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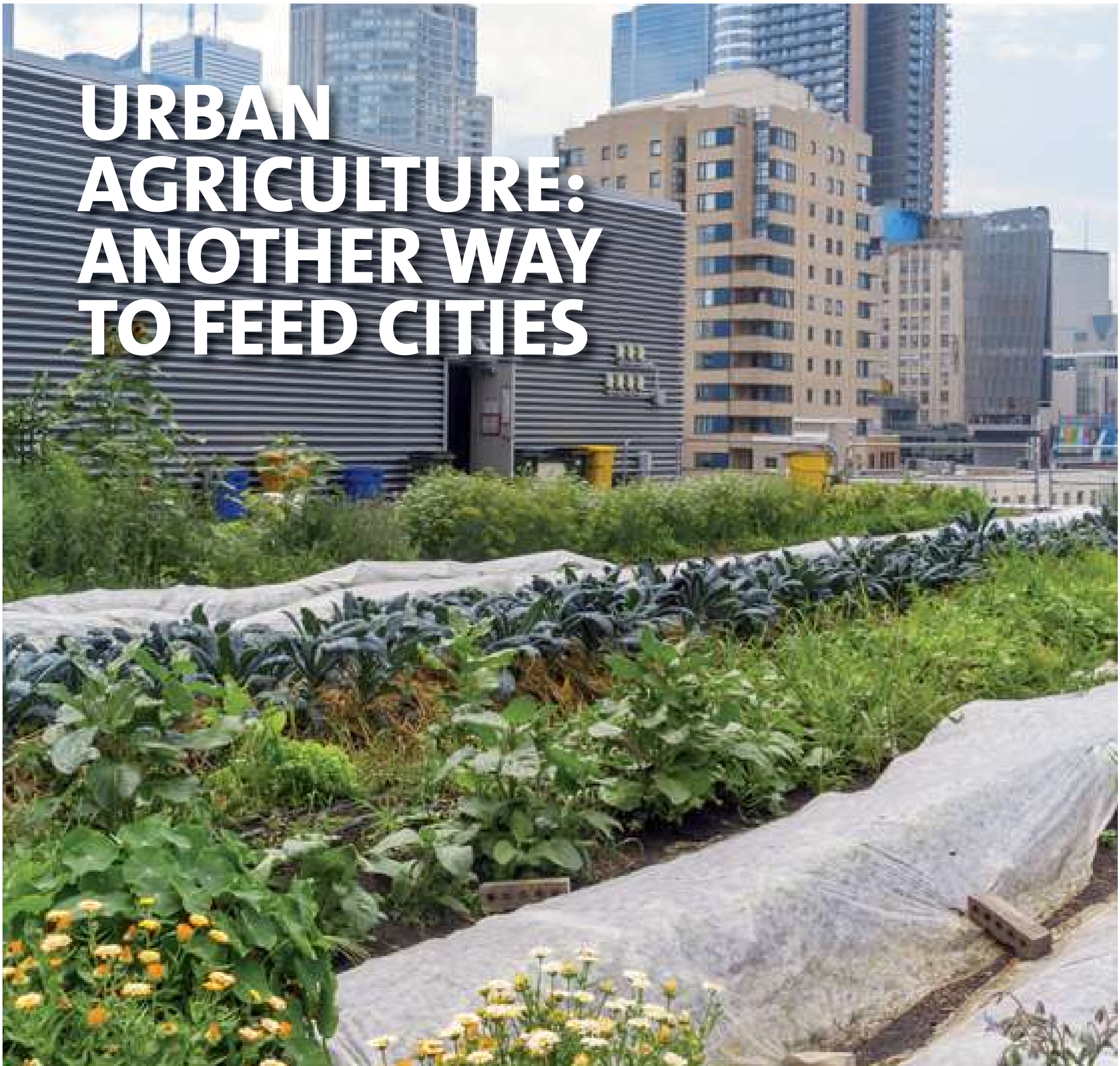

URBAN AGRICULTURE: ANOTHER WAY TO FEED CITIES

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THINKING TOGETHER TO ILLUMINATE THE FUTURE

THE VEOLIA INSTITUTE

Designed as a platform for discussion and collective thinking, the Veolia Institute has been exploring the future at the crossroads between society and the environment since it was set up in 2001. Its mission is to think together to illuminate the future.

Working with the global academic community, it facilitates multi-stakeholder analysis to explore emerging trends, particularly the environmental and societal challenges of the coming decades. It focuses on a wide range of issues related to the future of urban living as well as sustainable production and consumption (cities, urban services, environment, energy, health, agriculture, etc.).

Over the years, the Veolia Institute has built up a high-level international network of academic and scientific experts, universities and research bodies, policymakers, NGOs, and international organizations. The Institute pursues its mission through high-level publications and conferences and foresight working groups.

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Review coordinated by Mathilde Martin-Moreau, Lorraine de Jerphanion & David Ménascé, Archipel&Co.

THE REVIEW

The Veolia Institute Review - FACTS Reports is a high-level international publication compiling diverse perspectives on topics at the crossroads between society and the environment.

The review was launched in 2007 with the aim of sharing best practices from the field, to help find solutions to problems in the economy, development, healthcare, environment, agriculture and education, in both developing and developed countries.

The interdisciplinary review is a vehicle for sharing the experiences and expertise of different stakeholders (researchers, academic experts, policymakers, companies, NGOs, international organizations, etc.), with the aim of taking advantage of a diversity of perspectives on a given topic, by combining feedback on best practices from the field and expert analysis. The articles are subject to a reading committee prior to publication.

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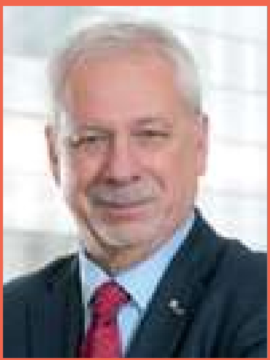
Pierre Marc Johnson - Lawyer and international negotiator and former Prime Minister of Québec
Chair of the Veolia Institute Foresight Committee



With 9 billion people by 2040, feeding the planet's population will be one of humanity's greatest challenges. Under the combined weight of mushrooming population growth, rapid urban expansion and the challenges raised by the climate emergency, how we feed our cities is an increasingly pressing concern. In 2050, 80% of the world's food will be consumed in cities. One current trend is to bring food production closer to them. It is worth examining as it provides a solution to the problem of food being transported great distances before finally arriving at the retailer or consumer. This trend is reviving ancient practices that existed back when cities were still places where agriculture could co-exist. In 19th century Paris, market gardens made it possible to directly produce and consume within the city limits.

At the same time, another global challenge – the climate emergency – is increasingly forcing us to rethink our resource management methods, including reimagining the ways that we grow or rear our food. Currently, food production is responsible for almost 25% of global greenhouse gas emissions, and poorly managed fertilization exacerbates pollution of the air, ground and water. We need to imagine an improved food production system grounded in better use of resources. This will involve moving to a circular economy, particularly in towns and cities.

Faced with the acceleration of these tendencies and determined to bring about a reinvention of food policies, urban agriculture is emerging as one driver for this new-look approach. Although urban agriculture cannot feed whole cities – potential yields are too low and restricted to certain types of food – it does make it possible to rekindle bonds between the urban and natural worlds, between cities and their foodstuffs, as well as helping to meet local demand. It is a very successful form of agriculture that is cropping up more and more in emerging and developed economies alike. The movement involves a growing number of actors: municipalities, supermarket and agro-alimentary companies, architects and engineers as well as civil society organizations that seek to develop this form of agriculture, usually driven by a desire to strengthen local ties and change people's buying and consuming habits. But it is a movement that takes many forms and it is important to distinguish between them, identifying the varied aims of its promoters: food self-sufficiency and productivity in highly built-up environments, short circuits and limited environmental impacts, or simply rekindled social ties.

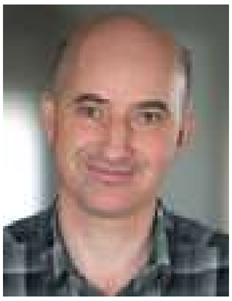
With this issue of its FACTS Reports, the Veolia Institute seeks to offer an analysis of the rise of urban agriculture at the city and territorial levels (urban and peri-urban agriculture), to understand the forces at work and the diversity of the actors involved, to show the types of issues that each form of urban agriculture can provide answers to and, lastly, to highlight the conditions needed to scale up.

This issue is divided into three sections:

- the first sets out the background for the rise of urban agriculture in developed and emerging economies. After a look at the historical background, it then examines a few of the key issues raised by urban agriculture: ability to improve food autonomy, ties between city and territory, the role this new form of agriculture can play in combating the climate emergency, and the role of policymaking in its development in cities;
- section two identifies different types of urban agriculture, seeking to highlight the various myths and realities that surround the subject. The aim is to show the potential offered by each type of technology and what can be expected of each form of agriculture in terms of productivity, environmental impacts and revitalization of the social fabric;
- the third section analyses successful programs and examines the cases of cities like Singapore, which have employed urban agriculture as a major lever for development. This final section also sets out to explain the obstacles and to pinpoint factors that might allow urban agriculture models to operate on a larger scale.

INTRODUCTION

Nicolas Renard - Director of Foresight, Veolia Institute



Cities and agriculture seem two incompatible worlds. Yet we are seeing more and more urban agricultural projects taking shape. Are these attempts to feed city-dwellers, who will account for three-quarters of our planet's population by the middle of the century? Far from it. Urban and peri-urban agriculture will never produce enough and will, at best, account for a few percent of global food production. But these few percentage points could make the difference locally in the event of a farming sector crisis. Very few cities have followed Havana and Singapore in choosing a productivist model for urban agriculture.

Urban agriculture is in reality less about helping cities to achieve food self-sufficiency and more about helping to feed citizens differently. "Differently" means quality produce distributed via short circuits, bringing producers and consumers closer to each other. It is a more sustainable model with the smallest possible environmental footprint. It is also a process that helps cities to rekindle an age-old relationship with food that was stretched to a breaking point during the 20th century. In the past this relationship was direct, as evidenced by the siting of community gardens and slaughterhouses in towns and cities. This symbiotic relationship was destroyed by soil sealing, greater building density and ballooning land prices. The early 21st century is seeing a renewed interest in urban agriculture. Irrespective of the food produced, it is a concept that creates employment, strengthens social bonds, builds resilience to climate change and improves biodiversity. By allowing nature back, urban agriculture helps to regreen the city and reincorporate it into the major natural cycles.

Previously exiled beyond the city boundary, new forms of agriculture are now returning to city centers

But what can cities offer agriculture? As well as proximity to consumers, cities offer high CO_2 concentrations that accelerate plant growth because carbon is the raw material for living things. Cities also offer financial resources. But the real key lies elsewhere. What the city offers agriculture is access to its unused resources: vacant spaces, roofs in particular; waste heat, 2 to 3 degrees Celsius warmer than surrounding countryside; the organic matter embodied in its household and green waste; runoff water, and so on. Urban agriculture recovers all of these generally unused resources. This is why it is so resolutely part of the circular economy.

What is so striking about this agriculture is the extreme diversity of the forms it takes. It can be open air or indoor, in carefully sealed, protected and controlled environments. It can be horizontal, like the community gardens of São Paulo, or vertical like in New York. At ground level or in cellars or basements. Manual, like in Addis Ababa or robotized and automated like the farming factories of Japan. It can be on standalone plots or incorporated into existing buildings. It may be designed to reduce food bills for poor families, like in Quito or, conversely, to supply premium produce sold at high prices, like in Brussels. Its objective may be leisure, education or production. It can use simple ancestral models or the latest technologies to maximize yields and minimize inputs. Its inspiration may come from conventional agriculture, hydroponics, aeroponics, permaculture, and more.

Booming it may be, but there are a number of challenges that urban agriculture needs to address. These include becoming more professional, and recruiting and training competent workers. It has to find profitable business models – because growing in the city is expensive – and ensure that its produce is safe and does not reintroduce multiple urban pollutants into the food chain. Lastly, and most importantly, urban agriculture has to find ways to compete for land with other more profitable projects. This is why it needs active support from municipalities, which must embed urban agriculture into their planning policies.

This issue of the *Veolia Institute Review – FACTS Report* is a mixture of cross-disciplinary studies and reports from the field, from emerging as well as developed economies. It shines a light on the renaissance of urban and peri-urban agriculture, its changing forms and technologies, its potential and limitations.

Previously exiled beyond the city boundary, new forms of agriculture are now returning to city centers. Cities around the world are rolling out initiatives designed to relocalize part of their food systems. This shows that urban agriculture is far more than just a niche phenomenon. And what is emerging in parallel to this movement is a new balance between the city and its food. It is creating a new urban space that combines city life with agricultural production – a new "rurbanity" created not by an influx of city-dwellers into the countryside, but by rurality taking root in the city. One thing is certain: the city of tomorrow will once again be a food-producing city.

1. NEW AGRICULTURAL PURPOSES IN THE CITY

Arising where individual practices meet private initiatives and reflections on urban policy, the revival in urban agriculture serves multiple causes, from strengthening links between the city and nature to creating new urban development models, via reinventing food production systems.

Reintegrating nature into the city

In response to urban dwellers' aspirations, urban agriculture is calling upon ancient practices to reintroduce natural and productive spaces into the city, to bring the rural and urban ways of life closer together, and recreate the social link. In particular, the current surge that cities are experiencing in shared gardening, and the individual and collective composting studied by the researchers Marjorie Tendero and Carola Guyot-Phung, are contributing to this dynamic, while also offering new outlets for organic waste. Architecture and urbanism also play a central role in repairing the links between city and country, embodied by Anthony Bechu architectural firm's approach, inspired by biomimicry and the circular economy.

Strengthening urban food production systems

Since the end of the 19th century, the expansion of the agro-industrial productivist model has contributed to distancing the city from the agricultural areas that feed its inhabitants. But now cities are retaking control of their food provision and inventing new economic models. Facing the limits of conventional agriculture and the challenges of massive urbanization and climate change, urban stakeholders are reclaiming the idea of food, notably by reinventing practices in urban agriculture, as Nicolas Bricas and Damien Conaré from the UNESCO Chair in World Food Systems demonstrate.

Renewing urban development

Urban and peri-urban agriculture was identified as a real development tool as far back as the 1990s. Its potential has even been recognized by international organizations such as the United Nations Food and Agriculture Organization (FAO). On this basis, the example of the urban areas of Jakarta, Indonesia, and Addis Ababa, Ethiopia, demonstrate the importance of agriculture in the large conurbations of the southern hemisphere, contributing both to the livelihood of their inhabitants and to the resilience of urban systems in the face of economic, social and environmental crises. The inclusive agriculture program of the city of Quito, Ecuador, provides autonomy to vulnerable populations through food security and access to new sources of revenue, credit and employment. In the North as in the South, from Toronto, Canada, to Antananarivo, Madagascar, the multiple environmental benefits of urban agriculture have been widely documented by the RUAF Foundation. Short supply circuits, reduction of heat islands, carbon capture and the infiltration of rainwater are just some of the services agriculture provides to the urban environment.

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HISTORICAL PERSPECTIVES ON THE TIES BETWEEN CITIES AND FOOD

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Old postcard showing La Villette market in Paris

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Damien Conaré, a graduate agronomist (ISTOM), has been Secretary General of the UNESCO Chair in World Food Systems since 2011. His work focuses on three main fields: coordination of action research programs on sustainable urban food systems, training (notably a Master's degree in Innovations and Policies for Sustainable Foods), and dialogue between science and society (conferences, publications, etc.).

The 20th century marked a step change in how cities think of their food supply. In the preindustrial world, where cities grew organically, urban layouts were heavily shaped by food, as witnessed by the city center locations of sites such as markets and slaughterhouses. Hygiene policies and then the imperatives of food security in an urbanized world, gradually pushed food and farming out of the city entirely, engendering a progressive distancing between cities and their food. This distancing encompasses many forms, at once geographical, economic, cognitive and political. Some cities, such as Toronto, Canada and Belo Horizonte, Brazil have pioneered incremental reappropriation of food policies by a variety of urban actors. The revival of urban food policies extends well beyond questions of urban agriculture and food production. However, urban agriculture does have a role to play in this respect. The challenge is less about feeding cities – it is a form of farming with a limited production potential – than about reintroducing nature and agriculture into the heart of the city, while simultaneously rebuilding social ties. The symbolic dimension should not be underestimated.

INTRODUCTION

Cities were closely linked to their food until the advent of the Industrial Revolution in the 19th century. Town centers were laid out to enable close access to locations judged to be of strategic importance: buildings symbolizing political, legal and religious power, but also markets. The market, just like the slaughterhouse, made visible to townsfolk the processes by which supplies from farming were turned into food. In this model of the "organic city" (Steel, 2008), town centers were literally shaped by food. Conversely, globalization and the rise of global cities around the turn of the 20th century had the effect of distancing cities not only from their national economy but also from the local embeddedness, incrementally weakening the ties between the city and its food. Recent environmental, social and health crises, and the emergence of the city as the primary force of the 21st century, have gradually made it possible to reintegrate the question of food, long abandoned by urban policymakers, into the agenda for public policymaking in cities. In this new era, the capacity of urban agriculture to speed up a revitalization of the ties between cities and food is a question that needs raising.

DISTANCING THE CITY FROM ITS FOOD

LIMITS OF THE INDUSTRIALIZED FOOD SYSTEM

A series of technical and scientific advances that began in the late 19th century have revolutionized and industrialized traditional farming, leading it into the era of modernity, such as the use of extracted resources (first coal then oil), mechanization, and the development of pesticides and herbicides. The discovery of the Haber-Bosch process, named after two German chemists, which makes it possible to fix atmospheric nitrogen to produce nitrate fertilizers for use in agriculture, paved the way to higher yields while ending the reliance on natural fertilizers and recycled manure. The rise of this system of modern agriculture was a response to the overarching necessity of feeding an ever-growing population in the aftermath of the Second World War. In France, an integrated system was put in place to meet this demand, including banks, insurers and research and teaching bodies all dedicated specifically to the farming sector. Creating this system proved to be a success: yields rose, food was abundant and safe from a public health standpoint, and so on. Some business activities formerly exercised in towns and cities, such as slaughterhouses, moved to the outskirts in parallel with a policy drive to align the urban environment with the precepts of hygiene. This process of relocation helped to increase the distance between towns and food, as did planners' increasing lack of concern for food-related issues.

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Old postcard showing Montreuil, near Paris

And yet, for close on 50 years the agro-industrial system has been showing its limits and is the target of increasing criticism for economic, social, environmental and health reasons.

- **From the economic and social standpoint**, the question of how to share the value added among the various actors in agro-alimentary chains is debated increasingly heatedly. As regions have become ultra-specialized, the vast majority of value added is now divided among dominant actors (seed companies, agri-food businesses and supermarket operators), to the detriment of producers. Furthermore, over-production leads to large-scale wastage and foods losing their value at a time when food insecurity is on the rise.
- **From the environmental and health standpoint**, the conventional agricultural model has also proven to have limits and negative consequences. Agriculture is one of the major greenhouse-gas-emitting industries contributing to the climate emergency. The use of synthetic products combined with intensive growing methods and limited crop rotation leads to soil pollution and impoverishment, lower biodiversity and, inexorably, to yields that are flatlining. And the sheer abundance of food, the massive use of fats, sugars, salt and chemical additives to provide texture, flavor and conservation in processed foods, leads to people becoming overweight or obese, which are risk factors for pathologies such as cardiovascular diseases and some cancers.

MANY FORMS OF DISTANCING

The distancing between cities and their food is at once geographical, economic, cognitive, social and political.

- **Geographical distancing**: urban sprawl and lower transportation costs using fossil fuels lead cities to seek supplies from sources at ever greater distances.
- **Economic distancing:** arises due to the multiplicity of intermediaries between agricultural producers and consumers to transport, process, store and distribute food.
- **Cognitive distancing**: there are very few contacts between urbanites and the rural world. Knowledge of the agricultural and food industries is mediated exclusively through science and the media. Some urbanites are unable to identify many types of fruits or vegetables, let alone describe how they are grown. This lack of knowledge can create a degree of anxiety in the minds of people who eat food about which they know nothing in terms of how it was grown and processed.
- **Social distancing:** the individualization of food behaviors at the expense of commensality erodes the social norms that made food something everybody took for granted. Each individual is now responsible for their own food choices and has to define, in the face of incessant pressure, what is and is not good to eat.
- **Political distancing**: people's control over their food system is reduced to choosing what to buy, and where. They feel stripped of their ability to influence the system, powerless in the face of special interest lobbies.

Supermarkets are in many ways a symbol of these forms of distancing: the foods displayed on the shelves are packaged in ways that suit the retailer, rendering the work put in by the producers invisible to consumers.

But the situation can be qualified in two ways. First, markets remain one of the rare places where city and food come together, and markets continue to have a place in the urban fabric. Second, this distancing is not taking place at the same speed in every part of the world. There remain many cities, particularly in developing economies, where the boundaries between urban and rural, producer and consumer, are far more porous. In many African and Asian cities, people grow food or raise animals, grind seeds, grate manioc, dry foods; street-sellers cook in front of their customers; urbanites retain links with their home villages, and so on.

TOWARD A NEW BALANCE BETWEEN CITIES AND FOOD

CITIES, CRITICAL ACTORS FOR THE 21ST CENTURY

While the 20th century was that of the nation state, the 21st may well be the century of the city. Firstly, in a purely structural sense, since over 50% of the world's population already lives in towns and cities; there are now 4.2 billion urbanites compared to 751 million in 1950 (when 30% of the population was urban). In 2050, almost two-thirds of the world's population will be living in cities, a total of 6.7 billion people. Africa and Asia, continents that are today predominantly rural, will account for 90% of urban growth. In these two continents there are three countries where the pace of change really stands out: China, India and Nigeria will together account for 40% of urban growth in the years leading up to 2050.

The rapid growth in the extent of built-up areas poses major challenges to cities in terms of housing, infrastructure, transportation, energy, employment, health and education. As places where human activities are concentrated, cities also accumulate factors that fly in the face of sustainability. For example, cities produce 70% of greenhouse gas emissions. But for the past two decades or so, cities have emerged as key actors across their territories by reclaiming social, political and economic power in the face of gradual disengagement on the part of states. Cities are also in the frontline in the quest for responses to contemporary environmental challenges. Ever since the 1992 United Nations Earth Summit in Rio de Janeiro, more and more Agenda 21-related initiatives are being rolled out by municipalities of all sizes. Networks that have been established to help deal with the climate emergency include Metropolis (139 cities), the International Council for Local Environmental Initiatives (over 1,500 local government authorities) and the C40 Cities Climate Leadership Group (94 cities). At the end of 2018, the combined efforts of 27 city-members delivered a 10% fall in greenhouse gas emissions compared to the peak recorded five years previously. In addition, almost 1,000 cities from all over the world belong to a network of transition towns, helping them to design resilience strategies to cope with this major risk and reduce our collective oil dependency. These networks facilitate exchanges of best practices and promote collaborations, including with the private sector. They also comprise a political force able to influence national and international policymaking.

These resolute commitments to ushering in greater sustainability are gradually leading cities to look at the food implications too and rethink their policies in this area, encouraged by the Milan Urban Food Policy Pact. The 180 cities that are signatories to the Pact are all committed to fostering the development of sustainable food systems.

THE REVIVAL OF URBAN FOOD POLICIES

Cities' responses to the ever-greater distancing in their relationships to food involve myriad initiatives that aim to relocate food to urban centers or nearby. Cities have considerable assets and resources at their disposal when it comes to managing food questions. They produce biomass on a daily basis that, if properly recovered and processed, can become a source of fertilizer for farmers. They are places with great concentrations of knowledge (research centers, universities, etc.), infrastructure and decision-making centers, meaning that they also have the wealth needed to roll out innovative urban food strategies. For some 20 years, an ever-growing number of cities have been developing their own food policies that take account of a range of different dimensions, from production to processing, and including distribution, consumption and waste management. There is an array of levers available to them as they seek to foster relocalization: catering services, particularly school kitchens (for example by including clauses that place certain obligations on suppliers); land-use management (for example protecting productive spaces); setting up farmers' markets; etc.

Cities' responses to the ever-greater distancing in their relationships to food involve myriad initiatives that aim to relocate food to urban centers or nearby

Some cities have pioneered this drive to reconnect with their food. One such is Toronto, Canada, which has been trialing innovative urban food policies since the early 1990s, setting up the Toronto Food Policy Council to represent views from all areas of the food sector. North America is one of those regions where distancing of ties between the city and its food is pushed to extremes. In Toronto, setting up the Food Policy Council led to the expansion of community gardens on vacant lots in districts that had been identified as food deserts. Today, over 300 North American cities have a Food Policy Council.

Logo of the Toronto Food Policy Council - ©Neglia Design

Belo Horizonte, Brazil's third city and the capital of Mina Gerais state, has also been extremely proactive in terms of its food policy (Rocha, 2001). In 1993, Brazil was still classified as a developing country. Poverty was persistent: 38% of the local population lived beneath the poverty line and large numbers of people were going hungry, with 20% of children under three suffering from malnutrition. Two municipal bodies dedicated to food security were set up during the 1990s: the Municipal Supply Secretariat (SMAB) and the Municipal Council for Food Security and Nutrition (COMUSAN). SMAB quickly became a crucial component of municipal food policy. As of 1995, it operated on a US$17.8 million budget, 46% from the federal government, 45% from the municipality and 9% generated by its programs. The aim was to supply the city with healthy farm produce in a win-win relationship. On the one hand, the city's poor gained access to good quality food. On the other hand, rural and peri-urban farmers, who struggled to find buyers for their produce, had access to a larger market. A number of initiatives were put in place: support for low-priced restaurants, setting up a food bank, imposition of a quota for local products in school kitchens, etc. The initiative proved to be effective and met with real success as it played a role in embedding the issue of food security into Brazilian policymaking at the national level. In 2003, when president Luiz Inacio Lula da Silva took office, he was inspired by this example to instruct his government to set up a national hunger eradication policy called *Fome Zero* (Zero Hunger).

Cities are incrementally reappropriating their food. Having been pushed out beyond the city boundaries, agriculture too is returning to urban spaces in the form of urban agriculture.

WHAT PLACE DOES URBAN AGRICULTURE HAVE IN PROVIDING FOOD FOR CITIES?

LIMITED POTENTIAL IN TERMS OF FOOD SECURITY

The years either side of the turn of the new millennium saw a sharp uptick in urban agriculture projects, created by actors with a wide range of backgrounds: residents' collectives, nonprofits, local government authorities as well as private businesses. Despite the wide range of sometimes divergent objectives, relocalizing food production inside urban spaces forms part of a wider move by cities to reconquer the food system.

But urban agriculture cannot really pretend to offer a pathway toward food independence for cities. Plots of city land devoted to growing crops in cities are tiny in comparison to current production and food needs. And

Fruit market in Cuba

since urban agriculture is unable to meet all food needs, it is important to keep the phenomenon in proportion. Even if peri-urban agriculture is included in the overall result, market gardening still prevails even though it represents a very small portion of our daily diet. For example, cereals and oilseeds are almost never grown in cities.

Havana is one of the rare cities to have developed an urban agriculture model that is focused on food self-sufficiency. After the collapse of the communist bloc in the early 1990s, Cuba was suffering from a severe economic crisis. Due to the U.S. economic blockade of the island, imports, food in particular, were under threat at a time when the country was experiencing a massive rural exodus. Against this backdrop, the authorities decided to revise the food production system with the primary aim of being able to keep the capital supplied with food. Vacant open areas in Havana were transformed into kitchen gardens.

This unique program is an outlier – very few other urban agriculture projects are in any sense productivist. The pitfall with relocalization of food policies occurs if they are presented as being a way of fundamentally calling into question the industrial agri-food system, whereas they are primarily simply a change of scale (Born & Purcell, 2006). Relocalizing is not necessarily about challenging the current system or making it any more sustainable. Urban agriculture, even in its most extreme forms, cannot suffice to deliver a comprehensive response to all the challenges and limits of the conventional agricultural system. Fundamentally, urban agriculture has aims other than food security, including social cohesion, education, absorbing rainwater to avoid flooding, and district cooling.

Urban agriculture embodies a very powerful symbolism. It heralds a progressive return to the "organic city" by bringing urban centers closer to their food and promoting the protection of productive spaces within the city

DEEPLY SYMBOLIC AND A POTENTIAL FOR INNOVATION

Urban agriculture embodies a very powerful symbolism. It heralds a progressive return to the "organic city" by bringing urban centers closer to their food and promoting the protection of productive spaces within the city. It also argues in favor of changes to how cities are laid out, promoting methods that are more in harmony with the natural environment. This role is both ecological and educational. Agriculture in urban settings is generally focused on reinforcing community ties and social cohesion by reaching out to include disadvantaged people, training people who are alienated from the job market and helping to foster inter-generational ties. This symbolical power should not be underestimated, as it plays a very important role in promoting the spread of innovative urban food policies.

Urban agriculture on the outskirts of Havana - ©Arnoud Joris Maaswinkel

Urban agriculture is also a valuable driver for innovation. For example, it can change people's perceptions of the role of the farmer. Traditionally something passed from father to son and agriculture is currently struggling to attract newcomers to the profession. Urban agriculture offers a chance for new types of farmers to emerge from a wide variety of backgrounds. They do not always intend to become life-long farmers. They may turn to this activity for a few years, as just one project or one more experience among life's many. Even if the image of the profession that they convey, albeit involuntary at times, can attract criticism from traditional farmers for a number of reasons, at the very least it helps to alter public perceptions of farmers and to rebuild bridges between the urban and rural worlds.

CONCLUSION

Never before has the planet produced so much food per head of population. Famines are almost a thing of the past and today's food crises mostly result from conflicts or disasters. And yet the agricultural model that has made this possible is widely criticized. At the other end of the chain, food is cheaper, more varied and of better quality. But people are increasingly perplexed and uneasy about their food, leading them to seek new relationships and to retake control of their food system.

City food policies set out to provide answers to these challenges. They build on civil society initiatives that allow them to experiment with alternatives, encouraging new ways of producing, distributing and consuming. Urban agriculture is part of this movement. It explores one way to reconcile city with agriculture that 20th-century modernity has scrupulously separated and specialized. It is inventing what may emerge as a third space, a new "rurbanity" where rural and urban combine and complement one another. This new arrangement is not only spatial. It is also social and economic, a mix of primary, secondary and tertiary activities because this form of "rurbanity" does not only aim at producing food. It also produces services to the environment and models of living things and systems, raising in turn the question of how these should be paid for. Can they be left for the market to regulate?

What is happening here is the invention of another form of "development", where agriculture and food can no longer be reduced to simply producing and consuming nutrients. How food is produced, traded and consumed is as important as what is produced, traded and consumed. For it is this "how" that defines our relationship with the world, our environment and other living things.

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URBAN AGRICULTURE IN THE GLOBAL NORTH & SOUTH: A PERSPECTIVE FROM FAO

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Paddy production in peri-urban areas of Colombo (Sri Lanka)
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The high-level conferences in agriculture of the late 1990s have provided the political impetus to mandate FAO to support urban agriculture across the world. The agency provides technical expertise and advice to national and local governments on food-related matters through key programs, initiatives and reports, while working closely with the private sector. FAO's holistic and systemic approach focuses on strengthening the complex linkages between urban, peri-urban and rural agriculture which characterize contemporary food systems, with the goal of enhancing the city region's food security and resilience. FAO also acknowledges the limitations and opportunities provided by contextual variables and the necessity to adapt programs according to the local populations' needs and aspirations. If food has not always been authorities' main priority in policy-making, current changes in the perception of food systems, pushed by societal demands to act against food waste and climate change, have fostered an increased attention to FAO's activities.

Since when and why has urban agriculture come to the forefront of the agenda of international organizations such as FAO?

Makiko Taguchi: FAO's engagement in urban agriculture can be traced back four decades ago and be characterized by a few milestone moments. The first was the second United Nations (UN) Conference on Housing and Sustainable Urban Development (i.e. Habitat II), which occurred in Istanbul in 1996. Habitat II brought together all UN agencies, high-level representatives of national and local governments, as well as private sector, NGOs, research and training institutions, around the objective of ensuring adequate and safe human settlements and shelters, as well as healthier and more livable cities. In this context, the United Nations Development Programme (UNDP) published *Urban Agriculture: Food, Jobs and Sustainable Cities*[1]. The report highlighted the compatibility of urban agriculture with an ever-increasing urbanization, demystified key points raised against urban farming, and identified solutions to the challenges faced by urban agriculture.

The context in the late 1990s provided the political impetus of integrating urban agriculture in FAO's work. The FAO Department of Agriculture has been governed by the Committee of Agriculture (COAG) since 1971. Constituted of over 100 Member States, COAG meets every two years in order to provide policy and regulatory guidance on issues relating to agriculture, livestock, food safety, nutrition, rural development and natural resource management. The 1999 COAG officially mandated FAO to work on urban agriculture.

With this recognized status and responsibility, FAO became more proactive in working on urban agriculture. In 2001, FAO launched a multidisciplinary initiative "Food for the Cities" which aims at addressing the challenges that urbanization brings to the environment and to urban and rural populations by building more sustainable and resilient food systems based on stronger rural-urban linkages. It was first established as an internal network to share information amongst people working in projects in urban areas and to have a more coherent approach towards urban-related activities. Then in 2009, we established the Dgroups Global Network "Food for Cities", which we have been managing since. It is a global network with over 3,400 members across 131 countries, which allows experts, activists, students, from development practitioners to academia, to connect research and practice on sustainable food systems and urbanization through an online platform.

Paddy production in peri-urban areas of Antananarivo, Madagascar
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1 Smit, J., Ratta, A., & Nasr, J. *Urban agriculture: food, jobs and sustainable cities.* 1996.

GROWING GREENER CITIES IN AFRICA: THE CASE OF THE DEMOCRATIC REPUBLIC OF THE CONGO

FAO supported the development of urban and peri-urban agriculture sector in five cities of the Democratic Republic of the Congo. It advised on measures that regularized title to 1,600ha of garden areas operated by 20,000 full-time growers. The project improved vegetable varieties and installed or upgraded 40 irrigation structures, which extended production throughout the year. Some 450 growers' associations were trained in good agricultural practices, while micro-credit helped beneficiaries start profitable small-scale enterprises. Market gardens in Kinshasa now produce an estimated 75,000 to 85,000 tons of vegetables a year, or 65% of the city's supply.

In Lubumbashi, the second largest city of the Democratic Republic of the Congo where population has expanded by more than 50% since 2000, a FAO project has created a flourishing urban and peri-urban horticulture sector. The area under horticulture has risen from less than 100ha to 725ha. Market gardens ringing the city produce more than 60,000 tons of vegetables a year.

Women producers in Quito, Ecuador, technically supported by municipal government initiative AGRUPAR, producing vegetables (and poultry) in their backyard garden - ©Makiko Taguchi

More recently, the importance of food systems and the interlinkage between rural and urban areas have been increasingly recognized by urban planners and decision-makers. The issue was included in the Goal 11 of the Sustainable Development Goals, dedicated to making cities resilient and sustainable (Target 11.a.: "support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning").

In 2016, Habitat III aimed at further exploring the implementation of this goal. It adopted the New Urban Agenda (NUA), which clarifies the importance of rural-urban linkages and the role of food security, nutrition and food systems for sustainable urban development.

Urban agriculture could be defined in many ways and is sometimes extended beyond the city's territory. What does the term "urban agriculture" encompass, in FAO's perspective?

M.T.: The most straightforward definition of urban agriculture is "growing plants or livestock within and around cities". But in terms of characteristics, urban agriculture usually operates at a small scale, for domestic purposes and self-consumption, being harvested by a household or community for food security purposes. This contrasts with peri-urban agriculture, which is usually bigger in size and commercially oriented. These are the global and general tendencies of these two types of agriculture.

We promote a territorial approach to look at urban agriculture, advocating that the food system cannot stay in the limit of the city: we need to go beyond urban and adopt peri-urban and rural agriculture

Guido Santini: The way urban or peri-urban is defined strictly depends on the context. Each country has its own definition and criteria to determine what draws the line between urban and peri-urban agriculture. It is often based on jurisdictional criteria, but it can also rely on food flow patterns and the supply chain of main commodities in circulation in the city and around it. It varies very much according to local characteristics, so there is no standard definition of what is urban and peri-urban. At FAO, we promote a territorial approach to look at urban and peri-urban agriculture, advocating that the food system cannot stay in the limit of the city: we need to go beyond urban and adopt peri-urban and rural agriculture. It is important to highlight that urban agriculture alone cannot provide sufficient food to guarantee food security for a city. It needs to be perceived as a complement to other sources of food supply, and more broadly, we need to think beyond urban food models by incorporating the broader region in connection with the city in urban food security strategies.

GROWING GREENER CITIES IN LATIN AMERICA: THE CASE OF HONDURAS

Tegucigalpa, the capital of one of the poorest countries of the world, embodies key urban development challenges in the developing world: informal settlements, an exponentially increasing population, insecurity, malnutrition, lack of basic services such as drinking water, sewerage, schooling, *inter alia*.

FAO and the district mayor's office launched the "Pilot Project for Strengthening Urban and Peri-urban Agriculture and Food Security" in the Central District in 2009. The US$480,000 project consisted of establishing and maintaining household gardens in four settlements in the East of the city, with the immediate goal of increasing the consumption of fruits and vegetables, and the ultimate goal of contributing to food security of people living in extreme poverty. Its guiding approach was to teach low-cost and locally-adapted gardening techniques and technologies that were easy to implement and maintain.

Since 70% of participants did not have any agricultural experience prior to the project, they participated in demonstration training centers to receive a two-months weekly training on home gardening (e.g. vermicomposting, seedling production, micro-gardening, hydroponics, pest control). In a second phase, the participants applied what they had learned by establishing their own home gardens, with technical experts following progress and providing guidance. The last phase of the project consisted of developing a system of credit for the future purchase of inputs of seeds and a barrel or tank for storing water.

The project, which ended in 2011, trained 1,200 people and affected 6,000 people overall. Beyond gardening skills, participants were also taught on food security, nutrition, and vegetables preparation. In the immediate, the vegetable intake of participants more than doubled and reduced family's food expenditure by US$20 to USS$60. Follow-up studies found that almost 90% of the people trained had established gardens and were growing up to 30 different species of plants.

Tegucigalpa became a signatory to the Milan Urban Food Policy Pact and is committed to strengthen its food system.

FAO has been leading different programs over the years on food and cities which notably seek to strengthen rural-urban linkages. How does urban agriculture fit into these programs?

M.T.: FAO is a UN technical agency and its main role is to implement projects with national and/or local governments by providing policy and technical expertise and advice, and to support them in the formulation and implementation of their own food and agricultural projects and policies. Historically speaking, the requests that we deal with regarding urban agriculture revolve around two main elements: **(1)** the technical elements – help authorities understand what kinds of technology and techniques should or could be used in their circumstances and **(2)** the enabling environment – support authorities identify which policies support each particular kind of work and objective, such as local, municipal, or even national legislation that governs land use and water access.

G.S.: FAO's goal is to provide a broader, systemic perspective to local governments which extends beyond urban agriculture alone. In order to support and understand urban agriculture, we need to link it to other dimensions of governance, such as nutrition, resource management and food waste. We advise local institutions to adopt such a system-wide approach. We also work in close partnership with the private sector, with which we have different forms and ways of engagement. We work on public-private partnerships through public procurements to feed schools, hospitals, etc., and we try to bring the private sector on our issues and areas of work if we need to create a shared vision on the food system in a city, as they play a key role in food systems. FAO builds partnerships with companies and is currently working to strengthen them.

M.T.: Regarding the place of urban agriculture among our organization, FAO has been working on several different projects related to urban agriculture since it has been mandated to do so. Due to the size of the organization, numerous departments and divisions deal with different aspects of urban food systems. Guido and I work at the Plant and Production and Protection Division, focusing on the production side. Apart from the Food for Cities Programme, the FAO Programme for Urban and Peri-urban Horticulture has specifically worked on urban agriculture over these last years. The program has assisted developing countries in removing barriers and provide incentives, inputs and training to low-income urban farmers, with the ultimate objective of optimizing urban farming production systems – that is, "growing greener cities". To assist policymakers in evaluating the potential of urban agriculture, FAO conducts surveys and exposes its findings on urban horticultures in specific regions in the Growing Greener Cities report (cf. boxes).

In the projects supported by FAO, do you promote any particular models or technologies or is FAO neutral regarding these issues?

M.T.: Each context and location has different needs and consequently they require different technologies and agricultural models. In very densely inhabited and built-up cities, there may be no other option than gardening on rooftops, such as in Cairo and Dhaka. Other cities' limitation may be climate or the population's restricted access to technological inputs. In cities where livestock still run free, it could be an issue of delimitating pastoral areas. In the developed world, some cities are promoting vertical farms, stacking layers of gardening and farming activities in a building, and underground farms, which allow to grow vegetables in tunnels and other infrastructures. There are numerous types of vertical farming that have developed according to this varying context. The case of Singapore is a high-tech, almost fully-automated kind of vertical farming, but in Colombia, internally displaced refugees have developed a technique of vertical farming based on a simple container or bag gardening along a wall. Hence, there are many ways to grow food in cities, and FAO does not promote one particular model or technology over the others. The only thing we do advocate for in these terms is that the techniques need to be chosen *and* adapted to best suit local characteristics and needs.

FAO works with authorities for them to understand needs and opportunities within their cities so that they can create an enabling environment for sustainable food systems and urban farming activities to flourish

GS: We can identify broad trends depending on the region of the world we are looking at. In the developing world, we tend to promote affordable solutions which require simple and cheap inputs, instead of expensive materials or spare parts. We need to acknowledge local limitations such as access to energy, electricity, water, space, financial resources, technology, etc. The goal is to formulate an urban agriculture strategy which is sustainable and appropriate for a precise context. It is not only about technology, but also about understanding different needs and market possibilities, so we can attend the former and maximize the latter.

GROWING GREENER CITIES IN LATIN AMERICA: THE CASE OF COLOMBIA

FAO has implemented three projects in Colombia which provided training and other technical assistance for urban and peri-urban horticulture in Bogota, Medellin and Cartagena, and in urban areas of Antioquia and Tolima departments. Assistance from FAO and other organizations has helped introduce various types of urban gardening - including backyard plots and micro-gardens on terraces and rooftops - to 50,000 urban residents. In 90 municipalities in Antioquia, more than 7,500 families are participating in urban and peri-urban horticulture programs.

Bogota and Medellin have joined the Milan Urban Food Policy Pact, and through the technical assistance from FAO to Medellin and its department of Antioquia, they have established a multi-level governmental platform called *Alianza por el Buen Vivir* (Alliance for Well-Being) to foster coordination and collaboration to improve the city region food system.

What kind of difficulties and challenges have you and the FAO team encountered while setting up urban agriculture projects, and how can they be overcome?

M.T.: In the general context, urban agriculture is in constant competition with other development works, such as buildings, parking lots, etc., which are often more profitable for cities. For instance, FAO was involved in the 1990s in the master plan of the development of the city of Kigali in Rwanda, in order to incorporate urban agriculture in its design. In the meantime, Kigali became one of the fastest growing cities in the world, facing great pressures from population growth, so green spaces that were designated for agricultural usage were reallocated for residential development. We have observed similar issues in other cities.

From a technical perspective, two main challenges arise. First, food safety is a recurring question because it has not been categorically and scientifically proven that urban agriculture is safe in terms of health. It implies that food is grown in urban areas which are potentially polluted, soils contaminated, amidst busy roads and unclean water. This is still an area that needs a lot more work and research. Second, urban agriculture often does not fall under the responsibility of the ministry of agriculture in most developing countries. Usually, agricultural services are exclusively provided to rural farmers, while urban farming activities are left unattended. As a result, there is no help in the provision of inputs like seeds, fertilizers, chemicals, and technical advice – resources that every farmer needs but are hard to find in urban contexts. Remedying this situation, as well as ensuring access to clean water, land, and capacity building, is crucial in supporting urban agriculture.

G.S.: From my perspective, the main challenges arise from (1) the political buy-in, that is, the fact that we need to bring to the table actors from different institutions, fields, interest groups, and levels to propose effective solutions. This is a governance issue, rather than a sectoral one specific to food-related topics. It is important to try to put in place a mechanism of governance that goes beyond the city's boundaries and jurisdiction. This challenge is coupled by (2) the limitation of our mandate, since we do not have the necessary administrative and institutional instruments to find common ground among different actors.

M.T.: One last issue that FAO faces is that historically, people do not deeply think about food in urban development, taking it for granted and excluding it from the agenda. Even in Habitat III we had to push for food-related issues to be included in the concluding document.

Many governments do not directly perceive the benefits of urban agriculture. They consider that food can be imported and therefore there is no necessity of developing urban food systems. However, we try to make the case that this is contingent upon how you perceive your food system: city authorities need to adopt a critical approach to the food system in order to see how it can be improved. This can usually be found in sustainable management practices of the environment. For instance, waste management has constituted a key persuasion tool at FAO because local governments are increasingly concerned with the excessive of organic food waste, which can be dealt with through urban agriculture.

Vegetable vendor in Analakely market in Antananarivo, Madagascar
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What are the main differences between the Global North and the Global South when it comes to urban agriculture?

G.S.: In the Western world, it is generally more normal for governments to think about food issues in cities, as they are forced to consider this relationship more deeply and seriously into account than most of developing countries. Their civil society is stronger and more demanding in relation to the way it is fed, and their institutions are somehow more open to this kind of thinking. For instance, cities have adopted numerous initiatives to make food systems more equitable and sustainable, including the Milan Urban Food Policy Pact, signed in 2015 by cities from all over the world during the Milan Expo 2015, embodying the international commitment for the coordination of food policies. This initiative, key to involve cities at the global level on this topic, was led by Milan with the support of major European and North-American cities, such as Toronto and New York. Meanwhile, countries in the developing world are slowly moving towards the normalization of urban agriculture in food systems, especially Latin America.

One issue that FAO faces is that historically, people do not think about food in urban development. Many governments consider that there is no necessity of supporting urban food systems

M.T.: There are key distinctions to be made between developed and developing countries in relation to urban agriculture, as they have different functions. The Global South often employs urban agriculture to fulfill food security and nutritional needs. In Latin America and in Africa, people cultivate in very limited spaces through innovative methods but for the end goal of food security, for them to feed their families and be able to survive. In comparison, urban agriculture in the Global North tends to be used as a mean to lead a more sustainable way of life or to create social ties within a community. There, urban agriculture has functions that are distinct from food security *per se*.

