There's something growing on the roof

ROOFTOP GREENHOUSES ▲ Idea ▲ Planning ▲ Implementation

ZFarm
Städtische Landwirtschaft der Zukunft

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Rooftop Greenhouse, Manhattan School for Children, New York City, USA

Urban agriculture of the future – on inner-city buildings

Urban agriculture is a major trend throughout the world at present – also in Germany.

Within the "ZFarm" research project, researchers from the Leibniz Centre for Agricultural Landscape Research (ZALF) joined forces with its partners Institute for Urban and Regional Planning (ISR) of Technische Universität Berlin and inter3 Institute for Resource Management to investigate the conditions required to grow fruit and vegetables on inner-city buildings. Using the example of Berlin, the project involved teaming up with Berlin's stakeholders to identify the potential, obstacles and necessary framework conditions surrounding the implementation and spread of rooftop greenhouses.

One product of the ZFarm project is this practical guide for realising rooftop greenhouses in the city. The aim of this manual is to provide support to stakeholders, experts, decision-makers and citizens in the practical implementation of such concepts in the form of recommendations for action.

Content

Eagle Street Farm, New York City

Building-integrated agriculture – a social, technical and creative challenge for urban development

Building-integrated agriculture offers a chance for climate protection and a large variety of opportunities for self-development for big-city residents. However, it also poses new challenges for the experts. Productive "gardening" in and on buildings must be made viable technically, constructively and, last but not least, from a design point of view. The practical guide you are now reading makes this topic manageable for users and planners, making implementation possible immediately.

This practical guide for "rooftop greenhouses" is the result of a research project in Berlin. It was kindly sponsored by the Federal Ministry of Education and Research. My administration contributed to the discussion process with its important project experience and findings from the "Pilot projects in urban ecology", as well as offering expert advice during the guide compilation process.

The guide clearly shows the complexity of the topics, which require interdisciplinary cooperation. It is thus a great achievement that this collaboration between the relevant Berlin stakeholders was so successful and that their knowledge and their requirements became part of this documentation.

New property resources for self-sufficiency in the big city.
The Senate Department for Urban Development and the Environment has been receiving a growing number of queries regarding "building-integrated agriculture". There is interest in both temporary use and long-term building concepts. The concepts are complex, and they bring into correlation the building services-related topics of supply and disposal, greening, the closing of building material cycles and the use of reclaimed nutrients to produce food. Urban agriculture is not dependent on natural ground, it offers advantages in the competition for urban land use and it reduces food transport distances. It can be practiced on rooftops, on facades, in tubs and inside buildings. Besides promoting food self-sufficiency, it also has other advantages for urban society: increasing the amount of neighbourhood green and enhancing biological diversity in the urban space.

This project is integrated into higher-level strategies. Against the background of climate protection and adaptation and reaction to climate change, Berlin has created the "Urban Landscape Strategy" and the "Berlin Biological Diversity Strategy". These strategies meet the current challenges facing urban development politically and technically; they formulate approaches to solving these problems and provide perspectives for the future. Within the framework of the "Berlin Urban Development Plan for the Area of Climate", innovative processes and technologies are described for the further development of buildings. One of Berlin's goals is to test innovative concepts related to climate protection. Resource-conserving and environment-friendly building methods will also be kept in mind for the large number of flats being newly built or refurbished in Berlin this legislative period. Urban agriculture touches on concepts of social urban development, too. In social hot-spots in particular, urban gardening can provide important stimuli.

For the first time, a manual for implementation. Urban development is not only theory; rather, its success can be measured by its built projects. With this guide, owner-builders, investors, planners, construction firms and public administrations are being given the chance to convert experience from planned concepts into new projects. It shows how much is possible on the way to an ecological city, and how high the bar for measuring future projects has been set.

I look forward to further good, innovative ideas for our city and wish us all the greatest success in implementing new projects in the field of urban agriculture.

Andreas Geisel
Senator for Urban Development and the Environment

Approaching building-integrated agriculture

A photomontage of strawberries in a rooftop greenhouse overlooking the Potsdamer Platz (Berlin)

Information and recommendations for action in approaching building-integrated agriculture (ZFarming), particularly rooftop greenhouses in cities, were elaborated within a "Roadmapping Process" in Berlin.

As yet, rooftop greenhouses are not very common in Berlin and the rest of Germany. Hence there is a lack of robust past experience and reliable regulatory management strategies. This guide is divided into two parts. The first part provides a general overview of the potential of rooftop greenhouses for the City of Berlin and offers recommendations for action aimed at policy-makers. The second part serves as guidance and decision support for operators and interested parties, and describes the challenges that can be expected or need to be met when planning, constructing and operating rooftop greenhouses. However, it is not the intention of this guide to design a concept or to provide guidance on how to operate a rooftop greenhouse without consulting professional experts from the realms of greenhouse construction, architecture, market gardening, and so on.

The aim of the guide is to provide readers with an overview of the subject, enabling them to decide which aspects need to be addressed when realising a particular type of rooftop greenhouse. The guide was created with the support of experts and stakeholders from Berlin in the course of a series of workshops held within the "ZFarm – Urban agriculture of the future" project. The practical recommendations were drawn up with the technical support of the City of Berlin's Senate Department for Urban Development and the Environment. The project was funded by the Federal Ministry of Education and Research as part of the Innovation and Technology Analysis funding priority within the Framework Programme Research for Sustainable Development (FONA).

The key issues that need to be taken into account when planning and operating rooftop greenhouses are addressed in sixteen chapters. The diagram on page seven provides an overview of the planning process.

The chapters are designed so as to provide an introduction to the respective topic, identifying peculiarities, providing references to legal requirements or example projects, and giving advice on how to overcome obstacles or challenges in specific planning steps or during operation. The technical terms used are explained in a glossary.

DETAILS ABOUT THE PLANNING PROCESS

Developing ideas and preliminary planning

Project planning starts with the phase of conceptual preliminary planning, in which the project initiative is initially outlined and the objective defined. Due to the complexity of rooftop greenhouses, it may make sense to work within a team of different experts at this stage of the project. Decisions should also be taken about the appropriate form of use and an adequate operator model in this phase.

Analysis and decision-making

The next planning stage focuses on identifying a suitable location, with the help of a catalogue of criteria. In the event of a varying starting situation, such as when the location is fixed before the concept is developed, the location needs to be scrutinised instead. In addition, construction and planning law regulations must be observed.

Marketing and public relations

The next phase involves analysing the potential sales market and marketing strategies, and devising press and public relations strategies

Production planning

Production planning is derived from the results of the first planning steps, which can be summarised under the term "reliable demand and sales planning". This phase involves thinking about suitable products and production methods, as well as the technical requirements (→ Chapter Greenhouse parts). In addition, planners can deliberate about an optional, optimising use of energy, energy supply, supply with fresh water and the disposal of waste water (→ Chapter Energy optimisation and resource efficiency). Requirements applying to quality assurance and certification options should also be dealt with at this stage of the planning process.

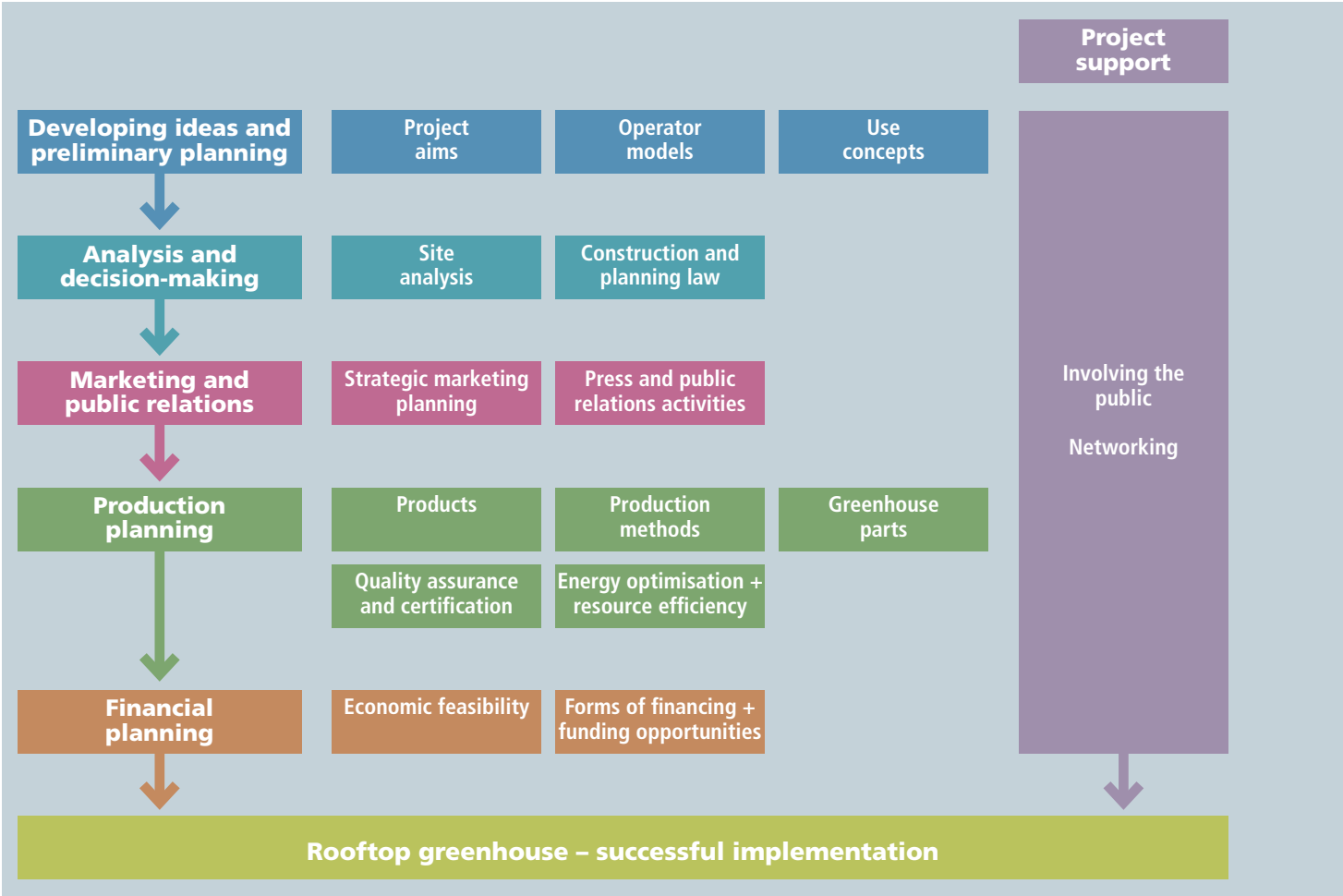
Financial planning

Based on the previous planning steps, the costs involved in the entire project and any potential forms of revenue can then be determined, and investment plans created (→ Chapter Economic feasibility and → Chapter Forms

of financing and funding opportunities). To achieve this, all organisational, procedural, temporal, personnel, structural and infrastructural aspects need to be taken into account.

Project support
The requirements concerning the involvement of users and local residents (participation) and networking with other projects, experts or specialist firms are relevant throughout the planning process.

Based on the planning steps presented, a comprehensive draft of the undertaking can now be drawn up, which is the condition for approval planning.



Potentials and recommendations for action

Container farm in Berlin,
ECF Efiicient City Farming Berlin

POTENTIALS

On its road to becoming a sustainable city that meets tomorrow's needs, Berlin has developed guidelines and strategies for coping with current challenges such as climate and resource protection, changing social demands and population growth. This guidance can be used to help policy-makers decide about measures and courses of action to be taken. Creative and integrative solutions are required. Rooftop greenhouses have the potential to become a component in sustainable cities' sets of measures.

Rooftop greenhouses offer interesting connecting factors, particularly with regard to strategies for protecting resources and the environment, as well as for guidelines for a social, innovative and economically viable city.

Innovative and forward-looking: flagship projects

Rooftop greenhouses are gaining in significance, not only in Germany, but throughout the world. Futuristic architectural designs increasingly reflect the topic, portraying innovative, exciting visions of a possible future. The first rooftop greenhouses, most of which were for educational or commercial purposes, were mainly established recently in North America. So far, hardly any such projects have been realised in Germany. The considerably positive perception of the pioneering facilities abroad suggests that the first rooftop greenhouses in Berlin would also act as flagships. Such outstanding projects would be ideal for presenting Berlin as an innovative, dynamic city at the national and international level. They could act as role models for testing new urban concepts, methods and technologies, attracting innovative, creative minds and tourists.

Consequently, rooftop greenhouses can contribute towards increasing social capital and enhancing Berlin's economic strength in the medium to long term.

Energy and resource efficiency

One key challenge for the future viability of cities is enhancing their energy and resource efficiency. In Berlin, this objective is established in such documents as the Urban Development Plan Climate. Although rooftop greenhouses are not resource-conserving by nature, they enable local material cycles to be established, thanks to the geographic proximity of the greenhouse to buildings. In this way, resources that have been deployed can be reused and therefore conserved. This is particularly the case with water, energy and organic waste. Taking this thought further, such cycles can also be transferred to entire blocks of houses or neighbourhoods, exploiting existing local potential. In this connection, a number of smaller and larger resource cycles can help improve efficiency:

Water cycles

- Cycle-based multiple use of water deployed
- Use of rainwater ⓘ and the treatment of waste water ⓘ from the building or other local sources for irrigating plants
- Use of evaporation water from the greenhouse to irrigate plants or cool the building.

Energy cycles

- Use of waste heat ⓘ from a building, wastewater heat or other local sources such as a swimming pool or a bakery, to heat the greenhouse
- Insulation of the building to protect against heat loss in winter and the impact of heat in summer due to the additional greenhouse layer ("thermal buffer element")
- The building and greenhouse are cooled by circulation, water-based ventilation and dehumidification systems
- Use of glasshouse surfaces to exploit solar energy using filtering glass surfaces.

Organic waste cycles

- Coupling fish farming and plant cultivation: reuse of nutrient-enriched water from the fish tank to water plants in aquaponic systems
- Reuse of organic waste occurring within the building or in the vicinity as plant nutrients
- One great advantage of all material cycles is the possibility to reduce nutrient exports and losses, reducing the need to apply artificial fertilisers.

Short supply chains

It is usually the case that food sold in urban supermarkets has been transported a long way before it ends up on consumers' plates. It is grown on the land,

often processed at a completely different place, and finally transported to the city. Residual materials are often transported back out of the city in the form of waste. In addition, many foods are offered for sale days or even weeks after their production, and a lot of energy is involved in the meantime for storing, processing and cooling the produce. This spatial and temporal separation of the production of food, the consumption of food and waste disposal causes long transport distances and increases the volume of traffic and energy-intensive cooling, with consequences for global warming and urban infrastructure. The possibility to produce food where it is sold and consumed, and to dispose of waste locally, helps to reduce carbon emissions and to ease the burden on cities. It contributes to implementing the urban planning model of short supply lines and to protecting the climate.

Bioclimate

As a consequence of climate change, the average annual temperature in Berlin is expected to increase; longer hot spells and more intense rain can also be expected. These changes will, for example, have a negative effect on the bioclimate, and on people's health and well-being, particularly in highly-sealed inner-city areas. Berlin's Senate Department for Urban Development and the Environment envisages a wide range of measures to enhance the bioclimate in its Urban Development Plan Climate. Some examples of the areas of activity defined in the document are roof greening, reducing the impact of reflection, and heat storage in buildings. Rooftop greenhouses can have a thermal "buffer element" effect, ensuring that the roof surface and the buildings below it do not experience extreme temperatures. Rooftop greenhouses can also act as recreational areas.

Regional economy

In recent years, there has been a marked trend towards regionalisation, as a response to globalisation. Regionalism stands for familiarity, authenticity, down-to-earthness and quality. It conveys a feeling of transparency, sustainability and social justice. The growing interest in regionalism also boosts demand for regional products.

Food is increasingly being produced for the local market, also in cities. Where space is scarce, rooftop greenhouses offer the possibility to produce food in the city in a way that saves space. Consequently, the population can be supplied with fresh, regional products, and the economy can benefit from the positive effects: rooftop greenhouses can create jobs and open up new regional marketing opportunities.

"Green" innovations

In the future, it will become increasingly necessary to combine sustainable development with economic progress. The green economy offers promising starting points to achieve this. One important mechanism in this respect is investing in environmentally sound and resource-efficient technologies such as solar energy and environmentally friendly building technologies.

Berlin has committed itself to this idea in a position paper drawn up together with representatives from the private sector and trade unions. The green growth strategy seeks to reduce greenhouse gas emissions, make cities more energy-efficient, and create new jobs, amongst other things. Rooftop greenhouses can play a role in achieving these objectives. Hence the spread of rooftop greenhouses could reinforce Berlin's pioneering role as the centre of the green economy, whilst helping to protect resources.

