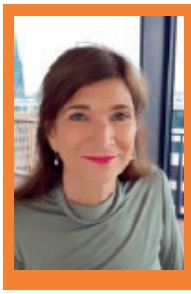
全球城市化趋势将对数十亿人的粮食供应产生巨大影响。它需要将现有的农产品生产和供应链重新思考。尽管先进的温室仍然是生产蔬菜、水果、花卉的主要方式，但由于大城市的需求不断变化，绿色科技的世界正在发生变化。越来越多的垂直农场供应的新鲜园艺产品将逐步增加，以满足不断增长的特大城市人口增长需求。垂直农场将成为未来几年城市建筑和基础设施的一部分。

Annemieke Roobeek 教授关于垂直农场的研究成果将在“中国温室2018”期间与大家面对面分享。抓住与专家面对面交流的机会吧！“中国温室2018”系列活动官网：www.cghs.cn。

Collaboration in ecosystems to unleash radical innovations in vertical farming



Prof. dr. Annemieke Roobeek
Professor for Strategy and Transformation Management at Nyenrode Business University, The Netherlands
And CEO/Founder of MeetingMoreMinds, based in Amsterdam, The Netherlands
Contact:
a.roobeek@nyenrode.nl
annemieke.roobeek@meetingmoreminds.com

Introduction

The worldwide trend of urbanization will have a tremendous impact on food supply for billions of people. It needs re-thinking of the existing production and supply chains into a data-driven, connected infrastructure of food production hubs in and near megacities. Beside large scale greenhouses nearby cities, more and more indoor- and vertical farms for fresh horticultural products will rise up in the megacities to meet growing demand of increasing population in megacities. Vertical farms will become part of the urban architecture and infrastructure of the years to come. It is about embedding fresh food production inside megacities in connected systems to secure excellent food quality and supply of fresh produce.

Novel forms of farming inside megacities

We see already dozens of examples of vertical farms in many places all over the world, but the vertical farm industry is still in development. There are very different ways of novel production of fresh produce: from containers to empty buildings and parking garages to multi-layered production in warehouses and high tech climate rooms. We are in the phase of experimenting in practice what could work. This is a fascinating time for exploration and discovering new business models for exploitation. Although some vertical farming entrepreneurs receive large amounts of venture capital, particularly in the US, it is not said that

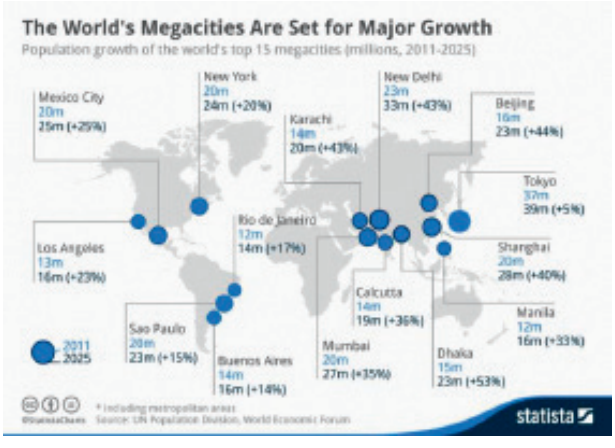
capital will determine the outcome yet. There is more needed than capital and that is where this article is about. Technology alone without deep knowledge about plant science is worth nothing. The same goes for making the right combinations of subsystems into connected growth systems. The challenges are in the complexity, connectivity and creation of ecosystems with key players on board. It is about learning from the data and patterns of the underlying integrated growth systems for vertical farming. It is a systems approach that will set the scene for the development of fresh produce inside cities in the coming years.

