Een kosteneffectieve optimalisatie tool voor de verdeling van blauw-groene infrastructuur ter mitigatie van het hitte eiland effect.

Louden Kremer

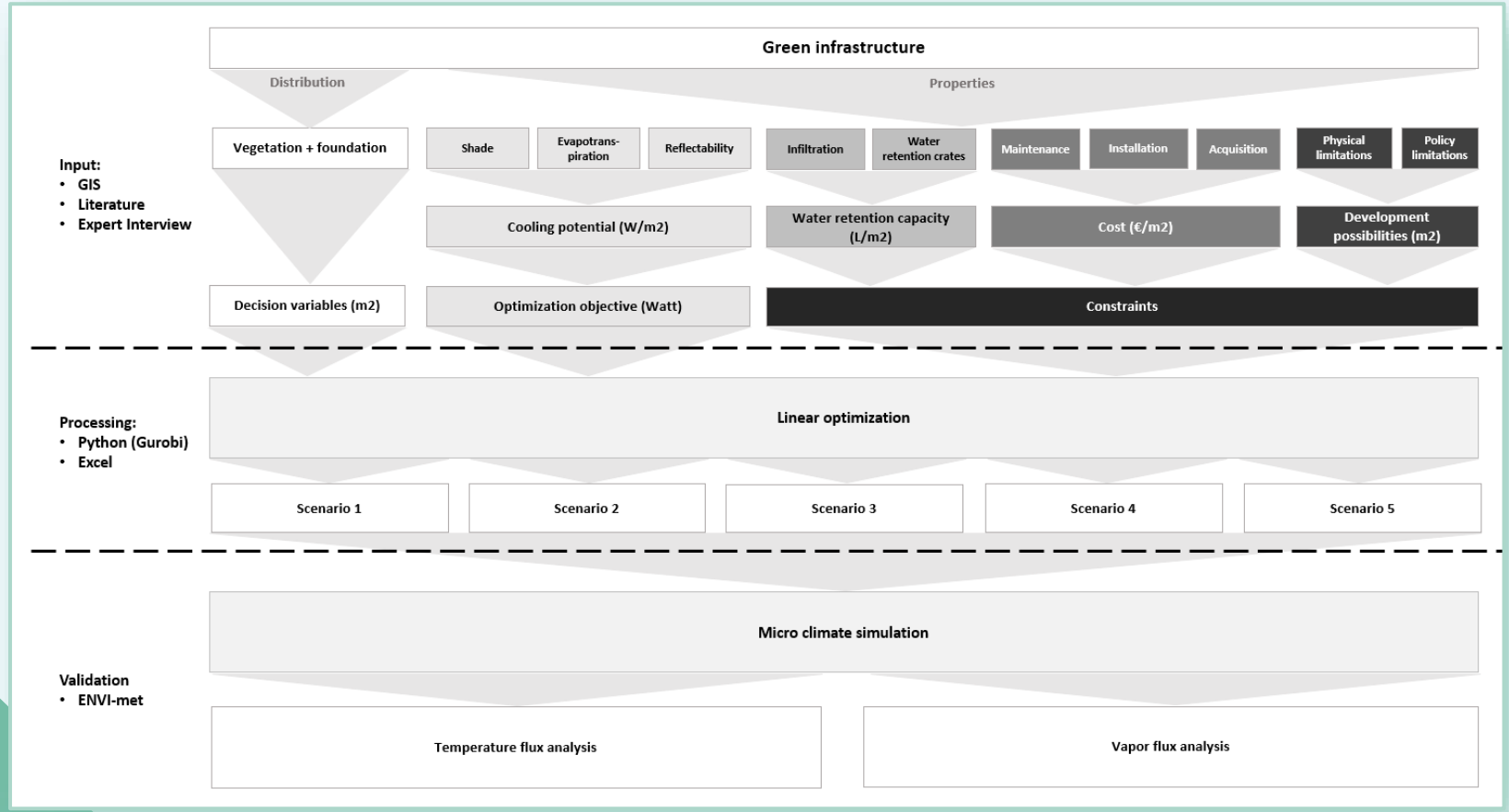
Supervised by:
Alessio Belmondo Bianchi Di Lavagna
Joris Voeten
Joeri Willet

