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Urban Agriculture: A Regenerative Urban Development Practice to Decrease the Ecological Footprints of Cities

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Abstract

Modern cities are characterized by intense human interactions and economic activities that- in many cases- have little or no consideration of the surrounding environment. Every day, the process of urbanisation is becoming more resource-intensive, and the results are grave, including, climate change, the loss of natural fertility of farmland and the loss of biodiversity all over the world. High-consumption modern lifestyles are mainly fossil-fuel powered, relying on resources from the world's ecosystems: a practice that increases the ecological footprints of cities. This paper aims at exploring means of decreasing the ecological footprints of cities: regenerative urban development practices being some of them. By concentrating on one of these practices, namely urban agriculture, the paper demonstrates how it would be possible to decrease the ecological footprints of cities through its integration on the city level.

It starts out by briefly defining the environmental problems our cities are facing today, then it moves on to explaining the concept of the ecological footprint. It shows how cities could decrease their ecological footprints through simple practices: such as those of regenerative urban development. This is done through demonstrating regenerative practices in different parts of the world, with a concentration on urban agriculture, as one of the most effective regenerative practices. It then moves on to explaining how it could be integrated within a comprehensive system in cities, so as to improve the environmental condition, to work on decreasing the ecological footprint and to start setting the stage for a regenerative city.

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Keywords

Ecological Footprint; Regenerative Urban Development; Urban Agriculture; Urban Metabolism; Circular Urban Metabolism

1. Introduction

Cities are characterised by intense human interactions and economic activities; they are the lively hubs of human reproduction and creativity. With their buildings and infrastructure systems, they are the largest and most complex structures ever made by humanity; and with their communication and transport systems, they have achieved extraordinary global reach. As centres of economic innovation, they develop according to capital investment priorities, technology options and competitiveness (Girardet, 2015).

Thus, in a rapidly urbanising world, large, modern cities are becoming more and more reliant on finite sources

of fossil fuel, through the adoption of consumer lifestyles. Taking a quick look at the numbers, it is noticed that from 1900 to 2013, the global human population increased more than 4.5 times: from 1.5 to 7 billion inhabitants. During the same time, the global *urban* population expanded 16-fold: from 225 million to 3.6 billion inhabitants, which is around 52 percent of the world population. In 2011, the more developed countries were about 78 percent urbanised, while developing countries were still at 47 percent. By 2030, 60% of the world population is expected to live in urban areas. It is also worth pointing out that nearly all the world's population growth is occurring in cities, and mostly in developing countries (Girardet, 2015). Urban growth is apparently unstoppable, powered by neo-liberal globalisation principles and policies that are transforming the lives and behaviour patterns of billions of people around the world (Girardet, 2015), to the extent that, at the beginning of the 21st Century, Nobel Laureate and atmospheric chemist, Paul Crutzen suggested that we are living in the “Anthropocene,” a new geological epoch, in which humans had altered the planet (Woo, Wortmann, Schurig, & Leidreiter, 2014).

The fact that high-consumption modern lifestyles are mainly powered by fossil-fuel, coming from finite sources in nature, has caused imbalances in the Earth's ecosystems. Also, for a very long time, cities have been developing without showing any consideration for nature, and human activities have become main contributors to pollution and environmental damage, in addition to the loss of biodiversity and climate change. Humans are depleting the natural capital stocks of the planet Earth and are eroding its resilience, when they should be benefiting from its natural regenerative capacity (Woo et al, 2014). Their actions are continuously turning inherently renewable systems—soils, forest ecosystems, coral reefs—into non-renewable ones, as they use the bulk of the world's resources and are not concerned where the vast quantities of solid, liquid and gaseous wastes end up, not knowing what is contained in the discharged waste and what damage this does to the environment (Girardet, 2015).

Cities, as complex interconnected systems, are designed to turn energy into “work”, flowing along roads, rails, pipes and wires. Throughout the process, the quality of the used fossil energy and raw materials deteriorates; thus, order, which is manifested in the form of cities, causes disorder elsewhere in nature. Consequently, the way cities function presently, and that is by focusing *only* on the organisation of exceedingly energy-dependent human activities and urban lifestyles, while disregarding nature, has increased the level of disorder, waste and pollution for the planet as a whole. Thus, cities are “entropy accelerators”: they deplete and downgrade the resources they depend on, in the process of using them (Girardet, 2015).

