Market Analysis Report

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Contents

1. List of abbreviations

CALs – CLEVER Action Labs

CCA – Climate Change Adaption

EFB – European Federation of Green Roof and Green Wall Associations

FR – Frontrunner cities (Hamburg, London, Milan)

GIES – Green Infrastructure and Ecosystem Services Strategy

GLA – Greater London Authority

NBS – Nature-based solutions

2. Introduction

A significant development in recent decades is the increasing urbanisation. Many authors describe this as a major driver of global land cover change with urban dwellers exceeding 50 percent of the global population. Furthermore, urban areas are predicted to absorb most of the continued population growth over the future decades (Grimm et al., 2008; United Nations, 2010). As a key effect of a growing share of urban population, cities tend to lose green space to create dwellings. Therefore, the extinction of nature experiences in urban communities is rising. This incremental green space loss can trigger a ratcheting-down effect where individual expectations of nature continually decrease through time (Lin et al., 2018).

To counteract this development, cities have constantly raised their interest in sustainable and alternative urban planning to increase their resilience towards environmental impacts as well as citizens well-being. To focus on these topics, nature-based solutions (NBS) have developed into an attractive alternative to traditional solutions in urban planning. A special characteristic about NBS is that they are inspired by nature and through their implementation bring it back into urban habitats, e.g. in the form of green roofs, climate trees or the retrieval of urban forests (University of Oxford, 2020). Since NBS are tailor-made to the respective framework conditions of the application areas, a multitude of social, ecological, and economic advantages can be generated both in their implementation and realization in the long term. As a result, more and more policy makers, urban planners, and further actors are showing a growing interest in integrating NBS into their urban development concepts (Frantzeskaki, 2019).

However, up to now NBS are still rare in many urban areas. To foster their uptake and e.g. the replication and upscale of NBS developed in the CLEVER Cities project, a market strategy is necessary. This strategy might help established and new firms to successfully promote and sell NBS. Yet, first an analysis of the current market situation for NBS is required as a basis for the development of a strategy. In this context, this report provides a market analysis on selected NBS applied in the frontrunner cities (FR), London, Hamburg, and Milan, of the CLEVER Cities project. Each NBS will be analysed on a national, regional or city level, depending on accessible information. Due to an unbalanced data availability the scope of the described NBS can vary. The described analytical level helps external city planners as well as companies, to understand market forces influencing the implementation of presented NBS in urban planning.

The market analysis follows the methodology of a “PESTEL” analysis. The PESTEL framework examines the macro-economic factors considering

- **P**olitical
- **E**conomic
- **S**ocial
- **T**echnological
- **E**nvironmental
- **L**egal

influences on the viewed market. This methodology is a common tool to support strategic decision makers looking for opportunities and risks in their business environment (Issa et al., 2010). The information needed

to implement the market analysis has been gathered by extensive desk research or was extracted from previous CLEVER Cities or partner project deliverables.

To provide a comprehensive insight into the market environment of the NBS, so-called "CLEVER Solutions" implemented within the framework of CLEVER Cities, the present report refers to three selected solutions: green roofs, vegetated noise barriers and urban gardening.

The structure of the market analysis is as follows: At the beginning of Chapter 3, the selected NBS of the FR are described in an introductory section. The following subchapters (3.1 to 3.6) deal with the respective analysis points of the PESTEL analysis. Accordingly, sub-chapter 3.1. refers to the political, 3.2. to the economic, 3.3. to the social, 3.4. to the technological, 3.5. to the environmental and 3.6. to the legal environment of the selected NBS. These chapters are followed by the development of market strategies for green roofs, vegetated noise barriers and urban gardening in the analysed cities. The market analysis is completed by a conclusion.

3. Market and competitive environment of chosen CLEVER Solutions

As described, this report provides insights into the market of green roofs, vegetated noise barriers and urban gardening. These NBS are implemented in the FR of the CLEVER Cities project. The following subchapters present a step-by-step PESTEL analysis of the selected CLEVER Solutions to outline the market and competitive environments. At first, the selected NBS are briefly described for a general topical introduction.

Within Europe, green roofs are a relatively common landscape tool for covering a building's flat roof partially or completely with vegetation. The growing interest in this NBS is inter alia reasoned by the fact that the building sector accounts for up to 40 percent of total energy consumption. Furthermore, buildings in European countries cause up to 36 percent of greenhouse emissions (Martinez-Molina et al., 2016). Green roofs can be an appropriate instrument to alleviate these problems by their various benefits (e.g. rainwater management or thermal regulations). As part of the CLEVER Cities project, Hamburg, Milan, and London implement and restructure green roofs on selected buildings to foster the urban development of the cities (CLEVER Cities, 2020a).

The market for vegetated noise barriers is difficult to define. It can be considered as a submarket of the noise barrier market. Vegetated noise barriers address the building sector in similar means as green roofs. Besides the great environmental impact of buildings, an increasing urbanization also reduces the general space which is available to bring nature into cities. To use the given space efficiently, the greening of (existing) walls and façades has become a promising strategy to integrate more vegetation into cities. The combination of typical urban structures with elements of nature usually provides multiple benefits while using minimal space. Therefore, this approach is also part of the CLEVER Cities project. In Hamburg, it is planned to green a large façade of a building as well as to add vegetation to an existing noise barrier (CLEVER Cities, 2020a). In Milano, a focus is laid on the promotion of green roofs and walls by an awareness-raising campaign. Moreover, the Tibaldi railway station is intended to be greened. Plans include a green wall as well as a noise barrier (CLEVER Cities, 2020a).

Besides the greening of buildings, sustainable cities often include urban gardening in their sustainable development plan to reintroduce the nature into urban space. Urban gardening involves mostly small-scale, open, shared gardening operations in urban areas. Overall, the focus is on sustainable cultivation of garden crops, environmentally friendly practices, and sensible consumption of agricultural products. Depending on the purpose, a variety of forms of urban gardening are practiced in the cities:

- Community, neighbourhood and district gardens, intercultural gardens
- Gardening in the road space, involving street landscaping or planting at the base of trees
- Cultivation of vacant lots, fallow land and city squares
- Projects in public gardens
- Crop gardens on the outskirts of the city (Urban Farming)
- Educational and environmental projects such as school gardens.

However, the “gardening in the city” theme often includes cultural, therapeutic, social, ecological, and political aspects (Fox-Kämper, 2018). All FR apply at least one kind of urban gardening in their CLEVER project implementation (CLEVER Cities, 2020a).

3.1. Political

The following chapter reveals the political environment for the chosen CLEVER Solutions in the FR Hamburg, London, and Milan. As mentioned before, green façades and urban gardening are often included into broader national policies and funding schemes, without being explicitly mentioned.

