Integrated hydro-economic modelling for urban stormwater fee estimation
– an incentive for better stormwater management?

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New Water Ways
SUSTAINABLE URBAN WATER MANAGEMENT

UiO : Department of Geosciences
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Background

A major problem in urban areas is the increasing production of stormwater. This is caused mainly by the inherent effect of utbanisation to replace former vegetated areas by impermeable surfaces, but also by more frequent storms. The effects are well known:

- Increased local floods, increased flood damage
- more pressure on existing storm drains
- more CSO (combined sewage outflow) events
- larger water volumes need treatment
- reduced groundwater levels

The traditional response has been to increase existing network and treatment capacity – a very costly approach. An alternative is to reduce surface water production by greener apporaches like LID/Sponge city methods.

Can stormwater fees be a solution?

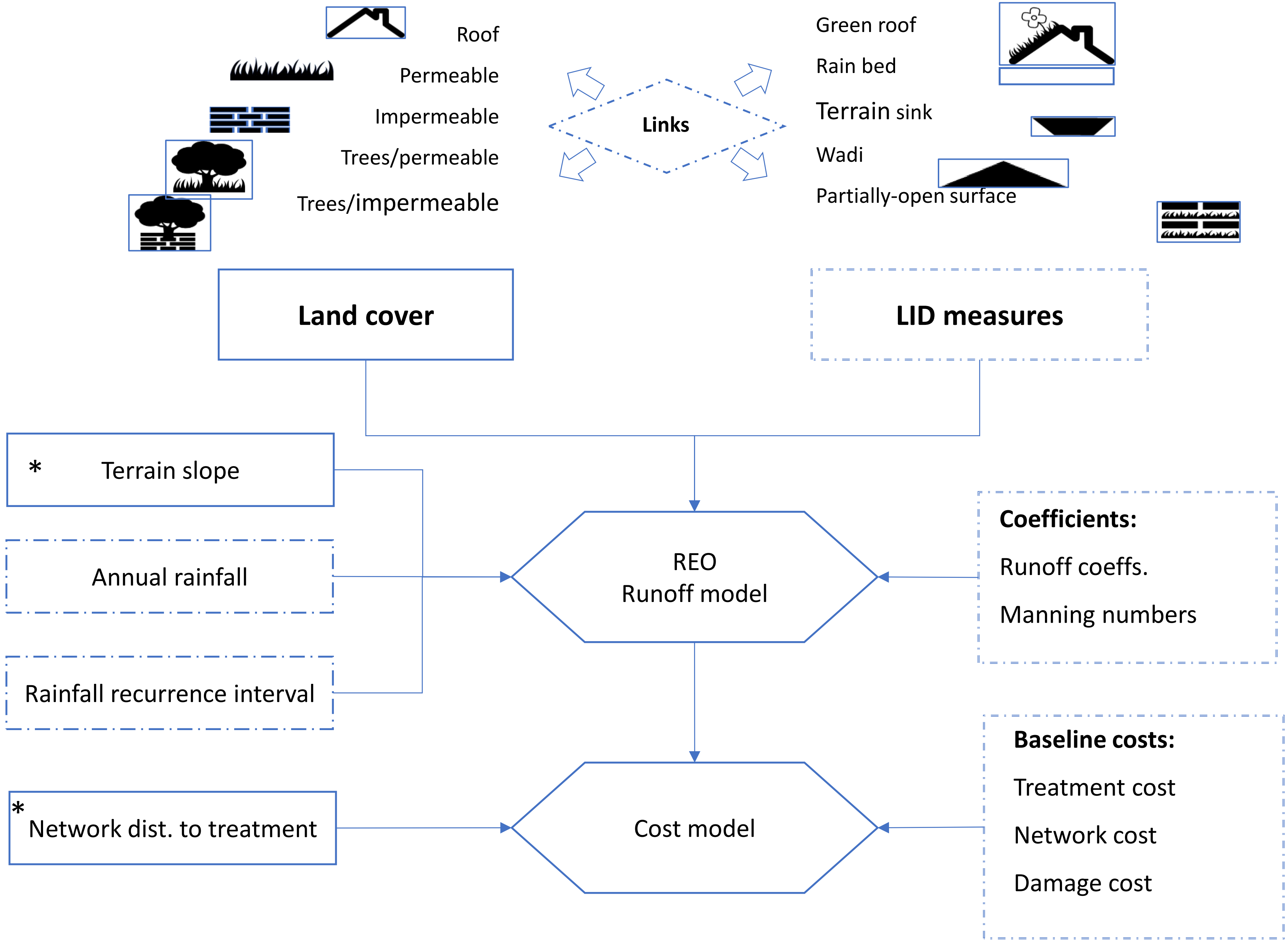
Surface water production occurs in most parts of the urban area, and most building owners are stakeholders in this respect, and could be considered actors in mitigating the problem.

