uncommon phenomenon, the problem lies with the unique rate of temperature rise: since the beginning of industrialisation, the global average temperature has already risen by 1.2 degrees. This rapid warming is due to anthropogenic (human–induced) greenhouse gases that literally heat up the planet — for example, nitrous oxide and methane from agriculture, but above all carbon dioxide (CO_2). CO_2 is released during the production of cement and the burning of fossil fuels — that is, during all activities of the Petropolis. Climate change does not stop at national borders and its negative effects are already being felt across the entire globe. If the temperature rises beyond 1.5–2 degrees by the end of this century, catastrophic consequences are to be expected.[14] The severe droughts, blazing wildfires and massive floods that have occurred during 2021 only offered a glimpse of what lies ahead if we do not resort to immediate action.

A NEW CITY FOR THE 21ST CENTURY: THE VISION OF THE ECOPOLIS

On the one hand, the division of labour and networked coexistence in the modern city has accelerated scientific, technological and economic innovations. On the other hand, the wasteful linear metabolism of the Petropolis, driven

by the burning of fossil raw materials, is destroying global natural capital at a threatening rate. In order not to lose advances that come with industrialisation (and in view of ongoing urbanisation), a return to the Agropolis is not an option. Nevertheless, the modern city has to change fundamentally in order to solve ecological problems.

In view of overstrained planetary boundaries, it is not enough to maintain natural capital at its current level. Rather, cities must be organised in such a way that they can actively regenerate lost natural capital. Therefore, what should be following the concept of the Petropolis is the ecopolis — a city that re-establishes a connection to its hinterland and its ecosystems and regenerates the resources and natural capital of its surroundings. This can be ensured through subsidiary, efficient, sufficient and consistent material cycles as closed and local as possible.[15] Where necessary, however, there is an exchange with more distant regions. The design and optimisation of the cycles therefore run from bottom to top (bottom–up). In this way, the key principles of the Agropolis are taken up, while the advantages of global exchange are retained. Efficiency and sufficiency both aim to minimise waste and emissions. While efficiency achieves this through organisational and technological optimisation, sufficiency is about changes in behaviour on the demand side. Finally, consistent material cycles do not automatically view the output generated by the city as waste, but use it as a resource.

Contrary to many predictions, the model of the compact European city is experiencing a renaissance, especially against the background of these challenges and in connection with increasing digitalisation. The following section will illustrate a few best practice examples of innovative thinking and urban planning to contribute to transformative change.

The ecopolis generates public space in urban planning through an optimisation of densities. Rather than expanding further and further into nature on the outskirts, old buildings, industrial areas and fallow land within urban settings can be renovated and upgraded. Instead of separate and widely spaced residential and industrial areas, city quarters are turned into liveable spaces with living, working, shopping, local recreation and culture areas. A vivid example of such a new urban livelihood that places citizens at the heart of their city is the 15-minute city model, designed by the French–Colombian Professor Carlos Moreno from the IAE Paris — Panthéon Sorbonne University, France, whose architecture project has received the 2021 Obel Award.[16] According to Moreno's model, each citizen can reach their daily needs such as housing, work, food, health, education and basic services within a 15 minute walk or bike ride. These near neighbourhoods have taken hold across many cities, most notably in Paris but also in Barcelona, Melbourne and Chengdu. The 15-minute city certainly provides a strong basis to reduce environmental impacts associated with urban population growth, while increasing the local stock of social capital thanks to a continuous involvement of local stakeholders and citizens. The 15-minute city should not be taken as the panacea for contemporary cities, however; rather 'we need to […] imagine new ways to implement its principle of proximity in other densities', as Moreno states.[17] In this spirit, Moreno's team announced the International Observatory of Proximities, a global ecosystem which will be launched in January 2022 to promote the notion of proximity in urban contexts. Among the new initiative's supporters are the C40 network, the UN Habitat and the International Union of Architects.[18]

The deliberate concentration at the

local level can benefit the efficient use of energy, resources and (transport) infrastructures. In effect, the ecopolis is no longer primarily geared towards the needs of fossil fuel infrastructure and machines. Instead, residents open up new urban spaces and design it according to their needs. The added value for city dwellers increases through regenerative material cycles. Local economic cycles enable city dwellers to become owners of urban infrastructure themselves or, as prosumers, to produce the goods they consume themselves. The city is also changing from a pure consumer to a hub for the production of sustainable products.[19]

