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Extended Abstract

With only about half of its area exceeding one meter above sea level (much of which is artificial), the Netherlands works to alleviate climate change and the stresses it imposes on society, such as flooding.

Rotterdam, the Netherlands's second-largest city and Europe's largest port, looks for opportunities to further develop proof-of-concept urban interventions that simultaneously face climate threats and serve economic and social needs.

One example is Rotterdam's 14.5 km^2 of flat roofs. Besides the potential for aesthetic and environmental benefits, this unique rooftop landscape is an opportunity for the Municipality of Rotterdam's water management efforts.

Within the realm of evidence-based and sustainable urban planning, DSSG is collaborating with Rotterdam to develop a tool to classify the current state of its green roofs in four categories (i.e., non-vegetation, extensive, intensive, and trees) using aerial and satellite images, as well as a normalized difference vegetation index (NDVI).

The goal is to expedite the development and to improve the care of green roofs in the city, with special attention to those that are intensive (i.e., intensive green roof systems have superior water retention capabilities). As additional components to Rotterdam's combined sewage systems (CSS), green roofs are fundamental pieces to its sustainable water management puzzle.

Our data includes aerial and satellite images from a designated Area of Interest (AoI) within the Municipality of Rotterdam. We also use shapefiles corresponding to rooftops, as well as color infrared images (CIR). After calculating a NDVI from the CIR, we analyze the distribution of pixels to classify the vegetation and non-vegetation areas of each rooftop and each AoI.

Our preliminary results considering the vegetation interval indexes from NASA (2010)[1] show that the majority of Rotterdam rooftops is non-vegetated (52%). The other half of the AoI is divided into three different areas, extensive (35%), intensive (8%), and trees (5%), respectively (see Table 1). Also, we investigate the vegetation and non-vegetation present in each rooftop in terms of its size and its percentage (see Table 2).

[1] Nath, Biswajit. "Quantitative assessment of forest cover change of a part of Bandarban Hill tracts using NDVI techniques." *Journal of Geosciences and Geomatics* 2, no. 1 (2014): 21-27.

For future work, we would like to create a model that can adjust the vegetation interval index to improve the accuracy of our results. This would show a more realistic classification according to the expertise of the Municipality of Rotterdam.

Table 1 - Classification for each AoI

Vegetation Type	Vegetation Interval	Area (sqm)	Area (%)
Non-Vegetation	-1.000 - 0.088	38160	52.520748
Extensive	0.088 - 0.210	25140	34.600933
Intensive	0.210 - 0.276	5675	7.810672
Tree	0.276 - 1.000	3682	5.067647

Table 2 - Classification for each rooftop

ID	Non-Vegetation (sqm)	Non-Vegetation (%)	Extensive (sqm)	Extensive (%)	Intensive (sqm)	Intensive (%)	Tree (sqm)	Tree (%)	Total (sqm)
296541915723723	893	20.4	1419	32.4	1516	34.6	555	12.7	4383
954412893616635	4097	59.2	1553	22.4	909	13.1	361	5.2	6920
877190628601592	9762	67.9	3755	26.1	723	5.0	133	0.9	14373
961372394571613	3204	61.6	1606	30.9	252	4.8	140	2.7	5202
376599944240492	888	54.1	405	24.7	231	14.1	118	7.2	1642
755152102886818	359	38.9	277	30.0	183	19.8	103	11.2	922
798599070195256	284	33.2	238	27.8	170	19.9	163	19.1	855
929366157762319	862	57.5	450	30.0	133	8.9	52	3.5	1497
142702550905143	99	17.6	125	22.2	90	16.0	250	44.3	564
309704615972073	101	29.2	100	28.9	66	19.1	79	22.8	346
283799978915544	327	51.2	133	20.8	66	10.3	113	17.7	639
131610254132184	186	47.3	103	26.2	48	12.2	56	14.2	393