PERI-URBAN AGRICULTURE: lessons learnt from Jakarta and Addis Ababa

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Typical mixed urban and rural land uses (*Desakota*) in the Jakarta Metropolitan Area - ©Didit O. Pribadi

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The 21st century has been called the urban century, as most of the human population is now living in urban areas. Current and future urbanization is mostly taking place at great speed in the Global South. The challenges are enormous and request different models of urbanization as developed in the Global North. High levels of informality and poverty will not go away in the decades to come, while capacity will remain limited to adequately provide urban dwellers with basic infrastructure and economic opportunities. Grave economic shocks and environmental disasters such as experienced in both the Jakarta and Addis Ababa urban regions are likely to remain features of these regions. Therefore, it is of utmost importance to strengthen the resilience of these cities in the best possible ways. The continued existence of agriculture in and near urban areas is an important means for this purpose that, however, is still poorly, or at best intermittently, acknowledged by politicians and urban planners, who are inspired by visions of "modern" cities where agriculture is rather a negligible activity.

INTRODUCTION

In the year 2050, 7 out of 11 billion people are expected to be living in urban areas (UN, 2018a). The Global South will absorb 90% of future urban population growth, notably in Asia and Africa. Annual rates of population increase of 5% are not an exception in the cities of these regions, meaning that the population doubles within approximately 14 years. To cope with these pressures would be an incredible challenge for any city, but it is overwhelming for many African and Asian cities where urban institutional capacities are mostly limited, governance mechanisms inefficient and urban growth is not accompanied by corresponding economic growth (Parnell & Walawege, 2011). Consequently, poverty levels are high and nearly 60% of the urban population in sub-Saharan Africa, and around 30% in Asia, are living in slums with poorly built homes and a scarcity of basic infrastructure such as electricity, water and sanitation (UN, 2018b).

In this situation, local provision of food, medicines, fibers and timber is a sheer necessity for the survival of many. Moreover, agricultural land can provide environmental, social and economic benefits such as generating fresh air that cools hot inner cities, offering places for recreation as well as opportunities for the generation of income and entrepreneurial activities in a mostly informal economy. However, the pressures of urban growth make it difficult to conserve farmland; but what is perhaps more problematic is that decision-makers and planners apparently still fail to recognize its value.

The following two stories of the city regions of Jakarta, Indonesia, and Addis Ababa, Ethiopia, will give insights into the current dynamics and the importance of agriculture in large urbanizing areas in the Global South. Based on our recent research findings, we will show how urban agriculture in peri-urban areas, i.e., the zones around and in-between the settlements in urban regions, can support the livelihood of citizens and strengthen the resilience of urban systems in times of economic, social and environmental crisis. Furthermore, we will explore the impacts of different scenarios for urban development on peri-urban agriculture and its societal benefits. The modeling approach can provide foresight information that is much needed to better conserve and integrate peri-urban agriculture into strategies for future urbanization in the Global South.

AGRICULTURE IN URBAN REGIONS AND LIVELIHOOD IN ECONOMIC CRISES: AN INSIGHT FROM THE JAKARTA REGION

JABODETABEK METROPOLITAN AREA, A RAPIDLY DEVELOPING CITY REGION

Jabodetabek Metropolitan Area (JMA) has emerged as the biggest urban agglomeration in Indonesia. *Jabodetabek* is an acronym for Jakarta, the capital city of Indonesia, surrounded by Bogor, Depok, Tangerang, and Bekasi as its hinterland. With a population of around 30 million, this area has been considered as the second largest megacity in the world (RIHN, 2014). If population growth continues as predicted, the merging of the JMA with the neighboring region of Bandung metropolitan may lead in the coming decades to the formation of the largest megacity in the world, which will be called the Jakarta-Bandung Mega Urban Region.

The rapid urban growth has put great pressure on the surrounding landscape, particularly agricultural land. Urban land use increased from just 9,373 hectares to 223,953 hectares between 1972 and 2012, with an average annual growth rate of 8.2% (Pribadi and Pauleit, 2015). In the same period, 178,509 hectares of farmland were lost. The problem is becoming more complex as labor-intensive farming such as rice fields is dominant. Therefore, urban expansion has occurred in already densely populated agricultural areas. The distinctive mix of urban and rural land uses has been termed *desakota* (McGee, 1991), derived from the Indonesian words *desa*, meaning village, and *kota*, meaning city. While some scholars have regarded desakota as a temporary phenomenon that will vanish after the completion of urban transformation, farmland in the JMA still persists as a dominant land-use type, even after four decades of rapid urbanization (Pribadi and Pauleit, 2015). A closer look at the dynamics of land-use change in peri-urban areas reveals that some farming types have even benefitted from urbanization while others have not been able to resist its pressures. This has important implications for issues such as food security, employment opportunities and ecosystem services provided by farming.

AGRICULTURAL CHANGES IN JMA AND THEIR ENVIRONMENTAL IMPACTS

Interestingly, agricultural land in peri-urban JMA has persisted in recent decades despite the huge expansion of urban land. As time-series of satellite image data revealed in our study, losses have been partly compensated for by the conversion into agricultural land of woodlands in remoter, hilly areas further away from the city center (Pribadi and Pauleit, 2015). Even so, fragmented farmlands have also survived closer to the urban cores. These agricultural lands are occupied by different types of farming. Distinctive distribution patterns indicate their varying capacity to adapt to the urban environment.

Cultivation of fruits and vegetables and inland aquaculture have been favored by the proximity of markets in nearby urban areas and the ability to produce on small parcels of land. Other farming types such as paddy fields, dry land agriculture and livestock are unable to compete with urban land uses and have been pushed out to remoter areas. In particular, the expansion of dry land agriculture has threatened remnant forests in upstream areas of the three major watersheds in JMA of the Ciliwung, Ciasadane, and Kali Bekasi rivers (Pribadi et al., 2018). Consequently, the percentage cover of woodlands declined from 34.4% in 1972 to 10.1% in 2012. As a result, environmental risk in Jabodetabek is increasing as the incidences of flooding and landslides have become more intense over time (Rustiadi et al., 2015).

THE ROLE OF AGRICULTURE IN TIMES OF ECONOMIC CRISIS

The overall contribution of agriculture in the JMA fell from 6.5% to 3.0% of GDP between 1993 and 2010. For a long time, this phenomenon was considered by policy makers as a normal consequence of urbanization as JMA was projected to become the biggest economic growth engine in Indonesia. In this situation, it was thought preferable to transform a low-value-added sector such as agriculture into high-value-added sectors such as industry and services. However, the sudden and strong economic crises in 1997-1998 and 2007 revealed the importance of agriculture in the JMA when food prices soared and unemployment was high.

Urban agriculture seems to have been regarded as a safety net in the emergency situation of the food crises, but it is again neglected under "normal" situations

Many industries and services collapsed during these crises. At the same time, food prices rose by 74% in 1998 (Studdert et al., 2001). While farmers benefitted from this situation, high food prices had serious implications for the affordability of food for the poor. Therefore, a policy was established in 1998 that allowed farmers to extend farmland by cultivating vacant land temporarily. There was a lot of vacant land at that time as many developers had occupied large tracts of land as an

Paddy fields adjacent to built-up areas - ©Didit O. Pribadi

investment for profitable future real-estate development. Since then, the agricultural sector's Gross Domestic Product, which had steadily declined since rapid urban development in JMA started in the 1970s, began to increase concurrently with other sectors and has continued to do so until recently (Pribadi and Pauleit, 2015). Our detailed analysis has shown that local agriculture is in particular connected to smaller, informal economic activities such as small-scale industries, stalls, and food-stall running by informal workers who do not have permanent jobs or regular salary.

Further policies introduced later to better conserve farmland and promote farming activities were poorly implemented after the end of the crises. Urban agriculture seems to have been regarded as a safety net in the emergency situation of the food crises, but it is again neglected under "normal" situations. Hitherto, agriculture is still projected to be lost in urban development scenarios (Hudalah and Firman, 2012).

Not all farming has the ability to support the urban market and urban food security (Pribadi and Pauleit, 2016). For instance, agriculture in the southwest of Jakarta is mostly for subsistence due to poor access to Jakarta and other cities in the JMA. Also, in the hills to the north, which are far from Jakarta, farming is mostly carried out by poor farmers and the harvest is only sold locally. Even so, it still helps poor people to get daily food. Agriculture in the surrounding areas east and southeast of Jakarta, on the other hand, is important to supply staple food for the urban market. Considering these different potentials of farming types and regions, it will be important to craft future policies for land management that are responsive to local contexts and thus increase the resilience and sustainability of the JMA.

KEY FACTORS FOR VIABLE AGRICULTURE IN URBAN REGIONS

We held interviews with farmers in a subcatchment of the Ciliwung river to gain further insights into their motivations and better understand the supporting and hindering factors for their business (see Pribadi et al., 2017). In particular we explored whether a diversification of farming activities, for instance by offering opportunities for recreation on farmsteads, could be a way forward to increase their viability under the pressures of urbanization.

Results showed that there are four main factors that influence the viability of different farming activities in the Jabodetabek region:

1. Access to markets
2. Economic revenues
3. Socio-demographic factors
4. Land tenure

A farming type like horticulture persists close to the cities to gain higher economic revenues through proximity to

Densely populated agricultural areas in peri-urban Jakarta Metropolitan Area - ©Didit O. Pribadi

the markets. Farmers even dare to take a risk by investing higher capital, particularly for renting the land for farming. Cultivation of fruits and vegetables is mostly run by the younger generation as it is a profitable but also risky business. Conversely, paddy fields still exist as landowners let farmers continue to farm normally without any formal agreement. As the land might be taken any time, farmers reduce this risk by lessening input and productivity. Mostly older farmers do not work fulltime in farming, but generate their main income as construction workers, traders, etc. Still, the farmers continue to cultivate paddy fields or dry lands for preserving their daily food needs. In addition, paddy fields are important for stormwater retention. Even so, these types of farming are particularly vulnerable to urbanization.

FUTURE POLICIES

The JMA has experienced economic crises that raised the awareness of the government and society concerning food security as an important issue in urban policy-making. However, there is still no single policy instrument that can effectively protect farmland. Although some districts in the JMA have established food-crop protected areas in their spatial planning policy, urban expansion seems unstoppable and is continually converting the area.

This situation highlights the importance of integrating agriculture into urban agendas instead of treating it as a restricted area disconnected from urban land-use dynamics

This situation highlights the importance of integrating agriculture into urban agendas instead of treating it as a restricted area disconnected from urban land-use dynamics. Agriculture should be considered as an element of urban land use and its value should be fully recognized in supporting food, alleviating poverty, creating jobs, generating income, and improving environmental quality as well as reducing the risk of natural hazards such as floods and landslides.

Most of all, the government needs to improve access to markets, increase economic revenues, and secure land tenure. Local agricultural products coupled with programs to support the production of fresh and healthy commodities should be promoted to increase the competitive advantages of agriculture in the JMA in the markets.

Moreover, non-commodity products and services such as agro-tourism should be developed and the provision of non-marketable public benefits (i.e., flood mitigation, reducing erosion, etc.) should be paid for to increase economic revenues of farming as a multifunctional activity. This strategy needs supporting policies mainly to: (1) develop the non-food markets and non-marketable public benefits of PUA, (2) improve farmers' capacity to manage multifunctional farming in producing food and non-food products and services, (3) enhance access to land, as farming is not only expected to produce food but also increase employment opportunities and ecosystem services, which are long-term objectives.

Lastly, secure land tenure is a prerequisite for the uptake of such mid- and longer-term agricultural programs. Poor governance in land management should be improved to hinder the occupation of farmland by urbanites who want to make property investments (Mokkonen, 2013). Not least, agricultural research and education is important to innovate farming. All these strategies are necessary to make the farming business more attractive to the younger generation.

THE NEED FOR COMPACT CITY DEVELOPMENT: ADDIS ABABA AND THE SURROUNDING REGION

THE IMPACT OF URBANIZATION ON AGRICULTURE IN PERI-URBAN AREAS

Globally, the rate of increase in urban land cover is predicted to be at its highest in Africa until 2030 (Seto et al. 2012). Urban expansion will be concentrated in five regions of which "the greater Addis Ababa" region in Ethiopia is one. Addis Ababa has already experienced a rapid rate of urban growth over the past decades. This expansion has mostly taken the form of spontaneous growth through legal landowners, land developers, and informal settlement dwellers. Due to the lack of appropriate government policy and strategy, which role is to guide these new developments on vacant land and to ensure that the urbanized land is fully used, the expansion of the city is leading to a loss of highly fertile agricultural land and green areas losing their valuable ecosystem services. Consequently, 24% of the farmland in Addis Ababa was lost in the short period between 2006 and 2011 (Woldegerima et al., 2017).

These losses have severe social and economic impacts for a significant part of the population living in Addis Ababa and the surrounding towns, as urban agriculture is still considered a significant means of livelihood for urban households in Africa and one of few stable income sources for farmers with limited qualifications (Zezza and Tasciotti 2010, Drechsel and Dongus 2010). More than 50% of the field crops and 70% of the vegetable production within Addis Ababa are used for household consumption (CSA, 2002), thus contributing to a balanced diet.

In cases of high food price crises or rises in oil prices, the role of vegetable production becomes even more valuable as the local inhabitants usually have irregular and inadequate access to food and insufficient purchasing power

Vegetable production located in the peri-urban regions is valuable due to its proximity to cities and consequently, transportation costs are relatively low when compared to rural areas (Smit, Nasr & Ratta, 2001). In cases of high food price crises or rises in oil prices, the role of vegetable production becomes even more valuable as the local inhabitants usually have irregular and inadequate access to food and insufficient purchasing power. Costs for food supply and distribution from rural areas to the urban areas, or to import food for the cities, are continuously increasing (AAOIDP, 2013; Tolossa, 2010).

FUTURE DYNAMICS IN ADDIS ABABA AND THE SURROUNDING REGION

The population of Addis Ababa is expected to increase in the next 15 years at an average annual growth rate of approximately 4%, reaching almost 9 million people in 2035 (UN, 2018a). However, not only is Addis Ababa expanding at a rapid pace, but growth is also taking place along the major outlets of the city into the surrounding region (Kassa, 2013). This growth is expected to translate into an expansion of settlements in the city and into the surrounding areas. Consequently, farmland will continue to decline in the city's surrounding area for urbanization and industrial development (AAOIDPP, 2013). The amount of farmland lost and the impacts on food supply, local livelihoods and the environment will very much depend on the mode of future urban development.

In the framework of the EU-funded project "Climate Change and Urban Vulnerability in Africa," a modeling approach, Urban Spatial Scenario Modeling (USSDM), was developed and employed to explore the consequences of two different scenarios of urban development for the conservation of agricultural land (Abo-El-Wafa et al. 2017): a scenario of continuing low-density urban sprawl corresponding to a business-as-usual scenario, and a high-density scenario that reflects the density of new residential developments of condominium housing that are implemented by the city government.

We simulated the future settlement expansion in the surrounding region of Addis Ababa until 2038. We then overlaid the simulated expansion on agricultural suitability maps, which served as spatial indicators for food provisioning. These indicators provide an insight into the productivity of land and its ability to produce different crops that are deemed important for the local population as being major constituents of the local diet, having an economic support role for urban farmers, and having high potential for import substitution. The selected crops were vegetables (cabbage), cereal crops (teff and bread wheat), and oilseeds (nigerseed).

According to the model's outputs, most of the settlement expansion (an average of 76% of future settlements) in the region would be located on land of relatively low agricultural suitability (marginal and very marginal suitability). At first glance, this might show a contradiction to the idea that urban expansion is mostly happening on

Condominium housing development in the eastern part of Addis Ababa, Ayat area - ©Hany Abo El Wafa

fertile land. However, this is due to the fact that the areas with low suitability dominate the study area. The scarcity of land that is moderately suitable for cultivation gives it an even higher importance due to its higher productivity (Radcliffe & Bechtold, 1989). More than half of all crops (16 out of 30) cultivated in the area would be threatened by future settlement development as more than 50% of the future settlement development would be located in suitable land for cultivating crops.

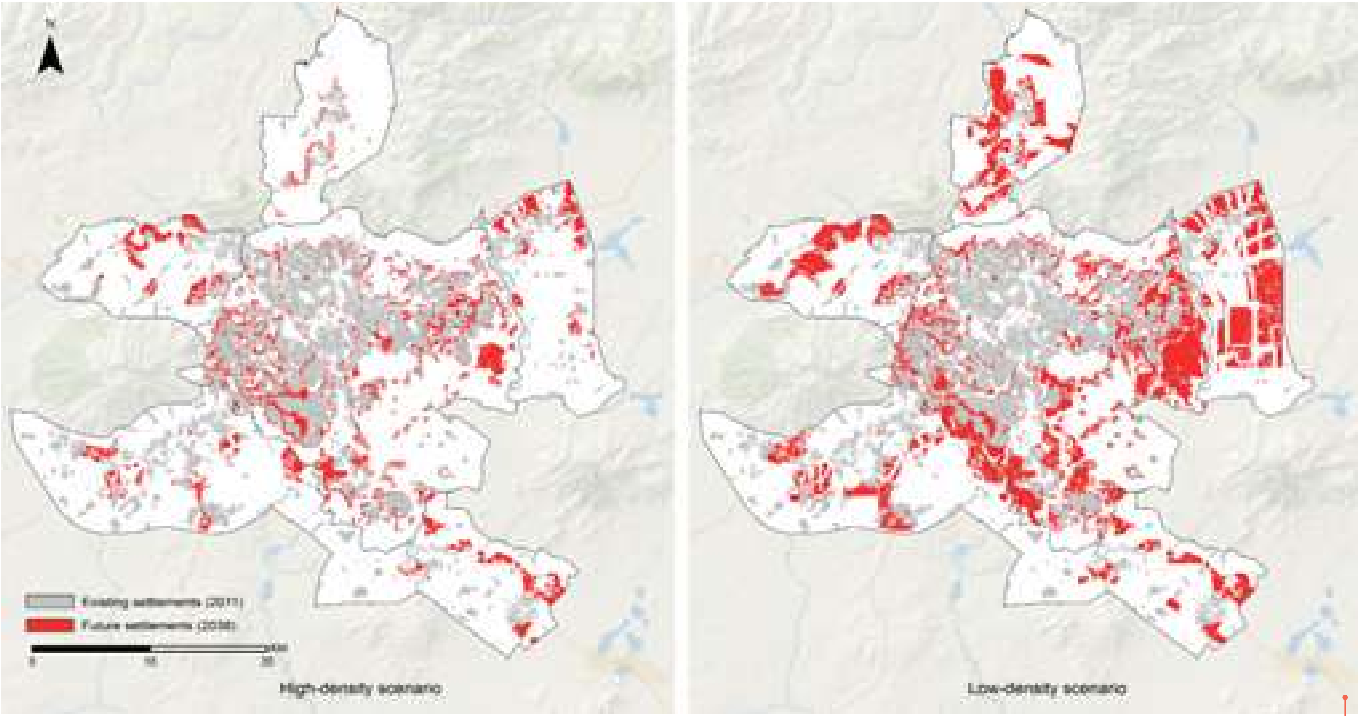
We observed dramatic losses of agricultural land in the low-density scenario as compared to the high-density scenario. Land moderately suitable for cultivating bread wheat and teff in the low-density scenario suffered higher losses of 467% and 174% respectively compared to the high-density scenario. This indicates the vulnerability of moderately suitable land for cultivating these two crops when compared to cabbage and nigerseed, which would have a moderate increase of 50% and 80% respectively. The modeled settlement expansion has occurred on land suitable for cultivating vegetables that are important for local consumption and provide economic support for urban farmers. On the other hand, the losses of marginally and very marginally suitable land for cultivating high-value crops would increase by 160% and 200% respectively in the low-density scenario.

Products obtained from those agricultural lands are especially important for the poorest households, who are the first ones affected by food-price shocks. Moreover, farming activities provide sources of income for those dependent on the population's urban and peri-urban agriculture (Egziabber, 1994). Given increasing population growth and the high amount of poor people depending on the informal economy, this situation is not expected to change any time soon. This highlights the role of urban and peri-urban planning that should intervene to address this challenge and to achieve sustainable future development ensuing from such explosive urban population growth.

STRATEGIES FOR COMPACT URBANIZATION AND GREEN INFRASTRUCTURE PLANNING TO BETTER PROTECT PERI-URBAN AGRICULTURE

Urban planning must promote the resilience of cities and achieve environmental sustainability in order to meet the challenges of urban transition caused by settlement expansion (Dyachia, Permana, Ho, Baba & Agboola, 2017).

We found that the densification of the existing built-up area and the adoption of a new model for compact development of new urban extensions that protect and integrate farmland would greatly increase urban resilience and food security. Implementing such strategies would lead to much lower losses of green infrastructure and its ecosystem services such as food provisioning, reducing the urban heat island effect and the risk to flooding during rainstorms.



Modelled future settlements in Addis Ababa and surrounding region in high-density and low-density scenarios (illustration: Hany Abo El Wafa, data sources: CLUVA project and USSDM results, Basemap: Ocean Basemap, Arcmap 10.4.1, ESRI)

Despite the existence of challenges to applying densification measures to other African cities, evidence from South Africa shows that densification and the more effective use of both vertical and horizontal space in a city are feasible (Pieterse & Fataar, 2016). Authorities in South Africa promote densification programs in residential areas that are accessible to employment opportunities with the aim of improving urban sustainability and integration after apartheid (Williams, 2000).

However, densification and high-density settlement expansion strategies have to be complemented by other measures that promote green and open space development inside the new expansion areas and give considerable weight to preserving and managing urban green spaces (Pauleit et al., 2005). This is important in order to alleviate other negative effects that could result from high-density settlements such as air pollution, reduced quality of life, reduced urban resilience and reduction of open-space areas for recreation (Haaland & van den Bosch, 2015).

The research also indicates that developing high-density settlement areas should not only be limited to the inner city (where land price is usually high). Horizontal development in smaller towns of the surrounding Oromia region would lead to large losses of suitable farmland in peri-urban areas.

Tools such as our scenario modeling approach have provided useful information for local administrations and decision-makers to develop land-use policies and planning that would be in favor of reducing the adverse effects of urban growth on the environment. As we noticed in workshops, it also acts as a platform for scientists, planners, policy-makers and the public to communicate, which would facilitate the integration of different stakeholders and enhance participatory urban planning and decision-making.

CONCLUSION

Local agriculture is crucial to provide urban and peri-urban dwellers with food, fibers and medicine for their own supply or local sales that increase their incomes and thus make them less vulnerable to economic crises and natural disasters. Moreover, this agriculture can bring important environmental benefits, such as retention of stormwater.

However, some particular farming types with high social and environmental co-benefits, such as paddy rice farming in the Jakarta region, have low profitability and demand a lot of space. Therefore they cannot resist the pressure from urbanization.

To better integrate agriculture into urban regions in the Global South, it is crucial to implement policies that support farming economically and enhance its multifunctionality, i.e., its capacity to provide co-benefits to urban society. The latter will provide strong arguments for preserving agriculture in urban regions that are increasingly vulnerable to economic and natural disasters, which will become more frequent under climate change.

Experience has shown that comprehensive master planning is not a successful approach in such cases of rapid and – to a great degree – informal growth because it is too slow, too complex and tries to coordinate and steer too many things at the same time. Therefore, urban planning should concentrate, on the one hand, on devising and implementing strategic key measures at city and regional scales, such as allocating urban centers and infrastructure as well as outlining where green infrastructure needs to be conserved as a lifeline. On the other hand, governments should significantly strengthen the capacity of local administrations in urban planning. These local stakeholders, who work on the ground, should be empowered to adequately address their respective challenges, which they know better than remote city governments. Lastly, as counterintuitive as it may seem, more compact urban development is needed in urban regions of the Global South. Even though pictures of crowded slums in Asian and African cities convey a different message, the reality is often that of sprawling low-density urban areas consuming enormous amounts of productive land. As the two contrasting scenarios for the Addis Ababa region indicate, an increase of density would have a positive effect on the preservation of farmland, and hence support a large part of the urban population with food and vital ecosystem services, and thus constitute an investment with long-term sustainability gains.

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HOW THE MUNICIPALITY OF QUITO SUPPORTS VULNERABLE CITY DWELLERS THROUGH URBAN AGRICULTURE

Alexandra Rodríguez Dueñas
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Female participant in the AGRUPAR program in her urban garden
©AGRUPAR

Alexandra Rodríguez Dueñas is an agronomist specialized in business administration and organic food production. She has been responsible for the Participatory Urban Agriculture Project (AGRUPAR) within the Municipality of Quito, Ecuador, since 2005. She is also the vice-president of the National Committee for the Evaluation of Organic Supplies. She has promoted Quito's adhesion to important global food-related networks such as the Urban Food Policies Pact of Milan, RUAF Foundation and Cityfood Network, and supported the creation of the Multi-Pacto Agro-Food Pact Platform of Quito PAQ to promote the construction of a food policy for the city.

Quito's Participatory Urban Agriculture Project (AGRUPAR) was created in 2002 with the goal of empowering vulnerable sections of the population through food security, income and employment by providing technical support, capacity building, infrastructure, entrepreneurship management, microcredit access, and applied research on agroecology along the entire food supply chain. AGRUPAR's embeddedness in local government allows urban farmers to be supported with far-reaching and cross-sectoral policies. International partnerships have also provided the conceptual, methodological and knowledge support that was needed for Quito to develop a local urban agriculture policy as part of a broader food system. Although changes of administration, budget cuts, and restrictive land-use legislation remain important challenges to the program, AGRUPAR has become a model of food and urban agriculture policy, providing valuable lessons for cities of the region and beyond. The program won the Future Policy Silver Award 2018, awarded by the World Future Council in partnership with FAO and IFOAM – Organics International.

Quito's Participatory Urban Agriculture Project (AGRUPAR) was created by the municipality in 2002 to support urban agriculture. What were the main drivers of the creation of AGRUPAR and how has it evolved so far?

Alexandra Rodríguez Dueñas: Although agricultural activities in Quito are ancestral, the process of designing and implementing strategic plans to organize them in the name of economic, environmental and sanitary goals is relatively recent.

In the late 1990s, Quito faced a pressing context where a diversity of factors contributed to an increased interest in urban agriculture. As the city hosted waves of migrants from the countryside and from abroad, Quito saw its population double from 780,000 to 1.4 million from 1980 to 2000. It is today estimated that the city's population will grow from 2.5 million to more than 2.8 million by 2022. Ecuador faced a severe economic crisis in the late 1990s, which further increased the urbanization process and created massive unemployment and poverty. In fact, 48% of Quito's population lived below the poverty line at that moment. Families in settlements and poor *barrios* started using small-scale agriculture to feed themselves, although it was yet unrecognized by the authorities. On top of these issues, Quito's mountainous location makes it highly vulnerable to landslides, which occur more frequently due to higher temperatures, less rainfall, and extreme rains that have come along with climate change. So addressing food insecurity and overcrowding was a foremost challenge for the city.

The success of AGRUPAR is directly related to its embeddedness within the municipality of the Metropolitan District of Quito (DMQ). This public entity has provided a reach, an impact, and a durability that would not have been possible otherwise

The municipality of the Metropolitan District of Quito (DMQ) started gaining interest in developing an agricultural project for the area. To further this goal, it hosted the International Seminar "Urban Agriculture in Cities of the 21st Century" in 2000. At the end of the seminar, all Latin American and Caribbean local government representatives present ratified the landmark Quito Declaration, which formalized, for the first time, cities' commitment to actively promoting urban agriculture initiatives.

In the same year, the city organized the Urban Consultation of Quito, which gathered a broad range of stakeholders such as the municipality, local organizations and international institutions, to establish the basis for the institutionalization of a municipal urban agriculture project. It was followed by a plan of action that implemented a pilot program in El Panecillo, the historic center of Quito, aimed at increasing food production in home gardens, reusing organic waste and building a community plant nursery.

The success of this first experiment led the Municipality of Quito to create AGRUPAR in 2002, in order to improve food security for the DMQ's vulnerable populations. First managed by the Department of Sustainable Human Development, in 2005 AGRUPAR came under the authority of the Agency for Economic Promotion, ConQuito, which objective is to promote socioeconomic development based on employment, equality, entrepreneurship, sustainability and innovation.

AGRUPAR is a municipal program, strongly backed by the City and a wide range of partners. To what extent have its governance and organization been success factors for rolling out the initiative?

A.R.D.: Several reasons explain the success of the AGRUPAR program, and its governance and organization have been key to developing and scaling up the initiative.

First of all, the success of AGRUPAR is directly related to its embeddedness within the DMQ. This public entity has provided a reach, an impact and a durability that would not have been possible otherwise. Unlike developed regions of the world, urban agriculture here in Quito – and more broadly in Latin America – is not only practiced as a hobby or a recreative activity but rather as a means of survival for people to be fed and have their main source of revenue. Local government needs to be involved for the program to reach areas of high necessity that are not easily accessed by NGOs or by the private sector. It also allows us to link urban agriculture with other types of city-driven actions, such as the regularization of settlements, citizen participation, sports, culture, education, health and environmental management, since it can perform different and numerous purposes around the theme of food security.

AGRUPAR was officially recognized as an independent organizational structure with its own budget within ConQuito in 2010, allowing urban agriculture to become an integrated and permanent service within the local public structure. The 2018 budget was US$283,336, in addition to US$27,000 of its self-management fund. Out of this, 10% is used for supplies and logistics, and for developing food-related policy, and 90% is allocated to the teams, who are constituted of technical, but multidisciplinary, operational staff. They include agronomy engineers, food engineers, drivers, managers, etc., who can bring technical assistance and better infrastructure to farmers. We are in direct contact with the program's teams in order to educate them but also to learn from them, recognizing the ancient

Couple of AGRUPAR participants - ©AGRUPAR

knowledge that Andean populations bring with them from the countryside.

Thirdly, our work through ConQuito allows us to work in close cooperation with its other departments (entrepreneurship, economics, training, popular and solidarity economy, productive chains, social responsibility, etc.) and stakeholders, both at the national and international scale.

At the national level, the directory of ConQuito is constituted of 174 partners, who come from academia, sectoral chambers, ministries, and even some representatives of the United Nations (UN). This mode of governance has enabled us to include urban agriculture in many other policy areas, such as health, environment, education, economic development, social inclusion, territorial development plans, and resilience. This has contributed to the program's broad reach, strength and sustainability.

At the international level, our international partnerships have been fundamental in the rollout of an urban agriculture project at the municipal level. Above all, the RUAF Foundation conceptualized what could and should be reached through urban agriculture, which it had developed with other cities, and inspired the conceptual basis of our own program back in the early 2000s. Our ongoing partnership has allowed AGRUPAR to share its experience with other cities among global alliances related to sustainable food systems, such as the Milan Urban Food Pact, the 100 Resilient Cities network, the Cities Climate Leadership Group (C40), the International Council for Local Environmental Initiatives (ICLEI), and the CITYFOOD Network supported by the RUAF Foundation and ICLEI.

The UN Food and Agriculture Organization (FAO) is also another longstanding partner. In urban agriculture exclusively, it has financed two projects for associations of producers, one for vegetable producers and one for honey producers. From 2015 to 2017, Quito was one of the eight cities in the world whose food system was diagnosed by the FAO and the RUAF Foundation as part of their joint City Region Food Systems Project, which uncovered the relations between the various inter-connected units and phases of this complex system (food production, transportation, distribution, supply chains, consumer habits, etc.). This study had an unprecedented impact on how food systems are perceived and embedded in their relation to sustainability and resilience. Consequently, in 2018, we invited various actors involved in Quito's food system from agriculture, academia, the private sector, farmers, social movements, and local and regional governments, to form the Quito Food Pact. This multi-stakeholder platform induces reflections on Quito's food system, aimed at designing effective and coordinated food policy for the first time. Local institutions and departments at all levels are seeing a whole new generation of public policies, one of which increasingly acknowledges the interconnectedness of policy areas, including urban agriculture's various roles and impacts, be it the city's strategy in resilience, waste reduction or employment creation.

On a day-to-day basis, what are AGRUPAR's main activities in Quito?

A.R.D.: AGRUPAR's mission is to promote urban agriculture in order to further food security, gender equality, social inclusion, and income-generating activities in Quito. The program particularly targets the empowerment of women and children, vulnerable communities (the elderly, people with disabilities, the unemployed, people in rehabilitation, etc.), and minorities (indigenous people, refugees, migrants, etc.). Most of our participants are poor, have a low level of education and often receive government financial support.

AGRUPAR explicitly recognizes and furthers the inherent linkages of urban agriculture interlinked with wider policy areas at the city level, such as social, environmental and economic policy. Its main implementation strategies are the following: technical assistance provision and capacity building, creation and improvement of infrastructure and urban livestock, microentrepreneurship management, marketing and promotion, microcredit access, and applied research on agroecology. These actions are undertaken along the entire food chain:

a. **Production**: We support organic/agroecological food production by urban gardens, whether they are managed by families who grow on their own land, by communities that manage the use of municipally owned land, by schools, or by institutions. We offer training, provide seeds, seedlings, poultry, bees, inputs and equipment, and build infrastructure for climate change adaptation, such as composting, the creation of controllable conditions for culture, and other agroecological systems (micro-green greenhouses, drip irrigation systems, etc.).

b. **Market-orientation**: The program encourages producers to go beyond household food security and commercialize their products through the creation of microenterprises, providing them with business planning, marketing and accounting skills. Producers often diversify their production away from fruits and vegetables to meat, jams, sweets, bakeries, dairies and drinks. We also developed innovative ways to overcome poor farmers' restricted access to capital: producers have gathered in grassroots investment societies, where members contribute with a small sum of money that is used as micro-credit to finance farmers' productive necessities.

c. **Distribution**: AGRUPAR has also developed *bioferias* (organic produce markets or bio-fairs), in which only fresh and processed food grown by the project's participants can be sold. These exclusive points of sale allow urban farmers to sell the surplus of their food production at a fair price for both parties. This came as a solution to sell organic, locally grown food, after failing to compete in regular municipal markets with imported, cheap and pesticides-exposed foods. Moreover, farmers have formed networks to deliver directly their produce to food processing companies, hotels and restaurants.

d. **Consumption**: Bio-fairs aim at improving access to vegetables and increasing the visibility of food-related issues, contributing to AGRUPAR's educational role in promoting healthy food consumption patterns and fighting malnutrition in Quito, which affects 46% of children in certain places of the urban axis.

AGRUPAR operates on a cost-sharing basis with the participating farmers. For instance, it shares the costs with participating producers to guarantee their organic certification (currently, farmers cover 100% of the annual cost); around 20% of investments in productive infrastructure are covered by farmers themselves (the tendency of the last five years is for farmers to finance the entire cost of a micro-greenhouse or a drip irrigation system, with the exception of highly vulnerable beneficiaries), and farmers must pay US$1 or US$2 to attend a training session or to receive technical assistance.

Even though AGRUPAR mostly intervenes in urban areas, we also support projects in peri-urban and rural areas as Quito is a metropolitan district consisting of 32 urban parishes and 33 rural parishes. We cover the entire territory in an attempt to deepen the link between these different types of areas, as long as the cultivated land measures below 7,500 m^2 (above this threshold, farms fall under the responsibility of the government of the province and the national government).

What results and societal impacts has AGRUPAR achieved so far?

A.R.D.: AGRUPAR's impacts can be classified in four main categories: (1) improved availability of healthy food for poor city dwellers, (2) increased economic opportunities for urban farmers, (3) environmental benefits, and (4) significant changes in consumers' behavior.

In 17 years, the main achievement of AGRUPAR is improved access to better food for vulnerable populations. It has enabled the creation of 4,400 gardens covering 40 hectares of the DMQ, and these numbers are expanding greatly, as 200 new gardens open and 3 additional hectares are covered every year. These generate yearly production of more than 1,200 kg of food products. Roughly half is used for home consumption, strengthening vulnerable families' food security and diversifying their nutritional intake.

The other half of the total food produced is marketed, providing urban farmers with better opportunities in terms of revenue and thereby supporting their livelihoods. As of today, AGRUPAR has reached 4,500 vulnerable urban, peri-urban and rural farmers annually, covering 94% of the district. It has capacitated and supported more than 21,000 people, of whom 84% were women, through more than 16,000 training sessions and 82,000 cases of technical assistance, on top of the more than 2,000 production structures it has constructed. The program has created 15 weekly or biweekly *bioferias* (more than 6,500 have

A Quito resident buys vegetables from a local farmer in a *bioferia* - ©AGRUPAR

Key figures of the AGRUPAR program

4,500
vulnerable urban, peri-urban and rural farmers

Yearly production of more than
960,000 kg
of food products

The project has supported more than 21,000 people, of which
84% were women

been organized in total) where 105 types of organic food are sold, generating US$350,000 a year. Forty-eight community banks and several Collectives of Urban Farmers have also been created, offering better commercialization opportunities for their 3,000 members. Participants have seen a US$175 increase in their monthly income, achieving an average income of US$3,100 a year. The program has also led to the creation of around 340 jobs and 180 small enterprises, which are mostly formalized.

The program has also had important environmental benefits. Advanced agroecology techniques guaranteed by AGRUPAR help protect the soil, save resources like water and recycle waste (0.65 tons of waste per family per year), which constitute important adaptations to climate change. Seventy-two edible plant species are also maintained in gardens, contributing to the preservation of Quito's biodiversity. In addition, local, in-city production requires less transportation, refrigeration and packaging, which contributes to reducing energy and plastic consumption. The program has also helped rehabilitate formerly abandoned land into productive land.

We have also observed significant changes in consumer behavior in urban dwellers, as food-related issues have come forward in the national debate, pushed by the visibility of our educational actions. People are more aware of the value of local consumption, the negative effects of pesticides, the role of farmers in food systems, and the importance of a diversified, balanced diet.

Overall, the program has directly benefited a total of 74,000 people, and indirectly more than 100,000, which include responsible consumers who have learned about health and nutrition and diversified their diets.

Being part of a city program explains, at least partly, the success of AGRUPAR throughout the years. Even so, have you also faced challenges related to governance, notably in a context of reduction of public expenditure?

A.R.D.: It's sure that one of the most obvious difficulties is related to changes in local administration, as it causes uncertainty on the level of support that the new government will attribute to AGRUPAR. The reduction of the program's budget has also forced us to look for external funding by cooperating with NGOs and other organizations.

There are other challenges worth mentioning. Historically, we have struggled to find space in the different local laws and regulations, since we do not have our own ordinance. Rather, there is a large range of different ordinances related to different themes, and we have fought for these to include urban agriculture. This is the case for the Climate Action Plan, the Resilience Strategy, the Social Responsibility Ordinance, the Waste Management Strategy, and others, which now have come to evoke the importance of urban agriculture, recognizing the intrinsic connection between different policy areas.

The use of public space for farming purposes also imposes important restrictions, since it can only be exploited by a legally formed association. However, urban agriculture is mostly used by communities who will be unlikely to form a legal entity, since everyone selling food grown on municipal land must pay US$500 a month – an inaccessible sum of money to AGRUPAR's vulnerable participants. Thus, only 30% of our gardens are located in municipal spaces for now. Although we have already identified and mapped all different vacant public spaces that could be put to productive use, we still need to make progress in changing the city's restrictive land legislation for these spaces in order to contribute to subsistence entrepreneurship and employment creation. We need to consolidate this with a high risk of occupancy, which occurs often here.

We are currently attempting to implement a project in a closed airport. The city ordinance has allocated a large area of this new park to the implementation of urban agriculture activities. Our ambition is that this area becomes a center for transmitting Quito's urban agriculture, a productive space destined for community usage, and a showroom for different irrigation systems and cultivation techniques (drip systems, vertical farming, cultivated boxes, etc.). We would like to show park visitors (10,000 per weekend) that farming is accessible to everyone, and modulable to every scale.

The city needs to look beyond the construction of gardens with a single objective (education, recreation, etc.) and adopt a broader outlook to understand how a municipal program can respond to the needs of different groups of the population

If you were to provide advice to other municipal agencies across Latin America or even across the world, what key lessons would you draw from your experience at AGRUPAR, if they are at all transferable?

A.R.D.: I absolutely think that AGRUPAR's model is easily transferable to other cities, be they in Ecuador, other Latin America countries, or other vulnerable contexts, to serve for the development of national or local-level food policy. A local urban program must, above all, be sustainable and entrenched in the long term. That is why AGRUPAR has never attempted to adopt a political stance, rather opting for discretion. As a result, it has survived through four changes of municipal administrations, and is not the target of strong opposition from any party. Moreover, AGRUPAR is not a welfare program but a participative one: instead of handouts, it shares costs with participants, who must be strongly committed to the program to build a garden and learn the skills to maintain it. Even if AGRUPAR disappears, these people's activities will not. The program has also been able to respond and to adapt to the changing needs of the farmers – by, for instance, developing micro-credit activities.

At the national level, urban agriculture is practically invisible, since Ecuador's status as a major agricultural exporter (of bananas, cacao, broccoli, flowers, etc.) has contributed to the mentality that food is destined to be sold, resulting in a fragile internal food sovereignty – 95% of food is imported (from other provinces of the country and other countries) – and very little consideration is paid to small farmers who feed the cities. Quito has emerged as a country and region-wide model in which food sovereignty is implemented at the smallest scale: that of the urban farmer, who plays the key role of locally supplying the city. It has demonstrated the importance of generating employment and entrepreneurship, of enhancing access to vegetables, and of reducing food dependence from other regions, adopting a true social responsibility role. While other Ecuadorian cities have attempted to roll out urban agriculture, such as Cuenca and Manta, Quito has demonstrated that this is a process that takes time, as it implies gaining the trust of vulnerable people, the backing of significant political will, as well as a strong, official and long-term-oriented team. It is worth mentioning that AGRUPAR has an "open door" and cooperation approach to other cities, as we strongly encourage exchanges on experiences, lessons and methodology.

Lastly, our experience has taught us that in developing urban agriculture policy, the city needs to adopt a holistic approach: we need to look beyond simply the construction of gardens with a single objective (education, recreation, etc.) and adopt a broader outlook to understand how a municipal program can respond to the needs of different groups of the population. For example, school-aged children need to learn about the origins of food, nutritional diversity and the problem of food waste – information they can transfer to their parents. This differs from a garden meant for adults with disabilities, whose focus will be on developing senses such as scent and touch, and on giving a feeling of usefulness and integration in society. Meanwhile, urban farming can be the main resource-generating activity of a woman-led household, empowering women by allowing them to work at home while taking care of their children. Lastly, migrants and refugees, from the countryside and from Colombia and Venezuela, can be integrated into society through farming and supported when they leave their roots and arrive in Quito with nothing. AGRUPAR has been able to respond to the multi-dimensionality of Quito's varied societal needs.

URBAN AGRICULTURE AS A CLIMATE CHANGE AND DISASTER RISK REDUCTION STRATEGY

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Urban agriculture in floodzones in Antananarivo, Madagascar - ©RUAF

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Urban and peri-urban agriculture is considered as a strategy that can bring multiple benefits and help to build resilient urban food systems at the city region level. Cities have an important role to play in climate change mitigation and adaptation, disaster risk management and in enhancing the climate resilience of their vulnerable residents. Major emitters of greenhouse gas (GHG), cities are not only contributing to climate change, but are also directly and indirectly impacted by it. Acute or chronic climate change is threatening access to basic urban services such as water, energy and food for growing populations. Key issues include rising temperatures, increasing rainfall, flooding and urban food insecurity. Rapid urban growth will only increase the number of highly vulnerable urban communities, with the urban poor being most at risk. Only with a coordinated approach and action at the global, regional, national and local levels can the climate change emergency be curbed, and its effects mitigated.

INTRODUCTION

Urbanisation and climate change are closely linked. More than 50% of the world's population lives in urban areas, and by 2050 this figure is projected to rise to nearly 70% (UNPF, 2018). Urban areas consume as much as 80% of the energy produced worldwide and account for over 70% of energy-related global greenhouse gases (GHGs) – and both these figures are expected to rise. It is estimated that almost 90% of the increase in CO_2 from energy use will be from developing countries, especially from fast-growing cities in Asia and Africa (IEA 2008). Moreover, poor waste management in many cities contributes to chlorofluorocarbons (CFCs) and methane emissions (UN Habitat, 2018).

Whereas growing cities already face considerable challenges, such as ensuring safe housing, infrastructure, economic opportunities and adequate, safe, nutritious, affordable and culturally appropriate food for their populations, they also have to cope with climate change and the looming risk of climate-related disasters, which are among the most serious environmental, societal and economic issues facing the world today.

However, cities also possess the capacity to take scalable action, as they harbour the bulk of economic activity, and cultural and social capital. Over the past decade, many local authorities have acknowledged their potential to influence both the causes and consequences of climate change and are contributing to national and international climate change strategies. In this context, urban and peri-urban agriculture and forestry offer solutions to these challenges and help build more resilient cities.

THE CONTEXT OF INCREASED VULNERABILITY OF URBAN AREAS

Climate change, together with a decrease in green cover, parks, trees and agricultural activities that absorb GHGs in cities, poses serious threats to urban infrastructure, access to basic services and quality of life, while negatively affecting the urban economy (World Bank, 2010). The recent report of the Intergovernmental Panel on Climate Change (IPCC) on global warming of 1.5°C (IPCC, 2007, 2018) highlights the heightened exposure of cities to extremes of temperature, sea-level rise and severe storms, and the subsequent effects on infrastructure systems, water, health and economic development. Cities are increasingly being affected by both acute shocks amplified by climate change (such as droughts, floods, windstorms, forest fires or landslides) and chronic stresses resulting from longer-term projected climate change or uncontrolled urban growth. The most vulnerable cities are those in arid and water-stressed countries, island states, and less developed countries, as well as coastal and low-lying cities. In areas where climate change results in reduced precipitation, human settlements may be affected by drought, reduced water tables and food scarcity. In the past decade alone, Mumbai, Colombo, Bangkok and Manila are among the Asian cities that have faced massive disruptions to food systems, asset losses, price rises and hampered business operations for as long as three months due to events like waterlogging and flooding. Climate change also aggravates the urban heat island effect – that is, the increase of mean-day temperatures in built-up areas due to human, industrial activities and reflection of heat by buildings and pavements – which can result in increased energy use through air conditioning, air pollution and smog, and health problems for residents.