On another note, any future city needs to address both its physical and digital dimension. Therefore, we need to conceive the digital as an urban territory and imperatively apply innovative thinking in urban settings depending on their local DNA.[20] A predominant example for digital participative democracy is the urban transformation process implemented and advised by Francesca Bria in the city of Barcelona through the digital platform Decidim.org[21] to encourage public participation by promoting the exchange between citizens and public authorities.[22] With more than 400,000 inhabitants contributing to this 'hybrid system of digital democracy', voices and needs of different groups could be amplified and thus generated a glimpse into common political goals at the urban level.[23] According to Bria,

> '70 per cent of the suggestions and proposals generated by those meetings has become part of the city government agenda, including fundamental points such as increasing the extension of cycle paths and green spaces, new spaces for culture, support for local production, shops and crafts according to a circular economy model, public management of water supplies, projects dealing with the reduction of environmental pollution.'[24]

From vision to implementation: The regenerative city as a process

In order to transform the Petropolis into an ecopolis, systematic control (governance) and clear and transparent communication are required. The governance of this process creates incentives for decentralisation and enables coordination across different political levels and sectors. But which steps are essential for the realisation of the ecopolis?

The first step consists in the development of a concrete and city-specific concept. This process would have to be inclusive in scope and involve both different actors and sectors, including representatives from politics, administration, science and local companies as well as civil organisations and youth groups. The model developed in this way applies in the long term with clearly formulated interim steps and is supported by as many local interest groups as possible.

In a second step, the concept would have to be translated into tangible, long-term and ambitious goals. Such long-term goals are particularly important in order to create predictability for all actors. The achievement of these objectives must be verified on the basis of easily measurable performance indicators.

Lastly, a steering group (task force) would have to be set up and institutionalised, consisting of representatives of various and locally rooted actors in the city. To this end, it produces sector-specific implementation plans (road maps) based on the specific wishes and expectations of stakeholders and scientific studies. The plans contain their own goals and indicators. In addition, the steering group would coordinate the close cooperation between various urban actors and hence promote the exchange between different sectors in order to prevent 'silo thinking'. Since ecological problems often have multiple

causes and effects, a coherent and cross-sectoral approach is necessary to solve them. Likewise, the steering group would also coordinate the interaction of various political levels and administrative units, for example with surrounding communities or the national government. In practice, national governments can contribute to the establishment of regenerative cities through targeted funding and financing programmes.

The change from the Petropolis to the ecopolis affects many sectors such as energy, water, waste, food, etc. The primary need for action, however, is in the area of energy. The use of fossil raw materials is limited — both in relation to the natural abundance of coal, oil and gas, as well as (much earlier) to the absorption capacity of CO_2 in the atmosphere. Renewable energies, on the other hand — sun, wind, water, geothermal energy and, under certain circumstances, biomass — are infinite and therefore the basic fuel of the ecopolis.

The supply of renewable energy is a central element of the ecopolis. While fossil fuels enable central and continuous use due to their physical properties, renewable energies require a decentralised and flexible use. The need for 'polycentric urban development' as presented by the Scientific Advisory Council on Global Change (WBGU)[25] is the natural result of the expansion of renewable energies in a large country such as Germany. A subsidiary cellular energy system is therefore ideal to ensure the integration of renewable energies. First of all, each unit (or cell) optimises energy generation and consumption. If buildings are efficiently built, equipped with efficient household appliances and, where possible, with a photovoltaic (PV) system on the roof and an electricity storage or combined heat and power unit in the basement, a large part of the energy supply can be achieved. Neighbourhood approaches

that rely on larger electricity storage in a street or a local heating supply with, for example, industrial waste heat, can bring about the energetic self-sufficiency of entire city districts.[26] This type of energy supply also enables a decentralised ownership structure: municipal utilities and local energy cooperatives find business opportunities and private households consume their own electricity and become prosumers (producers and consumers). Where there is a lack of energy, cities use wind and bioenergy from their surrounding areas. City administrations can promote the change in the energy system by switching the supply of their own buildings to renewable energies, for instance, designating areas for wind energy or leasing public roofs for the installation of PV systems through energy cooperatives. Metropolises can also cover a large part of their energy supply in this way — a larger part than in the fossil energy industry. In the end, the lack of energy is imported via transmission grids from regions with a surplus of renewable energies.

