



FARMING ON TOP: ROOFTOP AGRICULTURE FOR HEALTHY CITIES

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The world is facing many problems nowadays, including a growing number of people living in cities, many of whom often do not have easy access to fresh food. To solve this problem, it is necessary to develop a new kind of agriculture that provides city residents with food security while also protecting the environment. Rooftop agriculture could be a solution. Rooftop agriculture is a type of urban agriculture, in which food is grown on the tops of buildings. Rooftop agriculture can have many benefits. For example, it can reduce the extreme heat in the city during summer, it can help to decrease urban poverty, and it can help people to socialize more. In addition, rooftop agriculture can even benefit the buildings themselves. Rooftop agriculture is becoming more popular across the world, thanks to these benefits. We hope it will become an important part of the sustainable cities of the future.

KEY POINTS

- Researchers have found that the interest in rooftop agriculture has been increasing across the world.
- Most examples of rooftop farms are in developed countries, whereas there is still not much rooftop agriculture happening in less-developed countries. This is unfortunate because it is often more common for people in less-developed countries to have difficulty finding and affording enough food. If rooftop agriculture were increased in these countries, it could help with the food security of the people living there.
- Rooftop agriculture can also improve the wellbeing of building residents, providing them with opportunities to socialize and help with gardening, which many find enjoyable.
- If rooftop agriculture developed for innovation purposes increases, new technologies will be developed that will increase the amount of food that can be grown and sold to city residents.
- Local food production can reduce the pollution and additional expense associated with trucking food in from the countryside.

WHAT IS ROOFTOP AGRICULTURE?

The world's cities face many problems nowadays. For example, the urban population is growing quickly and climate change is affecting storms management and causing excessive heat. As a result, food is often difficult for poorer populations to access, as well as for certain groups, including immigrants and older people, which are often socially excluded. **Urban agriculture**, which means growing food within cities, can help to reduce these problems. In fact, urban agriculture can provide many benefits to a city. For example, it can reduce the excessive heat that builds up in cities during the summer, it can create small communities of people that allow for improved social interactions, it can help small businesses to grow and make money, and it can help guarantee **food security** to decrease a city's reliance on food that is transported in from the countryside.

In most cities, there are only a few empty spaces with soil to grow plants, which is an obstacle for urban agriculture. Luckily, the cultivation of crops on rooftops, called **rooftop agriculture** [1], can help to overcome this problem (Figure 1A). In rooftop agriculture, plants are grown in a soil-filled container or soil-free **hydroponic** systems. The amounts of water, soil, or other resources needed for rooftop agriculture can vary greatly, depending on the cultivation system and the types of plants grown. For example, a hydroponic system uses zero soil but lots of water, whereas only 20 cm of soil may be needed to grow small plants (e.g., lettuces) if soil-filled containers are used (Figure 1A).

URBAN AGRICULTURE

The cultivation of food within or close to the city.

FOOD SECURITY

The ability for all people to have access to food.

ROOFTOP AGRICULTURE

The cultivation of food on the rooftops of city buildings.

HYDROPONIC

Describes the cultivation of plants in water, without soil.

Figure 1

(A) Rooftop agriculture in containers filled with soil. (B) An open-air rooftop garden on top of a housing complex in Bologna, Italy. This rooftop farm was created for social integration.



Figure 1

Rooftop agriculture can be good for the buildings, too. For example, plants can help to insulate buildings from extreme temperatures, thereby reducing the amount of energy needed for heat and air conditioning, as well as the pollution produced by the heating and cooling processes. This also lowers the costs to heat or cool the building. Rooftop agriculture can also reduce noise pollution from the city and protect the roof from sun, rain, and wind.

