With support from

Federal Ministry
of Food
and Agriculture

by decision of the
German Bundestag

EXPERT STUDY

DCZ 中德农业中心 Deutsch-Chinesisches AGRARZENTRUM

Concepts of urban and peri-urban agriculture in Europe and China and their potential contribution to food security and climate-resilient food production

Rita Merkle

January 2023

GFA CONSULTING GROUP
General Agent BMEL
Berlin Office

IAK AGRAR CONSULTING

iamo
Leibniz Institute of Agricultural Development
in Transition Economies

CAAS

FECC

Disclaimer:

This study is published under the responsibility of the Sino-German Agricultural Centre (DCZ), which is funded by the German Federal Ministry of Food and Agriculture (BMEL). The views, results, conclusions, and/or proposals stated therein do not necessarily reflect the opinion of the BMEL.

About the author:

Rita Merkle is an independent consultant working in the field of sustainable agricultural development. She holds a PhD in geography from the Free University of Berlin. Rita Merkle currently works as cluster manager for the IURC-China cooperation in sustainable agriculture and agri-food systems.

Published and edited by:

Sino-German Agricultural Centre (DCZ)
Room 201, Foreign Economic Cooperation Centre (FECC) of MARA
55 Nongzhan Beilu, Chaoyang District
100125 Beijing, China
Tel.:+86 (0) 10 6500 0958
Email: info-dcz@iakleipzig.de

Publication as PDF:

This publication is available free of charge from the DCZ website at https://www.dcz-china.org/home.html

Table of contents

List of figures

1. Introduction and purpose of the study

The world is rapidly urbanising and long-term prospects continue to predict that the world will further urbanize over the next decades. While today slightly more than half of the world population (55%) is urban, more than two thirds of all people may be living in urban areas in 2050 (UN, 2018). In China, an estimated 80% of the total population will live in cities by 2050, whereas in Germany even 84% of all people may be living in cities (UN, 2018)[1]. At the same time, only 15–20% of the world's food is produced in urban areas (Santini, 2022) making food security for urban populations already a major challenge that will only intensify[2]. Moreover, climate change, together with environmental challenges due to the pressure on existing resources will make it increasingly difficult to farm. Eventually, unpredictable crises such as the Covid 19 pandemic or the war in Ukraine further undermine the resilience of cities, especially in terms of food security. In the face of these global challenges, urban agriculture has evolved from being considered a marginal phenomenon to a globally recognised tool for sustainable development and has been the subject of significant research over recent years[3].

Both China and Germany (in the broader context of the EU) prioritise the development of a sustainable agricultural system and face the common challenges of food security and environmental issues described above. Also, the concept of urban agriculture is relatively new in both China and Germany (and the EU). However, differences exist for example when it comes to the land tenure system or the role of different stakeholders in the agricultural system and consequently, best practice examples also vary.

The present study provides an introduction to the concept and definition(s) of urban agriculture, describes the state of knowledge in German and Chinese research, as well as the political support for research of relevant technologies and practices in Germany and China. It then presents examples and best practices to show the diversity of urban farming practices in Germany, Europe and in China.

[1] In 2018, in China 59% of its total population were living in urban areas, in Germany 77% lived in urban areas (UN, 2018).

[2] Payen et al. (2022) specifies, based on other scientific research, that "it is estimated that between 5% and 10% of the global production of legumes, vegetables and tubers is currently delivered by urban agriculture, while between 15% and 20% of global food is produced in urban and peri-urban environments."

[3] The most comprehensive reference list to date is in FAO, Rikolto and RUAF (2022). On 14 pages, it includes not only academic research articles, but also publications by international organizations and institutions such as FAO and RUAF, open access databases, public websites, as well as relevant materials from FAO's Technologies and practices for small agricultural producers (TECA) platforms.

2. Methodology

The study is linked to an Exchange Workshop on Urban Agriculture organised by the Institute of Urban Agriculture (IUA) of the Chinese Academy of Agricultural Sciences (CAAS) together with the S&T platform of DCZ on December 13, 2022. This first online exchange between scientists from IUA and German institutes helped to identify research topics related to urban agriculture in the two countries and possible fields of research collaboration.[4]

In addition, a kick-off event in September 2022 to launch a strategic platform on Controlled Environment Agriculture (CEA), organized by the German Agricultural Research Alliance (DAFA) also gave insights in the German research landscape on this topic.

In-depth interviews with participants of the Exchange forum were conducted to deepen the understanding of topics and needs for further cooperation. However, the tight time frame of the study, which coincided with the turn of the year and the Christmas holidays, meant that only two participants responded positively to the request for an in-depth interview.

A literature review helped to collect secondary data in order to better understand and frame the topic of urban agriculture in Europe/Germany and in China, and identify best practices and experiences in Europe/Germany and China. The literature review includes research articles, publications by international organisations and institutions, and other open access databases and websites.

The study also builds on the author's past and current work on urban agriculture as cluster manager on sustainable urban agriculture of the International Urban and Regional Cooperation (IURC) China programme of the EU which is implemented in a second phase between 2020 and 2023. The IURC programme promotes innovation through inter-regional cooperation between the EU and its partners, based on a triple helix approach with stakeholders involved from business, governments and research. It aims to lead and develop a form of decentralised international urban and regional cooperation in the fields of sustainable urban development and innovation. In the sustainable urban agriculture cluster, one out of 15 clusters of the programme, five cities from China and six regions from Greece, Italy, Spain, Slovenia, Romania and the Czech Republic are involved, but no cities or regions from Germany.

[4] For a summary of the event see Böhme, M. (2022), available at: https://www.dcz-china.org/2022/12/16/4th-exchange-forum-promotes-exchange-in-urban-agriculture-research/

3. Urban agriculture

3.1 Concepts and definitions

Food production and direct marketing of food in and around cities has historically been an important factor in the shaping of cities. However, the concept of „Urban Agriculture“ has only been developed recently and began to take hold during the 1990s (FAO, 2022). There is no universally accepted definition of urban agriculture, but it is recognised that urban agriculture comprises many forms, being therefore a multi-dimensional concept, and including a broad range of meanings and perspectives on what it entails. Sometimes ”urban agriculture” (UA) is opposed to “peri-urban agriculture”, in other cases urban and peri-urban agriculture (UPA) is opposed to rural agriculture. The use of the term “urban (and peri-urban) agriculture” (UPA) as opposed to rural agriculture has been subject to confusion, debate and delimitation. Based on the extensive literature that exists on the subject, McEldowney (2017) deduced its essential aspects as in contrast to conventional agriculture and in the “Urban and Periurban Agriculture Sourcebook” of FAO, Rikolto and RUAF (2022), a useful overview of the main differences and common features of rural agriculture and UPA is provided[5].

A widely accepted and one of the most frequently cited definitions reflecting the dynamic and multifunctional nature of urban agriculture is by Mougeot (2000):

> *“Urban agriculture is located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, and grows or raises, processes and distributes a diversity of food and non-food products, (re-)uses largely human and material resources, products and services found in and around that urban area, and in turn supplies human and material resources, products and services largely to that urban area.”*

This definition[6] makes reference to the concept of peri-urban agriculture taking place in the urban periphery in the transition zone between the inner city and the rural areas and is sometimes referred to as “urban fringe agriculture” (McEldowney, 2017).

This peri-urban dimension is also integrated in the recently published “Urban and Periurban Agriculture Sourcebook” (FAO, Rikolto and RUAF, 2022) quoted above. It provides two definitions, a short, concise one and a longer, more comprehensive definition:

[5] Another very useful research study on the topic has been requested by the European Parliament's Committee on Agriculture and Rural Development from the Leibniz Centre for Agricultural Landscape Research (ZALF), “Urban and Peri-urban Agriculture in the EU”, published in April 2018. See Piorr, A, Zasada, I, Doernberg, A, Zoll, F and Ramme, W (2018).

[6] This definition is also quoted in the recently published “UA typology update” of the European Forum on Urban Agriculture (EFUA) project, a 4 year project (2020 – 2024) funded under the European Union’s Horizon 2020 Research and Innovation Programme. See Jansma, J.E., Veen, E.J., Vaandrager, L., Muller, D. & Berg, W. van den. 2022.

"Short definition:

Urban and peri-urban agriculture can be defined as the production of food and other outputs and related processes, taking place on land and other spaces within cities and surrounding regions.

Long definition:

Urban and peri-urban agriculture can be defined as practices that yield food and other outputs from agricultural production and related processes (transformation, distribution, marketing, recycling…), taking place on land and other spaces within cities and surrounding regions, involving urban and periurban actors, communities, methods, places, policies, institutions, systems, ecologies and economies, largely using and regenerating local resources to meet the changing needs of local populations while serving multiple goals and functions."

In this study, urban agriculture also encompasses peri-urban agriculture, along with the above given definitions and also in accordance with the definition given by a transdisciplinary working group of researchers from across Europe on "Urban Agriculture Europe" which was funded by the European COST Action TD 1106 (2012 – 2016) with the aim to gain deeper understanding of Europe's different forms of 'Urban Agriculture' and to develop a common language in the urban agriculture research field that was emerging worldwide at the time. They focused on the question of definition, developed a typology of urban agriculture and gave examples and short case studies to demonstrate the diversity of urban farming projects in Europe. They published the first comprehensive publication on this subject in Europe (Lohrberg et al. 2015), and, among further publications, also an online atlas containing 253 UA projects[7].

Therefore, sometimes it will be addressed simply as urban agriculture, but always encompassing the peri-urban dimension, sometimes, to underline that peri-urban agriculture is part of the concept, it will be addressed as "urban and peri-urban agriculture" (UPA).