So far, the transport sector has also been dependent on fossil fuels. In most cities, petrol or diesel-powered cars are still the primary form of transport — despite the obvious emergence of electric cars and charging stations in many urban settings. The harmful emissions impose a high cost on public health by attacking the respiratory tract of city dwellers or causing stress through noise pollution.[27] With a renewable energy supply, the mobility sector could further accelerate electrification of the transport sector in cities. Low-emission transport systems plus bicycle-friendly city planning significantly improve the quality of urban life.[28]

A wide range of battery charging stations is an effective incentive for switching to such technologies; however, emission-free cars alone will not solve the problem of wasted space and resources

through individual transport. In Germany, city dwellers cover around 36km in 84 minutes by car every day. As a result, cars park almost 23 hours a day. That takes up space: 'Contemporary cities devote up to 70% of public space to accommodate motor vehicles.'[29] In Los Angeles, for instance, 14 per cent of the urban area is used for parking spaces alone.[30]

In the specific case of Barcelona, the Catalan capital has experienced an extreme population density, resulting in high levels of environmental pollution, anthropogenic heat and mounting public health concerns. The superblocks developed by the Urban Ecology Agency (BCNEcologia) — a public consortium that is integrated into Barcelona City Council — have proved to be a vital solution for tackling these issues by banishing through-traffic and freeing up space for residents' needs.[31] The superblocks consist of nine blocks each being pooled to multi-block areas (approx. 400m x 400m) with the ultimate goal to convert the urban central grid into a pedestrian-friendly zone and to reroute traffic around these 'superilles' ('super-islands' in Catalan).[32] The benefits of this innovative urban and transport planning strategy are the reduction of motorised transport and the promotion of sustainable mobility, as well as the bold reclaim of public space for people and expansion of urban greening that increase the overall urban resilience and reduce public health concerns.[33]

> 'With work beginning in 2022 to a budget of 38 million euros ($45 million), the plan represents one of the most thorough revamps of a major European city so far this century.'[34]

This innovative renegotiation of the Catalan capital's physical habitat goes in line with the UN sustainable development goals (SDGs), specifically SDG11 on sustainable city and community development. It is not surprising that the superblock model has already been implemented in many other cities ranging from Vitoria-Gasteiz (Spain), Quito (Ecuador) and Buenos Aires (Argentina) to Vancouver (Canada).[35]

The ecopolis, therefore, underlies a well-developed and affordable public transport system, also a well-established infrastructure for cyclists and a simple and convenient system for car and bike sharing. Furthermore, commuter and delivery traffic is reduced through forward-looking urban planning and intelligent solutions for the 'last mile' in mail and parcel delivery. In contrast to rural areas, cities with their higher population density offer excellent conditions for creative and efficient solutions beyond individual transport.

A further advantage arises in connection with significantly fewer cars in urban settings, since some of the parking lots and streets could be unsealed, freeing up urban space for local recreation and green spaces. These green spaces — including the installation of multifunctional green rooftops — have many advantages: they provide living space and food for insects and birds, which in turn are essential for the pollination of (useful) plants and thus also have an economic value. In this spirit, the C40 cities network, an alliance of major cities for knowledge transfer in achieving the climate goals at the local scale, is actively engaging to build healthy, equitable and resilient communities in line with the Paris Agreement and the SDGs.[36]

Increasing the resilience of cities: Climate adaptation and mitigation

Economic damage from floods and heavy rain can equally be avoided by unsealed surfaces and green roofs: they act like a sponge by absorbing part of the water and ultimately relieving the sewage system.

In summer, plants cool the air and thus counteract the dangerous development of heat on concrete and tar surfaces.[37] Anthropogenic heat has become an incremental threat, raising, especially in metropolitan areas, the impact of the so-called 'heat island' phenomenon.[38] In Europe, the heat wave of 2003, with nearly 70,000 deaths, 'was the second most significant natural catastrophe in Europe during the past century after the Messina earthquake in 1908'.[39] In response to these challenges, more greenery in and around the city has proved to increase the public health and well-being of city dwellers.[40] Reforestation and renaturation projects in the urban outskirts preserve biodiversity and bind CO_2 from the atmosphere. In addition, green spaces inside and outside the city can also be used for agricultural purposes. Urban agriculture includes both urban gardening (operated by individuals or groups for self–sufficiency) and urban farming (operated for the [commercial] supply of a larger part of the population). Both practices represent an alternative to intensive agriculture and open up additional areas for food supply. Community urban gardening in public spaces promotes social cohesion in urban society. A predominant example is 'La Petite Ceinture' (small belt) in Paris, a former double-track railway line that ran through the city until 1934. Nowadays its tracks are covered by a wild stretch of land, supporting various plant and animal species and have been made available to the public on a regular basis combining nature trails, cultural venues, sports facilities and even shared gardens.[41]

Indeed, urban farming offers cities with a declining population or intermediate cities special development opportunities. The marketing of regional (and seasonal) food through certificates or at weekly markets also increases regional added value and strengthens the connection between the city and the surrounding area. The reduction of transport routes and the shortening of cooling and storage times can equally protect the climate. Greater use of urban and regionally produced food could also raise awareness of the value of food and thus reduce food waste. Specifically, there are distinct initiatives seeking to promote a transition to more democratic food systems in terms of public health and equality.[42]