It can be stated that several strategies and policies by the European Commission aim to foster the applicability of NBS in Europe. As examples, the “Green Infrastructure and Ecosystem Services Strategy” (GIES) and the “Climate Change Adaptation” (CCA) can be highlighted with a particular focus on the greening of buildings. GIES aims to increase biodiversity in cities with a focus in the UK and Switzerland. In order to reach this goal, a wide range of NBS services for buildings is promoted by the European Federation of Green Roof and Wall Associations (EFB) to address issues related to water, air pollution and temperature control. The CCA in particular aims to address issues related to climate change by fostering the implementation of green roofs in urban environments. Further EU initiatives foster green roofing to lower the carbon load of buildings, especially in hot climates or extreme weather regions (EFB, 2018)[1].

In comparison to green roofs, the political environment for green noise barriers is still immature as the very specific topic seldomly finds its way onto policy agendas. Clearly, it is influenced by the political environment of both, noise protection in general and vertical greenery. The latter one however, is also often subsumed under general urban greening or the more prominent green roof discussions. Therefore, the GIES and CCA of the European Commission mentioned before, can be considered to have a positive influence for the application of green noise barriers as well. Nevertheless, the EFB considers the green roof and wall markets to be reliant on progressive policies at a regional or city scale which ensure their implementation on new developments (EFB, 2015). Up to now, only in a few cities there are schemes which (often amongst other measures like green roofs) support green walls or façades. However, these are never explicitly dedicated to green noise barriers as well and it is unclear if they would also be covered.

In regard to urban gardening, given its potentially long implementation timeframe of urban gardening, a continued political support within local government is of great interest. This support is needed to create sustainable urban gardening initiatives that last several years (World Health Organization, 2017). Fortunately, urban gardening is widely acknowledged and gains more attention by policy makers and scientists from global to local level. On European level, research funding through the European Framework Programmes and Horizon 2020 has supported the generation and spreading of knowledge and innovation for urban gardens with highly increasing budgets and recognizing and exploiting the functional diversity and capability for integrated system approaches to counter the alienation towards nature (Piorr et al., 2018). In

[1] Please refer to the CLEVER report “Multi-level policy framework for sustainable urban development and nature based solutions” for a more detailed description of policies and funding schemes.

contrast to well-developed policy schemes for green roofs, urban gardening is often based on citizen engagement. In all FR, different initiatives connect the growing interest in local food production between citizens and public or private landowner of vacant spaces. Despite these private incentives, public interest in using this NBS for integration, socialization and teaching is constantly growing.

As stated by Fox-Kämper (2018) urban gardens or allotment sites in the United Kingdom vary tremendously in size, ownership, management, and form. Primarily they are used for the provision of home-grown food and all the additional benefits to health and wellbeing that they can bring to the individual and the community. Many allotment sites are owned by local authorities, county, borough, city, town, and parish councils. If the site is owned by any of the above and has been specifically provided as allotments, they will then have legal statutory protection under the Allotment Acts. Some allotments are leased from private landowners and again do not have statutory protection. There are a few sites which are donated to the community by deed of covenant and are quite often under the management of the local authority (Fox-Kämper, 2018).

Hamburg

An analysis of the political market environment in Hamburg reveals that the recent elections for the parliament in the beginning of 2020 resulted in a greener coloured political landscape. Main topics of the last election campaign were transport, climate, and housing policies. Therefore, the increase in public support for green issues lead to positive tendencies affecting green roofing in the federal state (NDR, 2020).

This trend towards green and sustainable urban development has been reflected in the city's urban plans even before the last election. This is illustrated by the fact that Hamburg was the first German city to develop a Green Roof Strategy in 2014. The goal of this pilot-strategy was to plant 100 hectares of green roofs in the metropolitan area within the next years. To achieve this, the Hamburg Ministry of Environment, Energy, Climate and Agriculture has provided financial support of 3 million Euro in a first stage until the end of 2019 and prolonged the program until the end of 2024. In the course of this, building owners were able to receive subsidies to cover up to 60 percent of installation costs, capped at 100.000 Euro per installed green roof on existing or newly built residential and non-residential buildings (Hamburg, 2020; Climate ADAPT, 2020). Besides the described financial support schemes for green roofs, the environmental authority in Hamburg also lately introduced target founding for voluntary built green façades and living walls (Investitions- und Förderbank Hamburg, 2020; UBA HH, 2020)

In addition to creating financial incentives, the city of Hamburg also addresses their residents by knowledge sharing via communication and dialogue. The city-wide awareness campaign "On Your Roofs, Get Set, Green" uses posters, brochures, online marketing, and newspaper articles to share the benefits of green roofs. Another promotional activity is the greening of public buildings to present green roofs to the residents. Furthermore, a dialogue between authorities, local politicians, architects, engineers, and economists has been initiated (Climate ADAPT, 2020).

In addition to these regional policies, the German government has developed national subsidies and tax advantages to increase the attractiveness of green roofs. This mixture of federal and local laws addresses the issue of climate change with the support of targeted subsidies and higher tax rates on grey roofs (VanWoert et al., 2005; Dongfang, 2017).

London

In contrast to the public funding initiatives of the City of Hamburg, the Greater London Authority (GLA) has no government grants, funding, or other financial incentives for owners of domestic properties interested in setting up green roofs (Renewable Energy Hub, 2020).

Nonetheless, the GLA has met the challenges of increasing urban population and threats of climate change. In 2008, the GLA introduced the “London Plan”, introducing a spatial planning framework for the city as London’s response to climate change. The land-use planning process of the London Plan led to an increase of green roofs and became the primary application tool for this NBS (EFB, 2019; Renewable Energy Hub, 2020). It sets a strategic planning policy framework which influences the policy frameworks of the boroughs in London (Local Plans). Conclusively, the London Plan aims to promote urban greening and nature-based decision making in the city by claiming that large building developments are expected to incorporate green roofs when feasible. The London Plan is noted in Policy 5.10 as the city’s general sustainable urban planning framework. Its sub policy 5.11 has a special focus on green roofs, stating that large developments should be designed to include green roofs and walls where feasible to address the challenges of climate change, sustainable urban drainage, enhancement of biodiversity, accessible roof space, improvements of appearance and resilience as well as the possibility to grow food. Each of the 32 boroughs plus the City of London incorporate this policy in their local plans to address these challenges in sustainable urban development (EFB, 2019; Mayor of London, 2020).

To foster the green urban development in London, London has introduced the “London National Park City Plan” and became the first global National Park City in 2019. The aim of this plan is to create a healthier, greener, and wilder living environment in urban areas. Therefore, London citizens and urban planners are encouraged to green for instance grey concrete walls, balconies, or roofs. A consortium of more than 250 associations and institutions support this initiative with knowledge sharing and hands-on activities (National Geographic, 2019).

With regards to future policy development in London, a policy on urban greening which requires all new developments to include a greening element in order to improve biodiversity, rainwater run-off and air/noise pollutions and urban temperature regulation is planned to be integrated into the next Local Plan (Green Infrastructure Consultancy, 2018). It makes use of the so called “Urban Greening Factor” which assigns scores to green infrastructure elements to inform decisions about levels of greening (Green Infrastructure Consultancy, 2018). This tool also includes a score for green wall-modular systems or climbers rooted in soil (Landscape Institute, 2019). Hence, it can be expected that awareness and demand for vegetated walls in general will rise in the nearby future. This might also benefit the green noise barrier market.