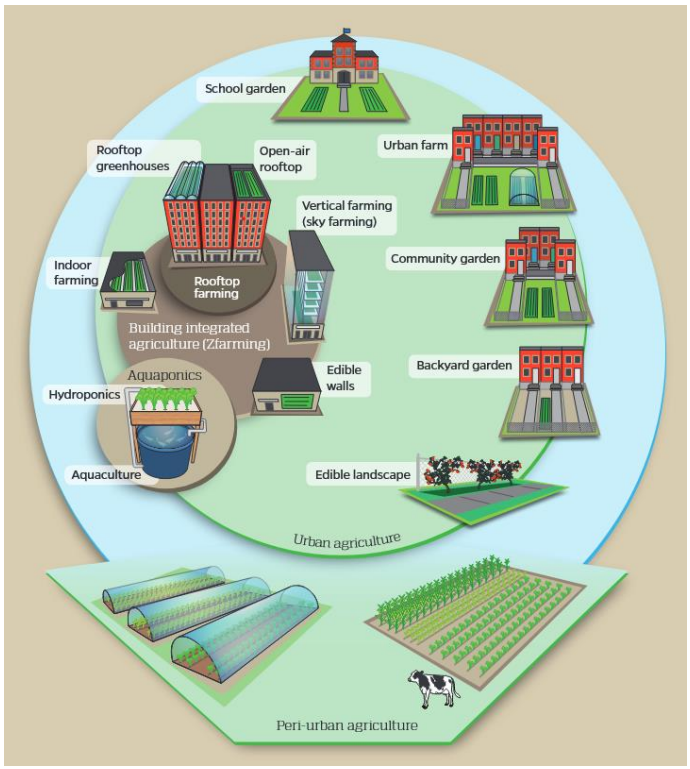
3.2 Scope and typology

In this chapter, the typology is based on the distinctions made in Europe as they were first elaborated under the COST Action and further developed in the Horizon 2020-funded EFUA project. The author does not know whether a specific typology has been developed in China that takes Chinese specificities into account. To date, to the author's knowledge, only researchers of Waterloo University in Canada tried to develop a typology of urban agriculture in China (Luehr et al, 2020).

UPA has a very vast scope and can take many different forms. They include different urbans spaces (rooftops, indoor farming, allotments) and growing systems, e.g., soil-based agriculture versus hydroponics or vertical farming (see Figure 1).

[7] See online : http://www.urban-agriculture-europe.org/online-atlas.html. Accessed June 2022.

Figure 1: Scope of urban and peri-urban agriculture



Source: Santo, R., Palmer, A., Kim, B. 2016.

The COST project draws a broad distinction between the two categories of urban farming and urban gardening, which were then subdivided in 13 types. In the case of urban food gardens, which usually have social or ecological objectives at their heart and where providing income from agricultural activity is not the primary objective, these include for example areas for individual production, such as allotments and family gardens, and areas where more collective actions are performed, such as educational, therapeutic and community gardens. In the case of urban farming which is based upon more traditional farm business models, leisure farms or local food farms are for instance included[8].

However, the increasing complexity of UPA, which is experiencing rapid development, has meant that these typologies no longer reflect the full diversity of UPA. For instance, indoor and vertical farms or Controlled Environment Agriculture (CEA) growing systems were not sufficiently recognisable in this first European typology. Based on a combination of empirical research, questionnaire surveys and literature reviews, the EFUA project has therefore further developed the COST typology making the initial distinction between gardening and farming more specific and reflecting the large variety of urban agriculture performances in Europe. It contains six main categories (see Figure 2). The typology is based on a survey of 112 Urban Agriculture initiatives across Europe.

[8] See McEldowney (2017) for an analysis of the COST typology.

Figure 2: Comparing typologies of the Cost Action, the literature review and interviews, and the survey

Cost Action (2016)	Literature review and interviews (this report)	Survey (this report)
Urban farming	Urban farms	Urban farm
		Zero acreage farm
		Social farm
		DIY garden/farm
Urban gardening	Individual urban gardens	
	Community Gardens/ Collective Gardens	Community garden
	Landscape-integrated UA	Community park

Source: Jansma, J.E., Veen, E.J., Vaandrager, L., Muller, D. & Berg, W. van den. 2022.

These six categories, or "clusters" as they are denominated in the report, are each further analysed along four groups of dimensions – spatial, production, operational and community dimensions – each of which contains two to three variables[9]:

> *"1 . Urban farm: high acreage, outdoor production, urban or peri-urban, privately owned, production oriented, diverse produce (animal and plant based), additional services, production sold e.g. CSA farm.*
>
> *2. Community park: low acreage, outdoor, urban or peri-urban, production for own consumption, diverse additional activities at site e.g. forest garden.*
>
> *3. DIY garden/farm: medium acreage, outdoor production, urban or peri-urban, mostly vegetable production, a group of people or individuals responsible, for own consumption e.g. allotment garden or self-harvesting farm.*
>
> *4. Zero Acreage farm: low acreage, build-in urban area, privately owned, out of soil production, production oriented, diverse (plant based) produce, production sold e.g. vertical farm.*
>
> *5. Social farm: medium acreage, outdoor production, privately owned or part of an NGO, produce is sold, gifted or for own consumption, additional services e.g. health care farm.*
>
> *6. Community garden: low acreage, outdoor, urban, production for own consumption, diverse additional activities at site e.g. educational garden."*

The authors stress that the suggested typology is not absolute neither, and that it shows some overlap between the types 3, 5 and 6. As already mentioned before, the authors also underline

[9] The authors underline the four dimensions correspond to the perspectives used in Piorr, A, Zasada, I, Doernberg, A, Zoll, F and Ramme, W (2018). The variables are not presented as an absolute value but rather as a position between two extremes.

that "while the diversity between urban agriculture initiatives is large, this diversity cannot be easily 'caught' in mutually exclusive types," and sometimes there are grey zones between types. For example, a community park sometimes offers allotment gardens or an allotment garden in the DIY cluster might as well have a commercial business component with a farmers family selling their products. The four dimensions representing ten variables are therefore instrumental to understand the broad diversity of UPA.

At this point, another classification will be briefly presented, which was developed to examine how agricultural food productivity of urban systems compares to conventional agriculture. Payen et al. (2022) conducted a global meta-analysis to quantify crop yields of urban agriculture for a broad range of crops and explored differences in yields for distinct urban spaces and growing systems. Observations for yield values were based on three broad categories: the type of crop grown, the urban space used for food production, and the characteristics of the growing system. What is of interest here is the further categorisation of the urban space category and the further sub-categories of the growing system category. Urban space has been sub-divided in two broad categories of which the grey spaces category again contains further sub-categories.

Figure 3: List of categories used to classify observations per urban space in Payen et al. (2022)

List of the Categories Used to Classify Observations per Urban Space

Urban space		Definition	Includes
Gray spaces	Façades	Urban food production located on buildings' façades	Green walls, suspended balconies
	Ground	Urban food production taking place on ground-based urban land, that is to say land that is not located on or within a building and that is not classified as a green space	Brownfields, vacant lots, parking areas, roadside and pathways, school and university grounds, religious spaces
	Indoor	Urban food production located within existing buildings	Plant factories, growth chambers, offices, private flats and houses
	Rooftops	Urban food production taking place on buildings' rooftops	Rooftop gardens, rooftop farms, rooftop-integrated greenhouses
Green spaces		Urban food production taking place in urban vegetated spaces traditionally located within built-up areas and in "natural" environments, that is to say areas of vegetation or bodies of water located in an urban landscape	Allotments, parks, community and private gardens, yards, urban farms, forests, coastal areas, riparian spaces, wilderness areas

And in terms of the growing system, three aspects of the growing system on yields were considered: whether farming was conducted vertically or horizontally, the type of medium used to grow the crop ("hydroponic systems" and "soil-based systems") and the level of conditioning of the environment the crop was grown in ("controlled-environment agriculture with sunlight," "controlled-environment agriculture with artificial light," and "open-air agriculture")[10].

The advantage of this typology which includes forms that are all included in the above-mentioned typology is that it has been developed to understand the contribution of UPA to food security and food resilience.

[10] The types of crops grown are based on the categories developed by the Food and Agriculture Organization of the United Nations (FAO, 2022).

3.3 European and German research on urban agriculture

The discussion so far has shown that conceptual research on urban agriculture is still fragmented, and that the upsurge of interest in urban agriculture has been accompanied by a broad range of research publications.

3.3.1 EU-funded research on urban agriculture

A review on the history of European UPA funding, starting from the year 2000 and undertaken by Piorr, A, Zasada, I, Doernberg, A, Zoll, F and Ramme, W (2018) shows that EU R&D expenditures mirror the changing importance attached to the subject. While the focus in the early 2000s was on investigating the phenomenon in developing countries, it gradually changed to look at it as a phenomenon in response to rural-urban pressures and at present to a solution-oriented approach to climate change related nature-based solutions in cities, innovations in the city region food system and to up-speed technological solutions for future innovative cultivation practices as well as regionalized multi-actor governance models. The gradually enlarged thematic scope of funded research programmes which went along with a rapidly expanding amount of expenditure illustrates this changed perception and the potential knowledge gaps that require public research and development support.

Under **Horizon 2020**, the EU funded about 28 projects to UPA under three different funding programmes[11]:

1. *H2020-EU.3.2. SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy*

   These projects address urban agriculture by developing urban agriculture (e.g. EFUA), short value chains (e.g. SMARTCHAIN), small-scale processing (e.g. FOX) or urban food policies and urban-rural synergies (e.g. ROBUST or CITIES 2030).