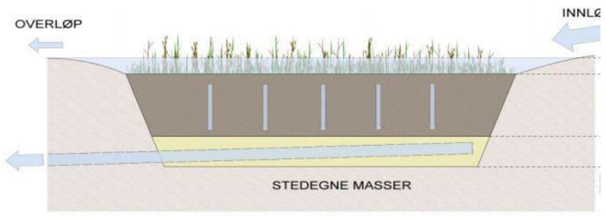
Stormwater fees have been discussed, as excess surface water certainly is cost for society, mainly carried by the municipalities.

A static fee does however not have any incentive for the landowners to take mitigating action. We have therefore as part of a Norwegian Research Council project, «New Water Ways» established a pilot study in Oslo that demonstrates a methodology that links a fee estimate directly to the individual structure of a bulding lot, and that can be operated by the actual landowner, hopefully in a quest to reduce the surface water production and by that his fee level.

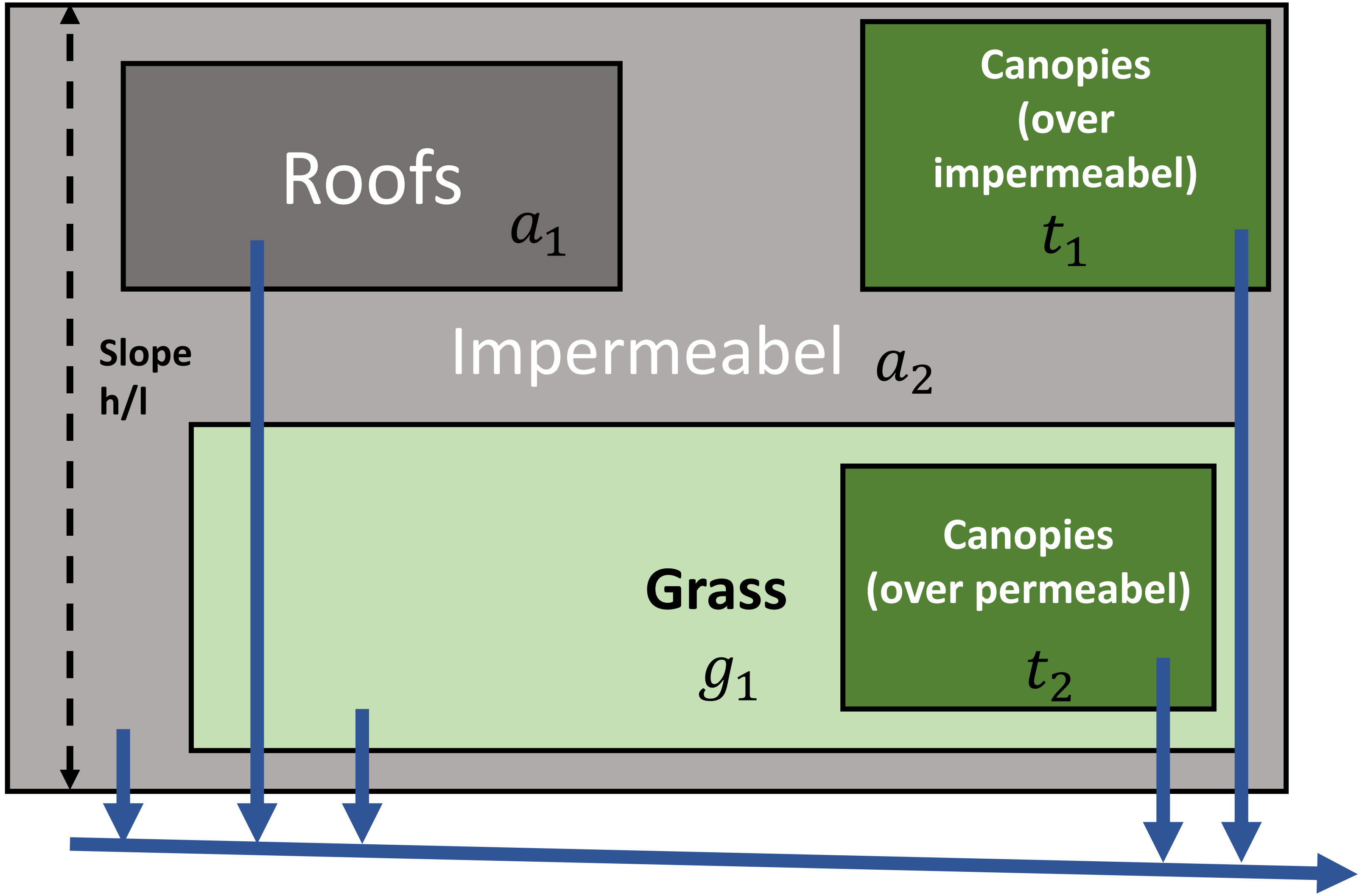
This presentation is based on the peer-reviewed paper: D.N. Barton, Z.S. Venter, N.R. Sælthun, I.S. Furuseth og I. Seifert-Dähnn 2021: Brukerfinansiert klimaberedskap? En beregningsmodell for overvannsgebyr i Oslo. Norwegian with English summary. Vann 4/2021, 18 pp. and on the report N.R. Sælthun & D.N. Barton, Z.S. Venter 2021: REO: estimering av overflateavrenning fra urbane felt. NINA-rapport 1851b. Norwegian Institute for Nature Research.

