Urban Transformation and Implementation of Green Development Strategies - Case of Gothenburg

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Abstract. Urban green space strategies in Gothenburg have been recently developed for planning biodiverse and resilient urban environments, where densification is perceived as an opportunity for achieving higher-quality urban green space. Loss of important ecosystem services (ES) such as habitat for species and its fragmentation has long been considered the primary cause for biodiversity loss and ecosystem degradation. The concept of Nature-Based Solutions (NBS) is currently promoted to provide simultaneous environmental, social and economic benefits, and help to build urban resilience. Yet, there is an observed knowledge and methodological gap on the development links between the built and natural environment. This article aims to discuss modelling urban environments for biodiversity of green areas. The main idea behind the research work presented in this paper is to investigate and explore possibilities to model and develop future integrated built and natural habitats that meet needs of people. This aims to investigate what are the tools that better integrate urban ecosystem services into built development and reflect on planning strategies for Gothenburg's green urban space. The results show a necessity to promote an approach of going beyond calculating accessibility to green areas, but also taking into consideration planning for qualities of urban green space in relation to city's shape and urban form. Spatially explicit indicators for ES like Green Area Factor are required to support real urban planning practice for biodiversity conservation and prioritization of green infrastructure in the urban development process. Complexity of urban systems, ecological assessment of quality of "urban green" is an emerging prerequisite in Gothenburg's planning strategy due to ongoing rapid densification process. There is an expressed need for long term perspectives in planning with new tools and methods for assessing values and benefits associated with urban green space.

1. Introduction

Urban areas are dynamic and complex landscapes, where urbanization's effects on nature are influenced by socio-ecological processes across multiple scales (Ernstson et al., 2008). Delivery of urban ES depends on the spatial structure of ecosystems [1]. The TEEB-Report for Cities [2] suggests that ES could be used as a tool; thus, cities can make positive changes, saving on municipal costs, strengthening local (green) economies, enhancing quality of life and securing livelihoods. There is a need to develop place-based empirical knowledge, citizens' science and to define appropriate measures/policies for better integrating generation of ES into spatial planning [3]. There is a necessity for practical applications, appropriate methods for identification and quantification of individual services, suitable models, indicators and the integration of system components [4]. NBS represent a large number and variety of benefits that humans freely gain from the natural environment and from properly-functioning ecosystems [5]. The concept became widely used after the Millennium Ecosystem Assessment in the early 2000s [6]. The ME Assessment identified and outlined four groups of ES: provisioning ES such as production of food, supporting ES such as pollination, regulating ES such as climate regulation and cultural ES such as recreational benefits. Implementation of nature-based solutions into the urban context are traditionally carried out in projects related to household plots (backyards, home gardens), community allotment gardens or utilization of empty parking spaces, buildings, roofs, along roadways or rights-of-way [7]. There is an observed weak integration between built and natural environment.

It is acknowledged that planners, architects and engineers that take an active part in sustainable urban development are important players which should understand how they can shape these ascendant

ecosystems [8]. Another challenge remains the gap between practice and science, a need for improved collaboration, and coordination of city development projects with research. Bridging the gap between science and policy regarding knowledge on urban ES typically involves a number of challenges [9], drawing on multiple sources): 1. there are difficulties among practitioners to process the uncertainty present in scientific publications; 2. even when expert studies exist, there is a shortage of scientific tools to situate the complexity of interacting systems within relevant scales and contexts; 4. where decision makers obtain appropriate knowledge, there is a delayed effect on policy making, public awareness and action, and scientific knowledge may be seen as just one of many involved perspectives; and 5.different values or views of stakeholders and significant paradigm differences are presenting the process of mediating approaches to urban ES issues.

The main idea behind the research work presented in this paper is to investigate and explore possibilities to model and develop future integrated urban and natural habitats that meet needs of people. This aims to bridge the knowledge and methodological gap on the development links between green and urban and investigate what are the tools that better integrate urban ecosystem services into built development.

This paper aims to discuss some recent methods of implementation of ES in urban planning and design taking the city of Gothenburg as case. In section 1, the importance of NBS is defined by human needs and societal norms. Section 2 gives an overview of tools and methods to promote ES and integration of built and natural habitats. Section 3 introduces and reflects on the planning strategies of Gothenburg's Green Strategy and the areas of Gothenburg, where ecosystem services are present. The paper ends with a discussion on an expressed need for long term perspectives in planning with new tools and methods for assessing values and benefits associated with urban green space.