2. *H2020-EU.3.5. SOCIETAL CHALLENGES - Climate action, Environment, Resource Efficiency and Raw Materials*

   These projects are focusing on urban agriculture as one type of solutions amongst others. For example, the Nature4Cities project (2016 – 2021) addressed nature-based solutions in general to fight and adapt to climate change, with urban agriculture solutions being part of these solutions.

3. *H2020-EU.2.3. INDUSTRIAL LEADERSHIP - Innovation In SMEs*

   These projects often adopt a bottom-up research approach focusing on vertical farming and highly specific technological innovations.

Sometimes the programme lines of these projects overlap, as this was the case for instance for the Horizon 2020 INFARM project (2016 - 2018) in which German private stakeholders were involved (for further information see below in chapter 4.1.4, p.17, best practice examples).

[11] The 2018 study of ZALF researchers Piorr et al. (2018) cites 18 projects under Horizon 2020, and in a presentation given by a representative form the R&I Unit of DG Agriculture and Rural Development on a Conference within the EUFA programme in March 2022, another 10 projects were cited. See Van Borm, I. (2022).

Under the H2020-EU.3.2 Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy programme, the following projects are still running[12]:

- FOX - Innovative down-scaled FOod processing in a boX (06/2019 – 11/2023)
  Objective: Develop advanced technology applications in fruit and vegetable processing
  Coordinated by the German DIL Deutsches Institut für Lebensmitteltechnik e.V.
- SHEALTHY - Non-Thermal physical technologies to preserve healthiness of fresh and minimally processed fruit and vegetables (05/2019 – 10/2023)
  Objective: Assess and develop an optimal combination of non-thermal sanitization, preservation and stabilization methods to improve the safety while preserving the nutritional quality of fresh fruits and vegetables.
  The Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB) is a consortium partner.
- CITIES2030 - Co-creating resilient and susTaInable food systEms towardS FOOD2030 (10/2020 – 09/2024)
  Objective: Create a future proof and effective Urban food systems and ecosystems (UFSE) via a connected structure centred in the citizen, built on trust, with partners encompassing the entire UFSE and real-scale pilots in 10 selected cities, one of them being Bremerhaven[13].
  Three German stakeholders are consortium partners: 1. Stadt Bremerhaven, 2. Verein zur Förderung des Technologietransfers an der Hochschule Bremerhaven e. V., 3. biozoon GmbH from Bremerhaven.
- FOOD TRAILS - Building pathways towards FOOD 2030-led urban food policies (10/2020 – 10/2024)
  Objective: Transforming integrated urban food policies into measurable and long-term progress towards sustainable food systems through the creation of City Region Food Systems (CRFS) – an approach that aims to foster the development of resilient and sustainable food systems within urban centres.
  Coordinated by the City of Milan, German stakeholders are not involved.
- EFUA - European Forum for a Comprehensive Vision on Urban Agriculture (11/2020 – 10/2024)
  Objective: Unlock Urban Agriculture's potential by achieving better knowledge, better deployment, and better policies in this field.
  Coordinated by the RWTH Aachen, and the Fachhochschule Südwestfalen as one consortium partner amongst others.

One Horizon2020 project fostered the EU-China cooperation in promoting urban agriculture for food security, resource efficiency and smart, resilient cities, the SiEUGreen Project (Sino-European innovative green and smart cities) which ran from January 2018 to December 2022. This project

[12] Still running projects under the two other funding programmes were not further investigated. Projects listed in the ZALF-study all ended at latest in 2022.

[13] See the project homepage at: https://cities2030.eu/

will be further described in the next chapter, since there were no German stakeholders in the project consortium involved.

Under the present **Horizon Europe** programme period (2021 – 2027), there are also several projects linked to UPA[14]. In Cluster 6 "Food, Bioeconomy, Natural Resources, Agriculture & Environment" there are several closed calls, to mention just a few in link with UPA[15]:

1. "Integrated urban food system policies – how cities and towns can transform food systems for co-benefits".
2. "Circular Cities and Regions Initiative's project development assistance (CCRI-PDA)"
3. "Social innovation in food sharing to strengthen urban communities' food resilience"

Many other projects are open or forthcoming, e.g.:

4. "Cultured meat and cultured seafood – state of play and future prospects in the EU"
5. "Unlock the potential of the New European Bauhaus in urban food system transformation"
6. "Impact of the development of novel foods based on alternative sources of proteins"

3.3.2 German research on urban agriculture

As pointed out in the previous chapter, German research institutions, but also private sector stakeholders are involved in many EU-funded research programmes addressing UPA from a social, economic and environmental point of view, sometimes directly, sometimes within a broader focus on climate change related questions in cities for example.

This thematic breadth is also reflected in the German research landscape, which includes scientists with a background in social and/or economic sciences as well as scientists with a background in natural sciences or engineering. This wide range was also reflected in the list of participants at both, the Exchange Workshop on Sino-German Collaboration in Agricultural Sciences supported by DCZ, and the kick-off event of the strategic platform on Controlled Environment Agriculture (CEA), organized by the DAFA. Not only "technical" experts were invited, but also social and economic scientists and experts to explore the technological potential and the economic risks and social acceptance of new ways of producing food and ensuring food

[14] Cluster 5 "Climate, Energy and Mobility" projects are not taken into consideration in this chapter, as it is not easy to evaluate their link to urban agriculture. This link is much clearer for the Cluster 6 projects.

[15] Further information on who has been assigned in conducting the projects are not yet available online. For funding and tenders of Horizon 2020 Cluster 6 see: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-search;callCode=null;freeTextSearchKeyword=;matchWholeText=true;typeCodes=0,1,2,8;statusCodes=31094501,31094502,31094503;programmePeriod=null;programCcm2Id=43108390;programDivisionCode=43121563;focusAreaCode=null;destinationGroup=null;missionGroup=null;geographicalZonesCode=null;programmeDivisionProspect=null;startDateLte=null;startDateGte=null;crossCuttingPriorityCode=null;cpvCode=null;performanceOfDelivery=null;sortQuery=sortStatus;orderBy=asc;onlyTenders=false;topicListKey=topicSearchTablePageState

security[16]. These two events gave a good overview of main research institutions in Germany dealing with urban agriculture. The most prominent scientists (in representation of their institutes) were present at these two events.

To complement the picture on CEA research, the DAFA identified eleven research sites in Germany (see map 1 below), some of which were represented at the two events mentioned above. Some of them, as the RWTH Aachen, are not only focusing on CEA, but also have important ongoing research on "social" and engineering topics in landscape planning including urban agricultural heritage.[17]

German CEA research in the field of plant production is concentrated on individual projects mainly in Aachen (Fraunhofer Institute), Berlin ("Urban Agriculture", Humboldt University Berlin), Bayreuth (University of Bayreuth), Großbeeren/Brandenburg (Leibniz Institute for Vegetable and Ornamental Crops), Osnabrück (Osnabrück University of Applied Sciences), as well as in Weihenstephan at the Technical University of Munich and the Weihenstephan-Triesdorf University of Applied Sciences.

In terms of animal production, several institutes are involved in aquaculture, aquaponics, insect production and production of other novel livestock. These include: Leibniz Institute of Agricultural Technology and Bioeconomics Potsdam, University of Giessen, Thünen Institute, TU Braunschweig, FH Südwestfalen, Leibniz Institute of Freshwater Ecology and Inland Fisheries[18], University of Göttingen, Institute of Inland Fisheries Potsdam-Sacrow, Agricultural Centre for Cattle Husbandry, Grassland Management, Dairy Farming, Game and Fisheries Baden-Württemberg, Bavarian State Research Centre for Agriculture, State Research Centre for Agriculture and Fisheries Mecklenburg-Western Pomerania, Saxon State Office for the Environment, Agriculture and Geology, University of Veterinary Medicine Hanover and Research Institute for Farm Animal Biology Dummerstorf.

[16] More information on the DAFA event including the programme is available at: https://www.dafa.de/veranstaltungen/cea1/. A video recording of the event is available at: https://www.youtube.com/watch?v=1gD3HV11iCQ&t=1560s.

[17] The Institute of Landscape Architecture of RWTH Aachen with its Head of Institute Prof. Lohrberg has been involved in important European research on the subject. It was coordinating the COST Action and is now also coordinating the EU-Horizon 2020 European Forum on Urban Agriculture (EUFA) project. See online: https://www.la.rwth-aachen.de/cms/LA/~nbff/Forschung/lidx/1/

[18] The Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB) has worked, for example, on Tomato-fish aquaponics for professional application in the INAPRO-project funded under the 7th multi-annual Framework Programme funding period.

Figure 4: German research sites in the field of vertical farming

Source: DAFA webpage, https://www.dafa.de/foren/plattform-controlled-environment-agriculture/

However, in social and engineering sciences some stakeholders are worth to be mentioned additionally.

As has become clear already above, the **Leibniz Centre for Agricultural Landscape Research (ZALF)** has conducted important research on UPA for the European Parliament's Committee on Agriculture and Rural Development, and in the following on urban food policies in Germany (Doernberg, A., Horn, P., Zasada, I., Piorr, A. 2019)[19]. At present, the institute's research focus in UPA is on sustainable land use and food supply in the urban-rural nexus with a project funded by BMBF on this topic[20].