An increase in climate change-related extreme weather events and natural disasters, as well as chronic shocks, impacts food production, processing and distribution along the entire food supply chain. Cities are highly vulnerable to the disruption in critical (food) supplies, and climate change exacerbates this vulnerability. Urban economies suffer as rural agricultural production is adversely affected by storms, floods, shifting seasonal patterns, droughts or water scarcity. At the same time, changing temperature and precipitation patterns affect what crops can be grown in a given locale (Lotsch, 2008, UNEP, 2009). Increasing food prices resulting from food supply disruptions directly impact consumers in urban areas because they are almost entirely dependent on purchasing (rather than growing) their food. The hardest hit are vulnerable populations who are already experiencing or at risk from food insecurity. Furthermore, the effects of climate change on (productivity in) certain rural areas can result in more migration into cities (for economic or environmental reasons), leading to the accelerated growth of slum areas.

ASSESSING THE FOOD SYSTEM'S VULNERABILITY TO CLIMATE CHANGE

The city of Toronto, one of the RUAF Partners, has been committed to building a sustainable food system for years as a priority in its resilience planning. Recent research from the Initiative for a Competitive Inner City (ICIC 2018) investigated the risks posed by climate change to food distribution and access within Toronto. The analysis identified six key vulnerabilities to extreme weather events for Toronto's food system: urban flooding; infrastructure; the Ontario Food Terminal (wholesale market); vulnerable neighbourhoods that are already lacking in grocery provisioning; food insecurity; and coordination. Multi-actor involvement in addressing these issues is key.

Moreover, climate change disproportionally affects the urban poor and vulnerable groups (such as the elderly and disabled), a large percentage of whom live in informal settlements in low-lying and flood-prone areas on steep slopes, with limited access to viable livelihoods and precarious food and nutrition security (including the "silent hunger" of micronutrient deficiencies). In the event of a disaster, these settlements can rapidly become uninhabitable and prone to disease epidemics, disrupting the dwellers' ability to access (or safe use) of any home-stored foods, home gardens and cooking facilities.

The urban poor are also particularly vulnerable to variations in food prices and income, since food makes up a large part of their household expenses (often over 60%). A nutrition study implemented by the RUAF Foundation (Prain, 2010) in low-income neighbourhoods of five large cities showed that many poor urban households reduced the number of meals during financial and food crises and turned to cheaper and less nutritious food, with negative effects on the nutritional status of family members (particularly women and young children).

THE NEED FOR RESILIENT FOOD SYSTEMS

Increasing international policy attention is paid to the role of cities in contributing to more sustainable and resilient food systems, which are able to withstand and recover from the effects of crises, whether they are natural disasters such as droughts, storms and floods or socioeconomic shocks.

A resilient food system is understood as: "A system that has the capacity over time to provide sufficient healthy, sustainable and fair food to all in the face of chronic stresses and acute shocks, including unforeseen circumstances... A resilient food system is robust (it can withstand disturbances without losing food security), has redundancy (elements of the system are replaceable and can absorb the effects of stresses and shocks), is flexible, can quickly recover lost food security and can adapt to changing circumstances" (Carey et al, 2016).

A resilient food system is thus likely to have some of the following features:

- diversified food supply chains that draw on large-scale and small-scale systems of food production and distribution, using a variety of approaches to production and distribution, and that draw on both commercial and community-based sources, without being dependent on one source;
- the capacity to draw on waste streams (wastewater, food waste and organic waste) for food production;
- the capacity to create synergies and achieve multiple benefits across a range of policy objectives, e.g. increasing access to healthy food and creating jobs;
- is people-centred and inclusive – people are at the heart of the food system, benefiting from increased access to healthy, sustainable food and from employment, and they engage actively with the food system as citizen-consumers;
- the capacity to monitor and address threats and reduce disaster risks in food systems;
- contributes to reducing GHG emissions and is an important local strategy for climate change adaptation and mitigation;
- supports effective land management and soil restoration.

THE RISE OF INTERNATIONAL FRAMEWORKS PROMOTING URBAN RESILIENT FOOD SYSTEMS

The UN 2030 Agenda for Sustainable Development recognises the need to "Make cities and human settlements inclusive, safe, resilient and sustainable" (Sustainable Development Goal 11). It also includes goals for sustainable agriculture to help reduce poverty (SDG 1), improve nutrition and reduce hunger (SDG 2), ensure sustainable consumption and production patterns (SDG 12), and help to combat climate change and its impacts (SDG 13). The Paris COP21 agreement (2015) and the Sendai Framework for Disaster Risk Reduction 2015-2030 both recognise the fundamental priority of safeguarding food security and ending hunger and the vulnerabilities of food production systems to the impacts of climate change. They underline the need for increased ability to adapt to the adverse impacts of climate change (both chronic stresses and sudden shocks). UN-Habitat addresses urban and human settlement issues in National Adaptation Plans (NAPs), essential in articulating the adaptation needs and priorities of countries (UN Habitat 2019).

UN-Habitat coordinates the Cities and Climate Change Initiative (CCCI) that seeks to enhance the preparedness and mitigation activities of cities in developing countries. The ICLEI Seoul Declaration for Sustainable Cities, adopted in 2015, and the UN-Habitat New Urban Agenda, adopted in Quito in October 2016, emphasise the need to "strengthen food system planning" and recognise that dependence on distant sources of food and other resources can create sustainability vulnerabilities and supply disruptions. The agenda includes a commitment to "support urban agriculture and farming, as well as responsible, local, and sustainable consumption and production, and social interactions, through enabling accessible networks of local markets and commerce as an option to contribute to sustainability and food security".

C40, the network of the world's leading cities, promotes actions to reduce GHG emissions and climate risks; in 2016 it launched its Food Systems Network, in partnership with EAT.

As of April 2019, over 190 cities around the world had signed the Milan Urban Food Policy Pact (MUFPP), committing themselves to build more sustainable and resilient urban food systems. The Pact includes among its recommended actions: "Develop a disaster risk reduction strategy to enhance the resilience of urban food systems, including those cities most affected by climate change, protracted crises and chronic food insecurity in urban and rural areas."

These international frameworks acknowledge the importance of sub-national governments and other actors adopting direct, locally appropriate measures to reduce climate impacts on food systems, rather than relying on national-level solutions that may be inadequate or unsuitable to local conditions. They can serve as a call for national governments to support and enable efforts by local governments, through framing policies, funding and locally applicable programmes.

All in all, building resilience in a city requires an integrated and, ecosystems-based approach that considers mitigation (e.g., strategies to reduce greenhouse gas emissions), adaptation (e.g., reducing the vulnerability to climate change) and development (such as poverty alleviation, income generation and food security) (World Bank, 2010). Urban and peri-urban agriculture and forestry may be suitable strategies to address this triple challenge.

ENHANCING THE POTENTIAL OF URBAN AGRICULTURE THROUGH CITY REGION FOOD SYSTEMS APPROACH

Agriculture has always been practised in and around cities, but only recently has urban agriculture been formally recognised in international agendas. Urban and Peri-urban Agriculture and Forestry (UPAF) is defined as the growing of trees, food and other agricultural products (herbs, pot plants, fuel, fodder) and raising of livestock (including fisheries) within a built-up area (intra-urban agriculture) or on the fringe of cities (peri-urban agriculture). UPAF includes various production systems such as horticulture, livestock, (agro-) forestry and aquaculture as well as related input supply, processing and marketing activities.

The most striking feature of UPAF is not its urban location but rather the fact that it is an integral part of the urban socioeconomic and ecological system (Mougeot, 2000). UPAF uses urban resources (land, labour and urban organic wastes), grows produce for urban citizens, is strongly influenced by urban conditions (urban policies and regulations, high competition for land, urban markets, prices, etc.) and impacts the urban system (having effects on urban food security and poverty, as well as having impacts on ecology and health). Interest in UPAF is triggered by recognition of its (potential) multiple co-benefits and contributions. Beyond its potential impacts on food security, health, urban environmental management, social inclusion, community building and local economic development, UPAF has also been recognised for the important role it can play in resilience.

During the last 10 years, urban agriculture has rapidly moved from a "fringe interest" into the centre of attention of policymakers and urban planners, both in developing and developed countries. Feeding an urbanising world has become an imperative for cities (FAO, 2012, 2014). The (re-)introduction of productive landscapes into city design and development planning has now been widely accepted (Bohn, 2010). This aligns with urban development concepts like rural-urban linkages (FAO, 2013) and "mosaic landscape development" (Tuts, 2011), Urban Food Systems, and City Region Food Systems (FAO/RUAF, 2015, Blay-Palmer, et al. 2018). Developed by RUAF Partners and the FAO, the city region food system (CRFS) perspective provides a platform on which to build concrete policy and offer investment opportunities to address pertinent developmental issues with the objective of achieving better economic, social and environmental conditions in both urban and surrounding rural areas. Building a sustainable and resilient CRFS requires political will – integrating available policy and planning instruments (e.g. infrastructure, logistics, public procurement, land use planning), involvement of various government departments and jurisdictions (local and provincial), and inclusive organisational structures at different scales (municipal, district, etc.). An effective CRFS offers a lens through which this integration and coherence can be addressed at a specific territorial level (FAO, RUAF, 2018)

IMPROVING FOOD SECURITY WITH A CRFS APPROACH

RUAF collaborated with the City of Antananarivo, Madagascar to improve food security and income of the urban poor, and on the integration of urban agriculture in urban land use planning in order to reduce the impacts of climate change, notably flooding (AULNA project). The collaboration is continuing for the development of a city region food policy. Urban farming is an adaptation mechanism that helps to secure people's ability to provide themselves with fresh, locally produced food, while reducing transport related GHG emissions.

As part of a sustainable CRFS, UPAF can play a role in:

- reducing "food miles" by producing fresh food close to urban markets;
- reducing fertiliser use and energy consumption by productive reuse of urban organic wastes;
- enhancing rainwater infiltration;
- reducing the urban heat island effect by increasing the surface of green areas;
- enhancing carbon sequestration (urban forests);
- providing better diets, urban food security, jobs and income;
- reducing the vulnerability of the urban poor and enhancing their coping capacity;
- diversifying income opportunities: creation of "green jobs"; safety nets in times of economic crisis;
- enhancing community building, innovation and learning;
- keeping low-lying zones free from construction so that floods have less impact, stormwater runoff is reduced, and excess water is stored and infiltrates green open spaces;
- enabling productive reuse of organic wastes, thereby reducing methane emissions from landfill and reducing energy use in the production of fertilisers;
- reuse of urban wastewater to free fresh water for higher value uses and reduce emissions from wastewater treatment.

Governments and city administrations must recognise the opportunities offered by UPA to improve urban food security and livelihoods. By adopting policy responses that better integrate agriculture into urban development, developing countries can reap considerable benefits, especially enhancements in social, economic and environmental sustainability (FAO Statistical Yearbook 2012: 216).

CITY STRATEGIES USING URBAN AND PERI-URBAN AGRICULTURE AND FORESTRY

The following measures may be taken by city governments to strengthen climate change adaptation and risk reduction strategies through UPAF:

1. integrating urban food security and urban agriculture into climate change adaptation and disaster management strategies;
2. maintaining and managing agriculture projects as part of the urban and peri-urban green infrastructure;
3. identifying open urban spaces prone to floods and landslides, and protecting or developing these as permanent agricultural and multifunctional areas;
4. integrating urban agriculture and forestry into comprehensive city water(shed) management plans, and in social housing and slum upgrading programmes;
5. developing a municipal urban agriculture and food security policy and programme.

By adopting policy responses that better integrate agriculture into urban development, developing countries can reap considerable benefits, especially enhancements in social, economic and environmental sustainability

Toronto (Canada) includes UPAF in its city climate change action plan. Actions include financial support for doubling the existing tree canopy by 2020, community-based projects, e.g., community orchards and gardens, home gardens, etc., and the promotion of composting organic wastes and rainwater harvesting. It also includes the reduction of the city "food print" by requiring shipping distance on food labels, promotion of regional products, support of farmers' markets, and preferential procurement of locally-produced food.

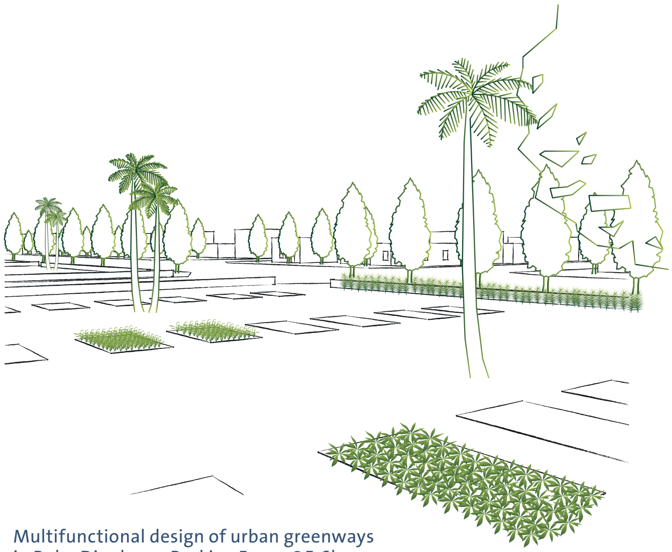
In 2017 the Metropolitan District of Quito (MDQ) (Ecuador) published its resilience strategy, a development in partnership with the Rockefeller Foundation's 100 Resilient Cities initiative. The strategy includes the need to develop a solid food economy, alongside other measures to reduce vulnerability to natural hazards, and proposes the development of a plan to strengthen the city's food system.

In Bobo-Dioulasso (Burkina Faso), land surface temperatures increased approximately 6% a year in the period 1991-2013 due to increased urbanisation. The city now promotes agroforestry activities in open urban lots (greenways), while protecting the peri-urban forests to help reduce urban temperatures. The greenways are planted with different fruit-bearing tree species and space is provided for recreation. Involved households have increased consumption of fresh vegetables and reduced their food expenditures. The new policy in Bobo Dioulasso includes acknowledging agroforestry and gardening as urban land use.

Rooftop gardens in Toronto - ©RUAF

In dense urban centres and settlements where space is limited, cities can promote rooftop gardens to increase thermal comfort in apartments located under the rooftop. Agricultural rooftops also provide food for the household and possible income for sales. A scenario developed for Vancouver (Canada) illustrates that if half of the city's usable rooftop space were used for urban agriculture, it could generate around 4% of the food requirements of 10,000 people. When combining this with hydroponic greenhouses, this figure could be increased to 60%. Kathmandu Metropolitan City-KMC (Nepal) has been promoting rooftop gardens in the city since 2012. By promoting household waste recycling, urban waste volumes that otherwise would end up in landfill are reduced. KMC trained over 500 households in rooftop farming, built demonstration rooftop gardens, and formulated a rooftop garden policy. In 2014, KMC signed an agreement with the Ministry of Federal Affairs and Local Development to ensure that by the end of 2016 at least 20% of all households in the city produce vegetables from their rooftop.

Other cities promote UPAF for reasons of food security, local economic development or environmental management. In the following cases, UPAF is not supported by climate change programmes, actors or funding, though they do have a bearing on climate change adaptation or mitigation. Freetown (Sierra Leone) has zoned all wetlands and low-lying valleys for urban agriculture in order to promote urban agriculture production for food supply and job creation, which at the same time increases water infiltration, reduces flooding, and keeps the flood-zones free from legal and illegal construction.



Multifunctional design of urban greenways in Bobo Dioulasso, Burkina Faso - ©F. Skarp

Growing built-up surfaces associated with urbanisation also reduce water infiltration and increase water runoff during rainstorms. With increasingly intense rainfall, flooding is common in cities that lack adequate drainage systems. Urban and peri-urban agriculture can reduce the impacts of higher rainfall by keeping low-lying zones free from construction so that floods have less impact, runoff is reduced, and excess water is stored and infiltrated. The cities of Kesbewa (Western Province, Sri Lanka) and Rosario (Argentina) promote the preservation and protection of green and productive areas on stream banks to reduce flood risks.

Promoting agricultural rooftop gardens in Kathmandu Metropolitan Municipality, Nepal - ©ENPHO/KMC and RUAF

Cities also promote sustainable urban and low-carbon development with potential connections to UPAF policy and implementation measures. As part of its Urban Master Plan (2005-2020), the city of Beijing (China) aims to preserve farmland and green spaces, designate permanent green areas in city fringes and corridors, promote wastewater recycling and rain and flood water harvesting, protect forest areas and parks, and certify and subsidise energy-saving production.

Besides integrating urban agriculture and forestry as part of climate change strategies and plans, better integration of food policies with land-use and zoning policies, waste management programmes, transportation projects and economic development policies is called for. In São Paulo (Brazil) and Lima (Peru) urban agriculture is integrated in social housing and slum upgrading programmes by including space for home gardens or community gardens, street trees for shade and fruits, and "productive parks". In Rosario (Argentina), fiscal and tax incentives are provided to landowners who lease out vacant private land to groups of urban poor willing to produce on this land. Cities can also make municipal land available to groups of urban poor for gardening purposes, either through short- or medium-term lease arrangements, or by providing occupancy licenses to the urban poor producing informally on municipal land. As in La Paz (Bolivia), these contracts with farmers often include conditions regarding safe and sustainable land, crop and waste management practices. Municipal land that is provided might be earmarked for other uses but not yet in use as such, including land that is not fit for construction.

THE WAY FORWARD: BRIDGING THE DATA GAP

To support the promotion of UPAF as an effective component of climate-compatible development strategies and climate change financing, greater empirical evidence and quantification of its benefits are needed. Besides, climate change vulnerabilities for urban and city regional food systems can dramatically vary from place to place. Cities therefore need to choose the specific types of urban and peri-urban agriculture and forestry that best fit their CRFS, and their local socioeconomic, climatic, agronomic and spatial conditions. Yet there is a general lack of awareness and data on the possible role that they can play.

Even though statistics on the impact of disasters are collected and reported for all sectors, they do not capture the impact of climate change on the food system at the city region level. Moreover, many cities do not yet have a local climate change action plan or resilience strategy – and where they do, food system resilience tends to be included only to a limited extent.

There is a pressing need to better understand the impacts of climate change (both acute shocks and chronic stresses) on urban and city region food systems and their vulnerable populations, to serve as a basis for planning and monitoring. Cities and city regions that actively plan for resilient food systems will help ensure that (a) the food supply chain is diversified and resilient to future climate impacts and that (b) food access returns to pre-disaster levels as quickly and as equitably as possible, so that all residents have adequate access to food in their neighbourhoods.

CREATING ADAPTABLE TOOLKITS

FAO and RUAF Global Partnership (led by Laurier University) are collaborating on a second phase of the City Region Food Systems initiative to strengthen attention to resilience and adaptation to climate risks. Local governments of three pilot cities (still tentative) in Vietnam (Danang), Rwanda (Kigali) and Madagascar (Antananarivo) will receive support in (i) assessing the resilience of the CRFS to both acute shocks (e.g. natural disasters affecting a city) and chronic stresses (e.g. projected longer-term climatic changes), and (ii) identifying adaptation strategies to strengthen the resilience to these shocks and stresses. The new methodology module on climate risk and vulnerability assessment will build on existing FAO tools and approaches; it will be flexible enough for application to very diverse CRFS contexts in both developing and developed countries.

If urban and peri-urban agricultures are to be further promoted as integral strategies for climate change adaptation, mitigation and disaster risk reduction, respective indicators and monitoring frameworks are needed to better understand its actual contributions. Both cities and international organisations are calling for more monitoring data in order to better design climate change strategies, plans and financing mechanisms that include urban agriculture.

Data could be effectively used to (1) develop GHG emission and air pollution reduction plans, considering UPAF as well as other interventions, (2) develop local food system strategies or urban afforestation/reforestation programmes (selecting species that can adapt to changing climates) and (3) integrate UPAF in urban planning as an appropriate use for vulnerable sites. In addition, data could (4) enhance awareness among citizens, the private sector and policymakers on UPAF and climate change, (5) obtain national and international support and funding for mitigation and adaptation measures involving UPAF and (6) mainstream UPAF in the international agenda by showing its social, economic and environmental benefits.

DATA MONITORING FRAMEWORKS (EXISTING AND UNDER DEVELOPMENT)

With support from UN-Habitat and the Climate and Development Knowledge Network (CDKN), RUAF designed a framework for indicators and tools to monitor the actual adaptation and risk-reduction impacts and development benefits of urban agriculture activities in different cities.

FAO, MUFPP Secretariat, RUAF and partners have developed the MUFPP monitoring framework to help cities in formulating and monitoring urban food policies and in assessing progress made by cities in achieving more sustainable food systems. A methodological guide to help cities and partners in collecting and analysing the right data for the indicators is being drafted. The guide will also highlight the connections with the Sustainable Development Goals (SDGs). The framework is now being piloted in three signatory cities, Antananarivo, Nairobi and Quito, under the guidance and technical support of FAO and RUAF.

CONCLUSION

Policy participation of all actors in the food chain, from producers to consumers, needs to be enhanced to ensure relevant, accountable, equitable and sustainable action. Taking into account the needs and perspectives of vulnerable populations, whose homes, livelihoods, health and food access are most at risk from climate-related events, should be enabled by governance mechanisms.

Prompt action, e.g. enhancing energy efficiency, reducing pollution and promoting urban greening results in direct positive impacts on public health, improved quality of living, and cost savings on energy. This provides cities with opportunities to address deficiencies in housing, green spaces and services, and to create jobs and other local economic development opportunities. There is a pressing need to enhance awareness of local governments and other stakeholders involved in urban climate change programmes, about the potential of UPAF in climate change adaptation and mitigation, as well as its developmental benefits.

Finally, exchange of best practices and the development of monitoring tools are key to identify the types of production that are most appropriate to local contexts (e.g. farming in flood zones; agro-forestry on steep slopes; community gardening; promotion of aquaculture, etc.) as well as to design and implement projects where UPAF would yield the highest climate change impacts and co-benefits.

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- Policy brief: Integrating urban agriculture and forestry into climate change action plans – Lessons from Sri Lanka
- Practitioner brief: Rooftop Agriculture – A climate change perspective
- Final report: Integrating urban and peri-urban agriculture and forestry into city climate change strategies

THE REVIVAL OF URBAN AGRICULTURE: an opportunity for the composting stream

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Urban composting is currently booming, especially thanks to the new outlets that urban agriculture offers for organic materials. Faced with the challenges of the sustainable city of tomorrow, this practice, whether individual or collective, engages citizens and offers a decentralized response with positive impacts for the environment and for neighborhood social relations. Its success involves making material available in a common space, a communication system and support from residents' initiatives. Technical, ecological, agricultural, economic and social aspects must be considered to ensure its success, while scientific knowledge is essential to inform, overcome certain obstacles and ensure the quality of this urban form of production.

INTRODUCTION

Although not required to do so, 30% of French households sort their biowaste at the source[1]. Previously, these tended to be ad hoc local initiatives, but there is now a real buzz around urban composting. This is happening in connection with urban agriculture programs, as composted organic waste is used to supply urban and peri-urban agriculture[2].

As of 2015, the average person in France was producing 437 kilograms of household waste a year.[3] Of this waste, half is made up of recyclable materials and a third of organic waste. Composting therefore allows reduced consumption of resources by encouraging their recycling and local reuse.

1 ADEME, Fabienne Muller, Guillaume Bastide, Isabelle Deportes, Olga Kergaravat, and Cloé Mahé, "Comment réussir la mise en œuvre du tri à la source des biodéchets? Recommandations pour les collectivités," [Report], Angers, France, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), *Expertises*, 2018.

2 Joël Sotamenou, "Les facteurs d'adoption du compost en agriculture urbaine et périurbaine au Cameroun," *Terrains & travaux* 1, no. 0, 2012: 173187.

3 ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), "Déchets - chiffres clés," [Report], Angers, France, ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), *Faits & Chiffres*, 2018.

COMPOSTING: THE PROCESS AND RECOVERY STREAMS

A TECHNIQUE FOR RECOVERING AND PROCESSING ORGANIC WASTE

Composting is the fermentation of organic waste in the presence of oxygen (under aerobic conditions) and humidity, in controlled conditions. This produces a stable fertilizing material rich in humic compounds: compost, which is used as an organic soil improver to enhance the structure and fertility of soil. But the renewed interest in composting should not overshadow the complexity of this technique. The composting process comprises four phases (mesophilic, thermophilic, cooling and curing), throughout which the composition of organic products and of living organisms changes.

The first three phases make up the decomposition phase (see Figure 1). During the mesophilic phase, large quantities of carbon dioxide are released and a great deal of oxygen is consumed, causing an increase in temperature. This is particularly significant in the mesophilic and thermophilic phases, when the energy contained in the organic matter is transformed into heat, and the temperature can reach between 50 and 60 °C (and even 70 to 80 °C in heaps measuring several dozen cubic meters). During the cooling phase, the temperature gradually drops and fungi colonize the material. At the same time, microbial activity lessens. Below 30 °C, microorganisms remain active, and larger organisms (macroorganisms), such as compost worms, mites, springtails, woodlice, beetles and centipedes start to appear. This is the curing phase. The decomposition of organic material continues and humus forms.

The four phases of the composting process

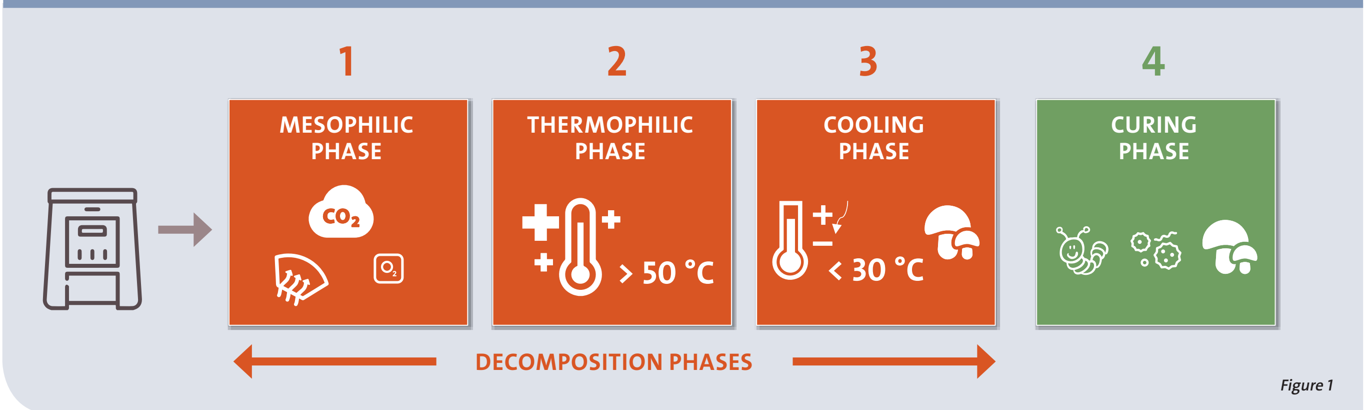

Figure 1

ORGANIC WASTE

Organic waste, also known as fermentable waste, biowaste and biodegradable waste, refers to green garden waste such as lawn clippings, dead leaves, hedge clippings, or wilted indoor flowers and plants, and animal waste, such as droppings, dung and manure. This waste can be broken down by microorganisms and organisms such as worms, mites and insects.

Organic waste also includes degradable kitchen waste, such as fruit and vegetable peelings, coffee grounds, tea bags, cheese rind, eggshells, vegetable food leftovers (bread, rice, potatoes), plus cellulose household waste such as absorbent paper (paper tissues, paper towels, coffee filters) and newspaper, wood ash, and untreated sawdust and wood shavings.

ORGANIC WASTE AND MAIN SOURCES OF WASTE

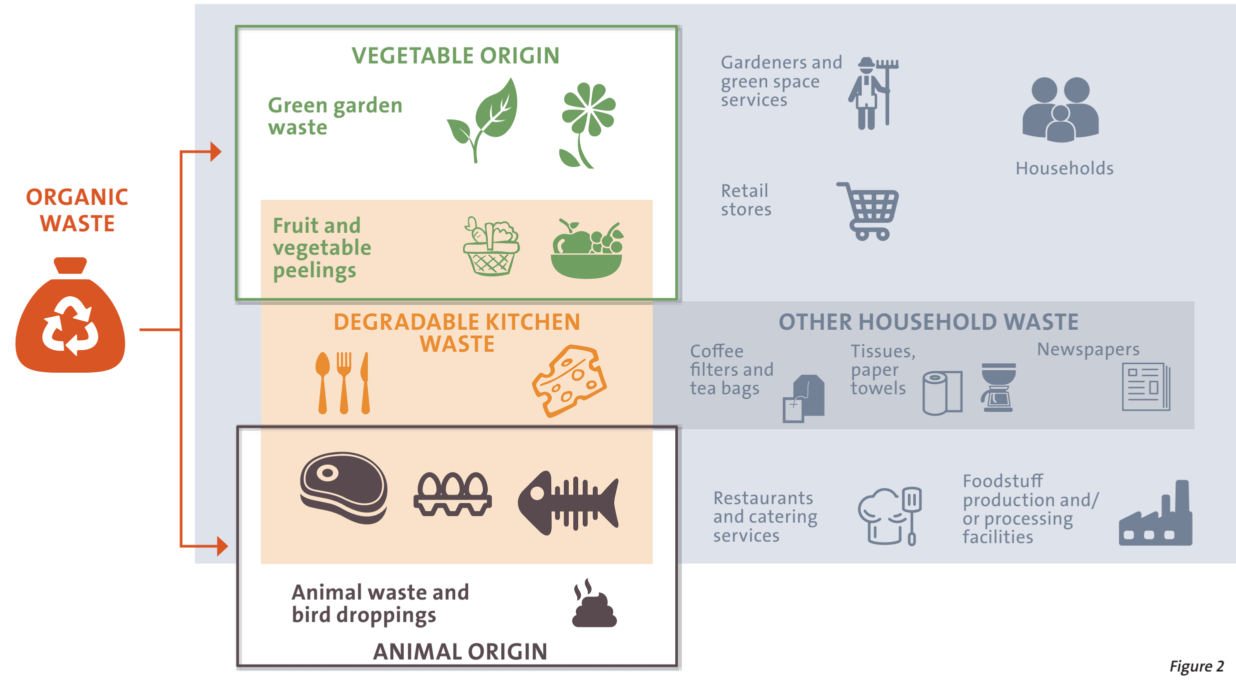

Figure 2

French biowaste regulations in a nutshell:
Biowaste or organic waste is defined in article R 541-8 of the environmental code as: "all non-hazardous biodegradable garden or park waste, all non-hazardous food or kitchen waste, including that from households, restaurants, caterers and retailers, and all similar waste from foodstuff production or processing facilities".

Some key figures:
Households produce 18 million metric tons of biowaste per year, including:
- 5.1 million metric tons of mainly green waste processed in homes (mulch, compost, etc.)
- 3.8 million metric tons of green waste sent to disposal facilities
- 1.6 million metric tons of biowaste collected separately (mostly green waste – food waste amounts to 5-10% by weight).

Remaining biowaste amounts to around 40% of household waste, or more than 8 million metric tons, and is mostly food waste. The amount of kitchen and green waste processed in homes is equivalent to the amount collected by public services.

THE DIFFERENT COMPOSTING STREAMS

Composting is an organic waste recovery and processing stream that works at every scale, from the domestic to the neighborhood or town level, right up to industrial plant scale.

This makes composting suitable for a range of socioeconomic and geographical situations. There is a distinction to be made between domestic composting and industrial composting. The latter takes place in centralized, large-capacity industrial facilities producing from 2,000 to 100,000 metric tons per year, or even more. These facilities enabled the processing of more than 7.2 million metric tons of organic waste in France in 2010[4].

Domestic composting, on the other hand, covers individual and collective composting. Individual composting is carried out by individuals or private households, at the bottom of the garden, or by apartment dwellers, using a wormery. Use of the latter is showing a marked increase. Collective or semi-collective composting is carried out at the foot of an apartment building, or in a communal area or garden. These have seen strong growth in recent years.

THE REVIVAL OF AN ANCIENT URBAN PRACTICE

A HISTORY OF COMPOSTING

Composting is mentioned in the “Book of Nabatean Agriculture” from the third millennium BCE; the book is a synopsis of the agricultural knowledge of ancient Mesopotamia[5]. Archeological digs have also found household waste in manure from the Middle Ages, but it is not known whether this was accidental or an informed practice[6]. Although the medieval town was marked by the separation of agricultural areas located outside the walls from the intra-mural spaces[7], urban agricultural practices already existed[8]. For example, places for medicinal plants or vegetable gardens have been observed behind some dwellings and in abbey gardens. The practices of composting and farming inside towns seem to have developed concurrently until the 20th century, through a phenomenon of “agrarianization of towns.” This phenomenon takes very different forms, from urban farms to family gardens; makes use of various surfaces, such as planted roofs and walls or gaps between buildings; and employs disparate techniques, such as organic growing and hydroponics[9].

The 20th century marks a separation. The urbanization of agriculture happened relatively quietly, but urban expansion accentuated competition for use of space. Areas that were previously agricultural were now located in urban or peri-urban settings. Beyond the usage conflicts provoked by urban expansion, composting developed significantly in the agricultural sector, and research work on composting techniques emerged in its wake. For example, in 1936, the botanist and agronomist George Washington Carver (1864-1943) published a study entitled “*How to Build Up and Maintain the Virgin Fertility of Our Soil*,“ which recommended using compost to maintain the fertility of soil exposed to increasing environmental pressures. A few years later, in 1943, the publication of “*An agricultural testament*” by the English agronomist and botanist Albert Howard (1873-1947) rekindled interest in composting methods[10].

RENEWED POPULARITY

Urban composting is currently attracting strong interest through the expansion of urban agriculture, which is raising urban residents’ awareness of food production. Additionally, the sustainable city concept has highlighted the value of making compost from urban waste. The timeline in Figure 3 shows the main steps implemented since the 2000s to encourage composting on every scale, both individual and collective. In 2006, France’s National Plan to support home composting rounded off its national waste prevention plan of 2004. The publication of numerous research studies and methodological guides followed. A notable example is the in-house composting guide[11] aimed at all public or private organizations with a shared canteen (schools, tourist attractions and restaurants, for instance), the guide to shared or semi-collective composting[12] aimed at users of communal or co-owned gardens, and more recently, the practical guide to composting and mulching aimed at households[13].

The National Plan for Waste Prevention 2014-2020[14], along with the next Plan (in consultation since April 2019), highlight the increasing importance of composting in waste management. To achieve its 2025 waste reduction targets, the waste plan envisages increasing the number

4 ADEME, *Le compostage - fiche technique*, [Report], Angers, France, ADEME (Agence de l’Environnement et de la Maîtrise de l’Énergie), 2015.

5 Sabine Barles, *L’invention des déchets urbains : France 1790-1970*, Champ Vallon, Milieux, June 15, 2005. Mohammed El Faiz, “Un traité des engrais d’après le ‘Livre de l’Agriculture Nabatéenne’,” *Journal d’agriculture traditionnelle et de botanique appliquée* 39, no. 1 (1997): 525.

6 Nicolas Poirier and Laure Nuninger, “Techniques d’amendement agraire et témoins matériels. Pour une approche archéologique des espaces agraires anciens,” *Histoire & Sociétés rurales* 38, no. 2 (2012): 1150.

7 Paula Nahmias and Yvon Le Caro, “Pour une définition de l’agriculture urbaine : réciprocité fonctionnelle et diversité des formes spatiales,” *Environnement urbain/ Urban environment*, 6 (2012): 116.

8 Pascale Scheromm, Coline Perrin, and Christophe Soulard, “Cultiver en ville… Cultiver la ville? L’agriculture urbaine à Montpellier,” *Espaces et sociétés* 158, no. 3, (2014): 49.

9 Marion Ernwein and Joëlle Salomon-Cavin, “Au-delà de l’agrarisation de la ville : l’agriculture peut-elle être un outil d’aménagement urbain? Discussion à partir de l’exemple genevois,” *Géocarrefour*, 89, December 23, 2014, no. 12: 3140.

10 Grace Gershuny and Deborah L. Martin (ed.) *The Rodale book of composting: simple methods to improve your soil, recycle waste, grow healthier plants, and create an earth-friendly garden, Second revised edition-1992* (New York: Rodale Books, Rodale Classics, 2018).

11 Agnès Demolles, Christian Nanchen, Pascal Retière, and Roger Proix, “Guide méthodologique du compostage autonome en établissement,” [Report], Angers, France, ADEME (Agence de l’Environnement et de la Maîtrise de l’Énergie), 2012.

12 ADEME, *Guide méthodologique du compostage partagé (ou semi collectif)*, [Report], Angers, France, ADEME (Agence de l’Environnement et de la Maîtrise de l’Énergie), 2012.

13 ADEME (Agence de l’Environnement et de la Maîtrise de l’Énergie), “Le compostage et le paillage,” [Report], Angers, France, ADEME (Agence de l’Environnement et de la Maîtrise de l’Énergie), *Clés pour agir* (2019).

14 ADEME, *Le compostage - fiche technique*, [Report], Angers, France, ADEME (Agence de l’Environnement et de la Maîtrise de l’Énergie), 2015.

Major dates relating to composting since the early 2000s

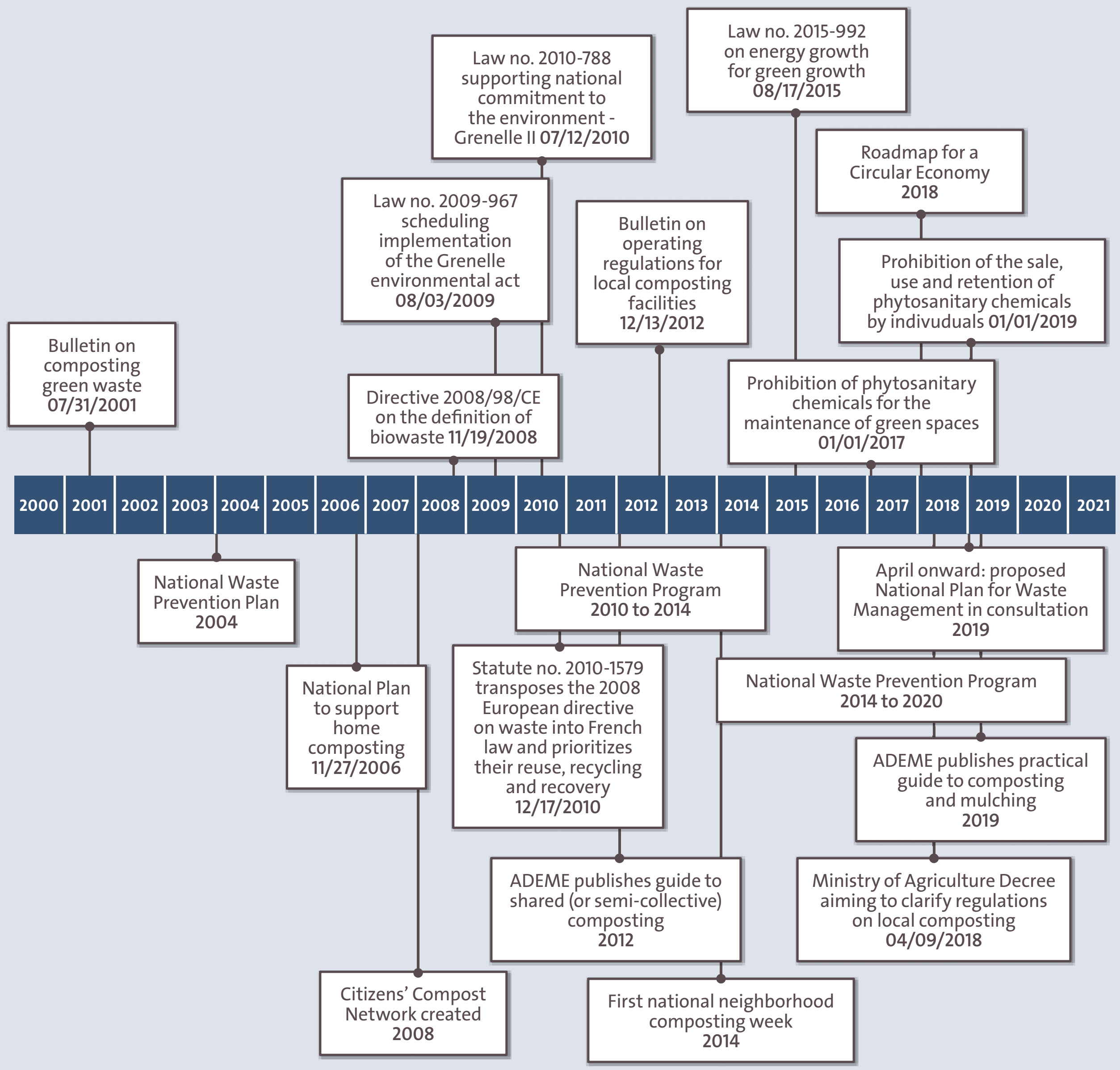

Figure 3

of neighborhood composting facilities, composting hubs and biogas plants, so that "everyone can access a neighborhood waste management solution." Currently, according to ADEME, there are more than 600 composting hubs, and around 60 local government authorities have a doorstep biowaste collection system in place, serving 2.2 million residents[15]. Thanks to these facilities, the volume of composted waste is increasing – it reached 7.7 million metric tons in 2014, which represents a 103% increase from the year 2000[16]. This volume will probably continue to increase, as the 2018 roadmap for the circular economy included a reduced value-added tax on purchases of neighborhood composting equipment and compostable bags.

15 ADEME, *Guide méthodologique du compostage partagé (ou semi collectif)*, op. cit.

16 ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), "Déchets - chiffres clés," op. cit.

FOCUS ON THE EXPANSION OF COMPOSTING IN SELECTED CITIES[17]

In the urban community of **Toulouse** Métropole, composting has grown significantly. Between 2011 and 2012, the percentage of households with a garden composter increased by 53% in Aigrefeuille, by around 40% in Toulouse, Beaupuy and Mons, and by just under 20% in Drémil-Lafage, Quint-Fonsegrives and Pin-Balma.

In the urban community of Grand **Chalon**, the number of home composters distributed to households multiplied 14-fold between 2006 and 2013.

In **Nantes**, no fewer than 38 shared composting facilities were established in 2018, and 15 more in 2019. Currently, there are more than 200 shared composting facilities, in schools, homes and even family gardens.

17 Data source: https://www.data.gouv.fr/fr/datasets/compostage-domestique/ et http://www.compostri.fr/carte/

COMPOSTING IN A COMMUNAL GARDEN: THE EXAMPLE OF THE *LA CRAPAUDINE* VEGETABLE GARDEN IN NANTES

Environmentally friendly practices adopted in communal gardens include collecting rainwater for watering, using compost as natural fertilizer and banning the use of chemical treatments. These practices were all implemented long ago in the *La Crapaudine* vegetable garden. Created in 1998, this family garden in south Nantes comprises 91 plots ranging from 35 to 150 square meters, with a total area of 16,580 square meters. The garden is managed by the *Jardins de la Crapaudine* association, which supports gardeners and organizes activities with other local associations to strengthen social links and make gardeners aware of chemical-free products and methods. Since January 1, 2017 the Labbé law prohibits the use of chemicals in green spaces, forests, roadways and paths accessible or open to the public.

Through the Compostri non-profit organization, composting has been used in this park since 2011 to reduce the use of pesticides. A 1,400-square-meter educational space is also available to the city of Nantes's green space and environmental services as a master class and showcase for urban composting. This area also helps raise public awareness of composting and there is a training area dedicated to individual and shared composting using heaps and wormeries. Activities to raise park users' awareness are also held during national neighborhood composting weeks, which take place every year in March and April. The composting space is not restricted to subscribers and members of the family garden – any local resident can dispose of their biowaste in the composting shed provided. In this way, the shared garden is helping to spread eco-friendly values and behaviors.

More than 200 shared composting facilities are currently operating in the Nantes Métropole area: more than 80 in homes, the same again at the foot of apartment buildings, and around 15 in family gardens.

Awareness poster issued for the 2019 French national waste composting awareness week

A PRACTICE WITH MULTIPLE BENEFITS FOR THE CITY

Compost helps sustain urban agriculture[18] and is the source of numerous benefits[19] in the multifunctional context of the city.

In physical terms, the use of compost improves the soil's structure, reducing the risk of soil erosion by wind and water. Compost also increases the soil's water retention capacity, making it more drought-resistant[20]. Compost improves the soil's plasticity, density and structure[21]. Chemically speaking, the use of compost increases the soil's carbon, nitrogen, phosphorus and potassium content, as well as trace elements and organic matter[22]. These substances are necessary for plant growth, and therefore for soil fertility. In biological terms, compost contains significant biomass and supports an extremely rich microbial population[23]. Applying compost also increases microfauna in the soil. All these elements contribute to soil fertility[24].

18 Camille Blaudin de Thé, Amandine Erktan, and Charles Vergobbi, *La filière agricole au cœur des villes en 2030*, AgroParisTech, Paris, France, 2009.
Camille Dumat, Tiantian Xiong, and Muhammad Shahid, *Agriculture urbaine durable: Opportunité pour la transition écologique*, 2016.

19 M. Charland, S. Cantin, M-A. St-Pierre, and L. Cote, *Recherche sur les avantages à utiliser le compost*, [Report], Québec, Centre de Recherche Industrielle du Québec (CRIQ), Dossier CRIQ, 2001.

20 Heba Ahmed Khalil Ibrahim and Mohamed Abdel aziz Balah, "Study the Use of Compost Tea in Weed Suppression," *International Journal of Environmental Research* 12, no. 5 (October 2018): 609618.
Suwandi, Armi Junita, Suparman, Abu Umayah, Harman Hamidson, A. Muslim, and Chandra Irsan, "Curative Activity of Watery Fermented Compost Extract as a Bark Treatment against Tapping Panel Dryness," *The Open Agriculture Journal 12*, no. 1, April 30, 2018: 7483.