Kennisleemte

“In the current practice, optimal selection of GI (Green Infrastructure) practices for such areas are generally conducted based on expert judgement, and there are no systematic methodologies currently available for this process” *(Jayasooriya et al., 2020).*

- Planning Support System (PSS)
- Onderbouwde keuzes
- Vooroordelen verminderen
- Communicatie methode

Conceptueel raamwerk



Belangrijkste aannames

- Wegenplan volgens concept C, type groen flexibel
- Energiebalans
- Gebasseerd op een warme/droge zomerse dag. Geen verdamping zonder extra waterretentie.
- Top-down benadering

Keuze variabelen

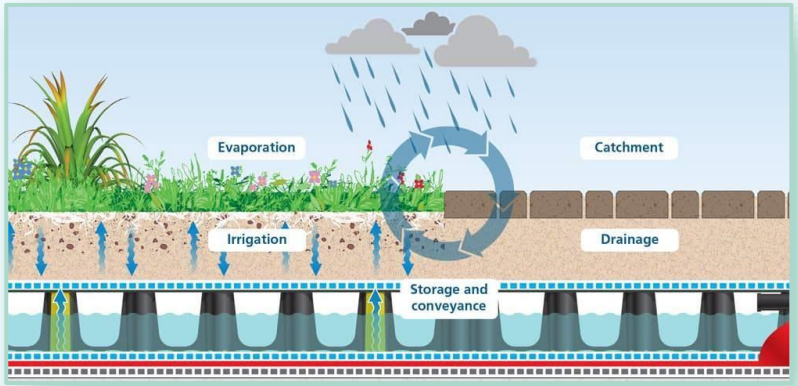
1. Gras
2. Gemengde haag
3. Meerjarige grassen/kruiden
4. Stedelijke boom
5. Groene parkeerplaats
6. Groene gevel