The **Leibniz Institute of Ecological Urban and Regional Development** in Dresden is also working on several aspects of UPA and Dr. Martina Artmann for instance has worked together with Dr. Kathrin Specht (Artmann, M. et al. 2021) from the Research Institute for Regional and Urban Development (ILS) in Dortmund who presented an investigation into the consumer acceptance of CEA foods on the DAFA event. Dr. Artmann managed for example the institute's project "Edible Cities" which ran from 2017 to 2022, funded by the DFG. It assessed urban greening strategies as systemic solutions for social challenges of urbanization, developed a

[19] This publication was an output of the EU-funded "Food Planning and Innovation for Sustainable Metropolitan Regions (FOODMETRES)" project under the 7th multi-annual Framework Programme funding period.

[20] See online : https://www.zalf.de/de/forschung_lehre/projekte/Seiten/details.aspx.

conceptual evaluation framework and experimented with using the example of edible cities in Germany[21].

3.4 Research on urban agriculture in China

In China, the promotion of agriculture, and this also applies to the promotion of sustainable agriculture and sustainable urban agriculture, is driven by concerns about food security and closely linked to production targets. This role of agriculture is also reflected in research on urban agriculture. As highlighted by the IUA director Qichang Yang on the exchange workshop, developing urban agriculture is crucial for making China's food system more resilient and producing sufficient food with the limited resources available. For this purpose, the CAAS Institute of Urban Agriculture was founded in 2018 regrouping leading Chinese scientists in the field, with five of the six research departments focusing on high-tech solutions - in smart horticultural equipment, plant photobiology, cultivation of functional and ornamental plants, urban organic waste recycling and plants and human health - and one department on the theory and planning of urban agriculture. In a follow-up interview, a German stakeholder emphasised that the scientists of the functional plant cultivation and application research team are among the top scientists in the world in their field and are also ahead of German scientists. It could not be verified, but one can assume that this is probably also true for the researchers in the other "technically" oriented departments.

As for the rest of the research landscape on urban agriculture in China, it was impossible to get a clear picture because, as in Germany, research is very scattered. Information on other research institutes was derived from research articles and international research projects.

The above-mentioned Horizon 2020 SiEUGreen-project (2018 – 2022) was an EU-China collaboration to study the potentials of urban farming as an integrated and transformative part of resource-efficient and resilient urban environments, including showcases in three selected European and two Chinese urban and peri-urban areas (Changsha and Beijing)[22]. (For further information see best practice in chapter below). The project was coordinated by the Norwegian University of Life Sciences (NMBU) and included two Chinese research institutes in the consortium, namely the Institute of Vegetables and Flowers of CAAS (Prof. Jiang Weijie), and the Rural Development Institute of the Chinese Academy of Social Sciences (CASS) and four private-sector Chinese stakeholders.

The Horizon 2020 project "proGIreg" (productive Green Infrastructure for post-industrial urban regeneration - 06/2018 – 05/2023) aims to develop nature-based solutions (NBS) which are citizen owned and co-developed by state, market and civil society stakeholders[23]. It is also coordinated by RWTH Aachen, by Prof. Lohrberg of the Institute of Landscape Architecture, including one Chinese research institute in the consortium, namely the Institute of Urban Environment of CAS. The project has created eight Living Labs in urban areas which put less focus

[21] See the project homepage at: https://www.ioer.de/en/projects/edible-cities . The publication in collaboration with Dr. Specht, for example, was an output of this project.

[22] Project homepage available at: https://www.sieugreen.eu/

[23] Project homepage available at: https://progireg.eu/

on food-producing sites but more general on green infrastructure solutions to address the challenge of post-industrial regeneration. One Living Lab is in Dortmund, and one in China, in the city of Ningbo. Due to Covid-19 induced challenges for on-site activities, the Ningbo Moon Lake Park Living Lab has so far been focusing on innovative water quality monitoring and aquatic plant maintenance, to improve the water quality in Moon Lake and to gather data to support the planning of local environmental compensation processes.

In a recent publication, it is said that the Chinese Academy of Sciences (CAS) is one of the top-eight institutions worldwide involved in the field of urban agriculture (see Yan et al., 2022). Its research in the field of UA involves many aspects, such as environmental science, rural tourism, agricultural pollution, carbon emissions, land use, and eco-system services.

At the Harbin University of Commerce in Heilongjiang, Dr. Dong CHU is teacher and researcher in urban landscape design. She spent a year as a guest researcher with Prof. Katrin Bohn and Prof. André Viljoen and maintains, together with Prof. Bohn and Prof. Viljoen, the Productive Urban Landscapes blog (see Annex).

At Shenzhen University, Department of Landscape Architecture in School of Architecture and Urban Planning, Dr. Yichen JIANG works a postdoctoral fellow. He obtained his doctoral degree at RWTH Aachen, at the Institute of Landscape architecture and has extensively worked on urban agricultural heritage in China. His latest publication compares characteristics of urban agricultural heritage sites and related policies and management methods for their conservation in China, Germany, and Italy[24].

At RWTH Aachen, a young Chinese PhD candidate, Mr. Luoman ZHAO is working on the spatial dimension of urban food planning and informal urban food systems in China[25].

Finally, *Turenscape* Landscape Architects was established in 1998 and is one of the first and largest private landscape architecture and urban design firms in China, founded by Prof. Kongjian YU, Professor and Dean, College of Architecture and Landscape Architecture, Peking University. The company is a certificated first-level design institute by the Chinese government, involved in all the major landscape projects in the past 20 years. It has planned and designed over 300 ecological cities and 1000 landscape projects in China[26], among others the Shanghai Houtan Park (see best practices below), or the Rice Filed Campus at the Shenyang Architectural University, both projects are mentioned on the blog of Katrin Bohn. The bureau is closely linked to Peking University with a Turenscape Academy Beijing office located on the Peking University Science Park.

[24] See online at: https://www.sciencedirect.com/science/article/pii/S0197397522002077

[25] Five publications of Mr. Zhao Luoman are available at: https://www.la.rwth-aachen.de/cms/LA/Forschung/~nbga/Publikationen/lidx/1/?search=Zhao++Luoman&page=

[26] See their projects on: https://www.turenscape.com/en/project/index/1.html and for Turenscape Academy: http://www.turenscapeacademy.com/

However, it is not clear if research was or is conducted in China, as it has been the case in Europe, to get a better knowledge on urban agriculture and existing best practice in China. In empirical social science research, there are a few isolated studies on the practices of agriculture in Chinese cities, but they focus primarily on what would be considered peri-urban agriculture by Western definitions (see Luehr et al., 2020). A coordinated and networked vision for urban agriculture in China is just at the starting point with the establishment of the IUA.

4. Best practice examples in Germany/Europe and China

In view of how extensive, diverse and complex the UPA types, practices and experiences are in Europe – and they are still evolving - the following examples represent part of the multiple ongoing initiatives covering several types of urban farming systems. As mentioned before, coordinated research on urban agriculture is just at the beginning in China with the establishment of the IUA, but best practice examples are not yet systematically recorded, based on a typology that reflects the situation in China.

4.1 Best practice in Germany

Germany offers best practice examples especially for allotment gardens, vertical farming and community gardens.

4.1.1 Allotment gardens in Germany

Allotment gardens (*Schrebergärten* in German) have a long tradition across many European countries where an allotment garden movement has emerged with the industrial revolution in the 19th century, providing city dwellers opportunities to produce food themselves. However, this tradition is nowhere more well-established than in Germany where these small, distinctive plots are a characteristic feature of many towns. In Berlin, they already existed at the beginning of the 19th century. While the origin of the so-called Schreber-movement was in Leipzig and naturopathic associations were founded in Saxony that intended to educate children and parents for physical exercise, the development in Berlin relates to two lineages, the "leaf colonists" (Laubenkolonisten), a "bottom-up" movement and the allotment gardens of the German Red Cross, described more like a top-down movement. Both lines have in common that allotment gardens were established from the beginning and that these were also at the centre of all associational thinking and action. They differed in that the allotment colonists, mainly self-help workers, created plots on fallow land - most of the land belonged to the city, but churches and private owners also offered unused land - for short-term use, and grew coarse vegetables there, mainly in annual crops, and erected simple shelters or arbours. In contrast, allotment gardens ("worker gardens") were created by the Red Cross for workers and other needy Berliners, building on the experience with gardens for the poor. In 1901 the first Union of the Planting Associations was founded by the Laubenkolonisten in Berlin and in 1921 the unification of all allotment garden organisations in Germany into a unified allotment garden association was decided. The Berlin subdivision campaigned for modern allotment gardens for workers and the unemployed and the proletarian element dominated the life of the association. For example, the first permanent colony in Germany, Rehberge, opened in 1929 in the workers' district of Wedding. The Berlin provincial federation had 66,570 members in 1929.

The German Federal Allotment Garden Federation (BDG) has represented the interests of allotment gardeners at national level since 1921[27]. Since 1983 the federal allotment garden law has regulated the purpose of allotment gardens and defined the conditions for their non-profit

[27] See webpage of the association on: https://kleingarten-bund.de/de/

status. The development of Berlin's allotment gardens was regulated in 2004 in a special allotment garden development plan. However, there is still a strong threat to the preservation of allotment garden areas due to the increased housing construction in Berlin. Over time, the BDG has responded to changing social conditions and expectations, so that today its members represent a large and diverse cross-section of society. However, education and training have always been at the heart of the association, and the BDG has always stressed the importance of passing on horticultural expertise to future generations. Other important messages include the importance of natural gardening methods, the need to ensure biodiversity and soil protection and the role of nature in urban planning.

At present, around 5 million people in Germany use an allotment garden (including family and friends) through 13,453 participating local associations. Allotment gardens are on average 370 m² in size. Statistically, however, it is 438 m² when associated green spaces and service facilities are included.

This corresponds to a huge area of 44,000 hectares of valuable green infrastructure throughout Germany[28].