Creating new areas of development

Increasing land sealing and competition for space in the city mean that urban open spaces are becoming increasingly scarce. The City of Berlin has established the guiding principle of productive landscapes, amongst other things, in its "Urban Landscape Strategy". In so doing, the city refers to current urban trends and seeks to establish spaces for creativity where people can practice agriculture and be creative. Urban gardening, guerrilla gardening and urban beekeeping are phenomena caused by the increased need to use urban areas communally and productively. In its description, the guiding principle of productive landscape relates to open and green spaces. However, rooftop greenhouses enable new areas to be tapped for micro-farming. Whether in the shape of a communal garden on residential buildings of units, on the roofs of corporate buildings for employees, on homes for the elderly and hospitals – areas for creativity and food production, that simultaneously act as social meeting areas and places for recreation, can be created beneath glass roofs.

Social urban development and education for sustainability

In addition to political and technical activities, there needs to be a change in awareness and behaviour at the individual and social level in order to adapt to climate change. With an aim to fostering this mental shift, Berlin

In Chicago, locally grown products are offered under the label "Farmed here". A building acts as the growing area for herbs and lettuce, which are sold in local supermarkets.

The New York delicatessen supplier Eli Zabar grows tomatoes, lettuce and bell pepper in greenhouses on the roof of a supermarket. The products are sold and processed in the adjacent supermarket and restaurant. The waste heat ⓘ from the bakery is used to heat the greenhouse.

has joined the education campaign "Education for Sustainable Development". This campaign seeks to transfer knowledge about the foundations and interrelations concerning nature protection, nutrition, agriculture, climate protection, energy and participation to the urban population of all ages – but, above all, schoolchildren and youths.

At the same time, the intention is to raise the ability to apply this knowledge. School and educational gardens are an ideal way to actively promote these objectives. They can be used to illustrate growth and interrelations, enabling communal problem-solving strategies to be tested. If outdoor areas become scarce in schools and educational facilities, rooftop greenhouses can fit the bill. The advantage of rooftop greenhouses is that whole material cycles can be recreated and observed in a controlled setting. In addition, teaching staff and schoolchildren are not so tied to the seasons.

RECOMMENDATIONS FOR ACTION FOR DECISION-MAKERS

The realisation of building-integrated agriculture requires drive and framework conditions that are conducive to the objective. Four areas of activity in which decision-makers, funding authorities and private initiators can play a role are presented below:

- Improving framework conditions
- Raising awareness
- Providing infrastructure and
- Advancing and promoting innovations.

Improving framework conditions

The political sector and local government can improve the setting for the realisation of rooftop greenhouses in a political/strategic and regulatory sense. In this case, huge progress can be made at very short notice and without great effort with regard to standardisation and planning reliability for the approval authorities and project planners.

The inclusion of building-integrated agriculture in urban development policy or urban planning framework plans (such as the Urban Development Plan Climate and the Urban Landscape Strategy, see above) would boost its importance for urban development. In addition, there is an ever-growing number of role models for regional supply framework or action concepts throughout the world. These may also include concrete approaches for urban agriculture, besides the objectives of local food production, such as the construction and joint use of a small-scale, local marketing, logistics and processing infrastructure. In the regulatory sense, clarity is required with regard to the eligibility for granting permits for rooftop greenhouses. In order to achieve planning reliability, consistent regulations need to be agreed upon and know-how pooled in planning guidelines.

Another urgent aspect is how rooftop greenhouses are classified in taxation law. So far, it has not been regulated whether products grown in rooftop greenhouses should be taxed on the basis of property tax A (as is the case for agriculture) or whether they should be liable to value-added tax, which makes a big difference when it comes to examining the feasibility of rooftop greenhouse projects.

When procuring produce for canteens, public bodies can increasingly ask for locally and sustainably produced food. In the context of EU competition law, public authorities are allowed a certain amount of freedom here. Federal state governments and the German government could also proactively work towards adapting the legal framework.

In general, the objective should be to embrace the non-monetary benefits of building-integrated agriculture for the city by setting appropriate incentives for house builders. In addition to the existing possibility of being exempted from paying rainwater fees, this could include the positive assessment of rooftop farms as compensation or replacement areas and the application of the biotope area factor and consideration of social and ecological criteria in the allocation of public properties.

In most rooftop greenhouses, plants are grown in soilless substrates or in channels without any substrate at all in order to achieve higher yields. However, this has drawbacks in terms of organic certification because these rooftop greenhouses more or less rule out the possibility of gaining organic certification. To ameliorate this situation, city gardeners could join forces to either work towards the expansion and improvement of existing certification or to define new certification as a measure of quality.

Raising awareness

Berlin's city marketing and the Federal State of Berlin can raise awareness of the topic of building-integrated agriculture in general and of rooftop greenhouses in particular on the website berlin.de, at trade fairs and in a variety of media formats. They can highlight the substantive and technological diversity

of building-integrated agriculture: from low- to high-tech, from small- to large-scale, from socially oriented to commercial. Looking ahead, information and clarification can then foster interest and acceptance amongst consumers, residents, building owners and decision-makers. The role played by rooftop farms and general urban agriculture in achieving the regional, resource-efficient supply of food ought to be communicated.

Targeted public relations can illustrate the advantages and potential of rooftop greenhouses and identify the costs, conditions for success and approaches for realisation, encouraging target groups and potential initiators, property owners and investors to realise concrete projects. Holding specialised conferences and theme events for the public has proven to be a key driver in exchange and networking in the field of urban agriculture. Both the Senate Administrations and the federal ministries have already successfully initiated such events. The momentum generated by such events needs to be maintained and boosted.

The Federal State of Berlin could initiate and promote the implementation of model projects that act as flagships. Berlin has a number of areas and occasions that would be ideal for such an undertaking: for instance, Tempelhofer Feld or the International Garden Show (IGA 2017) and "Sleeping Giants".

Providing infrastructure

City-wide networking through the exchange of information and mutual support can be a great step forwards for urban agriculture on the whole. All kinds of active stakeholders are conceivable within such networks, from Senate Administrations, scientific institutions and research projects to individuals. Until now, however, there has been no common forum for project initiators in which they can also engage in exchange with property owners, investors, gardeners, agriculturalists and associations.

One networking tool could be to set up an (online) database for space made available by property owners. The same portal can then also be used for the provision of information, for self-presentation by project initiators, for mutual assistance and exchange of resources, as well as for joint marketing campaigns. Public authorities in particular should act as role models and pioneers by making suitable areas available on their buildings.

The establishment of a central "Urban Agriculture" Transfer Office can also be recommended for the purpose of providing individual, intensive consultation. This could particularly promote assistance regarding financing issues, funding opportunities and legal aspects, as well as the exchange of knowledge and experience.

Advancing and promoting innovations

There is a great need for research into the further development of greenhouse technologies on roofs. Research questions range from the further development of cultivation technologies (for example, water and energy cycles, lighting) and quality assurance issues concerning (urban) development potential and obstacles, to market strategies and social science aspects such as the acceptance of innovations. The targeted performance review and evaluation of existing projects can provide useful experience about any subsequent improvements and adjustments that may be needed, particularly in this early innovation phase.

Literature and web links used

- Abgeordnetenhaus von Berlin (ed.) (2006): Lokale Agenda 21. Berlin zukunftsfähig gestalten. Berlin: www.stadtentwicklung.berlin.de/agenda21/
- Bildung für nachhaltige Entwicklung: www.bne-portal.de
- „Green Economy" – Chance für Berlin: www.berlin.de/landespressestelle/archiv/2009/11/04/144860/
- Senatsverwaltung für Stadtentwicklung (ed.) (2011): Stadtentwicklungsplan Klima. Urbane Lebensqualität im Klimawandel sichern. Berlin: www.stadtentwicklung.berlin.de/planen/stadtentwicklungsplanung/download/klima/step_klima_broschuere.pdf
- Senatsverwaltung für Stadtentwicklung und Umwelt (ed.)(2012): Strategie Stadtlandschaft Berlin. natürlich urban produktiv. Berlin: www.stadtentwicklung.berlin.de/umwelt/landschaftsplanung/strategie_stadtlandschaft

1 | Project aims

Type 1: COMMERCIAL – The New York start-up company Gotham Greens shows how commercial production can be achieved in a rooftop greenhouse on an industrial site.

DEFINITION OF PROJECT AIMS

The first step when planning a rooftop greenhouse is to clarify the main objective of the envisaged project because all subsequent steps are largely determined by this decision. Requirements planning (sales and cultivation concept, technical and structural requirements) can only be tackled once the main objective has been decided upon. Economic feasibility is also significantly influenced by the objective of the project (→ Chapter Economic feasibility). The reasons for wishing to operate a rooftop greenhouse can be very diverse. The five most common reasons or objectives can be differentiated into the following types:

1. Commercial
2. Urban living quality
3. Social and educational
4. Innovation incubator
5. Image-oriented

It goes without saying that a project may also pursue a number of objectives simultaneously, meaning that combinations of these aspects are equally possible.

TYPE 1: COMMERCIAL
Commercial building-integrated agriculture

The main objective of these projects is to commercially operate agricultural building space for profit (usually as a main source of income). Such projects are often initiated by innovative start-ups or agricultural enterprises seeking to develop new markets. Fresh produce and sometimes processed products are sold at markets, to restaurants, via supermarkets and/or as produce boxes delivered regularly to the home. The roof surfaces used for such projects are usually leased.

Ideal for: supermarkets, industry, warehouses, office buildings and sleeping giants ⓘ
Target groups: urban consumers, the retail food industry and wholesalers

TYPE 2: URBAN LIVING QUALITY
Quality of life through building-integrated gardening

Projects of this nature are primarily found on residential buildings as residents' gardens or sometimes on commercial areas as staff gardens. They act as communal gardens, creating productive, green areas for recreation in an urban environment. The aim of this type of gardening activity is to enhance the quality of life of urban residents or employees.

Ideal for: residential buildings (multiple dwellings), private units, companies
Target groups: residents, company staff

TYPE 3: EDUCATIONAL AND SOCIAL
Educational and socially oriented building-integrated gardening

These projects focus on teaching social and ecological values in connection with growing food. Such projects are initiated and operated by non-profit, social institutions and associations or by educational establishments, usually on their own buildings. The products grown are either processed in affiliated kitchens (such as cafeterias or canteens) or used to meet the participants' own requirements.

Ideal for: schools, hospitals, health care establishments, educational facilities, community centres and youth centres, public bodies, non-profit institutions
Target groups: schoolchildren, students, disadvantaged individuals, patients

TYPE 4: INNOVATION INCUBATOR
Building-integrated agriculture as an innovation driver

In this case, the primary aim of building-integrated urban agriculture is to test innovative and sustainable food supply models. Research activities are often linked to the project. Those involved seek to raise awareness of the topic and to help spread the idea. Occasionally, projects are initially realised as prototypes outside the building so as to gain experience for later implementation on rooftops.

Ideal for: research institutions, universities, foundations, companies with a "green" image, art/cultural institutions
Target groups: academia, business, the media, investors, the interested public

TYPE 5: IMAGE-ORIENTED
Image-oriented building-integrated gardening

The gardening activity is operated as a side-line from the perspective of sustainability and innovation in order to market another core business. In this case, the gardening activity undertaken on or in the buildings where the core business takes place need not necessarily be profitable. Products are processed and/or sold in the core business – usually restaurants, cafés or supermarkets.

Ideal for: cafés, supermarkets, hotels, restaurants, companies with a "green" image
Target groups: café and restaurant patrons, customers, consumers, guests

Type 3: FOR EDUCATIONAL AND SOCIAL PURPOSES – At Manhattan School for Children in New York City, the rooftop greenhouse acts as a "green classroom", giving children access to food production.

Web links to the projects mentioned
- ECF | Efficient City Farming GmbH, Berlin, Deutschland: www.ecf-center.de
- Gotham Greens, New York City, USA: www.gothamgreens.com
- Manhattan School for Children, New York City, USA: www.manhattanschool.org
- Robertas Pizzeria/Garden, New York City, USA: www.robertasgrows.com

Type 4: INNOVATION – The company ECF | Efficient City Farming GmbH tests its prototypes for a rooftop greenhouse on the site of the malting plant in Berlin.

Type 5: IMAGE – Roberta's Pizzeria in Brooklyn, New York: a small rooftop greenhouse and an associated garden are used to supply the pizzeria with fresh produce.

All five types enable additional social benefits to be generated. Rooftop greenhouses installed for educational and social purposes are particularly predestined for achieving social objectives. However, the "quality of life", "innovation" and "image" motivations also have great potential for creating added social value. Commercial building-integrated agriculture has the least leeway in this respect. The following examples give an idea of how such added social value can be created.

SCHOOLS AND NURSERY SCHOOLS

Projects can be implemented as traditional school gardens or demonstration plots (also outside the school premises). The aim of these projects is to enable children to experience nature and to learn about the environment. School garden projects foster participation, and help strengthen the sense of community.
Particular challenges: the issues of financing and ensuring continuous operation (e.g. during the summer holidays) present problems. It must be ensured that projects are integrated into the curriculum effectively. Compliance with safety regulations governing access to roofs by children must also be ensured.
Related practical examples: "Öko-Insel: das Grüne Klassenzimmer" (Eco Island: the Green Classroom) (FEZ Berlin)

HOMES FOR THE ELDERLY AND PSYCHIATRIC INSTITUTIONS

Sensory and therapy gardens enhance sensory perception, help promote health (e.g. brain exercises for dementia patients) and may provide meeting places, recreation areas and safe havens.
Particular challenges: detailed knowledge of disease patterns and their progression is required. Owing to patients' physical and mental constitution, their contribution to operations may be limited. In the event of short stays (e.g. on a psychiatric ward), it may not be possible to ensure the continuity of gardening work. The climate in a greenhouse may be unsuitable for this target group.
Related practical examples: hospital rooftop garden (German Red Cross Hospitals Berlin: Wiegmannklinik), therapy garden of Berlins medical center at Evangelisches Krankenhaus KEH (Evangelisches Krankenhaus Königin Elisabeth Herzberge).

DETOX CENTRES, SHELTERED ACCOMMODATION AND SHELTERED WORKSHOPS

Occupational measures are created, enabling residents to assume responsibility by performing gardening activities.
Particular challenges: there should be barrier-free access to the greenhouse. Owing to the participants' physical and mental constitution, their contribution to operations may be limited.
Related practical examples: nurseries run by Moasik e.V.

EMPLOYMENT PROJECTS

In projects involving recipients of ALG II unemployment benefit, fruit and vegetables can be grown to contribute to self-sufficiency or for additional income (by selling produce). It may also be possible to develop one's own brand, set up cooperatives (food coops) or establish a barter exchange.
Particular challenges: it may be difficult to secure financing and to find sponsors. The enterprise ought to be self-sustaining in the long term.
Related practical examples: intercultural neighbourhood garden with self-sufficiency exchange, for example, in collaboration with Arbeiterwohlfahrt AWO (Ton-Steine-Gärten), employment projects run by Landschaftspark Herzberge (Agrarbörse Deutschland Ost e. V.)

ADULT EDUCATION

The aim of such projects is primarily to educate adults about the environment, raise consumer awareness, achieve food production transparency, enable participation and encourage the exchange of theory and practice.
Particular challenges: it is important to ensure that the project is planned and realised in a decentralised way, and adapted to local conditions so as to avoid problems of acceptance, for example. To this effect, it is also important to involve local actors and initiatives, and to take account of gender mainstreaming ⓘ aspects. Good public relations need to be ensured.
Related practical examples: open-air museum for agricultural and food culture focusing on ecology (Domäne Dahlem), Italian Renaissance Garden (Gardens of the World), Exotischer Kräutergarten (exotic herb garden).

INTERCULTURAL GREENHOUSE

These projects are aimed at individuals/families with a migration background, who are able to rent allotment patches or plots. Such projects focus on promoting integration and intercultural exchange, as well as demonstrating and exploiting their ability to participate fully in society and in decision-making processes.

Particular challenges: experience gained in intercultural gardens can be drawn on in the search for financing and funding options. Projects should be clearly visible to the public so as to reach the target groups.

Related practical examples: Interkultureller Garten Rosenduft

FACTS AND TIPS

- The "non-profit" criterion is regarded as a good basis for gaining initial funding. However, the enterprise needs to be able to cover its costs in the medium and long term.
- Consuming produce grown on one's own patch reduces the amount of money spent on food, ensuring the provision of fresh, local products.
- Jobs are created when products are further processed and refined, diversifying the product range.
- Long-term socio-educational support should be secured for social projects.

Individuals objectives may be combined as required, enabling problems identified in certain fields to be addressed or potential to be better exploited. In order to increase the prospects of achieving economic viability, it may make sense to integrate the rooftop greenhouse into other forms of utilisation (with a bar, art projects or open use of roof space).