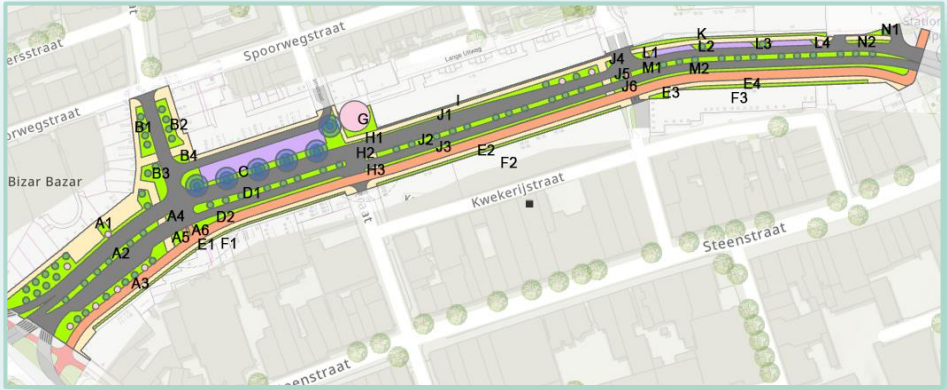

Keuze variabelen

1. Permavoid system



2. Doorwortelbare ruimte

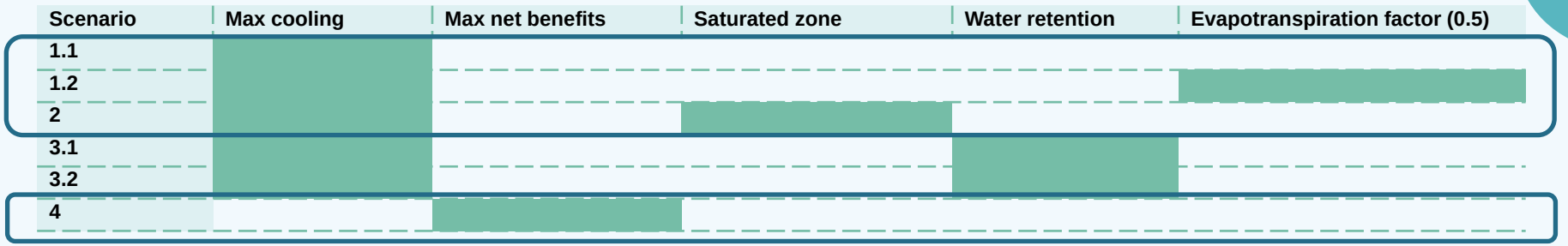
Input data



Zone	Area (M2	Grass (A)	Grass + RET (AY)	Mixed hedge (B)	Mixed hedge + RET (BY)
A1	414	400	400	400	400
A2	155	155	155	155	155
A3	294	269	269	269	269
A4	7	7	7	7	7
A5	27	27	27	27	27
A6	4	4	4	4	4
A7	23	23	23	23	23
B1	114	114	114	114	114

Code:		Cost (acquisition + installation) (€/m2)	Maintenance (€/m2/year)	Shading (W/m2)	Evapotranspiration (W/m2) (summer	Additional Reflection (W/m2)	Total cooling effect (W/m2
F	Green Façade	400	2,81	0	0	45	45
FXY	Green Façade + DWR + RET	400	2,81	0	188	45	234
A	Grass	5	1	0	0	40	40
AY	Grass + RET	85	1	0	170	40	210
B	Mixed hedge	73	0,88	0	0	45	45
BY	Mixed hedge + RET	153	0,88	0	188	45	234
C	Perennial planting	20	0,88	0	0	21	21
CY	Perennial planting + RET	100	0,88	0	209	21	231
D	Remaining tree	0	0	89	124	0	212
EX	Tree + DWR	127	2,12	89	0	17	149
EXY	Tree + DWR + RET	162	2,12	89	124	17	323
G (K, KX)	Open paving patterns	135	0,22	0	0	20	20
GY (KY)	Open paving patterns + RET	150	0,22	0	85	20	105
GXY (KXY)	Open paving patterns + DWR + RET	170	0,22	0	85	20	105

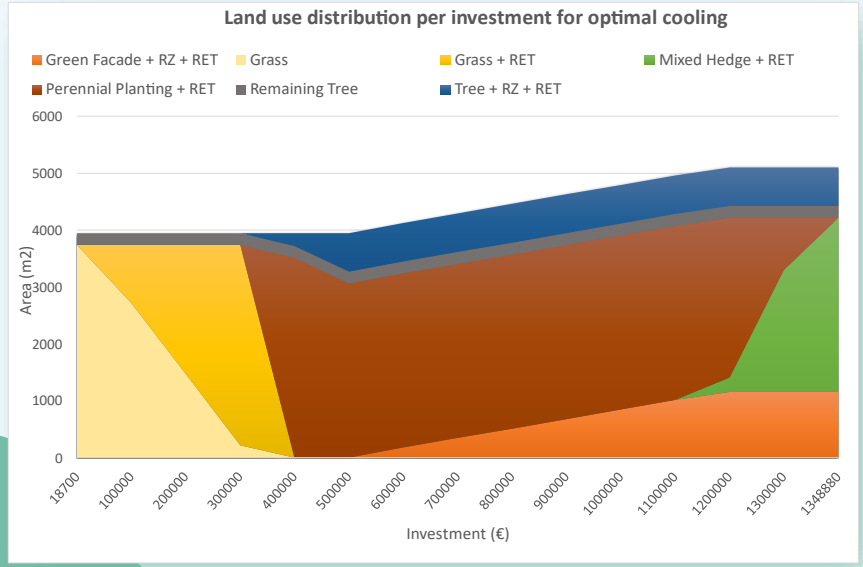
Scenario’s


Scenario
Max cooling
Max net benefits
Saturated zone
Water retention
Evapotranspiration factor (0.5)
1.1
1.2
2
3.1
3.2
4