Milan

Due to its geographical location at the foot of the Alps, the city of Milan suffers from climate challenges such as low winds and higher temperatures than surrounding municipalities. To address issues related to climate change and rise in urbanisation, the city also introduced sustainable green development strategies (Forbes, 2019).

There are several green building incentives already implemented in Italy, e.g. for energy saving measures, however none of these directly addresses green walls or façades. For the year 2020 a so called “façade bonus” which aims to restore external facades of buildings was introduced (idealista, 2020). It works in form of a tax deduction and only applies for specific zones of cities. “Façade decorations” are covered, yet it is unclear if also the vegetation of façades is supported. Anyhow, noise barriers seem to be excluded as the policy is only restricted to existing building façades.

As one of green building initiatives of the city, the “Carta of Milan” can be named. This strategy highlights the importance of green urban infrastructures as a minor tool to meet environmental targets. It is a result of the 2015 Milan Expo representing the work of 5.000 people for a protection of biodiversity or environmental and nutritional education. Therefore, the strategy applies green infrastructure actions to foster ecological connections and the creation of ecosystems in the region (Ministero delle politiche Agricole alimentary e forestali, 2020; Oppla, 2020).

The “Ecologica Regionale Plan” for the Lombardy region encourages inter alia the implementation of green roofs in the region to address climate change issues by introducing nature back into the urban context. This strategy is supported by the “New Territorial Governance Plan – Milan 2030” which has been passed in October 2019. The aim of this plan is to lower the cities ecological footprint by introducing new regulations for the construction of new buildings. According to this policy, all new buildings from 2020 onwards need to be carbon neutral. Therefore, the construction of green roofs on new buildings is encouraged to integrate greenery into urban intervention and to meet the climate goals (Comune di Milano, 2020; Regione Lombardia, 2010).

Furthermore, the implementation of sustainable urban structures in Milan benefits from incentives such as the “Green Bonus” which has been promoted by the Gentiloni government in 2018. The relaunch of this financial aid enabled 24 million Euro funding for residents who are interested in implementing green roofs. The support is staggered according to the type of intervention and covers between 2 and 53 percent of the costs incurred (Comune di Milano, 2019a; Comune di Milano, 2019b).

To specifically promote urban gardening, Milan introduced the “Milan Urban Food Policy Pact” with the aim of developing sustainable food systems that are inclusive, resilient, safe and diverse, and that provide healthy and affordable food to all people (Glavan et al., 2018). Additionally, the Lorenteggio Regeneration Programme includes different interventions concerning public housing, mobility, green spaces and public services. The investment for this program amounts about €100 million. In particular, the construction’s costs of G129 are partly covered by the Municipality of Milan (Glavan et al., 2018).

3.2. Economic

The following subchapter analyses different factors influencing the economic and competitive environment of the NBS. To give a holistic impression, general market forces will be presented followed by regional particularities in Milan, London, and Hamburg.

Despite the growing interest in NBS, private incentives are still rather low for the implementation of these systems. Due to the characteristics of the NBS, economic benefits are often only visible after a longer period of time (Besir & Cuce, 2018). Therefore, they face difficulties in capturing value. Even though, financial benefits e.g. via energy savings of green roofs are recognized, the long-term calculation of financial values is hindered. This difficulty is reasoned by the absence of an accounting framework for assessing social and ecological non-monetary benefits (Besir & Cuce, 2018; CLEVER Cities, 2018, EFB, 2015).

Another financial market barrier is created by the fact that the construction of green roofs and noise barriers is associated with higher initial installation costs compared to grey alternatives. These costs are reasoned by the fact that they are individual solutions that need to be designed for each building. Ongoing maintenance costs (at least two visits per year) also need to be considered, which restricts the market growth (Feng & Hewage, 2018; Landscape Development and Landscaping Research Society, 2018; Shafique et al., 2018).

As described, vegetated noise barriers and green roofs offer multiple additional benefits compared to grey ones and might also mitigate the aesthetic burden which comes along with such large structures. A contemporary problem, however, is that these benefits are usually not easily perceived in economic terms. Yet, higher costs for materials, installation and maintenance are obvious. Therefore, the willingness to pay for vegetated solutions remains low and grey noise barriers and roofs often prevail. However, rising incomes and living standards might foster market growth for NBS in the future as the appreciation of the environment and the awareness of harm due to its destruction might grow with economic prosperity.

Despite this, the multifunctional character of the described CLEVER Solutions offers great potential for additional handicraft and high skilled jobs such as gardeners, landscapers, or architects. Depending on the types and sizes of green roofs, noise barriers or urban gardens, a combination of different human resources is needed. A potential shortage of such skilled workers could impede market growth. Yet, these solutions offer great opportunities for cooperation activities between a variety of stakeholders such as knowledge sharing between research and development facilities, consulting activities as well as education and training or network activities (EFB, 2015, Piorr et al., 2018).

Considering the regional market environments for the selected CLEVER Solutions, it became apparent, that green roofs are the only NBS with available detailed market data. As stated by Grand View Research (2020), the global green roof market size is expected to grow by 17 percent until 2027. Currently, Europe is the leading market for green roofs, with a constantly rising interest in alternatives to grey roofs due to political incentives. Additionally, Europe is the market leader in green roofs technology addressing the emerging market with the development of new products and services to meet the needs of a growing global market (EFB, 2015).

One economic advantage of green roofs is that buildings equipped with a green roof benefit by the expanded life span of their roof. Green roofs can last up to 40 and 55 years, depending on the selection of the plant layer (compared to a life span of about 20 years of grey flat roofs). This longevity of green roofs is reasoned by greenery in the form of a vegetation layer which protects the roof surface from direct weather influences, UV radiation and temperature fluctuations on the roof surface (Freie und Hansestadt Hamburg, n.d.). Hence, the roof's layer system is an important variable influencing the success of this NBS which is highly dependent on the plant's health. Therefore, it is valuable to select the plants by geographic location, rainfall intensity or humidity as well as sun and wind exposure and the soil depth. If a roof is successfully greened, energy savings regarding heating and cooling costs can be reached. Additionally, potential rainwater drainage fees can be reduced, since plants use parts of the rainwater (Besir & Cuce, 2018; Shafique et al., 2018; Free and Hanseatic City of Hamburg, 2017).

The design of green roofs and the used materials are similar among different manufacturers. Nonetheless, each manufacturer developed its own processes to implement green roofs, which leads to competition between the market actors. These processes are highly sensitive and mostly kept confidential to achieve competitive advantages in the markets. Therefore, specific information on the mixture of substances, internal production, and installation processes as well as technical information of different green roof systems are not publicly available and lead to pricing differences between the suppliers (Bianchini & Hewage, 2012).