Web links to the practical examples mentioned

- Agrarbörse Deutschland Ost e. V.: www.agrar-boerse-ev.de
- Arbeiterwohlfahrt (AWO): www.awo.org
- Domäne Dahlem: www.domaene-dahlem.de
- DRK-Kliniken Berlin: Wiegmannklinik: www.drk-kliniken-berlin.de/unternehmen/meldungen/der-dachgarten-der-drk-kliniken-berlin-wiegmann-klinik-auf-dem-westend-gelaende-wurde-gruendach-des-jahres-2010
- Exotischer Kräutergarten: www.exotischer-kraeutergarten.com
- Italienischer Renaissancegarten der Gärten der Welt: www.gruen-berlin.de/parks-gaerten/gaerten-der-welt/renaissancegarten/informationen
- Interkultureller Garten Rosenduft: www.suedost-ev.de/interkultureller_garten/interkultureller_garten.php
- Landschaftspark Herzberge: www.landschaftspark-herzberge.de
- Mosaik e. V.: www.mosaik-berlin.de
- Öko-Insel FEZ: www.fez-berlin.de
- Robertas Pizzeria/ Garden, New York City, USA: www.robertasgrows.com
- Therapiegarten des Evangelischen Krankenhauses Königin Elisabeth Herzberge: www.psyb.de/tga
- Ton-Steine-Gärten interkultureller Nachbarschaftsgarten: www.gaerten-am-mariannenplatz.blogspot.de

A rooftop garden was created on the roof of the Wiegmann-Klinik of the German Red Cross Hospitals Berlin as an area for recreation and retreat and a meeting place for patients.

2 | Operator models

Brooklyn Grange is a 4,000 m² rooftop farm on a former factory building in New York City, USA.

Rooftop greenhouses can be planned, constructed and run using various constellations of operators. The key differentiating elements are the number of project participants and the organisational form.

Note that, due to their innovative character, rooftop greenhouse projects usually pose an increased risk with regard to their technological and financial realisation. This is mainly because the project participants, approval authorities and potential investors are lacking in know-how. In spite of thorough preliminary planning, for instance, planning and construction costs may turn out to be higher than originally calculated; the innovative technologies applied may be unsuitable after all, liability regulations that are difficult to clarify may hamper the progress of implementation or prevent it altogether; and potential investors may be difficult to find. These difficulties need not be an obstacle for smaller-scale, financially independent projects of an experimental nature. In general, the prospects of success can be increased and risk shared if several participants with different relevant competencies join forces. A contractor could also be commissioned to construct and operate such a system.

Three operator models for rooftop greenhouses are compared in the table below.

FACTS AND TIPS

Web links to the projects mentioned

- Bright Farms, New York City, USA : www.brightfarms.com
- Brooklyn Grange, New York City, USA: www.brooklyngrangefarm.com
- Eli Zabar's Vinegar Factory, New York City, USA: www.elizabar.com/-C24.aspx
- Himmelbeet, Berlin, Germany: www.himmelbeet.com
- New York Sun Works, New York City, USA: www.nysunworks.org
- The Science Barge, New York City, USA: www.sciencebarge.org
- Urban Farmers, Zürich, Switzerland: www.urbanfarmers.com

Further reading

- New York Sun Works: The Greenhouse Project Information Packet: www.nysunworks.org/projects/the-greenhouse-project-at-ps333
- Wiggert, M. (2009): Risikomanagement von Betreiber- und Konzessionsmodellen, in: Lechner, Hans/ Heck, Detlef (Eds.): Schriftenreihe, Issue 29, Verlag der Technischen Universität Graz, Graz.

The "Science Barge" is a greenhouse on the hull of a ship, moored on the Hudson River in Yonkers, New York. It serves as a prototype for a sustainable urban farm and as an environmental education centre.

	Single-handed owner-operated enterprise	Cooperation within a project company	Contracting through professional development
Description	Implementation by a single unit (an enterprise, an alliance with very few individuals – often lacking in extensive knowledge), possibly additional partners who do not, however, assume any responsibility	Several participants within a project company (initiators, consultants and planners, construction companies, investors and future operators)	Construction of the rooftop greenhouse is outsourced to a contractor (service provider). Often as a group of partners who have become professional collaborating in joint pilot projects. Work is outsourced to additional external partners, rather than integrating them into the project.
Advantages	▲ Little coordination and organisational effort required ▲ Speedy implementation ▲ High degree of flexibility	▲ Combination of a wide range of technical expertise ▲ Risk is shared among several project partners ▲ Higher credit rating ▲ Profits are shared ▲ Exchange of knowledge and experience, also for follow-up projects	▲ Reduction of implementation risk by exploiting existing know-how ▲ The whole scope of experience and knowledge required is covered ▲ Clients are subject to low levels of stress during the implementation phase ▲ The risk lies with the contractor
Dis-advantages	▲ All of the risks and duties are assumed by the project initiators ▲ Risk of failure and of overestimating one's own abilities	▲ A lot of effort is involved in drafting contracts, coordinating matters and taking decisions ▲ Higher minimum economic volume required for sufficient profitability ▲ Risk of a participant withdrawing	▲ Under certain circumstances, a lower degree of innovation and less flexibility due to the implementation of standardised, tried-and-tested modules
Suitable for	▲ Smaller projects of an experimental nature not requiring complex technology	▲ Technologically and/or conceptually innovative, cost-intensive projects	▲ Projects that wish to have a high degree of professional development and planning reliability
Possible legal forms	▲ Sole proprietorships ▲ Association	▲ Consortium (ARGE)/ civil law partnership (GbR)/ partnership (all participants are liable with their own assets) ▲ Limited liability company (GmbH) and Unternehmergesellschaft (UG, a company that allows entrepreneurs with low start-up capital to form a limited liability company) (liable with company assets) ▲ Cooperative societies (particularly suitable for broad participation, giving projects of general interest an economic basis)	▲ Limited liability company (GmbH) / public limited company (AG) / other entrepreneurial company
Examples of projects	▲ Brooklyn Grange, USA ▲ Eli Zabar's Vinegar Factory, USA	▲ The Science Barge, USA ▲ Himmelbeet Berlin, Germany	▲ Bright Farms, USA ▲ New York Sun Works, USA ▲ Urban Farmers, Switzerland

Urban farmers "LokDepot" in Basel, Switzerland. Pilot project for a commercial rooftop greenhouse that can be erected on the roofs of supermarkets, restaurants, hotels, residential buildings, and so on.

3 | Use concepts

Creating a conceptual design for the use of rooftop space requires know-how from a variety of disciplines.

Depending on the objective concerned, rooftop greenhouse projects can be used for a number of purposes. At the same time, each usage exhibits specifications with regard to their legal form, financing options, workflows and challenges. The table below gives an overview of various use concepts. It is broken down into the different project types: commercial, quality of life, for educational and social purposes, innovation and image (→ Chapter II.1 Project aims). These concepts should be used as inspiration for developing one's own projects.

FACTS AND TIPS

It may be particularly economically viable and effective to combine several of the objectives listed in the table. Economically oriented projects, for example, can be combined with a social purpose or can offer additional services.

Many projects are faced with the challenge that initiators and users have a lack of technical and gardening know-how, as well as limited management capacities. One suggestion to resolve this problem could be to gain external organisational support and guidance from experts.

Rooftop greenhouses for public and semi-public use (such as a restoration or a show/school greenhouse) are much more likely to be subject to insufficient controllability. This can lead to damage caused by carelessness or vandalism. Suggestions to resolve this problem could be to: clearly define who may access the area; provide adequate instruction to users; ensure the area is supervised; and clarify whether it may be used by the public.

Web links to the practical examples mentioned

- Bright Farms, New York City, USA: www.brightfarms.com
- Brooklyn Grange, New York City, USA: www.brooklyngrangefarm.com
- Eli Zabar's Vinegar Factory, New York City, USA: www.elizabar.com/-C24.aspx
- Food from the Sky, London, Great Britain: www. foodfromthesky.org.uk
- Gartendeck, Hamburg, Germany: www.gartendeck.de
- Greenhouse Perth, Perth, Australia: www.greenhouseperth.com
- inFARMING project of the Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Oberhausen, Germany: www.infarming.de
- Lufa Farms, Montreal, Canada: www.lufa.com
- Maison Productive, Montreal, Canada: www.productivehouse.com/en

Project type	Commercial	Quality of life	
Type of use	Horticultural farm	Staff garden	Gardening as an experience (commercial)
Purpose Objective	Commercial vegetable and fruit growing	Improving office buildings, increasing the attractiveness of the workplace, team building, image and marketing	Gardening as an experience, education (children and adults), vegetable and fruit growing (for pick-your-own and commercial use)
Specific challenges	Search for sponsors and investors	Lack of knowledge, usage conflicts	Investment costs, refinancing, running costs, search for sponsors and investors, usage conflicts
Legal form Funding body	Limited liability company (GmbH), civil law partnership (GbR), consortium (ARGE), registered cooperative (eG)	Integrated in company	Limited liability company (GmbH) / non-profit organisation (gGmbH) / cooperative society
Financing	External investor, property owner, CSA, crowd funding, own capital	Own capital	Investments: own capital, investor, property owner, CSA, crowd funding, support; operation: user fees, revenue from the sale of products
Operation Maintenance	Users	Staff, consulting firm	Own responsibility
Practical examples	Brooklyn Grange, Lufa Farms, Urban Farmers	Zuidpark	Food from the Sky

		For educational and social purposes		Innovation		Image
Residents' garden (initiated by users)	Tenants' garden (initiated by property owners)	Homes for the elderly, residential facilities, nursery schools	School use	Crop plants as a secondary function	Research	Restaurant/ hotel/ supermarket
Own use (private), increasing quality of life, social cohesion	Improving residential buildings, increasing quality of life, improving the social fabric, reducing the number of vacant premises, rent increase	Increasing quality of life/ local recreation, fresh vegetables, social meeting point, recovery, education	Education (pupils), school as an "ecological learning location"	Primary heat production, secondary local recreation and cultivation	Testing innovative and sustainable food supply models	Own use (commercial), image and marketing
Refinancing, running costs, usage conflicts	Loss-making enterprise (market advantage does not compensate for high costs in the long run), lack of knowledge, usage conflicts	Lack of knowledge, usage conflicts	Operation and maintenance, lack of knowledge	Cultivation and care of plants, lack of horticultural knowledge	Possibly (share) financing, running costs, long-term continued existence of infrastructure (follow-up funding / subsequent use)	Lack of knowledge, investment costs, refinancing, operating costs
Association, cooperative society	Residential housing company, property owner	Limited liability company (GmbH), association, home for the elderly	Association, actual school, school sponsor	Property owners, energy contractor (GmbH)	Project group	Secondary income, integrated in main line of business
Cooperative shares, public support, house owner, foundations	Own capital housing company / property owner	Sponsor, private investor, community of heirs, public support	School sponsor, development association, public support, sponsors	Own capital, borrowed capital (energy contracting without banks), public support	Public or private research funding	Own capital, external investor, property owner
Association, cooperative society, operator commissioned by users under their shared responsibility	Commissioned operator / contractor	Operating company / association with professional guidance	External operator with professional guidance, personal contributions from pupils, teachers and parents	Energy contractors (gardeners), commissioned operators, own use and operation	Research facility, practice partners, spin-off	Owner-operated enterprise or commissioned operator
Gartendeck	Via Verde, Maison Productive	Wiegmann-Klinik	Manhattan School for Children	So far none, similar: watergy pilot plant	Skyfarming Hohenheim, IGB „Tomato-fish", inFARMING Fraunhofer UMSICHT	Eli Zabar's Vinegar Factory, Greenhouse Perth, Bright Farms

- Manhattan School for Children, New York City, USA: http://info.mscnet.org/cgi-bin/show_page_rip_external.pl?XRIP=43
- New York Sun Works, New York City, USA: www.nysunworks.org
- Skyfarming: University of Hohenheim, Stuttgart, Germany: www.uni-hohenheim.de/pressemitteilung.html?&tx_ttnews[tt_news]=7029&cHash=c845477fcc
- The Science Barge, New York City, USA: www.sciencebarge.org
- Tomatenfisch: Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Germany: www.tomatenfisch.igb-berlin.de
- Urban Farmers, Zürich, Switzerland: www.urbanfarmers.com
- Via Verde, New York City, USA: www.viaverdenyc.com
- Watergy pilot plant, Berlin, Germany: www.watergy.de/einsatzbereiche/gebaeudeheizung-mit-feuchtluft-solarkollektor-und-erdwaermetauscher
- Wiegmann-Klinik (German Red Cross Hospitals), Berlin, Germany: www.drk-kliniken-berlin.de/unternehmen/meldungen/der-dachgarten-der-drk-kliniken-berlin-wiegmann-klinik-auf-dem-westend-gelaende-wurde-gruendach-des-jahres-2010
- Zuidpark, Duivendrecht, the Netherlands: www.zuidpark.nl

4 | Site analysis

Various levels need to be considered in the site analysis of urban spaces.

When planning a rooftop greenhouse, numerous requirements with regard to the site and the building must be considered and examined. The site requirements (e.g. minimum area of roof, the statics of the building, accessibility, proximity to target groups) depend largely on the project objectives and the intended use concept. For this reason, it is vital to draw up a preliminary concept containing the key elements of the project before investigating the locational criteria. Four main locational criteria that require consideration when planning a project and assessing a site are listed below.

SITE-SPECIFIC CRITERIA

Roof qualities	
Size	The suitable size of a rooftop greenhouse depends on the use concept in question: in the case of image, educational and socially oriented projects and those intending to increase the quality of life, very small greenhouses are viable. Commercial projects usually require a minimum size to enable profitable operation. The details vary (e.g. a minimum of 1,000 square metres) and, again, depend on production and sales planning. Although yields per unit area from horticultural production can generally be translated to rooftop greenhouses, the considerably higher investment costs must be taken into account when planning area and yield.
Pitch	Flat roofs are best suited for rooftop greenhouses. Under certain circumstances, they can also be constructed on slightly inclined roof surfaces. The maximum pitch angle depends on the use concept, the cultivation method chosen and detailed planning for the greenhouse. The pitch also influences sunlight conditions: the higher the roof pitch, the sharper the radiation angle and, consequently, the more exposed the area is to the sun.
Constructional design of the roof	The constructional design is relevant when building a rooftop greenhouse. A differentiation can be made between the following roof types: warm roof – cold roof – inverted roof – water impermeable concrete roof ⓘ – Berliner Dach (Berlin roof). These roofs differ with regard to the structure of their thermal insulation and the associated suitability for roof greening and roof greenhouses. In specific cases, civil engineers and statics experts should be consulted.
Duration of solar radiation / degree of shading / exposure to light	Sufficient sunlight is necessary for plant growth; it must also be ensured that plants are protected from excessive solar radiation and hence heat stress. Sunshine conditions at the site can be assessed in terms of the use and production concept (e.g. production or show greenhouse); light transmission depends on the materials used. The Berlin Solar Atlas may provide guidance. It illustrates the solar potential of (partial) roof surfaces in Berlin, taking into consideration aspects such as shading and roof pitch. The FIS Broker ⓘ for Berlin may be useful when making a more specific assessment of potential roof surfaces for rooftop greenhouses (see Facts and tips)
Accessibility	Accessibility must be ensured based on the use concept: does the project involve commercial production or is it also used for demonstration purposes? Which groups of people should have access to the greenhouse? Depending on this, the following aspects need to be clarified: How can accessibility be ensured with regard to structural and organisational aspects? What requirements must be met concerning production logistics (e.g. goods lift, deliveries and collection, storage and packaging rooms)? What does this mean regarding permitting processes? Which insurance and fire protection specifications must be observed?
Bearing load and statics	The suitability of a site is largely determined by the weight-bearing capacity of the roof and the building. The load of the greenhouse structure (including greening elements) must be considered in addition to snow and live loads. The following loads must be examined and ensured: live load, snow load, load reserves (e.g. for the structure). The relevant German standards include: DIN EN 13031-1:203-09 and DIN EN 1991-1:2010-12

Building	
Other uses of the building	Depending on the envisaged use concept and production planning, any other usages of the building (housing, industry, social facilities, and so on) must be considered so as to create synergies and to avoid conflict (→ Chapter Construction and planning law). → Chapter Project aims (see below) provides information about which types of rooftop greenhouse can be combined effectively with different types of building use.
Height	The height of the building and the number of floors are particularly relevant with regard to two aspects: ▲ Wind: if the building is very tall, high wind speeds and wind-drag loads must be considered. Wind loads must be determined for each specific building. In Germany, the following standards must be observed: DIN 1055-4, DINV 11535-1 and DIN EN 13031-1. ▲ It has to be assessed whether an additional structure, such as a greenhouse is legally permissible on the roof (→ Chapter Construction and planning law).
Building structure/ fabric	When planning a rooftop greenhouse, the following building-related aspects need to be observed: ▲ Access to the roof ▲ Infrastructure of the building (public and internal infrastructure for supply and disposal systems, e.g. toilet facilities) ▲ Disturbances caused by the greenhouse, e.g. light emissions from the greenhouse, shading effects, noise pollution, intrusiveness on privacy/ neighbourhood protection; adverse effects on the greenhouse, e.g. light reflections from other houses, shading. ▲ Sightlines, i.e. the visibility of the greenhouse from surrounding buildings/apartments and from the street, and hence also urban compatibility; sightlines may also be relevant with regard to heritage and monument protection. ▲ Redevelopment requirements: clarify whether redevelopment measures will be implemented in the foreseeable future and whether it makes sense to construct a greenhouse there in that case. If redevelopment work has just been completed, it will be more difficult to implement structural changes. ▲ Suitability of the building infrastructure to create synergies between the rooftop greenhouse and the building: the extent to which energy-related synergies and closed resource cycles (water, thermal/air management, use of solar energy, use of rainwater ⓘ, and so on) can be realised and whether it makes sense to combine them with other uses of the building must be clarified. ▲ Possibility of combining the greenhouse with an open garden (depending on the use concept) ▲ Ability to dismantle the greenhouse or use it temporarily
Legal aspects	In order to assess the legal feasibility of a rooftop greenhouse, it has to be examined whether the project is permissible according to the following legal requirements: Planning regulations (Federal Building Code (BauGB) and Federal Land Use Ordinance (BauNVO)) ▲ Preparatory land use plan ▲ Type and degree of building and land use (floor space index ⓘ, site coverage index ⓘ, cubic index ⓘ), permitted number of full storeys ▲ BauGB Sections 29 to 38: Permissibility of development projects (in particular Section 34) Building regulations (State building regulations) ▲ formal: planning permission procedure; construction supervision ▲ substantive: minimum social standards and minimum standards of design; hazard control (e.g. fire protection) Ancillary building law (e.g. heritage and monument protection, nature conservation) For more detailed information about the legal aspects, → Chapter Construction and planning law.