Connectivity in the food infrastructure

Growing micro leaves and salads in a container is one step, and installing LEDs a second, but it is miles away from radical innovation in indoor and vertical farming. The breakthrough will be in the integrated systems. We should not underestimate the challenge of connecting separate technical installations into integrated high tech solutions as a globally and locally connected food infrastructure. Beside the technological challenge there is a local marketing challenge to create B2B high-end demand channels at the same time. The high production output of multi-layered vertical farms requires a guaranteed local market. Although there is a growing population in megacities the organization of the marketing and distribution for this growing demand is a challenge in itself. Traditionally Greentech companies build greenhouses and install technical subsystems and deliver turnkey projects. Growers take care of the production and auctions or traders overlook the sales to supermarkets and other channels. In case of vertical farming inside cities this traditional value chain will change. From linear production chains it will transform into networks and ecosystems. The role of auctions and traditional traders will disappear and there will be an immediate connection between the production in the vertical farms and the market. This means that upfront the different channels from supermarkets to restaurants, hospitals and other B2B customers must be in place. Also the role of local government is important, because they will put more emphasis on the food security and food safety for their citizens. In the coming years it will become normal to negotiate with local government and mayors of cities about the output in terms of x-many tons of tomatoes, salad and other fresh produce per year. To bring all these highly different parties together in an ecosystem is what we need to do to fulfil the rising demand of fresh produce in megacities. This is a new role of connecting networks of networks, which has not yet been played by parties in the Greentech or horticulture.

Quantum leap

The advancement of breakthrough, integrated



concepts for guaranteed output and outcome of vertical farms is still in the experiential phase. We are at the beginning of a quantum leap in the transition towards feeding megacities. The creation of constructive relations between different parts of the ecosystem to secure a constant food supply is still in its infancy. It requires a radical new way of organising technology and marketing innovation with public and private parties in ecosystems. Ecosystems are combinations of networks of networks around a complex challenge. Feeding Megacities is such a challenge. Networking, collaboration, creativity, diplomacy and working with many different parties on solutions for 'the day after tomorrow' are key ingredients that will change the landscape in the horticulture industry and that of food supply infrastructure in megacities in particular. In short, let's explore the journey for Feeding Megacities.

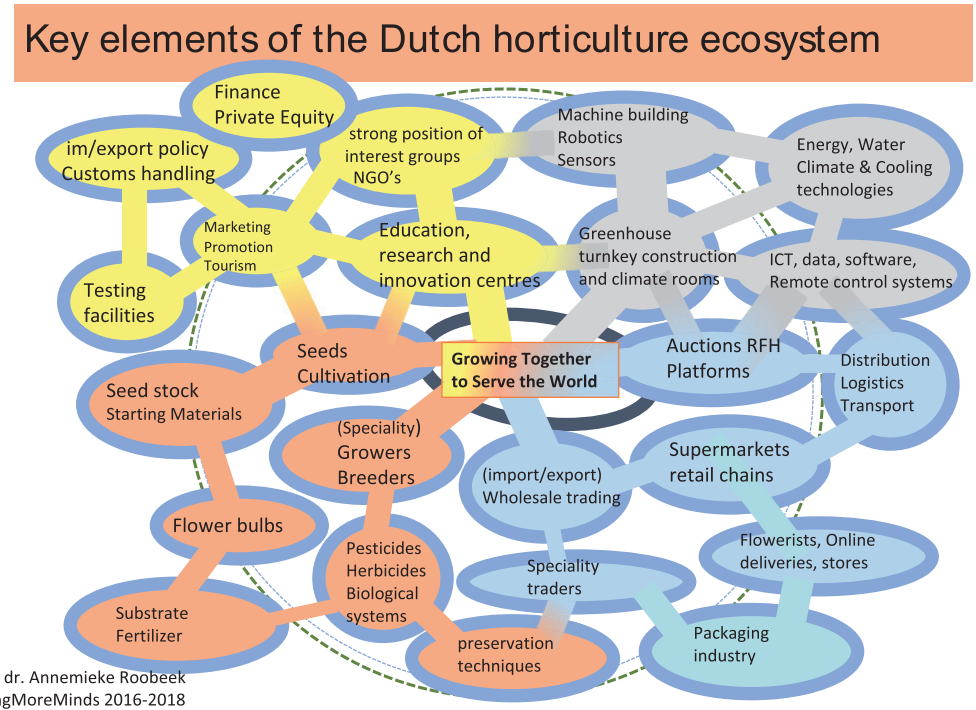
A food infrastructure of connected vertical farms in Mega Cities