Competing solutions of commercial green roofs to address climate change include brown roofs, cool roofs, or a combination of green and cool roofs with solar installations. Brown roofs are essentially almost the same system as green roofs but based on recycled building materials such as soil or spoil from the site. Brown roofs are often left natural and therefore do not require a high level of maintenance. Cool roofs are often implemented on historic buildings with flat roofs or on roofs that are too steep for plant material. This system features roofing material with a high reflectance to reflect heat. At last, green roofs can also be installed in combination with cool roofs and solar installations. This combination can foster the efficiency of solar panels, since green roofs cool their surroundings, while solar panels operate less efficiently in extreme temperatures. Furthermore, panels can protect roof vegetation by offering shelter from wind or intensive heat (National Park Service, 2020). This great variety of green roof options illustrates how flexible this NBS can be adapted and applied to different conditions.

Green noise barriers can only be considered as a substitute for grey ones in a narrow sense, meaning only if noise protection is considered. A significant distinction is whether the basis of the "green" barrier consists of natural materials, like e.g. earth mounds or wooden structures, or of grey structures like concrete, brick, or glass etc. Hence, the question evolves whether traditional grey noise barriers which are combined with vegetation (subsequently) can be considered as a green noise barrier or only the ones which are completely based on natural materials. Since most benefits of vegetated noise barriers also apply to vegetated grey structures, this market analysis focuses both kinds of these solutions. The possibility to combine (existing) grey structures with vegetation might at least partly lead to complementary market growth instead of competition between traditional noise barrier suppliers and green ones. Also, many firms might provide both options at the same time. In any case, adding vegetation to noise barriers also offer chances for cross-industry cooperation e.g. with local plant cultivation businesses.

Like green roofs, the market for noise barriers in general grew considerably in Europe in recent years (GMI, 2020). Globally, the market is expected to grow further due common trends (e.g. MarketWatch, 2020). As more and more people live in cities, the need for effective land use rises and people, industries and traffic move closer together. Hence, the need to protect residents from noise due to traffic, industries or other activities will increase. Rising incomes and living standards (in developing countries) might also lead to a higher willingness to tackle problems like noise exposure. As lots of noise barriers are commissioned by the state, general economic growth, and the size of e.g. transport or other construction budgets might play a significant role for demand and market growth. In times of general economic crises budgets dedicated to public infrastructure and to noise protection might shrink as such measures might often not considered to be necessary. All in all, it is uncertain how much of the expected general market growth will be attained in detail by vegetated noise barriers and green roofs.

The market environment of urban gardening is rather different from the previously described NBS. The urban garden is considered as an innovative space of agriculture. Urban gardening is often driven by consumer concerns towards industrial food systems which are often associated with anonymous, low-quality products or environmentally harmful production processes. Due to this trend, the demand for local food which is produced nearby and has short supply chains is growing. This trend opens new economic perspectives that are considered for urban food strategies and new relationships between food producers, retailers, and consumers. Additionally, the growing interest stimulates innovations in terms of urban production methods via cross-sectoral cooperation (Piorr et al., 2018; Sonnino, 2009).

Hamburg

In the assessment of the market potential for green roofs in Europe, it became apparent that most literature on green roofs is available for Germany. This indicates that the German market is the one of the most mature and therefore has the most data available. In 2015, 86 million square meters of German roofs have been greened. Thus, more than ten percent of German buildings feature green roofs. Furthermore, German companies have been leading the market, followed by Dutch market players (Shafique et al., 2018; EFB, 2015). Besides big market players, local construction companies also show expertise in implementing the CLEVER Solutions such as varieties of green or brown roofs, vegetated noise barriers and urban gardens. Since these companies cannot be assigned to a specific industry or carry out the preparation of the NBS as an ancillary activity, there is a lack of applicable data for market analysis.

This well-established German market is to some extend reasoned by the comprehensive federal strategies in Germany, especially in Hamburg. The city introduced the “Green Roof Strategy” in 2014 based on four pillars: financial incentives, dialogue, regulation and science. Since 2014, 30 hectares of green roofs have been implemented reaching a total of 154 hectare in the Hamburg are. This number splits into 39 percent of implemented green roofs on housing, 35 percent on industry and business buildings and 25 percent other surfaces. Not accounted for in the 154 hectare are large areas such as 2.000 underground parking lots with intensive green roofs as well as the 1,85 hectare of a motorway lid under construction (Climate ADAPT, 2020; Free and Hanseatic City of Hamburg, 2017). This programme lasted in its first stage to 2019 and was now prolonged in a second stage until 2025 and extended by façade greening.

Additionally, Hamburg plans to implement these incentives after the “Green Roof Strategy” has expired. As Hamburg is constantly experiencing a growing number of residents, constant infrastructure projects are implemented to generate residential and commercial buildings. These new residential constructions were estimated to add 44 hectare of green roof potentials, together with estimated 66 hectares for new business constructions. Hamburg aims to use 20 percent of this new created surface for greening activities (Climate ADAPT, 2020).

Despite these positive insights to the green roof market in Hamburg, the challenge of high installation costs becomes apparent when analysing the regional market. This is illustrated by the fact that up-front installation costs for green roofs have been three times higher than a grey alternative in 2017, representing an average of 1.5 percent of a building’s overall construction costs for one- to two-storey buildings. However, the costs equalize over a 40-year period. By including the available subsidies, a green roof is in Hamburg even cheaper in the long run (European Federation Green roofs and Walls, 2015; Dongfang, 2017; Free and Hanseatic City of Hamburg, 2017).

The consideration of the development of urban gardens revealed that these are particularly popular in Hamburg. Hamburg has a long tradition of so called “Kleingärten” which are private allotment gardens for people of all ages and social backgrounds to use them as a nature-geta-away to spend time in the nature, socializing and growing their own food. Urban allotments are currently experiencing a renaissance offering a desirable private space outdoors - something greatly coveted in urban Hamburg. Currently there are more than 33,000 allotment garden lots scattered across the city of Hamburg. Together they cover an area of more than 14 million square meters (Freie und Hansestadt Hamburg, 2016). The initiative of developing Kleingärten is expended to other urban environments such as retirement homes, public places in neighborhoods or schools.

London

Even though London does not offer direct financial funding or subsidies, the city is known as a leader in urban greening in the United Kingdom with regard to policy, planning and the general number of installed green roofs (40 percent of all green roofs in the United Kingdom are in London) (EFB, 2019; Renewable Energy Hub, 2020).

The potential of green roofs in London’s urban planning is displayed by the fact that between 20 and 25 percent of all urban surface areas are roofs. As estimated by the EFB, around 30 percent of these roofs have the potential to feature green roof systems. By identifying the additional potential of greening existing roofs as well as new establishments, the market has highly expanded in London. As of 2019, more than 40 percent of the total green roof market in the United Kingdom was in London (EFB, 2015; EFB, 2019; Raji et al. 2015; Besir & Cuce, 2018).