21Thuy Thu Doan, Thierry Henry-des-Tureaux, Cornelia Rumpel, Jean-Louis Janeau, and Pascal Jouquet, "Impact of compost, vermicompost and biochar on soil fertility, maize yield and soil erosion in Northern Vietnam: A three year mesocosm experiment," *Science of The Total Environment* 514 (May 2015): 147154, doi:10.1016/j.scitotenv.2015.02.005.

22 M. Mladenov, "Chemical composition of different types of compost," *Journal of Chemical Technology and Metallurgy* 53, no. 4 (2018): 712716.

23 C. Aubry and C-T. Soulard, "Cultiver les milieux habités : quelle agronomie en zone urbaine ?" *Agronomie, Environnement et Sociétés* 2, no. 1 (2011): 89101.

24 Miguel A. Sánchez-Monedero, María L. Cayuela, María Sánchez-García, Bart Vandecasteele, Tommy D'Hose, Guadalupe López, Carolina Martínez-Gaitán, Peter J. Kuikman, Tania Sinicco, and Claudio Mondini, "Agronomic Evaluation of Biochar, Compost and Biochar-Blended Compost across Different Cropping Systems: Perspective from the European Project FERTIPLUS," , *Agronomy* 9, no. 5, May 4, 2019: 225
Rubén Forján, Alfonso Rodríguez-Vila, Beatriz Cerqueira, Emma F. Covelo, Purificación Marcet, and Verónica Asensio, "Comparative effect of compost and technosol enhanced with biochar on the fertility of a degraded soil," *Environmental Monitoring and Assessment* 190, no. 10 (October 2018).
Thuy Thu Doan et al. "Impact of compost, vermicompost and biochar on soil fertility, maize yield and soil erosion in Northern Vietnam," *op. cit.*

The benefits of urban composting combined with urban agriculture

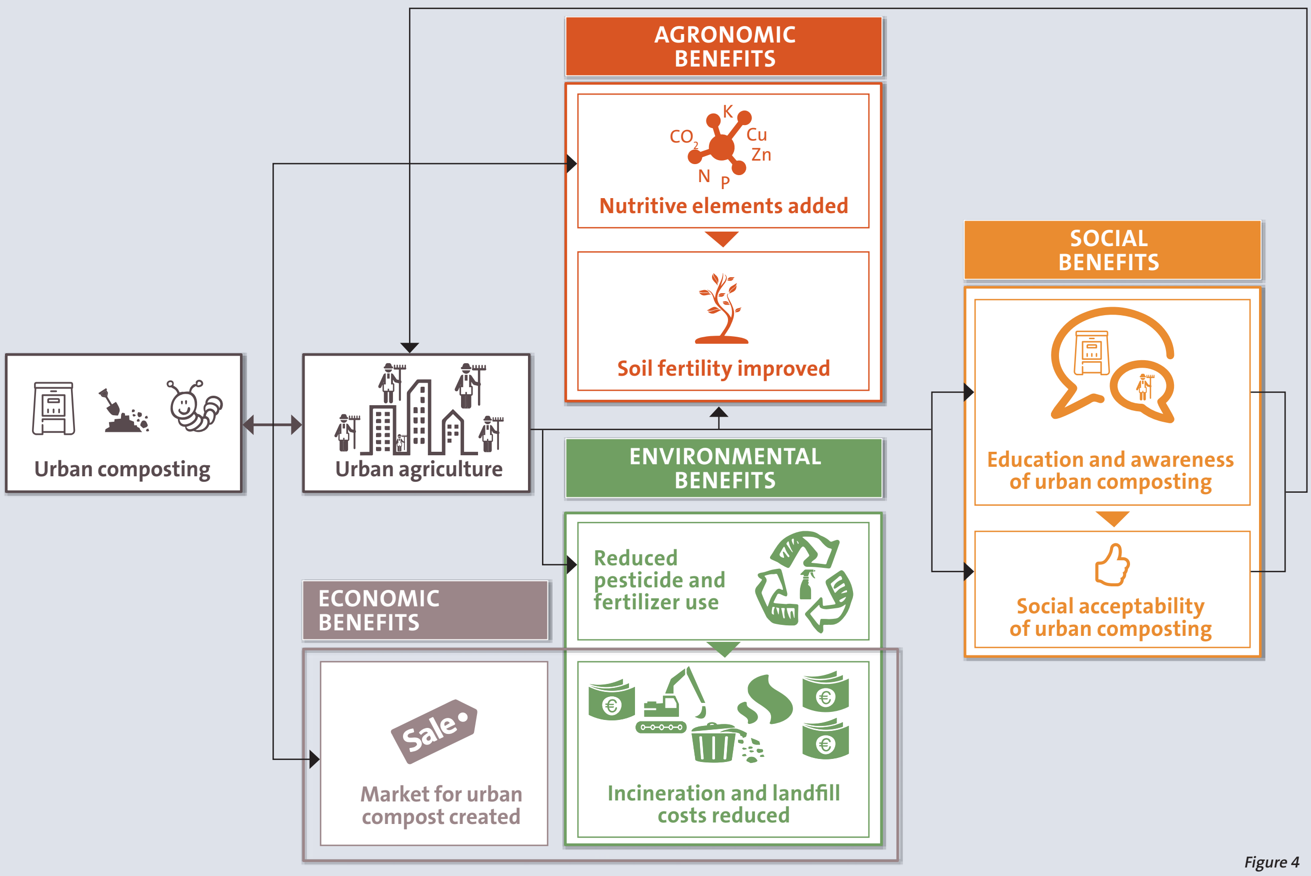

Figure 4

Composter at the foot of an apartment building – ©City of Nantes

From an agronomic viewpoint, therefore, the use of compost improves the physical, chemical and biological quality of the soil. In the city, it can enrich urban soil, planted roofs and terraces for growing vegetables[25]. It therefore contributes to improving crop soil fertility in the urban environment[26]. The practice of composting in the context of urban agriculture also alters its relationship to the city. Essentially, as the city eats, it also produces[27]. Just like when they generate electricity from renewable sources, citizens who produce compost become suppliers to the city, providing it with fertilizer for its green spaces.

Economically, urban agriculture represents a potential market for compost produced in an urban setting. Also, from both the economic and environmental viewpoint, composting has the advantage of its short distribution chain, as it occurs where waste is produced. This also eliminates the difficulties and costs associated with transportation and industrial recovery, which involves incineration or landfill, especially given that these sites are relatively costly and difficult to establish, due to the nuisance they pose to local residents.

Composting also brings environmental benefits by reducing reliance on pesticides and chemical fertilizers[28], especially in the agricultural sector where their use is still widespread. On the other hand, using compost on contaminated soil can considerably reduce the pollutant content, including

25 B. P. Grard, N. Bel, N. Marchal, F. Madre, J. F. Castell, P. Cambier, C. Chenu, S. Houot, N Manouchehri, S. Besancon, J. C. Michel, N. Frascaria-Lacoste, and C. Aubry, "Recycling urban waste as possible use for rooftop vegetable garden," *Future of Food: Journal on Food, Agriculture and Society 3*, no. 1 (2015): 2134.
Mert Eksi, D. Bradley Rowe, Rafael Fernández-Cañero, and Bert M. Cregg, "Effect of substrate compost percentage on green roof vegetable production," *Urban Forestry & Urban Greening* 14 no. 2 (2015): 315322.
Baptiste J.-P. Grard, Claire Chenu, Nastaran Manouchehri, Sabine Houot, Nathalie Frascaria-Lacoste, and Christine Aubry, "Rooftop farming on urban waste provides many ecosystem services," *Agronomy for Sustainable Development* 38, no. 1 (February 2018).

26 Rosanne Wielemaker, Oene Oenema, Grietje Zeeman, and Jan Weijma, "Fertile cities: Nutrient management practices in urban agriculture," *Science of The Total Environment* 668 (June 2019): 12771288.
Rosanne C. Wielemaker, Jan Weijma, and Grietje Zeeman, "Harvest to harvest: Recovering nutrients with New Sanitation systems for reuse in Urban Agriculture," *Resources, Conservation and Recycling 128* (January 2018): 426437.
O. Cofie, A. A. Bradford, and P. Drechsel, "Recycling of urban organic waste for urban agriculture," in *Cities farming for the future, Urban agriculture for sustainable cities*: 209242.
J. P. Harris et al. "The potential use of waste-stream products for soil amelioration in peri-urban interface agricultural production systems," in *Waste Composting for Urban and Peri-urban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa*, ed. P. Drechsel and D. Kunze (Wallingford, United-Kingdom): 128.

27 Giulia Giacchè, *"De la ville qui mange à la ville qui produit: l'exemple des Horteloes Urbanos de Sao Paulo,"* [Report], Nantes, France, Laboratoire ESO (Espaces et Sociétés), *ESO Travaux et Documents - Dossier Transition sociale et environnementale des systèmes agricoles et agro-alimentaires au Brésil*, 2016.

28 Mohammad H. Golabi, M. J. Denney, and Clancy Iyekar, "Value of Composted Organic Wastes as an Alternative to Synthetic Fertilizers for Soil Quality Improvement and Increased Yield," *Compost Science & Utilization* 15, no. 4 (September 2007): 267271.
Teresa Hernández et al. "Use of compost as an alternative to conventional inorganic fertilizers in intensive lettuce (Lactuca sativa L.) crops—Effects on soil and plant," *Soil and Tillage Research* 160 (July 2016): 1422.
Rizwan Ahmad, Muhammad Naveed, Muhammad Aslam, Zahir A. Zahir, Muhammad Arshad, and Ghulam Jilani, "Economizing the use of nitrogen fertilizer in wheat production through enriched compost," *Renewable Agriculture and Food Systems* 23, no. 03 (September 2008): 243249.

Composter in an urban garden – ©City of Nantes

lead, copper and oil-based products in enriched soil.[29] Using compost alongside roads offers another environmental bonus by absorbing rainwater and reducing soil washout.[30]

Also, through urban agriculture, the use of compost offers a route to social acceptability for growing crops offground or on city rooftops. In return, urban agriculture initiatives also help to raise awareness and educate the public about composting practices, which enhances its social acceptability still further.[31] Urban agriculture raises public awareness of food production and organic waste management and recycling.[32] The benefits of composting extend beyond the boundaries of urban agriculture and also contribute to creating real circularity in the use of compost.

OBSTACLES TO COMPOSTING

Despite the numerous positive effects of composting, there are significant obstacles limiting its use. Among these are environmental and health risks. Administrative and regulatory barriers and people's perceptions of organic waste also constitute obstacles that require effective public communication with compost users to further promote its use.

POTENTIAL ENVIRONMENTAL AND HEALTH RISKS

Carbon dioxide is the main gas produced during composting. Several other gases in smaller quantities can also have a non-negligible effect on health or the environment: nitrous oxide and methane are greenhouse gases; ammonia contributes to environmental acidification and eutrophication; various other volatile sulfurous and organic compounds can potentially create odors and health issues.

Additionally, composting occurs in the presence of microorganisms that can cause disease. The risk of disease is potentially greater for people working in a composting hub[33]. However, in recent years, the amount of kitchen and green waste processed in homes has been equivalent to the

29 Wan Namkoong, Eui-Young Hwang, Joon-Seok Park, and Jung-Young Choi, "Bioremediation of diesel-contaminated soil with composting," *Environmental Pollution* 119, no. 1 (August 2002): 2331.
AM. Taiwo, A.M. Gbadebo, J.A. Oyedepo, Z.O. Ojekunle, O.M. Alo, A.A. Oyeniran, O.J. Onalaja, D. Ogunjimi, and O.T. Taiwo, "Bioremediation of industrially contaminated soil using compost and plant technology," *Journal of Hazardous Materials* 304 (March 2016): 166172.
Nadège Oustriere, Lilian Marchand, Gabriel Rosette, Wolfgang Friesl-Hanl, and Michel Mench, "Wood-derived-biochar combined with compost or iron grit for in situ stabilization of Cd, Pb, and Zn in a contaminated soil," *Environmental Science and Pollution Research* 24, no. 8 (March 2017): 74687481.

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amount collected by public services.[34] Home composting therefore presents risks that need to be mentioned.

In addition to microorganisms as a potential source of certain diseases, mostly respiratory, organic pollutants can also be found in compost because they are present in the organic waste that goes into the compost.[35] There is therefore a disease risk when stirring, turning or collecting compost, or when adding dry material, for example.[36] Diseases may be transmitted by inhalation or ingestion of organic dust particles, or through the skin.[37] These organic dust particles can contain microorganisms of fecal or animal origin, especially animal by-products from category 3 such as egg shells and certain meat residues. Although these are usually destroyed during the composting process due to the rise in temperature, this temperature increase is not systematic, especially in the case of home composting and small shared composters where the volume of composted waste is low, as this does not permit the

34 ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), "Impact sanitaire et environnemental du compostage domestique," op. cit.

35 Gwenaëlle Lashermes, Enrique Barriuso, and Sabine Houot, "Dissipation pathways of organic pollutants during the composting of organic wastes," *Chemosphere 87*, no. 2 (April 2012): 137143.
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Main environmental and health impacts of urban composting

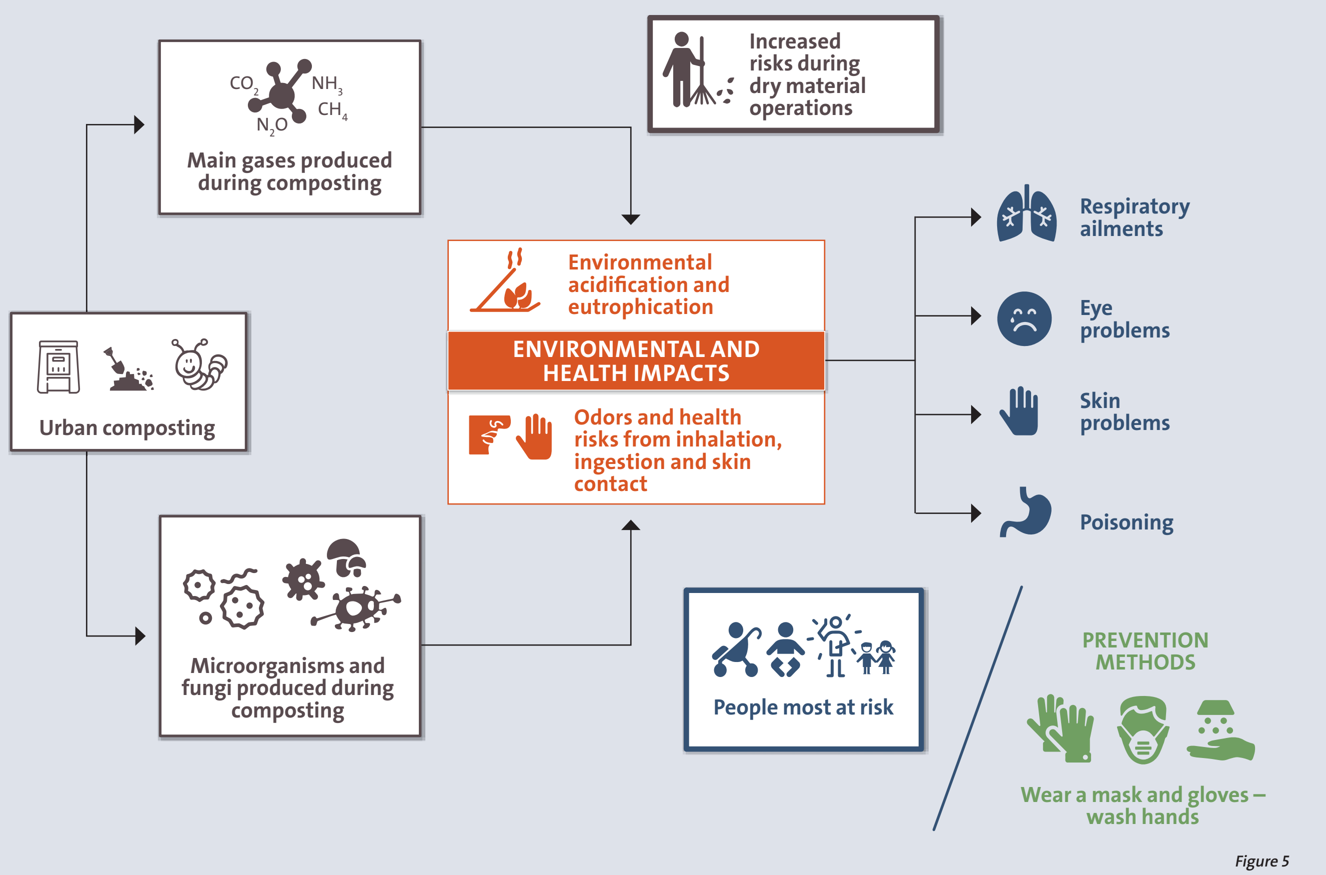

Figure 5

hygienization of the compost caused by the temperature increase.

In terms of other potential ailments, the main risk to humans is allergic or inflammatory in nature. Bacteria and fungi that grow during composting may also release toxins and allergens. Toxins of bacterial or fungal origin can cause respiratory discomfort or irritation (in the form of coughing and sneezing) and/or ocular discomfort, or non-allergic inflammation, such as irritation, chronic bronchitis or asthma flare-ups, for example. The multiplication of microorganisms such as aspergillus fumigatus, *aspergillus flavus* or *stachybotrys atra* can also cause necrotizing pneumonia, pulmonary disease, or hypersensitivity pneumopathy, also known as allergic alveolitis[38]. These diseases can also be caused by (involuntary) ingestion of soil or compost dust particles. This particularly affects unsupervised young children, who may subsequently develop gastroenteritis or acute diarrhea. Figure 5 summarizes the main potential environmental and health impacts of home composting.

However, the risk of infection is minimal. Chronic respiratory exposure to atmospheric emissions from compost are not likely to entail unacceptable risks.[39] Effectively, this type of reaction generally occurs in cases of repeated and prolonged exposure to the organic materials contained in the compost. Additionally, immunosuppressed individuals are most at risk: infants, young children, older people, or people with chronic illnesses such as asthma. Furthermore, to prevent these risks, wearing a mask and gloves is recommended when handling compost. It is also important to allow the compost to mature long enough that pathogens do not survive. It is also preferable to spread the compost around trees and ornamental plants rather than on the vegetable garden. If the compost is used on the vegetable garden, vegetables from the garden must be thoroughly washed.

ADMINISTRATIVE ASPECTS AND PUBLIC PERCEPTIONS

On a social level, compost use enables residents to increase their awareness and sense of responsibility with regard to their own waste production[40]. Observations of composting practice in different urban areas such as Bordeaux[41], Lyon[42] and Strasbourg[43] show that although compost users in an urban setting share the same aim in terms of sustainable development (reduction and recycling of waste), this clashes with regulations that are considered overly rigid. In addition, cooperation between the various volunteers and the urban community (including local government authority stakeholders) comes up against a difference in cultures linked to the need for each category of stakeholder to understand the challenges and expectations relating to recycling.[44] Faced with a regulatory framework they consider too rigid, users adapt and at times liberate themselves from local composting regulations. A study of the local compost regulations in the Strasbourg inter-municipal authority *(Eurométropole de Strasbourg)* showed that the list of allowed waste differs from one site to another[45]. This may also be observed in the advice given to students in different teaching establishments.

The different types of waste not allowed on certain urban composting sites may be explained by different motives, whether for pragmatic reasons of fast waste sorting, avoiding odors or esthetic nuisance, or aiming at a rather extreme form of "neo-hygienism"[46]. Initial attempts in Lyon to encourage home wormery use revealed these kinds of difficulties, despite personalized support being offered. These experiments were nevertheless able to show the advantages of a composting solution at the foot of apartment buildings, with collection guaranteed by the municipality.

Another major difficulty is the number and duration of administrative procedures to be followed when installing a composter. These are seen as prohibitive. In the city of Lyon, for example, it sometimes takes two years for a composting project to see the light of day[47].

38 Kari Reijula and Tapani Tuomi, "Mycotoxins of Aspergilli: exposure and health effects," *Frontiers in Bioscience* 8 (2003): s232s235.

39 ADEME (Agence de l'Environnement et de la Maîtrise de l'Énergie), "Impact sanitaire et environnemental du compostage domestique," op. cit.

40 Véronique Philippot, "Approche ethnologique de la pratique du compostage collectif citadin. Les vertus éco-citoyennes à l'épreuve de l'enquête," Paris, France, Muséum National d'Histoire Naturelle and AgroParisTech, 2011.

41 Nicolas D'Andrea and Pascal Tozzi, "Jardins collectifs et écoquartiers bordelais : De l'espace cultivé à un habiter durable?" *Norois*, no. 231, September 30, 2014: 6174, doi:10.4000/norois.5087.

42 Aurélie Dumain and Laurence Rocher, "Des pratiques citoyennes en régime industriel : les courts-circuits du compost," *Flux* 108, no. 2 (2017): 22.

43 Véronique Philippot and Sandrine Glatron, "Le compostage collectif urbain à l'épreuve de ses interdits: Enquête sur des sites strasbourgeois," *VertigO* 18, no. 2, September 5, 2018, doi:10.4000/vertigo.20743.

44 Aurélie Dumain and Laurence Rocher, "Des pratiques citoyennes en régime industriel," *op. cit.*

45 Véronique Philippot and Sandrine Glatron, "Le compostage collectif urbain à l'épreuve de ses interdits," *op. cit.*

46 Pascal Tozzi, "Ville durable et marqueurs d'un 'néo-hygiénisme' ? Analyse des discours de projets d'écoquartiers français," *Norois*, no. 227, June 30, 2013: 97113.

47 Aurélie Dumain and Laurence Rocher, "Des pratiques citoyennes en régime industriel," *op. cit.*

DICTIONARY OF COMPOSTING

Anaerobic digestion: another natural treatment method for organic waste. It produces gas that can be converted into energy (biogas) from the biological decomposition of organic matter in anaerobic (zero-oxygen) conditions. Anaerobic digestion mostly involves organic waste that is rich in water: wastewater treatment sludge, grease and matter from pumping out septic tanks and drains, and certain agricultural, agri-food industry and household waste.

Compost (or ripe compost): fertilizer obtained from composting.

Dry material: wood shavings or leaves used in waste composting to obtain an aerated compost.

Humus: the upper layer of soil formed, maintained and enriched by decaying organic matter.

Macroorganisms: living creatures that can be seen with the naked eye.

Microorganisms: microscopic living creatures such as bacteria, viruses and single-celled fungi (yeasts).

Wormery: plastic tanks containing layers of worms, which break down vegetable matter and peelings. It is the only viable composting solution in an apartment.

CONCLUSION

Advocates of the city as a service are currently questioning the content and methods of delivering public services, including through composting. Having previously been washed away in the tide of urban waste, more than a decade ago, biowaste rediscovered its historic route to recovery: composting. Composting offers an important resource for urban agriculture, which is constantly expanding. Public decision-makers and citizens have converged on a decentralized solution that is positive for the environment and enables a return to closer neighborhood social relations based on shared values, while also rationalizing costs for the municipality. The practice of urban composting has already passed beyond the confines of the family garden: education and awareness of composting are becoming more widespread, notably through urban agriculture and increasing public awareness of food production.[48] In this context, it is essential to mobilize scientific expertise, and research programs are currently under way to expedite the composting of new forms of biowaste, especially bioplastics, which are already arriving in composters with best practice yet to be established.[49] We now need to consider future conditions for efficiency and for safeguarding health and the environment.

48 Evelyne Boissonneault, *Sol, terre, compost : quels enjeux pour l'agriculture urbaine ?* Québec, Université du Québec à Montréal, 2017.
Sarah Taylor Lovell, "Multifunctional Urban Agriculture for Sustainable Land Use Planning in the United States," *Sustainability 2*, no. 8, August 4, 2010: 24992522.

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USING ARCHITECTURE TO RECONNECT CITIES WITH NATURE

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"Cloud garden" on the top of Tour D2
©Bechu & Associés

Working with his partners and his daughters Clémence and Aliénor[1], Anthony Bechu runs Bechu & Associés, an architectural firm that delivers projects in France and internationally, including in Russia, China, Morocco and Iraq. Its multi-disciplinary approach draws on the work of engineers, scientists, sociologists, urban planners, landscape and graphic designers as well as interior decorators, in order to create projects in the fields of urbanism, architecture and heritage conservation.

Along with her sister, Clémence Bechu is the fourth generation of the family to continue the story of the firm, which was founded in 1920. As head of Development, her work focuses extensively on innovative approaches and strategic partnerships for research and development and sustainability.

1 Aliénor Bechu is an interior architect and designer. She runs Volume ABC, the firm's interior design branch.

The combination of climate change and massive urbanization makes city ecosystems vulnerable. Faced with this reality, bioclimatic architecture and regenerative planning provide a wealth of tools that include urban agriculture, which is increasingly widespread in the context of growing green value in the real estate sector. Bechu & Associés is an architectural practice that embraces this movement, working with its partners to design parametric modeling tools to improve the sustainability of architectural and urban planning projects. In this process, bio-inspiration plays a key role, by leveraging nature's solutions to design places where climate and culture combine, and where nature repairs the ties that bind cities to the countryside.

Research center project for Climate City - ©Bechu & Associés

Bechu & Associés is passionate about integrating the living world into architecture to repair broken ties between cities and the countryside, particularly through regenerative planning. How does this feed into your architectural practice, and what role does urban farming have as part of this approach?

Anthony Bechu: It is now a commonplace that nature creates value in real estate, as evidenced by the plethora of labels such as BREEAM, LEED and WELL. The new awareness of the green value[2] of real estate assets is a very welcome sign. In March 2018 at MIPIM, the international real estate congress held in Cannes, our firm and 50 or so other professionals signed up to the BiodiverCity charter, created by the International Biodiversity & Property Council (IBPC), signifying our commitment to incorporating living systems into every architectural project. Biodiversity can be introduced into the city in *ad hoc* ways that inspire contemplation, such as open spaces, vacant plots and gardens, but also in a more productive form, such as rooftop greenhouses and collective vegetable gardens. Urban agriculture is a wonderful tool for boosting cities' resilience and sustainability. I'm thinking of things like Parisculteurs, GreenSky or the Fermes de Gally outside Paris, which offer a model for a specialized peri-urban farm able to supply city dwellers with locally grown fruits, vegetables and flowers. Our project portfolio includes the restoration of a former Banville garage, a building we designed 30 years ago. This will include planted roofs and a greenhouse on the top-floor terrace that will be open to the public and will grow supplies for the ground-floor restaurant.

Clémence Bechu: The engagements our firm has made are indicative of the growing awareness, made all the more acute by the climate emergency, that restoring ties between people and natural ecosystems is a real opportunity to innovate and build new models for urban development.

Cities are responsible for 60% of climate change and they are currently suffering its effects as well as the financial, social and health implications. To help cities deal with these issues, Yves Tourre, a climatology researcher at Columbia University,

Tour D2 at La Défense, Paris, 2014 - ©Bechu & Associés

2 "Green value" is the additional value created by a building that delivers better energy and environmental performance than another similar building.

“Cloud garden” on the top of Tour D2 - ©Bechu & Associés

and Laurent Husson, an aerospace specialist, have launched a project called Climate City that we are proud to partner with. The first specialist operator in urban climates, it proposes using drones and climate modeling tools to look at the climate between 150 and 1,500 meters above cities. This approach fills a gap in current climate analysis – the conventional approach for cities is generally meteorological only, and global analyses by expert groups such as the IPCC do not provide any tools to help city policymakers. Data collected by Climate City will make it possible to pinpoint heat islands in a city as well as anticipate pockets of air pollution or flooding, helping to decide the best locations for green spaces as part of cities’ climate plans. We have worked on the design of a research center that will be the headquarters for this initiative, and in a more general sense we work for the emergence of climate-aware urban planning.

Our regenerative planning approach involves not only reintegrating nature into the city, but also reintegrating the city into nature’s core cycles. In common with many other industries, planners and architects can seek inspiration from nature’s circular way of organizing things. Nature works in loops, quite unlike the linear ways humanity has favored, and this applies as much to procurement as to waste management, energy and water cycle. A bottomless wealth of positive interactions makes nature a formidable engineer, so why not copy it!

Urban agriculture is a wonderful tool for boosting cities’ resilience and sustainability

Your approach consists in seeking inspiration in natural morphologies and processes. Can you give a few examples of this bio-inspiration as expressed in architectural projects?

C.B.: Bio-inspiration takes the living world as a model, seeking to use architecture to recreate a relationship with nature. There are two forms of bio-inspiration: biophilia and biomimicry.

Biophilia involves directly or indirectly integrating nature into human installations to create wellbeing. This is the approach we used in 2015 for the project to renovate the Miramar hotel and thalassotherapy center in Arzon, Brittany. We took inspiration from marine ecosystems when structuring the space and creating the interior design. Biophilia can be applied to design using organic forms, and natural materials and colors whose impacts on the quality of life are scientifically proven.

Accommodation district for the Skolkovo Innovation Center, Russia, 2017 - ©Bechu & Associés

Biomimicry, as theorized by the American biologist and author Janine Benyus, is a resolutely scientific approach. Biomimicry involves following the example of organisms and living systems, based on observing their morphology and processes, to develop innovations able to provide answers to contemporary ecological challenges.

A.B.: For Tour D2 (2014), we took an approach halfway between biophilia and biomimicry as part of the renewal plan for the La Défense business district of Paris. The honeycomb exostructure wrapping the tower was based on the organic model of the periosteum membrane that covers bones. This allowed us to use 30% less material with a consequently lower carbon footprint. At the top of the 171-meter tower the “cloud garden” transforms the tower into an allegory for a tree with an island of urban biodiversity where birds have established their nests.

Besides, biomimicry has enabled us to construct buildings with outstanding energy performance in parts of the world with severe climate constraints.

Biomimicry has enabled us to construct buildings with outstanding energy performance in parts of the world with severe climate constraints

For the Skolkovo Innovation Center in Russia (2017), we drew on the social organization of penguins when setting out the ground plan for the district that houses researchers’ families. Working with biologists and using fractals[3] found in nature, we were able to gain 5°C above the outdoor temperature in midwinter at each of the 10 circular plots.

For the Mohamed VI Polytechnic University project currently underway in Laayoune, in Western Sahara, careful study of desert lines and analysis of climate data led us to design a building that is 80% energy passive and whose indoor temperatures will never exceed 26°C in high summer without using air conditioning (apart from inside the main lecture theater). We also developed a wastewater recovery system for spray-cooling the space, in applying principles from the circular economy.

C.B.: These projects demonstrate the relevance of biomimicry. They are first made possible by convictions shared with the developers who are financing the project, and above all, because they are multi-disciplinary collaborations. These are collective creations, made possible thanks to the work of

3 A fractal is a mathematical object, such as a curve or surface, whose structure does not vary with changes in scale. Fractals are commonly observed in nature.

Indoor water spraying for the Mohamed VI Polytechnic University project, Laâyoune, Western Sahara - ©Bechu & Associés

scientists, engineers and consultancies specializing in the environment, parametric modeling and structure. For each project, we set up a team with the range of complementary expertise needed for us to jointly define the structural objectives, obtain the relevant data and generate the algorithms that help us to create our plans. Other actors are also helping to spread the word about this approach among the general public and fellow professionals. One such is Alain Renaudin, founder of Biomim'expo,[4] an annual event that we partner with, which showcases pilot bioclimatic initiatives to private and trade visitors alike.

Facilitating the return of rurality to city centers is our way of making sure that there is a place for everybody at the center of the "village," bridging the gap between history and modernity

Some territories use biomimicry in planning for their future growth. One such is France's Nouvelle-Aquitaine region, whose proximity to the ocean means it is particularly engaged in climate issues. In Biarritz, the Technocité innovation cluster will be home to a marine center of excellence in biomimicry for researchers from IPREM (the Institute of Analytical and Physicochemical Sciences for Materials and the Environment), a CEEBIOS branch (Senlis European Center for Excellence in Biomimicry) and a business incubator. The project is the subject of an architectural competition and our proposal is one of those selected. We adopted an ecosystemic approach inspired by the relationship between ocean and climate. With expert input from climatologist Yves Tourre and Françoise Gaill, who specializes in the biology of abysses, we designed a regenerative building that should qualify for Living Building Challenge certification. This certification, which would be path-breaking in France, imposes among other things 105% energy self-sufficiency (net positive) and full autonomy in terms of water. Just as ascidians filter seawater, our project, which we call *Estran,* filters water from the land. It has a roof that is both active and liquid, a biomimetic ecosystem in its own right that fits into the land and sea systems of its environment. It filters and removes pollution from the water in its environs (from roadways, rainwater and wastewater) for use in the building and it returns to nature the purified water it has no need for. The project also includes an educational pathway and a wetland zone to encourage the site's biodiversity to the fullest. Just as in nature, this project is above all a system that provides services to its neighbors, and vice versa.

4 The 3rd consecutive Biomim'expo will take place on September 11 and October 22, 2019 at the Hotel de Ville and Cité des Sciences et de l'Industrie in Paris.

N.B.: The competition was still under way at the time of writing. The winner will be announced during the August 24-26 meeting of the G7 in Biarritz.

What role do you think rurality and farming can play to reestablish connections between city and nature?

A.B.: Reconciling city with nature requires more than just a scientific approach. We are also striving to heal divisions between the urban and rural worlds, which is an element of the current societal crisis in Europe. In emerging economies, massive urbanization is uprooting people from the ways their lives were previously structured. They have to renounce their long-established practices to live in spaces often designed on the American planning model. This applies particularly in Africa, where megacity planners often overlook all reference to the founding social and cultural models of the African village.

These are issues we are working on in China. In satellite cities[5], we are looking into ways to bring the rural world back into the heart of the city, recreating ties between country- and city-dwellers through landscaping and shared spaces. In Shenyang, capital of Liaoning province and the economic and cultural hub of northern China, we worked with local policymakers on the design of a master plan for an eco-city on a 10-square-kilometer site. For the purposes of this major China-France cooperation project, we highlighted the importance of a regenerative planning approach to remove pollution from sites and create an urban district truly integrated into the rural landscape. We used the Biogée city model we have developed along four guiding principles: hyperconnectivity, mixed-use, energy management, and balanced space management. This is the ideal of a city where farming world and aquatic systems occupy a central place. Moreover, to be sustainable, the city of the future cannot turn its back on its past nor its culture, including its rural past. It must also reflect its history and geography. This is the thrust of the projects in our portfolio in the medieval cities of Pingyao (2008) and Putian (in progress). Located 800 km southwest of Beijing in the province of Shanxi, Pingyao is a UNESCO world heritage site where we have created public spaces that pick up on the idea of the gallery, a traditional Chinese space for socializing and learning. Inspired by feng shui, we have also set out a park crisscrossed by canals in the area around the ancient ramparts that were formerly hidden by industrial clutter. In Putian, a city that has preserved a balance between rural and urban, we are currently working on ways to make best use of the city's fish-farming basins.

Facilitating the return of rurality to city centers is our way of making sure that there is a place for everybody at the center of the "village," bridging the gap between history and modernity. Urban agriculture, by integrating both productive and contemplative green spaces in a city, is part of this process.

5 Satellite cities are smaller cities located near to larger ones.

Master plan for the eco-city of Shenyang, China

2. THE PLURALITY OF URBAN AGRICULTURE MODELS

Observed all over the world since the early 2000s, the revival of urban agriculture takes various forms, from the most technological, practiced in controlled environments, to the most "low tech" ones, such as intensive organic micro-market farming. Equally well implemented in developed as in emerging economies, these different models are suited to a wide range of local contexts, such as community gardens, rooftops and vertical farms.

A great variety of sources of inspiration

Faced with the limits of a conventional agricultural model that is incapable of feeding the future world population without endangering natural resources and consumer health, the heads of urban agriculture projects are exploring new growing methods, drawing as much inspiration from the possibilities of new technology as from the closed-loop operation of natural ecosystems, in a circular economy approach. Following the permaculture approach, the Bec Hellouin farm in Normandy has developed non mechanized farming techniques with no chemical inputs that enable them to produce large quantities from small areas. These techniques are especially well suited to restricted space in cities. Similarly, recirculation aquaculture, such as the one practiced at Lostallo in the Swiss Alps, makes it possible to farm great-quality fish, indoors and with a reduced physical footprint. The economic and environmental performance of this model offer a glimpse of its possible applications in an urban setting.

Many types of urban agriculture

To understand how urban agriculture can really change our production model, it is worth establishing a classification of the different models, highlighting their advantages and disadvantages. This is the task to which the SYSTEMIQ consultancy has committed itself, by distinguishing open-air urban agriculture from agriculture in a controlled environment, which draws on aeroponic, hydroponic and aquaponic techniques.
Although in years to come, controlled-environment agriculture could substantially enhance the food self sufficiency of cities, its high cost is confining it to peri-urban areas and, in the medium term, makes it difficult for developing economies to access. Vertical farming specialist Dickson Despommier also shares this observation – integrated into a circular economic system, these innovations are highly promising in environmental terms, but require technological skills and financial resources that are currently only feasible in developed countries.

On the other hand, outdoor urban agriculture integrates easily with the urban fabric, especially on roofs. It not only presents environmental advantages, but offers other social, educational and psychological benefits. In São Paulo, communal gardens prove to be real laboratories for social innovation. Part of the advent of "edible cities," they contribute more broadly to the construction of a new urban model, based on a democratized management of public space and a better social and environmental balance. However, the productivity of this type of agriculture is not sufficient to sustain food production in any meaningful way or to become commercially viable.

Technological innovations and social and environmental synergies

These two major families of urban (and peri-urban) agriculture are not opposite and can be combined, giving rise to numerous synergies. The BIGH Farming company came up with a hybrid model, implemented in Brussels on the roof of a market hall, which combines the economic solidity of an aquaponic farm (fish farming and horticulture in near-closed circuits) with an outdoor vegetable garden employing people re-entering the job market. This example invites us to imagine innovative business models to maximize the positive impact of an urban farm via a public service offer or co-financing through related commercial operations. In short, the ambition for urban agriculture is not so much to feed the world as to feed cities in a different way.

Mathilde Martin-Moreau,
Lorraine de Jerphanion
and David Ménascé,
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Coordinators

URBAN AGRICULTURE: BOON OR BUST?

Martin Stuchtey
Founder and Managing Partner,
SYSTEMIQ

Tilmann Vahle
Associate,
SYSTEMIQ

Heads of lettuce in Taiwanese controlled-environment farm YesHealth iFarm - ©Association for Vertical Farming

Martin Stuchtey is co-founder and managing partner of SYSTEMIQ, a company focusing on coalition building, co-creation and investment in the transition toward circular industrial systems. Together with Dame Ellen MacArthur, he launched the Circular Economy Initiative at the World Economic Forum, and later initiated the World Bank's 2030 Water Resources Group. He is also Professor for resource strategy and management at the University of Innsbruck, Austria.

Tilmann Vahle has worked on topics of sustainable innovation and environmental resources management in both the public and private sectors. After a two-year consulting experience at EY in Munich, he joined SYSTEMIQ where he has been working on circular economy for food, mobility and energy systems. He holds degrees in environmental management and policy from the University of Lund, Sweden, and in sustainable development and international economy from University College Maastricht.

Agriculture needs a revolution to be able to feed 9 billion people by 2050 within planetary boundaries. Urban agriculture (UA) is heralded as a solution, but can it deliver? To answer this question, different types of UA need to be discussed with their distinct advantages and limitations, particularly differentiating conventional open-air extensive farming from high-yielding Controlled Environment Farming (CEF). The former is too low yielding to support food production in a meaningful way but can enhance community, provide education services, psychological value and improve local environmental conditions – particularly if applied on urban rooftops. This kind of farming is rarely commercially viable but offers significant societal value. Business models could range from being offered as public services to being cross-subsidized through attached commercial operations. Distinct from this, some forms of CEF may provide substantial contributions to food outputs in years to come, as CEF can be expected to grow significantly, driven by inherent efficiency advantages over current food value chains. However, it tends to be highly capital- and knowledge-intensive and will likely develop at the fringes of cities due to economic considerations. As such, it is a form of peri-urban agriculture (PUA) and could become part of a peri-urban circular economy for food.

INTRODUCTION

The green revolution of the 1950s has been one of the greatest successes of humanity: immense gains in agricultural yields have been achieved and it is estimated that half of the world's population is alive as a direct consequence of synthetic fertilizers[1]. Adding the invention of pesticides and antibiotics also allowed us to produce food with a level of output productivity and reliability never previously imagined. Still, by 2050, humanity will need to feed 9 to 10 billion people. This will require expanding food production by about 50% compared to today's levels[2].

However, the global food system is far from "sustainable" and further expanding food production becomes increasingly challenging: few productivity gains are being realized while pressure on fertile land is increasing. We are indeed "mining soil" – at a rate of an estimated 25 billion metric tons per year globally, and since topsoil regenerates only slowly, it is essentially a fossil resource and possibly the only one we cannot substitute. Moreover, climate change is expected to negatively impact yields of key crops such as wheat and rice through warmer climates and add to problems of soil erosion. It may also exacerbate eutrophication, which is already wreaking havoc in ecosystems around the world.

1 Our World in Data (2017). How many people does synthetic fertilizer feed? https://ourworldindata.org/how-many-people-does-synthetic-fertilizer-feed, Accessed April 18, 2019

2 Food and Agriculture Organization of the United Nations (2018). *The future of food and agriculture. Alternative pathways to 2050.* Rome.

In this context, urban agriculture (UA) has been receiving lots of attention in recent years, and is often heralded as a key building block in a sustainable food future. Its proponents highlight benefits of short transportation distances, visions of integrated living and food systems, and community-building opportunities. Additionally, drastically more efficient production and fantastically high yields seem possible. Added to this, claims of opportunities for integrated production and waste disposal solutions, or production of custom-designed foods, are often heard. Could UA offer an answer to all our problems?

CONTEXT: THE CHALLENGE OF FEEDING THE WORLD, A BITE TOO BIG TO CHEW?

Today agriculture uses 70% of all freshwater and 50% of all fertile land and causes around 25% of all man-made CO_2 emissions. It is also linked to catastrophic biodiversity loss especially through land conversion and pesticides. As a result, humanity has extinguished 60% of global species over the last 50 years alone. Agriculture thus contributes substantially to the transgression of at least four of the nine planetary boundaries – those criteria that define a safe operating space for human existence – defined by the Stockholm Resilience Institute. The challenge is to square the human needs of billions of people without irreversibly creating ecosystem conditions that humanity has not seen in all its existence – ones that will most likely be unfit to support our civilization[3].

As pointed out in the report "Cities and the Circular Economy for Food" published by the Ellen MacArthur Foundation and SYSTEMIQ in early 2019, currently the global food system creates societal costs of an estimated $5.7 trillion annually – or two dollars for each dollar spent on food[4]. Of these costs, $1.6 trillion are due to production-related health issues: $200 billion from air pollution caused by agriculture (an estimated 20% of particulate ambient air pollution, causing 3.3 million premature deaths per year, comes from agriculture). Exposure to pesticides creates social costs of an estimated $0.9 trillion, $150 billion of which in the EU alone. Overuse and poor management of antibiotics in the food system contributes significantly to antimicrobial resistance, causing an estimated $300 billion of damage in lives lost and additional healthcare. In particular, this last issue is set to increase drastically if no action is taken.

Clearly, just optimizing the current "food system" – ranging from production of inputs through farming, distribution, processing and consumption to managing waste – will be insufficient to surmount these challenges. There will not be one single way to solve these problems. We will need to both drastically improve our current ways and develop new ones. A new agricultural revolution is needed, creating in effect a regenerative, circular economy of food – one where production is compatible with healthy natural systems, where waste and pollution are designed out, and materials are used optimally.

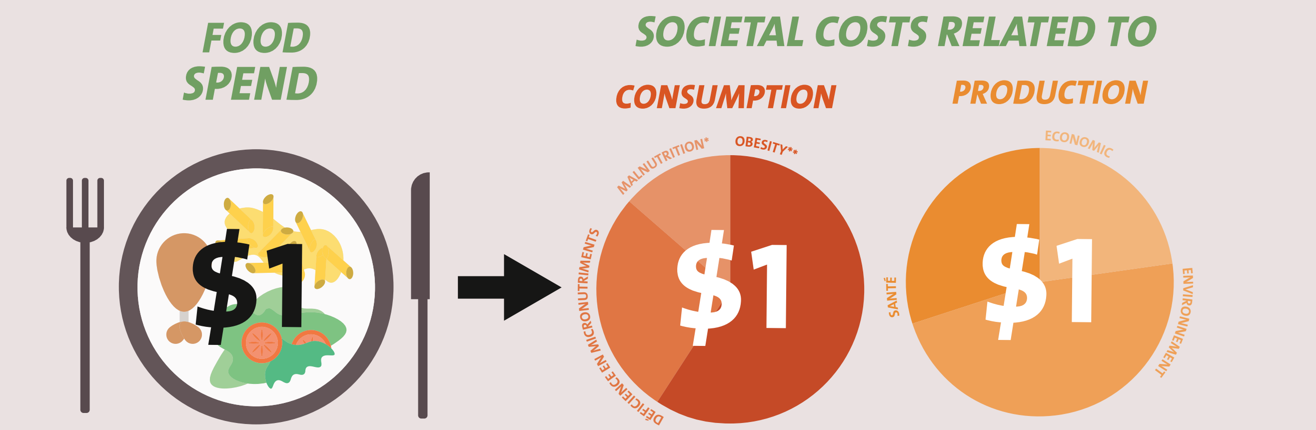
Yet many well-intended efforts to make farming more benign have proven to be less than successful by various metrics. In fact, recent meta-studies investigating effects of organic farming paint a mixed picture at best of its environmental footprints[5]. In the meantime, more symbiotic ways of farming are being explored, ranging

3 EAT-Lancet Commission on Healthy Diets From Sustainable Food Systems (2019). *Healthy diets from sustainable food systems*

4 Ellen MacArthur Foundation (2019). *Cities and the Circular Economy for food*

5 Clark, M., and Tilman, D. (2017). Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. *Environmental Research Letter 12*

Total costs of the global food system as per the Ellen MacArthur Foundation (2019)



*Excluding obesity; **Due to diet
Based on *Cities and Circular Economy for Food* analysis – for details see Technical Appendix.
Source: https://www.ellenmacarthurfoundation.org/assets/downloads/Cities-and-Circular-Economy-for-Food_280119.pdf

Figure 1

from conservation and regenerative agriculture to agroecological and syntrophic farming approaches. While showing enormous potential, such concepts are yet to be defined and studied thoroughly. So far it seems that their success is highly context-specific and often fails to transfer or scale. Taking them to mass market has suffered from ideological debates in the past. Clearly, more work is to be done to unlock alternative farming practices' potential for the food system at large.