Structure

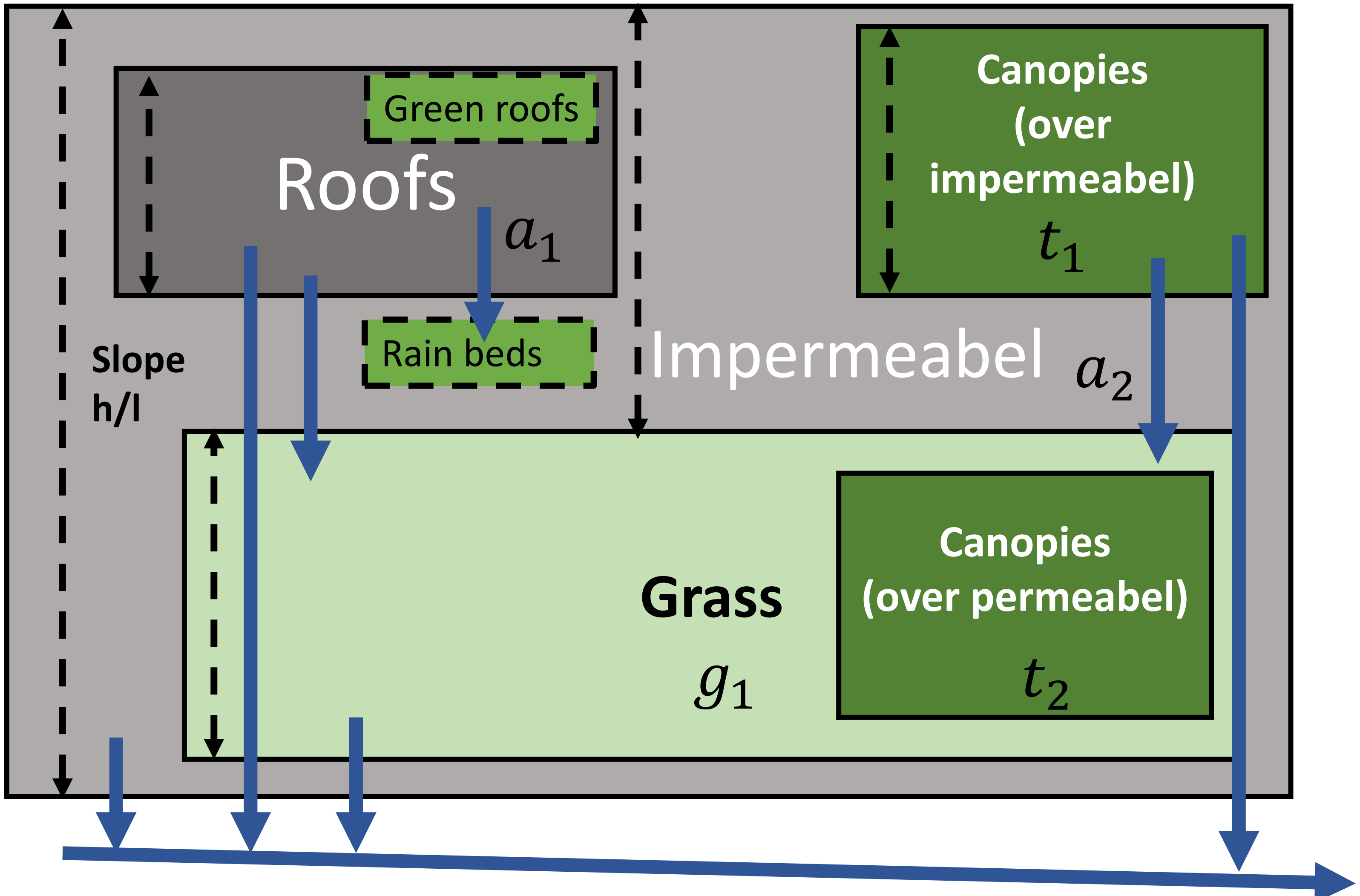

Roof
Permeable
Impermeable
Trees/permeable
Trees/impermeable
Links
Green roof
Rain bed
Terrain sink
Wadi
Partially-open surface
Land cover
LID measures
* Terrain slope
Annual rainfall
Rainfall recurrence interval
REO
Runoff model
Coefficients:
Runoff coeffs.
Manning numbers
* Network dist. to treatment
Cost model
Baseline costs:
Treatment cost
Network cost
Damage cost