Milan

Since Milan is exposed to extreme temperatures in summer, green roofs in the city can reduce the temperature of the roof by up to 50 percent (Comune di Milano, 2019a). Green roofs therefore offer a

suitable alternative to conventional roofs to help the city prepare for climate change. During the last years, many public buildings have been upgraded with green roofs such as kindergartens, sport facilities, hospitals, or schools. In addition, more and more office buildings and private homes are being greened because of the “Green Bonus” (Comune di Milano, 2019a; Comune di Milano, 2019b).

As of 2019, 97 hectares of Milan’s roofs featured green roofs. Like Hamburg (with its ambitious goal), Milan aims to increase the amount of greened roof surface to 130 hectares within the next years. To achieve this goal, the city of Milan initiates cooperation on a broader regional level to foster the implementation of green roofs in the Lombardy region (Comune di Milano, 2019a).

Like Hamburg, Milan has a strong history in urban gardening. Since the early 20th century Milan has developed home gardens due to a self-sufficiency policy. This home growing habit lasts until today, which is shown by recent spatial analysis which revealed that the size of gardens in Milan has constantly increased since the 1960s. Furthermore, Milan recognized the fact that the demand for regional “km 0” food is increasing which favours the establishment of urban gardening (Europarc Federation, 2020; Glavan et al., 2018).

3.3. Social

Besides political and economic factors, a market is also characterized by its specific social environment and its influence on market actors. The following subchapter reveals selected social impacts on green roofs, vegetated noise barriers and urban gardening.

First, it needs to be mentioned that the implementation of green roofs faces general, non-place related obstacles. Such limitations are posed by e.g. cultural habits or possible cooperation obstacles and tend to increase by the number of stakeholders involved. A lack of management in the cooperation activities of residents, architects, owners, or environmental engineers can hinder the construction of the green roof system. Furthermore, the functionality of the roof may even decrease and damages to the building may arise if the responsibilities are not clearly defined. The perception of green roof benefits by the named stakeholders can change in means of time, context, and social perception (EFB, 2015; CLEVER Cities, 2018; Dongfang, 2017; Walters & Midden, 2018; Shafique et al., 2018).

A main benefit which the vertical greenery offers compared to many grey structures is the aesthetical value. In particular massive grey structures like noise barriers often adversely affect the urban landscape if they are not designed carefully. As vegetation is often rare in urban areas, but is usually considered to have pleasant appearance, vegetated walls might hence provide significant aesthetic value (see Radic et al., 2015 for an overview). Compared to green roofs, their vegetation can usually easily be seen by people passing by. In the literature, aesthetic values of vegetation are assigned to cultural ecosystem services (MEA, 2005). Generally, a rising public awareness for climate change and the multiple environmental benefits of NBS will presumably add to the demand for green noise barriers. Also, a rising appreciation of cultural ecosystem services is observed. In industrialized countries, the demand for cultural ecosystem services is expected to rise due to e.g. higher budget shares for recreation (Milcu et al., 2013; Carpenter et

al., 2009; Vandewalle et al., 2008). Hence, demand-driven market growth due to social influences can be expected.

If green roofs, vegetated noise barriers and urban gardening are successfully implemented, they actively support urban areas in bringing the residents closer to nature. This strengthens the awareness of residents for nature and food production and can foster social cohesion by realizing joined neighbourhood projects. Furthermore, green roofs inter alia support urban areas in their resilience towards emerging societal and environmental trends by increasing resident's well-being and longevity of rooms while creating habitats supporting biodiversity. Since many city initiatives aim to foster their residents sense for nature and healthy living, the NBS offer great potential to reach these goals (Barron, 2006; Walters & Stoelzle Midden, 2018; Niachou et al., 2001; Liu et al., 2020; VanWoert et al., 2005).

Urban gardens, as urban spaces bring people into close contact with nature in an otherwise built environment, combating the ratcheting-down effect by encouraging interactions and knowledge of nature. Although the primary purpose of urban gardening may be food production, they also represent areas of social and recreational value as well as environmental education and knowledge sharing (Lin et al., 2018). Indeed, aside from the improvements in food security, urban gardens are a powerful means to establish contacts and overcome loneliness, as well as to increase knowledge, skills, and positive attitudes towards nature and environment (Ochoa et al., 2019). All in all, next to offering personal well-being, active recreation, and social cohesion benefits through the performance of gardening activities, urban gardening also provides activities involving the cultivation of vegetables and fruits providing access to healthy food (World Health Organisation, 2017).

In addition, recent research from other European cities reports that rather than just places of food production, urban gardens are also multifunctional spaces for social interaction, leisure and recreation, which cannot be compensated with harvested production or economic income, and without which the gardeners would perhaps not even participate. Urban gardening is recognised as being one of the important pillars for sustainable social development in the cities and contributing to social cohesion by constructing alternative networks that impact social growth and the common good (Glavan et al., 2018). Besides this, urban gardening, and particularly community activities, can also encourage lifelong learning among adults, especially low-skilled unemployed or jobless individuals, who risk being marginalized by society. According to the Lisbon Strategy (Ochoa et al., 2019), education and training are critical factors for increasing the economic growth, competitiveness, and social inclusion of Europe (Glavan et al., 2018).

As more and more people with diverse backgrounds will live closer together in the future, increasing pressure for integration occurs. This might lead to more appreciation for activities like urban gardening and benefit the demand for urban gardening facilities. On the downside, a recent study from Berlin and Barcelona reports acceptance problems for urban gardening. Due to anticipated low quality of the products and potential health risks associated with urban contamination, but also the gentrification potential and competition technical innovations such as limited use of greenhouses or better composting of urban household wastes (Piorr et al., 2018). This indicates that societal acceptance for urban gardening in general is high, but a certain preference for traditional small-holder systems, whereas technology driven urban, zero-acreage solutions are seen critical.

3.4. Technological

The following subchapter introduces technological influences on the market and competitive environment of the chosen CLEVER Solutions.

First, it needs to be mentioned that the implementation of green roofs faces general, non-place related obstacles. Such limitations are amongst other issues related to installation and maintenance costs or roof weight limitations. The low number of high-quality, lightweight systems suitable to different climates and ecosystems underline this issue (EFB, 2015; Dongfang, 2017; Walters & Midden, 2018).

From a technical perspective, green roofs can amongst other things be separated by their weight, substrate layer or level of maintenance into intensive, simple intensive and extensive systems. Intensive greening features plants that need a high demand on the layer structure, and regular water and nutrient supply. Greening may include trees, lawns, or perennials. Due to the high requirements, intensive green roofs are comparable to ground-based parks in usage or design diversity (Landscape Development and Landscaping Research Society e.V., 2018; VanWoert, 2005).

Simple intensive green roofs are characterised by lower production costs compared to the previously mentioned technology. This is due to a limited variety of design and less demand of layer structure. Design and usage of this technology include shrubs, grasses, or perennials. Therefore, the usage of simple intensive roofs is limited compared to intensive green roofs, but production costs and maintenance efforts are lower (Landscape Development and Landscaping Research Society e.V., 2018).