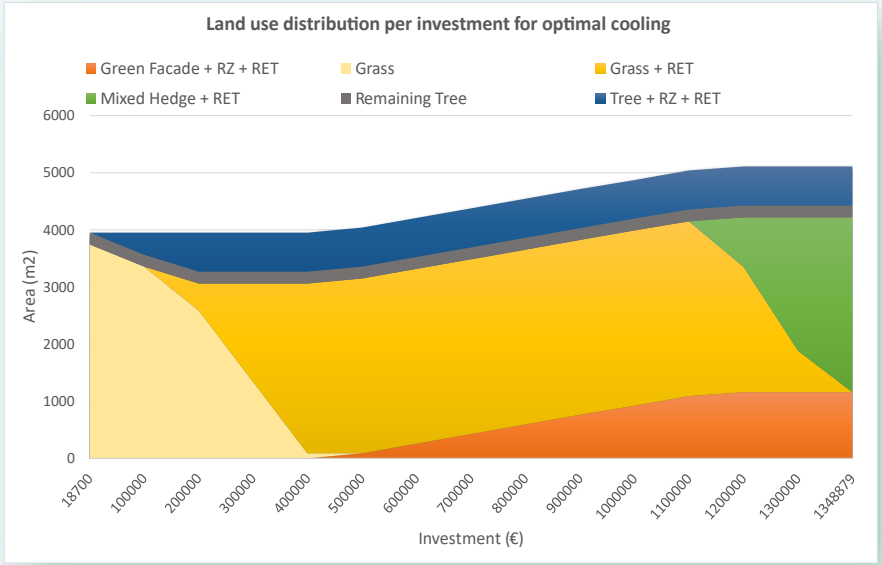
Scenario 1

Scenario	Max cooling	Max benefits	Max net benefits	Saturated zone	Water retention	Evapotranspiration factor (x0.5)
1.1						
1.2						

