Inventory and Potential Analysis of Green Roofs

"Remote sensing based setection of vegetation areas on roofs" for the development of the activatable area potential in cities for the fields of urban climate, urban drainage and species protection - a project funded by the German Federal Environment Foundation (Deutschen Bundesstiftung Umwelt - DBU).

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1. Introduction

In view of current climate developments (including overheating and extreme precipitation), green roofs continue to be a focus of attention. Many cities are therefore giving green roofs a particularly high priority in their climate change adaptation plans. A targeted expansion of the green infrastructure on urban roofs is therefore seen by many communities as an important component of future-oriented urban planning. An important basis for the development of local green roof strategies is therefore provided by specific geo data sets, which, in addition to the area and location of existing green roofs, also identify suitable roof areas for subsequent greening.

2. Operating Principle.Method

"The former German Roof Gardeners' Association (Deutscher Dachgärtner Verband e.V. - DDV), now German Association of Building Greening (Bundesverband GebäudeGrün e.V. - BuGG), together with the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt - DLR), has carried out the research project "Inventory and Potential Analysis of Green Roofs" and developed a standardized procedure for the analysis of existing and potential green roofs. The result of the project was the development of a software application that allows a fast and efficient analysis of urban roof surfaces. The procedure combines aerial or satellite images, i.e. remote sensing data, with high spatial resolution and building data. These data are usually held by cities in their geodata pools. The combined processing of the data sets enables green roof analyses for the entire city area down to the level of individual buildings.

For vegetation detection, remote sensing data are used, which include the visible red-green-blue spectral range as well as the near infrared range. Plants reflect the infrared radiation, which is not visible to the human eye, in a very differentiated manner and can therefore be effectively analysed using this signal. When the infrared channel of aerial photographs is displayed, the existing vegetation appears red in colour - the denser and more vital the vegetation, the stronger the reflection and the more intense the red. Based on various threshold values, the procedure automatically decides whether a roof is classified as green. Essential parameters are the strength of the vegetation signal, the absolute area size of the detected green roof area and the relative area proportion of greenery on the roof.

3. Data Basis

A. Data for Vegetation Detection

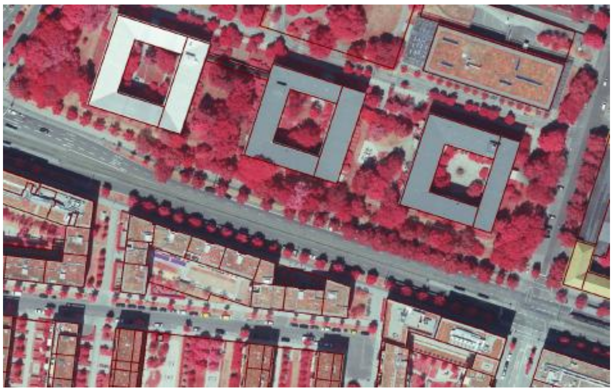
The basis for analysis is given by aerial or satellite images, which cover the visible spectral range (red, green, blue) as well as the near infrared (NIR) range. The NIR channel is absolutely necessary to determine a special vegetation index (Normalized Difference Vegetation Index - NDVI), with which the vegetation is classified by the software.

The better the spatial resolution of the remote sensing data, the more differentiated the analysis can be performed.
So-called true-orthophotos are ideal, as this type of image data does not contain any image-induced off-nadir tilt effects.

B. Building Data

Absolutely necessary for the analysis are building or roof geometries, e.g. from the Authoritative Real Estate Cadastre Information System (Amtliches Liegenschaftskatasterinformationssystem - ALKIS), from 3D city models or from other cadastres. These data are used to define the analysis areas for the remote sensing data and to calculate area sizes and relations.

Highly recommended for the inventory of green roofs and essential for the potential analysis of the rest of the roof stock is information on roof slope. This can either be included as roof type information per roof (flat roof, mixed roof, gabled roof, etc.) or derived via a Digital Surface Model (DSM).
Very useful, yet in principle optional data represent information on building heights or numbers of storeys.



Source: City of Munich / DLR

4. Results

A. Inventory of Green Roofs

By setting NDVI thresholds, the area percentages for the detected vegetation of the roofs are derived for four classes:

1. without vegetation
2. extensive roof greening or spontaneous greening
3. transition area extensive/intensive greening
4. intensive greening (trees, shrubs)

With the relations of the area shares the conclusion is generated whether a roof is designated as "greened". The rules for this can be modified.

For each building/roof all calculated and derived parameters are recorded in a table of values.
Based on these parameters for the individual buildings, statistical values for the entire urban area can be derived, such as

1. number of all roofs with green roofs in the urban area
2. percentage share of green roofs in the total number of all greened roof areas
3. vegetation area of all greened roof areas
4. number of all potentially greenable buildings in the urban area
5. percentage of potentially greenable roof areas of the total number of all roof areas
6. total area of potentially greenable roofs