URBAN AGRICULTURE – HYPE ONLY?

Among those alternative practices, UA appears more hype than truly disruptive at closer inspection. As far as data goes, there is little reliable evidence that farming in cities represents a significant contribution toward global food needs. There have been claims that UA is practiced by over 800 million people and provides up to one-fifth of the world's food. However, the bulk of the empirical evidence for such claims dates back to estimates from the early 1990s, and refers mostly to conventional small-holder, backyard farming[6]. Not only has the world changed dramatically since then, with likely only a few residents of Beijing or Delhi still growing a significant part of their own food, it would also appear that there are significant downsides to such farming practices (such as soil contamination and poor efficiency) with limits to scaling them meaningfully.

More recent estimates of the potential of UA are much more modest. One recent study estimates its maximum potential global contribution to food production at around 1-3% of global annual food production[7]. SYSTEMIQ's own estimates directionally confirm this, although our analyses indicate that this mostly consists of vegetables.

Vegetables, as important as they are for a healthy diet and long-term health, are not what feeds the world: proteins and calories are also urgently needed. But due to lower yields these are simply not profitable to produce in an urban environment. In the case of animal protein, beyond sheer cost considerations, there are other good reasons for moving production away from human settlements. These include hygiene, logistics and nuisance from odors and noise.

In the majority of cities, it may be difficult to secure the amount of land needed for substantial urban farming at reasonable prices. It would be hard to envision plots of vacant land large enough to sustain farming on a meaningful scale in a medieval Italian city, or a sprawling megacity in an economy in transition. Furthermore, due to local regulations like zoning laws, legal concerns including ownership and hygiene regulation, and competition for uses, even small areas may be difficult to secure in many cities.

6 Smit (1996). Urban agriculture, progress and prospect: 1975–2005. The Urban Agriculture Network (TUAN). Cities Feeding People Series, Report 18

7 Clinton et al. (2018). A Global Geospatial Ecosystem Services Estimate of Urban Agriculture. *Earth's Future*, AGU100.

CO_2 emissions of the EU food system: shares of the value chain steps. Logistics contribute only marginally

*including fertilizer inputs
Source: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC96121/ldna27247enn.pdf

Figure 2

Lastly, UA has been heralded as a solution to many environmental problems related to food. In particular, shorter transportation distances have been associated with lower carbon footprint, food packaging and food wastage. There seems to be evidence that, particularly for perishable goods like watery vegetables, less produce goes to waste if grown near its point of consumption. However, since produce still needs to be transported, a significant reduction in packaging should not be expected through more local production. And finally, since only a minor share of the carbon footprint of foodstuffs is due to transportation, the proximity argument appears to be largely moot: according to some studies, in the European Union, only around 5% of CO_2 equivalent emissions in the food system stem from transportation activities, while two-thirds come from agricultural processes themselves[8].
So, the appeal of UA appears to be spoilt. Or is it?

URBAN AGRICULTURE: NOT FEEDING THE WORLD BUT NOURISHING CITIES DIFFERENTLY

Maybe the question needs to be phrased differently. What if focusing on yield constraints and satisfying people's hunger from UA misses the point? What if urban agriculture was less about feeding cities, and more about nourishing them in different ways by improving urban environmental quality, enhancing climate resilience, and providing community spaces.

There are nowadays different types of food production that have been discussed in the context of UA, each of which has vastly different properties and as such must be viewed distinctly:

- Expansive urban agriculture (including backyard and rooftop farming)

8 European Commission Joint Research Center (2015). Energy use in the EU food sector: State of play and opportunities for improvement. *JRC Science and Policy Report.*

- Covered urban agriculture (greenhouses, including rooftops)
- High tech vertical and indoor farming (including container and warehouse farms)
- Aquafarming (controlled environment fish production)
- Aquaponics (combining fish rearing with one of the above for symbiotic effects)
- Insect farming (growing insect protein based on biomass, including potentially biowastes)
- Molecular agriculture (lab-grown meat and microbial production of essential components such as oils, vitamins and protein).

We propose here that only the first one, expansive UA, will have a significant role to play in cities (and to an extent its close cousin, covered UA), but through environmental and social services rather than food production. All other forms listed, while likely set for exponential growth due to economic drivers, would naturally gravitate toward the fringes of cities and thus constitute forms of peri-urban, rather than urban, agriculture. Instead, discussing them under the umbrella of "controlled environment farming" (CEF) is advisable to clarify the discussion. We will argue why.

On a theoretical level, this argument conforms with the model of the Isolated State formulated in 1826 by agronomist Johann Heinrich von Thünen. In this model, agricultural activities are located around a theoretical city in concentric rings. Each commodity's distance to the urban center is determined by profitability of production. Input variables include land prices, production and transportation costs, and sales prices. This simple model shows that while vegetable farming can be profitable near cities, animal husbandry and crop farming are only feasible further away[9].

Clearly, this simple model does not describe reality in its complexity. Also, conditions have changed dramatically since the time of von Thünen's writing, particularly due to huge reductions in transportation costs and the invention of refrigeration. Most recently, efficient lighting that enables indoor plant growing further changed the equation. Still, one key variable remains unchanged: the cost of land. In most cases, the marginal added benefit of shortening food transportation distances by placing production within cities will not justify the substantial premium that is placed on space. Considering the razor-thin margin most farmers operate on today, only vacant lots could qualify temporarily for UA. This can be observed in the USA where UA experienced a revival only after the real-estate crisis of the 2000s. That von Thünen's thinking is still up to date is exemplified by the work of the Amsterdam Institute AMS. When designing food systems for the Almere planned city, the institute explicitly referred to the principles of the von Thünen model.

Even for the highest-yielding forms of CEF, this rule holds; also, even those efficient modes of production would need logistics for inputs, intermediaries (e.g., packaging) and delivering outputs. Given the complexity of urban logistics, this is another argument against placing CEF in cities. Lastly, such capital-intensive operations benefit especially from economies of scale, something that is challenged almost by definition in dense urban centers. Questions of regulation such as zoning would add to commercialization costs. Only the most sought-after and most perishable products would ever justify this additional effort. So, while high-end restaurants may grow their own micro-greens in the future, it is unlikely that you will buy your potatoes from a container farm behind your apartment complex.

At the same time, both expansive and covered forms of UA tend to be low yielding and labor intensive, a far cry from highly optimized large-scale farming. As such, they would not be able to compete on price for food crops. But UA has additional benefits to providing food, including social and environmental services. If placed on rooftops, UA can reduce the climatization needs of buildings in a similar way to green roofs. Studies have found significant reduction of cooling needs in summer and heating needs in winter. Like green areas and extensive green roofs, UA can help reduce the urban heat island effect, and reduce stormwater run-off by between 60 and 100%. It can thereby retain water, improve the local microclimate and make cities more resilient to extreme weather events. In a reality of accelerating climate change, such functions will increasingly be vital for urban living. Areas of UA can also absorb and neutralize air pollutants, improving urban air quality[10]. Given that outdoor air pollution is listed among the top five contributors to the global burden of disease[11], this is no small feat.

The Von Thünen model, simplified: costs of land increasing with proximity to the city

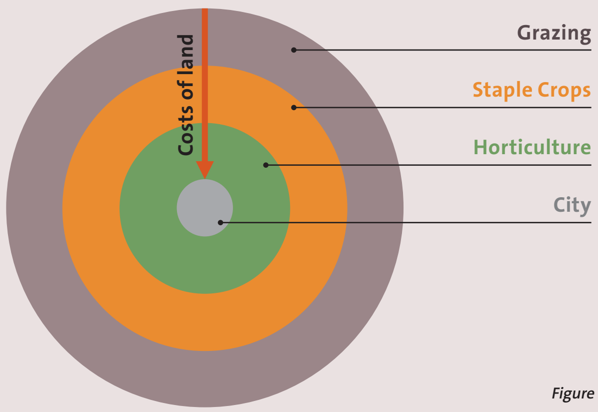


Figure 3

9 See for example: O'Kelly, M. and Bryan, D. (1996). Agricultural location theory: von Thünen's contribution to economic geography. *Progress in Human Geography 20*, 4

10 Michigan State University (2019). Benefits of Green Roofs. http://www.greenroof.hrt.msu.edu/benefits/index.html, Accessed April 18, 2019

11 Institute for Health Metrics and Evaluation (2018). Findings from the Global Burden of Disease Study 2017. Seattle. http://www.healthdata.org/sites/default/files/files/policy_report/2019/GBD_2017_Booklet.pdf

A last (but by no means least) ecosystem service relates to insects and pollinators. As insect populations have dropped by up to 40% over the last 50 years across the world[12], UA could throw a lifeline to these vital parts of our ecosystems (as part of larger and decisive action to protect biodiversity). In sum, UA can provide several valuable ecosystem services in urban centers that help build healthy cities.

The same study that found potential global UA food production of up to 1–3% of global food outputs per year estimates the value of ecosystem services of urban farming: by the authors' estimates, global urban vegetation suitable for urban agriculture is estimated as being worth $33 billion per year in total. This includes energy savings of up to 15 billion kWh, nitrogen sequestration of up to 170,000 metric tons, and avoided stormwater run-off of up to 57 billion cubic meters. In a scenario of "intense UA implementation," these services plus pollination, climate regulation, soil formation, and biological control of pests could be worth $80 billion to $160 billion annually[13].

An equally important benefit of UA may be of a social and psychological nature: shared gardens are an opportunity for local community building and creating a sense of purpose and belonging to neighborhoods. In some Chinese cities, UA is being used as a means to soften the cultural and emotional transition from a predominantly rural to highly urbanized society. This helps to create or perpetuate narratives of cultural continuity and equality between rural and urban areas. As such, UA can contribute to maintaining or strengthening social fabric. Additionally, UA can function as a platform for intergenerational exchange to foster cultural heritage and inclusion of the elderly. Meanwhile it can provide opportunities for non-market employment. For the large swaths of people that are expected to be pushed out of structured labor by automation, this may become increasingly important.

UA can also be used as an educational tool for schoolchildren and adults alike. It can thereby support understanding of natural systems and increase support for environmental policy in the long term. A greater appreciation of how food is grown might help incentivize people to lower food wastage (although arguably also risking conveying a somewhat romantic picture of agriculture).

Lastly, there is extensive evidence for the psychological benefits of both green spaces and outdoor recreational activities, both of which UA can contribute to. While applicable to the wider population, in some cases this is even being used in therapeutic approaches. In Japan, "forest bathing" has been part of the official national health program for decades due to its proven benefits to health. In some cities, such as Guelph, Ontario, so-called "healing gardens" are used to help former cancer patients to recover from their illness and treatment.

As argued above, rarely would expansive UA be profitable through food production. Integrating other functions into an urban environment – such as using UA as meeting space or event location – could help finance it, but even then it would likely operate on a narrow margin. As such, UA must likely either be operated for specific applications, such as the healing gardens of Guelph, or as an entirely non-commercial community-driven project.

One more way that UA can support business is what has been dubbed the so-called "shower head approach" in China. After the boom of shopping malls in many Chinese cities, much like in the west, online shopping has been putting pressure on retail in the Middle Empire. Creating green, recreational spaces on roofs provides those businesses with a way to incentivize people to visit. After being conveniently shuttled onto the roof, people are funneled through the shops floor by floor, with the hope that their hunger for shopping can be stirred; it's a modern form of trickle-down economics that might actually work. As such, UA is cross-subsidized by increased sales revenues from attached shops, and co-financed through integrated restaurants, cafés and the occasional gardening class. Food production has become a side element.

Given their potential for ecosystem and social value creation, UA facilities could also be considered a public service and as such be (co-)financed through public funds. However, being dependent on public funds and policy limits the scalability of UA. If negative externalities such as air or noise pollution were priced into other economic activities, further private investments could be attracted. However, a key prerequisite would be a widely accepted way of assessing UA's environmental and/or social value creation. One framework that proposes such a multi-capital assessment is that of Circular Economy. As such, a Circular Economy for Food could help promote UA.

One framework that proposes such a multi-capital assessment is that of Circular Economy. As such, a Circular Economy for Food could help promote UA

CONTROLLED ENVIRONMENT FARMING: NOT URBAN BUT SET TO GROW AND IMPACT

In contrast to the UA approaches described above, CEF-like vertical farming, aquaponics and molecular agriculture are conducted indoors and under controlled conditions separated from the outside world. Consequently, they do not require natural sunlight nor fertile soils, making it possible to implement them within buildings or even underground. They are highly input efficient and

12 Sánchez-Bayo, F., and Wyckhuys, K.A.G. (2019). Worldwide decline of the entomofauna: A review of its drivers. *Biological Conservation 232*

13 Clinton et al. (2018). A Global Geospatial Ecosystem Services Estimate of Urban Agriculture. *Earth's Future*, AGU100

City Garden farm on the rooftop of Jinqao shopping mall in Shangai - ©Nannan Dong, Tongji University

high yielding, setting them apart from "conventional" urban farming. Accordingly, they provide little to no environmental and social services.

CEF is becoming possible principally due to recent technological innovations like LED lighting, cheap sensors and machine learning. As such, various types of CEF have received significant attention in recent years. Corporations including German and Dutch lighting producers Osram and Philips dedicate divisions to their development and scaling. Venture capitalists and investors have started paying attention, too. For example, in 2018 U.S.-based vertical farming operator Plenty secured $200 million of venture capital and the backing of Amazon founder Jeff Bezos[14].

However, as argued above, such practices should not in fact be considered urban agriculture. Not only do they have, by design, little interaction with their surroundings and as such are not dependent on their location being urban, but also, at commercial scale there is little incentive to place these types of food production in urban centers due to costs of space and logistics. Locating those facilities in proximity to cities at logistically efficient locations makes more sense economically, allowing them to service nearby consumption centers flexibly. Therefore they could be categorized as peri-urban agricultural solutions (PUA). So discussing CEF under the umbrella of UA appears misleading and to the detriment of optimal support for both UA and CEF/PUA.

One reason for the hype and mixing of CEF and UA may be the possibility of placing container farms in nearly any location, making them icons of the technological developments of CEF in recent years. However, once technology continues to mature, they will likely remain a niche phenomenon or laboratory-type test beds due to limited economies of scale, as controlling units and climate control are key cost factors in high tech agriculture. Costs per unit of harvested vegetable have been estimated at four to ten times higher in container farms than conventional greenhouse farming, which can be expected to limit their commercial viability in the long term.

At the same time, CEF has the potential to significantly alleviate the ecosystem pressure compared to conventional farming. An industry-commissioned study conducted by KPMG, a management consulting firm, finds net positive socioeconomic effects of indoor vertical farming of €322 million annually compared to conventional farming for lettuce in New York City. These benefits are composed of substantially higher yields, 98% water saving, 23% reduced food losses and 60% reduced fertilizer needs. Additionally, 99% lower land usage and 7,000 metric tons of CO_2 emissions avoided are monetized in the study. Benefits are counteracted through economic losses from reduced job creation[15].

However, water, land and nutrient efficiency are not key differentiators in all regions of the world. Conversely, the comparatively high energy needs of CEF have raised criticism (and caused economic troubles). In fact, like-for-like energy demand of CEF has been found to be up to 10 times higher than that of greenhouses, and multiple factors higher than that of outdoor agriculture. Consequently, the use of renewable and other low-carbon energy sources like waste heat is paramount to rein in the carbon footprint of CEF.

Currently, the bulk of usual agricultural climate impacts do not stem from direct energy consumption. Rather, what dominates the CO_2 footprint are N_2O emissions from biochemical soil processes, land conversion, and upstream energy inputs particularly in fertilizer production. This last one alone contributes at least 3% of global CO_2 equivalent (CO_2e), as it is based on the energy-intensive Haber-Bosch process[16]. If, however, CEF were conducted with carbon-neutral energy sources, its reduced footprint of other sources of CO_2e could render it more climate friendly than conventional farming.

While the climate impact of CEF is therefore manageable and can indeed be positive, costs may not be. Since a lot of technical development is still taking place in the field, CEF is very capital and knowledge intensive. As a consequence, few CEF companies have been able to sustain operations for long. Those are typically able to offset the high capital and energy intensity with superior benefits tailored to local conditions. These include extreme climatic conditions (such as in desert climates in the UAE), unusually cheap energy (such as in Iceland with virtually free heat and electricity), or exceptionally high premium on space (such as Tokyo or New York City). In all those places named, successful CEF have been operational. For example, Tokyo-based

14 Bloomberg Technology (2017). SoftBank Vision Fund Leads $200 Million Bet on Indoor Farms. By Selina Wang, July 19, 2019. https://www.bloomberg.com/news/articles/2017-07-19/softbank-s-vision-fund-leads-200-million-bet-on-indoor-farming, Accessed April 18, 2019

15 OSRAM (2018). The value proposition. https://www.osram-group.com/en/innovation/value-proposition, Accessed April 18, 2019

16 Zhang, S. (2017). A chemical reaction revolutionized farming 100 years ago. Now it needs to go. *Wired magazine*, Science. https://www.wired.com/2016/05/chemical-reaction-revolutionized-farming-100-years-ago-now-needs-go/, Accessed April 18, 2019

Innovatus has been delivering 12,000 heads of lettuce per day from the fringe of the city into its urban center since 2015.

Business models for vertical farms remain nascent and risky for the time being, with more economies of scale and both technical and agronomical learning to be done before a wider range of produce becomes economical

While in principle most vegetables and pulses are amenable to CEF, companies have so far focused on highly perishable, high-value produce such as leafy greens, herbs, and some berries (and marijuana). Reasons for this include short growth cycles, with some CEF operators claiming to achieve up to 60 harvest cycles per year. Those lead to low specific energy requirements, rapid adaptability to demand and lower risks of contamination or pests damaging the crop. Moreover, losses are minimized should something go wrong along the way: one spoilt harvest due to pests or poorly adjusted inputs is less of a risk if your crop takes only a week to grow. Other favorable conditions are that, with leafy vegetables, large parts of the crop can be sold, the high market value of the produce and big potential in efficiency gains compared to conventional methods.

This suggests that business models for vertical farms remain nascent and risky for the time being, with more economies of scale and both technical and agronomical learning to be done before a wider range of produce becomes economical. Whether inherent advantages can be economically sustained for crops where a smaller fraction of the plant can be sold as food remains to be seen.

For insect farming, moving from small-scale, labor-intensive operations to large-scale industrial production proves difficult as well. Not unlike animal breeding, insect farmers need to consider the health of their breed and optimize systems accordingly. For scaling and commercialization, still more development is needed. This type of CEF may be the most compatible with the philosophy of circular economy, as insects such as crickets and black soldier fly larvae can be raised on a broad range of organic feedstocks including biowastes. This is also its key economic advantage: being able to utilize low-cost feedstock or even be paid for disposal can add to its bottom line.

Aquaponics, meanwhile, could provide a highly input-efficient mode of fish production. For those systems, symbiotic effects of plant and fish production in a closed loop system promise multiple benefits regarding water purification, feed and fertilizer inputs and multiple revenue sources. What sounds good on paper often leads to challenges in real life: the comparatively high complexity of such systems can lead to unfavorable economics much as for hybrid vehicles. Price premiums for guaranteed zero-contamination, zero-antibiotic fish might be able to offset those downsides.

Lastly, of all the solutions discussed, molecular agriculture might deliver the largest impacts in all dimensions of sustainability if it replaces beef and fish meal. Those solutions are the most nascent, in many cases barely beyond laboratory status. Consequently, costs are still high. For example, Maastricht-based Mosa Meat – the company that famously produced the first stem-cell-based burger for an infamous €250,000 – aims to commercialize its product at a price nine times that of its conventional equivalent. In the long run, however, the company expects production costs to drop below those of livestock meat. They base this on the belief in economies of scale and substantial upstream efficiency advantages compared to conventional beef production. Given the obscene inefficiencies in producing beef today, this prediction seems credible. Whether other, more trophically efficient types of meat like pork or chicken could be replaced by cultured meat in an economically and environmentally meaningful fashion remains to be seen.

In summary, the various forms of CEF promise a range of benefits compared to current production methods but, in most cases, still lack the maturity or economics to penetrate the mass market. For the foreseeable future, major hurdles include energy requirements and capital costs. The associated cost penalty may be offset in the medium term by substantial efficiency advantages, additional revenue streams and premiums for better ecological and health performance compared to conventional produce. The extensive use of waste and renewable energies is a *sine qua non* for this scenario, but in itself could enable an abundance of food once further cost reductions for renewable energies are realized as expected. That way, various types of CEF can be expected to grow significantly over the decades to come and, as opposed to UA, contribute meaningfully to global food supplies.

CEF conceptualized as part of a peri-urban food system, reconnecting cities with their surroundings

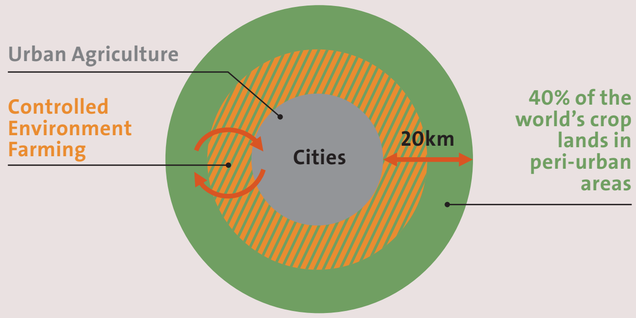


Figure 4

Exhibition of the Taiwanese YesHealth Farm model
© Association for Vertical Farming

GOING FULL CIRCLE. CONNECTING URBAN AND PERI-URBAN AGRICULTURE IN A CIRCULAR ECONOMY FOR FOOD

Already today, 40% of all cropland is located within 20 km of cities[17], largely due to the historical location of cities in fertile lands. This means that a large share of value added in the agricultural sector takes place here. Consequently, this needs to be considered when promoting UA. As cities sprawl, these croplands are the first to be threatened by land conversion, putting local communities and fertile soils at risk. At the same time, urbanization has led to an increase in the urban-rural dichotomy regarding income along with cultural attractiveness. By becoming part of this peri-urban agricultural landscape, CEF could help reconnect peri-urban communities with urban centers culturally, through material flows, and economically. While providing fresh produce for cities nearby, it could provide income to those peri-urban areas that have been under economic pressure for years. By using inputs much more efficiently, CEF could also benefit urbanites by lowering agriculture's impacts on air and water quality, as well as relieving freshwater stress. CEF projects could also recycle and upcycle nutrients from urban organic waste flows and thus contribute to a more productive, circular use of organic matter.

Until now this has remained unprofitable in most cases, and no regulated market exists for the resulting fertilizer products. Lacking clear standards and labels, it is difficult for (potential) producers to demand the premium they would require to offset the additional costs[18]. Given this lack of standardized market and limited experience with such innovative fertilizer products, using them constitutes additional costs and risks to CEF operators. Thus, upcycling of nutrients needs to be developed separately so that standardized controlled quality is available. Once this is achieved, the high levels of purity – for example, in recovered phosphorus fertilizers – would suit the selling points of CEF (guaranteed low contamination, environmentally friendly) and justify premium prices. This would support the creation of a more symbiotic relationship between cities and their surroundings – a peri-urban circular economy for food.

17 Ellen MacArthur Foundation (2019). *Cities and the Circular Economy for food*

18 Yara (2019). Veolia and Yara partner to propel European circular economy. https://www.yara.com/corporate-releases/veolia-and-yara-partner-to-propel-european-circular-economy/, Accessed April 19, 2019

CONCLUSION: FAST FORWARD TO 2039. A FUTURE-PROOF CIRCULAR FOOD SYSTEM BASED ON URBAN COMMUNITY FARMING AND PERI-URBAN HIGH-TECH AGRICULTURE

In a world experiencing ever more regular and more extreme climate shocks, where many ecosystems have become unstable due to rapid biodiversity decline, high-tech and regenerative agriculture have been boosted by governments and business alike. Agricultural inputs are used more efficiently than was the case in the 2020s, thanks to precise live measurements and largely automatized farming methods. Deep agronomic understanding helps to use natural and mechanical remedies for pest control, having rendered synthetic pesticide use all but obsolete. Governments put high premiums on protective measures for the remaining flora and fauna, while land grab has been largely stopped at least in the developed countries like the EU, Indonesia and China by means of draconian penalties for infringements.

In cities, many rooftops and open spaces are used as means to grow vegetables locally while providing recreational space, and to buffer the rare but intense rainstorms and to reduce temperatures in the scorching hot summers. Children learn about the history of natural ecosystems and past farming practices here. Starting from elementary school, they are educated about the reasons for moving away from the inefficient, environmentally destructive and morally problematic ways of producing meat in the early 21st century. Luckily, after becoming mostly uneconomical compared to novel production methods, such practices lost economic importance and thereby political support; ultimately, they were outlawed. Nowadays, most meat products are grown in-vitro and printed from substrate to the specifications of the consumer. Only subsistence farmers and the most affluent eat meat produced through slaughter or hunting.

Fish, on the other hand, are produced indoors at industrial scale. While ethical concerns about this are being discussed in public, the consensus is that it is the far better alternative to the deep sea fishing that almost led to oceanic ecosystem collapse. Insect farms provide high-quality protein to the fish farms, all the while converting by-products from agricultural activities into valuable plant nutrients.

Meanwhile, most vegetables are being grown in large automated facilities on the outskirts of the cities. They are produced on demand and delivered same day to people's doorsteps. The few inputs they require are provided largely from urban waste streams, ranging from water to substrate and vital plant nutrients.

This retraction of agricultural activity from natural ecosystems into controlled environments has thus helped fill the gap to feed the world population and stop ecosystem collapse – just about.

VERTICAL FARMS, BUILDING A VIABLE INDOOR FARMING MODEL FOR CITIES

Dickson Despommier
Professor Emeritus of Public and Environmental Health,
Columbia University in the City of New York

Automated vertical farm Techno Farm Keihanna, capable of producing 30,000 heads of lettuce per day in Kyoto, Japan - ©Spread

Dickson Despommier is an Emeritus Professor of microbiology and Public and Environmental Health at Columbia University (New York City, USA). After conducting research on ecology and intracellular parasitism, he has developed the concept of vertical farming since 1999 with graduate students in his medical ecology class. He is the author of the 2010 book *The Vertical Farm: feeding the world in the 21st Century.*

The number of vertical farms has grown to several hundred farms across Asia, Europe, and North America since the first appeared back in 2010. Using different types of technologies, vertical farms are a new type of Controlled Environment Agriculture (CEA) that could be described as a stack of greenhouses on top of each other, multiplying the plant yield by the number of floors comprising the vertical farm. It has now become a solution to most of the issues deriving from traditional outdoor farming: by occupying less land, it can contribute to the restoration of forests and by operating within a circular economy framework, it uses fewer resources and reuses organic waste. Impacts on health could also be significant as outdoor farming contributes to the spread of global infectious diseases. While vertical farms require a high-tech environment, which can mostly be acquired in wealthy countries, the model could rise in the coming years as a viable solution to increase food sufficiency of cities across the world with the support of local authorities and international organizations, as well as with the multiplication of large commercial growers.

You have been working for several years on the concept of vertical farming. Could you elaborate on what qualifies as a "vertical farm"? Do different types of vertical farms exist?

Dickson Despommier: Vertical farms are a type of Controlled Environment Agriculture (CEA). CEA strategies are far from new, as they emerged in the 1700s. They have traditionally taken the form of greenhouses, which have greatly contributed to the global food supply over the last decades. Vertical farms differ from greenhouses in terms of their height. Indeed, a vertical farm can be simply perceived as a stack of greenhouses on top of each other. Therefore, for the same amount of ground space used, the plant yield is multiplied by the number of floors of the vertical farm. The higher the vertical farm, the more produce it yields, albeit with the same footprint. Consequently, they are now capable of producing millions of tons every year.

Vertical farms mainly differ amongst each other in terms of the technological methods used to grow edible plants indoors.

- **(1)** The first one, hydroponics, consists of growing plants on a neutral and inert substrate (e.g. sand, clay, and rock material), which is regularly irrigated by a liquid fortified with minerals and nutrients that are necessary to sustain plant growth. Hydroponic systems use 60-70% less water than traditional outdoor agriculture. They are widely employed by hundreds of thousands of commercial greenhouses and vertical farms throughout the world.
- **(2)** The second process of vertical farming is aeroponics, through which plants are grown without the use of any soil (or soil replacement): their roots, hanging down in the air inside a closed container, are exposed to a fine mist of nutrient-laden water, regularly sprayed through a nozzle. While this is a relatively new method for growing edible plants – it was first developed in 1983 – it is increasingly employed by commercial vertical farms such as Aerofarms and Tower Garden in the US.
- **(3)** Finally, a hybrid method, aquaponics, integrates fish production into the hydroponic growing scheme. More precisely, it uses fish waste as a nutrient source for the plants after treatment, operating as a closed loop ecosystem for indoor farming. However, this system's complexity and high cost hinder its widespread use. The former two methods are the most common forms of CEA.

Is there a particular model of vertical farming you perceive as more optimal for the future than others?

D.D.: In terms of methods, aeroponics has two advantages in comparison to hydroponics: it uses approximately 70% less freshwater, and aeration of the nutrient solution is unnecessary through this technology so that the system becomes more profitable and easier to monitor. Aeroponics is a more efficient process of vertical farming. Nevertheless, farmers using aeroponic systems have faced a challenge for some time: the nozzle used to spread the nutrient-enriched water mist used to clog regularly. However, Shanghai-based AEssenceGrows developed a nozzle design that would not clog when delivering water to aeroponic plants, improving the reliability of the mist system. AEssence today supplies an in-house engineered patented aeroponic system which allows vertical farms to grow numerous kinds of produce.

But besides the technological aspect, to be promising and sustainable, the business model of an urban vertical farm should be viable. For instance, Infarm offers a high-potential commercial design for vertical farms. Infarm, for which I consult, is a startup created in 2013 in Germany that has now expanded to several European countries and has over 200 employees. It designs high-tech indoor gardens in supermarkets produce aisles employing hydroponic systems and a biomimicry design for its growing-trays, which are stacked vertically and housed in a protected environment. The Infarm app monitors all aspects of grow technology, such as pH levels. Supermarkets such as Metro have partnered with Infarm to build small-scale LED-powered grow modules in their stores so that consumers can themselves pick the fresh vegetables they want to consume, albeit these are more expensive and hence tend to be purchased by the upper middle class.

Together, AEssence and Infarm are good examples of start-ups providing an extremely strong growing system for urban settings, both technically and commercially.

What factors have contributed to the emergence of vertical farms, historically and geographically?

D.D.: As far as I am aware, the first vertical farm appeared in Japan in 2010. Rather than a commercial enterprise, it was established as an experimental farm at Chiba University by Dr. Kozai and his research team. Following the 2011 earthquake, tsunami and nuclear crisis, 5% of the farming in Japan was destroyed or unusable due to saltwater and nuclear contamination. The government made a public call for a solution, and Dr. Kozai suggested his vertical farming model which grows food in a controlled, safe indoor environment, clean from contaminated water or soil. The Japanese government started to provide widespread support to vertical farms and their numbers have greatly increased. As of 2018, there are several hundred commercial vertical farms operating throughout Japan's islands, such as Spread Co. Particularly easy to grow in this sort of setting, leafy green vegetables, became a key element of the Japanese food habits.

The second country to engage in vertical farming was South Korea. It started with an experimental seed bank complex based in Suwan and then expanded to provide agricultural training so that people could replicate the model themselves. This has resulted in a strong industry that has spread throughout the country.

The third known case of vertical farming was a 3-story building in the old meatpacking district of Chicago. Each story grew a particular kind of product: fish, mixed greens, and fish foods and barley. This initiative, which started in 2013, was fully dedicated to educational purposes.

Since then, a large number of vertical farms have mushroomed across the world. They doubled in one year, and since then have been experiencing incredibly rapid growth. Over the next five to ten years, the number of vertical farms has the potential to increase at a geometric rather than at an arithmetic rate. That means that vertical farming is on the way to become a common feature of city landscapes and that cities will have the capacity to produce significant quantities of food for more than 60% of the urban population.

I would explain this recent development through two main factors:

- The first **(1)** is that the time for innovation in urban agriculture is right. Indeed, although the idea of a vertical farm might have been developed several years before 2010, it may not have gained the attention necessary for its survival and expansion. However, the market today is receptive to vertical farms, driving its success.
- This is enhanced by a second factor: **(2)** rapid climate change. It should not come as a surprise that the number of vertical farms is evolving at a similar pace to anthropogenic climate changes. Planners of vertical farms are motivated by the realization that the earth's environment and climate are being disturbed by current modes of food production so that innovative ways to grow food are necessary. At the other end, environmentally-aware consumers and citizens welcome vertically farmed products into their food consumption habits. As the climate continues to be disrupted, populations continue to multiply, and cities continue to expand – all of which are unlikely to slow down – food production and consumption are forced to assume new and more sustainable patterns, in which vertical farming plays a central role. Thus, vertical farming is expected to continue expanding and scaling across the world.

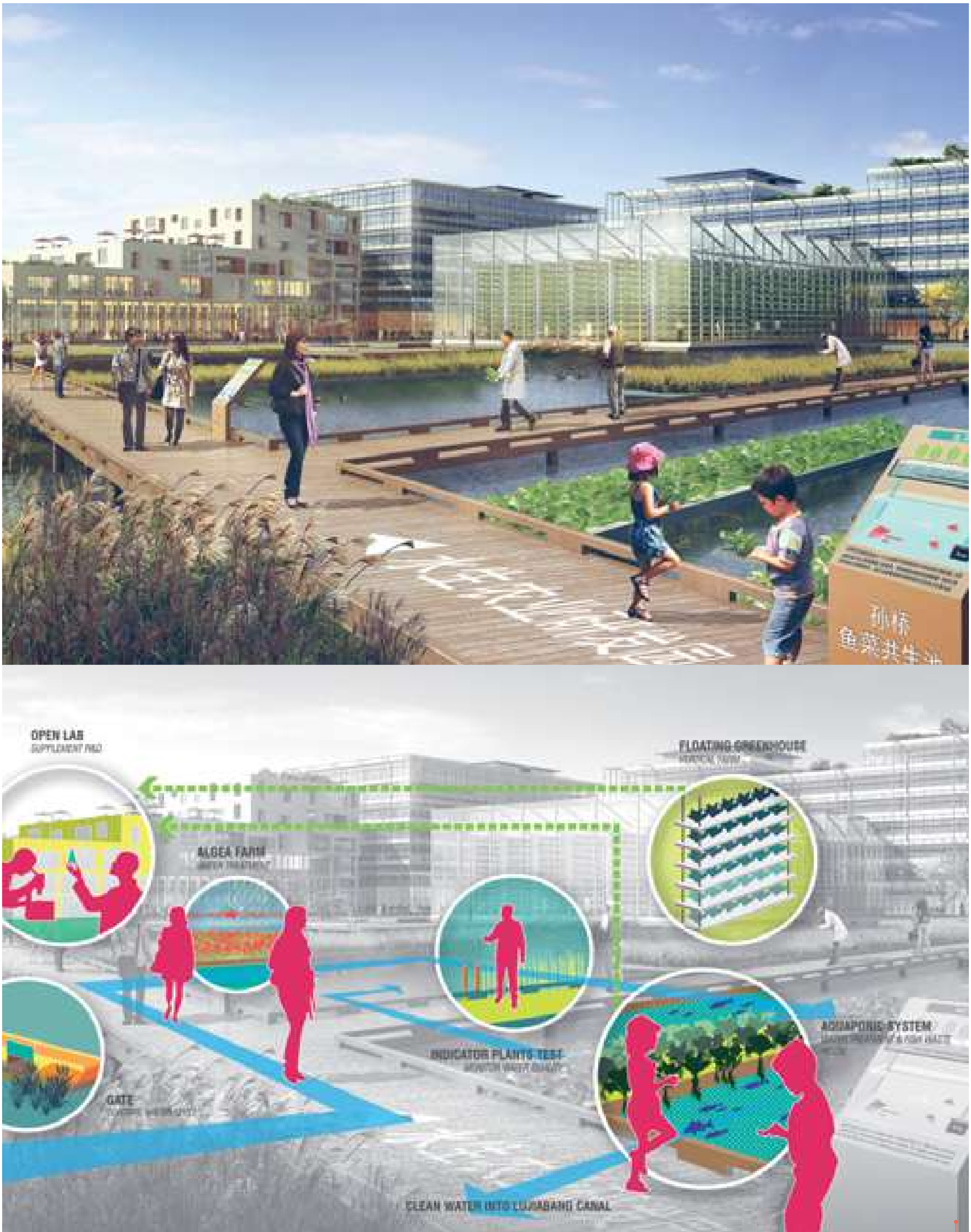
An uncountable number of vertical farms have mushroomed across the world. They doubled in one year. That means that vertical farming is on the way to becoming a common feature of city landscapes

You often depict traditional outdoor farming as an unsustainable model of agriculture. To what extent and how can vertical farming contribute to the sustainability of food systems?

D.D.: Vertical farming is a valuable solution to the issues involved with traditional outdoor farming. Its first and foremost contribution is on the environment. There is a broad consensus among academia, policymakers, international organization staff, and society in general that the contemporary system of outdoor soil-based farming is unsustainable and largely responsible for climate change. Half the world's trees – the equivalent of the size of Brazil – have been deforested for the sake of agriculture. As it is well known, trees are a core element that sequesters carbon dioxide and produces oxygen, so that the destruction of forests for agricultural land use has a considerable role to play in climate change. Indoor farming, notably vertical farming, would allow us to reduce the amount of land that is necessary to feed the ever-increasing world population, which is particularly important considering that the latter is expected to grow up to 9.8 billion in 2050. Vertical farms could even contribute to the restoration of 60 to 70% of forests (two trillion trees), which would sequester enough carbon to reverse the rate of global warming.

Admittedly, indoor farming cannot be expected to fully replace all of the 1.87 billion hectares devoted to crop production. For instance, rice is highly costly to grow indoors, while beef is almost impossible to raise indoors. However, it can become a considerable source of food which would decrease the need for excessive farmland usage. Indeed, other animals such as crustaceans, fish, and poultry can be produced in vertical farms, as well as cattle food – growing soy indoors could have a great impact on deforestation. Even if indoor farming does not fully replace outdoor farming, it may well complement the food system facing the increasing pressures of demographic growth coupled with land scarcity.

Additionally, vertical farming can operate through "zero" pollution circular reuse grow systems. Not only can urban farms contribute to land use, but also to the reduction of other natural resources such as water and energy, and to the reutilization of organic waste. Further, growing food indoor could have a significant impact on global health. Outdoor farming is one of the main causes of global diseases since half the world gets sick from vegetables contaminated with human feces. Growing food in a controlled environment would allow everyone to grow safe-to-eat, healthy food and thus decrease the number of diseases throughout the world.



The Sunqiao Urban Agricultural District integrates vertical farming systems in conjunction with research and public outreach in Shanghai, China
©Courtesy of Sasaki

Vertical farms decentralize the food system, as well as democratize the food supply, since it increases supply, lowers prices, and therefore contributes to food access to all sections of the population, including the poorest. More equitable and widespread access to food will further enhance urban systems' sustainability.

It is also interesting to compare the advantages of vertical farms with those of other types of urban agriculture. For instance, open lots are a common way of growing food in an urban environment, as seen in La Paz (Bolivia). However, open lots are in close contact with car exhaustion, which penetrates the soil, is absorbed by plants, and consumed by people. Another example is that of building gardens on rooftops, which can only be done in regions of the world where winter temperatures are mild. While greenhouses deal with this issue, they cannot yield sufficient food to feed the increasing number of urban dwellers. Vertical farms can be perceived as an ideal method of urban farming, as it optimizes land use and increases food density per square foot of farming space.

There is however great hope that vertical farming can become commercially viable at a large scale. Diversifying the crop selection could further contribute to the success of vertical farms since most today focus on highly productive leafy green vegetables

What needs to be done for vertical farming to expand?

D.D.: Vertical farming faces several kinds of challenges.

- **(1)** First, the question of training and indoor farming skills is very important. Commercial vertical farms operate like any other business, and there are numerous reasons why businesses fail. They require constant oversight of all aspects of the growing environment, as well as employing skilled and experienced staff, who can identify and correct problems in the growing system. I would suggest that schools of agriculture should offer specialized degrees in urban farming, which could not only train city dwellers to work in urban farms, but also stimulate them to work in them, further driving growth in the sector.
- **(2)** Commercial viability is definitely a challenge for vertical farms. There is however great hope that it can become sustainable at a large scale. Some have suggested that the energy cost of running a vertical farm makes it difficult to realize a profit. However, as the price of electricity and LED lights become cheaper, the profitability of vertical farms will undoubtedly increase. Diversifying the crop selection could further contribute to the success of vertical farms, since most today focus on highly productive leafy green vegetables.
- **(3)** Next, opposition from city dwellers and politicians to urban agriculture remains common. Many assume that due to the dense, crowded, contaminated environment of cities, these are not appropriate spaces for vegetable growth. Nevertheless, as the industry matures, indoor farming gains visibility, and the advantages of vertical farming become obvious, it will get easier to get approval for their construction from city planners and other stakeholders, so that vertical farms will gain a lasting place in urban centers.
- **(4)** Last, vertical farms remain relatively expensive to build, maintain, and endure. These are abundant in places such as Japan, Singapore, Taiwan, and the US, where people have high purchasing power. However, the challenge now resides in spreading vertical farming to poorer populations. In places like India, Africa, South East Asia, Latin America, urban agriculture has been growing. But vertical farming, as it requires more expensive technology, has been lagging. Expanding it to larger shares of the population, large commercial growers must step in, as well as international organizations in order to encourage it and make it more accessible. It is only a matter of time for poorer people to demand what the middle class already has access to, at the right market price, and at that point, vertical farming will emerge in cheaper forms.

Vertical farming is often perceived as a "futuristic" model of urban agriculture. According to you, how will cities look like in 50 years?

D.D.: Urban dwellers need to re-imagine city planning and buildings, enabled by the current technological advances which already allow for alternatives modes of production.

I believe buildings will acquire entirely new functions in 50 years. Buildings today are functionless columns of steel, glass, and concrete which endlessly consume resources such as electricity for air conditioning and heating. Instead, architects should develop buildings that integrate vertical farming systems and that are made of alternative materials such as wood timber (i.e., laminated wood). An example is the Sunqiao Urban Agriculture District, a 1,000-hectare master plan designed by Sasaki Architects in Shanghai[1]. This could lead to a hyper-localized mode of consumption in which citizens buy and consume produce from their own buildings. Further, buildings could be equipped with a circular economy infrastructure. For example, they could have water harvesting systems that capture and store

1 See more: http://www.sasaki.com/work/

The Living Tower is an urban vertical farm concept associated with a residential and business campus
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rainwater, contributing to the decrease of clean water usage and waste. Further, solar panels could integrate buildings, especially in regions of the world where solar light is constant and abundant throughout the year.

In sum, buildings in the future will have similar characteristics to that of trees, creating a decentralized food production system that contrasts with today's grids. We are currently on the way to developing this possibility, embraced by architects, academics, and policymakers, as seen in the *Réinventer Paris* (Reinvent Paris) conference, of which I had the opportunity to be part of the jury. SOA Architects have also designed this kind of building, named *La Tour Vivante* (The Living Tower), which associates agricultural production, dwelling and activities along the building[2].

Buildings in the future will have similar characteristics to that of trees, creating a decentralized food production system that contrasts with today's grids

Meanwhile, supermarkets could embrace the benefits from both AEssence and InFarm: indoor growing systems could continually produce vegetables and be located in their aisles, replacing today's boxes, cans, and packages, and customers could directly order on an app the vegetables they wish to purchase and obtain them freshly grown and harvested.

Ultimately, vertical farming could contribute to climate change efforts, reduce the usage and waste of resources, enhance people's health and productivity, enabling us to depict a more positive outlook on the future of cities than commonly done.

2 See more: https://archello.com/project/la-tour-vivante-the-living-tower#stories

PERMACULTURE AND BIO-INTENSIVE MICRO-AGRICULTURE: THE BEC HELLOUIN FARM MODEL

Charles Hervé-Gruyer
Co-founder of the Bec Hellouin farm

©Ferme du Bec Hellouin

The Bec Hellouin farm was created by the husband and wife team of Charles and Perrine Hervé-Gruyer. As trained educator, Charles spent 22 years organizing scientific expeditions on board an educational boat before retraining in psychology and physical therapies. At the same time, he created his experimental farm to test environmentally friendly farming practices and methods, such as permaculture, that were little-known in France at the time. Charles co-leads the research programs at Bec Hellouin farm, run with partners that include the French National Institute of Agricultural Research (INRA) and AgroParisTech. He has acted as consultant during the creation of several experimental farms.

The conventional farming model is increasingly criticized for its negative environmental impacts and inability to feed our planet's ever-growing population with limited resources. Unlike the intensive model, the permaculture and bio-intensive micro-agriculture model developed at Bec Hellouin places nature at the heart of farming. The idea is to produce large amounts from small areas, at the same time replenishing the biosphere and gradually moving away from use of chemical inputs and fossil fuels. Although the Bec Hellouin model was created in a rural setting in northern France, its innovative approach is rooted in the circular economy and is equally suited to application in urban settings, where micro-farms provide myriad services to the local community, such as local produce, environmental benefits, microclimate, social ties, and more.

BEC HELLOUIN FARM

Perrine and Charles Hervé-Gruyer created the Bec Hellouin farm in northern France in 2004. It started out as a large family kitchen garden designed with the idea of becoming self-sufficient in food. At the end of 2006 they set up as professional farmers and two years later they decided to follow permaculture principles, a biomimetic method that was little-known in France at the time. Today, they make a living from their produce (fruit, vegetables, eggs and products such as cider) and from providing training to other people interested in setting up environmentally friendly farming projects. In total the farm employs seven people full time to handle its farming, training and research activities. Sylva, an institute founded by Perrine and Charles, has run studies since 2011 to assess the economic performance of organic market gardening techniques and the impact on biodiversity and soil quality; it works with its scientific partners AgroParisTech, the French National Agronomy Research Institute and the Free University of Brussels.