OVERLØP
STEDEGNE MASSER

Single lot parameters and interlinks from remote sensing alone



Parameters and interlinks, combining remote sensing and information from owner



Rational formula and concentration time for plot elements

Dynamic concentration time:

- Mannings formel: $v = M \cdot R^{2/3} \cdot S^{1/2}$
- Combines with kinematic wave on rectangular sloping surfaces:
- $T_c = 7\left(\frac{L}{M\sqrt{S}}\right)^{3/5}(ci)^{-2/5}$
- c is runoff coefficient, i is precipitation intensity over by duration (D, set to T_c) (based on ASCE 1992)
- For this purpose IDF curves are approximated with a power formula, $i = mD^{-n}$ where D is set to T_c - this makes T_c solvable.

$$T_c = (mC^{-2.5})^{\frac{1}{-2.5+n}} \quad \text{where } C = 7\left(\frac{L}{M\sqrt{S}}\right)^{3/5} c^{-2/5}$$

- m and n are given by the frequency in the IDF curve

ASCE. (1992). Design and Construction of Urban Stormwater Management Systems. ASCE Manuals and Reports of Engineering Practice No. 77 . New York: American Society of Civil Engineers.

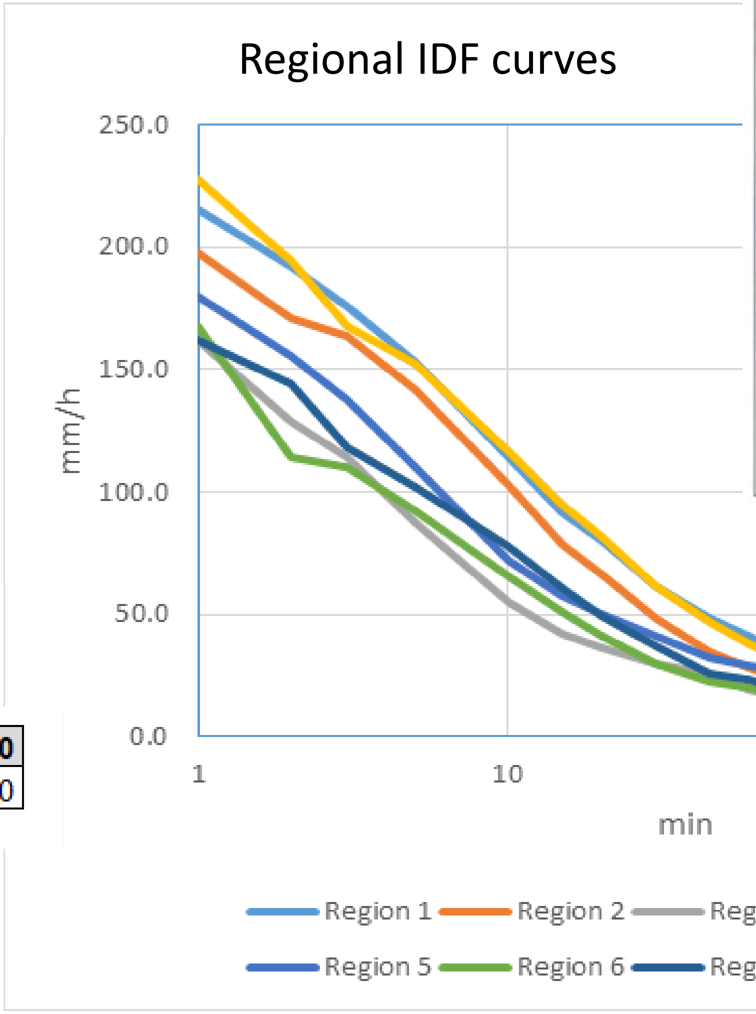
Parametrization of IDF curves

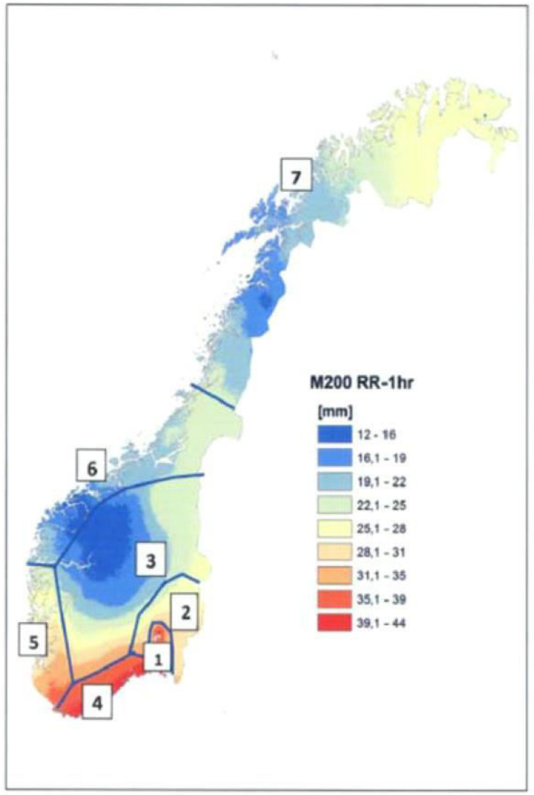
Piecewise parametrization of 200 year IDF curve