Different types of use can be realised, depending on the characteristics of the building.

Seedlings in a rooftop greenhouse in the inner-city area.

Surroundings	
Building structure and urban density	The following aspects must be observed: ▲ Solitary or integrated location of the building ▲ Need for climate-adaptive measures/green areas ▲ Noise and air pollution (need to reduce pollution or risk of pollution)
Legal aspects	See above; the following aspects must also be observed: ▲ Informal planning (e.g. urban development plans) ▲ Special urban planning legislation (e.g. whether the building is located in a redevelopment or urban development area or whether it is covered by a preservation statute)
Socio-demographic structure	Depending on the idea for using the rooftop greenhouse, the socio-demographic structure of the surrounding area may be of interest (with regard to target groups, acceptance, and so on). The relevant information can be obtained from statistical surveys conducted by the cities. In this respect, the relevant factors are: ▲ Population/social structure ▲ Mindset/lifestyle ▲ Income ▲ Peculiarities
Potential interference with the environment	Positive ▲ Cooperative activities ▲ Noise protection ▲ Enhancing the quality of life ▲ Spill-over effects (attracting companies/institutions from the food industry) Negative ▲ Emissions (light, noise) ▲ Traffic (deliveries and collection) ▲ Air contamination from pollutants
Social infrastructure and central facilities	Depending on the use concept, the following facilities in the surrounding area may be of interest when establishing cooperative activities: ▲ Catering establishments, retailers, universities, administrative bodies, associations and schools
"Soft" location factors	Depending on the use concept, the following "soft" location factors should be taken into account at the planning stage: ▲ The area's image ▲ Urban living quality ▲ Proportion of green areas ▲ "Planning climate"
Transport structure	Consideration should be taken of ▲ Connections (local public transport, by foot, bicycle or car) ▲ Accessibility, development of the neighbourhood / premises

Macro level	
Urban structure	When planning a rooftop greenhouse, it needs to be considered to which rooftop greenhouses make sense in the city or urban district. Depending on the concept of the project, the following aspects are of interest: ▲ Urban density and the availability of open spaces in the area: examine the need for rooftop greenhouses ▲ Interplay between the city and its surroundings: clarify the role of the surroundings in supplying the city with food, and examine the potential functions of an urban rooftop greenhouse ▲ Prospects for urban rooftop greenhouses in the city concerned: derive long-term development paths for rooftop greenhouse projects in the city and determine whether one's own project is a pilot project or more of a kind of "nucleus"
Market / competitive situation	The market and competitive situation at the planned site should be analysed, particularly in the case of commercial undertakings. In this connection, both the macro and the micro location (the city as a whole/district) play a role (→ Chapter Strategic marketing planning)

FACTS AND TIPS

Those interested can search for potential areas for commercial rooftop greenhouses and open rooftop farms in Berlin on a map at www.zfarm.de. The areas presented are based on data from the Berlin Solar Atlas and the Geoportal Berlin (FIS Broker, Senate Department for Urban Development and the Environment). The map shows flat roofs in Berlin, and provides information such as the size of the area, what the building is used for, the approximate height of the building and, in some cases, the homogeneity of the areas. However, the map contains no information about the static suitability of roof surfaces.

Weblinks

▲ FIS-Broker ⓘ, Geoportal Berlin: www.stadtentwicklung.berlin.de/geoinformation/fis-broker
▲ Berlin Solar Atlas: www.businesslocationcenter.de/solaratlas

Rooftop greenhouses can be erected on roofs of supermarkets, restaurants, hotels, residential buildings, and so on.

5 | Planning and building law

Vertical cultivation systems on the roof of a factory building in Chicago.

PUBLIC BUILDING LAW

One central aspect of the site analysis is the examination of different areas of public building law to determine whether the envisaged use concept is permissible and eligible for approval at the chosen site. Different legal frameworks must be examined in order to assess this. Since this site check takes place at a very early stage of the project planning process, it could be that the use concept may not yet have been developed in great detail. Depending on this, it may not be possible to complete a number of statements at this point in time. However, it may be possible to rule out certain development prospects or to identify legal barriers.

The following set of check points should be addressed in advance (for details, see, for example: Finkelnburg, Ortloff, Kment 2010 and 2011; Schmidt-Eichstaedt 2005; Hauth 2008):

Areas of public building law	Check points
Planning law (Federal Building Act, BauGB)	▲ Is the use concept permissible under applicable planning law? Assessment pursuant to Sections 30, 33, 34, 35 BauGB. ▲ Could the use concept perhaps be approved on the basis of exceptions and dispensations pursuant to Section 31 BauGB? ▲ Are there any regulations within the framework of special urban planning legislation (e.g. redevelopment area, urban development area, preservation statute)?
Federal state building regulations	**Substantive (material) building regulations** ▲ Is the use concept compatible with the substantive requirements of state building regulations? **Formal building regulations (planning permission procedure, construction supervision)** ▲ Is the undertaking, or parts thereof, subject to approval? ▲ Under which procedure are decisions taken?
Ancillary building law (e.g. sectoral planning, emission control, heritage and monument protection, nature conservation, waste legislation)	▲ Which ancillary building law requirements apply to the use concept? ▲ Which ancillary building law requirements arise from the use concept itself?
Informal planning (urban development plans)	▲ Which informal plans have been made for the envisaged site? ▲ Could they have an impact on the planned use concept (in the short and long run)?
Development (e.g. infrastructure provision)	▲ Does the use concept necessitate additional land development measures? ▲ Who is expected to pay for these?

Specific issues concerning the aforementioned areas that arise in particular due to the novelty of implementing rooftop greenhouses in Berlin and the lack of know-how are addressed in detail below.

PLANNING LAW

Planning law regulates the use of land and real estate. Legally binding land use plans contain the legally binding designations for urban development. With a view to constructing rooftop greenhouses, the category and intensity of the built use and the building design are of particular interest. Under certain circumstances, the shape of the roof may also be stipulated (the shape of a roof is not routinely the subject matter of a legally binding land use plan, only due to Section 9 para. 4 BauGB in conjunction with Section 12 of the Act implementing the Federal Building Code (AGBauGB)). Since rooftop greenhouses are often implemented on existing buildings, and always in built-up interior areas, the following aspects must always be examined:

- Does a legally binding land use plan exist (Section 30 BauGB) or has a preparation process been completed (Section 33 BauGB)? (In Berlin, the land use plan of 1961 is still valid).
- Does the envisaged project comply with the designations in the legally binding land use plan?
- Can the project be approved as an exception to the designations contained in the legally binding land use plan (Section 31 para. 1) or can a dispensation from the designations be granted (Section 31 para. 2)?

If there is no legally binding land use plan, decisions must be taken under Section 34 BauGB, provided that the project is in the unplanned interior area. Section 34 BauGB regulates the permissibility of development projects within built-up areas. The project must blend with the characteristic features of its immediate environment. Section 34 BauGB applies to changes to an existing building and to new constructions. A selection of designations in the legally binding land use plan that are particularly relevant for rooftop greenhouses are described below (it goes without saying that all designations in a legally binding land use plan are of relevance).

Category of the built use

The permissible category of the building's use is determined by the type of land use areas mentioned in the Federal Land Utilisation Ordinance (BauNVO) and in the legally binding land use plan. BauNVO specifies which categories of uses are permissible in different land use areas. In order to assess undertakings, is it relevant whether rooftop greenhouses and aquaponics systems are classified as agriculture or commercial businesses.

	Classification
Commercial horticulture on/in buildings	▲ Horticultural companies run on a full-time basis (including those operated without direct use of soil) are classified as a branch of agriculture, and not as a commercial business (König, Roeser, Stock 2003, marginal note 21-30). ▲ If greenhouses are exploited as an integral part of another use (e.g. as a "green classroom" at a school), they are not classified as commercial horticulture. Private use of a greenhouse is not classified as horticulture either. **Land use areas** Unlike other agricultural and forest holdings, horticultural companies are permissible in the following land use areas: ▲ Small settlements ▲ Mixed-use zones ▲ Village areas ▲ Horticultural companies may only be operated in general residential areas as an exception to the rule. ▲ Special areas, provided that they are expressly designated as permissible there. "In land use areas in which horticultural companies are not expressly mentioned, they may not be approved as commercial businesses because they belong to agriculture" (König, Roeser, Stock 2003, marginal note 27).
Aquaponics systems on/in buildings (combination of fish farming and horti-culture)	The combination of horticultural production and fish farming constitutes a special case, particularly because there are no clear regulations as yet. Under certain circumstances, it may be relevant whether horticultural production or fish farming is the dominant element.
Operations for processing and further processing only	▲ Operations purely for processing and further processing agricultural products are classified as commercial businesses, and not as horticulture, and are permissible in areas where businesses are allowed. ▲ However, this is only the case if primary production or production typical to horticulture and processing definitely do not occur (König, Roeser, Stock 2003, marginal note 26).
Retail areas, physical structures	A shop for on-site sales is also permissible as part of the operation (König, Roeser, Stock 2003, marginal note 26), whereby the issue of accommodating the shop in the building may under certain circumstances place certain demands on accessibility, safety, and so on. Packaging equipment, tool sheds and such like are not secondary structures; they fall under the definition of use for the horticultural company (König, Roeser, Stock 2003, marginal note 25).

Rooftop greenhouses of the delicatessen supplier Eli Zabar on the roof of a supermarket in New York City.

Intensity of the built use

The intensity of the built use of a property is also stipulated in the (qualified) legally binding land use plan; as per the Federal Land Use Ordinance (BauNVO), it defines the volume of the structure permissible on a property (Finkelnburg, Ortloff, Kment 2011, p. 173). Rooftop greenhouses constitute interior space; they change the height of the building, and – depending on the state building regulations – represent an additional storey (see below). For this reason, the following designations must be examined whether they permit roof structures such as greenhouses (the plot coverage index is irrelevant when planning rooftop greenhouses on existing buildings):

- Maximum permissible floor space index, floor space
- Full storeys (the respective state building regulations define when a super structure such as a rooftop greenhouse counts as a full storey, see below)
- Height of the building (in particular, a differentiation must be made between the ridge height, the top edge of the building, the maximum height of the building and, where applicable, exceedance possibilities for certain roof structures)
- Cubic index (in commercial, industrial and other special areas only).

Building design and shape of roof

The building design may also be stipulated in the legally binding land use plan; it determines the distance to the side property line (Section 22 BauNVO). A differentiation is made between open and closed building design. Concerning rooftop greenhouses, the closed design is mainly relevant because, in this case, a building must be erected on all storeys without a side distance from boundary of neighbouring plot to boundary of neighbouring plot. If a roof shape is stipulated in the legally binding land use plan or if it arises from the immediate surroundings in the event of an evaluation pursuant to Section 34 BauGB, this must be observed accordingly.

SUBSTANTIVE (MATERIAL) BUILDING REGULATIONS

Substantive building regulations seek to control hazards and to ensure that social and design standards are met. Building regulations are regulated at federal state level; reference is subsequently made to the Berlin Building Regulation (BauO Bln). As with any building projects, in the case of a rooftop greenhouse it must be examined whether the structure generally complies with the Building Regulation. Only certain aspects shall be addressed at this point..

Building class	The installation of a rooftop greenhouse can, under certain circumstances, lead to the building being assigned to another class of building, due to the altered height (definition of building classes: Section 2 (3) BauO Bln). This may affect the requirements applicable to fire safety properties of walls/ceilings/roofs (Fourth Section of BauO Bln), escape routes/openings/surrounds (Fifth Section of BauO Bln) and the technical building systems (Sixth Section of BauO Bln).
Full storeys	Whether or not a rooftop greenhouse is classified as a full storey affects not only its permissibility, but also the property owners'/investors' decision whether to implement a rooftop greenhouse or another (more profitable) use. According to Section 2 (11) BauO Bln, a rooftop greenhouse counts as a full storey when its top edge protrudes on average more than 1.40 m above the ground surface and it has a clear height of at least 2.30 m over no less than two thirds of its surface area. An upper storey of a building that is set back from the exterior walls (mezzanine floor) and storeys in the attic are only classed as full storeys if they have a clear height in accordance with Sentence 1 over no less than two thirds of the surface area of the floor below. Full storeys are defined differently in other state building regulations.
Distance space	Distance space to adjacent properties must be observed (except when exterior walls are erected on land boundaries where construction is allowed). The applicable distance space is calculated based on wall height, see Section 6 (4) (5) BauO Bln. Therefore, attention must be paid to whether, and to what extent, a roof structure such as a rooftop greenhouse has an effect on the necessary depth of the distance space.

Other relevant legal areas

In addition to aspects that are inherently connected to the construction of an installation, potential consequences and the corresponding legal areas also have to be considered. In the case of rooftop greenhouses, these legal areas are, in particular:

Legal areas	Remarks/examples/consequences
Emission control legislation	Contamination from air pollution, noise, vibrations, light, heat, radiation, etc.
Nature conservation legislation	Emissions
Legislation concerning the respective interests of neighbours	Private legislation concerning the respective interests of neighbours: e.g. due to emissions; public legislation concerning the respective interests of neighbours: provisions of BauGB and state building regulations.
Legislation on the protection of heritage and monuments	Alteration of the substance of a listed building
Waste legislation	Plant remains, possibly animal waste

FACTS AND TIPS

Rooftop greenhouses are not suitable as mitigation and compensation measures as provided for in the Nature Conservation Act at present; however, this is by all means conceivable in the case of open rooftop farms.

Due to the generally high investment costs involved, rooftop greenhouses are only suitable for interim use to a limited extent.

Not enough experience has been gained in the implementation of rooftop greenhouses in Germany. Consequently, this legal information is merely provided as guidance. Owing to the novelty of such projects, it is therefore strongly advisable to contact the competent planning office at a very early stage of the planning process.

Literature used

- Baugesetzbuch (BauGB)(2007): BauNVO, PlanzV, WertVu.-Richtlinien, Raumordnungsgesetz. dtv: München.
- Finkelnburg, K., Ortloff, K.M. und Kment M. (2011): Öffentliches Baurecht Band I: Bauplanungsrecht. JuS-Schriftenreihe/Studium, Band 107, C.H. Beck: München.
- Finkelnburg, K., Ortloff, K.M. und Kment M. (2011): Öffentliches Baurecht Band II: Bauordnungsrecht, Nachbarschutz, Rechtsschutz. JuS-Schriftenreihe/Studium, Band 108, C.H. Beck: München.
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ECF container farm on the site of the malting plant in Berlin, ECF | Efficient City Farming Berlin.

6 | Strategic marketing planning

Strategic marketing planning describes a comprehensive entrepreneurial planning process that serves to

- Create future success potential
- Identify and select relevant target groups and markets
- Gain a competitive edge and
- Implement this through relevant activities in shaping the product, price, sales and communications.