Currently, *and with such behaviours*, the urbanising humanity's impacts on the environment are of great concern. In 2012, people used more natural resources in eight months than the Earth can produce in one year; under current trends, by 2030, even two planets will not be enough (Woo et al, 2014).

Human impacts on the world's ecosystems are demonstrated by the ecological footprints of cities: simply explained, an ecological footprint is the amount of land required to support people's lives and lifestyles. It is a measure of people's impacts on the environment and is commonly used as a guide toward a footprint that—*if adopted by all people*—would not exceed the productive land on earth. It is worth pointing out that the larger and the richer the city, the more it tends to draw on nature's bounty from across the world rather than its own local hinterland; ecological footprints could be hundreds of times larger than the cities themselves. In an urbanising world and as our populations grow and global consumption increases, it is essential that we measure nature's capacity to meet the demands on our planet. Thus, cities need to work on minimising their ecological footprints.

This could be done through regenerative urban development practices, which are restorative, renewing and revitalizing. They look into circular systems from the surrounding natural environment and draw inspiration from them, representing a paradigm shift and introducing a new way of thinking. Humans are considered as being inseparable from nature and its ecosystems. Such practices see humans as part of a larger community of life. Most importantly, they are not seen as only consumers, but also as producers of resources for other species. Accepting this idea, humans actually start acting as being part of nature, following its laws and designs (Hes & Plessis, 2015). Biophilic design looks closely into natural processes on the one hand, and thoroughly studies patterns and ways of place-making on the other, with the aim of facilitating this re-integration with nature. This paper sees urban agriculture as one of the most significant regenerative practices, which falls under biophilic design, showing how

it is integrated within cities and how it contributes to minimising ecological footprints.

2. Research Approach

The research adopts a comprehensive approach that is organised on different levels. In order to understand how urban agriculture could contribute to minimising the ecological footprint of a city, the research is supported by a literature review that covers the definition of “regenerative urban development”, “circular urban metabolism”, and “ecological footprint”. An analytical approach is implemented through the close examination of urban agriculture examples from different parts of the world, pointing out their regenerative characteristics within cities and how they contribute to minimising ecological footprints, while embracing circular urban metabolisms. Finally, conclusions are drawn as to how urban agriculture could be integrated in cities. The research hypothesis is supported through data analysis and graphics.

3. Literature Review

The research topic requires the understanding of several terms, namely: “regenerative urban development”, “circular urban metabolism”, “ecological footprint”, and “biophilic design”.

3.1. Regenerative Urban Development

The term “regenerative design” was first introduced by John Tillman Tyle, a landscape architect, in his book *Regenerative Design for Sustainable Development* in 1994 (Hes & Plessis, 2015). He pointed out that the linear models, on which the development of cities is based, will ultimately lead to the degeneration of the systems that supply energy and materials, as well as other services to our cities. Alternatively, he suggested that the supply systems for energy and materials must be continuously self-renewing, or regenerative- see Figure 1.

Lyle proposed that the working landscape in future cities should be the unifying, integrating network of urban form, instead of being a decorative addition.

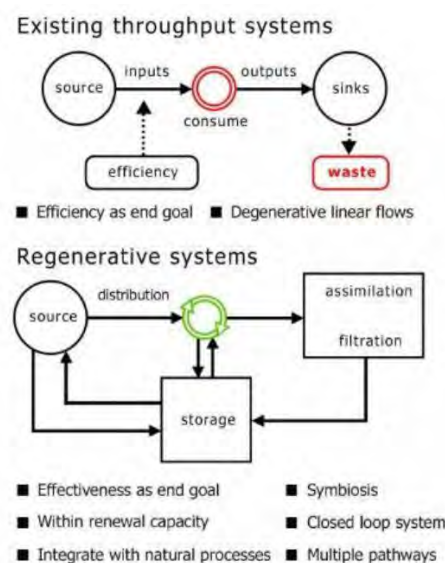


Figure 1. Lyle’s comparison between flows in degenerative and regenerative systems (Hes & Plessis, 2015).