Region	m1 <5 min	n1 <5 min	m2 5 - 45 min	n2 5 - 45 min	m3 > 45 min	n3 > 45 min
1	218.8	0.210	371.8	0.525	944.9	0.714
2	198.6	0.201	433.3	0.646	445.0	0.687
3	165.2	0.374	206.3	0.567	295.8	0.606
4	228.7	0.258	389.7	0.540	567.7	0.670
5	185.5	0.299	261.0	0.549	261.9	0.530
6	160.3	0.359	280.1	0.651	157.6	0.528
7	166.6	0.297	305.6	0.623	319.2	0.658

Scaling the IDF curve to different return periods

Gjentaksintervall	2	5	10	20	25	50	100	200
Forholdstall	0.46	0.58	0.67	0.75	0.77	0.85	0.92	1.00





Surface storm water costs

Network costs — **Plant capacity** — **Treatment** — **Environmental costs**

$$p_j = K_{li} * \frac{l_j * Q_j}{\sum_1^N (l_j * Q_j)} + K_{ri} * \frac{Q_j}{\sum_1^N Q_j} + k_{rd} * Q_j + k_m * f * Q_j$$

j : Lot number

p_j : proposed fee for lot j

l_j: distance to plant

Q_j : surface water contribution for lot j

K_{li}: annual investments in increased network capacity

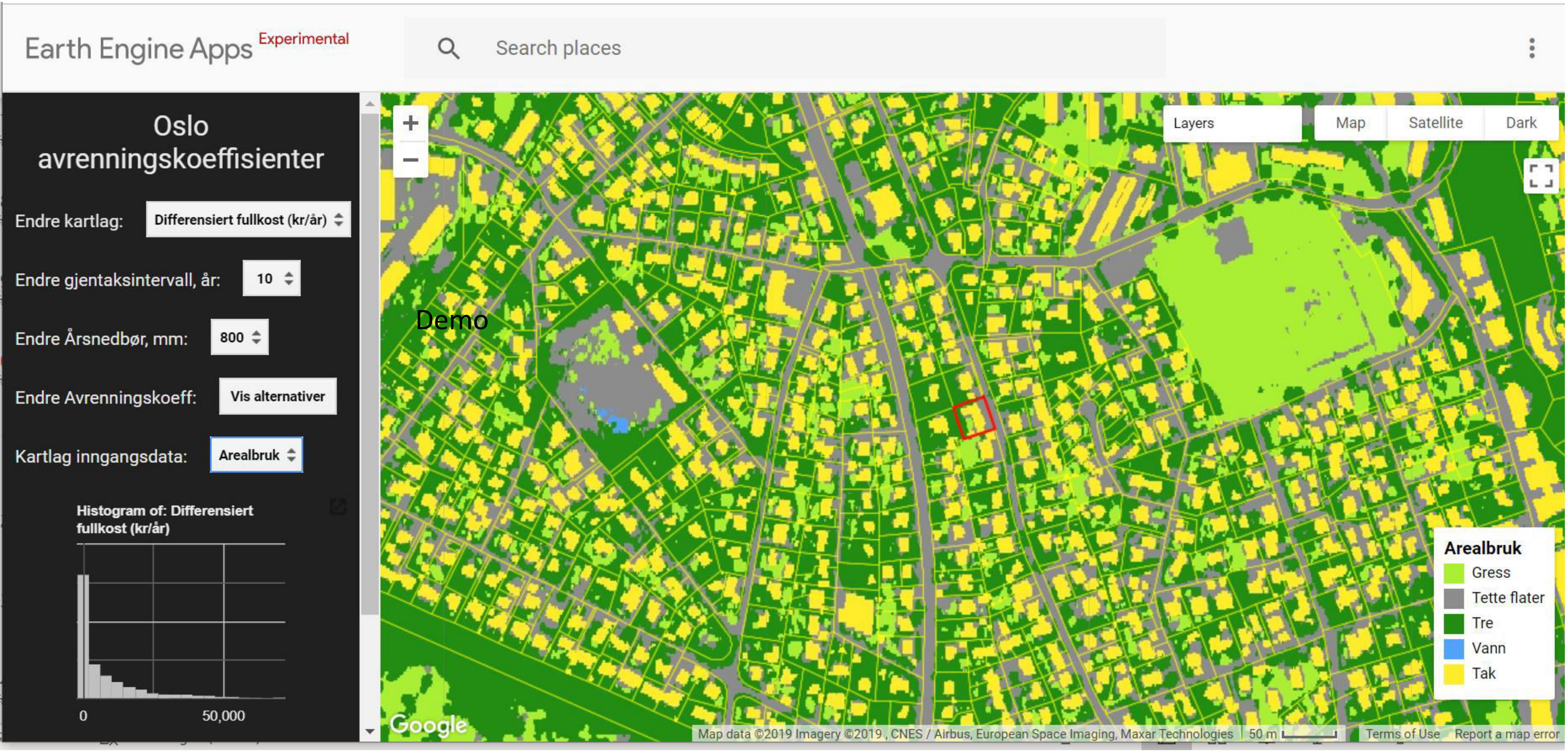
K_{ri} annual investments in increased plant capacity