2.Nature Based Solutions & Urban Development

The concept of NBS is promoted to better understand the role of urban nature and ES for human wellbeing. NBS are solutions to societal challenges that are cost-effective, can provide simultaneous environmental, social and economic benefits, and help to build resilience [10]. In situations of increasing competition for urban land and densification, it is essential to improve our understanding of the benefits of urban nature and how to balance such benefits against other development needs and pressures.

The idea of societal benefits from ecosystem processes has for long been an issue for discussion in European spatial planning and development [11]. The understanding of NBS depends on the potential benefits for humans that are the focus of interest in the respective assessment).

Urban planning is indispensable for assessing spatial processes and components with respect to their contribution to land use functions. Urban development is committed to ensuring public interests, therefore its guiding principles should reflect societal values. The interests of private and public actors should be kept in check by planning and regulations that assure the long-term usability of natural resources. There is an increasing awareness that greenery provides a range of important benefits to city residents it is important to develop integrated assessments of ES benefits and values provided by urban greenery [12]. ES provided by urban green areas were valued in the Gothenburg study of Andersson-Sköld et al. as highly important and ranked in comparison to other important city development aspects such as improvements in public transportation, housing, culture and entertainment. The study presented a developed methodological framework gaining estimates of perceived values of ecosystem services obtained from interviews with the public and workshop activities with civil servants.

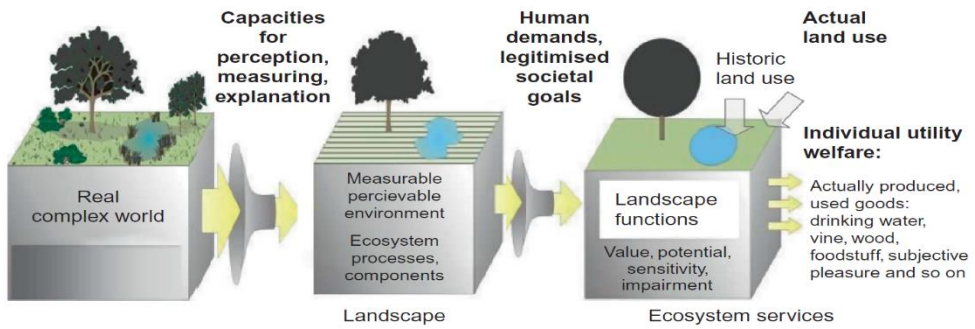


Figure 1. Landscape functions are defined by human needs and societal norms [11].

3. Integration of built and natural habitats

The concept of ES is currently promoted in Sweden in the planning for more compact and sustainable cities [13][3]. Although recognizing the usefulness of the ES concept, there are many remaining challenges [14]. A sustainable urban development strives for an optimal relationship between built (grey) and green infrastructure, urban development and the quality, as well as the quantity, of green urban space. Increase of built-up areas often corresponds to the decrease of impervious surfaces and green or open land. This combined effect of increasing population and loss of permeable surfaces is likely to result in greater and more frequent floods but also loss of habitat for species and biodiversity due to fragmentation of natural habitats and drastic and persistent alteration of habitats [15].

However, despite the recognition of the usefulness of the ES concept, there are many remaining challenges identified by professionals linked to integrating the concept into land use planning including a gap between research and practice.

Planning for integration of urban and natural habitats remains a challenge in cities. There is clear evidence that biodiversity of habitats of species plays a key role in the delivery of most ES [2]. Biodiversity is a total sum of organisms including their genetic diversity fitting into communities and ecosystems. Biodiversity includes diversity within species, between species, and between ecosystems [6]. Drivers that indirectly affect biodiversity are caused by urbanization including population, technology, and lifestyle. This shows that biodiversity and human wellbeing are inseparably related. Maintaining functioning ecosystems capable of delivering multiple services thus requires less fragmentation of these areas and better connectivity. A study done for Stockholm [16] suggests that there is needed evaluation of tools measuring qualities of urban green areas and their role for ES in order to allow a design and planning practice to gather information and knowledge about specific aspects of green areas. There is an urgent need to integrate different tools for mapping and analysis of ES in a form of platform. The Stockholm study discusses different tools (fig.2) described already in Stockholm planning policy. They include biotope and sociotope map, and a tool implemented in a regional scale in Stockholm: MatrixGreen [17]. Proposed other additional tools in study include Visibility Graph Analysis (VGA) originated from Depthmap in Space Syntax to test connectedness between different biotopes and accessibility to visual corridors for ES pollination [14]. Accessibility to green spaces can be measured by another 'Place Syntax Tool'-PST [18] developed by KTH and Chalmers. PST is an open source tool for performing spatial analyses. It combines network description of the urban environment with conventional descriptions of attraction into the combined accessibility analysis. Berghauser-Pont argues that the tool allows not only to capture that each resident has a certain amount of green space but also certain qualities in that green space within an analyzed distance (in the study distance of 500m). It would also allow to measure how many people potentially could be co-present in that green space.