At last, extensive green roofs are to be mentioned. This system is more prevalent because it consists of largely self-sustaining vegetation with regeneration capacity and lower maintenance and production effort. To keep costs and maintenance at low level, regional plants are used which can adapt to extreme weather conditions and have high regeneration capacities such as mosses, herbs, or grasses (Besir & Cuce, 2018; Landscape Development and Landscaping Research Society e.V., 2018).

With regard to the complexity of this NBS, the application of green roofs faces some technological difficulties such as a need to develop more efficient local substrates to reduce water as well as the design of a more environment-friendly alternative to the polymer applied in green roof layers. Furthermore, a greater effort in cooperation of different fields for the application and management of green roofs is highlighted as well as life-cycle analysis to market the benefits of green roofs (Shafique et al., 2018). Despite these difficulties, the latest technological innovations in the market already enabled the application of low-density polymers with reduced weight for green roofs. With regard to research in this field, it needs to be mentioned that German companies have been technological leaders for a long period of time. Within the past years, new countries enter the market with innovative products and processes and European companies need to recognize their contribution to the market to not fall behind. Also, a lack of global innovation towards the production of high-quality lightweight roof systems thwarts the market growth of this NBS (Bianchini & Hewage, 2012; EFB, 2015).

Generally, vertical greenery can exhibit several forms with technical differences. Green façades are façades which are covered by plants which are attached to the soil and just grow up to along the façade. In case of a living or green wall, plants are usually pre-planted and attached to structural elements on the wall without a connection to the soil. Even though several standardized construction elements might exist, most projects

need to be adapted to the surroundings and the context (EFB, 2015). Depending on their design, noise barriers vary in requirements regarding space and technical prerequisite like ground stability. In general, vegetated noise barriers need more space than non-vegetated noise barriers. Also, they usually need some kind of (natural) water supply and light. If located close to large streets, the selection of suitable plants is crucial. Also, they need to be resistant to salts and exhaust gases if they are used alongside roads.

In contrast to the well-developed green roofs, the vegetated noise barrier market faces some technological hurdles. For the noise barrier market in general, a lack of effective technological development is a major challenge for industry growth (GMI, 2020). High cost as well as space requirements and aesthetic concerns combined with a lack of awareness regarding product benefits lead to the problem that consumer might often perceive noise barriers as luxurious products rather than a necessity. Hence, technological developments which lead to cost reductions are important for market growth. As described above, green noise barriers with vegetation can provide multiple additional benefits over traditional noise barriers and can hence increase acceptance of and demand for noise barriers.

In case of vegetated noise barriers, two types of vertical greenery can be chosen according to their purpose and the conditions (see UNaLab, 2019 for an overview). Living or green walls consist of plants which are usually pre-planted and attached to structural elements on the wall without a connection to the soil. For this reason, living walls usually require irrigation systems and come along with higher maintenance costs (Besir & Cuce, 2018). Recently, also noise barriers, which are constructed wholly from recycled materials evolved (CEDR, 2017). In all cases, it is important that structures offer support for the vegetation attached.

Regarding green walls in general, the European Green Roof & Wall Association considers the lack of innovation, in lightweight systems, a crucial barrier (EFB, 2015). Cost as well as performance regarding to environmental criteria can still be improved for vertical greenery in general as well as for green noise barriers. Up to now, there are only few companies which focus on wholly green noise barriers consisting of natural materials. For larger projects like noise barriers for roads, normal grey structures are combined with soil-based vegetation in most cases. In general, there still seems to be significant potential for innovation regarding the design of green noise barriers and used materials, like e.g. using recycled or natural materials and finding most effective, resistant, and maintainable plants for specific contexts. Also, further design options regarding aesthetic considerations could lead to increased application. A reduction of production and installation as well as maintenance costs could lead to an increased demand for green noise barriers as many people might still choose grey structures over green ones because they fear higher costs. In any case, it is important for companies offering green noise barriers to keep up with ongoing innovations in the grey noise barrier market as more (cost) effective grey structures might be a threat to green ones. Also, it might still be promising to combine grey innovative structures with vegetation, even subsequently, to at least enable benefits from vegetation with (existing) traditional noise barriers.

The availability of high-tech urban gardening systems is not commonly widespread. From a social perspective, modern cultivation technology often struggles with consumer acceptance. Many consumers have a romanticized image of agriculture being low-tech and traditional and thus, often reject modern methods such as hydroponics, aquaponics or aeroponics. These technologies offer new ways to grow food in urban places. Hydroponics offer the possibility to grow plants without soil by using a nutrient-rich liquid. The aquaponics technology makes use of fish, who create ammonia-rich waste which can be turned into

nitrates to fertilize plant beds. The system has a circular function to create pleasant habitats for both, plants and fish. Last, aeroponics have initially been invented by the NASA to potentially raise crops in space and uses nutrient-rich mist (Technology, 2020).

When considering the technological influences on urban gardening, it can be highlighted that the potential synergies of combining farming and buildings are also not fully unlocked, yet. Existing buildings are often not suitable for retrofitting them with technology necessary to create energy loops and to close material cycles. Investment costs for setting up new buildings designed for farming activities are even higher. Overall, it is necessary that architects, engineers, and farm designers come together to jointly expand and refine necessary technology (Piorr et al., 2018).

3.5. Environmental

As briefly mentioned in the previous subchapters, the installation of CLEVER Solutions offers a variety of environmental benefits, which help cities to enhance their climate change resilience. The following chapter aims to sketch positive as well as challenging environmental influences on the market environment.

Green roofs tackle climate threats by several positive impacts to biodiversity and urban climate. One benefit to be named is the thermal regulation feature of green roofs. Due to the layers of green roofs and the well-chosen vegetation, which can survive in the regional climate, green roofs have a great impact on roof isolation. During the summer, the surface temperature of green roofs can be up to 12 degrees Celsius lower than for conventional roofs. In cold months, the difference is found to be up to 4 degrees Celsius. Reasoned by this, green roofs consume between 2 and 16 percent less energy during the summer (Arkar et al., 2015; Coma et al., 2016; Besir & Cucue, 2018).

Furthermore, green roofs can mitigate impacts of additional extreme weather events. On the one hand, they help to slow down winds in urban districts. As highlighted by Arkar et al. (2015), the plants can slow down the wind speed by up to 0.43 meter per second compared to absent vegetation. On the other hand, green roofs can support the management of heavy rain events since the vegetation and substrate layers can retain between 40 and 90 percent of the rainwater. Also, the vegetation captures fine dust from the air. Hence, green roofs are a suitable tool to increase the comfort in cities by decreasing air pollution. Apart from this, green roofs also address noise pollution. The green roof vegetation can absorb sound waves and therefore reduce sound levels in urban districts. Finally, green roof systems enhance urban biodiversity by creating living spaces for pollinators and insects (Arkar et al., 2015; Climate ADAPT, 2020; Shafique et al., 2018; Lundholm, 2006). Nonetheless, as mentioned before, it needs to be highlighted that all benefits of green roofs heavily depend on the roof vegetation, roof depth, used substrates and prevailing climate conditions (Arkar et al., 2015; Shafique et al., 2018).