k_{rd} unit treatment costs

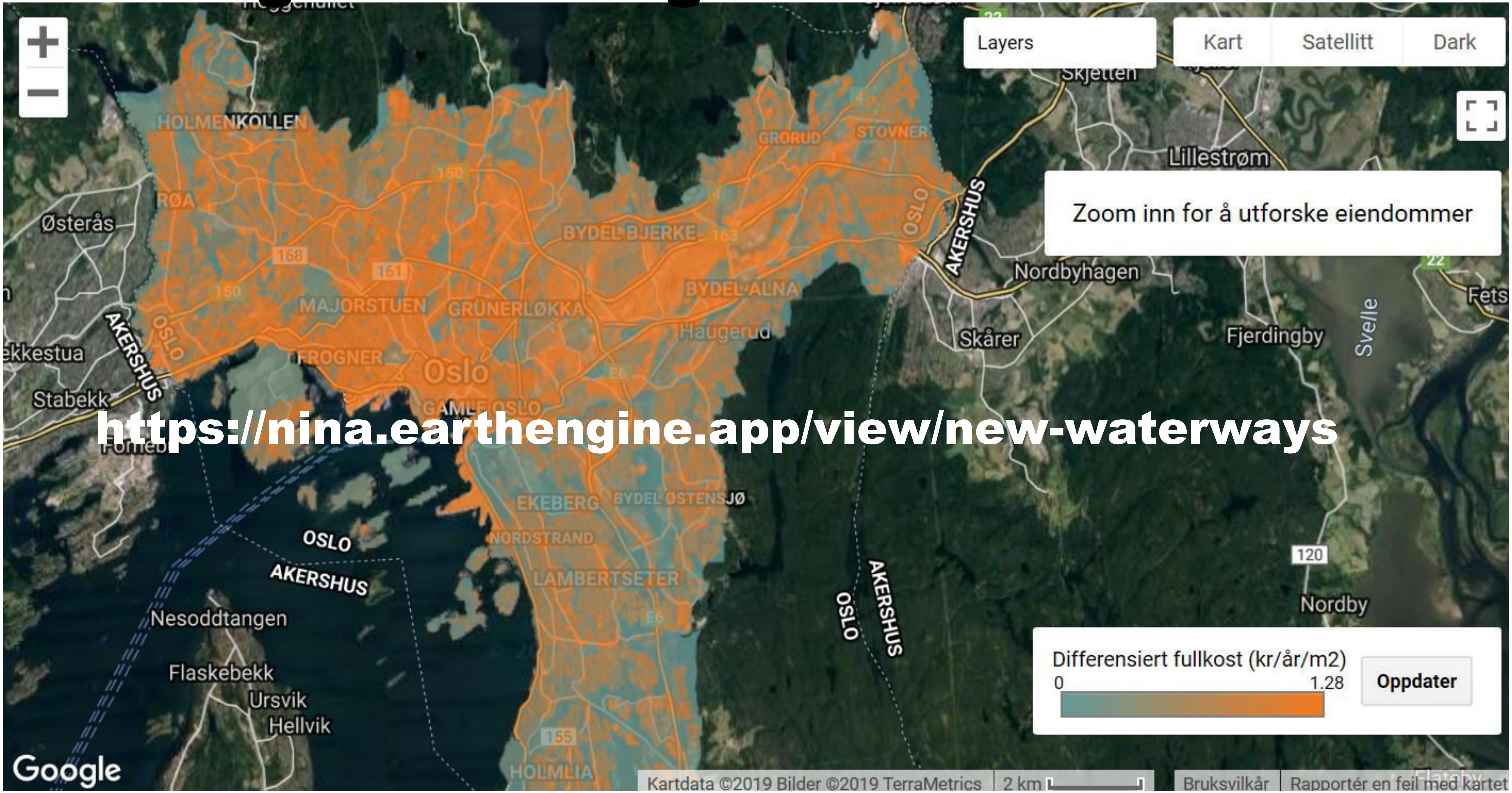
k_m unit environmental costs

f: part of surface storm