Vertical farms are characterized by the production of food in completely controlled, climatized, and stacked growing environments with very high outputs per square meter. Special light-recipes and advanced LED-lights can optimize growth processes. Pesticides are unnecessary in these closed systems and the food safety can be guaranteed. The use of water can be minimized. Food can be produced all year long under constant conditions. This contributes to fresh food security for citizens in cities. Furthermore, the ecological footprint is smaller due to shorter supply and distribution chains. This leads to less food waste because customers are close-by, almost literally around the corner. Vertical farms are still in its infancy, but rapid

changes are underway. They will become databased and interconnected to safeguard food security and food safety tailored to the local tastes.

The growth of vertical farms will mostly be seen in the greater metropolises in Asia and the United States, Canada, and areas in the Middle-East, like the Emirates. Be it harsh weather conditions, environmental considerations or booming population, new ways to grow fresh produce nearby will come up and it will happen in cities. As Panag Khanna shows in his TedX on megacitiyclusters it is connectivity that will thrive the new infrastructures. (see e.g. https://www.youtube.com/watch?v=U7y4GImwPLQ Parag Khanna, megacities and connectivity).

In my opinion infrastructure in a global network of civilization living in megacities is more than ICT cables, satellites, airports, railways, metros, high ways, canals and waterways. It is also about a food infrastructure in megacities that is connected to a global network of highly sophisticated data centres. In these data centres the best knowledgeable information about growth processes and varieties are collected, studied and provided for specified local production in indoor or vertical farms. Instead of thinking in separate entities of production my vision is that in different parts of the megacities the production facilities for fresh produce are connected to guarantee the optimal output in a sustainable way. It will allow for differences between the tastes and local preferences, but the quality is excellent and guaranteed. It may sound science fiction in 2018, but in a few year time it will be seen as a solution for Feeding MegaCities. Think about the megacity clusters of hundreds of kilometres around Bejing, Shanghai, Hong Kong and Guanzhou, Delhi, Teheran, Instanbul, Sao



@Prof. dr. Annemieke Roobeek
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Integrated systems for a connected food infrastructure as challenge

There is a need for a connected infrastructure of highly advanced production systems for fresh produce of high quality and guaranteed output. The technological challenge is twofold. It lies in creating integrated system solutions for securing optimal output and excellent quality of fresh produce in these indoor or vertical farms. And in connecting the data of these city farms into learning systems for fresh food supply in megacities. Currently there are many subsystems in greenhouses, sometimes connected per greenhouse, but often not in larger systems.

The research we did with the team of MeetingMoreMinds (www.meetingmoreminds.com) shows that in many countries, from Canada, the US, Japan, Israel and Korea, there are companies working on vertical farming. However, there is not one country in the world that has such a strong and advanced technology and knowledge infrastructure for the next generation of indoor and vertical farms as the Netherlands. It is the only existing ecosystem in the world that has all elements and companies as well as institutes of knowledge are all located very close together within 100 kilometers. Besides there is a natural way of informal networking in the Dutch culture. As second largest exporter of food in the world and with world leaders in the field of Greentech, horticulture, floriculture, trade and distribution, it has a unique position.

Momentum is now

According to our research, there are huge opportunities for the Dutch Greentech and horticulture industry to develop next level growth systems for indoor and vertical farming. A prerequisite is that there should be more collaboration and not only fierce competition among the parties. The collaboration should also be extended internationally to local parties in the megacities and to specialized suppliers worldwide. The competition in vertical farming isn't resting either. Amazon and Microsoft, Silicon Valley start-ups, but also IBM, Fujitsu and GE are seeing the opportunities and are investing out of deep pockets in (sub)systems for vertical farming. Bundled expertise in practice will have to be the Dutch answer to stay in the lead in combination with coalitions of local parties. This can become the gamechanger in the market of advanced, connected and data-driven vertical farm infrastructure for megacities. If there ever was a momentum to create consortia to make vertical farming happen, it is now. To organise ecosystems with representatives of Dutch horticulture and Greentech industry, but also with international architects, consultancy firms, local urban planners, knowledge institutions and financial institutions. The momentum is now.