As the study suggests all tested tools in Stockholm show possibility to model urban green spaces for different ecological and social benefits. The proposed platform is GIS-based and aims to measure both accessibilities to green spaces and connectivity between these spaces. It allows also to assess functionality of these areas from the social and ecological perspective.

Figure 2. Examples of tools applied in the Stockholm study to assess accessibility, connectivity, and functionality of green areas from the social and ecological perspective [16].

4. Gothenburg Green Strategies

Ongoing urban exploitation is increasing a pressure to transform urban green spaces in the city. According to the *Green Strategy* (*Grönstrategi –en tät och grön stad* [19]), a part of a Master Plan, Gothenburg aims to become a dense and green city with immense green qualities, from both social and ecological perspective. *Green strategy* includes two main targets: *Gothenburg is a dense city where public places contribute to a rich and healthy urban life*, characterized by: *a rich animal life and ecosystem services considered.* The Green Strategy is based on realizing region-wide green wedges extending from the outer edges of the region, across municipal borders all the way to central parts of Gothenburg. The idea is to strengthen the green wedges in the city centre so that both humans and animals can move in the city through greenery. The blue-green straw, water with surrounding greenery, is a great asset but long cohesive stretches are sought.

Despite the coherent regional perspective of growing green corridors in the city, the local context is still challenging. Firstly, some urban spaces are lacking walking access to parks within 300m distance. They include Gothenburg centrum, Backa along E45 north, post-port and industrial waterfront areas along the Göta River (e.g.: Masthugget, Majorna, Lindholmen, Eriksberg, Ringön). Moreover, except many park areas maintained very well in the city there are many temporary projects promoting "greening" of urban environments "Pop-up Parks" (2016), temporary "urban farming" in Frihamnen or Ringön.

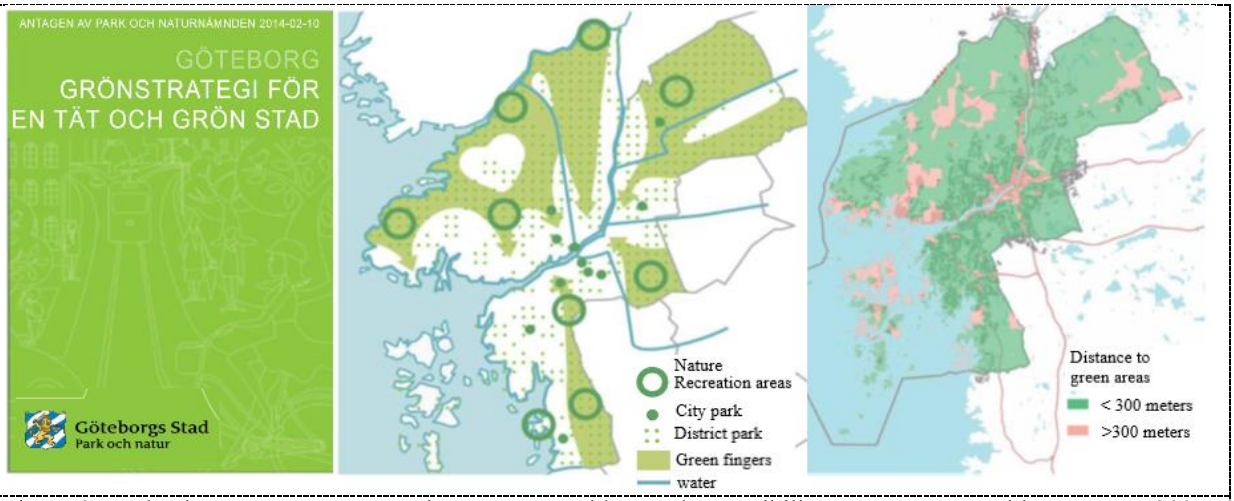


Figure 3. Gothenburg Green Strategy, city's green corridors and accessibility to green areas with "< "or ">"300m [19]

In the Gothenburg region (city and surrounding municipalities) some recently developed projects promoting implementation of ES include Stadsodling in Jubileumsparken, as well as various interventions by *Stadsjord* including aquaponics and vegetable growing into the urban matrix. However, these are temporary and often pushed out by development. Another example of a developing project that may prove a more permanent implementation of ES in the urban built environment is Gärdsås Mosse. Understanding the dynamics, benefits and limitations of these and other initiatives is crucial to the integration of ES into the urban built environment.