The growing interest in a circular economy model by governments, local authorities and urban stakeholders that designs out waste and increases the sustainability and resilience of cities shows the increasing importance of a shared vision to regenerate natural systems for common good. According to the MacArthur Foundation, cities can embed circular economy principles in their urban core with buildings, mobility and products as key areas where opportunities reside.[43] There is a range of action-examples on low-carbon circular economy that can be assessed across the globe —for example, the launch of facilities dedicated to reducing electronic waste and fostering digital inclusion, such as in Brazil,[44] or the development of electric mobility in urban settings, with Shenzen being the first city 'in the world to reach a goal of 100% electrically run buses'.[45]

In general, avoiding waste is a central feature of the ecopolis, since avoidance remains the top priority in the waste hierarchy of reducing, reusing and recycling. In the case of electrical devices, bicycles or clothing, this also includes extending the actual service life. Public and community repair offers in the city can equally contribute to this. With regard to the waste hierarchy, the next step would be the reuse of pre-owned items, for example, by selling them or giving them away. In Berlin, an equivalent facility was launched last year — the B-Wa(h)renhaus (a German pun meaning both 'conserving house' and department store)

— which sells used and upcycled clothing, furniture and electronics over a total area of 7,000 sq. ft.[46]

The final step in the waste hierarchy is recycling, whereby waste is processed so that components can be reused. To the contrary, materials that could not be recycled are used wherever possible; organic residues, for example, are composted and used as fertiliser or fermented in biogas plants and converted into electricity. In South Africa, for instance, the Western Cape Industrial Symbiosis Programme (WISP) in Cape Town has been established, which facilitates the exchange of underused resources among manufacturing companies to reduce waste by prolonging material use and keeping valuable resources in the circular flow of the industrial sector.[47] Since its launch in 2013, WISP has diverted over 104,900 tonnes of waste from landfill and created 218 jobs primarily in small and medium-sized enterprises (SMEs).[48]

A pivotal forerunner in bringing circular thinking and regenerative sourcing into the construction market is Built by Nature, a brand-new network and grant-making fund which accelerates the use of timber in the construction sector across Europe. By aiming for a zero-carbon built environment, Built by Nature promotes a circular bioeconomy while enhancing forest stewardship and regeneration.[49] With a forward-looking construction method in the building sector, parts of buildings could also be removed and/or reused before ultimately being demolished.[50]

The proper disposal of waste is the goal of the waste hierarchy. It is better if waste ends up in landfills provided for this purpose than if it ends up in seas and waters in an uncontrolled manner or is incinerated. Untreated wastewater should also not get out of the city, as this could lead to an eutrophication of the surrounding ecosystems. In the ecopolis,

water is used efficiently by residents and companies, rainwater is collected and recycled, and wastewater is completely treated. Heat can also be recovered from the still-warm wastewater from households and businesses and used to heat the buildings.

CONCLUSION

A regenerative city can be the role model for an environmental and economic future path of a city towards more resilience

The regeneration of the city affects both its various sectors and the public space and entails significant benefits. Natural resources and ecosystems are no longer being degraded (eg through a complete supply of renewable energies), but instead actively restored. This can be seen in the reclaim of public space for people and the expansion of urban greening, but also in the increasing use of fertiliser from waste for urban agriculture to serve public health, activity and equality at the local level. There is also the possibility of creating new urbanity geared towards people and their specific needs, which makes the city both worth living in and more worth living in.

From an economic perspective, the regenerative city also offers economic added value: the fact that energy or food is less imported but more locally produced can benefit the creation of jobs and capital is kept in the city. The demand for craftspeople and repair services also enhances the regional added value and can strengthen social cohesion. Likewise, a more decentralised economy can equally decentralise the distribution of property. It can be seen that regenerative cities are a self-perpetuating urban habitat in scope as they cover a large part of their supply themselves or from the immediate vicinity, which makes them resilient, ie

less susceptible to external shocks and disruptions in complex globalised systems. In this way, they also increase their independence and their ability to manage themselves.

Community urban production and the promotion of exchange and sharing are part of the ecopolis. This offers opportunities to strengthen human interactions and mutual understanding. City quarters that offer their residents a wide range of options such as parks, green areas and cultural places become meeting places. Likewise, fewer cars and more local food also promote the health of residents.

It is important to note that the regenerative city is not a final state in which the beginning and the end have to be clearly defined. In fact, it describes a process of constant renewal and development. Regenerative urban development is characterised by transparent and inclusive discussions and democratic decision-making processes. The resident of the ecopolis does not only gain economic sovereignty as a prosumer, but also political sovereignty as a citizen by being given greater opportunities to shape local politics. The regenerative city approach ensures that future generations of city residents will also have both the natural and social capital they need.

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