1.1



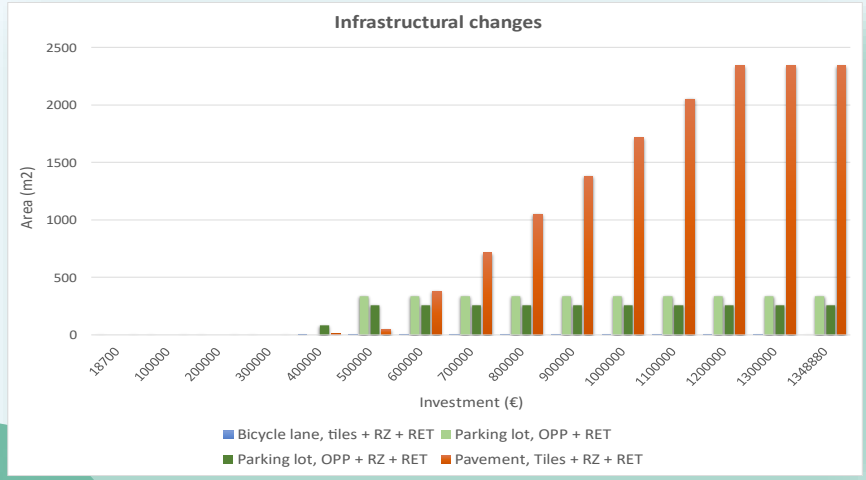
1.2



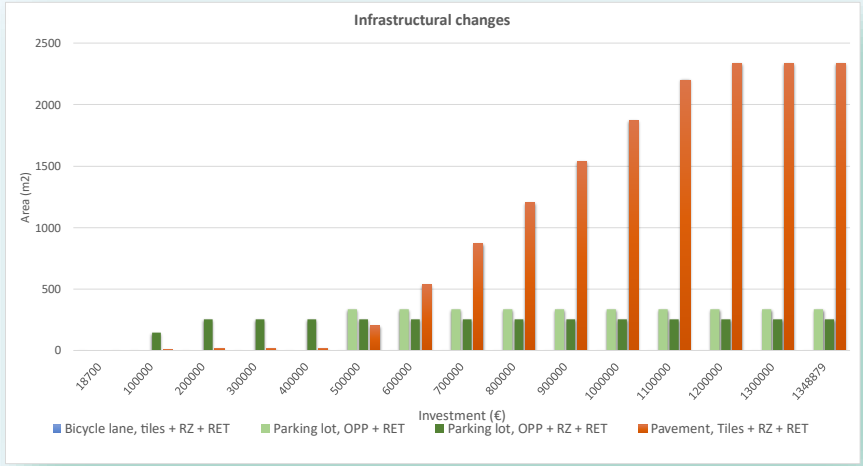
Scenario 1

Scenario	Max cooling	Max benefits	Max net benefits	Saturated zone	Water retention	Evapotranspiration factor (x0.5)
1.1						
1.2						

1.1



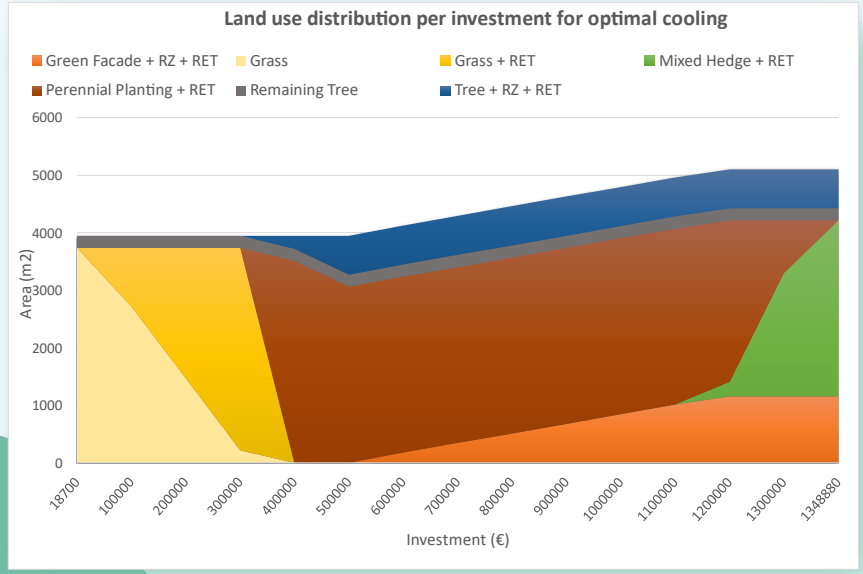
1.2



Scenario 2

Scenario	Max cooling	Max benefits	Max net benefits	Saturated zone	Water retention	Evapotranspiration factor (x0.5)
1.1						
2						