Regenerative design or development does not only refer to reviving a system, or restoring it to a better state, but to

changing the system into something different and more effective, as well as to bringing about a new way of being and a thorough change in the mindsets of people and communities (Hes & Plessis, 2015).

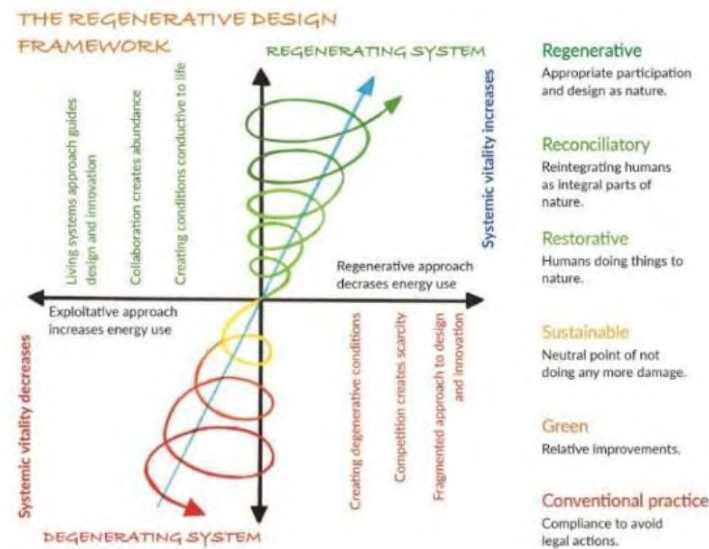


Figure 2. The framework of regenerative design ("The Ecologist", 2017).

To get a better understanding of regenerative systems, Figure 2 shows the transition from conventional practices, all the way to regenerative ones. It is noticed that conventional practices have little or no consideration of the impact a design has on the environment. They generally comply with requirements in order to avoid legal actions. Green design does not question production or consumption patterns that have negative environmental impacts. They merely minimise energy use, waste and pollution. Green design is actually called "less-bad design". As for sustainable practices, they are neutral, with the aim of avoiding environmental damage and reaching maximum efficiency. In the case of restorative practices, humans start doing good things to nature, which leads to reconciliation, where humans are integrated with ecosystems, until they reach regenerative practices, which see, not only humans, but also human development, social structures and cultural values as inherent parts of ecosystems. Not only do they seek to restore the capacities of ecosystems, but they also regenerate them, while understanding the diversity and individuality of each place and seeing the design process as an ongoing, participatory process (Girardet, 2010). As one moves towards degenerative practices, more energy is needed and more waste is produced; while moving in the direction of regenerative practices, less energy is needed and less or "zero" waste is produced.

Regenerative practices are thus, life-supporting, resilient, adaptive, optimising, systems-based and values-led. Taking on regenerative development means applying comprehensive strategies that enhance and restore the environment, as well as the relationship between cities and their ecosystems, from which they actually draw resources for their nourishment, moving from linear systems of resource use to circular ones. Regenerative urban development is an integrated approach that sees humans, human developments, political frameworks, and socio-cultural structures as innate parts of ecosystems. There are many examples of good regenerative urban development practices, including regenerating soils, watercourses and urban agriculture on the city level. Consequently, such practices allow cities to reduce their dependence on fossil fuels and encourage the use of renewable energies; they improve waste management systems and urge the reliance on local hinterlands, which ultimately reduces the ecological footprints of cities.

3.2. Circular Urban Metabolism

The term "metabolism" was first used by the ecologist Arthur Tansley in order to describe living organisms. Later in 1935, Tansley expanded this term to include energetic and material streams from inorganic development of settlements and introduced the expression of "urban metabolism", which was later defined as a framework to simulate a city's complex flow systems as if it is an ecosystem, including people, water, energy and so on. Simply put, urban metabolism studies how efficiently interconnected city systems function, while using existing resources and infrastructures on the one hand, and managing waste on the other. Recently, it has been defined as "the sum total of the technical and socio-economical processes that occur in cities, resulting in growth, production of energy, and elimination of waste".