ANALYSIS AND PLANNING

Particularly due to the novelty of rooftop greenhouse projects, it is advisable to undertake comprehensive, fundamental marketing planning. The starting point for planning is a SWOT analysis to determine the internal strengths and weaknesses as well as the external opportunities and threats (market/industry structures, general framework conditions). Individual building blocks for such a planning process are summarised in the table below, together with examples.

Marketing building block	Central issues	Example
Company idea / objective	What is the primary purpose of the venture? How do customers benefit from it in particular? Which problems does the service resolve, and for whom? What is the unique selling point (compared to competitors)?	Concerning the purpose of the venture, → Chapter Project aims. Services can also be relevant products in addition to marketable products. Furthermore, the actual project can also be understood as a "product" that serves one's own corporate strategy (e.g. in the case of image projects). A differentiation must therefore be made between: ▲ Horticultural products, processed products (e.g. vegetables, herbs, sauces) ▲ Services (e.g. courses, workshops, events) ▲ Consultancy services for the implementation of other projects ▲ The rooftop greenhouse as part of one's own corporate strategy (e.g. staff gardens, restaurant gardens)
Market coverage	Which products and services will be used to reach the target groups, and via which markets?	▲ **Niche strategy:** Product: e.g. rare lettuce varieties Market: e.g. top-quality restaurants ▲ **Product specialisation:** Product: e.g. herbs (fresh or processed) Markets: e.g. catering, top-quality retail food industry (organic/regional) ▲ **Market specialisation:** Products: wide range of products (e.g. a variety of one's own fresh and processed vegetables complemented by bread and cheese from cooperating organisations) Markets: e.g. organic/regional-conscious home delivery basket subscribers ▲ **Selective specialisation:** e.g. fresh vegetables for direct marketing; leasing vegetable beds to interested urban citizens; leasing the installation as a venue
Positioning	Which competitive advantage can be offered (price, quality, image, services, etc.)? (Porter 1990)	Rooftop greenhouses offer primary quality advantages (e.g. freshness) and convey certain values (e.g. local food, environmental aspects, cultivation transparency). Both aspects should form the basis of the marketing strategy.
Cooperation	How can I improve the marketing of my products and services through cooperative activities? Which services can be covered by potential cooperating organisations?	**Horizontal cooperation** ▲ Joint marketing e.g. cooperation with local farms to jointly fill home delivery baskets (Lufa Farms); cooperation with a non-profit organisation to offer educational services (Brooklyn Grange and City Growers) ▲ Joint research and development ("Tomato-fish" by IGB and ECF) **Vertical cooperation** ▲ Cooperation with retailers or other distributors e.g. long-term produce purchase agreements ⓘ with the retail industry (Brightfarms); supplying companies and their staff to promote well-being at work (Lufa Farms) ▲ Co- or ingredient branding ⓘ ▲ Processing rooftop greenhouse products to make top-quality local products could be conceivable

IMPLEMENTATION

After deciding upon the basic nature of one's venture, it now has to be realised by shaping the marketing mix accordingly (product policy, price policy, distribution policy, communication policy). The following table provides an overview of key aspects in the four marketing mix fields:

Marketing mix	
Product policy	▲ Product properties (based on the expectations and behaviour of the target group) ▲ Name ▲ Brand ▲ Differentiation from competitors ▲ Premium product
Price policy	▲ Cost-based pricing ▲ Demand-driven pricing
Distribution policy	▲ What is the (purchase) behaviour of the target groups? Which places (of purchase) are relevant? ▲ Distribution channels (also pay attention to bargaining power), e.g. direct marketing, appointed dealers, production facilities for experience
Communi-cation policy	▲ Imaging and branding (also by way of certification, for example) ▲ Appearance ▲ Communication (media strategy) ▲ How to reach the target group; appropriate choice of advertising vehicles, communicators

Honey from the roofs of New York. (left page)

FACTS AND TIPS

Literature used

Porter, M.E. (1990): Wettbewerbsstrategie: Methoden zur Analyse von Branchen und Konkurrenten. Frankfurt/Main: Campus-Verlag.

Web links of the practical examples and marketing concepts mentioned

- ▲ Brightfarms: cooperation with the retail industry or other distribution partners in the retail industry (www.brightfarms.com/s/#!/retail_partners)
- ▲ Brooklyn Grange Farm and City Growers: cooperation to offer educational services (www.brooklyngrangefarm.com/city-growers)
- ▲ Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB) and Efficient City Farming (ECF): joint research and development concerning "Tomato-fish" (ASTAF-Pro) and urban farming (www.tomatenfisch.igb-berlin.de)
- ▲ Lufa Farms: cooperation with local farmers to jointly fill home delivery baskets (www.lufa.com/en/local_quebec_farmers)
- ▲ Lufa Farms: supplying companies and their staff to promote well-being at work (www.lufa.com/en/Corporate_subscription_program)

Aquaponics system "Tomatenfisch" (tomato-fish) by the Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB) at the FEZ Berlin.

7 | Press and public relations activities

Public relations can be used proactively in order to effectively communicate one's own project or the products manufactured, and can be shaped in line with one's own objectives.

The following check list may be useful when devising a public relations strategy:

Objective of press and public relations activities The aim of public relations varies depending on the objective of the respective project.	**Potential objectives comprise:** ▲ Gaining investors/sponsors for the rooftop greenhouse ▲ Addressing potential members or customers ▲ Providing information to existing members or customers ▲ Advertising the project, creating a certain image ▲ The media should report about the project
Target groups Public relations are rarely directed at the public at large. Determination of the target groups is vital to the success of public relations.	**Potential internal target groups are:** ▲ Association members or staff **Potential external target groups are:** ▲ (Potential) customers, interest groups, politicians, potential investors or the media.
Media and activities The choice of appropriate media and activities must be aligned to the respective target group.	**Potential media and measures include:** ▲ Print media: newspapers, magazines, posters, flyers, brief portraits, newsletters ▲ Online: website, Facebook profile, Twitter, e-mail newsletters, project video ▲ Radio/TV: specialist programmes, regional and interregional broadcasting stations ▲ On the ground: information board, open days, guided tours, join-in campaigns, competitions, exhibitions ▲ Ambassadors ▲ Patronage ▲ Links to existing activities such as Environment Day.
Peculiarities regarding the project/product Here it is a matter of determining how the project/product differs from others.	**Potential differentiating elements include:** ▲ Particular proximity to consumers ▲ Freshness ▲ Transparency ▲ Social commitment → USP = unique selling point
Image The project/product's image and how it is perceived can be influenced by targeted external presentation.n.	Certain "image role models" can be useful at this point for guidance purposes.

Basic rules for preparing information

A number of rules apply when it comes to preparing information for press and public relations activities; these are described in relevant guidelines (Facts and tips: further reading). The most important aspects are described here briefly.

General guidelines	▲ In order to ensure that all of the relevant aspects/subjects are considered in press releases or other public relations activities, reference can be made to the questions → **Who? What? Why? Where? When? How?** ▲ The message should be clear and easily understandable for everyone. ▲ Choose simplified language (do not use too many technical terms, if used – explain them) and short sentences. ▲ All details must be reliable and up-to-date.
Preparing information for target groups	▲ Personalise: put yourself in the position of the target group and adjust the language accordingly. ▲ Let us take the example of an information brochure: make sure it is designed attractively; use different headings; illustration; little or no continuous text, but notes (clarity enables readers to grasp the content quickly).
Preparing for the media (e.g. press releases)	▲ The content should be prepared so that journalists can make further use of it easily. ▲ The key statements should appear in the first few sentences. ▲ Where applicable, name potential interviewees.

FACTS AND TIPS

Further reading

- ▲ Cappon, R. J. (2005): Associated Press. Handbuch. Journalistisches Schreiben. Berlin: Autorenhaus.
- ▲ La Roche, W. von (2011): Einführung in den praktischen Journalismus. Berlin: Econ/Ullstein.
- ▲ Schneider, W. (2011): Deutsch für junge Profis: Wie man gut und lebendig schreibt. Reinbek bei Hamburg: rororo (Rowohlt).
- ▲ Schneider, W. und Raue, P.-J. (2012): Das neue Handbuch des Journalismus und des Online-Journalismus. Reinbek bei Hamburg: rororo (Rowohlt).

8 | Products

When deciding which products to grow in the rooftop greenhouse, reference should be made to the following success criteria.

The product:
- ▲ Can be marketed easily
- ▲ Is promising for fresh food markets or the prospects of further processing and refining it are good
- ▲ Can be evaluated as positive from an ecological perspective
- ▲ Can easily be realised with regard to the technical circumstances, i.e. operators have the necessary equipment and expert knowledge.

The acreage of a rooftop greenhouse is relatively small compared to in rural agricultural production. In order to be able to operate economically nevertheless, product niches can be exploited for cultivation in rooftop greenhouses (additional options, → Chapter Strategic marketing planning). Product niches arise from growing old or rare varieties, for example. The

Product	Potential	Remarks
Leaf vegetables / lettuce	Leaf vegetables and lettuce have great potential because, as fast-growing plants, they produce a lot of mass in a matter of days. Here, too, the focus should be on unusual or special varieties.	Production centres around fresh food markets. It would also be conceivable to further process the vegetables into a convenience product: cleaned, cut and packed ready for use.
Herbs	Traditional culinary herbs such as chives, parsley, basil, coriander and dill are ideal for production for fresh food markets. Other potential product niches include unusual herbs that are difficult to obtain on the wholesale market.	The main advantage is the freshness of the products. For this reason, it only makes sense to further process them (e.g. in the form of dried herbs or pesto) if the harvest would otherwise remain unused.
Native berries / soft fruits	The types of native fruit that have particularly good prospects of successful marketing are soft fruits. This is the case not only for fresh food markets, but also for processed and refined products (jams, juices, dried fruit, etc.)	Only strawberries are suitable for hydroponic cultivation. All other soft fruits need a solid substrate.
Cucurbits (family)	Cucurbits are ideal for cultivation. The range of products comprises pumpkin, cucumber and melon plants.	Cucurbits can be preserved well by freezing or pickling them, offering potential for further processing (e.g. chutneys or pickled products). The seeds can also be further processed.
Tomatoes	Rare varieties such as black tomatoes or zebra tomatoes are ideal for marketing purposes, generating large profits	When growing tomatoes, it is recommended to keep a colony of bumble bees for pollination because it is otherwise very difficult to pollinate tomatoes.
Fish	Fish production can be combined with other products using aquaponic cultivation. It offers ecological advantages due to the dual use of water and nutrients.	Fish require a certain amount of preparation before they can be sold. Most purchasers require intermediate processing (gutting, filleting). Further refinement (e.g. pickling or smoking) is also conceivable.
Other products	Other products that are suitable for production in rooftop greenhouse are seedlings and algae.	

key marketing advantage of products from an urban rooftop greenhouse is the freshness of the products.

For this reason, products for fresh food markets such as unusual herbs, lettuce varieties or fruiting vegetables that are difficult to obtain on the wholesale market are particularly promising.

FACTS AND TIPS

1. Unsuitable products include

▲ Root vegetables, brassica, energy crops, legumes, worms and larvae, exotic fruits, other animals..

This is mainly because they require a lot of energy; there are technological barriers (such as thick layers of substrate); the climate is unsuitable; they are economically unattractive products; or there is too little public acceptance for them.

2. Organic farming in rooftop greenhouses

With regard to the quality of crops, a differentiation can be made between various levels:

▲ Organic cultivation within an association (Naturland, Bioland, demeter, …)
▲ Certified organic farming in compliance with EC standard
▲ Conventional methods of cultivation.

It is generally difficult to grow organic vegetables on rooftops. Hydroponic cultivation fails to meet the criteria for the organic label because it does not permit hydroponics. Artificial fertiliser may not be used either, without which it is difficult to produce sufficient quantities and a good quality of produce under hydroponic cultivation. Cultivation in soil requires a lot of effort because the substrate has to be replaced or disinfected after each harvest to prevent the occurrence of pests.

3. Seasonal cultivation in rooftop greenhouses

It also makes sense to grow different varieties seasonally at the ideal time (for the respective variety) in greenhouses in order to be able to grow produce cost-effectively. For example, the greenhouse would have to be cooled in summer in order to grow lettuce.

However, changing crops may also create difficulties:

▲ Every time crops are changed, an interruption of around 4 weeks is required in order to prepare conditions for the new crop (cleaning, and so on).
▲ The individual products place different demands on cultivation techniques. Herbs, for instance, require different cultivation techniques to fruiting vegetables and lettuce. For this reason, products cannot be arbitrarily combined.

Further reading

Companies offering old/rare varieties:

▲ Dreschflegel: organic seed: www.dreschflegel-saatgut.de
▲ VERN: Verein zur Erhaltung und Rekultivierung von Nutzpflanzen in Brandenburg e. V.: www.vern.de

Algae production:

▲ BIQ Algae House with algae façades: www.biq-wilhelmsburg.de

Growing tomatoes using hydroponics.

9 | Production methods

Fish tank and plants from the aquaponics system in the test plant of Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB) in Berlin.

There are different ways to grow vegetables in greenhouses. Consideration has to be given as to which production method and type of greenhouse are suitable for achieving the objective (→ Chapter Project aims).

The following summary of potential production methods (including a brief description with advantages and disadvantages) supports the decision-making process.

Method	Description	Advantages	Disadvantages
Cultivation in soil	This traditional production method is rather unusual in rooftop greenhouses because there is no naturally produced soil available on the roof, meaning that the disadvantages would outweigh the advantages.	It is generally possible to obtain organic certification.	Due to the heavy weight involved, it would have to be examined whether the roof is able to bear the load. Transporting the soil to the roof and possibly replacing it also involve a lot of effort. The soil has to be replaced from time to time in order to comply with hygiene standards. Plans must be made to ensure that water can be drained (installation of a drain water collection channel if the roof slopes or a drainage layer).
Cultivation in substrate	Various materials (soil-like substrates, mineral wool, igneous rock, perlite, coconut bags, grow bags, and so on) can be used with this method. When deciding which base substrate to use, regional products should be considered so as to avoid unnecessary transportation.	Porous base substrates have particularly good storage capacities for water and nutrients. Blowable substrates make it easier to transport the substrate on to the roof; they are also easier to spread. Productive uses are possible from a substrate layer of 8 cm in height (e.g. for some lettuces and herbs). A greater product variety can be realised with layers exceeding 15 cm. Organic certification can be obtained under certain circumstances.	The substrate may weigh a lot in a water-saturated state (approximately 200 kg/m² in the case of a 15 cm substrate). With some materials, it may be necessary to replace the substrate, which involves a great deal of effort. Large volumes of waste materials may be generated in some cases. Water drainage must also be planned for this method.

Method	Description	Advantages	Disadvantages
Hydroponics	With hydroponics, the roots are constantly fed in nutrient- and oxygen-rich water. Either a plant and filter substrate is used in addition (e.g. mineral wool, coconut fibres or expanded clay) or the plants are grown in channels. Drip and retention irrigation ⓘ are commonplace, as well as the nutrient film technique (NFT) ⓘ. The estimated minimum size for commercial systems is approximately 1,000 square metres.	Since plants receive an optimum supply of water and nutrients, yields can be increased. The circulation of nutrient-enriched water means that water consumption can also be considerably reduced. Since the substrates are light and only small quantities of substrate are required, the system weighs less than those involving traditional cultivation in soil. Systems are modular, and require comparatively little space.	It takes a lot of technical effort concerning automatic control to find the right dosage of water and nutrients. With circulating nutrient solutions (NFT ⓘ and retention irrigation ⓘ), there is an increased phytosanitary risk (phytosanitary protection ⓘ). Organic certification is not possible at present.
Aquaponics	Aquaponics is a combination of hydroponic culture and aquaculture (fish farming) in a circulatory system; here, the nutrients contained in the fish water are fed to the plants. The estimated minimum size for commercial systems is approximately 1,000 square metres.	Systems may vary in size. Different vegetable crops and various species of fish can be used. Since nutrients excreted by the fish (N, P) are absorbed into the fish water, both fish and plants are produced sustainably. In addition, this system also has the same advantages as hydroponic systems.	The system is costly, but no more expensive than separate installations. The fish tank weighs a lot (solution: place the hydroponic system on the roof and the aquaculture elsewhere). In traditional aquaponics, the supply cycles for some vegetable varieties and fish species are not optimally co-ordinated (→ facts and tips). They are also subject to the same disadvantages as hydroponic systems.

FACTS AND TIPS

Aeroponics is a special form of hydroponics in which the root zone is supplied via a fine mist of nutrients.

Recommendation: if possible, hydroponics or aquaponics systems should be connected to the building control system.

Aquaponics ASTAF-PRO: this latest type of installation was developed by Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB). It comprises two circulatory systems (aquaculture and hydroponics) connected with one another via a one-way check valve which is used to feed the nutrient-rich fish water into the hydroponics. In this way, optimum growth conditions can be created in both subsystems. It is a virtually zero-emission system requiring very little water (reduced to 3 per cent fresh water/day).