1.1



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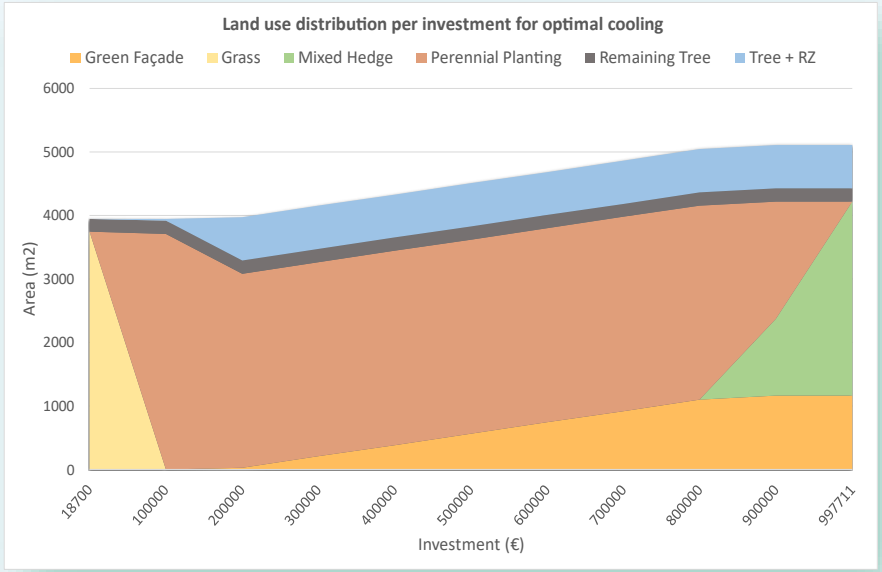
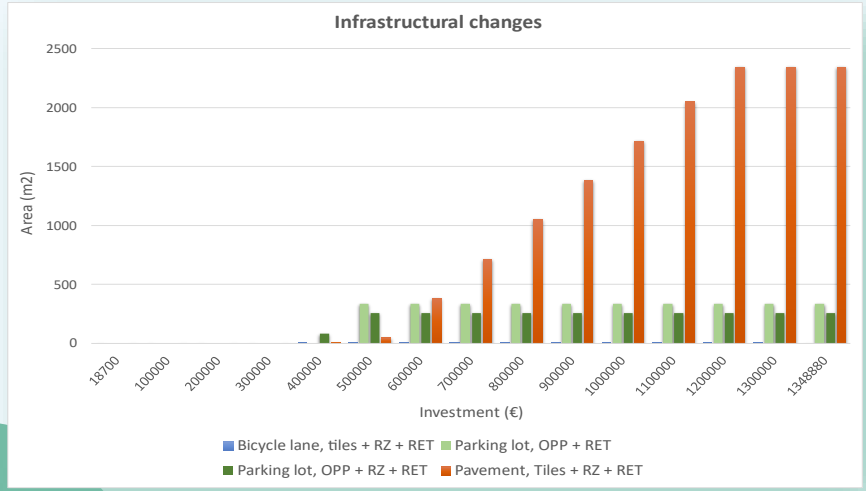


Scenario 2

Scenario	Max cooling	Max benefits	Max net benefits	Saturated zone	Water retention	Evapotranspiration factor (x0.5)
1.1						
2						

1.1



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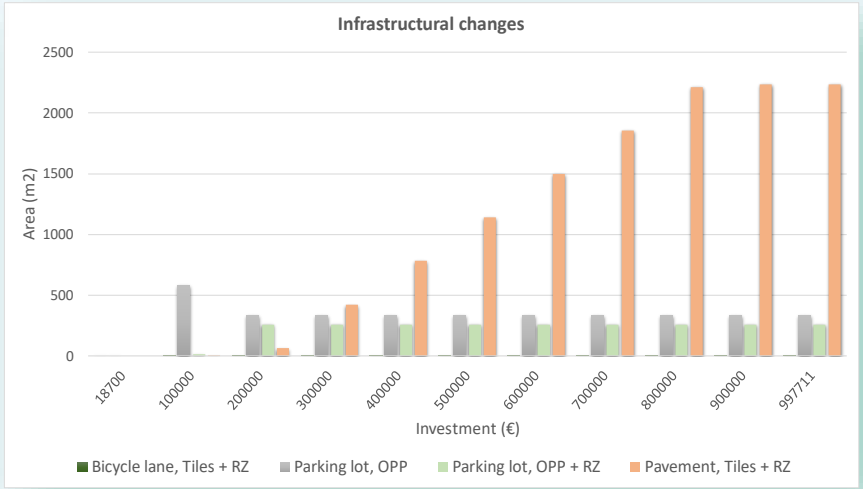
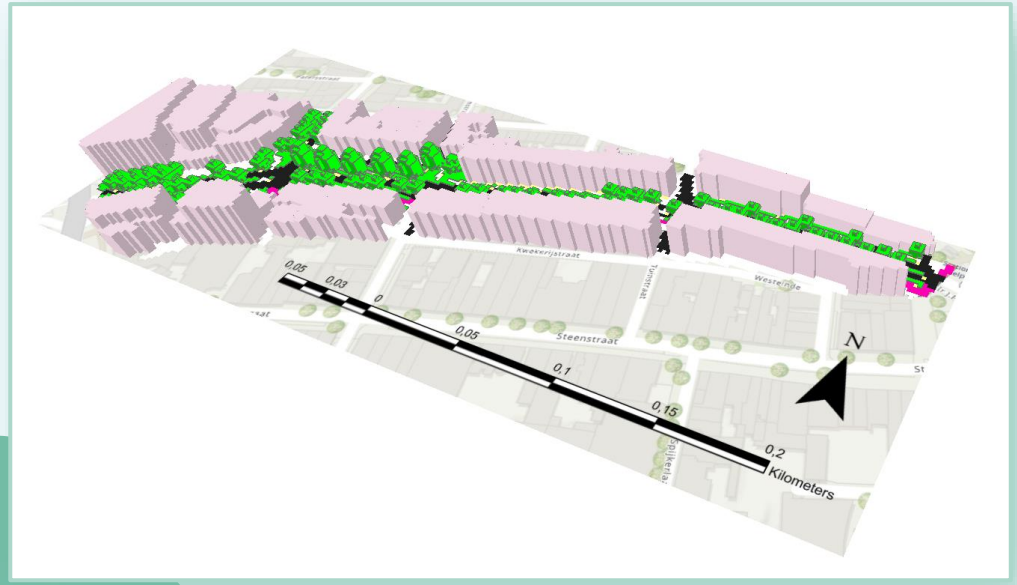
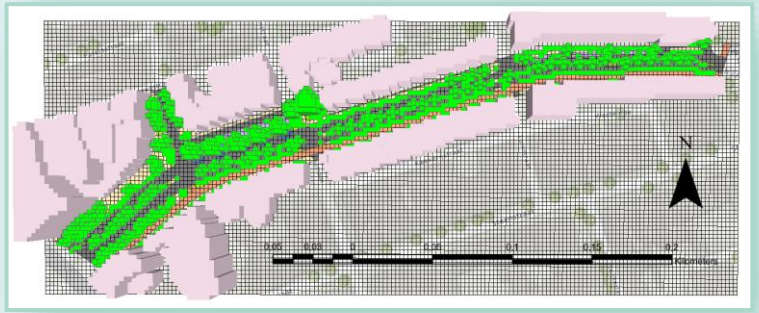