Conclusion: The German allotment gardens are a good example of urban gardens, mostly located in the periphery of cities, demonstrating individual commitment to food, but at the same time maintained by a group of people (the BDG), based on historically grown and modern social values such as social cohesion and education for a sustainable approach to nature. They might be a good example for China on how to develop informal small-scale intra-urban agriculture (see chapter 5.2.1 below on this form of UPA in China).

4.1.2 Community gardens

Germany has also a vast experience in community gardens where the sense of community is generally more important than the food growing activity, although food production is still a core element of the garden. Community gardens are spaces with a strong local participation ethos; they are created and developed, both for and by, the local residents themselves. Anyone can be involved in creating and using the gardens. They are generally located in central urban city spaces and respond directly to the needs of the local community. Most of the time, the land is provided by the local government for a small contribution or even free of charge.

The highest density of community gardens can be found in Berlin and its city region, counting 134 community gardens[29]. Some well-known initiatives are for example the community garden on the former airport base at Berlin Tempelhof ("Interkultureller Garten 103+") founded in 2016 on 1,600 m² or the Prinzessinnengarten, created in 2009 in Berlin- Kreuzberg on 6,000m² and moved to Berlin-Neukölln in 2019 on 7.5 hectares. This latter one is also a good example for the

[28] For facts and figures see webpage of the association at: https://kleingarten-bund.de/de/bundesverband/zahlen-und-fakten/ . The example is also included in the EFUA project list at: https://www.efua.eu/projects/german-federal-allotment-garden-federation-bdg

[29] See the interactive online map on the "Urban community gardens in Germany"-Webpage, which is also listed in the annex: https://urbane-gaerten.de/urbane-gaerten/gaerten-im-ueberblick

fragile legal system of allotment gardens in Berlin which does not provide the guarantee for permanent preservation[30].

A good example of a community garden within a more complex institutional arrangement can be found in Gelsenkirchen, the **"Hugo biomass Park"** which has been developed as a recreation area on 25ha integrating a community garden component and an environmental education component[31]. On the former industrial wasteland was no public access. To overcome the many challenges, the project was based on a participatory approach. It included many different stakeholders (landowners, the local ministry of environment, the city of Gelsenkirchen, The Ruhr University of Bochum, the Agenda 21 office and local citizens) which were considered important for the success of the multi-faceted project. The knowledge and experience of these stakeholders helped to tackle problems such as the need to import topsoil from external locations.

Conclusion: The various German "traditional" community gardens are good examples for the potential of bottom-up initiatives providing multifunctional benefits to urban residents. Local authorities primarily play a mentoring and enabling role. The Hugo Biomass Park community garden shows the importance of multi-stakeholder involvement in this highly complex re-greening project of a former coal mine.

4.1.3 "Belvedere Park" – a productive landscape park in Cologne's outer green belt

Germany is not a hotspot of community parks, but the Belvedere Park located in an urban fringe area of Cologne is worth being mentioned. The creation of the park in 2014 was part of the green infrastructure project by the city in order to link its open spaces in the outer green belt of the city where agriculture has traditionally been the dominant land use to create a green network for recreational and ecological purposes and to provide better defined boundaries to residential areas. The 300-hectare site which was still under agricultural production before the creation of the park has been changed into an innovative "productive" park linking classical parkland design elements such as meadows, trees and paths with agriculture as the core component, thus reconnecting urban dwellers with agriculture in the landscape. The pathway design is suitable for both recreational use (walkers and cyclists) and for agricultural machinery and four steel observation platforms were created for visitors to observe the fauna and flora of the park from above and appreciate the landscape. Moreover, in the middle lies the Max Planck Institute for Plant Breeding Research, which cultivates the fields. The institute has created a "science barn" and a crop plant garden showcasing some of the species that have traditionally been grown on this site for about 3,000 years[32].

Conclusion: Belvedere Park is a good example of a community park combining food production in a publicly accessible space with a diversity of activities and services, thus delivering

[30] See the garden's webpage at: https://prinzessinnengarten-kollektiv.net/ueber-uns/

[31] See description on the EFUA webpage at: https://www.efua.eu/projects/hugo-biomass-park

[32] For further information see EFUA project map at: https://www.efua.eu/projects/belvedere-park-cologne-germany, or the benefit leaflet in the document and report category of the project on the Community Research and Development Information Service (CORDIS) webpage of the EU at: https://cordis.europa.eu/project/id/101000681/results

multifunctional benefits. It is also interesting for its integration of a scientific research site where scientific findings are communicated to the population in a praxis-oriented way.

In Heidelberg, an interesting inner-city agricultural park is currently being planned. The planning phase, based on a multi-stakeholder consultation process, was finished last year. The implementation, yet, has not started[33].

4.1.4 Vertical farming – Infarm and its retailing partners as an example for zero acreage farms

Zero Acreage Farms comprise a wide variety of forms ranging from high-tech to low-tech, and from non-profit to commercial farming. Its main characteristics are space efficiency, its emphasis on circularity, resource efficiency, and its integration within (or on top of) buildings. Vertical farming is one example, others are for instance floating farms, raised beds on rooftops (or in underutilized industrial areas), green facades or production systems in cellars which rely on artificial lighting.

Germany has an outstanding best practice example in vertical farming, namely the company Infarm, a Berlin-based start-up founded in 2013 that develops in-store farms for retailers and restaurants to be able to produce more than 75 different crops covering herbs, leafy greens, microgreens and mushrooms directly on site[34]. Therefore, it has developed intelligent hardware and software solutions and highly modular indoor farming units than can be stacked for example in supermarkets, restaurant or warehouses. Each unit is fitted with sensors that monitors parameters like temperature, humidity, water and lighting that can be remotely adjusted in order to optimize the farming conditions. In 2022, the company had a partnership with more than 30 retail chains (Edeka, Metro, Migros, Casino, Amazon Fresh etc.) and a few restaurants (e.g., Good Bank in Berlin) in more than ten countries of operation in Asia (Japan), North America (Canada and USA) and in Europe with more than 1,850 stores worldwide offering their produce[35]. The technology behind this type of urban farming is complex and expensive, requiring substantial investments in R&D. As mentioned in chapter 3.3.1, Infarm has received in its early stages an EU grant with which they were able to develop the product and move to the proof-of-concept stage enabling the described worldwide expansion.

Conclusion: Infarm is a good example of a vertical farming company that shows the close links of research and industry necessary for its development, but also for maintaining and progressing the high level of performance for the quality and diversification of the product portfolio and further progress in the reduction and mitigation of its carbon emissions. The company is also a model for a successful business management that has succeeded to overcome the start-up period of these kind of farming systems. Restaurants and retailers working with them are

[33] See project webpage at: https://iba.heidelberg.de/de/projekte/landwirtschaftspark Prof. Katrin Bohn was involved in the project planning in an advisory function.

[34] Butturini, M., & Marcelis, L. F. M. (2019) distinguish four categories of vertical farms: Plant factory with artificial light, container farm, in-store farm and appliance farm.

[35] See the company's "Impact Vision Paper 2022", available at: https://cdn.sanity.io/files/zdn5d6bc/production/c1ef63d60c862e4fc01727e46630b0804f6a3b26.pdf

examples both of the successful market strategy of vertical farming products and the implementation of these high-tech solutions.

4.1.5 ECF Farm Berlin - Aquaponics as another example for zero acreage farms

The also Berlin-based ECF Farmsystems started business in 2015 combining aquaculture (production of perch) with hydroponics (production of basil)[36]. Products can be ordered online and picked up on site. They are also distributed regionally to Berlin food retailers and Berlin gastronomy & catering companies.

Conclusion: The company is a good example for closed loop cycling of water and nutrients techniques, and reduced food miles as fish and produce are sold locally. Economically, the company has developed a reliable distribution network integrated in regional food system and it aims to provide healthy food and job opportunities.

4.2 Best practice in Europe

The following examples provide best practice in other European countries for which these countries can offer more advanced experience than Germany.

4.2.1 Rooftop gardens and vertical container farms in Paris

Rooftop gardens

The City of Paris actively supports urban agriculture through different programs and support for local stakeholders engaged in urban agriculture. In 2016, the city created the **Parisculteurs program** to facilitate and accelerate the installation of agricultural projects in the urban space with the objective to find sites - rooftops, walls, parking lots, open lots - and to give farmers the opportunity to establish their production in Paris[37]. These urban agriculture projects endorse ecological cultivation practices that prohibit the use of pesticides and agrochemicals.

At present, the city has several rooftop gardens, each having a distinct objective.

The social integration garden on **the rooftop of the sports hall Vignoles (Le Jardin sur le toit)** was inaugurated already in 2009[38]. The garden covers about 800m², built on prestressed concrete beams, which support rectangular wooden containers, filled with 40 to 60 cm deep soil. The garden facilities comprise educational plots, a beehive, collective shelter, a composting area and a henhouse. The project brought together a social housing association, an architect's firm and the La Fayette Accueil Association, a nursing home and rehabilitation center that manages the garden. The association uses the garden as part of its strategy to support isolated or distressed people favoring social and professional integration. Moreover, a local residents' association also has plots in the garden and the rooftop garden also includes space for environmental education

[36] See Company webpage online at: https://www.ecf-farm.de/en

[37] For the webpage of Les Parisculteurs see: https://www.parisculteurs.paris/en/home/ . The Association is also listed as best practice in the EUFA project list at: https://www.efua.eu/projects/les-parisculteurs.