water triggering CSO

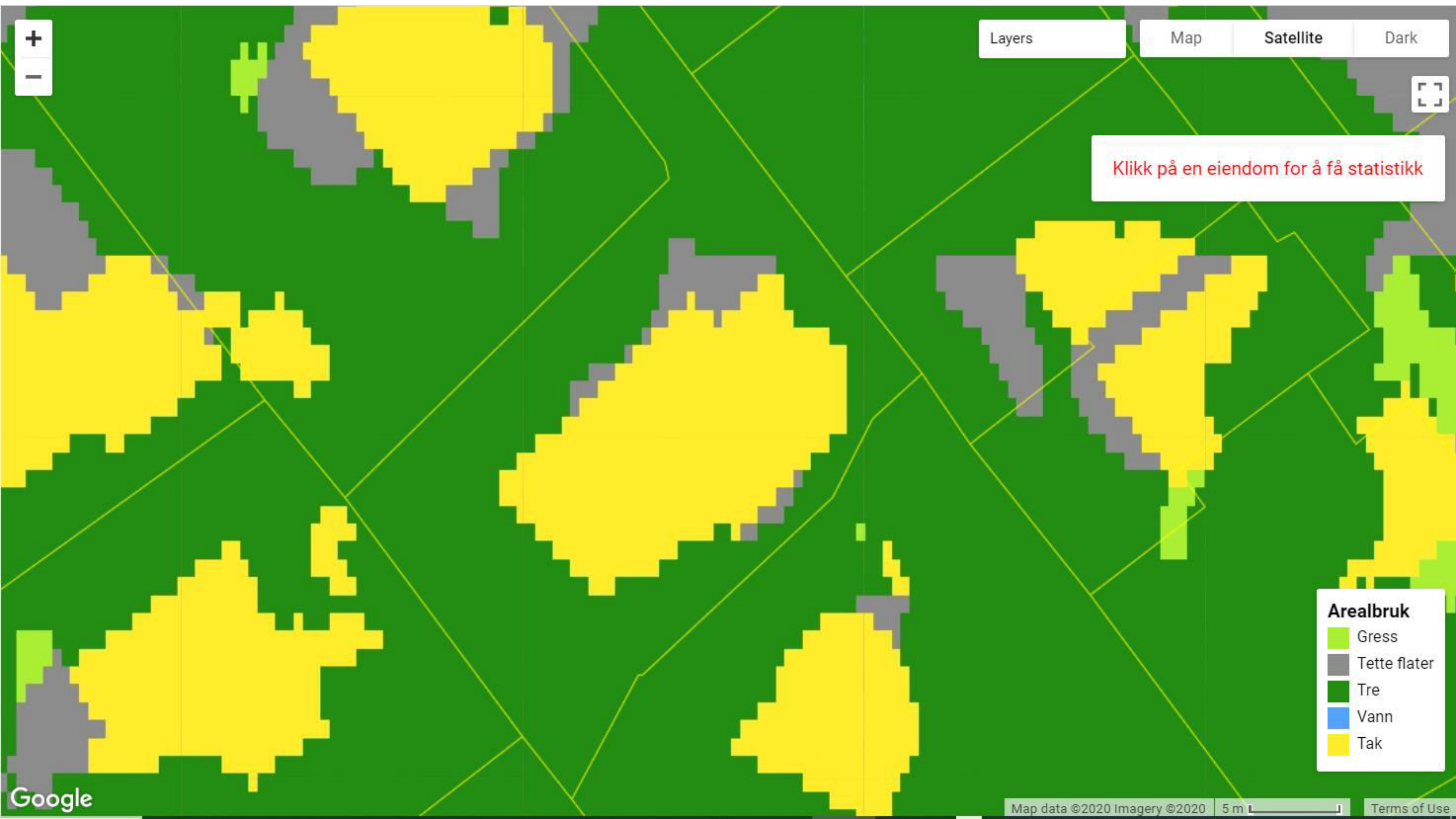
Demonstration app combining GIS and hydrological model