- www.igb-berlin.de/aquaponik-astaf-pro.html
- www.tomatenfisch.igb-berlin.de

Further reading

- Göhler, F. and Molitor, H.-D. (2002): Erdlose Kulturverfahren im Gartenbau. Stuttgart: Eugen Ulmer Verlag.

10 | Greenhouse parts

Hydroponic cultivation of vegetables on fish tanks. Rooftop greenhouse at Manhattan School for Children.

After having chosen certain crops and a suitable production method, detailed planning is required concerning the greenhouse equipment.

Which parts are required depends on the dimensioning of the greenhouse, the objective of the project (e.g. commercial or social), the local conditions (including development conditions) and the financial budget. For this reason, no general recommendations can be given as to which equipment and parts are necessary for a rooftop greenhouse. The following check list essentially shows which parts are generally available and which options for use they offer.

Parts	Explanations
Roof sealing	It must be ensured that adequate roof sealing exists.
Supporting structural elements	The supporting structure must offer sufficient stability (e.g. against wind, snow). The weight of the base and structural elements (trusses, beams, frames, standing walls, etc.) must be considered when calculating the total weight and, if necessary, adapted to the load reserves.
Greenhouse covering / walls	The weight of the covering increases the necessary bearing load of the roof. A wide range of materials are available. Lighter materials (e.g. foil or plexiglass) reduce the weight of the greenhouse. However, they may offer less stability and light permeability. (Wind speeds, for example, are faster on the roof than on the ground.) The choice of covering also influences the use of light and energy.
Transport infrastructure to and from the rooftop greenhouse	How items such as substrates, plants, plant residues, harvested products will be transported must also be considered at the planning stage. It may be necessary to use freight elevators. For hygienic reasons, the hydroponics and aquaculture products required for aquaponics systems must be transported separately.
Supply and waste pipes	Pipe planning is the toughest challenge when installing rooftop greenhouses. It is contingent upon the given circumstances in the existing building. Any existing connecting pipes need to be ascertained and demand identified. Plans should include the following pipes for rainwater ⓘ, effluent, drinking water, heat, electrical energy, data and communications, as well as building control systems. Sanitary facilities need to be planned.
Irrigation and fertilisation	Fertilisation can be combined with irrigation. A variety of techniques, such as drip and retention irrigation ⓘ or NFT ⓘ can be applied. Adequate water supply and effluent disposal systems must be considered at the planning stage. Precipitation water can be used as process water ⓘ. It may be necessary to undertake a chemical analysis of the drinking and process water (e.g. degree of water hardness). **Note:** If precipitation water is used, it must be ensured that it does not contain any pollutant loads (e.g. due to herbicides such as mecoprop ⓘ). When planning the supply pipes, it needs to be clarified whether the rainwater should be collected in a cistern or a tank on the roof (see Konzepte der Regenwasserbewirtschaftung 2011).

Parts	Explanations
Heating	The Central European climate necessitates the installation of a heating system. It also ensures the stability of the greenhouse by melting the snow. Heating systems available for conventional greenhouses can also be used in rooftop greenhouses. It is possible and appropriate to use waste heat ⓘ, also from waste water ⓘ (in/for the building or greenhouse) in order to save costs and reduce CO_2 emissions. This is usually only profitable in the case of larger installations (→ Chapter Energy optimisation and resource efficiency).
Cooling	Cooling systems are not required in Central European climates. Alternatively, cooling can be achieved via interior and exterior shading or air humidification systems (adiabatic cooling ⓘ, e.g. exhaust air cooling using rainwater ⓘ) (→ Chapter Energy optimisation and resource efficiency).
Ventilation	The same conditions of use apply as with greenhouses on the ground. Ventilation flaps can be installed in the standing wall and ridge area (natural ventilation) or fan ventilation can additionally be installed (to further improve the indoor climate).
Lighting	The same conditions of use apply as with greenhouses on the ground. Depending on the crops, assimilation lighting ⓘ or photoperiodic ⓘ lighting can be used as additional lighting. Care must be taken that sufficient working, orientation and safety lighting is available. **Note:** Shading as a result of the prevailing roof conditions and surrounding buildings may mean that additional lighting is required.
Cultivated areas	Beds on the ground and on benches, concrete floors, stationary tables, roller tables, mobile tables, channel tables or hanging devices can be used to grow crops. The type and size of the cultivated areas depend on the production method, and must be taken into consideration when calculating the weight.
Computer-aided control	Whether or not a building control system should be used to control and monitor climate and growth factors (including irrigation) depends on the type and scope of the control tasks. If available, it is advisable to connect such a device to the building control system. Alternatively, conventional electronic controls can be installed.

An important part of the planning stage in the case of existing buildings is calculating the total weight of the rooftop greenhouse so as to check whether the roof is able to bear the load. The following aspects are crucial when calculating the total weight: the empty weight of the greenhouse (supporting structure and covering), the weight of the crops (substrates, water volume and plants (and aquaculture) as well as the total load of the technical equipment (including cultivated areas, control system and pipes). Depending on the style of construction, however, the rooftop greenhouse can be bolstered at points with a high load-bearing capacity.

FACTS AND TIPS

Literature used and further reading

- Diezemann, M. and Brunko, W. (2005): Planen, Bauen und Sanieren im Gartenbau. Taspo 01/05, INDEGA.
- Senatsverwaltung für Stadtentwicklung Berlin (2010): Konzepte der Regenwasserbewirtschaftung. Gebäudebegrünung, Gebäudekühlung. Leitfaden für Planung, Bau, Betrieb und Wartung.

Eli Zabar´s rooftop greenhouse, New York City, USA.

11 | Energy optimisation and resource efficiency

Watergy building prototype in Berlin with a greenhouse as a humid air solar collector. Here, the greenhouse acts as heating for the building. Warm, humid air from the collector is dried and either fed straight into the building's heating system or stored for later use.

When planning to build a rooftop greenhouse, energy optimisation and resource efficiency involve linking the supply of water and disposal of waste water to the building. Running costs can also be cut by including waste water and energy systems.

The options available for supplementing a rooftop greenhouse mentioned here are not necessary, but optional for optimising a rooftop greenhouse in terms of energy and resource consumption. One of the advantages of using network technologies is that running costs can be reduced (e.g. heat recovery, water/waste water fees). They also constitute added value for the general public (e.g. improving the urban climate or consuming fewer resources). A number of technologies are presented that are ideal for supplementing and optimising rooftop greenhouses. Some of these technologies are integrated in the building. Others are placed outside of the building, requiring additional infrastructure.

The general approach for using such technologies is to:
1. Observe local conditions,
2. Develop an overall concept,
3. Implement it in stages.

Thermal energy	Technology	Purpose of use
Gas-powered combined heat and power unit (CHP)	A gas-powered CHP simultaneously produces heat and electricity (combined heat and power). Its performance is designed for housing complexes and business establishments. On the heating side, the CHP is operated at the same time as a boiler. Both heat generators are connected to the heating system for warming heating and drinking water.	The CHP acts as a supplement to the power supply. Utilisation of waste heat ⓘ is also possible for heating purposes, and CO_2 occurring from combustion can be conveyed to the greenhouse in order to increase yield.
Heat pump	A heat pump is a device that pumps thermal energy from a lower temperature reservoir (usually the surrounding area) to a system to be heated with a higher temperature (space heating) as useful heat together with the drive energy, with the help of a mechanical work source. Geothermal heat pumps utilise the temperature difference between the ground and outside air to transform heat (however, uncertainty remains in relation to the ecological risks involved). Air/water heat pumps extract heat from the outside air; the heat from the air is then raised by compression and can be used to heat process water.	The aim of heat pumps is to provide air conditioning to the greenhouse by utilising outside air, saving heating energy. The heat can also be used for the building.

Thermal energy	Technology	Purpose of use	Remarks
Adiabate exhaust air cooling ⓘ	Exhaust air cooling is air-conditioning technology with which (rain)water-based interior spaces can be cooled or heated using evaporation and condensation technology. More information about the advantages of this technology can be found in the guide entitled "Konzepte der Regenwasserbewirtschaftung" (rainwater management concepts).	Exhaust air cooling is used to provide air conditioning to rooms/buildings or the rooftop greenhouse, saving (heat and/or cooling) energy. At the same time, cold (at night) and heat (during the day) can be obtained, stored and used in the building or neighbouring buildings as required.	The extraction and storage of heat and cold from evaporation is not yet very common. However, it has already been deployed successfully in pilot plants (e.g. watergy). The (rain)water and interior circulation cycles are kept separate from one another for hygienic reasons.
Waste water heat recovery	Energy is extracted from waste water ⓘ via a heat exchanger.	The aim of waste water heat recovery is to heat rooms/buildings or the rooftop greenhouse to save heating energy.	An example project "greywater recycling ⓘ with heat recovery (Arnimplatz)" is being implemented in Berlin
Use of water	**Technology**	**Purpose of use**	**Remarks**
Use of process water ⓘ	Greywater and rainwater ⓘ are used as water sources for the greenhouse.	The use of process water ⓘ to irrigate greenhouses saves drinking water. Running costs (e.g. rainwater fees) can be reduced in this way.	See DIN 1989-1 concerning the use of rainwater in the guide "Innovative Water Concepts: Service Water Utilisation in Buildings" (Berlin Senate Department for Urban Development)
Use of cooling water	Waste heat ⓘ from power plants (e.g. combined heat and power plants) is used to provide air conditioning.	Used cooling water is utilised to provide air conditioning in rooms/buildings, which saves heating energy and makes use of existing energy sources.	The use of cooling water is location-specific because the distance to consumers is a cost factor that limits transport routes.
Solar energy	**Technology**	**Purpose of use**	**Remarks**
Photovoltaics	This involves installing a photovoltaic solar system on top of or next to a rooftop greenhouse.	Any area not taken up by the greenhouse is used for photovoltaic solar systems to generate power for the greenhouse.	The integration of photovoltaic cells into the roof of the greenhouse has not yet reached market maturity. The present technology shades the plants too much.

FACTS AND TIPS

- All technologies are conceivable for new constructions and existing buildings. If used in old buildings, it is important that the building is completely redeveloped with regard to its supply and disposal systems.
- Biogas plants are unsuitable for use in the city because have little chance of receiving approval due to the danger of explosion and odour nuisance in cities. This is compounded by the fact there is insufficient space for the fermenter in the city or on top of the building.
- It makes no sense to sell or feed surplus thermal energy into the grid because only small quantities are produced. In any case, it would be too expensive to transport the energy and to construct the necessary pipes.
- Local cycles should be favoured. For example, waste heat from the immediate vicinity could be used at the source point. It may be advisable to build rooftop greenhouses close to industrial facilities. If waste heat is generated in the actual building (e.g. a bakery or swimming pool), this could also be used. In this connection, attention must be paid to the cost-benefit ratio (construction and maintenance costs).

Further reading and web links

- Grauwasserrecycling mit Wärmerückgewinnung (Arnimplatz), Berlin, Deutschland: www.nolde-partner.de/node/32
- Senatsverwaltung für Stadtentwicklung (Ed.)(2007): Innovative Water Concepts: Service Water Utilisation in Buildings, Berlin: www.stadtentwicklung.berlin.de/bauen/oekologisches_bauen/download/modellvorhaben/betriebswasser_deutsch2007.pdf
- Senatsverwaltung für Stadtentwicklung (Ed.)(2010): Konzepte der Regenwasserbewirtschaftung. Gebäudebegrünung, Gebäudekühlung. Leitfaden für Planung, Bau, Betrieb und Wartung. Berlin.
- Watergy Pilotanlage, Berlin, Germany: www.watergy.de/einsatzbereiche/gebaeudeheizung-mit-feuchtluft-solarkollektor-und-erdwaermetauscher

12 | Quality assurance and certification

Seedlings in substrate.

QUALITY ASSURANCE

Quality assurance in the production of food in rooftop greenhouses embraces not only minimum standards, but also additional self-defined quality characteristics stipulated by operators and producers. Since with regard to quality assurance there are no major differences compared to traditional production in greenhouses, existing findings and requirements can be drawn upon for the most part. In contrast, the decision whether the project is to be of a commercial or social nature influences the issue of quality assurance, and should be clarified at an early stage.

An overview of the minimum standards to be complied with concerning quality in the production of food is provided below.

Hygiene standards	In order to ensure compliance with hygiene standards in food production, regulations concerning the production, storage, processing and preparation must be adhered to. Such regulations include separating the means of production from the products when storing different products and on all transport routes. → Chapter Production methods
Occupational health and safety	Occupational health and safety standards must be complied with in order to ensure health and safety in the workplace. Occupational Health and Safety Act: law on the performance of occupational safety and health measures to encourage improvements in the safety and health of workers at work.
Phytosanitary aspects ⓘ	In order to reduce the risk of plant diseases in production, access to the greenhouse should be severely restricted; only qualified horticulturalists should be granted access. (Semi-) public access necessitates special measures. For this reason, access by external visitors is usually not permitted in the case of purely commercial production.

FACTS AND TIPS

Additional self-defined quality characteristics

An added value can be gained for the image of the undertaking, company or project by creating one's own quality characteristics.

- In rooftop greenhouses, recycling management aspects can be supplemented by recycling water, using waste heat to generate energy or by using cooling systems, for instance (→ Chapter Energy optimisation and resource efficiency).
- Regional marketing can be viewed as an added value, which can additionally be illustrated using certificates/regional brands (e.g. "von hier" (from here)).
- Supplementary environmental services on or around the building (such as allowing plants to grow on the façade), for example, can improve the microclimate of the building.
- The choice of special varieties can improve quality.
- Another added value can be achieved by undertaking to comply with social standards (e.g. deploying staff from sheltered workshops).
- Orientation towards transparent production can generate an added value for the image of the project.
- Forms of cooperation and participation, such as neighbourhood discounts, may encourage customer loyalty.
- With the self-imposed principle of "environmentally friendly procurement", clients can include ecological criteria as award criteria in the evaluation of tenders.

Literature used and further reading

- Arbeitsschutzgesetze 2013, 54. neubearbeitete Auflage, C.H. Beck
- Bundesministerium für Arbeit und Soziales, BW Bildung und Wissen Verlag und Software GmbH (Eds.)(2013): Übersicht über das Arbeitsrecht/ Arbeitsschutzrecht – 2013/2014
- Informationsdienst für umweltfreundliche Beschaffung: www.umweltbundesamt.de/produkte/beschaffung/
- Umweltverträgliche Beschaffung, Service Rundschreiben VI A 08/2012: www.stadtentwicklung.berlin.de/service/rundschreiben/de/download/rs/2012/RsVIA_082012.pdf
- Information about environmentally compatible procurement:: www.stadtentwicklung.berlin.de/service/gesetzestexte/de/beschaffung

CERTIFICATION

Certification can be used to create added value and to gain customers (confidence-building).

Due to the wide range of seals and certificates, only a brief overview can be given here. Surveys generally confirm that consumers consider regionalism and confidence-building through the use of quality labels and certification to be important. However, a differentiation must be made between general quality assurance certification and additional voluntary certification responding specifically to consumers' requirements.

Examples of certification include:

- Regional brands (e.g. Spreewald, Berlin/Brandenburg "VON HIER" (from here))
- Genetically modified-free food (e.g. "ohne Gentechnik" (without genetic modification))
- Fair-Trade
- State codified certification systems (e.g. QS seal)
- Systems devised by the private sector (e.g. club model organic certification by growers' associations).

FACTS AND TIPS

Practical example

The regional brand Berlin/Brandenburg "VON HIER" was launched in 2007. More than 50 products have been certified. The development partners are pro agro, the Bundesverband der Regionalbewegung (Federal association of the regional movement), the associations Brandenburg 21 e. V. and Berlin 21 e. V. The regional brand was developed in collaboration with the food trade (based on the UNSER LAND (our country) model from Greater Munich). It combines successful product marketing with social objectives. The branding programme is open to small and medium-sized enterprises from the Berlin-Brandenburg region, provided that they and their products meet the programme's sustainability criteria.

Testing the substrate.

13 | Economic feasibility

Plant cultivation in the commercial indoor farm "The Plant" in Chicago.

The economic feasibility of rooftop greenhouse projects needs to be assessed on a case-by-case basis. For this reason, it cannot be said at this point whether or not rooftop greenhouse projects can be economically viable in general. All organisational, procedural, temporal, personnel, structural and infrastructural aspects need to be taken into account at the planning and risk assessment stage. The factors below influence the economic feasibility of rooftop greenhouses, as well as the specific issues and challenges that need to be addressed. In the end, economic feasibility decides whether the project can be realised and, if so, how.

Not enough experience has been gained in the implementation of rooftop greenhouses in Germany. Consequently, these economic feasibility check lists contain key factors that need to be considered in the planning stage; however, they do not claim to cover all aspects.