[38] See https://www.torontomu.ca/carrotcity/board_pages/rooftops/gymnase_vignoles.html and http://jardinons-ensemble.org/spip.php?article234.

for local elementary and secondary school children. In 2011, Paris adopted a Biodiversity Plan that called for the creation of at least 15 similar rooftop gardens by 2020.

The **Communauté Facteur Graine**, located on top of a post office, produces vegetables, herbs, fruits, and flowers for the 500 employees that work below in the city.

Also worth mentioning is the 2,500m² rooftop farm on top of **L'Opéra Bastille**, being one of the several Les Parisculteurs urban farms. Vegetables such as zucchini, cherry tomatoes, rosemary, thyme are grown on top of this world-famous opera house.

Nature Urbaine Paris (NU-Paris)[39] has opened in spring 2020 on a 14,000m² rooftop garden on top of the Paris Expo Porte de Versailles exhibition center, making it the largest of its kind in the world. NU-Paris is made up of agricultural engineers and market gardeners from all walks of life and of all ages. At the origin of the project in 2015 was Viparis, the manager of Paris Expo Porte de Versailles. It has worked with the two expert Agripolis and Cultures en Ville for the planning of the project and which became founders of NU-Paris in 2020. There are spaces for commercial famers and the possibility to rent vegetable gardens for local residents. Moreover, one event greenhouse of 200m² that can be privatized, and educational visits and workshops are organized open to all but targeting schoolchildren in particular. Local residents can rent squares of 1m² at an annual basis, altogether 156 squares are available and were exploited by June 2021. By the same time, about 34% of the area dedicated to market gardening, i.e. an operational production area of more than 4500m², were exploited. Farmers use two growing techniques: aeroponics (in columns) and hydroponics (in gutters). By 2024, at the end of the development, the objective is to deploy a production area of more than 80,000 m² with 1832 columns and 3540 culture gutters, exploited by 22 farmers. The production of NU-Paris is picked and distributed every day to the surrounding restaurants and hotels located in the direct vicinity of the Porte de Versailles Exhibition Center.

Container farming

In Germany, Infarm is an example for in-store vertical farming. In France, the vertical Agricool farming company, based in Paris and founded in 2015, developed container farms to produce strawberries using aeroponics. Encountering economic difficulties, the company was sold in 2022 to VIF Systems, a leading company in the development of technical equipments of different sizes in hydroponics and in controlled environments – plant cupboards, containers and 100m² "farms". Still under the brand name Agricool, it produces at present in Paris in 13 shipping containers equipped with self-contained vertical farming systems, offering a variety of seven fruit and vegetables – lettuce, herbs and strawberries – which are sold in 90 shops in Paris[40]. All products are produced without pesticides, grown in the city, less than 15km from their place of consumption and the containers are operated on 100% renewable energy.

Conclusion: The Paris rooftop gardens are good examples of different spaces that can be used for rooftop farming covering different business models and using different technologies. The container farm is a good example of yet another vertical farm system which is not developed in

[39] See the webpage of the initiative (only in French) at: https://www.nu-paris.com/nature-urbaine/. In English, a short description is online at: https://workshopsinfrance.com/places/rooftop-gardens-of-paris/

[40] For Agricool see: https://www.agricool.co/fr. For VIF systems see: https://vif-systems.com/

Germany so far. And the urban agriculture food policy of Paris is a forerunner in Europe in terms of urban food policies.

4.2.2 Community parks in Italy

Several good practice examples of community parks within peri-urban belts of cities can be found in **Italy** where food and access to high quality food has always been important to the population, also city dwellers. The **South Milan Agricultural Park** is made up of 42,000 ha, an agricultural park that primarily provides local residents of Milan with sustainable and fresh food and second, to make the park accessible as a place for leisure attracting tourists and citizens, allowing them to partake in courses and leisure activities. The cities of Parma and Rome also have community parks, which are presented in the literature as best practice examples, the **Picasso Food Forest in Parma** and the **Parco Ort9 in Rome**[41]. The Picasso Food Forest is an urban community-managed food forest that was born from the citizen movement, Fruttorti Parma, in 2012. The food forest was developed on previously underutilized land. This land now provides recreational and educational greenspace for the local community. The citizen-based initiative Parco Ort9 was inaugurated in spring 2017 on the outskirts of Rome. 107 allotments are available for production. In addition to cultivation, the project promotes social cohesion. There are a set of shared values, which include the use of permaculture and the donation of part of the produce to charity. Diverse projects and workshops organized by different associations and NGOs are destinated to urban gardeners, local residents and schoolchildren.

Conclusion: Italy provides a long experience with community parks which are not available in Germany, especially in the peri-urban space.

For further best practice in Europe, projects presented on the EFUA homepage are helpful and examples provided on other useful webpages that are listed in the Annex.

4.3 Best practice in China

Best practice examples in China are often based on the typologies that were developed in the Global North. As described above, only one Canadian study tries to develop a Chinese typology examining three distinct forms of urban agriculture in China. These are presented first before other examples are listed.

Luehr et al (2020) note that urban agriculture within the Chinese agricultural discourse and policies is fraught with uncertainty, because first, the dichotomized land-use categories – rural land versus urban land – shape the access of residents to land for agricultural purposes and present food production in urban areas as inefficient and second, policies aim to make cities more urban and rural areas more like the countryside while at the same time the state's 'urban modern agriculture' (*dushi xiandai nongye*) plan only emphasizes peri-urban regions for robust domestic production and multifunctional urban agriculture.

[41] For Milan see: https://blogs.brighton.ac.uk/pulr/2017/03/02/south-milan-agricultural-park/. For Parma and Rome see the EFUA project webpage at: https://www.efua.eu/projects

4.3.1 Small-scale intra-urban agriculture in Nanjing, Jiangsu province

Small-scale intra-urban agriculture reflects these uncertainties in an exemplary way. Lower-income individuals, mainly retired persons with a rural background but also migrants, are growing vegetables in vacant spaces close to their homes. They usually use spaces around the city without formal permissions. Garden plots range from 0.5m² to 100m² in core districts, and from 100m² to 1,300m² in new urban areas. This informal food production forms within the intra-urban space of Chinese cities are also studied by Zhao at RWTH Aachen, also for Nanjing, and it can be assumed that these forms of small-scale urban gardens exist in all Chinese cities.

Conclusion: It seems difficult to visit these plots as best practice examples since they belong to the informal economic sector, but they play an important role for food production for a certain population category.

4.3.2 Intra-urban capital-intensive agriculture

This intra-urban production form usually comprises high-tech, indoor, greenhouse or vertical farming operations, mostly undertaken by private enterprises, with usually strong links to researchers and industry. Luehr et al (2020) note that capital-intensive intra-urban initiatives are not mentioned in agricultural development related policies, although these firms largely embody principles of modern agriculture prioritized by the state. They conclude that these initiatives are tolerated not as an economically viable, long-term food security strategy, but as a development model for multifunctional agriculture. Private company best practice examples are cited to be found in Shanghai or Beijing in the article, but without any further description.

Nevertheless, one example is the **Sanyuan Farm in Beijing** Haidian District, one of the five pilot showcases in the SiEUGreen Horizon2020 project[42]. Besides planting in greenhouses, the project also combined vertical farming techniques and aquaponics. The showcase aquaponics system was completed in October 2019, is 20 m long and 4 m wide. Each growing season is expected to produce 1,500 kg of fish and 6,000 kg of vegetables (30 to 40 varieties of vegetable and 8 to 10 varieties of fish).

Conclusion: The booming interest in vertical farming in China has led to the creation of companies engaged in this high-tech farming solution. It might be interesting to discover some of them and ask IUA for concrete best practice examples.

4.3.3 Peri-urban agro-tourism farms

These commercial farms are specialized in growing, and sometimes processing, agricultural products with a farm size ranging from 3 to over 200 hectares, with most around 100 hectares. They are mostly private run and sometimes open up opportunities for consumers to engage in the production process, from planting to picking and consuming the harvest, while lodging is provided, and restaurants at the farms improve the agritourism experience. This is mainly done to build trust and provide transparency in the food production practices. They also often develop food system traceability for consumers through for example scanning a product's barcode with

[42] See online at: https://www.sieugreen.eu/Showcases .

a mobile device. Again, the study does not provide names of the enterprises, eight of them are in Yangling, one in Nanjing.

However, one example of this form of peri-urban private-run multi-functional farms is the Ecoland Club Farm (ECF) which describes itself on its webpage as "the first Schrebergarden Community Farm in China"[43]. ECF was set up by Dr. PAN Tao in 2010 in Shanghai's Fengxian District. Dr. Pan got inspired by the phenomenon of 'Schrebergarten' (allotment gardens) during his studies in Germany and transformed the conventional Schrebergarden concept to a "Schrebergarden 2.0" model, as mentioned on the homepage. On a total area of 8.5 hectares, there are plots for farming and for leisure activities, and since 2022, with the support of DCZ, 2,000m² are reserved for a Global Fields initiative[44]. To date, there are about 400 plots for rent to farming – with organic farming as principle - with plot sizes varying from 60m² to 200m² depending on the membership contract. Four kinds of memberships are possible: 1. Regular member – for 5,000 RMP per year - without owning an allotment, with the possibility to enjoy the nature on the communal spaces and participate in harvesting and other club activities (fishing, barbecue, hot pot etc.). 2. Premium member – for 7,500 RMB per year – without owning an allotment but getting a basket of fresh green home-grown vegetables delivered to the house every week. 3. Super member – for 9,000 RMB per year – owning an allotment plot of 60-80m² with 4kg of fresh farm produce every week included in the fee, and the possibility to build to small cottage. 4. "Shareholder member" owning an allotment plot of 200m². Included in the fees are hired farmers who plant and tend the vegetables in the gardens. The allotment members can decide which vegetables or fruit they want to grow on their plot, and an "Ecoland Farm" mini-app offers further help with harvesting. In the meantime, a second allotment farm was set up in the district and Dr.Pan also intends to invest in Kunming and even in Germany.