Ecosystem services can be adversely affected in planning and construction. In 2018 Gothenburg Municipality published guidelines for compensation measures for ecosystem services in planning and development projects : "Grönytefaktorer och kompensationsåtgärder" – "Green Area Factor (GAF) and compensation measures" [20]. The guidelines state that in the case of exploitation, efforts should be primarily made to avoid or minimize the impact on ecosystems. The GAF is a measure of how much ecosystem services in an area provides, that is, how much help we get from green and blue surfaces to deal with certain environmental challenges in new detailed plans or other development projects as presented on a digram (Fig.4). Diagram shows that in case of exploitation of land with green assets; efforts should be primarily made to avoid or minimize the impact of development by using protective measures, to: 1. Avoid negative influences - choose another location; 2. Minimize negative impact; Only if 1,2 is not possible compensation should be considered: 3. Equalize - restore value in the immediate area; 4. Replace - compensate by measures at another location or value. If the city of Gothenburg is not the owner of the land, the measures can be voluntarily regulated or described in development agreements with a developer or landowner. A site-adapted GAF model (such as Gothenburg's model) should take into account the site's environmental challenges and ecosystem services needed the most (Fig.5). This means that the value can vary for one and the same type of surface, such as lawn, as it is different in managing each ecosystem service (such as aquatic water, biodiversity or recreation).

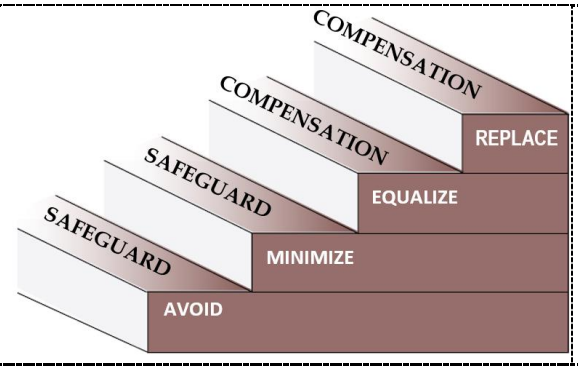
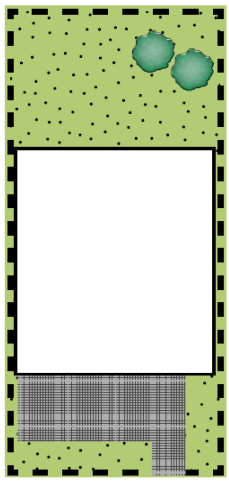


Figure 4. Compensation / action staircase [20].

Examples of implementing NBS suggest exploring more possibilities for such integration. Green Area Factor (GAF) is simple and uncomplicated method: safeguarding and enhancing the presence of vegetation in the built environment [21]. In the GAF calculation (Fig.5), the particular parts of the land (a plot, block or park) are thus weighted according to their ´ecological value´. The formula to calculate GAF is given below where the targets can be defined differently depending on the type of development. It expresses the ratio of ecologically effective surface area to the total land area [22].



PLOT	VALUE	m²	ECOEFECTIVE AREA (PRODUCT)
Soil, lawn	0,4	30	12,0
Bush	0,4	3	1,2
roof	0	40	0
Surface, hard	0,25	10	2,5
SUM		83*	15,7

The total plot area is 80 m2.
* The grassland under the bushes and the bushes are counted separately. Therefore, the sum exceeds the total area.

$$\text{Green Area-Factor} = \frac{\text{sum of all eco-effective areas}}{\text{total plot area}} = \frac{15,7}{80} = 0,20$$

Figure 5. Example of calculating GAF for a small area [21].

In Gothenburg there is observed growing interest to investigate and explore possibilities of modelling and planning better integrated urban and natural habitats that meet needs of people. This requires bridging the knowledge and methodological gap on development links between green and urban and investigate what are the tools that better integrate urban ecosystem services into built development. There are four selected ES from the aforementioned Millennium Ecosystem Assessment [16] to address in this paper in the context of Gothenburg: 1) *Food production* as provisioning service; 2) *Local Climate* and 3) *Storm Water Treatment* as regulating services representing the role of ecosystems; 4) *Recreation*: Cultural Service as non-material benefits people obtain from the contact with ecosystems. Gothenburg is considered to be a “green city” and areas supporting these ES should be investigated as a system of green areas across scales (region-city-district) in order to gain knowledge about their characteristics like accessibility, connectivity, and functionality from the social and ecological perspective.