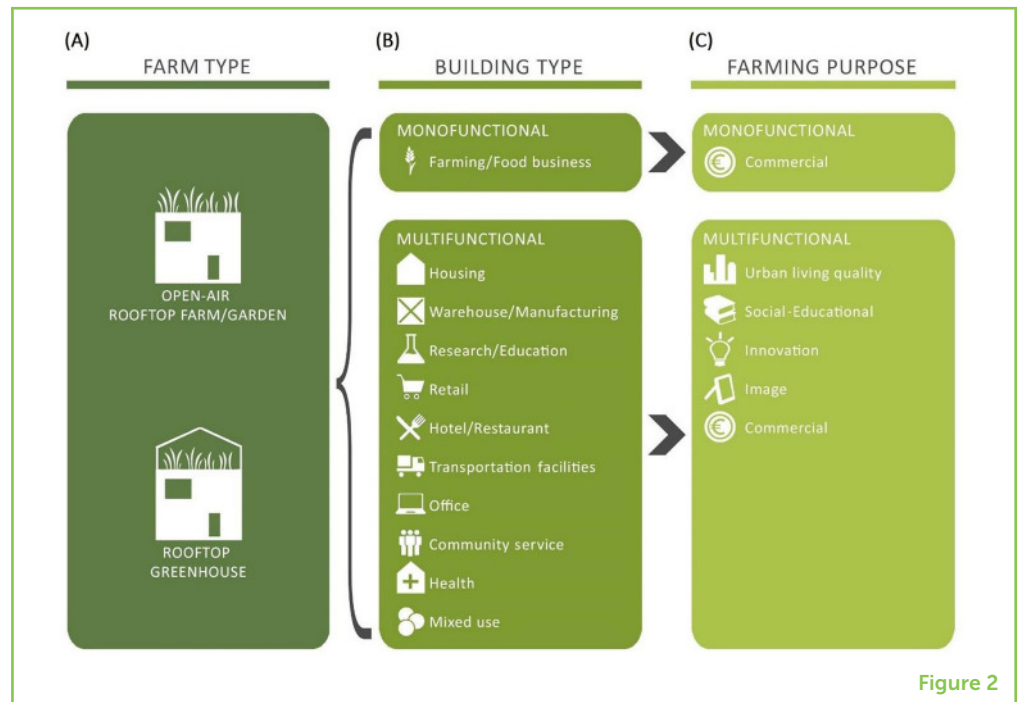
TYPES OF ROOFTOP AGRICULTURE

We can classify rooftop agriculture in various ways (Figure 2). First, we can distinguish two types of farming: rooftop greenhouses, which are rooftop farms with protective structures covering them, and open-air rooftop farms, which do not have protective structures. Rooftop greenhouses protect crops from conditions like cold and wind, and they allow cultivation during the winter. However, open-air rooftop farms are easier to construct and less expensive. For this reason, open-air rooftop farms can be used in places where there is less money to spend on urban agriculture.

The buildings used for rooftop agriculture can be of two types. Buildings can be monofunctional, which means they are used *only* for plant cultivation. In this kind of building, plants can be grown

Figure 2

(A) Rooftop agriculture can be classified according to whether the farm is open-air or covered by a greenhouse. (B) Rooftop agriculture can occur on buildings that serve only for food production (monofunctional) or on top of buildings with other purposes (multifunctional). (C) Rooftop farms can be created to meet various objectives.

**Figure 2**

inside, too. Multifunctional buildings have more than one function. These buildings can be houses, supermarkets, schools, or hospitals, and the rooftops are the only cultivated part. Any type of building with a flat rooftop can be used for rooftop agriculture, but there are important considerations. For example, engineers must ensure that the added weight on the roof is safe for the building, and emergency exits, and protective railings must be present, for the safety of those using these gardens.

Rooftop farms can be created for various purposes. There are five main objectives of rooftop cultivation. Some rooftop farms are created to improve *urban living quality*, such as to give people a place to relax and enjoy nature. Others are created for *social-educational* purposes, such as to help different groups of people interact with each other, or to teach people about gardening (Figure 1B). Some rooftop agriculture is established for *innovation*, in which they create new technologies. Sometimes rooftop agriculture is used to improve the *image* of a building, making it more beautiful. Lastly, *commercial* rooftop farms are those created to make a profit [2].

ROOFTOP AGRICULTURE IS GROWING!

Rooftop agriculture is gaining popularity across the world, thanks to its benefits. Researchers have been working to understand the worldwide development of rooftop agriculture (Figure 3). By searching articles and websites, researchers counted 185 examples of rooftop agriculture across the world. Most of this rooftop agriculture is found in North America and Europe. South America has the lowest number

Figure 3

(A) Over the years, rooftop agriculture has become increasingly popular across the world. (B) Each black dot shows an example of rooftop agriculture identified by researchers. You can see that North America and Europe have the greatest concentration of rooftop farms.