Conclusion: This form of peri-urban agriculture best practice might be interesting for German stakeholders for their combination of different economic activities, the consumer participation in these companies and the use of modern technical devices.

4.3.4 Rooftop gardens in Shanghai – best practice in rooftop farming

In Shanghai, the experimental V-roof project was founded in 2011 with the aim to bring agriculture to the city's roofs. Technologies such as anti-seep, pest control using fermented manure, automatic irrigation, cycling purification, and anti-ultraviolet plastic containers were used to ensure the garden ecology is preserved[45]. In 2016, the city then announced a plan to add two million square metres of greenery to the roofs and walls of the city's buildings by 2020. It is stated that they have achieved this goal with around 20 farms filled with greenery, herb gardens, vegetable plots, and animal farms established in the city. In one of them, technology has helped citizens to take care of their plants through a mobile app which allows to virtually

[43] See webpage of the farm at: http://www.ecolandclub.com/#%E5%86%9C%E5%9C%BA%E6%9C%8D%E5%8A%A1. More information can be also found in booklet comparing this farm with a Hongkong allotment farm at: https://issuu.com/cocolin219/docs/urbanfarming_booklet or in an article in the Frankfurter Allgmeine at: https://www.faz.net/aktuell/wirtschaft/wohnen/garten/chinas-schrebergarten-soll-nach-deutschland-kommen-17439700.html?premium

[44] See DCZ webpage: https://www.dcz-china.org/2022/08/29/dcz-participated-in-global-field-meeting/

[45] See online at: https://www.torontomu.ca/carrotcity/board_pages/rooftops/V-Roof_Shanghai.html

monitor the development of the plants and even to provide distantly artificial sunlight and water when required[46]. Shanghai is said to be the nation's leading city in the field of rooftop farming according to Tongji University professor of landscape design Liu Yuelai[47], but other examples can also be found in Beijing, Wuhan, Shenzhen or Chengdu.

Conclusion: Although the idea of rooftop gardening is a relatively novel way to grow food in Chinese urban areas, there are technological devices not used in Germany/Europe so far.

4.3.5 Community-supported agriculture (CSA) in China

The 10th China Community Supported Agriculture Conference, which took place in 2019 in Chengdu, showed the extent to which CSA in China has gained legal status and is perceived as a genuine part of the way forward by all three levels of government in China (local, provincial and national) as alternative food initiatives that promote diversified agroecological systems[48]. In China, the majority of CSAs appear to be producer led, and there are agreements that have been signed with several local and provincial governments to ensure that agricultural land is being preserved to produce "ecological food". The Little Donkey Farm—located in Haidian district in Beijing is the most prominent CSA farm in China based on a citizen's farm management model. It accessed land and financial resources with the support of the local government. Another CSA farm —the Big Buffalo Farm—in Changzhou, Jiangsu Province also received support from the local government. In 2019, it was estimated that there were more than 1,500 CSA farms across the country (Lin Z., 2022), mainly located on the peripheries of cities. Little Donkey Farm, however, is the best known and mediated example since it was the first CSA farm in China[49]. It was established in April 2008 and occupies about 15ha in Beijing's Haidian District and is today a collaboration between Beijing's Haidian District's Agriculture and Forestry Ministry, Renmin University's School of Agricultural Economics and Rural Reconstruction Department. Three schemes of participating arrangements exist in the farms's "work share program": DIY farming, trust land and VIP family garden. In terms of distribution, there are also several schemes (e.g. in pick-up shops or home delivery) depending on individual needs. Moreover, training and educational events are provided to teach citizens the techniques of how to plant their "own" land.

Conclusion: Little Donkey Farm is a good example to observe the EFUA category "urban farms" in China and the functioning of short supply chains in Chinese cities.

4.3.6 Urban gardens in China

The Shanghai Houtan Park has been presented as an example that integrates food into green infrastructure planning in China[50]. The site was built in 2010 on a narrow linear 14-hectare band

[46] See an article on Dao Insights at: https://daoinsights.com/opinions/why-are-rooftop-gardens-taking-off-in-china/

[47] Cited in a 2017 Sixth Tone article on "Shanghai's edible rooftops". Online at: https://www.sixthtone.com/news/1001052/shanghais-edible-rooftops

[48] See more information on: https://www.fao.org/family-farming/detail/en/c/1177534/

[49] See the blog of Prof. Bohn (https://blogs.brighton.ac.uk/pulr/2017/07/01/little-donkey-farm-china/) and the farm's homepage at: http://www.littledonkeyfarm.com/plugin.php?id=aiview_dzx:pages

[50] See Bohn and Chu (2021) and the blog of Prof. Bohn.

that used to be a lay down yard for a steel factory. The park evokes memories of an agricultural society, and it proposes a future ecological society. It is a reminder of the local agricultural heritage with crops planted in an ornamental way to reconnect with the site's agricultural history. Crops include sunflowers to rice to green clover and provide small economic benefits. On the Turenscape homepage (see chapter 3.4, p.14) many other green park examples can be found, many of them also integrating crops in an ornamental way as reminder of agricultural heritage.

Conclusion: China has many big-scale urban gardens that have been developed recently in an effort to re-green the city's infrastructure. Planning processes behind these projects would be of interest for German/European landscape architects.

4.3.7 Urban agricultural heritage sites

China has unique agricultural heritage sites with symbiotic practices, e.g. an Orchard Dike-Pond systems or a Mulberry-dyke and Fish Pond System. The first one is on the Urban Agricultural Heritage Interactive Atlas (see annex), the second is described on the blog of Prof. Bohn. The two systems are early prototypes for an agricultural cycle model and an environmentally friendly ecosystem. They have proven to be an eco-friendly agricultural landscape and could serve as existing aquaponic models for a continuous productive (urban) landscape with ecological and economic value.

Conclusion: Although the first example is listed on the urban agricultural heritage list cited above, it is situated in a rural landscape, which is also true for the second example. However, they can be models which have proved their value to be integrated in urban landscapes.

5. Knowledge gaps and requirements

An impressive work has been done to understand the spatial characteristics, production features, operational parameters, and social dimensions of UPA. Nevertheless, the literature review, forthcoming research projects on UPA, the exchanges on the DCZ-CAAS workshop and the interviews have revealed where uncertainties exist, and further research is needed. And as it is stated in the latest Urban Agriculture Magazine, published by RUAF Global Partnership on Sustainable Urban Agriculture and Food Systems (RUAF 2022):

> *Although the number of studies and publications around the UA domain was already growing in 2001, the number has expanded today to a level that was hardly imaginable back then. Nevertheless, much of the data is still anecdotal and difficult to compare. As such, while multi-city and multi-country studies have become more common, the challenges of assessing the scale and impacts of UA remain significant. Moreover, support for UA has not become institutionalised to the same extent as the research has expanded.*

The following list does not intend to be complete but features the most relevant issues.

Urban agriculture in general: The productive potential of different urban food production systems and their agronomic suitability needs further understanding. Studies tend to focus on particular crops (such as leafy greens and tomatoes) and overlook others (mainly fruit), there is a gap especially for soft fruits and fruit trees, as these crops are likely to be widely grown in urban areas. There are also few studies for specific crop categories in grey spaces. Uncertainty regarding the sustainability of urban food production and how it may vary depending on where and how crops are grown needs further investigation and more life cycle assessments of urban agriculture need to be conducted to assess whether producing food in cities and towns for urban dwellers is more resource-efficient than existing supply chains. The expansion of inter- and transdisciplinary research is also needed that integrates social and ecological research, especially addressing urban agriculture ecological and social multi-functionality and relationships of urban agriculture governance to social and ecological systems[51]. Concerning the terminology, efforts will continue to develop. In China, however, terminology is not yet so well assembled and needs further investigation.

Vertical farming: Uncertainties about different aspects of intensive vertical farming: its cost-effectiveness, scalability, the environmental sustainability and its social acceptance, e.g., research is ambiguous about whether overall carbon emissions are lower for vertical farming than for traditional farming methods, how to reduce operational costs and the high energy demand and challenges to make vertical farming economically profitable and how to increase consumer acceptance[52].

CEA: Research needs are similar to vertical farming since methods of CEA are used in vertical indoor farming to manage e.g., humidity, temperature, gases, light, nutrients, water or

[51] For this latter point see ZImmerer KS et al. (2021), which was also confirmed in the interviews.

[52] For recent publications see for example: Butturini, M., & Marcelis, L. F. M. (2019) and the recent publication (December 2022) on vertical farming by the European Parliamentary Research Service (Kuljanic, N. 2022).

pathogens. Topics that need to be further investigated are for example: sustainable energy supply from renewable sources, land consumption and land saving potentials, closing of material cycles / circular economy, food quality in CEA, diversification of planted crops, GHG reduction effects etc.

Food policy and urban landscape planning: Sufficient knowledge about the effectiveness of the different food policy instruments and appropriate mixes is lacking for a targeted choice of measures and instruments. Knowledge on planning processes to integrate food-productive infrastructure in urban environments is also limited. Currently, nature-based solutions are widely explored, which sometimes include "sub-solutions" linked to urban agriculture (e.g., community-based urban farms and gardens, city aquaponics infrastructures) especially in Europe, but without focus on productive urban landscapes solutions.