The concept of circular urban metabolism is tangential to regenerative urban development. Drawing its inspiration from nature's ecosystem, whose outputs by different organisms are recycled back in the system once again (Girardet, 2010), this process is the key to all regenerative practices. In order to better comprehend circular metabolisms, they are compared with linear metabolisms in Figure 3. In linear systems, inputs and outputs are unrelated, causing environmental problems; while in circular systems, almost all the outputs are inputs in the ecosystem, achieving minimum pollution and producing minimum wastes. In this sense, nature is the greatest, most efficient teacher on how to create circular metabolic urban systems.

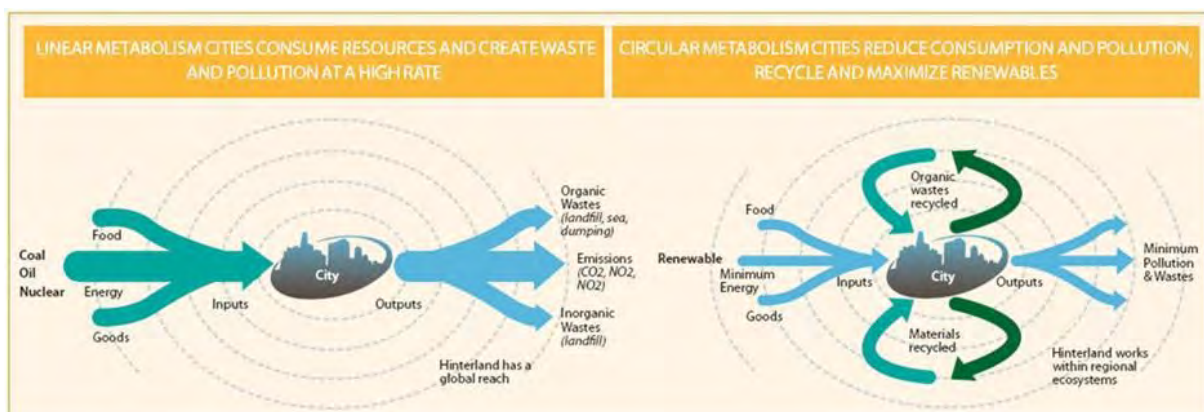


Figure 3. Linear versus circular urban metabolism (Girardet, 2008).

3.3. Ecological Footprint

According to the Living Planet Report 2016, "the Ecological Footprint equates humanity's demand on nature to the amount of biologically productive area required to provide resources and absorb waste" ("WWF", 2016); the measurement unit is global hectare (gha), which quantifies both the ecological footprint of people or activities, as well as the biocapacity of the earth or its regions. One global hectare represents the average productivity of all biologically productive areas (measured in hectares) on earth in a given year ecological footprint takes the following six categories into consideration, based on WWF (2016), see Figure 4.

- **Cropland footprint**, covers the demand for land on which to produce food for human consumption, feed for livestock, rubber and oil crops.
- **Grazing land footprint**, refers to the amount of land needed to raise livestock, for meat, dairy, leather and wool products.
- **Fishing grounds footprint**, covers the demand for inland water ecosystems necessary to support seafood catch and aquaculture.
- **Forest product footprint**, refers to the demand for forests to provide fuel wood and timber products.

- **Built-up land footprint**, refers to the demand for biologically productive areas needed for housing, industrial structures, infrastructure and transportation.
- **Carbon footprint**, covers the demand for forests as the main ecosystems available to sequester carbon that is not otherwise absorbed by the oceans. It captures different rates of carbon sequestration, depending on the degree of human management of forests and includes the emissions related to wildfires, soil and harvested wood.



Figure 4. An illustration of the ecological footprint ("Global Footprint Network", n.d.).

The above map (Figure 5) has been extracted from WWF Living Planet Report 2016. It shows that the average ecological footprint per person per country differs because of varying levels of consumption and also based on the demand for individual footprint components. It is worth pointing out that high ecological footprints (5.25 gha and more) are found in rich countries with demanding lifestyles that depend on fossil fuel consumption. In some of these countries, the per person ecological footprint is six times larger than the available per capita share of global biocapacity (1.7 gha). There are also countries, with the world's lowest income, whose ecological footprint per person is less than half the per capita share of global biocapacity, indicating that many people in such countries struggle to meet basic needs (WWF, 2016).

Many cities have recognised the problem and have started to integrate regenerative urban development practices in their systems in order to decrease their ecological footprints. This paper concentrates on one of these significant practices, namely urban agriculture.