4.1. Food production.

Figure 6. This Slottsskogskolonien, an example of urban farming in Majorna-Linne district (source: Google map, 2018)

Good example of growing "gardening culture" in the city is *Slottsskogskolonien* in Majorna-Linne district (Fig.6). Allotment gardens are popular in Gothenburg. There is also a growing number of urban areas where courtyard boxes are located for the seasonal outdoor gardening from May to September (e.g.: Sandarna, Älvsborgsgatan 11-17) or indoor as green houses in the Million Programme district of Gårdstensberget.

The local scale design and integration of built environment with NBS needs to be more explored in terms of using free land and parts of buildings like traces, balconies, roofs for a neighborhood scale food production. Green houses attached to buildings or located in the proximity of houses are in general not much popular in Gothenburg. Food production is rather seen as a hobby or alternative for spending free time. Food market offers good products in Gothenburg and society is not demanding new areas convenient for food production in the city centre. It is different for suburban villa areas (i.e.: along road 190 and Gunnilse, Olofstorp, etc.) or million programme (i.e. in Angered, Gårdstensberget, etc.) where the practice of gardening and promoting ecosystem services is much popularized among inhabitants [23].

4.2. Regulating Local Climate and Storm Water Treatment.

Ecosystem services taking part in the regulating local climate are represent for example by urban cooling [16]. Trees and green space lower the temperature in cities, they also play an important role in regulating air quality by removing pollutants from the atmosphere: harmful pollutants like ''greenhouse'' gases (i.e. methane-CH4, chlorofluorocarbons, nitrous oxide - N2O, and tropospheric ozone - O3 or carbon dioxide - CO2). Vegetation (ES like forests, wetlands) regulates water flows including lakes, rivers, surface and sub-surface flows. Land use changes play a big role in regulating extreme events, high rainfall, and runoff events. Forests, wetlands, parks may be more effective than grass land or herb dominated communities.

In Gothenburg the role of vegetation in regulating local climate and storm water treatment is basically reserved for parks and bigger forest areas located close to settlements in the city. There is still a lot of space around buildings managed for parking and open spaces with impermeable surfaces filled with asphalt and concrete. Design of integrated urban form and its surroundings with vegetation could be more promoted.

4.3. Recreation.

Walking and playing sports in green space is a good form of physical exercise and relax in urban environments. Green space plays an important role in maintaining mental and physical health of citizens. In Gothenburg the biggest volume of recreational space is accommodated mostly in many parks in the city or playgrounds, football fields located in the proximity to housing areas. Recreation is an ecosystem service promoted well in the city, still the challenge remains connecting these cultural services together in the form of green pathways, corridors in-between different settlements and within them. Big priority given to automobile and transport functions in the second half of XX century is noticeable in the city. Parking areas and roads often compete with green and open spaces in the urban areas. Solution could be to reduce parking space, replace asphalt and concrete sealed spaces with permeable surfaces concrete blocks, stone or gravel, allowing vegetation grow in-between. Another strategy remains to redevelop urban settlements for pedestrian-friendly spaces. Forming

system of green paths and corridors could be beneficial for managing ES in the city and enhancing biodiversity of green areas.

5. Discussion and Conclusions

There are possibilities and opportunities in Gothenburg to promote actions and research initiatives in which theories, models and methods for sustainable urban development and NBS can be tested in practice. As suggested by Hostetler et al. [24] planning for protecting ecosystems in cities is important and planners and researchers must expand the geographic scales of conservation efforts to move beyond individual species and beyond individual places to embrace whole ecosystems.

Collaboration with local actors is a key for integrating ES and NBS into the built environment. An overall broad and well networked architecture and urban design/planning basis for close collaboration with other disciplines (ecology, sociology, etc.) and actors in the Gothenburg region can be helpful. A cornerstone is the intimate collaboration between research and the local actors already engaged in building or realizing projects based on implementation of ES in the Gothenburg region. Research work aiming at testing innovative processes on how to involve citizens in the process of building resilient communities to increase qualities of ES in the urban built environment should be prioritized. A Stockholm case described in this paper suggests that a GIS based platform of tools [16] should be developed to help to measure both the accessibility to green spaces and connectivity between them to be able to assess functionality of these green areas for people (i.e. the social perspective) and other species (i.e. the ecological perspective).

Addressing a question of applicability in practice of tested tools/methods, also from stakeholders' perspectives, could be based on the social discussion and evaluation of benefits derived from the integration of selected ecosystem services into the development of urban areas in Gothenburg [12].

Collaboration of key stakeholders in Gothenburg to develop and promote NBS and sustainable transformation is crucial and needs to be strengthen on all levels of urban development process. Policy strategies needs to be linked to decision making in the city (detail planning and construction projects) prioritizing implementation of NBS in the built environment on a regular basis.

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