Urban Jungle: Green City Planning as an Attractive Concept for Megacities to Face Increasing Social, Economic, and Environmental Challenges

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Abstract

Over the last couple of decades, massive migration to urban areas caused significant growth of cities worldwide. Many urban areas exceeded the number of eight million inhabitants and are therefore regarded as so-called megacities. Due to the rapid pace of population growth, many of these megacities lack on a structural approach in sustainable city planning. Issues such as pollution and general social and environmental degradation were the consequences, which affected the well-being of inhabitants on a large scale. The present informative paper suggests a new approach to cope with these current problems: green city planning. Based on previous research conducted by various authors, it is argued that green roofs, green walls, and green spaces can pose a viable solution to environmental issues in megacities, while at the same time enhancing positive social, clinical, and psychological aspects for citizens. Further economic benefits, such as reduced energy consumption for buildings, increased life span of roofs, and city storm protection, offer cost saving potential in the long run. It therefore makes greening initiatives more feasible in the market area. Through an all-encompassing view on city greening, this paper presents several greening measurements. Assessments on the benefits and applicability are additionally provided with an eye kept on the future.

I. Introduction

In face of an increasingly rising world population together with a general migration trend, large urban areas are nowadays confronted with significant problems. Cities, which exceed the number of eight million people, is also called a megacity (Haas & Neumair, 2013). The problems they have to cope with are a side effect of providing the necessary habitat for proper living conditions for its inhabitants. Being confronted with increasing immigration waves from rural areas, most megacities are unable to provide the required infrastructure and living capacities, especially in developing countries. If megacities grow in an unorganized manner, general environmental problems are evoked that are becoming increasingly urgent. These cities have to deal with traffic accumulation, an increase in industry, and higher energy consumption. Pollution is a consequence, which is, for example, reflected in gaseous pollutants in the air and higher toxicity rates in water facilities, such as ground- and storm water, but also nearby rivers or lakes, which serve as drinking water supplies.

Other problem is urban heating due to heat-reflecting and absorbing surfaces, resulting in higher temperatures in megacity centers. Further consequences are noise problems, evoked by traffic and the dominance of hard and even surfaces, which are more likely to reflect sound. These hard and non-porous surfaces are in addition also problematic in relationship to storm-water runoff, which can accumulate and, if heavy precipitation takes place, result in destructive flooding. Hence, environmental degradation and pollution is a social and eco-

nomic burden for megacities. On the one hand, it leads to increased health pressure for citizens and general social and psychological indisposition, which is seen in its extreme form in slums. On the other hand, it leads to consequences such as energy consumption, the decline of general health conditions of citizens, and also storm damage, illustrate the evermore-costly economic dimension for unsustainable city planning.

Integrating nature into cities in terms of green roofing, green walling, and plantation measurements such as parks, recreational spaces, and wetlands, is a concept to approach these problems. The burden of the previous mentioned social and economic impacts are rising on a global scale, urging governments and policy makers to come up with clever and affordable solutions. Green city planning measurements can be a potential and promising remedy.

In academia, scholars often argue from two different perspectives. On the one hand, nature and its services can be evaluated solely from a humane standpoint. This anthropocentric perspective sees the benefits provided by nature as a utilitarian and quantifiable concept. It follows the premise that the better a natural service benefits humans, the more valuable it is.

On the other hand, arguments can be formed from an eco-centric perspective. This point of view questions the existential division between human and non-human nature. Scholars, who follow this approach, deny to judge about the merit of any living creature. They argue that nature possesses a non-economical, intrinsic value (Grey, 1993). The intangible aesthetic, identity, and cultural aspect of nature should not be seen as a resource, which is there to be quantified, nor should its existence be seen as to be exploited. As humans are also responsible for environmental degradation and pollution, they are implied to implement a policy that reinstalls and preserves ecosystems' functionality and biodiversity.

In this paper, it is attempted to argue that these two standpoints do not need to be conflicting, but can complement each other. Green roofs, green walls, and green spaces can be important agents in doing so. They are integrated into an all-encompassing view. These measurements will be presented separately, while outlining their social, clinical and psychological, and environmental services for private house-owners and the public. These services and their applicability will be evaluated in a cost-benefit evaluation. The aim is to spread awareness about the mostly disregarded fields of applications. From there, the future potential of their applicability in megacities is derived. The line of argumentation will lead to the conclusion that the integration of green city planning, namely green roofs, green walls, and green spaces, is an attractive concept for megacities to face increasing social, economic, and environmental challenges.