To find out more:

- *Vivre avec la terre - Manuel des jardiniers-maraîchers*, [Living with the Earth - Handbook for Market Gardeners] Perrine and Charles Hervé-Gruyer, Éditions Actes Sud, 2019
- *Permaculture - Guérir la Terre, nourrir les Hommes*, [Permaculture - Heal the Earth, Feed the People] Perrine and Charles Hervé-Gruyer, Éditions Actes Sud, 2014.

Bec Hellouin farm is an inspiration to many farmers, whether rural or urban. Your model has helped raise the profile of more environmentally respectful farming techniques as well as permaculture. What are the principles behind permaculture and can they help us meet the food and farming challenges of tomorrow?

Charles Hervé-Gruyer: Today's conventional agriculture will be unable to feed everybody tomorrow. Reliance on mechanization and chemicals mean today's farming is based on overexploitation of finite resources (fossil fuels, phosphate mines, etc.). It depletes soils – almost 30% of arable land has been destroyed over the past 50 years – as well as exhausting water resources, drastically eroding biodiversity and contributing to climate warming. This type of agriculture is rapidly destroying our planet. And yet if we look to the future, in 50 years' time oil will have run out or be unaffordable, the planet will be home to over 10 billion humans, with depleted water reserves, less arable land and an increasingly unstable climate. This means we have to look at other paths, other solutions.

Quite unlike the overexploitation model, permaculture takes its inspiration from nature, accepting that nature is amazingly wise and can create abundance seemingly from nothing. Human installations modelled on the natural world is the permaculture path to living sustainably, on a planet whose finite and limited capacities we are increasingly aware of. First set out in 1978 by two Australians, Bill Mollison and David Holmgren, permaculture quickly spread among "greens" in the English-speaking world. Its advocates were communities with little formal agricultural training, motivated by a desire for self-sufficiency and often living on society's margins. Permaculture tended to be adopted in family or collective gardens, for growing fruits and vegetables, and was at times dismissed as simply a great way for amateurs to enjoy gardening. But just because that was what happened in the past, there is no reason to limit it to these types of applications in the future. Bec Hellouin was one of the first farms to incorporate permaculture ideas into large-scale organic farming. We are market gardeners and arborists, and we also raise small livestock. But people are increasingly talking to us about designing systems on a larger scale, for cereals and cattle for example. Permaculture ideas can help us to completely rethink our agricultural system. Permaculture gives us the tools we need to design sustainable human systems that take their inspiration from nature and living ecosystems. Once you start to observe nature you realize that natural ecosystems comprise a vast number of components that relate to each other through an extremely dense web of relationships: what is waste for one is resource for another because nature works in loops. If we want our human installations to be sustainable, this has to be designed-in from the outset so that every component can interact properly, allowing us to achieve maximum energy efficiency and productiveness with minimum inputs and resources.

Bec Hellouin was one of the first farms to incorporate permaculture ideas into large-scale organic farming

©Ferme du Bec Hellouin

How does the Bec Hellouin farm integrate this approach in its commercial organic farming operations?

CH-G: By forcing us to look closely at the relationships between the farm and its surroundings, a permaculture mindset enabled us to create a farm that is as autonomous and resilient as possible. Producing its own resources makes it less dependent on the outside world, meaning that it is better able to deal with crises, whether these be climate-related or social and economic upheavals. We are trying to create a diversified environment that mixes cultivated plants with trees and animals, a system that we call agro-sylvo-pastoral. We've created a microclimate, the amount of organic material is fast rising and soil quality is improving. This also helps us to manage our water efficiently. We avoid evaporation by making sure soil is never left bare,

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using straw to keep it covered. However, this water-responsible approach does have its limits and we still have to water during very dry spells. But instead of using water from the utility network or drilling a well to abstract groundwater, we try to divert and store as much water in every possible way, just the same as we try to capture sunlight. We've dug 25 ponds at our farm and created a system of swales, which are trenches with a bank on one side that follow the contours of the land. Instead of running off, water now leaches into the soil. Our approach is heavily inspired by permaculture; we start by trying to minimize resource use, and next we set out to produce in a manner that is natural and zero cost.

But permaculture is not our only source of inspiration. Although it did help us to sketch out the main guidelines for our farm, as permaculture's founders were not themselves farmers, we also had to look elsewhere for farming techniques that aligned with our goals. We looked all around the world – at ideas from Japan, the UK, Cuba and the USA – to try and identify the most natural possible farming practices. We were looking for systems that use no fossil energy, relying on human- or animal-powered machinery, and had in many cases stood the test of time. From the carefully groomed agriculture seen in Japan and Korea to bio-intensive micro-agriculture in the USA, we try to leverage synergies between elements of proven and highly efficient practices. It is this combination of farming techniques inspired by miniature smallholdings that has made us so productive. *Maraîchage biologique permaculturel et performance économique* [Organic market-gardening and economic performance], a study we ran with INRA and AgroParisTech from 2011 to 2015, provided science-based validation for our practices. In 2015, 1,000 square meters of market garden at Bec Hellouin grew produce worth €55,000 at market (whereas organic market-gardening in France produces average returns of around €30,000 per 10,000 square meters). And we've progressed since then. The more time we devote to a plot of land the more its productiveness increases, to the extent that in polytunnels we're sometimes seeing yields of up to €200 per square meter. There have also been very positive impacts on biodiversity: the farm attracts more birds, including rare species, insects and earthworms than the surrounding land. This type of micro-farm can produce an abundance of quality food for humans and act as a biodiversity oasis. There are currently seven of us making a living from the farm's three activities: farming, permaculture training and research programs.

In 2015, 1,000 sq. m. of market garden at Bec Hellouin grew produce worth €55,000 at market (organic market-gardening in France produces average returns of around €30,000 per 10,000 sq. m.)

Your farm is in northern France, in a rural setting in Haute-Normandie. Can urban farms learn from your model?

CH-G: The truth is that our model is in fact based on lessons from urban farming. The American gurus of bio-intensive micro-agriculture, Eliot Coleman and John Jeavons, borrowed heavily from the rich tradition of market gardening in 19th century Paris. Producing large quantities from small spaces dotted around the inner city, Paris' market gardeners were able to supply the city with quality fruit and vegetables all year round, even exporting as far afield as London. Paris' pioneering urban farmers left considerable written records, and these are a real inspiration to us. Perfected first in the royal gardens at Versailles then in 19th century Paris, these techniques were further developed in the United States before returning to France at Bec Hellouin, and they are now widely used in many urban agriculture projects. The way these ideas have been handed down to us does not mean that we're looking to the past. We've taken a new look at them in the light of knowledge unavailable to our forebears. Today, urban farming is a movement spreading around the world. Cities in both hemispheres are examining how to develop urban farming, which will become essential. If we experience a crisis in fossil fuel supplies, if the flow of food transportation is suddenly cut off, Paris only has enough food stocks to last three days. Expanding urban farming can be part of a response when setting out to make our cities more resilient.

The miniaturized, non-motorized agriculture that we practice at Bec Hellouin definitely has its place in urban settings because the idea is to produce a lot from a small area. Small city gardens, even people's lawns, can turn out to be extremely productive. We have a very diverse range of people who come here for training: people with an urban farming project, city-dwellers looking to start a new life in the country, local government policymakers and landscape gardeners interested in how to transform decorative spaces into food-producing spaces. We have worked to help create an outstanding example in Versailles, run by one of our former trainees, Gilles Degroote, working with Nature et Découvertes. The Gobert pond (1685) was originally created to supply water to the royal kitchen gardens and was reengineered last year to become a permaculture-inspired urban micro-farm.

©Ferme du Bec Hellouin

But growing in cities is subject to a different set of constraints than those applying in the countryside. The availability and cost of land, for example, are very different. What do you think are the conditions needed to produce in towns and cities in ways that align with the principles you advocate?

CH-G: It is true that feedback from the numerous municipalities we are in contact with shows that, despite a real commitment to see projects like this get off the ground, more often than not actual yields are not particularly high. Shared city gardens sometimes do not produce very much because they are tended by urbanites with little knowledge of gardening, and even less of agriculture. We advocate the incremental professionalization of city farming, the idea being to ensure that residents who want to reconnect with small-scale food production can be supported by skilled professionals, helping them to increase their yields and set up projects that are more overtly successful. Just this year (2019) we published a practical handbook (*Vivre avec la terre* - Live with the Earth) that summarizes the core techniques and concepts guiding our methods, particularly in terms of how these transfer to urban settings.

> *The miniaturized, non-motorized agriculture that we practice at Bec Hellouin definitely has its place in urban settings because the idea is to produce a lot from a small area*

There is no avoiding the fact that produce grown in urban settings costs more because of the scarcity and price of land, resources that have to be brought in from outside and, critically, because city farmers will be forced to pay far higher rents for their land than a colleague in the countryside. An urban farm will probably have difficulty surviving solely from selling its own produce and will always be dependent on support from the wider community. The fact is that, beyond their food-growing roles, these new types of farm provide additional environmental and social services to their localities, and it is only right that they receive payment for this. Urban farms also produce social ties and wellbeing, they bring nature back into the city, create jobs, food security, microclimates and so on. Studies have shown the positive impact a productive green island can have on human health. There are other studies indicating that greening the city is the best way to cut vandalism. All these services they deliver fully justify municipalities either providing a subsidy or supporting them in other ways.

There's nothing wrong with trying to introduce new sources of income other than just farm-grown produce. These are new practices and they must be thought of as part of a larger whole. At Bec Hellouin, the knowledge we acquire in the course of our research programs and the training we deliver all align with wider society's underlying needs. You should never hesitate to explore alternative ways of funding your activities. For instance, micro-farms in towns and cities can offer guided tours in return for an entrance fee.

Ultimately, the critical challenges that urban farming has to address are the following: professionalization, unambiguous support from the local community and reinvention of the economic model.

AQUAPONICS: A POSITIVE IMPACT CIRCULAR ECONOMY APPROACH TO FEEDING CITIES

Steven Beckers
Founder of BIGH (Building Integrated GreenHouses)
C2C-certified architect,
Lecturer and visiting professor at the Brussels Faculty of Engineering

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Cradle to Cradle-certified architect and lecturer at the Free University of Brussels, Steven Beckers founded Lateral Thinking Factory, a consultancy that supports positive impact circular economy implementations in the real estate sector. He founded BIGH (Building Integrated GreenHouses), based on Berlin's ECF Farmsystems model, in 2015 after running several studies into the urban agriculture potential of Brussels and its surrounding region. The goal was to develop a commercial model for an urban farm based on building-integrated aquaponics, inspired by building-integrated photovoltaics. The first farm in the BIGH network, Abattoir Farm, opened in the Anderlecht district of Brussels in January 2018.

The Abattoir Farm, BIGH's first full-scale production site, was set up in 2015 on the roof of Foodmet, a food market in the Abattoir neighborhood in the Anderlecht district of Brussels. Designed to positive impact circular economy principles, the project leverages numerous synergies between the farm, the building housing it, the district and the wider city. The aquaponic production system, linking fish-farming tanks to greenhouses for growing plants, recreates a natural ecosystem in an artificial environment. It produces minimal waste, requires limited energy inputs and delivers positive impacts to the environment. It also provides city consumers with year-round access to quality, locally sourced products (tomatoes, fish, herbs and berries). With Abattoir Farm, BIGH is advocating for a productive urban agriculture with an economic model reliant primarily on the sale of produce. The aim is to duplicate the model elsewhere in Belgium and Europe.

INTRODUCTION

With high numbers of vacant spaces, on rooftops in particular, cities are reservoirs of under-exploited productive capacity. In 2015 Lateral Thinking Factory mapped 600 hectares of Brussels rooftops and estimated that 60 hectares could be used to site food-growing urban greenhouses. Integrated into buildings, the greenhouses would make it possible to produce food in the middle of the city, creating jobs, upgrading the urban environment and boosting biodiversity. They also offer ways to recover unused resources, such as using surplus energy, capturing carbon dioxide, harvesting rainwater, etc., while also cutting buildings' ecological footprints. In the same vein, the aquaponic urban farm – fish-rearing and plant-growing in a closed ecosystem — that BIGH has developed on the roof of the Brussels Foodmet market aims to provide high-quality products for distribution via short circuits, encouraging residents to consume local produce. It offers the people of Brussels fish, tomatoes and herbs grown and raised in the city center, in an approach guided by the positive impact circular economy approach.

APPLYING THE POSITIVE IMPACT CIRCULAR ECONOMY TO URBAN AGRICULTURE

FROM CUTTING NEGATIVE IMPACTS TO CREATING POSITIVE IMPACTS: WHAT CRADLE TO CRADLE BRINGS TO SUSTAINABILITY

Sustainable development, as defined by the 1992 Rio Earth Summit, is essentially predicated on setting goals for reducing the negative impact of human activities using indicators such as the volume of CO2 emissions, water consumed or kilowatt-hours per square meter. The risk with this highly quantified approach lies in overly focusing on targets that can fast become outdated. For example, a major architectural project will often follow a 10-year cycle whereas certifications change on average every five years.

To avoid this pitfall, designs that use *Cradle to Cradle* (C2C) start from a qualitative analysis to later set quantified goals. The process begins by setting out a vision, such as creating a clear-air district, which is subsequently translated into ideas for action. Goals, strategy, tactics and quantified indicators are determined at a later date (see Diagram 1). Developed in the early 1990s by German chemist Michael Braungart and American architect William McDonough, C2C seeks to manage fabrication processes that allow infinite recycling of materials. Materials are not intended for plain recycling (*downcycling*) but are also enhanced for use in the future (*upcycling).* The idea is not just to reduce negative impacts but more important still, to produce positive ones.

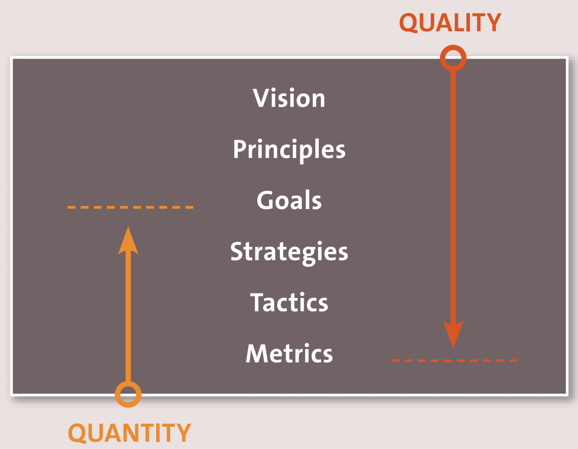
As applied to architecture, C2C's founders' vision of sustainability can be summed up as: "If buildings were like trees, cities would be like forests." Trees use photosynthesis to produce their own energy, they clean the air by capturing carbon dioxide, filter water while providing food and shelter for other species, and constitute a reserve of materials for the future. Inspired by these ideas it is possible to construct buildings that process their own water and filter their indoor air by employing non-toxic materials, probiotics and plants. These buildings are also adaptable to a range of uses, are flexibly designed and act as future materials banks (*BAMB – Building As Material Banks* European research project).

This positive impact circular economy approach is built on a progressive roadmap, not a brutal change of model. Turning off the tap on fossil fuels and switching to all-electric, or renouncing concrete in favor of building in wood alone, are radical ideas that risk triggering confrontations that will hamper rather than increase the speed of energy transition. Bringing about a comprehensive transformation in how cities are built and conceived requires a parallel drive to invent new ways of building and update long-standing techniques: for example, specifying wood while also working to create concretes with a positive carbon footprint, planning for electric vehicles as well as for using hydrogen and compressed air, and all the while working to limit the negative effects of fossil fuels.

IMAGINING URBAN AGRICULTURE ACCORDING TO THE PRINCIPLES OF A POSITIVE IMPACT CIRCULAR ECONOMY

Designing an urban farm as rooftop greenhouses that follow positive impact circular economy principles requires the creation of synergies between the farm, the building on which it is located and the farm's wider urban environment. It is important to take a holistic view of the urban environment by looking at the quality of the site, the air, water cycle, access to energy and raw materials, to mobility and food production networks and levels of biodiversity. The challenge is to incorporate these disparate dimensions while designing modular buildings and adopting a zero-waste approach, and without overlooking the project's social dimensions (see Figure 2).

The C2C qualitative approach



Source: Lateral Thinking Factory

Figure 1

Designing a project with a holistic urban approach

Source: Lateral Thinking Factory

Figure 2

- **What the city and the building provide to the farm**: the city offers the farm access to its labor force, proximity to consumers and the microclimate afforded by city rooftops. Sheltered from the wind and protected by the thermal qualities of concrete, the rooftops are generally 2 to 3 degrees Celsius warmer than the surrounding countryside. There is also a higher concentration of CO_2: 500 to 600 ppm compared to an average in the countryside of 400 ppm. It should be remembered that, above and beyond being a greenhouse gas, CO_2 is the living world's most critical building-block. The farm is also able to recover stormwater thanks to a drainage system that stores it. Sunlight falling on the building can be captured using solar panels to produce renewable electricity. This means the building provides the farm with space, heat and even the CO_2 emitted by its users, as well as utility network connections and access for logistics.
- **What the farm provides to the building**: in return, the farm offers the building thermal protection and insulation, substituting roof maintenance costs for rental income. It helps boost the real estate value of the building by improving its image and reducing its ecological footprint. Research is under way into a range of different models that would allow building owners to invest in fitting out the greenhouses, the idea being that this would in turn boost the value of their building.

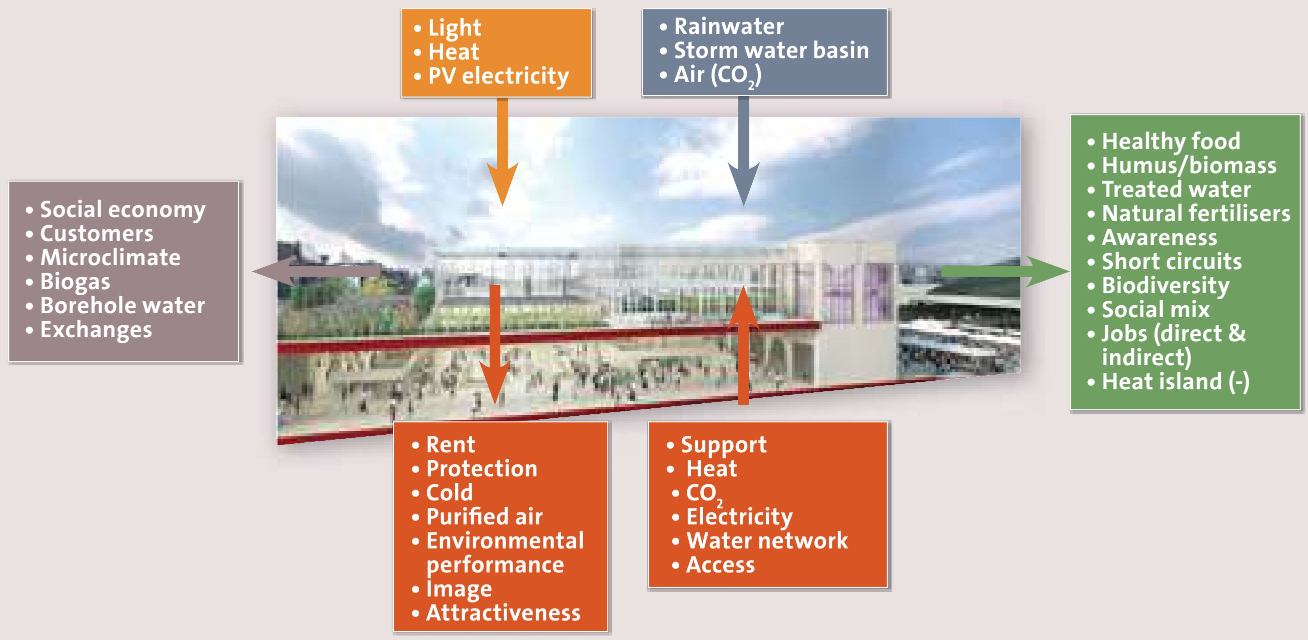
For the city, these positive interactions (*see Figure 3*) deliver year-round production of high-quality local produce that is free from artificial fertilizers, antibiotics and pesticides, as well as surplus humus and biomass that can be used for other non-farm purposes. They also provide the city with greater biodiversity and help to reduce heat islands because the greenhouse absorbs heat and the plants' humidity maintains the temperature below 26°C. This is a model that sees the urban farm become a center for innovation in the circular economy and for raising awareness about the importance of healthy eating. It also creates direct and indirect employment and, working with the social and solidarity economy, it can help to bring disadvantaged people back into paid work.

Abattoir Farm on the roof of Foodmet in Brussels - ©BIGH-isopix

BIGH'S ABATTOIR SITE IN BRUSSELS: AN INTEGRATED URBAN FARM MODEL

BIGH's first full-scale production site is Abattoir Farm on the roof of Foodmet, a food market that was restored in 2015 in the Abattoir neighborhood of Anderlecht in Brussels. The 4,000-square-meter surface is divided into 2,000 square

Positive interactions between the urban farm and its environment



Source: BIGH

Figure 3

meters of greenhouses and fish-farming installations, using the aquaponic method, and a further 2,000 square meters of outdoor kitchen gardens. The installation seeks to recreate a natural ecosystem in an artificial environment.

AQUAPONICS

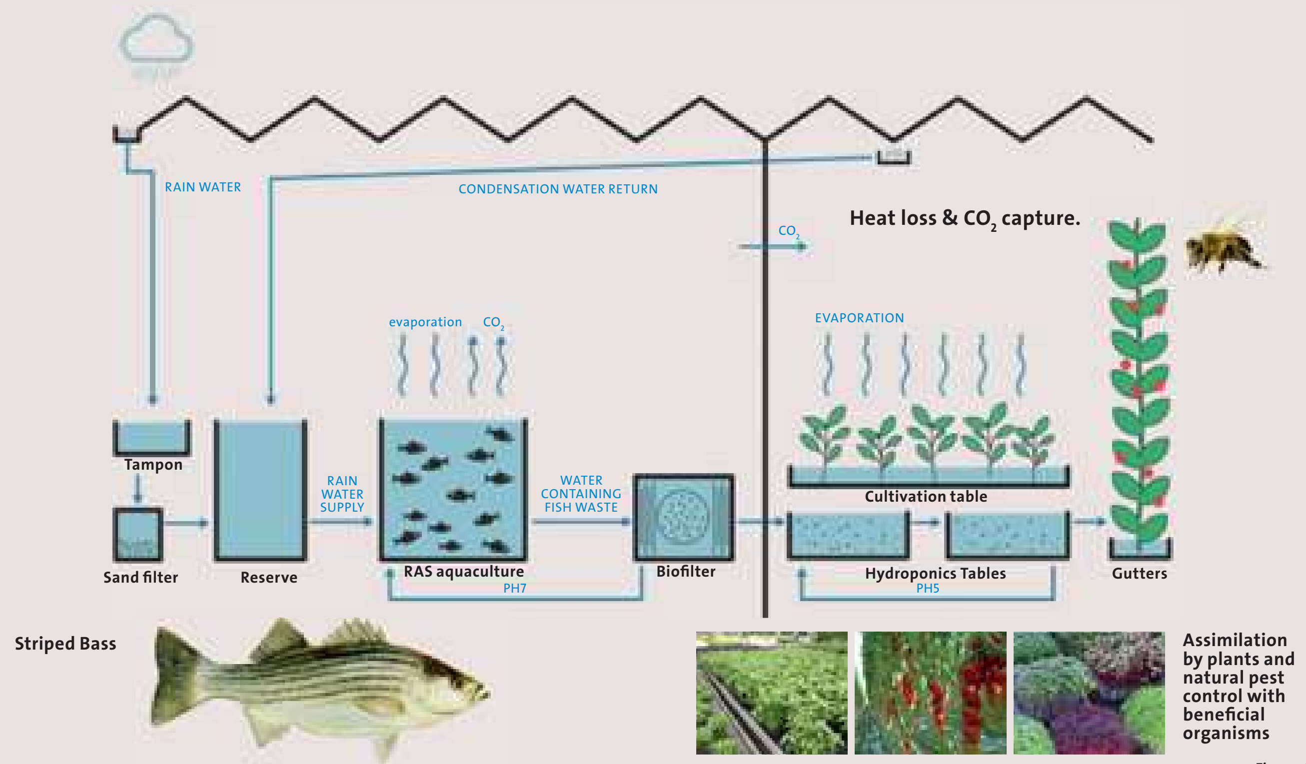
Well known to the Incas and used in Chinese rice paddies, aquaponics is a symbiotic combination of aquaculture (fish farming) and hydroponics (growing plants without soil). The system uses a bacterial process, with micro-organisms filtering and breaking down the ammonia in fish urine to create the nitrates that allow plants to use the nitrogen cycle to take nutrients from the water. For health reasons and to ensure the production of fish that are fit to eat, very little water from the plants is returned to the fish in the aquaponic system developed by BIGH. In fact, only condensed steam from the greenhouse is returned to the tanks. Fish and plants have indeed very different needs in terms of the pH value of water (pH7 for fish and pH5 for plants).

Designing an urban farm that follows positive impact circular economy principles requires the creation of synergies between the farm, the building on which it is located and the farm's wider urban environment

Water, an essential element in the circular economy, is the farm's primary resource, along with CO_2 and organic waste. The Recirculating Aquaculture System (RAS) uses a hundred times less water than conventional open systems. Even during a heatwave, the farm uses just 20 cubic meters of well water daily to supply its 200 cubic meters of tanks, cleaned every two hours by biofiltration, and the plants in the greenhouses and the outdoor kitchen gardens (4,000 square meters in all). Rainwater is harvested, filtered and used in the tanks too. Systems to filter and use water from fish tanks for growing plants hydroponically considerably reduce the amount of waste generated by the farm, unlike conventional fish-farming systems that discharge water into nature that is heavily contaminated with ammonia and antibiotics.

The seemingly burdensome task of constantly monitoring the parameters of the highly sensitive aquaponic ecosystem, with zero tolerance of antibiotics and chemicals, is in fact a guarantee of the healthiness and quality of the fish and plants produced at the farm. The use of bumblebees to pollinate plants in the greenhouse and mites and other insects to combat pests is proof of the lack of harmful chemical inputs in the system, which works on a closed loop. Lastly, the CO_2 emitted by the fish is also recovered and fed to the greenhouse to help the plants with photosynthesis.

The BIGH aquaponic farming model



Source: BIGH

Figure 4

Fish-rearing basins at the Abattoir site - ©BIGH-isopix

2,000 sq. m
of greenhouses and fish tanks

2,000 sq. m
of outdoor kitchen gardens

14
tanks

60,000
striped bass

35 metric tons
of fish raised each year

PRODUCING FISH AND MARKET GARDEN PRODUCE IN THE HEART OF THE CITY

The farm's 14 tanks contain 60,000 striped bass in various stages of development. The farm imports 9,000 fry monthly from a hatchery in Israel. The striped bass is a protected species that in the wild is found mainly in the salty waters of the St. Lawrence River. It was selected for its culinary qualities and ability to develop in freshwater over a 10-month cycle, compared to four years in the wild. Other species that are highly sensitive to water quality, such as Arctic char and different types of trout, can also be raised using the aquaponic system. The striped bass are reared without antibiotics in water kept at 23°C, a temperature they thrive in, with a constant current for them to swim against. Fed with certified GM-free food and kept in different tanks according to size, the fish are sold once they reach 350 to 600 grams. A total of 35 metric tons are produced each year and gutted fish retail for €18 to €22 per kilo, depending on size.

The market garden section of the farm produces three types of crop. One greenhouse grows two varieties of cherry tomato (red and yellow) on a coconut fiber substrate for 34 weeks a year. Tomatoes were chosen for biological as well as culinary reasons: they absorb a lot of nitrates as they grow, and their characteristic flavor makes it easy for consumers to judge the quality of the product. Some 15 metric tons of tomatoes are grown each year and are sold loose or on the vine for €15 to €25 per kilo, making them a high-end flagship product. Another 600-square-meter greenhouse is used year-round to grow organic plants in pots: 2,700 pots of kitchen herbs such as parsley, coriander, basil and thyme are produced weekly. Lastly, there is the more seasonal outdoor garden, where vegetables, fruits, salads and berries (blackberry, raspberry, bilberry and red currents) are produced from June to September for use in restaurants.

DIVERSIFIED ECONOMIC MODEL

A typology of the different types of urban agriculture projects makes it easier to understand BIGH's approach *(see Figure 5)*. A very large part of existing installations, in Brussels and elsewhere in Europe, are nonprofit projects that use urban agriculture to stimulate social bonds. Next come installations that focus on profile-raising and marketing, such as the greenhouse and garden on the roof of the Delhaize Boondael store in Brussels: aside from the marketing aspects, these projects are not economically viable but do influence consumers by spreading awareness about sustainable practices. Some companies have developed kitchen garden concepts as a consumer service: small private gardens are cared for on behalf of private individuals, sometimes even remotely managed via an app. Lastly, the fourth urban agriculture model involves truly producing food in the city, with an economic model that relies mainly on the sale of produce. These models each have purposes that are distinct yet complementary.

Abattoir Farm by BIGH belongs to the last category. Its economic model essentially relies on the sale of its produce, notably "local producer" sales in Carrefour supermarkets. The economic model also includes approximately €100,000 of earnings from corporate events and visits. Total revenue for the second trading year is estimated to be €1 million. The plan is to achieve profitability in the fall of 2019. Greater use of permaculture for the outdoor kitchen garden or, for future

Kitchen herbs grown in a greenhouse at the Abattoir site - ©BIGH-isopix

15 metric tons of tomatoes and **170,000** pots of kitchen herbs produced each year

Typology of urban agriculture projects

Source: Lateral Thinking Factory

Figure 5

installations, setting aside more space for growing plants in tunnels and fish farming will achieve better economies of scale and greater diversity of production that will make it possible to accelerate break-even for this type of economic model. There are also plans for a third party to open a restaurant onsite, a move that will give a further boost to the image of the farm's produce.

The farm employs the equivalent of five full-time staff, including two specialists in hydroponics and fish farming and an agronomist in charge of managing the farm. From the financial standpoint, there are several private and public investors in BIGH Holding (Lateral Thinking Factory Development, Fidentia Green Buildings, Talence and Finance. Brussels SRIB) with financing completed via a loan from BNP Paribas Fortis. Although Abattoir Farm was not eligible for public subsidy, BIGH Holding has received public assistance by virtue of being a newly established Brussels business.

SOCIAL AND ENVIRONMENTAL SYNERGIES

Located in a priority development district, the Abattoir Farm site helps boost the image of the Anderlecht district, which is now home to an innovative activity that is an example of the circular economy in action. Apart from the outdoor-grown berries that serve the local restaurant trade, the remainder of the 2,000-square-meter outdoor kitchen garden is set aside for the benefit of the social and solidarity economy. Since it opened, a partnership with nonprofit Atelier Groot Eiland has delivered training at the farm to around 60 participants, either disabled people or people returning to the workforce. Produce from the gardens is served in the restaurant run by Atelier Groot Eiland.

Outdoor kitchen gardens at Abattoir Farm - ©BIGH-isopix

In terms of its environmental management, the farm is embedded in the Foodmet building in line with the circular economy principles set out above. It works in a way similar to a cooling tower: heat from refrigeration units on the floors below is recovered by a heat pump, providing 60% of the heat needed for the greenhouses and fish farm, and the greenhouses also supply cold that is used by the market's refrigeration units and cold rooms. Also, some of the farm's electricity is generated by Foodmet's solar PV panels.

Lastly, the farm is almost seamlessly integrated into its neighborhood. It produces no bad odors, and light pollution is reduced by using LED lighting in the greenhouses and a system of vertical and horizontal night-time blinds. All the farm's produce is subject to permanent sanitary quality checks.

CONCLUSION

In the years ahead BIGH hopes to roll out a network of European urban farms that work in synergy with the city buildings and industrial sites where they are located, each of them combining food production with the circular economy. The type of city site it is looking for will have a useable productive surface of 2,500 to 3,000 square meters, perhaps more. There are plans to develop two or three more aquaponic farms in Belgium and projects exist for three more, in the Paris region, in northern France and outside Milan. Larger installations than at Abattoir Farm could make it possible to diversify the range of indoor crops. For example, dividing greenhouses into different zones would allow tomatoes to be grown easily with zucchini. Recovering guano, fish excreta separated from the water using mechanical filters, would also provide the farm with additional resources. Also, further improvements to current photovoltaic technologies will bring the site closer to energy self-sufficiency by fitting PV panels inside greenhouses.

The idea is not to replace crop growing practices used in the countryside. However, urban agriculture can share the burden of growing certain crops and provide farmers with new ideas. Under certain circumstances, circular economy principles as applied in cities can help answer some of the wider challenges facing farming.

Peri-urban areas also offer outstanding potential growth opportunities thanks to lower land costs and easy access to water and energy resources. In addition, the aquaponic technology model, which has clearly shown the effectiveness of its water filtration techniques, may be a first step toward the application of circular economy principles to wastewater treatment.

Aquaponic tomato-growing at the Abattoir site - ©BIGH-isopix

RECIRCULATING AQUACULTURE SYSTEM-BASED SALMON FARMING

Thomas Hofmann
Farm manager,
Swiss Alpine Fish

©Swiss Alpine Fish

Thomas Hofmann has been working in aquaculture for 15 years. He progressed from technician to researcher then project manager in Australia, Denmark and Spain, and has now joined Veolia as the aquaculture process manager in the Water Technology Aquaculture Business Unit. Since 2015, he has been providing assistance to Swiss Alpine Fish, a salmon farming site based on a recirculating aquaculture system in Lostallo in the Swiss Alps.

The Swiss Alpine Fish indoor salmon farm uses a recirculating aquaculture system that combines optimal resource management, respect for the environment and a high-quality product for the end customer. In the village of Lostallo in the Swiss Alps, the salmon are grown in a controlled environment, using no antibiotics or chemicals, in full compliance with sanitary standards. This sustainable and economically viable farming model could be used in urban settings where there is suitable infrastructure and access to good quality water, making this an encouraging prospect for private investors and consumers alike.

THE SWISS ALPINE FISH AG FARM

Swiss Alpine Fish is located in Lostallo, a village of 400 inhabitants located 200 kilometers from Zürich. Last summer, the farm harvested its first Atlantic salmon (*salmo salar*). Based on the RAS2020 technologies developed by Veolia, the farm uses a recirculating aquaculture system: water in the tanks is filtered seven times in a closed-loop circulation system in which the fish are not removed, no chemicals or antibiotics are used, and the need for freshwater is reduced. The farm is aiming for annual production of 600 metric tons of salmon, which will meet between 3-4% of demand in Switzerland. Some 50,000 eggs are imported from Iceland every 10 weeks, and it takes 24 months to produce a 4-kilo salmon. The farm employs a full-time total of 15 people working in different activities that range from fish growing to product processing and direct onsite sales. The remaining production is sold in supermarkets via specialist distributors or sold online under the Swiss Lachs brand. Set up by British investor Julian Connor, the farm should make its first profit this year, four years after the site was built.

1. The Swiss Alpine Fish salmon farm is mainly based on a recirculating aquaculture system. What are the advantages of this technology in both environmental and sanitary terms?

Thomas Hofmann: The alpine farm consists of an indoor installation in which the salmon are grown in tanks of clean mountain water, using no antibiotics or chemicals. This technology has three main advantages: (1) optimal resource and waste management, (2) a short-circuit system with a low carbon footprint and (3) production of very high-quality salmon for the end customer.

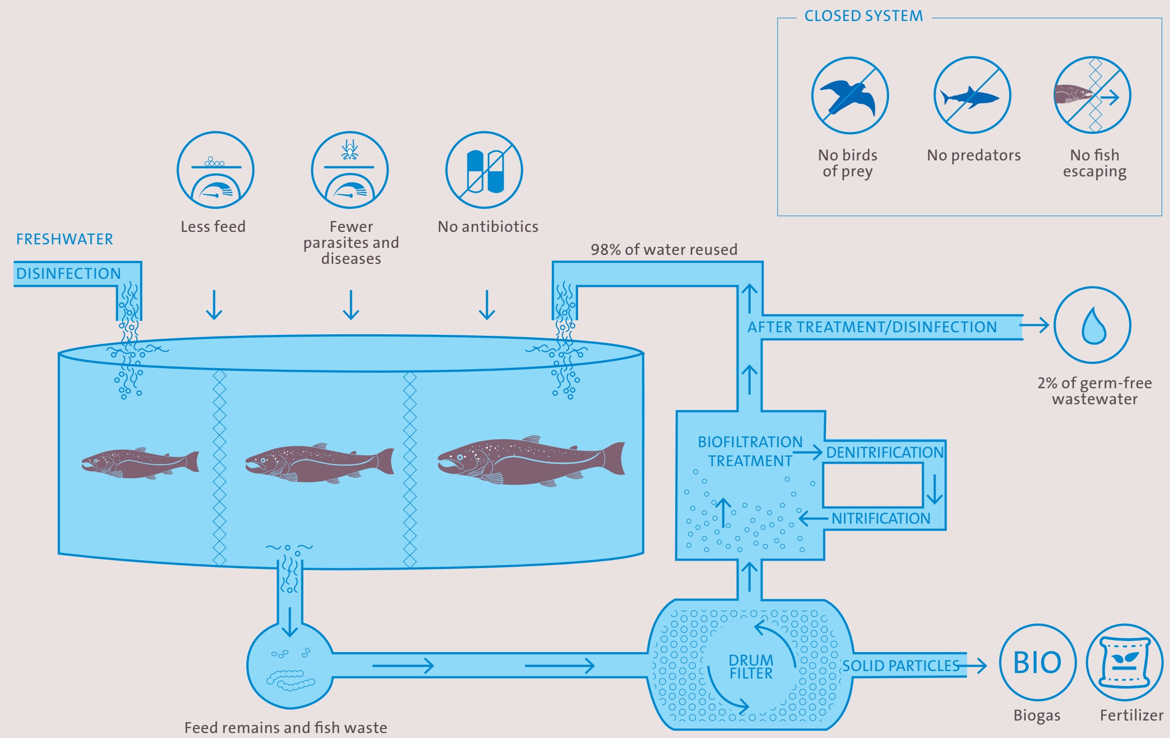
From the viewpoint of resource management, the *recirculating aquaculture system (RAS) recycles* 98% of the water needed for fish growing. The potable spring water is extracted at a depth of 25 meters and is continually recirculated in tanks after mechanical and biological filtration that removes ammonia, nitrites and nitrates. Only 1% of the water leaves the circuit and is returned to the river after treatment. Management of the farm's organic waste is also sustainable because the fish excrements and any uneaten food are concentrated in containers and used locally to produce biogas.

Transposing this installation, which is on the outskirts of a small Swiss village, to a Paris suburb could easily be envisaged

As for the distribution circuit, conventional fish growing involves phenomenally high transportation costs: fish that is harvested in Norway or Scotland is often processed in Poland before being sent back to Norway for distribution throughout Europe. Under this system, it takes seven to eight days for the fish to reach consumers. At Swiss Alpine Fish, all these processes take place on site and the salmon can be on the market, with no freezing needed, in just a few hours. So the products have a smaller carbon footprint, especially as the electricity we use in Lostallo comes from a hydropower plant. Also, the continuous harvesting of the fish means we have many different sizes, so we can meet demand from customers flexibly while also ensuring full traceability.

Lastly, the salmon grow in a controlled environment where they are protected from disease and parasites such as sea lice, so they can be grown without using antibiotics or chemicals. The water quality and temperature settings, as well as the techniques for transferring them between the different tanks, also avoid stressing the fish. Their food, which is fish meal made in Norway from

Recirculating aquaculture system



Source: Swiss Alpine Fish

The aquaculture farm and its products - ©Swiss Alpine Fish

European fish, is free of ethoxyquin, a harmful antioxidant that is often used to conserve fish meal imported from South America.

2. Your farm is located in a village of 400 inhabitants. Could this model of salmon farming be replicated in urban areas? If so, under what conditions could RAS be used in urban settings?

T.H.: The Swiss Alpine Fish farm is very compact. The salmon growing tanks are in a 60 x 30 meter building that is 10 meters high. That's a big advantage for setting up in a city. As well as the low land take, visual pollution can easily be reduced by choosing a suitable material for the façade – in Lostallo, it's wood – and salmon farming does not produce any offensive smells. The project has created employment and has been warmly welcomed by the local community. Transposing this installation, which is on the outskirts of a small Swiss village, to a Paris suburb could easily be envisaged.

The only vital condition for setting up a site using RAS is access to good quality water, whether freshwater or saltwater, with the possibility of discharging the water that is not recirculated. The cost of the water is an important component of the business model and being close to a lake or river is a definite advantage. Switzerland is of course well known for its freshwater reserves, but there are many possibilities for installing this kind of farm in cities in Europe. It's also possible to combine fish farming with using a hydroponic system to grow plants and form an aquaponic system.

3. The farm is expected to make a profit this year. What are the factors that explain this result?

T.H.: I see three main factors for our success: an advanced technology, and an attractive business model that pays well and also meets strong demand for high-quality, local products.

First, the RAS, with its filtration and water treatment systems, is the key to the farm's success, because it lets us create a very high-quality product that respects the environment. Next, the Swiss market, which is the farm's main market, has high purchasing power and is also very drawn to "Made in Switzerland." The water in the tanks where the Lostallo salmon grow is salted with Swiss salt! For a top-quality product – and, in the case of salmon, one that is seen as being for special occasions or even as a luxury product – the Swiss are very willing to pay even more for a Swiss product. In terms of price, a whole gutted fish sells for €14 a kilo and smoked salmon for as much as €90 a kilo. Consumers increasingly want to know what they're eating, and conventional Norwegian and Scottish salmon farms have badly damaged the image of the product and its environmental impact. A responsible approach to producing salmon is one that appeals to the consumer.

Lastly, salmon farming with RAS offers investment possibilities with high returns, good growth curves and low financial risk. The business model has attracted investment from major companies in the retail sector and from private investors who want to put their money into a sustainable project.

REAPPROPRIATING URBAN SPACE THROUGH COMMUNITY GARDENS IN BRAZIL

Claudia Visoni
Urban farmer and journalist

Gustavo Nagib
Doctoral geographer, University of São Paulo

The entrance gate of *Horta das Corujas*, the first community garden in São Paulo, is never locked and allows access 24 hours a day to any citizen - ©Gustavo Nagib

Claudia Visoni is a journalist, environmentalist, urban farmer, and co-state legislator as a member of the collective *Bancada Ativista* (Activist Caucus), a group of nine people who submitted a collective candidacy for the legislative assembly of the State of São Paulo in 2018. Claudia collaborates with several permaculture and political initiatives and volunteers in the *Horta das Corujas* community garden. She also dedicates a portion of her time to articulate urban agriculture activist networks in São Paulo.

Gustavo Nagib is a geographer pursuing his Ph.D. within the Human Geography Program at the University of São Paulo (USP), a visiting doctoral student at Sciences Po Paris, and a founding member of the Urban Agriculture Study Group of the Institute for Advanced Studies of the University of São Paulo (GEAU-IEA-USP).

Academic research on communitarian urban agriculture explores its role as an available alternative to make a different urban model come true, fostering a better environmental and social balance. Vegetable garden initiatives in public spaces can help expand the discussion about community actions, which tend to promote deep changes locally by making urban space management more democratic and signaling the transformation into an "edible city," where food can actually be produced. This view has contributed to the increasing emergence of community gardens across the developed world, but also in developing economies. This is the case, for instance, in São Paulo, where many community gardens have been created in the past few years by communities themselves as an expression of activism aimed at transforming public spaces and the city. This tendency was pioneered by the 82,000-member online network *Hortelões Urbanos* (Urban Horticulturists), which started off as an information-sharing platform for people gardening at home. The community eventually mobilized to create the *Horta das Corujas* (Garden of Owls) in 2012, the first community garden in Brazil's largest metropolis. Despite the difficulties in obtaining approval to build the community garden and the lack of legislation governing the use of public space, *Horta das Corujas* was successfully implemented and is still managed by volunteers, standing as a symbol of community-led initiatives that democratize public space and transcend traditional barriers to social integration.

INTRODUCTION

The urban environment has become the main center of inequality growth and the place where numerous families with an income of less than US$1.25 per day reside[1]. Urban agriculture is a mechanism for fighting socio-spatial inequalities, fostering the social economy, spreading new principles for food production and feeding people (mainly based on agroecology and permaculture). It is also a way of promoting different types of use and occupation of public spaces, assuring the right to the city and implementing activism, as well as transforming socio-spatial relationships at a local level in a way that might result in larger-scale future impacts. The focus of the current analysis is urban agriculture as an activist expression and community action at the local level in a metropolis. Community gardens have been spreading in several cities as a result of environmental activism aimed at restructuring the urban space, especially when it comes to taking over public areas and promoting different uses for them. In São Paulo, *Horta das Corujas* is a pioneering example of the type of activity that comes into being once local activists and communities come together to take action.

1 SANTOS, M. A urbanização desigual. São Paulo: Edusp, 2010.

URBAN AGRICULTURE AS ACTIVISM

Long considered as a primitive, temporary, deteriorating or inappropriate activity, the beginning of the 21st century has shown that urban agriculture has become the basis for an essential activity for improving the material and nutritional perspectives of urban populations while having a direct impact on urban environmental quality[2]. It is a broad concept, and its specifics vary as per the activity's context and location. The types of urban agriculture that can be found within a city and within different cities vary depending on the players, locations and relationships established in the urban space: from gardening to market-oriented farming activities both in intra-urban and peri-urban areas. Therefore, it is safe to say that each territory has its own type of urban agriculture, but what differentiates it is the fact that it is part of the urban socioeconomic and ecological system[3]. Among this diversity, urban agriculture can be practiced in the form of community gardens, which are pieces of land (private or public) that are cultivated collectively by a group of people.

In many cities, community gardens have spread as a result of community activism. Historically, in 1649 in the county of Surrey (England), fabric salesman Gerrard Winstanley gathered a small group of followers and took over the land on a hill for food production at a time of political turmoil and crisis in supply. Known as "diggers," these activists demanded from local authorities over the course of a few months the right to cultivation, inspiring similar movements in the region[4].

However, it was only in the second half of the 20th century, with the emergence of counterculture movements in the USA, that urban agriculture grew to become an activist movement known as "guerrilla gardening." Here, "guerrilla" refers to the occupation of public areas without obtaining previous consent, where communities take over abandoned or unused land. The ideological foundation for this radical action model is to challenge the socio-spatial order in place. It is an alternative to urban crises, as well as an expression of how urban space can be permeated by farming areas[5].