MONETARY FACTORS – CHECK LIST

Monetary expenditure

Consultancy / transaction costs
- ▲ Investigations into statics
- ▲ Planning costs/draft
- ▲ Building applications
- ▲ Financial/legal consultation, etc.
- ▲ Expenses for approvals

Financing costs
- ▲ Costs for the provision of financial resources
  (→ Chapter Forms of financing and funding opportunities)

Investment costs
- ▲ Construction measures (determination based on DIN 276)
- ▲ Greenhouse construction
- ▲ Technical facilities/cultivation systems (e.g. hydroponics)
- ▲ Building technology, supply and disposal
- ▲ Further processing and packaging equipment

Monetary expenditure

Running costs
- ▲ Rent/lease
- ▲ Insurance, taxes/charges, etc.
- ▲ Staff
- ▲ Servicing/maintenance
- ▲ Hygiene control costs
- ▲ Costs for organic label or association memberships
- ▲ Distribution expenses
- ▲ Further processing and packaging expenses
- ▲ Energy ▲ Water ▲ Waste ▲ Fertiliser
- ▲ Seedlings ▲ Substrates, soil etc.
- ▲ Storage
- ▲ Disposal of other residues

Monetary income

Proceeds from the sale of products
- ▲ Fresh products
- ▲ Processed products
- ▲ Income from catering

Proceeds from services
- ▲ Consultancy services
- ▲ Lease as an event location
- ▲ Training / workshops

FACTS AND TIPS

Further reading

- ▲ Senatsverwaltung für Stadtentwicklung (2007): Leitfaden für Wirtschaftlichkeitsuntersuchungen bei der Vorbereitung, Planung und Durchführung von Baumaßnahmen. Berlin.
- ▲ Nicht monetäre Bewertungsmaßstäbe, Rundschreiben VI C 01/2011, Arbeitsblatt 1: www.stadtentwicklung.berlin.de/service/rundschreiben/de/download/rs/2011/RsVIC_012011.pdf
- ▲ Senatsverwaltung für Stadtentwicklung (Ed.)(2010): Konzepte der Regenwasserbewirtschaftung. Gebäudebegrünung, Gebäudekühlung. Leitfaden für Planung, Bau, Betrieb und Wartung. Berlin: www.stadtentwicklung.berlin.de/service/rundschreiben/de/download/rs/2011/anlagen/leitfaden_07_2011.zip

Risk factors for the economic feasibility of rooftop greenhouses		
Risk factors	**Cause**	**Addressing the risk (improving opportunities, minimising risks)**
Adapting existing buildings	▲ Unforeseen redevelopment costs ▲ Use of roof not intended; statics need to be confirmed ▲ Competition for space	▲ Carefully selected location and preliminary planning ▲ With new constructions: plan from the outset ▲ With new constructions: look for appropriate sites/buildings
Construction planning, building applications	▲ Lack of know-how ▲ Unpredictable conditions and expenses ▲ The concept does not match the site (conditions) (planning and building law permissibility)	▲ Carefully thought-out preliminary planning ▲ Prepare applications for planning permission carefully and get in contact with the building supervisory board at an early stage ▲ Plan for building applications as an extra item of expense
Demand and competitive situation	▲ Uncertain sales market ▲ The food product market, and also the organic segment, are already largely saturated	▲ Communicate the distinctive feature and added value of rooftop greenhouses ▲ Create a brand and an image
Dismantling costs	▲ The need to dismantle facilities if the project is suspended or abandoned	▲ Take into consideration at the planning stage ▲ Agreements with investors and owners
Lack of experience	▲ High degree of innovation includes planning and forecast uncertainties ▲ Complexity requires interdisciplinary expertise	▲ Collaboration with a broad, interdisciplinary team of experts, even at the preliminary planning stage
Acceptance	▲ There may be problems of acceptance with regard to production methods, particularly in the case of hydroponics and aquaponics systems ▲ Organic certification is not yet possible in the case of hydroponics and aquaponics systems	▲ Create transparency for buyers
Conflicts of interest	▲ Conflicts between the need for stable, efficient production and ecological/social objectives	▲ Differentiated and clear corporate strategy and production planning
Negative external effects	▲ The effects of glare caused by the greenhouse ▲ Emission of light due to additional artificial lighting ▲ Odour nuisance ▲ Under certain circumstances, alteration of "traffic routes" ▲ Traffic generation in the vicinity ▲ Risk of vandalism	▲ Take into account when choosing the site

Opportunities for the economic feasibility of rooftop greenhouses		
Opportunities	**Cause**	**Addressing the risk**
Linking the greenhouse's energy to that of the building	▲ Use of waste heat ⓘ from buildings to heat the rooftop greenhouse ▲ Use of the rooftop greenhouse to generate energy for buildings ▲ Insulation rating of the rooftop greenhouse	▲ Take into account when choosing the site ▲ Communicate and, if necessary, determine the price of advantages vis-à-vis owners and investors
Save drinking water, rainwater fees and wastewater costs	▲ Use of process water ⓘ from greywater ⓘ– and/or rainwater* ▲ Rainwater harvesting	▲ Take into account when choosing the site ▲ Communicate and, if necessary, determine the price of advantages vis-à-vis owners and investors
Demand and competitive situation	▲ Products convey "values" (e.g. eco friendliness, fair cultivation, local identity) ▲ Urban consumers as broad-minded "pioneers"	▲ Incorporate values into brand and image ▲ Create transparency
Innovative nature	▲ (Initial) uniqueness owing to the high degree of innovation ▲ Innovation knowledge building	▲ Exploitation of the advantage to acquire capital (e.g. CSR ⓘ) ▲ Use of the expertise acquired for consultancy services, etc.
New marketing channels	▲ Direct marketing (no trade margins)	▲ Use of alternative, collaborative funding and distribution models (e.g. CSA ⓘ) ▲ Organisation of new local cooperative activities
Use of previously unused areas	▲ Unused roof surfaces are put to a productive use	▲ Communicate vis-à-vis owners, investors, those responsible for planning, and politicians

When assessing the economic feasibility of the project, it is also important to consider the chosen observation period and the inclusion of non-monetary assessment criteria (see circular at www.stadtentwicklung.berlin.de). In addition to purely monetary factors, indirect risks and opportunities can influence the economic feasibility of rooftop greenhouses. These mainly arise due to the high degree of innovation of rooftop greenhouses.

14 | Forms of financing and funding opportunities

Vertical cultivation system in the rooftop greenhouse of Manhattan School for Children in New York City.

The financing of rooftop greenhouse presents project managers with challenges. The comparative advantages, such as the proximity to consumers, energy and water efficiency or, in the case of social projects, participation in society and quality of life, are difficult to express in figures alone vis-à-vis investors.

ESSENTIAL ASPECTS OF FINANCING ROOFTOP GREENHOUSES

In order to secure financing, a measure programme, timetable and financing plan with concrete objectives and a business model are required, describing the steps to be taken to realise the idea of the project.

Three suitability questions can help to draw up these documents:

1. How much investment is required, and what own contribution can the project participants make?
2. How high are the running costs?
3. How can liquidity be guaranteed for at least the first 3 to 5 years?

It should be possible to run the operation at least on a cost-covering basis from the first year onwards, enabling it to exist in the long term and to not have to rely on grants. Since the greenhouse will be located on a rooftop, special technological and safety requirements are involved that can only be met with a certain degree of professionalism. In addition, it may not be advisable to implement rooftop greenhouses on one's own, i.e. the aim should be to establish a partnership involving several groups and companies for pioneering projects, enabling the financing and project realisation to be distributed to several people (→ Chapter Operator models and Chapter Use concepts).

FORMS AND SOURCES OF FINANCING

The potential sources of financing for rooftop greenhouse projects range from traditional bank loans and microcredit to social financing and crowd funding.

Form of financing	Conditions / criteria
External financing through conventional banks	▲ Amount of capital raised by the borrower ▲ Security for the loan ▲ Business plan, cash-flow plan and expected profit and loss account ▲ Minimum approximately € 50,000 because otherwise the appraisal costs will exceed the likely return
External financing through "specialist banks" (unconventional business areas such as ecological and social entrepreneurship)	▲ Overall concept with objectives, business model and financing plan ▲ Cheaper loans for projects involving civic commitment ▲ Comprehensive assessment of creditworthiness, also including characteristics of the borrowers and their social environment ▲ Collective securities can be given as security ▲ Exact account using a special questionnaire, which may also be useful for project planning
Microfinance institutions (advisors commissioned by the government): free microcredit from € 1,000 to € 20,000	▲ After a preliminary check, applications are forwarded to GLS-Bank as the sponsor ▲ Approval in small steps of, e.g. initially € 1,000 and later € 5,000 or € 10,000 ▲ Increases up to € 20,000 ▲ Term from a few months to a maximum of three years ▲ References or small guarantees from the borrower's personal and business environment are often required

Form of financing	Conditions / criteria
Private financing or social financing	▲ Individuals and companies join forces to establish a financing initiative with private funds ▲ Complex agreements → Integration of other sources of capital than just banks ▲ Greater chance of receiving conventional loans
Crowd funding: anonymous crowd of small investors	▲ Variety of models: credit market place smava (identifies the most favourable offers for loans between € 1,000 and € 50,000) ▲ Fundraising platforms kickstarter.com and visionbakery.com (for creative projects and innovative technologies) and betterplace.org (for non-profit projects) ▲ Innovestment, Companisto and Seedmatch (explicitly for start-ups, financial capital up to € 100,000, investors acquire silent participations → free feedback and review of own project idea and effective marketing – the more supporters/ multipliers the better)
Sponsoring	▲ Through parents' associations in the case of schools or through companies (corporate social responsibility, boosting image)

FUNDING OPPORTUNITIES

There are a number of support programmes that can theoretically be used to obtain funding. In principle, however, support programmes can only assist self-sustaining concepts.

- ▲ European Agricultural Fund for Rural Development (EAFRD): grants for innovations, environmental protection and energy efficiency → Grants are awarded to Berlin farms via the Federal State of Brandenburg (which is also responsible for Berlin's agriculture)
- ▲ European Social Fund (ESF): e.g. funding to create new jobs → via state or federal authorities or private sponsors, (see specific ESF funding guide issued by the Federal State of Berlin)
- ▲ European Regional Development Fund (ERDF): regional competitiveness and employment, e.g. grants for innovations, environmental protection and energy efficiency → in Berlin, grants are awarded within the Umweltentlastungsprogramm (UEP), amongst others
- ▲ Federal government's funding programmes (federal ministries and federal offices) as well as the Federal State of Berlin → Overview: e.g. funding guided issued by Investitionsbank Berlin
- ▲ Support within research programmes
- ▲ Other: foundations and the Employment Agency (e.g. for start-up enterprises)

Indirect support and general information

In addition to applying for funding, rooftop greenhouse projects can also make use of indirect support measures. These include tax relief or the exemption from payment of fees, such as reducing the rainwater fee for buildings where it can be proven that precipitation water is collected and not channelled into the sewage canal.

The following must be taken into consideration when acquiring funding:

- ▲ Not all funding opportunities can be combined freely.
- ▲ The search for funding should be treated as though of secondary importance. The business model and a financing model should always be established first, on the basis of which funding opportunities can be sought.
- ▲ Projects should not rely on secondary aid objectives (social, education, …) in order to gain basic funding.
- ▲ It is best not to finance running costs, such as the purchase of seedlings and labour costs, from subsidies, at least not in the long term, to ensure that the project can be operated long term even if funding conditions change.

Neither support programmes for agriculture and horticulture, new constructions or building redevelopments, nor those for the development of regional economic structures earmark separate support for rooftop greenhouses or have yet been claimed for rooftop greenhouses. The organisations responsible would have to check whether support can be granted.

FACTS AND TIPS

Information about financial planning

- ▲ It is still unclear how rooftop nurseries would have to be taxed – on the basis of property tax A as in agriculture or value-added tax.
- ▲ There could be problems concerning miscalculations of tax if, for instance, the full VAT rate has to be paid.
- ▲ The costs for planning, consultation, the search for loans and financing, networking, and so on, should be estimated to take up around 20 per cent of investment costs.
- ▲ There may be high transaction costs involved, for example for collective securities when applying for a loan from GLS-Bank.
- ▲ Attempts can be made to obtain support free of charge for securities or advisory and planning services, for example by obtaining advice from a non-profit association (e.g. from the foundation anstiftung & ertomis), partner companies or voluntary support.

Further reading

Assistance in developing a financial concept can be gained from the check list drawn up by GLS Bank: "Ökologische Landwirtschaft", Fragenkatalog zu Ihrer geplanten Finanzierung:

- ▲ www.gls.de/fileadmin/media/pdf_finanzierung_unterlagen-checklisten/checkliste_landwirtschaft.pdf
- ▲ Umweltentlastungsprogramm Berlin (UEP II): www.uep-berlin.de

15 | Involving the public

When planning or implementing a project, it may be important to include the public in the planning and implementation process. The level of public involvement may vary. The different intensities and forms of involvement pursue various objectives. Public involvement can be used at different points in time in the planning and implementation of the project, and realised using a variety of methods. In practice, the transitions between the different forms are not always clear-cut.

Eagle Street Farm, New York City, USA

Intensity of involvement	Objective behind involvement	Phase of involvement	Methods
Information With this form of involvement, the aim is merely to provide the population with information supplied by the respective groups of persons. It is virtually impossible for the public to influence concrete planning and shaping, and there is usually no intention for this to occur.	▲ Create transparency (inform the population) ▲ Create interest and raise awareness ▲ Promote acceptance ▲ Influence how a topic is perceived ▲ Foster confidence-building and strengthening ▲ Strengthen knowledge about food and connections to other aspects (health aspects) ▲ Create needs (e.g. for local products) ▲ Make experience accessible	▲ Brainstorming ▲ Flesh out planning ▲ Implementation (construction phase) ▲ Operational management ▲ Post-project phase	▲ Posters ▲ Circulars ▲ Information events ▲ Days of action or celebrations ▲ Project website ▲ Newsletters
Participation (consultation) In this case, affected persons and interested parties are asked to give their opinion and assessment. This way, they are given the opportunity to influence the project planning and implementation process in line with their opinions. However, their objections and recommendations are not binding for the project managers, and therefore need not necessarily be implemented.	▲ Promote acceptance ▲ Gather misgivings and criticism ▲ Record usage requests and interests ▲ Collect ideas for the design and implementation of the project ▲ Promote confidence-building and strengthening ▲ Reinforce the local social fabric: relations/community/neighbourhood spirit ▲ Create possibilities for participation ▲ Integrate existing know-how and expert knowledge	▲ Brainstorming ▲ Flesh out planning ▲ Implementation (construction phase)	▲ Discussion meetings ▲ Surveys (also online) ▲ Open Space Conference ▲ World Café

Intensity of involvement	Objective behind involvement	Phase of involvement	Methods
Co-determination This is the most intensive form of involving the public. In this case, the public is not only asked to give their opinions – these opinions become a major or constituent part of the project planning and implementation process. This can be achieved by ensuring public opinion is included indirectly in the project planning and implementation phase or even by granting the public the right of co-determination or transferring decision-making powers completely to the public.	▲ Promote acceptance ▲ Gather misgivings and criticism ▲ Record usage requests and interests ▲ Collect ideas for the design and implementation of the project ▲ Include target groups for active shaping ▲ Initiate commitment ▲ Promote confidence-building and strengthening ▲ Strengthen the local social fabric: relations/community/neighbourhood spirit ▲ Open up options for becoming involved ▲ Create possibilities for co-determination ▲ Create or strengthen a sense of personal commitment ▲ Include existing know-how and expert knowledge	▲ Brainstorming ▲ Flesh out planning ▲ Implementation (construction phase)	▲ Online dialogue ▲ Round tables ▲ Open Space Conference ▲ World Café ▲ Community-supported agriculture (CSA) ⓘ
Collaboration This involves active participation of the public in shaping the project as well as throughout the duration of project. It may include the active involvement in the construction and implementation of the project. In the case of rooftop greenhouses, forms enabling the public to grow their own produce or to harvest crops are particularly suitable.	▲ Include target groups for active shaping ▲ Initiate commitment ▲ Promote confidence-building and strengthening ▲ Foster personal skills ▲ Strengthen the local social fabric: relations/community/neighbourhood spirit ▲ Open up options for becoming involved ▲ Create possibilities for co-determination ▲ Create an experience and promote customer loyalty (pick-your-own) ▲ Enlist financial participation ▲ Open up employment options ▲ Create or strengthen a sense of personal commitment	▲ Implementation (construction phase) ▲ Operational management	▲ Involvement in the construction ▲ Vegetable patch sponsorship ▲ Neighbourhood gardens ▲ Pick-your-own ▲ Community-supported agriculture (CSA) ⓘ ▲ Days of action

The "Urban Canopy" rooftop farm in Chicago is operated according to the principle of Community Supported Agriculture (CSA).