Benefits of vertical greening in general strongly depend on the specific design of the wall and the choice of plants. Green noise barriers or façades usually perform very well with regards to the primary purpose of

these (grey) structures if they are designed properly. The layer of plants often helps to insulate against heat or cold (e.g. Besir & Cuce, 2018). The temperature reduction effects might occur for both, the area around the building, mitigating the urban heat island effect, and the inside of the building (EFB, 2019). Hence, vertical greenery can lead to energy and cost savings for residents. As well as green roofs, vegetated surfaces also do not reflect noise strongly and have high noise absorption properties (Radic et al., 2019).

Moreover, vertical greenery provides additional benefits as it offers a habitat for insects and birds, contributing to urban biodiversity, filters dust and binds carbon dioxide and other pollutants (Elgizawy, 2016; Marchi et al. 2015; see e.g. Radic et al., 2019 for an overview). Due to increasing economic activity and urbanisation, the environment in and around urban areas suffers progressively. This also leads to rising threats for human health e.g. due to depleted air quality. Globally, climate change can be considered one of the main environmental threats of the future. As vegetated noise barriers and façades can help to mitigate the impact of both in urban surroundings, it can be expected that further environmental stress increases the demand for vegetated noise barriers.

Besides the earlier stated social benefits, urban gardening also addresses climate change since the plants decrease air pollution and improve the local microclimate. Furthermore, urban gardening offers habitat for insects and pollinators, hence it increases the biodiversity of cities (Lin et al., 2018). Also, urban gardening is associated with improvement in personal environmental behaviours and overall environmental awareness. Urban gardening practices relate strongly with behavioural transformation, including positive outcomes in environmental practices such as recycling and trying to persuade friends or family to recycle, compost leftovers or choose to walk/bike to save petrol (Nova et al., 2020). Indeed, the type of urban agriculture has an important pedagogical role in enabling the urban population to make contact with the basis of its survival influencing its practitioners to a greater importance of preserving the environment like carrying out practices more environmental friendly (Nova et al., 2020).

Due to an expected rise of extreme weather events caused by climate change, the mentioned measures might experience an increase in demand. However, the CLEVER Solutions also face the threat of climate change. Scientist highlight a high chance of a shift in the rainfall distribution throughout the year, as well as rising temperatures and longer heat periods and an increase in extreme weather conditions (CLIMATE ADAPT, 2020). These can potentially harm the vegetation involved in all solutions or might lead to higher irrigation efforts and costs which makes the solutions less desirable.

3.6. Legal

The review of the legal framework conditions for the chosen CLEVER Solutions in Germany, Italy and the United Kingdom revealed, that certain legal standards need to be met for a successful implementation.

The consideration of the legal framework in Germany reveals that in general, green roofs do not require an additional planning permission here. Nonetheless, national or state laws need to be examined when entering the market. For example, it is possible that regional heritage protection and environmental laws may restrict the greening of buildings and limit the number of potentially implemented green roofs or façades in urban regions. Furthermore, construction planning laws define minimum standards that need to be considered in the planning of this NBS (Climate ADAPT, 2020; CLEVER Cities, 2018; Landscape Development and Landscaping Research Society e.V., 2018).

Besides concrete legal framework conditions to protect buildings, the construction of green roofs highly follows implementation guidelines introduced by the Landscape Development and Landscaping Research Society. These guidelines minimize fire hazards, damage to buildings, and foster the vegetation and biodiversity of green roofs in Europe since many countries lack of such detailed guidelines. As pointed out by the GLA, the United Kingdom lacks such legal framework conditions. Many British and Italian suppliers follow the standards used in Germany (Greater London Authority, 2008; Landscape Development and Landscaping Research Society e.V.; 2018).

In many countries, noise protection laws exist which enforce noise protection measures for e.g. roads, rails, loud industries or other noisy places like recreation areas or schools. In the EU, the Environmental Noise Directive aims to prevent and reduce environmental noise (Environmental Noise Directive (2002/49/EC)). Next to actions like operating restrictions, the usage of noise barriers is very common. Hence, legal requirements lead to a stable demand for noise barriers in general. Due to the proceeding urbanization and the accompanying increase of population densities and space shortage, a rise in need for noise barriers can be expected in the future. However, there are usually no requirements to employ any form of green noise barriers.

In general, for the construction of green noise barriers the same legal requirements apply as for traditional noise barriers. They need to be safe and should not impede residents or neighbours. For green walls and façades usually local laws and/or directives apply which address issues like e.g. stability, overhanging vegetation, fire risks or poisonous plants. Such legal requirements often seem to be a barrier for implementing vegetation. However, they are essential for security and hence long-term acceptance. A good communication of these requirements and well-informed suppliers can prevent potential reluctance due to legal requirements.

An introduction of legal requirements for greening (specific types/sizes of) noise barriers would be beneficial for the green noise barrier market as a certain demand would be ensured. From an economic point of view this requirement might be justified by the fact that the benefits of green noise barriers are usually underestimated, and public welfare gains or losses are usually not considered in private decisions. Furthermore, an EU-wide or international standardisation of legal requirements could make it easier for companies to access foreign markets.

Unlike unregulated private gardens, urban gardens on public land are regulated by the city authorities from an environmental and economic point of view (e.g. organic management type, organic fertilizers and plant-protection products use, type of crops - only vegetable, no trees, and non-profit production). Local authorities are mainly interested in regulating the terms of use and clarifying responsibilities, rights, and obligations. Therefore they often sign contracts and agreements with community gardening associations or individual gardeners, such as leasing contracts, contracts for maintenance or formal sponsorships; or, in those countries where this is allowed, such as Germany, informal permissions to use public spaces can be also granted (Glavan et al., 2018; Keshavarz et al., 2016).

4. Market Strategy

The following chapter summarizes the previous findings and develops blueprints for the risks, opportunities, and challenges of the CLEVER Solution markets.

In general, it can be derived that the overall political environment in the FR is offering a variety of enabling policies and support programmes to foster NBS in their cities. A rising awareness of climate change leads to a growing interest of cities to find effective solutions to increase city resilience by reintroducing nature into urban environments. As the analysis of the political market environment has shown, the need for nature-based solutions in response to climate change has been known for several years and has become more prominent, especially in the last decade.

4.1. Green roofs

The green roof markets in the FR face several positive and negative external influences. On the one hand, the political environment offers great market entry opportunities. Political decision makers recognized the positive impact of green roofs and created founding schemes and awareness rising campaigns to support this NBS. Also, the trend in sustainable urban development offers great entry possibilities and contributes to a growing demand for green roofs in Europe. Furthermore, the political schemes address a major challenge of green roofs: the difficulty in capturing short-term economic value. If political incentives are lacking, there is a great risk of underestimation of the environmental, social, and long-term economic benefits of this CLEVER Solution. Additionally, the higher implementation and maintenance costs are a challenge for the market entry of green roofs. Under consideration of long-term benefits, it again comes to attention that green roofs have a great market potential due to increasing climate change and its impact on cities.