II. The Services Provided by Green Roofs

Green roofs, walls, and green spaces such as parks, forests, and recreational spaces, contribute to the city, its inhabitants, and nature in various ways. Radical environmentalists who plead for the preservation of nature would consider this reason to be sufficient to integrate ecosystems back into cities. However, also arguing from an anthropocentric point of view, there are many benefits that the services of green roofs and green spaces provide, which give enough incentive to install, grow, and preserve them. An opportunity to integrate greening measurements in megacities is green roofs. In its simplest form, a green roof consists out of an insulation layer, a waterproof membrane, a layer of growing medium, and a vegetation layer (Oberndorfer et al., 2007). The potential is encouraging, as roofs represent on worldwide average 21% to 26% of urban areas, both residential and non-residential (Getter & Rowe, 2006).

Green roofs are distinguished between two major types, namely intensive and extensive roofs. Intensive green roofs can be seen as a gardening and living space, going beyond func-

tional utility by additionally providing aesthetical and social value. In contrast, extensive roofs are kept simple and seen solely as a functional unit for achieving cost savings. Important as seen from an eco-centric standpoint, vegetation on rooftops provides an ecosystem habitat for microorganisms, insects, and birds. The installation of green roofs thus contributes to local biodiversity conservation (Oberndorfer et al., 2007). The degree of biodiversity and local species depend on the choice of plants used and the intensity of greening. Arguing from an anthropocentric point of view, the vegetation of building tops provide various positive effects for private house owners, but also for the overall city.

In forests, about 95% of rainfall is absorbed, whereas only about 25% is absorbed in cities (Scholz-Barth, 2001). As megacities are dominated by even and hard surfaces, which are not impervious, storm water run-off accumulates in the streets and flows into groundwater or nearby lakes and rivers. These water facilities also serve as drinking water supplies and habitats for ecosystems. Moran and his colleagues argue that city storm water is highly polluted with oil, heavy metals, salts, and pesticides, harming wildlife and contaminating drinking water supplies (2005). Green roofs capture precipitation so that plants can use the water. Excessive water evaporates back into the air again. This process reduces annual storm water run-off of a roof by 60% to 79% depending on substrate depth, composition, plant species, and the slope of the roof (Köhler et al., 2002). Even after the saturation of the vegetation media due to heavy rainfall, green roofs affect delayed and slower water run-off, which vary from 95 minutes to 4 hours, giving sewing systems time to recover (Moran, Hunt, & Smith, 2005).

The plants and the growing medium of a green roof also act as a filter. Water quality is improved through purification and cleaning process which removes pollutants. Nonetheless, research results indicate that some degree of pollutants, such as phosphorus and nitrogen, are even increased in the run-off water due to the choice of soil and fertilizer (Wong, Hogan, Rosenberg, & Denny, n.d.). More research can lead to mitigation of these effects. Altogether, the quality of run-off water depends highly on the selected growing media and the density of plantation (Oberndorfer et al., 2007).

Another consequence of the predominance of dark and hard surfaces in cities is the urban heat island effect. Due to the little quantity of water available in soil for evaporation, solar energy is reflected and heats up city surfaces such as asphalt, leading to higher urban temperatures ranging up to 5.6 °C in comparison to surrounding countryside (USEPA, 2003). With the implementation of green roofs, the degree of water evaporation is increased and a cooling effect takes place. This temperature decrease is higher on roof level than on the streets. Nonetheless, a simulation model initiated by Bass and his colleagues shows that if 50% of the roofs in Toronto were covered with green elements, overall temperature reduction would reach 2 °C in some street areas (2003). Considering that the annual number of deaths provoked in the US through heat exposure is higher than the deaths caused by hurricanes, lightning, tornadoes, floods, and earthquakes combined, such temperature decrease is not redundant (Getter & Rowe, 2006).