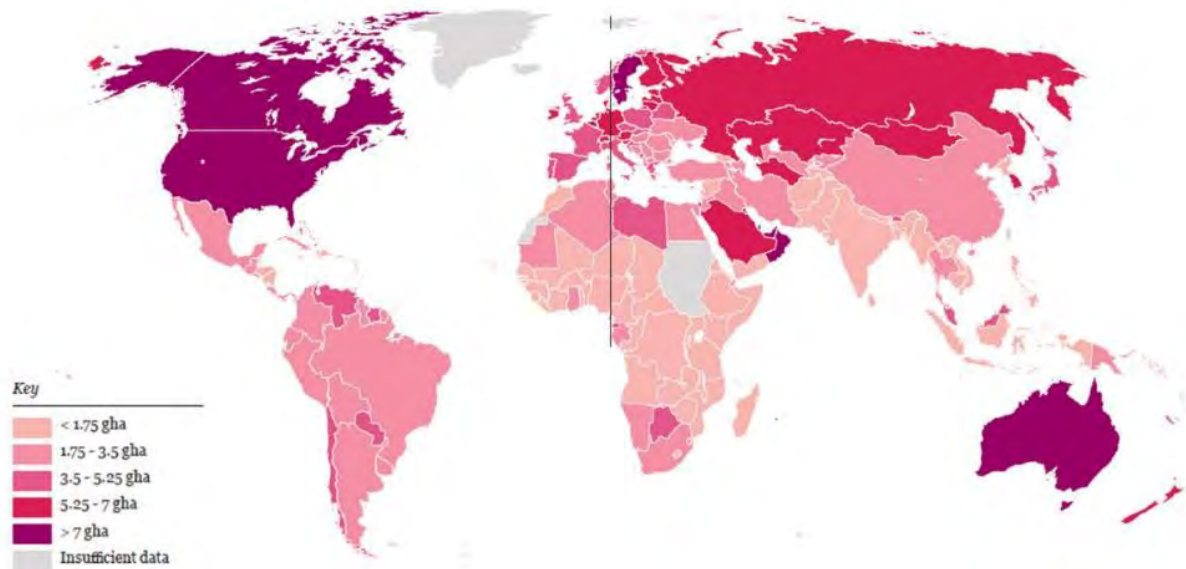


Figure 5. mapping the ecological footprint of consumption. Average ecological footprint in global hectares per person per country, in 2012. ("Global Footprint Network", n.d.; "WWF", 2016).

3.4. Urban Agriculture as an Regenerative Urban Development Practice

The idea of urban agriculture was inspired from the concept of the agropolis (see Figure 6), which- as described by the 19th century economist Johann Heinrich von Thünen- was the human settlement linked to its surrounding landscape, in the absence of advanced transport systems, and having a symbiotic relationship with it, assuring continuous productivity and fertility (Girardet, 2015).