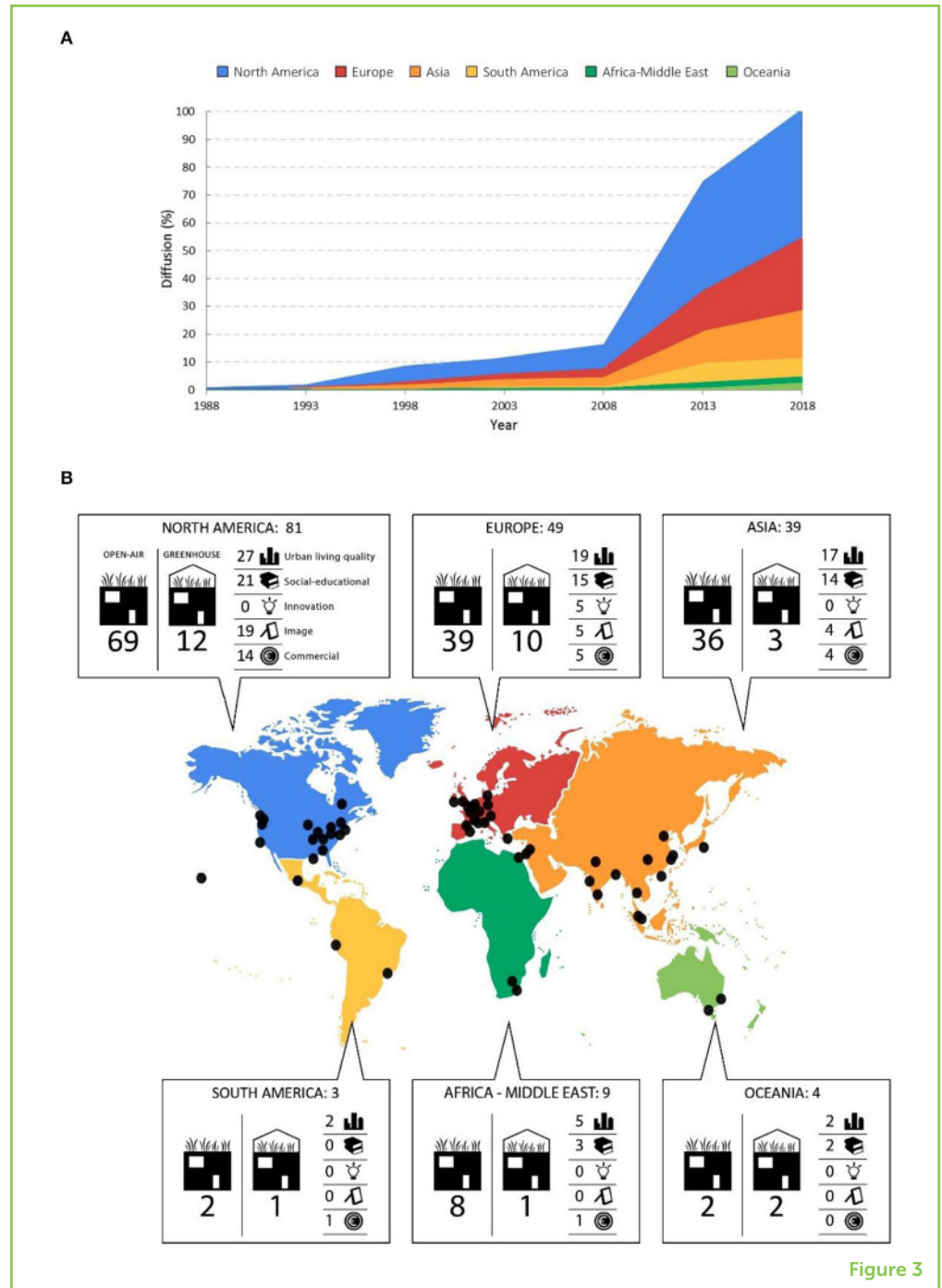


Figure 3

of examples. In total, there are 5 times more open-air rooftop farms than there are rooftop greenhouses. Urban living quality is the most common farming goal on every continent. Europe is the only country with innovation as an objective. The first example of rooftop farming was seen in the 1980s, but the number of rooftop farms did not reach a peak until 2010. Most rooftop farms are on the tops of schools and houses.

For all these reasons, rooftop agriculture could help to improve the world's increasingly crowded cities and the lives of the people living there. Rooftop cultivation is the future of the cities.

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We are a synthetic biology team with the international Genetically Engineered Machine (iGEM) in Lima, Peru. We are the only high school team in Latin America and are proud of our work with creating a detector for cadmium using bacteria. Most of us are second language learners and the age range of our group is 14–17 years old. We love GMOs!



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Elisa is a Ph.D. student and agronomist. She grew up in the countryside. Since she was a child, she has loved nature and agriculture. For this reason, she decided to study agriculture. Urban agriculture is the focus of her research. In fact, she believes that it is important to reconnect citizens with nature. *elisa.appolloni3@unibo.it



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