Fordeling av fremtidig full kost: 0.75 kr/år m^2

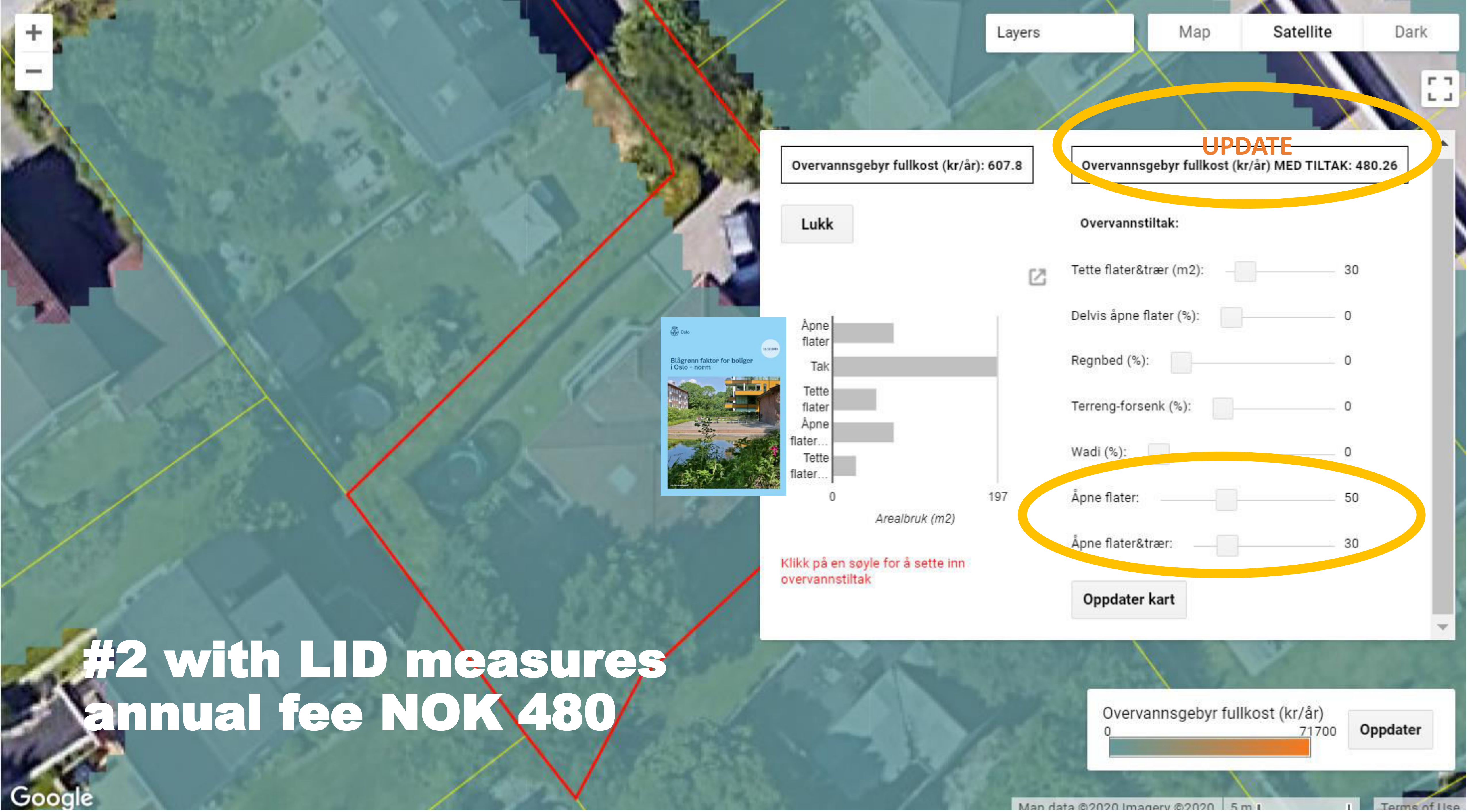


https://nina.earthengine.app/view/new-waterways



Layers
Map
Satellite
Dark
Klikk på en eiendom for å få statistikk
Arealbruk
Gress
Tette flater
Tre
Vann
Tak
Google
Map data ©2020 Imagery ©2020
5 m
Terms of Use

#1 basic fee (not considering LID) annual fee NOK 607


Layers
Map
Satellite
Dark
UPDATE
Overvannsgebyr fullkost (kr/år): 607.8
Overvannsgebyr fullkost (kr/år) MED TILTAK: 480.26
Lukk
Overvannstiltak:
Tette flater&trær (m2): 30
Delvis åpne flater (%): 0
Regnbed (%): 0
Terreng-forsenk (%): 0
Wadi (%): 0
Åpne flater: 50
Åpne flater&trær: 30
Oppdater kart
Blågrønn faktor for boliger i Oslo – norm
Åpne flater
Tak
Tette flater
Åpne flater...
Tette flater...
0
197
Arealbruk (m2)
Klikk på en søyle for å sette inn overvannstiltak
Overvannsgebyr fullkost (kr/år)
0
71700
Oppdater
#2 with LID measures
annual fee NOK 480
Google
Map data ©2020 Imagery ©2020
5 m
Terms of Use

Conclusions

- Technically and administratively feasible
- As insentive - economically low compared with the costs of installing LID measures, has to be combined with investment support or similar
- Psykologically: Users are in general positive to LID measures, but negative to «new» fees

Thank you for your attention!

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