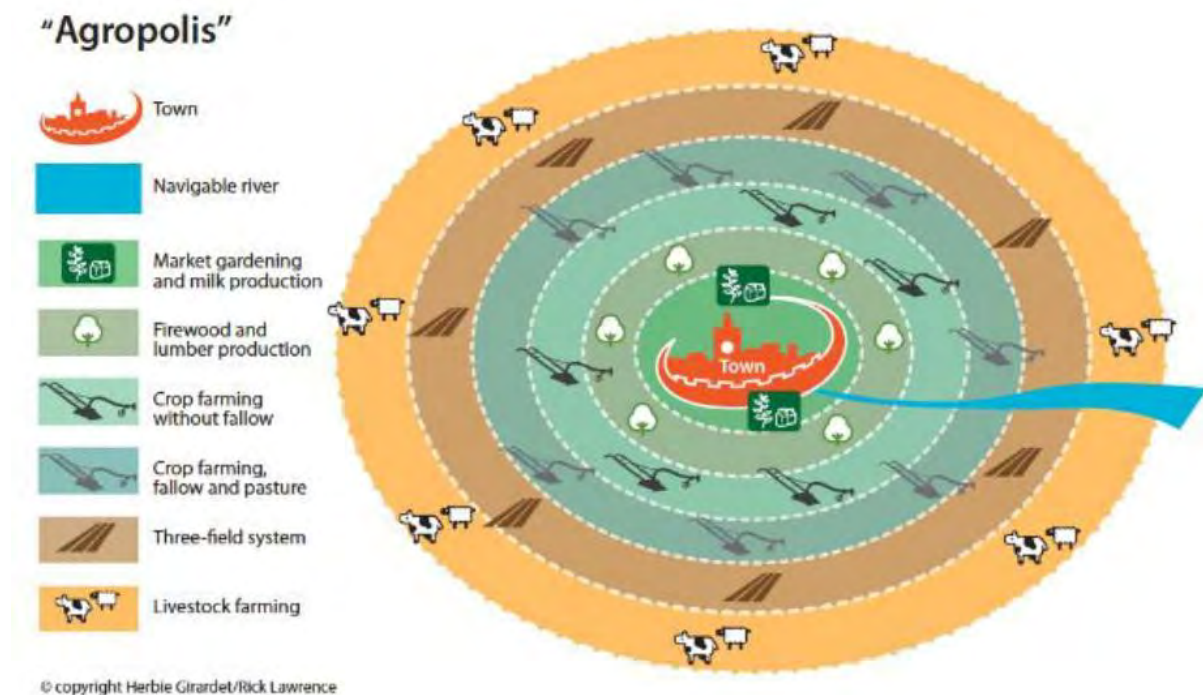


Figure 6. A diagram representing the agropolis (Girardet, 2015).

Land was cultivated very close to the city, which decreased the cost of transporting produce to markets and also guaranteed the freshness of the food, which did not have to travel long ways. Moving away from the centre of the city, timber, grains, and livestock farming were arranged logically, depending on how well they keep and how easily they could be transported to the city.

In many parts of the world, and as farming became increasingly mechanised, rural-urban migration started taking place over the years, with people wanting to move to cities, which they thought offered better living opportunities. When this happened, food had started being supplied to cities through more and more energy-intensive production systems (Girardet, 2010). Not only, but also the globalisation of the economic system and new lifestyles has greatly contributed to the fact that food started being supplied from different parts of the world, largely increasing the ecological footprints of cities and putting pressure on the world's productive land. In order to alleviate this pressure, and to find more efficient ways of supplying food to cities, as well as ensuring food security and improved nutrition, local food production has been encouraged. City people started reviving urban and peri-urban agriculture, which is a practice that greatly contributes to poverty alleviation and local economic development, in addition to the previously mentioned benefits (Girardet, 2015).

Urban agriculture is currently being practised in many parts of the world: in China, there's a national policy of surrounding cities with belts of cultivated land (Girardet, 2010). Megacities, such as Shanghai still maintain their urban farming, although due to the rapid growth of the city, much of it has moved to peri-urban areas (Girardet, 2015).

Closed-loop systems are used in urban agriculture in many parts of the world, utilising wastewater from residential and industrial areas for irrigation, as well as efficiently using nutrients, contained in urban sewage, which would otherwise end as pollutants in rivers and coastal water.

Havana, Cuba is one of the world's best examples of urban agriculture. It is a movement that started from the people, in response to serious food shortages after 1989. They encouraged each other to cultivate any available surfaces within Cuban cities, and ultimately, the government had to support the movement, which shows the effectiveness of bottom-up approaches, which involve the people and instigate a deep sense of belonging and participation. From the 1990s onwards, urban gardens started popping up everywhere: on wasteland, within housing blocks, in schools, in community centres, in hospitals and also in factories. The government provides producers with free land and tools, and it subsidises farm inputs, helping hundreds of thousands of people to improve their living conditions. Now, these productive gardens are prominently located in and around public parks, relating them to recreational activities. Urban agriculture comes in three main forms: cooperative gardens, private gardens and popular gardens. Currently, Cuba has become pioneering in biotechnology, offering advice on organic cultivation methods in other countries (Girardet, 2015).