Children harvest amaranth during school project weeks on the FEZ Eco Island in Berlin.

TARGET GROUPS

Depending on the objective and the timing, it may be appropriate to involve various target groups. These can include people from the following groups: trade, citizens' initiatives/interest groups, neighbourhood management, financial backers and participants along the value-added chain, horticulture, agriculture and architecture.

The choice of target groups may also be based on location-specific criteria, e.g. occupants, people who use the building, direct neighbours, residents from the urban district or the whole city. If the objective necessitates it, certain demographic criteria can also form the basis of the selection process, such as children, families, adults, the elderly, men, women, and so on. It is often expedient to involve relevant multipliers and motivators, who may play an important part in disseminating ideas and conveying attitudes and positions. It could also be important to involve relevant policy-makers as well as representatives from administrative bodies, academia and companies.

METHODS

A number of methods for involving the public are presented as examples in the following table.

FACTS AND TIPS

Challenges

- Including the population in the various phases of the planning and implementation process of projects is no guarantee that they will agree to the projects. The lack of decision-making powers can cause frustration amongst participants if their suggestions are not included or realised. In addition, in the case of heterogeneous opinions, representatives of disregarded opinions may also be unhappy after the involvement phase.
- Another problem is the incompatibility of the attention curve with the influence phases. In light of past experience, for example, the population's willingness to become involved is at its greatest when the visible part of the project realisation – i.e. the construction – has already commenced. In this phase, however, there are virtually no possibilities to exert influence.
- A lack of continuity of the participating group of people can have a problematic effect on potential votes and decision-making processes.
- Dominant people involved in the discussion may place their personal needs/requests in the foreground, meaning that vested interests rather the interests of all target groups are considered.
- The know-how gained in previous projects is too rarely archived and drawn upon.

For this reason,

- the type of communication should be as transparent, clearly structured and vivid as possible,
- involvement should be encouraged proactively at an early stage,
- moderation should be conducted professionally,
- good preparation needs to be ensured (including problem analysis and anticipation),
- sufficient resources need to be earmarked,
- the continuity of involvement needs to be ensured,
- a joint project culture needs to be established (common definitions of terms and values, a shared understanding of communication and the problem, common rules for the working culture, joint milestones, to name just a few),
- the results generated from earlier projects and/or processes should be recorded and exploited.

Method	Open Space Conference	World Café	Community supported agriculture (CSA)	Days of action and celebrations	Websites
Short description	Conferences are held on a pre-determined topic. Participants work on the topic in self-proclaimed thematic work groups.	This method is designed to initiate a creative process in a relaxed setting reminiscent of a coffee-house (spread over several sessions) that promotes the exchange of knowledge and ideas among participants, leading to new insights.	CSA ⓘ refers to an association of a group of consumers who have pledged to support a horticultural/agricultural holding.	Interested citizens and target groups are invited to participate in a specified programme.	They offer the interested group of people constantly accessible information – in some cases with the possibility to participate.
Suitable for	▲ Considering complex issues ▲ Setting the wheels in motion for a project ▲ Addressing large and heterogeneous groups	▲ Gathering and exchanging participants' knowledge and their perspectives ▲ Developing new ideas and identifying opportunities for action	▲ Giving the holding planning reliability ▲ Creating a high degree of mutual trust ▲ Exercising a strong influence over production	▲ Informing a great many people at the same time ▲ Shaping one's image	▲ Informing a great many people at the same time ▲ Initiating and shaping complex participation processes
Duration	2 to 3 days	1 day to 1 week	At least one harvesting cycle (6 months or 1 year)	By the hour, half a day, a whole day	Several weeks, months or years
Size of group	For a small, medium-sized or large group of people	From 15 people up to a large group of people	Depends on the size of the holding	For a medium-sized and large group of people	For a large group of people
Participants	Interested citizens, stakeholders, politicians and government officials	Citizens, decision-making politicians, government officials and business leaders, experts or representatives of various interest groups	Families and households with a regular and flexible demand	Anyone	Internet-affine target groups

FACTS AND TIPS

Literature used and further reading

- ▲ Participation & Sustainable Development in Europe: www.partizipation.at
- ▲ Senatsverwaltung für Stadtentwicklung und Umwelt Berlin (Ed.) (2012): Handbuch zur Partizipation, Berlin: www.stadtentwicklung.berlin.de/soziale_stadt/partizipation/download/Handbuch_Partizipation.pdf

High Line Park was created on a former elevated railway line in New York City.

16 | Networking

Networking describes the process of linking different people, groups of persons and subject areas.

A form of organisation often used in networking is a thematically clearly defined network. The people and groups within a network can be linked to one another to different degrees, depending on the issue and objective. The simplest form of a network is a list of people or groups of persons. The broadest type of network from an organisational perspective is an association, which organises internal collaboration between its members and represents their interests externally.

An overview of the greatest benefits and objectives of networking is provided below.

Benefits	Description
Sharing and gathering existing knowledge, improving clarity	Many actors and stakeholder groups have a great deal of theoretical and practical knowledge acquired, for example, from experience gained in their own projects. This knowledge can be useful in the implementation of new projects. Academia and development also benefit from the experience gained in practical projects; they can also make their knowledge and expertise available in a network.
Implementation of projects	The ultimate purpose of networking is to foster the implementation of projects. This complies not only with the vested interests of network members, but also with the interests of the whole network
Linking different areas and expertise	The path from planning to implementing projects requires a very wide range of competencies and skills. Effective networking brings together people from different areas, enabling them to engage in exchange and to advance ideas.
Raising awareness of the topic of rooftop greenhouses in general	An effective network is an important building block for the success of a topic. Depending on the organisational structure and level of commitment, a network can lobby for the topic, raising public awareness of the topic and its visibility.
Encouraging others to join in	A rooftop greenhouse network can lead to the generation of new ideas, encouraging new people to join in with activities.
Ensuring the continuity of the topic	Lots of knowledge is lost when projects come to a close or when experienced people depart. A network can assume the function of collecting and preparing this knowledge, ensuring the continuity of the topic beyond the completion date of individual projects.

OVERVIEW

There are a number of networks on the topic of urban agriculture in the German-speaking world. This table provides a selection of the key networks for Berlin and Germany as a whole.

Network (including sphere of influence)	Description
anstiftung & ertomis (Germany)	The foundation anstiftung & ertomis mainly provides advice to neighbourhood, local and regional networks. It promotes the participation of ethnic and other minorities, intercultural understanding and historical awareness, as well as active social, cultural and craft work. It identifies ways in which resource consumption can be reduced, promoting an ecologically and socially acceptable economy.
Lecker Gemeinschaftsdachgärten (Berlin)	The aim of this project is to initiate a community that constructs community rooftop greenhouses. To this end, "Lecker Gemeinschaftsdachgärten" seeks to build an infrastructure that creates contacts to other rooftop gardeners, organises the exchange of seed and plants, and gathers information and knowledge about the theory, practice and financing of projects.
„Berufliche Bildung Urban Gardening" Round Table (Berlin)	The aim of the "Berufliche Bildung Urban Gardening" Round Table is to train people, create networks and implement model systems in horticulture and farming. The Round Table was initiated within a project funded by the Deutsche Bundesstiftung Umwelt (German Federal Environmental Foundation).
stadtacker.net (Germany)	This platform enables people to engage in exchange about urban agriculture; it conducts comprehensive knowledge gathering, and informs about activities and projects in Germany. It is open to all those interested and involved in urban agriculture.
Vitacity (Berlin)	At Vitacity, existing garden initiatives and associations are linked to one another; support is given in the form of training and campaigns.
Will-Pflanzen (Germany)	The land exchange and contact platform brings together people who are offering their services or looking for someone who is offering their services; it is the result of the scientifically guided campaign Urban Gardening 2.0.
"ZFarm Network" for building-integrated agriculture (Berlin)	The participants of the series of workshops held within the ZFarm project (→ Chapter Approaching building-integrated agriculture) have joined forces to create a network. New projects will be presented and exchange fostered at meetings, to be held on an irregular basis.

FACTS AND TIPS

Web links for the above-mentioned networks

- anstiftung & ertomis: www.anstiftung-ertomis.de
- Lecker Gemeinschaftsdachgärten: www.gemeinschaftsdachgaerten.de/lecker
- „Berufliche Bildung Urban Gardening" Round Table: www.gfbm.de/modellprojekte/urban-gardening-in-berlin
- Stadtacker.net: www.stadtacker.net
- Vitacity: www.agrar.hu-berlin.de/fakultaet/departments/dntw/ubg/Forschung/vitacity
- Will-Pflanzen: www.will-pflanzen.de
- ZFarm network "Building-integrated agriculture": www.zfarm.de

Glossary ⓘ

Fish tanks from the aquaponics system on a container farm by the company ECF | Efficient City Farming GmbH in Berlin.

Adiabatic cooling: A method used in air-conditioning technology to air-condition rooms using evaporative cold. The method is applied indirectly by humidifying a different air current to the air current that needs cooling. Evaporative cold is a renewable energy because only air and water are used as sources for cooling. The principle of this process resembles that of sweating, where water evaporates due to perspiration. The heat required for the evaporation process is extracted from the air, causing a person's skin to cool down.

Assimilation lighting: Assimilation lighting (in the blue and orange/red spectrum) can be used as additional lighting in horticulture so as to increase photosynthesis rates in plants, enhancing plant growth. Assimilation refers to the photosynthesis of plants in which they absorb light energy, which is then used to convert carbon dioxide (CO_2) and water (H_2O) into carbohydrates.

BMZ: The cubic index (Federal Land Use Ordinance, BauNVO, Section 21) defines how many cubic metres of construction volume may be built or is available per square metre of site area. The construction volume is the total volume from the floor of the lowest full storey to the ceiling of the top full storey. It is a degree of building coverage, which is part of public building law in Germany. As such, it is an important control mechanism of urban development of the Federal Building Code (BauGB). It is stipulated in legally binding land use plans.

Building control system (GLT): The building control system is part of the automation of technical building equipment.

Co- and ingredient branding: Co-branding describes cooperation between established brands in order to market their products better. It involves the mutual image transfer of promises of quality. Ingredient branding is creating a brand for certain ingredients or components of a product. These ingredients appear as independent brands on the finished product, having an effect on customers' buying decisions. Both are strategic marketing tools.

CSA (community-supported agriculture): CSA refers to an association of a group of consumers who have pledged to support a horticultural/agricultural holding.. CSA is also sometimes known as "community-shared agriculture". Consumers make a commitment to purchase produce from the farm, and are able to gain insight into production and influence it in return.

CSR (corporate social responsibility): The term corporate social responsibility refers to the business community's voluntary contribution to sustainable development above and beyond legal compliance.

Demonstration projects: Large-scale demonstration projects are funded within pilot projects to demonstrate for the first time how advanced methods for avoiding or reducing environmental impacts can be realised.

Drip irrigation: This is the most widely used and proven irrigation technique. Two forms can be distinguished: drip hose and capillary hose irrigation. In the case of drip hose irrigation, consistent irrigation is ensured by placing drip hoses on the tables at 20 to 30 cm intervals. With capillary hose irrigation, plants take root in mineral wool, coconut fibres or a similar substrate. Every single plant has its own irrigation hose, which feeds the root zone with nutrient solution, drop by drop. Any excess nutrient solution is re-collected.

FIS Broker (interdisciplinary information system): Berlin's Senate Department for Urban Development has been recording and processing geodata on a large scale for many years. The existing databases are made available to a wide circle of users via the FIS Broker.

Gender mainstreaming: According to the Federal Ministry of Family Affairs, Senior Citizens, Women and Youth (2004), gender mainstreaming describes the requirement to make allowance from the outset for the differing interests and life situations of women and men in the structure and organisation of processes and work procedures, in results and products, communications and public relations work, and controlling, so as to facilitate the effective realisation of the objective of equality between women and men.

GFZ: The floor space index (Federal Land Use Ordinance, BauNVO, Section 20) indicates how much total floor space all of the full storeys of physical structures may have, relative to the surface area of the development site. It is a degree of building coverage, which is part of public building law in Germany. As such, it is an important control mechanism of urban development of the Federal Building Code (BauGB). It is stipulated in legally binding land use plans.

Greywater: According to European Standard 12056 – 1, defined as slightly polluted wastewater that does not contain human faeces. A part of domestic wastewater originating from showers, bathtubs, washbasins and/or washing machines but does not include toilet waste water and highly contaminated kitchen waste water.

GRZ: The site coverage index (Federal Land Use Ordinance, BauNVO, Section 19) stipulates the area of a building plot that may be built on. It is a degree of building coverage, which is part of public building law in Germany. As such, it is an important control mechanism of urban development of the Federal Building Code (BauGB). It is stipulated in legally binding land use plans.

Long-term produce purchase agreement: This agreement describes guarantees given by retailers for the long-term purchase of products. The term is derived from PPA – power purchase agreement – a contract for purchasing electricity from independent power producers.

Mecoprop: Methylchlorophenoxypropionic acid (MCPP) is a herbicide belonging to the class of hormone weed killers. This substance is added to "bitumen roofs" to provide protection against root penetration (see Handlungsempfehlungen zur Vermeidung der Umweltbelastung durch die Freisetzung des Herbizids Mecoprop aus wurzelfesten Bitumenbahnen. Senatsverwaltung für Stadtentwicklung und Umwelt und Landesamt für Gesundheit und Soziales. Last amended: 1 July 2013).

Monitoring: The systematic capture, observation or control of a procedure or process by means of technical aids or other observation systems. The function of a monitoring system is to intervene in a monitored procedure or process in the event that it does not proceed as desired or if certain threshold values are not reached or are exceeded. Monitoring is therefore a special variant of recording.

NFT: With NFT (the nutrient film technique), plants usually grow in metal or plastic channels through which a nutrient solution periodically passes or which are permanently wetted with a nutrient solution. The roots of plants are kept in the nutrient solution. The plants take hold in openings, foils stretched above them, in polystyrene or mats. High-growing species of fruit vegetable crops such as cucumber, bell pepper and climbers are tied up to a trellis.

Photoperiodic lighting: This is the use of artificial lighting to control the length of daylight or night time. Amongst other things, lighting triggers certain development processes (e.g. flower formation, when plants start to grow, and rest). Effects that trigger or delay flowering can be achieved through the photoperiodic effect, enabling the flowering time of plants to be controlled.

Photovoltaic solar system: A photovoltaic solar system converts solar radiation into electricity, which is consumed locally or, mainly, after having been distributed via the electricity grid. The PV module converts radiation into direct current via the photoelectric effect in the semi-conductor material of the solar cells. Several PV modules are connected to an inverter, which transforms direct current into alternating current, which can then be fed into the grid. According to the Renewable Energy Sources Act (EEG), net operators are required to guarantee remuneration for solar electricity fed into the grid, creating the foundation for the economic operation of photovoltaic solar systems. It is essential to ensure that the photovoltaic solar system is not affected by shading.

Phytosanitary protection: This includes the use of disinfectant mats at the entrance to the greenhouse, the disinfection of nutrient solutions using thermal processes or UV sterilisation and the application of beneficial insects to control animal pests.

Process water: According to DIN 4046: water with different quality characteristics serving commercial, industrial, agricultural or similar purposes including potentially potable water. According to DIN 1989:

Rainwater (According to DIN 1989): water from natural precipitation that is not polluted by human use.

Retention irrigation (also called the ebb and flow system): This method is mainly used for ornamental plants and for growing seedlings in greenhouses. A differentiation is made between ebb and flow systems on concrete (seedlings) and on tables. What all these systems have in common is that the plant roots are periodically flooded and retained in water enriched with nutrients for a certain length of time (depending on the size of the pot or container). Excess water is collected, filtered, disinfected and, if required, used for the next round of irrigation.

Sleeping Giants: This term was coined in 2011 at an event run by Berlin's Senate Department for Urban Development to describe large urban buildings that have lost their use and are now vacant. Since then, the term has often been used in connection with empty "XXL buildings". www.stadtentwicklung.berlin.de/staedtebau/baukultur/iba/download/Einladung_Schlafende_Riesen.pdf).

SWOT analysis: This acronym stands for strengths, weaknesses, opportunities and threats. A SWOT analysis is a strategic management tool. The development of a strategy is based on an analysis of the strengths, weaknesses, opportunities and risks involved prior to the commencement of the respective project.

Waste heat: Thermal energy that is created as a(n often undesirable) by-product (co-product) in chemical, physical or technical processes.

Waste water: According to the German Water Resources Act, waste water is water whose properties have been changed by domestic, commercial, agricultural or other usage, as well as water (effluent) and precipitation collected from rainfall from built-up or paved areas (precipitation water) drained during dry weather. Water for household and commercial areas of use that does not have to have the quality of drinking water.

Water impermeable concrete roof: Roof constructions made from water impermeable concrete are suitable for rooftop greenhouses.

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