In addition to urban heat, megacities, especially in developing countries, suffer from massive smog contamination, provoking health damages to citizens. Via the carbonate and oxygen metabolism of plants, gaseous pollutants and particular matter get filtered out or stored in plant tissues and later washed away through the soil. According to a research carried out by the climate protection partnership division in the US, a 93 square meter extensive green roof removes about 40 pounds of particulate matter per year. This amount is roughly what 15 passenger cars emit yearly on average driving in the US (Wong et al., n.d).

For private house owners the largest advantages of a green roof are energy savings and increased life-span of roofing membranes. Ordinary roof membranes become damaged and brittle through high sun exposure, as the re-

sulting day and night temperature fluctuations strain the materials through expansion and contraction. Fluctuations for a conventional roof rise up to 50 °C, whereas an extensive green roof's diurnal fluctuation is only 3 °C (Connelly & Liu, 2005). It is estimated that temperature moderation can extend the membrane life two to three times (Peck, Callaghan, Kuhn, & Bass, 1999). Furthermore, green roofs serve as an insulation layer, reducing temperature fluctuations which further results in an indoor cooling effect in the summer and a heat saving effect in the winter (Wong et al., n.d.). A research carried out in a multi storied residential building in Madrid indicates that especially the cooling effect can lead to high cost savings. The heating reductions from this extensive roof range from 0.12% to 0.2% and cooling reductions lie in between 6.2% to 6.4% (Saiz-Alcazar & Bass, 2005). A decrease in internal building air temperature of 0.5 °C may reduce electricity use for air-conditioning up to 8% (Dunnet & Kingbury, 2004). Considering that buildings consume 65% of total energy costs for temperature regulation, green roofs have a considerable saving potential, especially in hot climate regions (Kula, 2005).

III. The Services Provided by Green Walls

Another opportunity to install green plantations on buildings is the so-called vertical garden, or green wall. So far, these walls covered with plantation have been evaluated from an aesthetical rather than a functional perspective and solid research about the provided services is scarce. Bass and Baskeran carried out a case study about vertical gardens on the campus of the University of Toronto in 1996 (2001). The results indicate that, like green roofs, vertical gardens reduce urban heat temperature, energy consumption, and can also be expected to reduce storm water runoff. After all, green walls, in comparison to green roofs, differ slightly in their field of applications, as green walls are directly exposed to the street of a city. This location makes them especially attractive in the context of noise reduction, for example evoked by traffic. The hard and even surfaces of building walls are more likely to reflect sound, whereas the uneven shape of plants absorbs sound waves. At the airport in Frankfurt, Germany, a 10 centimeter deep green roof reduced noise levels by 5 decibel (Dunnett & Kingsbury, 2004). Such noise reduction effect can similarly be expected for green walls.

IV. The Services Provided by Green Spaces

With comparable effects but different advantages to make a megacity greener, are the urban green spaces, which are sometimes also called green infrastructure. They can be defined as natural, semi natural, or artificially introduced ecosystems within an urban area that, similarly to green roofs, provide beneficial services to its inhabitants (Zhou & Rana, 2012). The term is quite broad and includes many green areas such as parks, urban forests, and recreational spaces. They are often conceptualized as decorative purposes, but actually have positive repercussions on multiple levels that make them desirable to create.

First of all, clinical and psychological benefits serve as one of the incentives to integrate urban green spaces. Multiple studies show a positive correlation between human well being and exposure to green spaces. There exist several factors that explain this relationship. The first factor is that, similarly to green roofs, vegetation of green spaces filter polluted air and reduce urban heat, thereby improving people's health. Additionally, they provide an incentive for people to perform physical activities (Tzoulas et al., 2007). It is worth noticing that a general trend demonstrates a higher prevalence of allergies in urban areas than in rural areas. Even though a high number of factors have an explaining capacity with regard to the difference in prevalence, the two main statistically significant factors explaining the difference are air pollution from vehicle emissions, which "have been correlated with the increasing prevalence of respiratory allergies"

(Nicolaou, Siddique, & Custovic, 2005), and exposure to nature.

Furthermore, experimental studies indicate a general but significant reduction in stress levels when people are brought in contact with nature, as well as an increase in self-regulation of mood (Grahn & Stigsdotter, 2010). Such exposure is also known to reduce the risk of a range of cardiovascular diseases and cancers, diabetes, and blood pressure (Zhou & Rana, 2012). Moreover, patients generally undergo a quicker recovery of illnesses and surgeries (Grahn & Stigsdotter, 2010). The presence of green spaces offers an escape from people's daily worries and often encourages self-reflection (Chiesura, 2004). Hence, the sole experience of seeing or being in green spaces seems to promote human well being.