Another significant worldwide movement involves the permaculture concept (originating from permanent agriculture), representing a system of permanent, self-sustaining agriculture and human culture. It is a system of agricultural and social design principles centered around mimicking or directly utilizing the patterns and features observed in natural ecosystems, recognising cross-scale relationships and creating productive edible landscapes on a variety of scales from simple kitchen gardens to urban food forests (Hes & Plessis, 2015). This part concentrates on presenting permaculture design principles, which greatly support regenerative practices, such as (Hes & Plessis, 2015):

- Observe and interact
- Catch and store solar energy and other resources
- Obtain and yield
- Apply self-regulation and accept feedback
- Use and value renewable resources and services

- Produce no waste
- Design from patterns to details
- Integrate rather than segregate
- Use small and slow solutions
- Use and value diversity
- Use edges and value the marginal
- Creatively use and respond to change

Another innovative example of urban food production programme is “The Plant” in Chicago, USA, which has been established in a former meat packaging factory. The project comprises non-profit and for-profit companies that interact with each other for mutual benefit, demonstrating what resilient urban food production and economic development could look like. It is clearly an advanced regenerative system that turns the outputs of one business into the inputs of another (see Figure 7). Using renewable energy sources, the plant incubates small craft food businesses by growing salad crops, brewing beer and making bread. One third of the plant is used for an aquaponic crop growing system and the other two-thirds incubate a variety of sustainable food systems (Girardet, 2015).

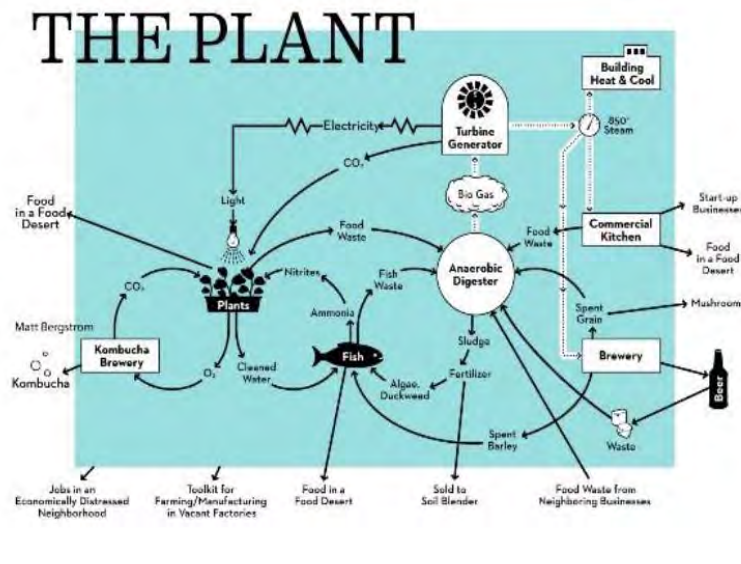


Figure 7. the Plant in Chicago: diagram representing a new kind of highly integrated organization; an innovative urban food production program (Girardet, 2015).

Below are some images (Figures 8, 9, 10, 11, 12 & 13) showing what urban agriculture could look like within cities.

4. Conclusions

Urban agriculture encourages re-integration with the natural environment within cities to restore and maintain ecosystems, while allowing communities to work together, thus, also reviving social fabrics. All the discussed examples of urban agriculture projects have been specific to the local natural and cultural contexts, where they have been implemented, therefore, supporting the key principle of efficient resource use and creating synergies between people and their surrounding natural environment.



Figure 8. Detroit's new agrihood ("Paste Magazine", n.d.).



Figure 9. Shanghai is planning a massive 100-hectare vertical farm to feed 24 million people ("Inhabitat", 2017).

It is clear that producing food where people live won't resolve all food production and distribution problems, but it could definitely alleviate some pressure off rural areas and, at the same time, improve human and environmental health. Urban agriculture allows for the creation of ecological spaces within urban areas, improving the surrounding exterior micro-climate and absorbing carbon emissions, besides creating interesting, active public open spaces and greenery within the city.

It could also be concluded that urban agriculture is evidently a regenerative practice, covering the same characteristics:

- It is life-supporting through working with nature, not against it, while considering biodiversity. It helps provide essentials for the community, while including social interaction, involvement and public participation, therefore, accommodating socio-cultural values and encouraging the sense of belonging to a place; all while improving human well-being.



Figure 10. Rooftop urban farming ("Urbanizehub", n.d.).



Figure 11. The essence of agrihood ("Shareable", n.d.).



Figure 12. the Lumen Building at the Wageningen Institute, an agricultural institute in the Netherlands, takes the indoor – outdoor idea of modernism to the next level, a world leader in the development of greenhouses ("Larigakis Architecture", 2015).