The purpose of community gardens is not always to promote food self-sufficiency. They also promote a collective reflection about the urban space as an actual space for permanent food production

Environmental concerns related to urban agriculture include political and activist efforts to reduce greenhouse gas emissions, the relocation of food production (bringing it closer to large population groupings), lower fuel expenses for the transportation of food and raw materials, and its educational role, among other aspects. Concurrently, it flourishes from the urban population concerned about food matters – particularly the origin and quality of available food – as well as about new forms of public space occupation, the enhancement of local cultures, and claiming the urban space from a social and political perspective.

Panoramic view of the community garden *Horta das Corujas*
©Gustavo Nagib

Community gardens promote the transformation and enhancement of public space with the purpose of fostering social solidarity and integration. The purpose of these initiatives is not always to promote food self-sufficiency for its volunteers. They promote a collective reflection about the urban space as an actual space for permanent food production. In public spaces, community gardens encourage heterogeneous and horizontal (instead of hierarchical) social relations, serving as an inspiration for other types of activism and as a public policy lab. These purposes and forms of action take full form in the example of the Horta das Corujas community garden and its supporting online network.

HORTELÕES URBANOS, AN URBAN HORTICULTURIST NETWORK

Since 2010, the streets of São Paulo have experienced the emergence of community gardens, a new form of activism that redefines the conceptualization of collective space, creates and strengthens communities, and reclaims

2 SMIT, J.; NASR, J.; RATTA, A. Urban agriculture: food, jobs and sustainable cities. Vancouver: The Urban Agriculture Network, 2001.

3 MOUGEOT, L. J. A. Urban agriculture: definition, presence, potentials and risks, and policy challenges. Ottawa: IDRC, 2000.

4 REYNOLDS, R. On guerrilla gardening: a handbook for gardening without boundaries. London: Bloomsbury, 2009.

5 NAGIB, G. Agricultura urbana como ativismo na cidade de São Paulo. São Paulo: Annablume, 2018.

A day of collective work in the community garden *Horta das Corujas*
©Gustavo Nagib

chemical-free food. It is also deeply related to new forms of collective organization, such as online networks.

The creation of community gardens within the city of São Paulo actually started with the creation of an online network – a knowledge-sharing platform – through a Facebook group called *Hortelões Urbanos*[6]. It was co-created in 2011 by Claudia Visoni and journalist Tatiana Achcar, who had farmed across the USA and New Zealand.

Eight years after its creation, the Facebook group now has 82,000 members. The exchange of experiences about home and community gardens takes place every day of the year, 24/7. Seven moderators take turns approving posts and moderating debates. In times of political divergence, "fake news," and spam diffusion, virtual communities tend to succumb to torrents of irrelevant or opportunistic posts. However, the group's managers, who voluntarily give their time to support the cause, have acted to maintain *Hortelões Urbanos* as a space where learning is shared. It is a valuable form of online activism. All coordinators also cultivate community and home gardens in São Paulo, Porto Alegre (in the south of Brazil) and Manaus (in the Amazon forest). Its members are scattered throughout the entire country, covering all states and thousands of cities, including some Brazilians living abroad and Spanish-speaking members from other countries. Members seek guidance in the improvement of urban garden management and obtain immediate, constructive responses. Over the years, the group has been able to support not only the individual training of fruit and vegetable gardeners but also to inspire and coordinate the establishment of community gardens in public spaces, as well as in closed compounds and other private spaces.

Getting approval from local authorities to start a community garden proved to be a complicated task

THE BIRTH OF *HORTA DAS CORUJAS*

Eventually, the question of whether the group should mobilize to create a community garden was posed. Shortly thereafter, it was decided that two work groups were needed: one would be in charge of an online mapping of gardeners, requiring inputs available in towns for urban agriculture; the other would be in charge of coming up with a community garden plan.

The first group ended up inspiring an initiative that became known as *Cidades Comestíveis* (Edible Cities) led by André Ruoppolo Biazoti, an important urban agriculture activist and researcher. The second group started preparing a comprehensive report that would be delivered to São Paulo's local government, listing the numerous benefits of urban agriculture, as well as describing the operational details and the potential benefits of having an urban garden in a green area known as *Praça das Corujas*, located in an upper-middle-class neighborhood, close to the bohemian district of Vila Madalena.

Getting approval from local authorities to start a community garden proved to be a complicated task. However, a member of the regional environment council helped with getting in

6 Hortelões (horticulturist) had become an obsolete word in Brazil, where it is used to refer to someone who takes care of an orchard.

touch with the regional mayor to obtain approval for the project. Regional city hall clerks visited the park to check where the activists envisioned starting the garden and gave their informal permission. It is important to note that urban community gardens in public spaces were neither prohibited nor regulated in the city of São Paulo – and that is still the case today.

Community gardens have become a new category of urban amenity in public parks, and they redefine the layout of the collective space, allowing for greater community integration

An informal group started a series of preparatory activities, which included putting signs up at the park and posting on social media calling for volunteers to attend a meeting on July 14, 2012. On July 29, the first joint effort took place: the community garden's temporary boundaries were set, and a water tank was set up in the wettest area, where a budding water table was detected.

Municipal workers surrounded the area with a wire fence about 1 meter high to prevent dogs from entering the garden and the gates are closed with a string. However, access is free to all. The launch of *Horta das Corujas* reflected the popularity of the initiative, as 300 participants attended the event, reflecting a strong will to grow food as a community. Only two weeks after that, another community garden, known as *Horta do Ciclista* (Garden of the Biker), on Avenida Paulista, the city's most famous avenue, was launched with the help of Claudia Visoni.

At first, city dwellers demonstrated mixed attitudes in regard to *Horta das Corujas*. A lot of people came to the community garden, asking questions and admiring the space, sometimes even joining the activity. However, a small part of the local population found the garden ugly and untidy and feared it would attract "bugs, cockroaches, rats and beggars," as once said by a woman who visited the park regularly. Over time, resistance to the garden decreased and the flow of visitors increased. Although thousands follow the Facebook posts on the work organization of the community garden, fewer than 10 people actually do the daily maintenance work. Tens or hundreds of people come on specific occasions to help. Moreover, an unknown number of people act in a predatory manner, stealing plants, tools, and even compost. The group of volunteers has learned how to deal with a large amount of work and the stolen items by adopting a more detached approach and coming up with strategies such as planting mainly non-conventional plant foods (NCPFs), which are less known and commonly mistaken for regular weeds, thus perceived as less desirable.

In addition to gardening activities, workshops, hands-on lessons and talks, social gatherings and a lively community life take place in the garden. It is open to all visitors, regularly frequented by schools, families, and groups of friends, as well as by students of all ages, and researchers from all over the world. The initiative has also received considerable media attention, by hosting interviews and photoshoots that help spread information not only about this specific initiative but also about community gardens in general. The 800-square-meter area also serves as an example of environmental regeneration (several springs have appeared), as well as a native stingless bees' sanctuary, and where planting techniques involving proper water management are implemented. Over 200 types of plants are cultivated there, many of which are rare, and its microfauna has become increasingly diverse and abundant.

CONCLUSION: THINK GLOBALLY, ACT LOCALLY (DO IT TOGETHER)

Over the second decade of the 21st century, a new type of urban activism has stood out with regard to the occupation of public spaces in the city of São Paulo: community gardens have become a new category of urban amenities in public parks, and they redefine the layout of the collective space, allowing for greater community integration based on growing food that is free from pesticides and other chemical products in intraurban areas. *Horta das Corujas* is a pioneering example of this community-driven type of activity.

Urban agriculture is not necessarily a new concept, but this approach sheds a new light onto it as a citizenship action aimed at rethinking the current urban-industrial lifestyle. Considering the urban production model and its resulting contradictions, this type of activism focuses on alternatives at the community level. This effort to occupy public spaces for food production, breaking down the individualistic tendencies of contemporary society, is a good example. From this perspective, urban agriculture becomes an important tool for challenging and transforming the urban model that prioritizes individuality and socio-spatial segregation.

This activity must be included in the urban reform agenda as a tool for democratizing urban space planning and management. Urban agriculture in public spaces meets the needs of different social groups and inspires the establishment of creative public policies that foster social integration. Today, in São Paulo, it is also an example of taking the lead in terms of alternatives to official planning and a mechanism that compels new urban utopias.

Thus, urban community gardens help democratize urban space, allowing the population to exchange information and experience the city, also offering more leisure options. This type of urban agriculture has improved socio-spatial integration by reducing social isolation. When community gardens such as *Horta das Corujas* are located in areas accessible to all citizens, including those not working directly in planting and maintaining crops, they allow a more intense urban experience based on the collectivization of the land.

3. THE CHALLENGES OF DEPLOYING URBAN AGRICULTURE

Deploying urban agriculture depends above all on the initiative of companies, startups and non-profit organizations, but also on support from the public authorities, particularly local government authorities. At the same time, work is needed to raise consumer awareness of these new production methods and to train urban farmers to create quality supply chains.

Commitment from local stakeholders

Whether led by a startup or a large company, any urban agriculture project, when scaling up, must rely on the commitment of all local stakeholders.

In Singapore, the startup Edible Garden City, specialized in urban market gardens, benefited from the support of local government in a public-private partnership that facilitated access to disused spaces and the easing of regulations. Its aim is to improve the island city-state's food self-sufficiency, given that 90% of food is currently imported.

For Veolia, the pilot projects undertaken in Lille and Brussels, in connection with non-profits and social enterprises, are making it possible to formulate a new offer for cities and regions that integrate urban agriculture solutions with the Group's core businesses.

Guaranteeing product quality and raising consumer awareness

Successful deployment of urban agriculture depends both on the assessment of risk and the management of farmers' practices, so as to ensure an offer of quality products to final consumers. In the northern and southern hemispheres alike, urban crops are exposed to different types of pollution, linked to production methods, air and soil quality, and the properties of the plants themselves. The research programs carried out by AgroParisTech and INRA on urban farms in the Paris area, and joint projects between France and Madagascar on the water-cress production chain in Antananarivo, helped in the creation of new tools for managing health risks. They also highlighted the crucial role of consumer awareness in creating urban food streams that are both prosperous and clean.

Promoting urban agriculture methods and making products more accessible

To encourage the scaling-up of new farming models, the social enterprise Open Team developed an original method for sharing expertise through online tools and on-site training, teaming an experienced entrepreneur with student replicators. An initial program was implemented in Nepal, with possibilities for promising replications in urban settings.

By developing accessible technology capable of transforming a simple city-dweller into an urban cultivator, the startup Agricool intends to deploy its container strawberry production model all over the world. Using hydroponic technology and the automation of complex processes, these ultra-local strawberries can be produced all year round in the middle of cities.

Lastly, democratizing access to products obtained from urban agriculture requires the involvement of the key agri-foods players as distributors, such as Monoprix in the case of Agricool strawberries, or true partners. For example, collaboration between wholesaler METRO and the startup Infarm resulted in the largest indoor urban vegetable garden in Europe, inside METRO's depot in Nanterre.

Mathilde Martin-Moreau
Lorraine de Jerphanion
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Coordinators

DEPLOYING URBAN AGRICULTURE SOLUTIONS: A NEW OFFER FOR REGIONS?

Loïc Couttelle
Project Director
2EI Veolia

Vegetable farm pilot project in Lille - ©Christophe Majani d'Inguimbert

After 24 years working in Veolia's waste recycling and recovery business in France as a regional operations director, Loïc Couttelle is currently project director at 2EI Veolia where he heads up the Urban Agriculture project. He also privately runs a 40-hectare farm on the outskirts of Lille.

Against a background of increasing soil sealing and dramatic climate change, urban and peri-urban agriculture offer solutions to new regional challenges. Veolia supports cities and industries in the management, optimization and development of their water, material and energy resources, and is leading the debate on creating new agricultural production systems in urban and peri-urban settings, in synergy with its historical businesses. Its innovative experimental approach has identified an agricultural model that is both intensive and high-quality, in partnership with startups, social enterprises and local authorities. The model combines aquaponics with bio-intensive vegetable microfarming, and delivers a number of ecosystem services while ensuring efficient production with high added value. Located on available land within urban and peri-urban areas, these solutions are a response to growing consumer expectations in terms of short circuits and the traceability of food products. They offer great opportunities for urban development to improve landscape quality and inclusivity in cities, along with the well-being of their inhabitants.

INTRODUCTION

Between 2006 and 2015, mainland France has witnessed the disappearance of more than half a million hectares of agricultural land and natural areas, the equivalent of losing a department like Seine-et-Marne, Drôme or Loir-et-Cher every 10 years in terms of agriculture and ecosystems[1]. Soil sealing[2], which is growing more rapidly than the population[3], is destroying natural environments and threatening biodiversity, while also increasing flood risks. In this context, developing new methods of producing and supplying food is more necessary and strategic than ever for regions. Urban and peri-urban agriculture removes some of the pressure on rural land and brings biodiversity back into the city in response to these new challenges. Sharing many synergies with the Veolia Group's historical businesses, this activity corresponds to the growing appetite of city dwellers and local authorities for high-quality food production, short circuits and greener cities.

1 "La nature sous pression, pourquoi la biodiversité disparaît" [*Nature under pressure, why biodiversity is disappearing*] *Bilan 2019 de l'Observatoire National de la Biodiversité*, Agence Française pour la Biodiversité.

2 According to Eurostat, sealed land includes built land and covered and stabilized ground (roads, railways, parking lots, paths, etc.).

3 +1.4% per year on average between 2006 and 2015.

AN INNOVATIVE EXPERIMENTAL APPROACH

EXPLORATION PHASE

Veolia's interest in urban agriculture arose from its conviction that real opportunities exist for the Group in this area. Since 2016, staff at 2EI have been working on the design of new intensive and high-quality farming systems in urban and peri-urban settings. Extensive research has also been carried out on existing urban agriculture projects around the world, to build an understanding of the challenges involved and key success factors. The study's goal was to imagine what role the Veolia Group could play in creating this new food production model, drawing on the expertise of its historical businesses. It also sought to identify robust and repeatable business models.

These preparatory studies revealed two forms of urban agriculture of interest to Veolia:
- aquaponics (1)
- bio-intensive vegetable microfarming (2)

The aquaponics system (1), which combines aquaculture with hydroponics, makes use of Veolia's expertise in the design and construction of aquaculture processes through its subsidiary Veolia Aquaculture, and in the construction of circular models for managing energy, irrigation and fertility.

Bio-intensive permaculture-based microfarming (2) offers the opportunity to create new inclusive food-producing ecosystems for cities, including through the rehabilitation of industrial wasteland, where Veolia has significant expertise in decontaminating and bringing sites up to standard.

Two pilot projects have emerged from these two urban farming models, thanks to partnerships formed with local stakeholders:
- the Ferme Abattoir project in Anderlecht (Brussels), headed by Steven Beckers, which inspired Veolia to take a stake in BIGH (developer and operator of aquaponic urban farms) in 2019;
- an experimental bio-intensive microfarm, inspired by techniques developed at the Ferme du Bec Hellouin[4] in Haute-Normandie and implemented with the social enterprise ELISE on the site of the national wholesale market (MIN) in Lomme (Lille).

In Brussels, the Ferme Abattoir is BIGH's first production site. Located on the roof of a food market, its aquaponics system (which links fish farming ponds with horticultural greenhouses) operates according to the principles of a positive-impact circular economy, thanks to numerous synergies between the farm, the building it rests on, the district and the city itself. This magazine contains an article[5] on the subject.

4 Cf. Interview with Charles Hervé-Gruyer, co-founder of the Ferme du Bec Hellouin, in this issue of FACTS - the Veolia Institute magazine, "Permaculture and Bio-intensive Micro-agriculture: the Bec Hellouin Farm Model."

5 Cf. Steven Becker's contribution to this issue of FACTS - the Veolia Institute magazine, "Aquaponics: a Positive Impact Circular Economy Approach to Feeding Cities."

THE VEGETABLE FARM PILOT PROJECT IN LILLE

Veolia, already active in communal services management in Lille, joined forces with the back-to-work social enterprise ELISE in early 2018 to launch a short circuit, bio-intensive urban microfarm pilot project on the site of France's second-largest national wholesale market in Lomme, on the outskirts of Lille.

Encircled by a large green belt, the European Metropolis of Lille is France's most agricultural metropolis, with almost 45% cultivated land and more than 750 farms.[6] Bringing the rural and urban worlds closer together is an integral part of the city's development strategy, and often inspires projects to rehabilitate industrial wasteland, which is not lacking in the region. The conjunction of these regional characteristics with a strong political will to take on the challenges of food production and soil sealing made this urban agriculture pilot project possible.

The project has multiple objectives:
- develop expertise conducive to this type of farming, in terms of agronomy, economics and organization;
- assess its environmental benefits;
- explore roll-out conditions;
- exploit the potential of this new activity from a social inclusion perspective.

The 6,000-square-meter plot has been disused for 30 years, but is now being cultivated using methods inspired by the

6 https://www.lillemetropole.fr/votre-metropole/competences/developpement-territorial-et-social/agriculture-et-alimentation

©Christophe Majani d'Inguimbert

Parisian market gardeners of the 19th century. To make every square meter as productive as possible, in a sustainable way, these methods, in use at the Ferme du Bec Hellouin, hinge on the following: growing on permanent boards, densely planted mixed crops, and the management of organic matter flows and soil richness. Operation of the farm is also systemically organized according to the principles of permaculture.

In addition, the experiment made it possible to develop a dedicated digital planning and decision-making tool, plus a method for teaching bio-intensive microfarming techniques tailored to disabled people and/or people returning to the workplace. The training will be tested on the experimental farm site with the help of two disabled ELISE employees.

FROM CREATING THE ECONOMIC MODEL TO DEVELOPING A SOLUTION

AN ECONOMICALLY VIABLE URBAN AGRICULTURE MODEL

While urban agriculture projects are often implemented on a small scale, with limited goals in terms of food production, Veolia instead wants to develop economically viable models centering on efficient production processes and strong local partnerships. Based on the experiments conducted in Lille and Brussels, Veolia's urban agriculture model combines vegetable microfarming and an aquaponic farm on the same site. These two activities complement one another from an economic, social, and environmental point of view:

- Although it is seasonal, **bio-intensive vegetable microfarming** requires little initial investment. The main costs arise from human resources, as production is not mechanized. The farm can operate in collaboration with the social and solidarity economy and provide an opportunity for people returning to the workplace. From an environmental perspective, the diversity and concentration of vegetable varieties offers high potential for carbon storage in the soil. According to a study carried out by the University of Liège[7] at the Bec Hellouin farm, the storage rate in plots cultivated using bio-intensive microfarming was between 7 and 26 times higher than the "4 per 1000" target[8], depending on the cropping intensity and production type. Other environmental benefits provided by this type of agriculture include increased soil permeability (which reduces the risk of flooding), retention of biodiversity, and the reduction of urban heat islands.

Based on experiments conducted in Lille and Brussels, Veolia's urban agriculture model combines vegetable microfarming and an aquaponic farm on the same site

- Faced with the fragility of fisheries stocks and the need to rethink our consumption of animal protein, demand for farmed fish is currently growing strongly. In this context, the high-quality aquaculture production made possible by **aquaponics** ensures the economic solidity of the model. Unaffected by the seasons, fish farming and greenhouse vegetable growing are almost continuous throughout the year, but do require highly specialized technical management. The main ecological advantage of aquaponics lies in making use of resources from the urban setting: heat, water, CO_2 and organic material. A real lever for circularity, this farming method draws on recirculating aquaculture system (RAS) technologies developed by Krüger Kaldnes, a subsidiary of Veolia Water Technologies. Equipped with an aeration device, this semi-closed loop system is designed to maximize production while simultaneously reducing pollution and water consumption, using a continuous mechanical and biological treatment system. Hydrotech Drumfilters separate solids, while carbon and nitrogen pollution are eliminated by the AnoxKaldnes™ MBBR (Moving Bed Biofilm Reactor) process, with biomass fixed to a suspended surface. This internal expertise provides a powerful competitive advantage to potential aquaponics projects supported by the Group.

DEVELOPING SYNERGIES WITH THE GROUP'S HISTORICAL SOLUTIONS

Urban agriculture now provides a major boost to Veolia's historical water, energy and waste businesses.

In the face of soil sealing, climate change and biodiversity loss, local food production solutions address needs expressed by city dwellers that foreshadow a profound transformation in consumption patterns, centered on short supply chains of traceable and high-quality products. In Asia and the Middle East especially, increasing food self-sufficiency is a major priority. In that respect, urban agriculture is an effective tool for transforming regions; Veolia's proposed intensive and high-quality production system, with its strong social dimension, is a move in this direction.

The development of urban agriculture solutions is in step with the Group's activities in two ways. Firstly, the Group's expertise in sanitation, developed with its water businesses, justifies launching activities linked to food production. Secondly, its technological expertise in effective circular systems is a key advantage in positioning Veolia as a pivotal player in this future strategic sector.

In addition, the many sites run by Veolia represent considerable land resources, with privileged access to heat and energy resources, and immense potential for future urban agriculture projects with their need for 1 to 1.5 hectares. It is now a question of convincing partners and subsidiaries that there is a genuine opportunity to be seized with positive impacts. Initial results are encouraging, as since 2018, the team responsible for this area has received

7 Valentin Sohy, Félix de Tombeur, and Jean-Thomas Cornélis, *Influence des pratiques de la Ferme du Bec Hellouin sur la fertilité et la matière organique du sol*, Université de Liège and Institut Sylva, 2017.

8 Based on solid, documented science, the international "4 per 1000" initiative launched by France at COP21 on December 1, 2015 aims to identify and implement actions to store carbon in soil. It takes its name from its target of a 0.4% annual increase in soil carbon stocks, in the first 30 or 40 centimeters of soil, which would significantly reduce the concentration of CO_2 in the atmosphere linked to human activity. https://www.4p1000.org/fr

numerous requests from business units, in Europe and beyond, interested in integrating these solutions into their range of services.

CHALLENGES TO LARGE-SCALE IMPLEMENTATION

SUCCESS FACTORS

Aside from the necessary synergies with the Group's activities and resources, the pilot projects enabled identification of the factors for successfully starting up urban agriculture projects and building sustainable food supply chains.

Involving local stakeholders

Local organizations (local authorities, associations and social enterprises) are the main stakeholders in the project. Aside from the land-use dimension of urban agriculture projects, strong political impetus at the local and national levels can accelerate scaling-up considerably. Public procurement plays a leading role in rolling out these solutions: urban agriculture can significantly help public-sector food providers to meet their new obligation to supply 50% of food from local sources or with origin and quality labels and 20% organic food by 2022 as required by the EGalim Law.[9] Whether they are a local authority or business organization, implementing a participatory system with technical support from Veolia constitutes a key success factor.

Becoming part of the local production system

It is crucial to remember that urban agriculture alone cannot satisfy all a city's food requirements. However, to ensure local production is not thrown off balance, it is essential for the project's success to work with farmers on keeping solutions compatible. This is why urban agriculture solutions must be designed and implemented to blend harmoniously with the local production system.

Shaping the local food supply chain

Developing urban agriculture requires the construction of regional food supply chains that necessarily involve building partnerships between different stakeholders, from production through to consumption.

Raising end consumer awareness of the quality of urban agriculture

The high quality of the produce obtained from urban agriculture must be emphasized and promoted, as must the environmental benefits offered by Veolia's chosen techniques. Additionally, understanding any psychological barriers relating to indoor production is an essential part of the marketing effort necessary for an urban agriculture project to succeed.

Building expertise to facilitate roll-out

Pilot sites make it possible to combine and consolidate the expertise required for Veolia's chosen agricultural methods to succeed, whether in the fields of agronomy, biodiversity, or operational processes and fertility management. This applies especially to the field of bio-intensive vegetable microfarming, where the dissemination of good practice around the world has so far been patchy. Tools for capitalizing and spreading knowledge are essential to the expansion and scaling-up of the urban farming solution.

Making urban agriculture a tool for inclusion

The link with the social and solidarity economy is essential: working with people excluded from employment via back-to-work organizations or local associations allows urban agriculture to fulfil its potential as a regional tool for inclusion.

IMPROVEMENT MEASURES

Various measures currently exist for improving the model:

- On a technical level, the model proposed by Veolia still needs to be standardized, which would optimize production while adapting to the features of the different sites. In view of this, Veolia recently launched a research program with the Institut Supérieur d'Agronomie in Lille, which aims to create practical techno-soils, composed of local organic and mineral resources, to enable vegetable microfarming on sealed or polluted land.
- The supply of fish food, currently based on fish meal that has been imported over long distances, is currently the least sustainable link in the production chain. It would be preferable to use insect-based feed, which would be facilitated by Veolia Group partnerships with startups working in insect farming.
- The circularity of the model could also be improved. The aquaponic farm operation currently depends on access to clean water to supply the system, via a borehole or the urban network. Research is under way into using recycled or desalinated water, but this is subject to confirmation that this model is acceptable to end consumers.
- The possibility of building processing facilities on site remains open.

CONCLUSION

As part of its mission to provide services to the environment, Veolia has developed expertise in the area of urban agriculture with a view to supporting regions in shaping high-quality local food production. The experimental phase implemented in Brussels and Lille uncovered a new activity compatible with all the Group's businesses, based on technical capabilities it already possesses via its existing recirculating water treatment and soil decontamination technologies. In response to one of the major challenges of the coming decades, the model proposed by Veolia and its partners can exploit unused resources in circular loops, create social value through employment, and continue to make urban spaces healthier and more pleasant places to live.

9 Law passed on October 30, 2018 to balance commercial relationships in the agricultural and food sector with making food healthy, sustainable and accessible to all.

BUILDING SUSTAINABLE URBAN FARMS WITH GOVERNMENT SUPPORT IN SINGAPORE

Bjorn Low
Founder and Managing Director
Edible Garden City

Edible Garden City manages a farm on the rooftop of Raffles City shopping mall. Harvests from here supplement the produce grown for restaurants at Citizen Farm - ©Edible Garden City

After a career in online marketing in London, Bjorn Low spent three years travelling and working on organic farms across Europe. He then decided to complement his initial training in business administration (MBA) and obtained a diploma in Biodynamic Agriculture in Great Britain. He returned to Singapore with the ambition of combining his knowledge of farming and his business skills: in 2012, Edible Garden City was started with the hopes of building urban farms to help Singapore tackle its food security challenges.

Launched in 2012, Edible Garden City is specialised in building urban gardens with the ultimate objective of increasing Singapore's resilience and people's connection to food within the city. It operates in the very particular environment of Singapore, a hyper-urbanised city where 90% of food is still imported. To implement a viable and sustainable urban farming model, Edible Garden City has chosen to develop different activities seeking to combine commercial activities with socially driven projects. From consultancy to community farming, Edible Garden City has built 200 edible gardens and can potentially produce a total of 150 kg of leafy greens and 150 kg of mushrooms per month through its "Citizen Farm". The project benefited from the support of the local government through a public-private partnership which has been key to allowing unused spaces to serve for community and commercial agricultural purposes and to reforming regulations to be more accepting of urban farming. This collaboration between local authorities and the privately managed urban farming company demonstrates the importance of cooperation among public and private actors to foster the development of farming initiatives at the city level.

INTRODUCTION

Singapore is a highly urbanised city-state constrained within a small island which is home to 5.5 million people with fairly high purchasing power. Agricultural lands account for less than 1% of its total land area.[1] It may therefore seem natural that 90% of its food is imported[2] and that Singaporeans are not naturally driven to work in agriculture or to reflect upon food's origins and how it is grown. This appears as a pressing issue, considering that global food demand is expected to increase by 70% by 2050, whilst climate change threatens worldwide agricultural production. Ensuring its population is well nourished by a food production model that respects the environment and promotes social cohesion is a key challenge for the city of Singapore.

Edible Garden City, an organisation specialised in building urban gardens, has sought to increase Singapore's resilience and people's connection to food since 2012. Its activity has recently expanded through Citizen Farm, a sustainable and socially driven community farm which commercialises its products and provides training and educational content. To develop a sustainable and viable business model, Edible Garden City received support early on from local authorities through a public-private taskforce which helped them overcome the challenges to urban farming in Singapore, such as the incompatibility of land use legislation with urban farming initiatives.

1 Ichioka, S. M. "Food Security and Community Bonding in a Globalised City-State: The Case for Urban Farming in Singapore". National Parks Board.

2 Kwek, A. "How Citizen Farm's Sustainable Urban Farming System Offers Ultra-Fresh Ingredients to Singaporeans". 2018.

THE EDIBLE GARDEN CITY PROJECT

A HOLISTIC APPROACH RELYING ON MULTIPLE INTEGRATED BUSINESS MODELS

Edible Garden City is a ground-up movement that started seven years ago as a way of introducing urban farming to the people of Singapore for residential, educational and recreational purposes. After building small-scale gardens for restaurants for three years, Edible Garden City's vision has evolved over the years with the ambition of giving "every city a farm, every home a garden, and every family a farmer".

Edible Garden City aims at shifting the focus away from trade onto consumers, rebuilding their connection to food and including them in food production. To further these goals, Edible Garden City's activity has diversified into three main ventures with the objective of combining economic viability with social impact. These perpetrate contrasting business models, which are intrinsically and ultimately interlinked as well as constitutive of Edible Garden City's holistic approach to urban farming.

The first and older line of activity of Edible Garden City is the urban garden consultancy, through which the firm builds and grows gardens on city buildings for property developers and restaurants, schools, malls, offices and private residences. Tailored to the customer's needs and goals, the consultancy consists of building a holistic plan to design, build, maintain and manage the urban farm, besides providing the necessary support and tools for its financial viability. Edible Garden City also provides training for customers (i.e. isolating the rooftop, composting), so that they can graduate from external aid and become independent in managing their own garden – an essential aspect in a sustainable model of urban farming. The second line of activity involves operating Edible Garden City's own urban farm, called Citizen Farm. It operates as a classic farm – albeit in an urban setting – by growing, packing and selling products directly to the market at a competitive price. Its customers are mainly composed of restaurants and people from the community, who place orders online and can either have it delivered to their home or establishment or pick it up from the farm themselves. The workforce of the farm is constituted of around 40 employees, who range from 22- to 65-years-old with a 70-30% share of women to men. Trained through an apprenticeship before being offered a full-time position, the farmers come from a diversity of backgrounds. Finally, Edible Garden City provides educational workshops and farm tours by engaging closely with schools, corporations and other communities interested in strengthening their internal sustainability. Citizen Farm and other gardens built by Edible Garden City operate as classrooms in which participants are taught agricultural content and curriculum in order to enable them to grow vegetables in their own spaces and to raise awareness about urban farming.

Leafy greens are grown on the farm in decommissioned shipping containers, using an indoor hydroponics set up ©Edible Garden City

In addition to these activities, Edible Garden City also exercises a range of social activities. It has collaborated with civil society organisations such as the Autism Resource Centre, Employment for People with Intellectual Disabilities and the Singapore Prison Service to teach farming skills to people with autism and mental disabilities and to inmates. Edible Garden City has helped build a sensory garden for hearing-impaired children and a 150-square-foot garden for the Pathlight school for autism. It also helps the schools design their farming curriculum and teach it to students. The Citizen Farm team is itself composed of some individuals with special needs and from disadvantaged backgrounds, furthering the farm's social role.

Beyond a simple food supplier, Edible Garden City is looking to have a bigger impact on the community through both its commercial activities and its social engagements, which form its social enterprise model of urban agriculture.

Edible Garden City's vision has evolved over the years with the ambition of giving "every city a farm, every home a garden, and every family a farmer"

EDIBLE GARDEN CITY'S MAIN RESULTS TO DATE

Since its creation, Edible Garden City has built more than 200 edible gardens, which vary across a range of sizes – from smaller (e.g. 1x2 or 1x3-square-metre urban gardens in small homes)

At full capacity, Edible Garden City's Citizen Farm urban farming project can produce 150kg of vegetables and 150kg of mushrooms - ©Edible Garden City

to bigger ones (e.g. a 10x10-square-metre rooftop garden). For instance, the Open Farm Community restaurant has transformed a former golf course into a 10,000-square-foot permaculture community garden which grows 50 varieties of vegetables and herbs, tropical fruit trees, and chickens used in the restaurant's high-quality, organic dishes. Another example is the OUE Downtown commercial building, whose rooftop is covered by a 5,000-square-foot garden which supplies herbs, flowers and salad leaves to the building's restaurants.

Citizen Farm itself grows up to 20 varieties of leafy salad greens such as lettuce, kale and spinach; herbs and microgreens such as basil, mint, lemongrass and coriander; and edible flowers and mushrooms. At full capacity, it can produce a total of 150 kg of leafy greens and 150 kg of mushrooms a month. These products are used in 50 businesses across the island, including world-renowned Michelin-star restaurants, luxury hotels, supermarkets and cosmetics producers. Despite the lack of external funding or high price premiums on their products, Citizen Farm has been profitable – albeit marginally. Citizen Farm has developed the "Citizen Box", in which a range of fresh products is supplied weekly to about 50 subscriber families.

The grounds of Citizen Farm are also home to Singapore's first insect farm, run separately by Insectta. Insectta currently uses food waste from the food manufacturing process (i.e. spent grains, okara and other items) to feed black soldier fly larvae. The larvae are sold as a livestock feed to local fish farms and pet owners. A natural fertiliser from the grass is generated for agricultural use as well. This method recycles food waste – a negative-value product – into useful positive-value products that give back to the economy. At a third of full capacity, Insectta recycles over 6 tons of food waste a month.

The farm also employs a combination of hydroponics, an indoor substrate-based system, and outdoor soil-based farming, and it is exploring using organic waste to grow mushrooms. The combination of these different techniques makes it possible to use considerably fewer resources than traditional farming.

A PUBLIC-PRIVATE PARTNERSHIP TO CONVERT UNDERUSED, MARGINAL LAND FOR URBAN FARMING

EARLY CHALLENGES FOR PIONEERING URBAN FARMING IN SINGAPORE

When Edible Garden City emerged, the initiative was confronted with a series of obstacles, intrinsic to its forerunner status. First, there was a considerable lack of space for farming in a densely inhabited city like Singapore. Land scarcity was exacerbated by a complex and restrictive regulatory legislative framework related to land use, since land dedicated to farming was extremely limited and no land allowed farming for social purposes, while land set aside for community purposes did not permit farming.

One of the two varieties of mushrooms grown by Edible Garden City, the pink oyster mushrooms have a bright pink colour and strong umami flavour, making them a favourite among chefs and home cooks - ©Edible Garden City

Regulations had not followed the evolution of technology which enabled mobile farming systems that can be easily adapted to various spaces, in opposition to the constraining operationalisation of sizeable traditional farms.

Second, Edible Garden City faced the difficulty of understanding the structure of local authorities to find the right city representative. Government agents were dispersed across numerous levels, departments and agencies. Developing Edible Garden City was also about dealing with a new, ill-defined concept of urban farming, as well as an unconventional proposal of designing, building and operating gardens on diverse city spaces, which had never been done before in Singapore.

The taskforce and Edible Garden City worked as a public-private partnership to develop the Citizen Farmproject, navigate complex land use regulations, and identify the obstructing factors to the development of urban gardens in the city

CREATION OF A DEDICATED PUBLIC-PRIVATE PARTNERSHIP TASKFORCE

Recognising the needs of Edible Garden City and the potential benefits of urban agriculture, Singapore's Ministry of National Development led to the birth of an interagency Urban Farming Taskforce with responsibility for analysing the potential impact of technological innovation on domestic food production. The taskforce and Edible Garden City worked as a public-private partnership to develop the Citizen Farm project, navigate complex land use regulations, identify the obstructing factors to the development of gardens in the city, and develop solutions to such. It also played a key role in persuading government agencies such as the Singapore Land Authority to allow unused spaces to serve for community and commercial farming and to reform regulations to be generally more accepting of urban farming. Coordinating internal communication among the authorities on the matter allowed Edible City Garden to establish effective dialogue with local government. Cooperation between Edible City Garden and government actors was necessary for them to work separately from there.

ACHIEVEMENTS

The outcomes of this public-private cooperation have been extremely fruitful. Edible City Garden was able to find the right disused terrain for its Citizen Farm on the 8,000-square-metres of land which used to house the Queenstown Remand prison, demolished in 2010. Citizen Farm was launched in June 2017 and has become a central piece of Edible Garden City's project.

Since then, the Singapore government has also announced the "30 by 30" project, which aims at bringing local food production up to 30% (from the current 10%) by 2030.

The government saw great value in the community creation and social bonding that emerged from the experience. It also allowed startups to test agrotechnology innovations, contributing to Singapore's technological capacity and economic productivity. The normative impact of the initiative was also significant, as even the Foreign Minister of India visited Citizen Farm. Singapore is now globally recognised as a regional leader and knowledge hub for urban farming. In addition, environmental sustainability has been strengthened through the concept of circular economic models for agriculture, and local food security has been enhanced as urban farms supplement food production and decrease external dependence. Admittedly, urban farming by itself cannot supply all the food consumed by urban dwellers, but it can nevertheless complement imports, especially those of products that can be harvested and grown again, such as vegetables, fish and eggs.

Admittedly, urban farming by itself cannot supply all the food consumed by urban dwellers, but it complements imports

THE NEXT CHALLENGES FOR SCALING UP URBAN FARMING INITIATIVES AT DIFFERENT LEVELS

To scale up urban farming, there are still challenges at different levels – global, national and at the scale of Edible Garden City.

AT THE GLOBAL LEVEL

- **Improving the definitions of urban farming itself:** at the global level, the main challenge for urban farming involves the need to enhance the existing definitions in the field, which relies mainly on the private sector. There must be more dialogue between private sector initiatives across the world to establish precise and rigorous categorisations of urban farms, peri-urban farms and rural farms. Such a development would help urban agriculture initiatives gain in organisation, visibility, legitimacy and understanding, which is needed to bring about support for their scaling and expansion. Only a common, precise definition and categorisation of different types of agriculture would allow the identification of problems and who does what best.
- **Building human capacity:** despite the recent growth in interest in farming, a lasting reality is the lack of experience and training in the sector as a result of farm employees being brought up as urban dwellers. Urban farms are obliged to hire untrained professionals from backgrounds other than agriculture and train them for a long period of time before they can be regarded as fully operational. As such, urban farms need to *build* human capability, rather than simply *acquiring* it. The general lack of manpower resources for the agriculture industry is a worldwide challenge, which requires more partnerships between the private sector and academia for higher studies to include farming as an option for students interested in the agricultural sector.
- **Support from decision-makers:** the case of Singapore illustrates how urban farming requires not only openness but also active support from local governments, as they determine the allocation of land and its usage. The structure of government, with its numerous points of access and stakeholders who do not always communicate with each other, can be a real barrier to developing urban agriculture, since it requires convincing numerous actors at different public sector levels, departments and agencies. Public-private partnerships are one of the many ways through which local authorities can support urban farming on rooftops, footpaths and vacant lots.

AT THE NATIONAL LEVEL

- **Increase awareness:** Singaporeans still lack widespread, deep awareness of acting upon more sustainable consumption patterns, which hinders the development of demand among the 5.5 million inhabitants with high consumption power.
  As a result of the limited spread of responsible consumption among the Singaporean population, urban farms need to spend money on marketing to 98% of the population. The situation is not the same worldwide. The European ecosystem is already mature, as illustrated by the conscience and initiatives against waste, the "buy local" movement and healthy diets. Singapore, notwithstanding its developed-country status, still has some way to go before reaching that sustainability stage.

AT THE PROJECT LEVEL

- **Adapting the right technology to the right project:** recent technological advances have made it possible to design layered indoor farms under controlled conditions, sometimes without the need for soil. They have also enabled farmers to get four to five times higher yields for the same space in comparison to traditional farming. Nevertheless, there needs to be the right fit with the right technology. Edible Garden City depicts a so-called "technology agnosticism" in that, rather than attempting to create a new kind of technology or supporting/depending on one particular kind of technology, its approach relies on employing different kinds of technology (e.g. aquaponics and hydroponics) and levels (i.e. no tech, low-, medium-, high-tech), which vary according to the needs of each situation and the objectives of each customer. Different technologies are continuously tested to observe their viability, advantages and drawbacks in different settings.
- **Understanding real impacts:** convincing the population and key stakeholders such as policymakers directly depends on urban farms' ability to demonstrate and

Gardening workshop at the Citizen Farm - ©Edible Garden City

understand their real impact. At Edible Garden City, more services such as data tracking, social and environmental impact measurements, and statistical infrastructure are to be incorporated this year through a specialised team, in order to measure activities not only internally but also with the community, and to convert the stories and testimonials they have achieved into concrete, measurable numbers and metrics. This is a crucial step for enabling Edible Garden City to understand its own impact on the community, the kind of social value it creates and its positioning among other societal initiatives, as well as to identify drawbacks and room for improvements. Building strong evaluation methods contributes to professional growth and to the ability to draw support from the broader population and attract potential partners.

CONCLUSION

Edible Garden City is today a successful social enterprise launched in the context of the hyper-urbanised and densely built-up cityscape of Singapore, where agriculture has never been a key economic activity or particularly present in people's minds or sustainability demands. The initiative relies on a holistic approach that combines different models to pursue its long-term vision of sustainability: commercial activities, community farming, educational content and societal engagements.

The support of local government through the creation of a public-private partnership taskforce helped communication with the multiple public actors and agencies, and made it possible to identify the main challenges to urban farming initiatives, notably the complexity of the regulatory framework for land use. The city of Singapore has affirmed itself as an early model of acceptance of and support for urban agriculture which has been widely regarded and reported. The city-state today stands out as a leader in urban food production and technology, ultimately contributing to resilience and food security while reconstructing the link between customers and food.

Important steps remain for scaling up urban farms at different levels. At the global level, the private sector needs to agree on definitions of urban agriculture and its different categories, and agricultural training should be provided like any other option in higher studies curricula. At the national level, governments and private enterprises need to reinforce efforts in raising awareness among customers. At the project level, urban farms must develop social and environmental impact metrics in order to attract cross-sectoral support, as well as to find and optimise their positioning among wider society. These are key challenges to enable Edible Garden City to expand to other global metropolitan hubs and to turn Singapore into a real "edible garden city".

REPLICATING POSITIVE-IMPACT PROJECTS: THE OPEN TEAM PLATFORM

Sokha Hin & Joanne Schanté
Co-founders of Open Team

Scale School program training workshop in Nepal - ©Open Team

Both engineers in the telecommunications field, Sokha Hin and Joanne Schanté worked for 10 years in different business sectors and launched several startups before devoting themselves to social entrepreneurship in 2013. In early 2015, following their participation in the UN's 20th annual Climate Change Conference (COP20) at the invitation of the French Environment Ministry, they cofounded Open Team, a nonprofit organization dedicated to replicating social and environmental innovations through a digital platform and acceleration program.

Open Team's mission is to support knowledge transfer and the scaling up of innovative projects in the fields of agroforestry, food security and responsible consumption, along with education, gender equality, renewable energy while ensuring respect for indigenous populations. The Scale School program enables entrepreneurs who have implemented mature and sustainable solutions to transmit the keys to their success to other project leaders. This replication model is currently being used at a biointensive microfarm in Nepal, combining permaculture with local knowhow – a fruitful learning experience focused on the challenges of deploying new agricultural practices with possible applications in urban settings.

INTRODUCTION

Spiral Farm House is a biointensive microfarm inspired by permaculture located in the Saptari district of Nepal. Its goals are to regenerate soil damaged by chemical contamination, provide the local community with food security, increase resilience to climate change, and create jobs. Convinced of the initiative's potential, the international team from the French social enterprise Open Team is supporting its scaling up and helping to share it with other farmers so they can adopt the same approach. More generally, Open Team aims to replicate mature social and environmental solutions by providing human, financial and logistical resources, thanks to a high-impact investment model and innovative skillsbased sponsorship. The Open Team knowledge-transfer model could equally be applied in other sectors.

THE OPEN TEAM KNOWLEDGESHARING PLATFORM

AN INITIATIVE THAT BEGAN LIFE AT THE LIMA COP20

Above and beyond the diversity of the projects and ecosystems involved, leaders of projects with high social and environmental impact often encounter the same difficulties in implementing their initiatives: scaling up, legal constraints, technical challenges, etc. At the same time, many social entrepreneurs are keen to share their know-how and explain the factors of their success. In 2014, at COP20 in Lima, the similarity between solutions developed by entrepreneurs in Latin America and those in Europe was very instructive. It showed the extent to which expertise has already been shared by thousands of NGOs and social enterprises, which have so much to learn from each other but lack the methodological framework to organize the transfer of knowledge and skills.

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Drawing on their considerable experience in the fields of telecommunications and social entrepreneurship, Sokha Hin and Joanne Schanté led a discussion on knowledge sharing. Although it is by no means a new issue, the advent of the internet and digital has revolutionized access to information on a planetary scale, as epitomized by the online encyclopedia Wikipedia. In 2007, the Nobel Laureate in Economic Sciences, Elinor Ostrom, in collaboration with Charlotte Hess, suggested looking at knowledge as a common asset[1], whose governance must be tackled at the international level. These ideas resonate even more strongly today, with increasing calls to put our collective intelligence to work for an ecological transition in the face of climate emergency.

CREATING A KNOWLEDGESHARING PLATFORM

The creation of Open Team initially made it possible to test various mechanisms for facilitating knowledge sharing between social entrepreneurs, supported by a scientific committee of 14 people with wide experience in different fields, including development assistance, key account business, entrepreneurship and innovation. In 2016, Open Team has been mandated by the French Environment Ministry to orchestrate the international 100 Projects for the Climate initiative. The aim of the call for projects was to map out the NGOs and social enterprises around the world spearheading innovative local solutions in response to climate challenges. One hundred champions were selected from the 600 projects mapped and their solutions presented at COP22. Open Team used the opportunity to create a collaborative platform establishing links between candidates and champions to facilitate knowledge sharing and capitalization.