From a social perspective, green spaces also seem increasingly desirable. Extensive green roofs may already represent an opportunity for greening within the city, but green spaces are actually accessible and can thus create opportunities for recreation and add aesthetic value to the city (Tzoulas et al., 2007). A counter argument to the latter value of urban greening is that the aesthetics might not be maintained during the winter months as the greenery disappears. However, when considering the services of green plantation measurements, all of them except for shade, are in any manner maintained and will therefore continue to be of indirect use to the city (Obendorfer et al., 2007).

Another service green spaces provide is the promotion of social ties. Studies show that people choose areas with nature as their preferred social environments (Tzoulas et al., 2007). Green spaces are therefore more eligible to facilitate social contact than urban environments and enhance a sense of community (Tzoulas et al., 2007; Zhou & Rana, 2012). Furthermore, exposure to green areas enhances an improvement of educational and working performances of children and adults, since it triggers imagination and creativity (Zhou & Rana, 2012). These various psychological and social gains are not relevant to green roofs, since they can hardly be seen by the general public. Green walls, on the other hand, can attribute a city with psychological assets of well-being through plant exposure, just as green spaces.

Besides the intangible impacts of green spaces in urban areas, there are also more practical uses in terms of protection. Natural disasters, such as hurricane Sandy that left devastating traces in New York City on the 29th of October 2012, urge governments to take measurements for storm protection (NASA, 2012). New ideas to create wetlands within the city are developed with the incentive to protect megacities. Instead of implementing storm protections such as drainages and dams, these natural wetlands can equally help to prevent flooding. An example of protection that wetlands can provide is the capacity of soil to soak up storm water, which is similar to the capacity of green roofs. In extreme cases, this will not be sufficient to prevent floods from occurring, but it makes it much easier to control them. This idea has already been applied to Toronto, where flood lands were created to catch the rainfall of hurricane Hazel (De Sousa, 2003). Lastly, green spaces also provide shade and cooling during the warm, sunny months. Plus, it retains some of the warmth of the city in the winter. Yet, an important precondition to the effective occurrence of these effects is a sufficient large surface area dedicated to green space. Looking at the effect green roofs have on a city's temperature, it can be deducted that a sufficient increase in green space on street level will have an equally large or an even larger effect.

V. Evaluation of the Services

Seen from both an eco-centric and an anthropocentric standpoint, green spaces, walls, and roofs provide many benefits in multiple areas. From an economical and practical point of view, however, it has to be applicable and economically reliable. Cities all over the world find themselves in different climatic, economic, social, and political situations. Due to this fact, implementing ideas, such as those that have

been discussed so far, might be challenging and even ineffective. It is therefore important that future research brings up insights on how to adapt certain ideas as to make it a viable solution specific to each city. In regards to applicability of green roofs, the plant selection criteria are a crucial point as the weather conditions on rooftops are harsh. Plants are exposed to extreme temperatures, drought periods, and high wind speeds (Dunnett & Kingsbury, 2004). Native plants are not always suitable to survive in harsh rooftop conditions and on thin substrate layers of green roofs. Such plants, in turn, can be used in relation to green spaces as they contribute to local biodiversity conservation. Extensive research on green roofs in different climatic conditions has been undertaken since the 1980s and with different substrate depths, showing that for extensive roofs succulent plants such as various sedum types are most suitable (Oberndorfer et al., 2007). They are very resistant, spread quickly, and can survive drought periods up to two years. Such characteristics make extensive green roofs also applicable for extreme dry climates around the world (Teeri & Gurevitch, 1986). In relationship to the urban heat effect, a research conducted by Alexandri and Jones revealed that "the hotter and drier a climate is, the greater the effect of vegetation on urban temperatures" (2006, p.492-493). Urban temperatures in humid climates also benefit from green surfaces, but to a lesser degree. If more research will be conducted in relationship to insulation savings and storm water run-off, then more will be known about the applicability in different climatic conditions.