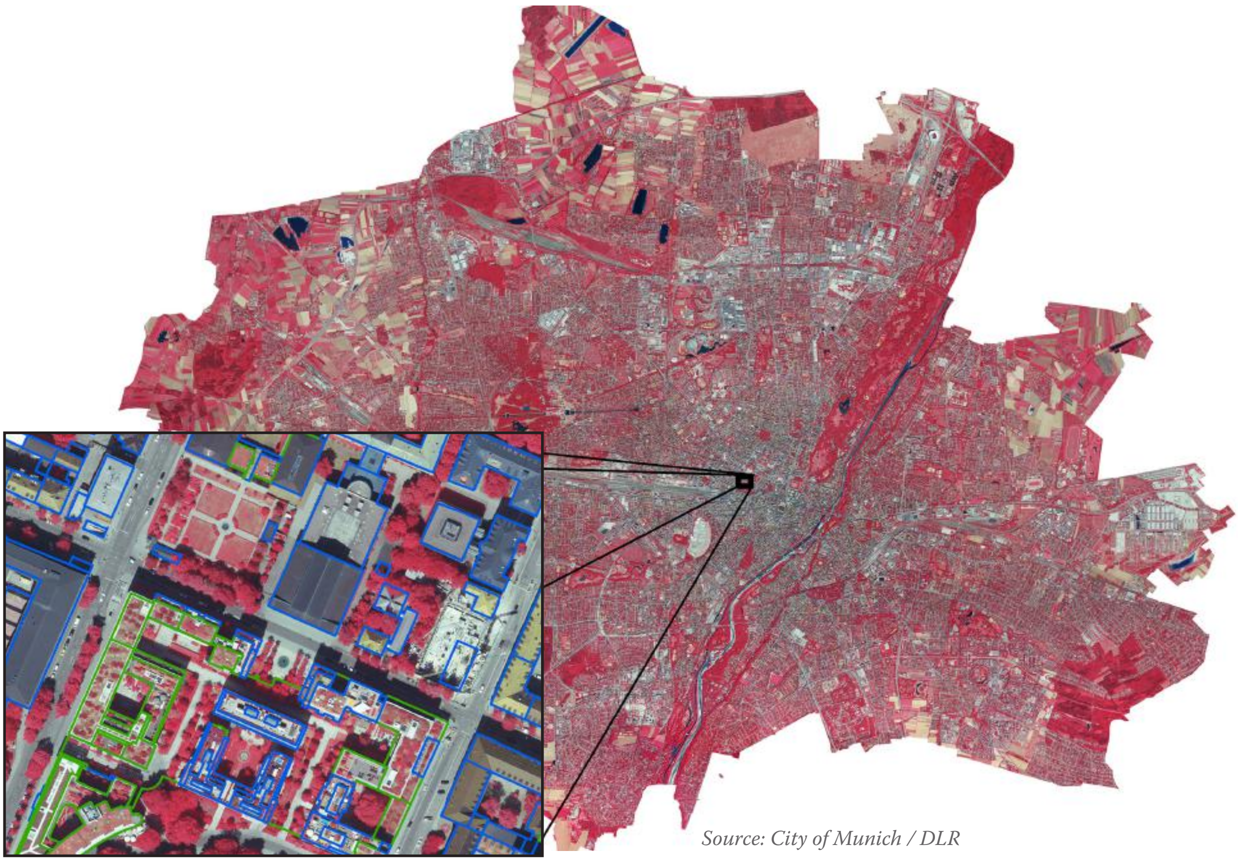
B. Potential Analysis

The potential analysis is used to detect existing buildings that can be greened afterwards. The decisive criteria for this analysis are "roof slope" and "gravel cover".

Roof slope
In comparison to flat roofs, the effort for greening sloped and pitched roofs (from about 10 - 15 degrees roof slope) is significantly higher. For the potential analysis, therefore, only buildings with flat or slightly sloped roofs are considered.

Gravel cover
In addition to the roof slope, the static load reserves are part of the constructive requirements, which have a particularly strong influence on the potential greenery. A simple extensive green roof weighs approx. 80 - 100 kg/m². Gravel roofs, which often have a load of approx. 100 kg/m², can therefore be converted into green roofs after removal of the gravel layer without changing the building statics. The software can analyse whether there is a gravel cover by defining colour value ranges.

Roof slop and building statics provide initial indications of potential greening. Further constructional requirements such as the condition of the roof sealing, the thermal insulation, the roof edge heights and the accessibility of the roof surface must also be checked on site.



Source: City of Munich / DLR

5. Areas of Application

The inventory and potential analysis concerning green roofs can be applied to the following topics:

1. integration of the data in models for the urban climate
2. integration of the data in models for drainage planning
3. integration of the data in models for biotope net-working
4. fixing special types of green roofs, depending on the urban area and the environmental focus
5. targeted municipal support for green roofs in areas with insufficient greenery
6. use of the data for general public relations

The system can also be used for the following interes-ting individual aspects:

1. control tool for the execution of green roofs
2. ecological upgrading of existing green roofs
3. feeding the data into the property valuation (cost savings on energy and precipitation water)
4. basics for the activation of social, public areas on roofs (neighbourhood meetings, urban gardening, sports & games)

Based on the above-mentioned method, roofs in Frankfurt, Munich and Stuttgart, for example, have been successfully inventoried and the potental for green roofs demonstrated.

6. Contact

The visualisation and development of existing green roof areas and unused area potential enables a very wide range of different applications, ranging from use in urban climate models and drainage planning to biodiver-sity aspects and the implementation of local green roof strategies. The method is offered as a remote sensing service standard by the company EFTAS Fernerkundung Technologietransfer GmbH from Münster, Germany, flanked by expert advice on green roofs and facades by the BuGG.

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Stand 25.05.2020