To date, the platform contains 3,000 projects from 80 countries, classified according to which Sustainable Development Goals (SDG) they address and their progress status: idea, in creation, active, in replication, or completed. Among these initiatives, soil regenerative agriculture inspired by permaculture is particularly well represented, both in rural and in urban and periurban settings. The platform features almost 200 projects focused on urban agriculture issues and how cities are adapting to climate risks, including the Baštalište network of community gardens in Serbia, Edible Garden City initiative in Singapore, Malaysian Urban Green Waste Reuse project, aquaponic solutions startup Save Our Agriculture in Cameroon, and Climate City initiative in France.

THE SCALE SCHOOL ACCELERATOR MODEL

AN ACCELERATOR FOR KNOWLEDGE TRANSFER

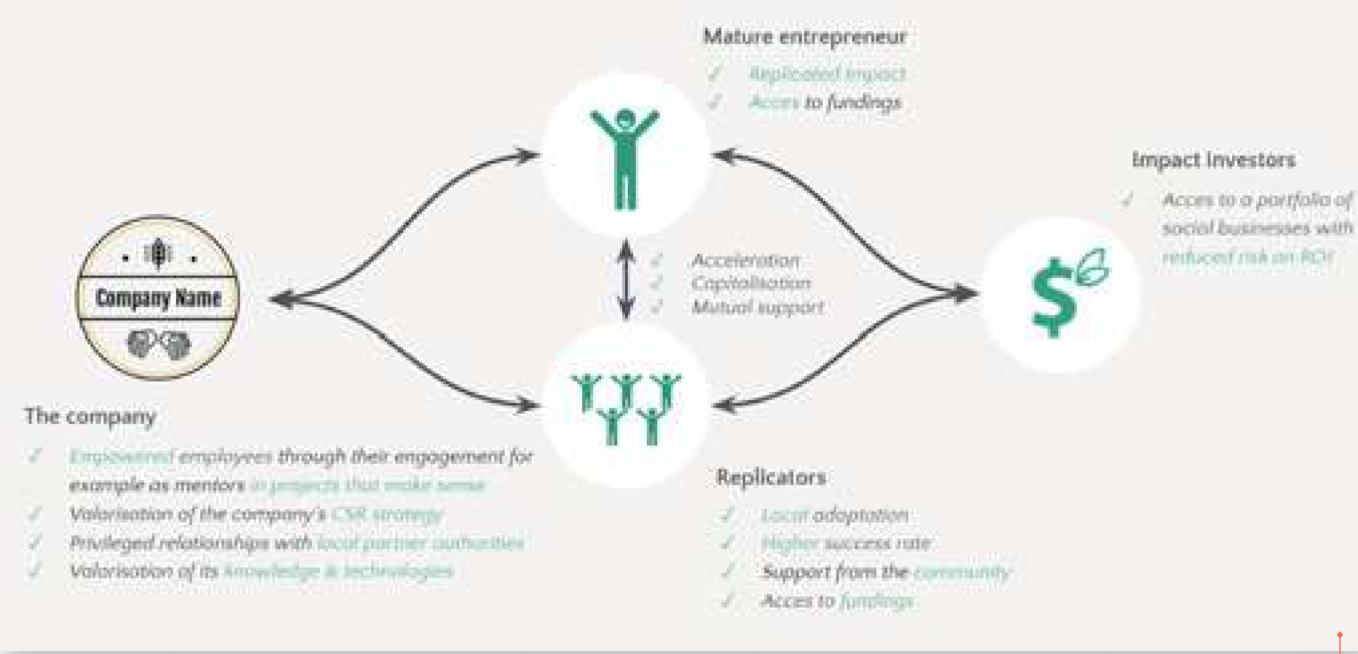
Building on the platform's success, Open Team decided to go even further and create a mediation framework for knowledge transfer. Implemented at COP22 in Marrakech, Scale Camp brought together around a dozen social entrepreneurs over two weeks and confirmed the feeling that simply linking parties digitally through the platform is not enough to bring about knowledge transfer. This "offline" experience allowed real synergies to emerge between the participants, who were able to work together and teach one another the techniques they each apply in their own region.

The approach was so productive that in 2017 Open Team launched its new Scale School program with the aim of meeting the need for face-to-face interaction. The program is an accelerator which aims to provide a framework for transferring knowledge between an accomplished entrepreneur and a group of student entrepreneurs working physically together on site, with the experience being documented to create a MOOC (massive open online course) and a knowledge hub, an opensource knowledge base.

IMPLEMENTING REPLICATION OF A PROJECT WITH HIGH SOCIAL AND ENVIRONMENTAL IMPACT

The Scale School three-year training program offers entrepreneurs with mature solutions the human, financial and technical resources they need to document their know-how and pass it on to a group of students entrepreneurs

1 Elinor Ostrom and Charlotte Hess, *Understanding Knowledge as a Commons. From Theory to Practice*, MIT Press, 2007.



The Scale School replication process

(replicators) hoping to replicate the technology and business model. The system could be described as a social and environmental franchise. In addition to sharing knowledge, the program's aim is to roll out proven successful environmental solutions on a large scale.

The Scale School threeyear training program offers entrepreneurs with mature solutions the human, financial and technical resources they need to document their knowhow and pass it on to a group of student entrepreneurs

The Scale School offers the tutor not only support from Open Team personnel, but also preferential access to investment and help from national and international experts.

Replicators' technical equipment needs are met in the form of a "package" (for installing an irrigation system or solar panels, for example) financed by micro-impact investors.

For these micro-investors, financing the replication of technology or know-how that has already proven successful minimizes their risk while maximizing the social impact.

The Scale School is also a platform for companies seeking to diversify their CSR strategy, which can involve their specialists in high social impact projects (skills-based mentoring of tutors) and offer their employees the opportunity to cofinance replicators' packages as micro-impact investors.

THE FIRST PROJECT TO BE REPLICATED: AN ORGANIC MICROFARM IN NEPAL

AN ENTREPRENEUR SUPPORTING ORGANIC AND TRADITIONAL FARMING KNOW-HOW

The first project the Scale School helped with the replication process promotes the agricultural expertise of indigenous peoples. A champion of the 100 Projects for the Climate initiative, the Spiral Farm House project was launched in 2013 by Sudarshan Chaudhary, a young Nepalese entrepreneur and former Secretary General of the Federation of Nepalese Indigenous Nationalities. He comes from a farming family and became aware at a young age of the major environmental and health problems caused by conventional agriculture, including soil depletion, reduced crop yields and chronic illness among Nepalese farmers exposed to chemical pollution. In 2013, having completed his studies in Kathmandu, he decided to return to his home village to transform his parents' farm into an organic farm[2] and reconnect with traditional Nepalese farming methods, as practiced before the introduction of agrochemicals in the 1970s. For three years, he worked to create a sustainable chemical-free food crop production model similar to permaculture: Spiral Farm House.

Located on the Indian border in the Saptari district, 30 minutes from the district's main city, Rajbiraj (population 40,000), Spiral Farm House successfully sells its produce

2 Although the farm's produce is not certified organic, no agrochemicals are used at Spiral Farm House.

Example of visual aids used in the Scale School – ©Open Team

locally, but hopes to supply the nearby urban centers, where residents' spending power is increasing along with their awareness of the benefits of organic farming. The first Scale School's aim is to respond to the challenge of scaling up and promoting alternative farming methods in Nepal, with the goal of creating an extensive network of organic microfarms organized in a cooperative which will distribute its produce in Kathmandu and other Nepalese cities.

THE REPLICATION PROGRAM

The Scale School's first goal is to replicate the Spiral Farm House model with other Nepalese farmers, then to roll the model out internationally to other NGOs and social enterprises. The first group of "replicators" undergoing training is made up of eight farmers, each from a village in the district, chosen for their motivation and leadership capabilities, which will facilitate the transfer of knowledge. Once they have internalized the new biointensive farming techniques, they will each in turn be able to train six to eight farmers from their village. Training takes place on the farm site and is delivered in Nepalese. It takes around four months at a rate of one or two days a week (the farmers[3] are often struggling and cannot afford to stop farming for longer than this, as they would risk losing their only source of income and/or food).

The Scale School's objective over the next three years is to train 5,000 farmers (5% of farmers in the district), enabling them to reach a potential market of 35,000 consumers. In terms of social and environmental impact, the expected benefits are manifold:

- raise standards of living and improve health for farmers by improving crop yields (biointensive farming model) and eliminating agrochemicals;
- offer consumers healthy, highquality food;
- promote good management of natural resources (especially water) and soil regeneration, making farms more resilient to the effects of climate change (especially the risks of lowland flooding).

Open Team personnel are divided between France and Nepal. From France, they provide support functions (program direction, digital communications, website administration, management of the MOOC platform and development of the teaching program). In Nepal, a Nepalese post-doctoral researcher specializing in analysis of Nepalese rural agriculture, three French agronomy students from AgroParis Tech and a Finnish startup manager support the training process and documentation of knowledge. Topics covered in lessons include the main principles of permaculture, effective management of resources (water, seed and soil), landscape design, and even vermicompost production. Alongside this technique-based teaching, Open Team organizes training in social entrepreneurship and "entrepreneur know-how", and advises the farmers on their future role as trainers. Each farmer/replicator also receives a starter kit (tools, seeds and compost) to help them put the techniques learned into practice on their own farms. An impact study is planned to accurately measure the project's environmental, social and economic benefits (in particular, the number of farmers actually converting to alternative farming methods).

3 35% of Nepalese farmers live below the poverty threshold.

CONCLUSION: EDUCATION AND OPPORTUNITIES

Implementation of the replication process raised a number of challenges. One of the most significant lay in creating teaching content to match the profiles of farmers in the Saptari district. For example, teaching materials had to be designed to reflect the fact that 55% of them are illiterate. Also, few of the farmers have internet access or the ability to use digital tools, including computers and smartphones, which limits the platform's usefulness as a way of relaying information and requires finding other ways to consolidate onsite learning. Open Team is therefore working on designing visual aids that can immediately be understood by any farmer anywhere in the world. These lessons learned in the training domain will be applied to upcoming replication projects focusing on plastics recycling and water management.

This project in Nepal has shown that in addition to the purely agricultural challenges, gaining access to large city markets requires forming partnerships with local farming collectives and public bodies to set up distribution channels in urban centers. There are also bridges to build with the rooftop agriculture initiative being promoted by the city of Kathmandu in connection with local NGOs (the Women's Society Cooperative and Rangjung Yeshe Shenpen[4]).

Although its focus is on organic permaculture, the initiative offers a number of lessons to help us better understand the necessary conditions for rolling out urban agriculture. At this stage, it would seem difficult to develop a single methodological framework. Projects such as the Scale School do nonetheless allow us to identify some key success factors: commitment from all stakeholders, a focus on training, and an approach tailored to the local situation.

4 "Urban agriculture in Nepal: understanding women's practices in Kathmandu" conference, http://www.au-lab.ca/2017/08/31/conference-lagriculture-urbaine-au-nepal-comprendre-les-pratiques-des-femmes-a-katmandou/.

URBAN AGRICULTURE AND HEALTH: ASSESSING RISKS AND OVERSEEING PRACTICES

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Experimental rooftop kitchen garden at AgroParisTech, rue Claude Bernard, Paris (CIPUrA project) - ©Baptiste Gard 2016

Christine Aubry is a Research Engineer at INRA and a consultant professor at AgroParisTech. While working on deforestation at the Development Research Institute (IRD) in Madagascar between 1999 and 2002, she discovered urban agriculture in Antananarivo. Since then, she has been interested in intra- and peri-urban agriculture in countries in the South and North. Nastaran Manouchehri is a Research Engineer at AgroParistech with a PhD in chemistry. Since 2012, she has been interested in the quality of urban crops and is co-responsible for the participatory research project REFUGE (Risk in Urban Farms: Management and Evaluation).

Practiced worldwide for its environmental and social benefits as much as for its food-growing potential, urban and peri-urban agriculture is exposed to various forms of pollution related to cultivation methods and urban air and soil quality, as well as to the varied reactions to pollutants exhibited by different crop types. Faced with this broad spectrum of factors, empirically proven methodological frameworks make it possible to assess health risks and oversee practices in close contact with all actors involved. This is the aim of the work undertaken by teams from AgroParisTech and INRA working on the T4P and REFUGE programs on urban farms in the Paris region, and the Franco-Madagascan ADURAA and QUALISANN programs studying vegetables-growing in Antananarivo, capital of Madagascar.

INTRODUCTION

Urban agriculture projects have been multiplying and diversifying since the turn of the millennium. With all types of solutions varying from aquaponic greenhouses on city rooftops to permaculture, we are witnessing far-reaching alterations in the ways that food is grown. But although the positive impacts of urban agriculture in economic, social, environmental and even nutritional terms are widely reported, it is also vital to look scientifically at the health risks that relate to agricultural production in urban settings. Studies in France and Madagascar highlight specific issues raised in both hemispheres when it comes to defining quality criteria for urban farming and creating the tools needed to support urban agriculture project owners while simultaneously fostering good practices on the part of growers and consumers alike.

POTENTIAL CONTAMINANTS AND CITY-GROWN FOOD

There are numerous factors to take into account when mapping the pollutants to which urban agriculture can be exposed, whether relating to the location where crops are grown, the type of crop, or the characteristics of the soil and pollutants.

POLLUTION SOURCES AND CONTAMINATION VECTORS

A distinction is made between ground-borne and air-borne pollution. The former transfers via the root system whereas the latter involves pollutants absorbed by the parts of the plant that lie above ground level. Water can also be a source of bacteriological or phytosanitary pollution from the use of harmful pesticides, particularly in southern hemisphere countries. Lastly, directly ingesting soil is also a contamination vector.

These distinctions are useful in pinpointing the issues in terms of pollution and growing produce in an urban environment that are specific to developed economies as well as those that apply to emerging economies.

The example of cress-growing in Madagascar, studied as part of the QUALISANN program, is a good illustration of the health issues facing urban agriculture in the southern hemisphere. The risks to city-grown food are mainly bacteriological from residents' wastewater, and are due to the location of production areas in low-lying, flood-prone parts of the city.

In the northern hemisphere, urban agriculture in inner cities and peri-urban areas is developing primarily in short supply chains using methods similar to organic farming, so residual pesticide levels are low. On the other hand, pollution from traffic and in the soil from former industrial uses is a major concern.

SOIL PROPERTIES AND POLLUTANTS

It is also important to differentiate between various types of pollutants, according to their harmfulness and properties when in interaction with their environment. Lead (Pb), for instance, is less mobile than cadmium but it transfers more readily to plants where the soil is acid and low in organic matter. So, the concentration of a pollutant in the soil is simply a partial indicator of pollution risk; another factor is the characteristics of the pollutants and of the soil.

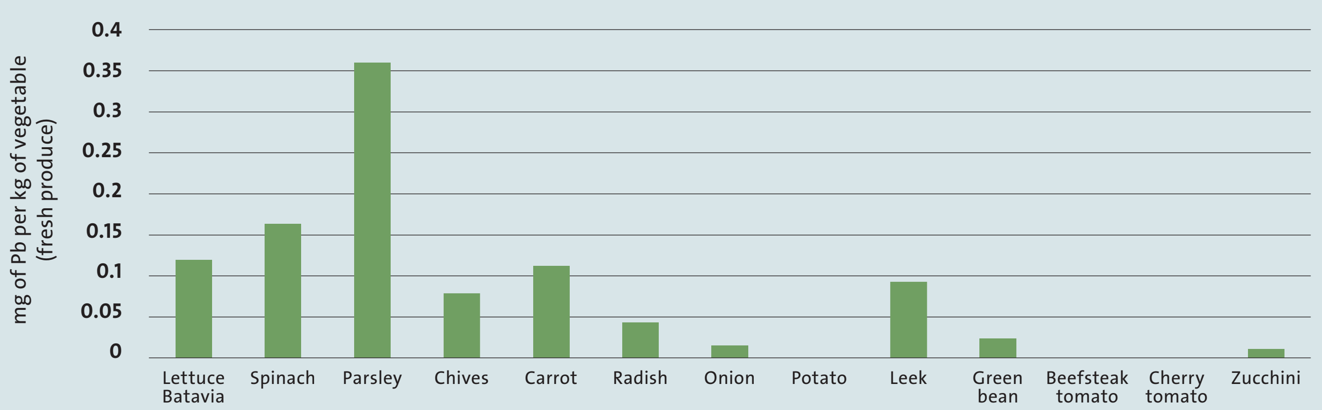
CROP TYPES

Not all crop types are equally sensitive to soil or air pollution. Lead pollution has very little impact on the edibility of fruit, but it does diminish the edibility of some vegetables. For example, leafy vegetables (lettuce, cabbage, spinach, etc.) that have a large area exposed to atmospheric particles, and root vegetables (carrot, radish, beetroot, etc.), are more exposed to risks than fruiting vegetables (tomato, pepper, eggplant, etc.). Certain garden herbs, such as parsley, are heavily exposed to soil and air pollution alike. In urban agriculture, great care must therefore be taken when choosing the location for cultivating such plants. The time it takes for a crop to grow is another consideration. The longer a plant is in the soil, the more it is at risk of being impacted by a range of pollutants; for example, this means that thyme, which is exposed year-round, is more sensitive to pollutants than basil.

URBAN AGRICULTURE MODELS

The type of urban agriculture also plays a not inconsiderable role in cutting or increasing some risks. Indoor urban agriculture, for example, will naturally tend to minimize the risk of air or soil pollution. But this model of farming raises other issues that relate to the amount of energy consumed, the profitability of the crops – in the light of the financial investment needed – or the artificial nature of such growing systems, which sometimes struggle to be accepted by consumers who are wary of wholly artificial local production systems.

Example of results analyzing lead (Pb) concentrations in vegetables grown in contaminated soil



ASSESSING HEALTH RISKS: MEASUREMENTS AND TOOLS

MEASURING POLLUTION IN URBAN AGRICULTURE: CASE STUDIES

In recent years several research projects and experiments have set out to measure the healthiness of urban produce at the local level.

T4P, which began in 2012, is a project run by a team of researchers from AgroParisTech and INRA. It aims to assess the feasibility and safety from a health standpoint of food grown on rooftops. Ten vegetable plots were selected from the 367 hectares of urban agriculture projects in the Paris region. Installed on rooftops of various heights and with varying nearby traffic levels, they permit a comparative analysis of the degree of pollution. Four of them are located on suburban shopping malls, in Porte de Versailles, Vélizy-Villacoublay, La Défense and Levallois-Perret; four others are on the roofs of buildings occupied by public transportation operator RATP. An experimental vegetable garden has also been established on the roof of AgroParisTech *(see photo below)*. The last site examined is on the roof of a Carrefour supermarket in Villiers-en-Bière. The results obtained so far are very encouraging. At only one site, where there are kitchen herbs that are especially sensitive to pollutants, were the EU's health norms exceeded. At all the other sites, concentrations of trace metals (cadmium, lead, arsenic, nickel) are 3 to 5 times lower than the European regulatory thresholds.

The study also measured pollution caused by highly carcinogenic polycyclic aromatic hydrocarbons (PAH) from wood stoves and road traffic. At the time of writing, the 45 vegetable samples analyzed exhibited concentrations of the most dangerous PAH in levels below the minimum regulatory thresholds set by the European Commission.

This means that in a city like Paris, once beyond a certain distance from major thoroughfares and above a certain height for growing (roughly speaking above the 3rd or 4th floor), the concentration of pollutants diminishes drastically; this means that vegetable crops grown there are generally harmless to eat.

In emerging economies, city-grown crops often face an accumulation of risks. The cress grown in Antananarivo is a good example and has been studied by a multi-disciplinary Franco-Madagascan research team of agronomists, chemists, economists, geographers, microbiologists and nutritionists since the early 2000s[1]. This work has highlighted the inherent risks relating to geographical location and the ways that cress is cultivated and sold. The capital of Madagascar presents health risks at every stage of the chain. Upstream, the topography of the cress-growing locations presents an initial risk factor as these are often close to major roads or housing, with the wastewater discharges this entails. In terms of the way the cress is cultivated, there is clear evidence of excessive use of pesticides, herbicides and fertilizers. Lastly, there are also risks engendered by the sales method: produce is not sorted or washed prior to sale, cars used for transportation are rarely cleaned and stallholders frequently rinse cress in dirty water because drinking water has to be purchased from standpipes.

Irrespective of the public health challenges, the food-growing role of urban agriculture remains central in southern hemisphere countries where the majority of fresh produce (vegetables, eggs, milk, etc.) is sourced from the city or its immediate environs.

REFUGE: A METHODOLOGICAL TOOL

REFUGE (urban farm risks: management and assessment) is a participative research program set up in 2016 by a research team from INRA and funded partly by AgroParisTech, then by ADEME (the French environment agency) and the Île-de-France Regional Council. It aims to develop an empirically proven methodological framework for assessing the health risks of urban agriculture. As part of a more wide-ranging study into how Paris's city farms operate, the REFUGE methodology is designed to assess and manage health risks relating to the presence of trace metals in soils and, more recently, total concentrations of PAH and hydrocarbons. It relies on twin complementary approaches, each the result of two years of experiments at micro-farms.

The first component seeks to describe existing forms of soil or air pollution using a range of techniques inspired by methods used by ADEME in its polluted sites and soils programs, which include soil analysis, study of the physicochemical structure, and drafting exposure scenarios for people likely to visit the site. These analyses are intended to make risks easier to interpret and are useful as decision-support tools. The diagnosis is nuanced in most cases. It is rare to encounter a configuration where pollution is inexistent or omnipresent and in most cases the reality lies somewhere between the two. Taking this as a starting point, it is then necessary to multiply the number of categories to take account of all possible situations: carrying out quantitative regression analysis of health risks, analyzing test vegetable samples, etc.

The second component of REFUGE is designed to improve management of previously identified risks through adoption of a health control plan. Health control plans are grounded in regulations that apply to conventional agriculture and use well-known risk management methods such as HACCP[2] (Hazard Analysis Critical Control Point). Health control plans include a set of good farming and food hygiene practices to adopt in order to improve risk management, including carrying out regular soil contamination analyses, preventive measures to guard against air-borne soil (wearing masks and gloves, careful watering), and performing tests on certain specific types of vegetables.

1 Work carried out as part of CORUS ADURAA (analysis of the sustainability of agriculture in the Antananarivo agglomeration) from 2002 to 2007, QUALISANN from 2007 to 2010, and LEGENDE, a current project run by CIRAD and INRA.

2 Introduced into the EU in 1993 by Council Directive 93/43/EEC on the hygiene of foodstuffs, HACCP is based on the following principles: identifying, assessing and describing the control points.

The REFUGE methodology is designed to be used by a range of different actors. The first of the project's components focuses primarily on municipalities, seeking to give them the tools they need to grasp the nature of risks that can be a problem for some plots used for urban farming, and to ensure that sampling takes place under the right conditions. Once they are better informed and aware of what is needed, municipalities can, where necessary, approach a consultancy with expertise in polluted sites and soil to provide them with a legally binding site appraisal. Health control plans are designed more to help in the implementation of urban agriculture projects by businesses or private individuals. In time, it is also possible and desirable for the ministry of agriculture to become involved in the nationwide promotion of health control plans for urban agriculture.

It is imperative to involve all actors in building a healthy urban agriculture activity, first of all by making sure that they know the risks

RECOMMENDATIONS AND OUTLOOK

It is possible to list several recommendations for improving the food safety of urban agriculture and, in a more general sense, for helping to drive its growth.

First of all it is vital to focus on crops that are best suited to this form of cultivation, and on developing products that complement, rather than compete with, conventional agricultural products. For instance, it is better to focus on growing produce with high added value, such as micro greens, mushrooms or exotics that might benefit from urban heat islands. It is important to remember that urban agriculture is less about growing large volumes and more about growing locally and offering innovative crops, at least in industrialized countries.

Next, it is imperative to involve all actors – municipalities, businesses, farmers and residents – in building a healthy urban agriculture activity, first of all by making sure that they know the risks.

In southern hemisphere countries, local people are relatively aware of the problem of bacteriological pollution. In Antananarivo people eat cress cooked, not raw, because locals place greater importance on food safety than on a lower nutritional value. But quality criteria for foodstuffs from urban agriculture in the southern hemisphere are generally yet to be fixed, and not all actors in the chain from producer to consumer are equally aware of the health risks. There are also other concerns that have to be addressed, particularly the health of farmers exposed to pollutants and the impacts of excessive pesticide use on biodiversity.

The situation in northern hemisphere countries is more contrasted. In France, municipalities' position on the subject of urban agriculture varies from the overly cautious, tending to overlook the benefits, to the majority that simply knows little about it, and are hampered by a lack of resources. Mirroring this are consumers, who also show varying degrees of awareness and mobilization. Although it appears that there is some concern about artificial cultivation systems, produce grown by urban agriculture is still hardly ever spotted on supermarket shelves, making it difficult to draw any conclusions at this stage.

There is also the question of providing appropriate tools for helping with risk management. It would be a good idea, for example, to bring together soil analyses and the monitoring of vegetables to make oversight of an urban agriculture project easier; currently, consultants tend to specialize in one field only. In the same vein, a digital version of the health control plan will soon be available and distributed as widely as possible to people and bodies involved in running urban agriculture projects. Working through its regional network of DRIEA offices, the French ministry of agriculture is incrementally adopting positions on these issues, which means it is vital that urban agriculture respects the same food safety standards for the use of contaminants and pollutants that apply to conventional agriculture. This will require new legislation in the future.

CONCLUSION

Maximizing the benefits of the potential offered by urban and peri-urban agriculture in economic, social, environmental as well as nutritional terms demands efforts both to improve understanding of the risks and to improve practices. This twofold challenge shows that greater collaboration between researchers, project owners and public authorities is more important than it has ever been.

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NEW TECHNOLOGIES IN SUPPORT OF URBAN AGRICULTURE

Guillaume Fourdinier
Co-founder and CEO, Agricool

Cooltainer in the Bercy district of Paris - ©Agricool

Guillaume Fourdinier gained a degree in management from the Grande Ecole IÉSEG in 2010. A farmer's son with real entrepreneurial passion, he set up his first business while still pursuing his studies, before founding Agricool with his colleague Gonzague Gru. The business started in 2015 on a family farm where the two co-founders decided to reuse an abandoned container. After several test phases and trials of more than 30 strawberry varieties, they came up with their first 100% connected and automated farm model with the goal of local, pesticide-free production.

Since 2015, Agricool has been developing container farm models designed for growing strawberries in the heart of the city. Following several years' research and development, this project, launched by two farmers' sons, uses a closed-loop aeroponic system, low-energy LED bulbs and software to provide optimal conditions for strawberries to grow. The yields obtained are 60 times greater compared with traditional strawberry-growing methods, and the strawberries have a 20–30% higher sugar and vitamin content, while the carbon footprint is reduced. To date, the Agricool model has relied on a few "cooltivators" trained in-house, but the aim is to harness new technologies to make this production method available to as many people as possible.

Agricool has developed a farm model that allows year-round strawberry production, without soil or pesticides, in containers using innovative technologies (Internet of Things, software, data, etc.). What roles do agronomy, engineering and software play in your farm model?

Guillaume Fourdinier: We have indeed implemented different technologies to grow strawberries in the urban environment as cleanly and efficiently as possible. Most tasks performed inside the container can be automated using the techniques and technologies we have developed. Planting and picking are the only tasks that are still done entirely manually.

First, we decided to verticalize our farming by using plant walls on the sides of the containers, which are completely modular, allowing optimization of the usable surface of the containers and the urban land on which we plant. One farm, comprising between 1 and 10 containers, normally produces between 4 and 20 metric tons of strawberries over the year. The fruits are continuously picked, as we are regularly adding strawberry plants, which grow in a three-month cycle and bear fruit steadily.

In traditional agriculture, doubling plant density per square meter means sharing resources such as light, nutrients, root space, etc., and consequently halving production. Conversely, our model uses technology to maintain sufficient inputs and increase density without losing yield. To this end, we designed our own system of LED lights, which allows us to provide a spectrum and light intensity tailored perfectly to the life cycle of the strawberry. This system uses little energy, but provides optimal lighting that maximizes plant density.

We also developed an aeroponic system in which our plants grow without substrate. Their roots are literally in the air, fed by a nutrient-rich mist, allowing them to grow unconstrained. This means there is no barrier to increasing the density per square meter. We operate extremely precise climate control that reproduces the day-night cycles to allow the maximum number of plants in a minimum of air, with perfect management of moisture supply, carbon dioxide level, temperature, etc. This is carried out within a technologically complex closed loop. For example, we had to find a suitable system to allow the water used to irrigate the plants to be recovered and reused. This is a complex mechanism because the plants consume different nutrients depending on the phase of the strawberry's life cycle (flowering or fruiting periods, for example).

In the end, we developed our own software, which allows us to track 100 data points per second in the container environment, and to automate the whole strawberry life cycle via algorithms that control the air and water conditions. The data we collect can then be used to analyze any anomalies.

Inside the Cooltainer - ©Agricool

What are the main advantages of your version of container growing, particularly in terms of resource usage (water, energy, etc.)?

G.F.: Our model is based on rational, scientific thinking and resulted from various observations.

On one hand, France imports 75% of the produce it consumes, and we know that imports harm the planet, especially when the produce is out of season. On the other hand, current food production will need to increase 70% by 2050 to feed the global population. Producing food directly in cities is a necessary alternative to an unsustainable model. However, land in cities is far more limited, expensive and difficult to manage than in rural areas. If food production within cities is to be sustainable and sustain people, for example to feed 20% of a city's inhabitants, it needs to be much more productive, but without using pesticides or reducing nutritional quality.

Our technology allows us to create far greater production capacity in the urban environment than in the open air, meeting the double challenge of fighting climate change and increasing food production. After four years of research and development, we have successfully multiplied the yield per square meter by 100 and developed a production model that remains stable throughout the year. We currently have eight containers in Paris with 40 plants per square meter, which is 60 times higher than the strawberries sold by large retailers. We can produce 7 metric tons of strawberries per year, the equivalent of a half-hectare field.

After four years of research and development, we have successfully multiplied yield per square meter by 100 and developed a production model that is stable throughout the year

Agricool strawberries on sale at Monoprix - ©Agricool

This increase in yield was achieved with no loss to taste or nutrients. On the contrary, our strawberries contain on average 20% more vitamin C and 30% more sugars than those bought in supermarkets – without genetically modifying the plants or using pesticides, which are harmful to both human health and the environment. Additionally, the closed loop consumes 99% less water than an ordinary greenhouse, and works using only renewable resources, whereas traditional agriculture uses machinery (tractors, etc.), transportation (ships, planes, trucks, etc.) and a lot more water. So, we are ecologically and sustainably producing pesticide-free strawberries that taste better and are healthier.

Right now, we're the first to make strawberries grow in Dubai, a rapidly growing city with high levels of wealth and consumption that is nonetheless forced to import almost all its food. Establishing local strawberry cultivation seems to be a change with enormous potential for expansion that could bring considerable environmental benefits.

Our "cooltivators" are not all agronomy graduates: our technology makes strawberry growing accessible by automating the most complex aspects and processes

Your model relies on training "cooltivators" to work your container farms. Is the job of "cooltivator" more like being a farmer or a programmer/data scientist?

G.F.: Our vision is to make better-quality products available to as many people as possible. To do that, we need to increase our number of farms, and therefore of farmers. However, the challenge is that farming is a job that requires several years of study and practice. The aim of our farms is to make the job of "cooltivator" accessible to as many people as possible.

Our "cooltivators" are not all agronomy graduates: our technology makes strawberry growing accessible by automating the most complex aspects and processes. The first things we look for in our candidates are motivation and a desire to learn, along with self-discipline and attention to detail. They then spend three months training in the planting, picking and monitoring of crops. Becoming a producer without being an expert is the key to our model, and will enable us to increase the number of farms. We hope that one day, anyone will be able to set up their own farm and become an Agricool farmer, working independently, but with our continuing support via distance monitoring of the farms. As well as our technology, using containers contributes to the democratization of agriculture, as they enable the building of diverse farms adapted to the space, means and goals of their owners.

In the future, we may see hybrid models emerge: an Agricool farm could be established within a traditional farm, or traditional farmers could work with us in the urban environment

Our team currently consists of 80 people from extremely varied backgrounds, from engineering to farming via marketing. This diversity is an asset for Agricool, because a mixture of knowledge fosters innovation. Our R&D department is the largest in terms of employees: we have 50 people dedicated to research. Our teams constantly strive to improve our model and study new methods for growing fruits to diversify our production. The strawberry is a first step – chosen because it is currently difficult to find quality strawberries on the market – but we want to develop other crop types, such as tomatoes.

Are end consumers, and even traditional farmers, not suspicious of Agricool urban farms, with no soil and based on cutting-edge technology?

G.F.: Most people have a quite emotional relationship with food and farming. Urban container farming, like many topics connected with technological innovation, can sometimes divide opinion. Different people react differently: optimists perceive technology as a key to solving problems, compared with more skeptical types who tend to be suspicious of things that might seem unnatural.

However, in our case this suspicious reaction is generally negligible. It seems most consumers are looking for ways to respond to the environmental challenges we all face, and are generally welcoming and positive about technologies that potentially offer solutions. Agricool is generally viewed as part of the solution to progressing to a more sustainable world.

As for the farming community, we have generally maintained highly positive relations with traditional farmers. Our relationship is not competitive, but rather complementary in terms of supplying cities with food. Many farmers come and talk with us with a great deal of enthusiasm and curiosity. We promote these exchanges with the aim of building and strengthening bridges between these different types of farming. In the future, we may see hybrid models emerge: an Agricool farm could be established within a traditional farm, or traditional farmers could work with us in the urban environment!

Three years on from starting the business, you have raised €25 million to industrialize your model. What are the next steps for Agricool?

G.F.: We've devoted a lot of skill and time to research in recent years. The main use of these funds will be to continue our efforts in this direction. We want to consolidate and improve our model to increase our yield, consume less energy and diversify our production.

Investments will next be used for deployment: our goal is to increase our current yields and to multiply the number of farms in France and internationally. Our goal is to get 200 people involved at Agricool by 2021 to deploy hundreds of containers with a view to industrializing and scaling up our model.

Cooltainer in the 13th arrondissement of Paris, near Station F - ©Agricool

PROMOTING ACCESS TO PRODUCE SOURCED FROM URBAN AGRICULTURE: THE CASE OF METRO AND INFARM

Florian Cointet
General Manager, Infarm France
Flavien Sollet
Store Manager, METRO Nanterre
Marie Garnier
Head of Quality and Sustainability, METRO France

Florian Cointet, General Manager of Infarm, in the METRO indoor farm - ©Maja Bialon

A graduate of the National Institute of Applied Sciences (INSA) and the ESCP European business school, Florian Cointet worked in strategy and operations teams at Givenchy, EFESO Consulting and EY-Parthenon before joining Infarm in September 2018 as General Manager (France).

Marie Garnier is a veterinary physician and has been Quality and Sustainability Director at METRO France since 2011, having previously been Quality Manager at the Monoprix supermarket chain for seven years.

A graduate of the Université des Eaux de Vie in Segonzac, Flavien Sollet joined METRO in 1997 and became manager of the Nanterre store in December 2016.

In November 2018, the METRO store in Nanterre opened Europe's largest indoor urban garden, operated by the startup Infarm. Incorporated directly into the wholesaler's store, the Infarm garden is based on a vertical hydroponic design using a closed water loop that allows production of several varieties of herbs throughout the year. Although yields are as high as 600-700 plants harvested per day, equivalent to 4 metric tons and 40% of the herbs on sale in the store, the environmental impact of this initiative is appreciably lower than with conventional farming.

Despite the inevitable differences in size and business culture – a startup working with France's leading supplier to the independent catering industry – the two organizations complement each other impressively well. Infarm grows the produce right inside the store with a full-time team of two people who deliver their herbs to METRO department managers literally just a few meters away, ensuring an ultra-local supply of super-fresh herbs.

METRO and Infarm signed a partnership agreement in 2018 to create Europe's largest indoor urban garden inside the METRO store in Nanterre. How did this come about?

Florian Cointet: To understand the origins of this collaboration between Infarm and METRO, we must go back to the creation of Infarm a few years ago. The project was started by Osnat Michaeli and the brothers Guy and Erez Galonska, who left Israel for Berlin in 2012. They wanted to make fresh fruits and vegetables accessible in winter without harming the environment and started to experiment with *indoor* growing methods. They began very simply by growing salad crops in their lounge.

They officially founded their startup Infarm in 2013 with support from investors and European Union funding. Their goal is to offer a new urban farming model that can provide high-quality, fresh, environmentally friendly plants, and their main business is building indoor vertical farms.

In 2015, with only a dozen employees on board, the startup gained the attention and trust of METRO Germany, with whom they signed their first partnership agreement. The wholesaler invested in an initial prototype, a small cube for growing herbs inside one of the largest stores in the Friedrichshain district of Berlin. The success of this first partnership enabled Infarm's expansion into other METRO branches.

A fresh injection of capital followed, which gave impetus to a strategy of expansion across Germany and Europe. In 2016, Infarm's French organization approached METRO France to enter a partnership to create a new indoor vertical farm dedicated to herbs, which opened in 2018.

Marie Garnier: The story of our partnership can basically be traced back to our visit to the METRO pilot in Berlin, which proved it was possible to make plants grow inside a retail space. After this meeting, we wanted to stay in touch with Infarm as they continued to develop their technologies and equipment. In the years following, we saw increasing demand from the community and from consumers for more responsible, and environmentally friendly production methods with a shorter supply chain. Our partnership with Infarm is in line with METRO's determination to meet these demands and new challenges.

We believe Infarm differs from other innovative urban farming initiatives because the real objective of their farms is to supply sales outlets, unlike other projects that have a primarily educational, entertainment or esthetic focus. These models are also interesting, but they address issues other than production. We are focused on Infarm and METRO's joint vision of harnessing urban farming to ensure sustainable and ultra-local provision that is also scalable. We also wanted to grow produce that meets our customers' demand for quality. This is now one of the key factors in the partnership's success – herbs grown on

Outside view of the Infarm indoor farm in METRO's Nanterre store - ©Maja Bialon

site, in the store itself, have real advantages in terms of both freshness and flavor compared with what you would usually find in supermarkets.

What are the advantages of the indoor farm model developed by Infarm inside the METRO store compared with other existing systems?

F.C.: Infarm has designed a vertical garden that can accommodate herbs at various stages of maturity and allows regular harvesting. Infarm vertical farms have a cabinet structure with a standard width and depth (2 x 1 meters) to accommodate the machinery beneath, but with variable height, so they can be adapted to more limited spaces. Farms can be added as you like, accumulating and adapting them to the space available. The one condition is having access to water and electricity. In the farm at METRO, there are 18 gardens in total, adding up to an area of 80 square meters. The plants are distributed across 200 trays, and each tray contains different stages of one variety. Young seedlings are planted in the middle of the tray, where they have more space to grow; growing plants are placed outside these, with the most mature plants positioned at the edges of the tray. Once a week, the plants at the edges are harvested.

In addition to this design, Infarm developed its own hydroponic system. The principle of *hydro* (Latin for water) – *ponics* (Latin for grow) is simple: growing things in water. This ancient method can be traced back to the Gardens of Babylon and to the Maya, who planted crops in rivers. The organic plant seeds are placed in a neutral substrate that supports their roots, then germinated in a nursery. When the computer system tells us they have germinated, the plants are placed in the water in the middle of the tray.

The water is used as a nutrient medium. It's stored in each module's tank, enriched with nutrient solution – the recipe for which was developed and is regularly modified by Infarm – that provides the nutrients required for plants to grow, such as calcium, potassium and magnesium. A robot constantly measures and balances the parameters (nutrients, pH, electrical conductivity, temperature, etc.) of the water used to irrigate each tray, which then flows back down into the tank. So, we reuse this water in a closed cycle, meaning very little is used – just enough to replace the water lost through evaporation.

To provide the light needed for photosynthesis, we use LEDs that reproduce white light. The intensity is less than with the red wavelengths, which can boost plant growth, but consumes less energy. We're currently working with a doctoral student from Paris Tech to lay down a more precise analysis of the life cycle of our plants and our resource consumption.

We also use many new technologies, such as the Internet of Things, robotization and artificial intelligence, to perfectly and continuously control the conditions in which the plants grow. Each farm has a robot and computer connected to the internet, which have 20 or so sensors to measure and adjust the various parameters (water, light intensity, ambient temperature, etc.), alter water levels by activating pumps, reproduce the day-night cycle, etc. All this information can be accessed through a computer or smartphone app that enables remote management of the parameters. Nothing's left to chance in this model!

You're only growing herbs at the moment. Why did you choose this type of plant?

F.C.: Infarm made a strategic choice to specialize in herbs because these plants are well suited to our *indoor* model, and also because there is real demand for quality herbs and original varieties.

Flavien Sollet: We started with really classic varieties, like chives, parsley, basil, etc. But we realized we could offer our customers more specific, more exotic varieties that are less commonly sold in France. These species were previously rarely sold due to their high price and low quality, but the availability of Infarm herbs has allowed us to increase our sales volumes for herbs that have increased their market share. This includes, for example, kale, garden cress, confetti cilantro and Thai basil, of which we now sell around 15 packs daily. Wasabi rocket, previously unknown to French chefs, has also been highly successful and is now in great demand. Recently a chef asked for sesame seed sprouts, which we'll be developing with Infarm. We're offering something extra that attracts new customers and adds to the diversity of restaurant owners' purchases.

Daily harvesting of herbs by the Infarm team - ©Maja Bialon

M.G.: We could describe that as research and development conducted directly with the customer. This creates a virtuous circle in which we respond to their requests in an almost bespoke manner.

METRO and Infarm are very different companies, in their business areas, their size and potentially their business culture. How are roles and responsibilities shared within your partnership?

M.G.: Our collaboration is actually based on how our structures complement each other. METRO made an initial investment to be able to benefit from having the garden in-store and established a partnership with Infarm for a complete service, with a dedicated team within the store who looks after the site day to day. METRO then takes over with everything involved in getting the herbs onto the shelves and marketing them.

F.C.: In this partnership, Infarm doesn't just provide the garden or limit its role to that of a supplier that would regularly deliver plants to the site. A two-person Infarm team works full time every day here at METRO Nanterre. They harvest the plants every afternoon, package them and then deliver them to the METRO department manager concerned. Everything is done in a space limited to around a hundred meters. This is pushing the short food supply chain concept to extremes!

But our collaboration goes further. The Infarm team is also on site to better understand the commercial dynamics of each of our plants, allow chefs and customers to taste and discover our produce, and offer new varieties depending on demand and what works best. We're in an ongoing dialog with METRO, their department heads and customers.

M.G.: These regular exchanges are one of the keys to the success of our partnership so far. I think the METRO and Infarm teams alike are learning a lot from this new experience and from this shared workspace that enables positive and constructive exchanges. For us, this is also a great source of motivation internally.

What are the current results of your partnership?

F.C.: We're seeing a very productive yield: 600-700 plants (i.e., 200 sachets of plants) are harvested every day, which is equivalent to 4 metric tons per year. This accounts for around 40% of herbs on sale in the METRO store in Nanterre.

The environmental footprint and the return on resources are far better than in traditional agriculture. The closed water loop uses 95% less water than conventional farms, and delivery takes place on site by simply travelling the few meters between the farm and METRO's shelves. Now that's what you call ultra-local production! Even the packaging is made from maize starch and totally compostable.

F.S.: Our customers have also been noticeably impressed by this farm. The price of Infarm herbs is somewhat higher (around 20% more compared with other herbs), which elicits two types of reactions. "Pro-produce" restaurateurs, mostly from high-end or casual fine dining restaurants, were instantly smitten with the local and sustainable production method, absence of pesticides, plants sold with the roots still attached and more marked flavor.

We are seeing a very productive yield: 600-700 plants harvested every day, which is equivalent to 4 metric tons per year. This accounts for around 40% of herbs on sale in the METRO store in Nanterre

Some customers' reticence over the price was overcome the moment they tasted the produce – that's the deciding factor. Restaurant owners often have very ingrained professional consumption habits, considering they have to keep dishes profitable. They are used to choosing the same kind of produce – the things they know. We are therefore undertaking a process of tasting, education and customer activation so they can discover the difference in taste between herbs from our garden and those from other sources, but also to help them discover new herbs and recipe ideas. At the opening, for example, we had the pleasure of welcoming Guillaume Gomez, head chef at the Elysée Palace, who placed an order. As the distributor, it's up to us to educate and raise awareness about new product types and production methods.

Green shiso on the shelf - ©Maja Bialon

METRO supports several initiatives linked to new agricultural production methods. What role can distributors play in improving access to produce from urban farms over the next few years?

M.G.: As a major supplier to restaurants in France, METRO is indeed actively supporting several projects dedicated to new farming methods. Supporting projects like this is part of our role as a large company. We have to respond to new demands from our customers, but also to support the adaptation and transition from conventional agriculture to more ecologically and socially responsible production methods.

METRO continues to explore and support *outdoor* and *indoor* farming alike, including our partnership with Infarm, in a response to social responsibility challenges such as relocalization, transportation and energy consumption. Regarding *outdoor* farming, we began with a partnership with *Fermes d'Avenir* (Farms of the Future), a nonprofit organisation working to accelerate agricultural transition that launched a pilot permaculture project. We currently also support *Vergers Écoresponsables* (Eco-friendly Orchards), a labelling program dedicated to environmentally friendly fruits growing in France. The approaches promoted by permaculture growers demonstrate a desire to develop a more sustainable way of farming, which we find extremely interesting and promising.

METRO continues to explore and follow these two types of farming, which appear to be different answers to the same question. This diversity is necessary because solutions are not always the same in different conditions. For example, *indoor* farming enables customers to buy herbs that are not readily available in France, in terms of quantity and quality. But for the moment, not everything can be grown using this technique, and not all METRO stores have the space needed to house indoor farms of this size. In these cases, the *outdoor* option seems a more likely solution.

Over the next few years, METRO hopes to continue with and improve its role as a platform for connecting producers and restaurateurs in the interest of transparency.

In January 2019, we also launched the METRO Foundation, which will focus on general interest measures in several areas: the meal itself, maintaining and appreciating French culinary heritage, and supporting initiatives reflecting on new models of production for the future.

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"The issue of providing food to cities is a constantly increasing challenge. In 2050, 80% of food will be consumed in cities."

Pierre Marc Johnson
Lawyer and international negotiator, former Premier of Quebec
Chair of the Veolia Institute's Foresight Committee

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Urban Agriculture: another way to feed cities

CITIES AND URBAN SERVICES