The fact that the global green roof market is expected to grow by more than 15 percent in the next seven years as well as increasing areas with green roofs in the FR underline the opportunities of this NBS. In addition, a rising number of citizens has a growing awareness of the consequences of climate change and loss of biodiversity. Consequently, the public interest in sustainable, resistant alternatives to original building methods of urban development is increasing. As scientists highlight an increase in extreme weather events such as heat periods or heavy rainfall events, the environmental benefits of greened roofs offer additional market potential to increase a city’s resilience towards these events.

On negative side effect of green roofs is the use of polymer elements. As the society more and more aims to prevent plastic, innovation incentives to develop an alternative, more environmentally friendly raw material are set. Increasing research interest, as well as ecologic alternatives to the usage of polymers offer room for green roofs to grow in perception. Since green roofs are made in a highly individualized way for each building, there are a variety of construction methods. These vary both in the types of green roofs and in the materials used, implementation processes and maintenance, which fosters to a strong competition that is currently dominated by German companies. Constant technological innovations have fostered the market opportunities of green roofs in the past years, but until now, there is still a low number

of high-quality, lightweight systems available that can be replicated to different climates and ecosystems, which dampens the market growth while opening opportunities for entrepreneurial market entry. In addition, the implementation and management of green roofs can be complicated due to obstacles such as cooperation obstacles of the affected stakeholders. If the stakeholders' interest is not managed in an appropriate matter, the functionality of the roof may be in danger.

4.2. Vegetated noise barriers

As major challenges for the replication of vegetated noise barriers, the lack of a clear market definition as well as the absence of clear political support schemes can be named. Reasoned by this, the market, and the political influence are still immature and offer space for improvements. An expanded introduction of targeted support and awareness rising schemes could be a suitable tool to further increase the awareness of citizens, building owners and construction firms. Also, long-term economic, environmental, and societal benefits often remain unrecognized. This poses a risk for market growth since urban planners and developers consider the high costs of vegetated noise barriers compared to grey solutions as one-time expenditures and may tend to neglect the prohibitive long-term cost saving of this NBS.

Despite the missing of a clear market, a continuous demand increase for green noise barriers in Europe can be detected. This is partly reasoned by a growing social interest in green urban development and an increasing urban population, leading to less space for green areas. Since vegetated noise barriers represent a submarket of noise barriers, the competition in this NBS-market is narrowed down to grey and green solutions. Currently, the market is dominated by few companies that focus on green noise barriers. A major advantage of green noise barriers is the positive aesthetical effect which is highly valued by citizens. As vegetation is easily seen, the benefit is recognized easily and reconnects residents and nature. Especially industrialized countries show a growing interest in cultural ecosystem services that enhance the climate, resilience, and biodiversity in cities.

With respect to the technological challenges, vegetated noise barriers represent individual solutions that need to be amended for each building. Even though standardized elements might exist, projects need to be adapted. This hinders an easy replicability of the NBS to different urban settings. Despite this, technological development and research in this field is lacking, which dampens the market growth while at the same time creating unique entry opportunities for specialized companies.

4.3. Urban gardening

Urban gardening has experienced a revival within the past decade. Citizens in FR set up initiatives to make the best use of vacant spaces in cities. A close cooperation between civil urban gardening associations and a rising public awareness of its benefits leads to an increasing recognition of this NBS in policy creation. Urban gardening is already widespread in the FR and is represented by well-organised initiatives that bring the interests of citizens and politicians closer together. This enables the use of vacant areas for urban gardening, which brings the ecologic and societal benefits closer to the people. In contrast to the previous

described CLEVER Solutions, urban gardening lacks a general market environment as many activities are privately organized. Increasing incomes and a rising interest in regional food production resulted in a continuous demand for urban gardening which is expected to increase. Positive societal effects of urban gardening foster this development.

Even though there are technologies available that enable urban gardening on even less free space, these technologies have not been widely accepted by the society and remain therefore mostly neglected. A great chance for urban gardening lies in the appearance of new technologies such as hydroponics or aquaponics. Since these are not yet adapted in broad contexts, awareness rising, and political support can help to initiate urban gardening in even smaller places.

5. Conclusion

All in all, it can be summarized, that the CLEVER Solutions offer great social, environmental, and economic benefits. Due to difficulties in capturing economic values the general private incentives for these NBS are low. Because of the long time periods until economic effects become visible, private incentives are often lacking. Political incentives address this entry barrier and enable NBS to enter the market more convenient. Additionally, the burden of greater implementation costs is also reduced by political subsidies. By offering subsidies, positive effects are highlighted while financial challenges for private actors are reduced.

A continuous support and awareness rising can enable long-term market growth and address the growing challenges of climate change. Furthermore, it became apparent that technological innovation is either rare or the acceptance of these new technologies is low. The major risks and challenges of implementing the CLEVER Solutions are missing financial revenue streams, undervalued benefits, mismanagement of involved stakeholders and varying environmental and legal requirements for NBS. Moreover, a growing perception of the issues of climate change lead to increasing interest and active call for green alternatives to grey buildings and infrastructure, which supports the market growth for the CLEVER Solutions. To successfully enter the market, individual solutions to meet regional environmental and construction requirements need to be created.

As the markets for most NBS are in a rather infant stage, firms which offer or plan to offer NBS usually only face competition from providers of grey substitutes. As these are only substitutes in a broader sense since they do not offer most of the multiple benefits which NBS contribute, the key element of market strategies should be to actively promote these (additional) benefits. Next to awareness rising campaigns of cities, dedicated marketing strategies might help to inform potential clients of the benefits of the provided NBS. Since market entries still might be kind of risky due to low demand and high (research and development) costs, established firms providing grey solutions might even have better capabilities to enter the market for NBS additionally rather than specified start-ups. However, not all NBS have close grey substitutes and it must be ensured that the provided NBS are really designed by NBS experts to offer qualified solutions. Safety issues or high maintenance efforts might endanger the future acceptance and uptake of NBS, so careful design and planning is required.

As outlined above, an important success factor for market growth is the reduction of cost and maintenance efforts, since these are still the largest disadvantage compared to standard solutions even if additional benefits are evaluated. Hence, firms should actively invest in innovative designs and materials which can help to reduce these.

In general, for many NBS cooperation e.g. with other local businesses and experts might make sense to find effective and tailor-made solutions. Generally, an exchange of know-how and expertise via international associations like the EFB might help firms to grow. Also, such associations can increase awareness and bargaining power.

If efforts like the ones described above are made by cities and companies to overcome some barriers, further market growth of NBS will likely be possible as many general influences encourage it in recent times.

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