Roofs are also considered to be highly ideal to place photovoltaic (PV) solar panels on to generate electricity, especially in sunny climates. It would depend on the priorities and needs of the megacity whether to use its roofs for greening or for PV solar panels, but there is a possibility for a compromise. The solar cells, which convert light into energy in a solar panel, perform most efficiently under cool circumstances. The surface area can easily heat up to high temperatures around 80 °C and can result in a loss up to one third of its efficiency (Zahr, Friedrich, Kloth, Goldmann, & Tributsch, 2010). Since green roofing causes less fluctuation in surface radiations of the roof and provides a cooler condition, the combination with solar panels may be an optimal solution (Scherba, Sailor, Rosenstiel, & Wamser, 2011).

Hence, the decisions to create green spaces, roofs, and walls depend on the way they are valuated. All-encompassing cost-benefit analyses, which cover the private and public benefits, are scarce. However, a lot of research has been done on the individual benefits green roofs provide for private house owners. Building owners can directly benefit from reduced energy use, reduced storm water management fees, and increased roof life if they install a green roof. A life-cycle cost analysis carried out in the climate of Singapore revealed net savings of 14.6% for extensive green roofs in comparison to conventional roofs (Wong, Tay, Wong, Ong, & Sia, 2003). This life-cycle analysis did not even cover benefits for the city and nature. Intensive roofs can be expected to be more costly, as the aim is to provide an accessible gardening space, which requires higher installation costs and intensive maintenance. The same counts for green walls, where trellis with soil aggregates need to be installed. Since public green spaces do not lie in the market area, because their installation belongs to governmental responsibility, little research has been done on their economic benefits. Yet, a study on the rainwater-runoff reduction due to green spaces in Beijing reveals interesting information in this regard (Zhang, Xie, Zhang, Zhang, 2012). It demonstrates that different types of green spaces have a diverse range of effectiveness in rainwater-runoff reduction, based on their capabilities to soak up water. It was calculated that the maintenance cost of all green spaces in Beijing was estimated higher than its monetary value. However, this calculation is only based on the service of rainwater-runoff reduction and ignores psychological, social, and other environmental assets. If these were also included into the monetary calculation, the sum would far outweigh the maintenance costs (Li et al.,

2005).

The economic benefits derived from integrating green spaces also vary between different areas within a city. In Beijing, for example, the proximity of green spaces is taken into account into the housing price and compensation rules for building them (Li, Wang, Paulussen, & Liu, 2005). Real estate areas thus economically benefit more from green spaces than industrial sites.

It can be concluded that, depending on the desired result, greening initiatives are not always the best solution. High reflectance roof membranes, for example, reduce the heat-island effect more effectively than green roofs (Scherba, Sailor, Rosenstiel, & Wamser, 2011), although they do not produce a solution to storm water management (Obendorfer et al., 2007). Reduced storm water run-off will save the city from storm flooding destruction costs. Furthermore, a decrease in the urban heat island saves overall air-conditioning costs in the summer and reduces cases of illnesses provoked through heat exposure, which in turn results in cost savings for health-care systems. Peck, for example, argues that if only 6% of the roof surface area in Toronto was green, the impact on storm-water retention would be equal to building a 60 million USD storage tunnel (2005). Such subtle, but very potential, cost benefits are mostly disregarded. Considering all the aspects, the cost savings of green roofs, walls, and green spaces lie in the long-term, which make them more complex to quantify. They cover cost reductions in multiple fields of public services, which policy makers are mostly not aware of, resulting in reluctance to engage in greening initiatives.

More general obstacles that hinder greening projects are lack of scientific knowledge, financing problems, and scarcity of resources for management of coordination, planning, and maintenance (Li et al., 2005). For example, even though research has shown that extensive green roofs are profitable, private owners are hesitant to install them, because they miss practical and technical information on how to do so. Although the participation of all actors such as that of private house owners contributes to the health of a megacity, the main actors in this multi-leveled issue are the governments. They need to foster incentives for green installations in the private sector through cost reductions and subsidies, which has already been done in Germany and Canada (Getter & Rowe, 2006). To avoid a lack of knowledge or management, governments could invest more into research and education. Furthermore, information for the private sector could be provided via uploading databases about technical and practical information. This would facilitate and encourage private plantation.