Urban agriculture heritage: There is more need to understand the qualities of inherited and vernacular systems of urban agricultural production and its benefits, e.g., for food supply, income generation, social cohesion, biodiversity, and urban metabolism. For China specifically, how to integrate traditional symbiotic agricultural production systems into the urban landscape, e.g., the mulberry dike fish pond system.

Bibliography

Artmann, M.; Specht, K.; Vávra, J.; Rommel, M. 2021. Introduction to the Special Issue "A Systemic Perspective on Urban Food Supply: Assessing Different Types of Urban Agriculture". *Sustainability 2021, 13*, 3798. https://doi.org/10.3390/su13073798.

Bohn, K, Chu, D. 2021. Food-productive green infrastructure: Enabling agroecological transitions from an urban design perspective. *Urban Agric Region Food Syst*. 2021; 6:e20017. https://doi.org/10.1002/uar2.20017

Böhme, M. 2022. 4th Exchange Forum promotes exchange in urban agriculture research. (Available at: https://www.dcz-china.org/2022/12/16/4th-exchange-forum-promotes-exchange-in-urban-agriculture-research/, accessed January 2023)

Butturini, M., & Marcelis, L. F. M. 2019. Vertical farming in Europe: Present status and outlook. In T. Kozai, G. Niu, & M. Takagaki (Eds.), Plant Factory: An Indoor Vertical Farming System for Efficient Quality Food Production (2nd ed.). Elsevier. https://doi.org/10.1016/B978-0-12-816691-8.00004-2

COST project. Online Atlas. (Available at: http://www.urban-agriculture-europe.org/online-atlas.html, accessed June 2022).

Doernberg, A., Horn, P., Zasada, I., Piorr, A. 2019. Urban food policies in German city regions: An overview of key players and policy instruments. *Food Policy 89 (2019)*. (Available at: https://www.researchgate.net/publication/337281797_Urban_food_policies_in_German_city_regions_An_overview_of_key_players_and_policy_instruments, accessed December 2022).

Food and Agriculture Organization of the United Nations (FAO), 2022. FAOSTAT - Crops and livestock products. Retrieved from https://www.fao.org/faostat/en/#data/QCL

FAO, Rikolto and RUAF. 2022. *Urban and peri-urban agriculture sourcebook – From production to food systems.* Rome, FAO and Rikolto. https://doi.org/10.4060/cb9722en

Jansma, J.E., Veen, E.J., Vaandrager, L., Muller, D. & Berg, W. van den. 2022. UA typology update (resubmission 10.08.2022). (Available at: https://cordis.europa.eu/project/id/101000681/results, accessed December 2022).

Kuljanic, N. 2022: What if we grew plants vertically? European Parliamentary Research Service, Scientific Foresight Unit (STOA). *At a Glance, December 2022*. (Available at: https://www.europarl.europa.eu/stoa/en/document/EPRS_ATA(2022)737130 , accessed December 2023).

Lin, Z. 2022: Is the 'solidarity economy' an alternative for China's urban food supply? Could farming conducted for social rather than financial profit help meet the challenges the pandemic has posed to food supply? *China Dialogue, May 2022*. (Available at: https://chinadialogue.net/en/cities/is-the-solidarity-economy-an-alternative-for-chinas-urban-food-supply/, accessed June 2022).

Lohrberg, F. & Licka, L. & Scazzosi, L. & Timpe, A. 2015. Urban Agriculture Europe: Agriculture Interacting with the urban space. Vicenza, Italy, Ideabooks.

Luehr, G., Glaros, A., Si, Z., Scott, S. 2020. Urban Agriculture in Chinese Cities: Practices, Motivations and Challenges. In: Urban Food Democracy and Governance in North and South. International Political Economy Series. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-17187-2_17

McEldowney, J. 2017. *Urban agriculture in Europe: Patterns, challenges and policies*. Brussels, European Parliamentary Research Service. https://doi.org/10.2861/413185

Payen, F. T., Evans, D. L., Falagán, N., Hardman, C. A., Kourmpetli, S., Liu, L., et al. 2022. How much food can we grow in urban areas? Food production and crop yields of urban agriculture: A meta-analysis. *Earth's Future*, 10, e2022EF002748. https://doi.org/10.1029/2022EF002748

Piorr, A, Zasada, I, Doernberg, A, Zoll, F and Ramme, W 2018, Research for AGRI Committee – Urban and Peri-urban Agriculture in the EU, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

RUAF 2022. 20+ years of RUAF. *Urban Agriculture Magazine, No. 38, July 2022*. (Available at: https://ruaf.org/urban-agriculture-magazine/, accessed December 2022)

Santini, G. 2022. The role of urban and periurban agriculture in promoting resilient local food systems. Presentation given on the EFUA Rome FACTS Conference, 29 March 2022. (Available at https://www.efua.eu/conferences/facts-conference, accessed June 2022).

Santo, R., Palmer, A., Kim, B. 2016. Vacant lots to Vibrant Plots: A review of the benefits and limitations of urban agriculture. Johns Hopkins Center for a Livable Future. (Available at: https://clf.jhsph.edu/sites/default/files/2019-01/vacant-lots-to-vibrant-plots.pdf, accessed January 2023).

United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision, Online Edition. (Available at https://population.un.org/wup/Download/ , accessed November 2022).

Van Brom, I. 2022. Urban Agriculture in Horizon Europe. Presentation given on the EFUA Rome FACTS Conference, 29 March 2022. (Available at: https://www.efua.eu/conferences/facts-conference), accessed June 2022).

Yan, D.; Liu, L.; Liu, X.; Zhang, M. Global Trends in Urban Agriculture Research: A Pathway toward Urban Resilience and Sustainability. *Land 2022, 11, 117*. https://doi.org/10.3390/land11010117

Zimmerer KS, Bell MG, Chirisa I, Duvall CS, Egerer M, Hung P-Y, Lerner AM, Shackleton C, Ward JD and Yacamán Ochoa C (2021) Grand Challenges in Urban Agriculture: Ecological and Social Approaches to Transformative Sustainability. Front. Sustain. Food Syst. 5:668561. doi: 10.3389/fsufs.2021.668561 FAO. 2017. The future of food and agriculture – Trends and challenges. Rome.

Annex

Overview of webpages with best practice examples

http://www.ua-heritage.com/atlas/

Urban Agricultural Heritage Interactive Atlas

Atlas showing FAO Globally Important Agricultural Heritage systems (GIAHS) and UNSECO sites, categorized along 12 Urban Agriculture Types: Community Garden, Commercial Farm, Educational Garden, Allotment Gardens, Squatter Gardens, Leisure and Educational Garden, Therapeutic Farm, Social Farm, Cultural Heritage Farm, Experimental Farm, Local Food Farm, Environmental Farm. It contains one example in Germany and one in China.

https://www.fao.org/urban-peri-urban-agriculture/en

FAO Urban and peri-urban agriculture Webpage (created in 2022)

The webpage contains a publication of six case studies, which are also included in the Sourcebook (FAO et al. 2022). The sourcebook mentions that a matrix with the 70 other examples presented in the sourcebook will be published on this website soon.

https://www.efua.eu/projects

Horizon 2020 EFUA Project Map

The interactive project map gives 33 examples of which 5 in Germany.

https://blogs.brighton.ac.uk/pulr/category/related-design-projects/

Productive Urban Landscapes blog

The blog set up in 2018 by Dong Chu (Harbin Commercial University, China), Katrin Bohn and André Viljoen (both University of Brighton, UK) provides 17 project examples that have a connection to productive urban landscapes in general and to the CPUL concept in particular. Two examples from Germany are presented and five from China[53].

https://www.torontomu.ca/carrotcity/categories.html

Carrot City Initiative Database

In 2008, a research group from Ryerson University in Toronto, Canada, initiated the Carrot City initiative with the aim to explore the various initiatives taken on urban agriculture around the world. The group of professors specialising in architecture and landscape design, considers how the design of cities, urban landscapes, buildings, and gardens can facilitate the production of food in the city. The case studies database, containing more than 100 examples, are organized into five categories representing distinct scales: City, Community and Knowledge, Housing, Rooftops, and Components. The fifth category illustrates products, technologies and systems that are innovating and facilitating food production in urban contexts.

[53] This is the source that provides the most examples from China.

It contains three examples from China, and two in Germany.

http://www.urban-agriculture-europe.org/online-atlas.html

The COST Action Urban Agriculture Europe project, funded by the European Cooperation for Science and Technology (COST), collected more than 200 case studies and made them accessible online in the Atlas of Urban Agriculture Europe. (This webpage was accessed in June 2022, currently it is "temporarily unavailable").

https://urbane-gaerten.de/urbane-gaerten/gaerten-im-ueberblick

The urban community gardens in Germany

A private foundation-funded webpage (available only in German) providing an interactive project map with more than 800 initiatives all over German, some of the community gardens are further specified as "Intercutural community gardens".

Overview of monographies, compilations, or articles with several best practice examples

Piorr, A, Zasada, I, Doernberg, A, Zoll, F and Ramme, W 2018, Research for AGRI Committee – Urban and Peri-urban Agriculture in the EU, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

Butturini, M., & Marcelis, L. F. M. (2019). Vertical farming in Europe: Present status and outlook. In T. Kozai, G. Niu, & M. Takagaki (Eds.), Plant Factory: An Indoor Vertical Farming System for Efficient Quality Food Production (2nd ed.). Elsevier. https://doi.org/10.1016/B978-0-12-816691-8.00004-2

FAO, Rikolto and RUAF. 2022. Urban and peri-urban agriculture sourcebook – From production to food systems. Rome, FAO and Rikolto. https://doi.org/10.4060/cb9722en