Figure 13. Urban agriculture within dense city blocks.

- It is inclusive, taking into consideration all social levels and ensuring food security, while generating income at different scales (small, medium and large enterprises), through the different job opportunities it provides: core farming jobs or supportive ones, like transportation, compost-making, food-related trades (processing and packaging), marketing and so on. Thus, it is- as mentioned above- a strongly life-supporting practice.
- It ensures the establishment of resilient, food-secure cities, ensuring food availability during times of disaster, when transportation and communication links might be disrupted (Zeeuw, Veenhuizen & Dubbeling, 2011).
- It plays an important role in improving urban resilience to climate change by maintaining vegetation within the city, which improves the urban micro-climate by capturing Co₂ and producing O₂, which also has a positive effect on air-filtration; and by reducing the urban “heat island” effect (temperatures in the built-up city are several degrees higher than in the surrounding areas) through creating more shade (Zeeuw, Veenhuizen, & Dubbeling, 2011).
- It is also optimising and flexible through its application on different scales within the city. Urban agriculture could be carried out by an individual or it could be family-based. Communities could share small pieces of land within their districts, going all the way up to medium and large-scale enterprises. It could take place in balconies, on the rooftops of buildings, in backyards, and in community gardens, up to different sizes of urban farms.
- It is adaptive to change and highly responsive, with people being part of the system. Urban agriculture also has restorative qualities, which help with adapting to different environmental circumstances.
- It adopts circular systems between urban domestic, agricultural and industrial sectors, such as encompassing the use of wastewater from domestic or industrial sectors in agriculture, as well as the use of organic wastes as fertilizers, to mention only a few examples.

Thus, urban agriculture is a regenerative practice that works with rather than for the community. It encourages community partnerships, which might not have existed before. It creates opportunities to benefit the unprivileged inhabitants, and it embraces and restores biological communities and functionality (Hes & Plessis, 2015).

Moreover, urban agriculture is an effective practice that minimises the ecological footprints of cities, since it exists in “intra-urban” areas or very close, in “peri-urban” areas, which are immediate surroundings. This, in turn, significantly reduces the distances travelled to transport food from one point to another, thus reducing carbon emissions. In addition, urban vegetation enhances carbon sequestration, by absorbing Co₂ and producing O₂, thus, filtering the surrounding atmosphere and decreasing air pollution, in addition to acting as breathing lungs within the built urban environment. Consequently, urban agriculture has significant effects on reducing the carbon footprints of cities. Moreover, by encouraging local food production, food exports, *which rely heavily on various means of transportation*, are minimised and cities start to rely more on their hinterlands: a key practice that minimises their

impact on the natural environment and the amount of land needed to support people's lives and lifestyles, which ultimately minimises the ecological footprints of cities.

Therefore, it is essential to integrate urban agriculture within the fabrics of existing cities, as well as within new cities. It is worth pointing out that, no matter how dense cities may appear, there are always open spaces and vacant lots that may be used for productive agricultural use. As for new cities, urban agriculture should be integrated within the early planning phases. However, in order to incorporate and activate such a practice, several measures need to be taken: (*the following is based on the Resource Centres on Urban Agriculture & Food Security*) (Zeeuw, Veenhuizen, & Dubbeling, 2011)

- Governments should recognise that urban and peri-urban agriculture is an integral part of the socio-economic and ecological systems of cities: either existing, under development, or in the planning process.
- Governmental policies at the national level need to create and recommend adequate frameworks, conditions, laws and regulations that organise the practice of urban agriculture within cities.
- The creation of an institutional home for urban agriculture is an important initial step, so as to receive proper attention and support from existing official institutions, including, but not limited to agricultural institutions and urban authorities. The urban agriculture institution would play an active role in the design and implementation of urban agriculture programs.
- The urban agriculture institution could also provide training and technical assistance to urban farmers and producers. It could also help facilitate marketing activities.
- Funds should be made available, preferably involving local authorities, as well as the civil society.
- Topics related to urban and peri-urban agriculture should be included in education system.
- Urban agriculture should be linked to recreational activities.
- The efficient use of irrigation water should be encouraged, as well as the application of safe and regenerative technological practices of urban agriculture.

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