VI. Looking into the Future

It is estimated that 65% of the world's population will be living in urban environments by 2025 (Li et al., 2005). Due to the considerable increase of urbanization, the cities become denser. As a consequence, the construction of green spaces in city centers will become more difficult and costly. Green roofs, which do not occupy additional building space, are therefore especially suitable to confront some of the problems of dense megacities. There is a high potential in the market of green roofs as growing rates increase. In Germany, for example, growing rates in the last ten years varied between 10% and 15% (Getter & Rowe, 2006). This development will lead to lower prices, which is a very attractive prospect for future investments. As people are slowly acquiring a more sustainability-orientated mentality, it will become increasingly profitable from a business perspective to comply with green development as it improves the corporate public image. An example is Ford Motor Company, who installed a 42,900 square meter green roof and became the subject of much media attention (ibid.). City planning projects and the construction of new buildings should involve architects and construction workers who are aware of the environmental implications green initiatives provide. They can help to integrate possible solutions into urban planning. For projects such as these, local governments

are the major actors, providing guidelines and incentives to promote green city building and planning.

Another aspect for future application, where so far little attention has been drawn to, is indoor greening. Future designs and architecture of buildings could try to implement green planting, applying the positive psychological and social effects of plants on human well-being to in-door spaces and buildings. An example of what a building of a megacity could look like in the future is the 'BIO campus' in project in Istanbul, Turkey. Besides "light-reflecting colors, various water features" (World Architecture News, 2012) and other structures that make the building more sustainable, the design includes greening by planting lush vegetation inside and outside. This way, the temperatures are kept cool naturally and it contributes to a pleasant atmosphere (Zimmer, 2012).

Other futuristic ideas address the autonomous supply of food and water of a building and its citizens. Applications of sustainable ideas such as farming in megacities and purifying storm water run-off to drinking water through plants and soil are currently restricted because of complications due to air pollution. With further research and the application of current knowledge, harmless effects will probably be mitigated, enabling such ideas to become possible and practical. Such futuristic ideas are an opportunity to think outside of the box and find creative ways to make a megacity more pleasant, safe, healthy, and environmentally friendly.

VII. Conclusion

Megacities are dominated by glass, bricks, and concrete. They are areas in which humans have almost complete control over their surroundings and where greenery is strictly contained. Integrating nature more within megacities is a visionary approach, entailing that city and nature are two concepts, which do not stand in each other's way, but are fully compatible. Combining cities and nature, also in terms of bio-systems and bio-diversity, can lead to a harmonic cohabitation. It is a philosophy that shall foster the view that humans do not necessarily need to see nature as a simple, utilitarian concept that is solely there to exploit, but to follow the idea that nature also possesses an intrinsic, aesthetic, and identity value. But even arguing purely from an anthropocentric point of view, introducing nature back into these cities in the form of green roofs, walls, and spaces is profitable in the long run. Further solid cost-benefit research, which encompasses all-inclusive private and public benefits, will help to integrate a better valuation of the greening measurements and their services and encourage future investments. In addition to economical assets, they have positive effects on social and psychological well-being and contribute to nature preservation. Nonetheless, whether the anthropocentric or the eco-centric standpoint is used to form arguments, green city planning has a large potential in the future.

The fact that all actors, namely governments, businesses and citizens, can only gain from this rising green sector, should encourage overall investment. Besides cost-benefit calculations, extended research should be undertaken in the field of applicability. Data should be extended to various outcomes of benefits, depending, for example, on climate or plant and soil selection. Governments could spread awareness and foster incentives in forms of subsidies, communication with architects, and cost reductions, so that already existing ideas have the opportunity to be put into action. Moreover, accessible databases could provide useful technical and practical information for businesses and private house-owners.

Even though this paper is directed at megacities, some of the proposed solutions to environmental issues megacities are dealing with can be applied to many urban areas. Since city planning is not a universalistic concept due to possible territorial, environmental, social, economic, and political dynamics, research on the potential of applying city greening will vary between different urban areas. Ultimately, increasing the well-being of humans and nature

is a goal on a global scale, which can only be achieved by mass compliance and commitment. Uncovering the all-embracing effects and taking into account the long-run perspective, it can be concluded that green city planning is an attractive concept for both the present and the future.

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