Microklimaat simulatie

Scenario	Max cooling	Max benefits	Max net benefits	Saturated zone	Water retention	Evapotranspiration factor (x0.5)
1.1						
2						

ENVI-met

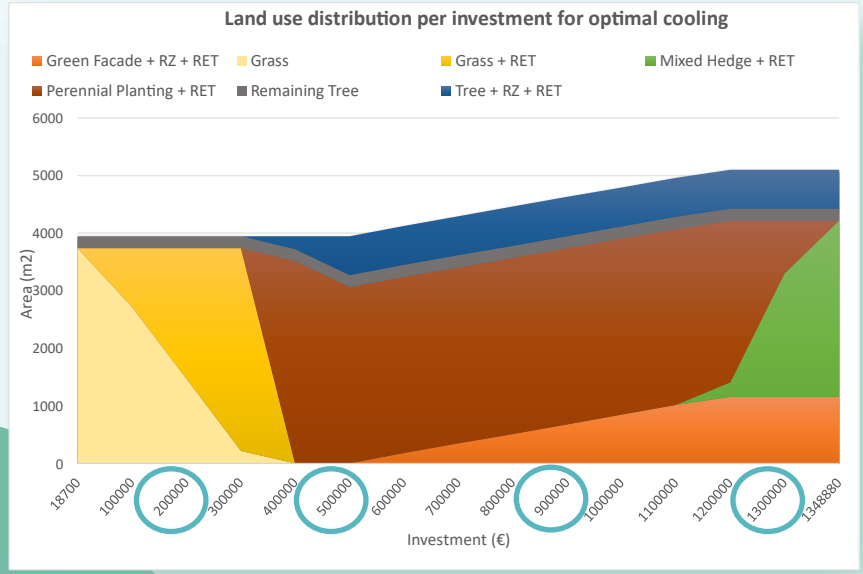




Simulatie

Scenario	Max cooling	Max benefits	Max net benefits	Saturated zone	Water retention	Evapotranspiration factor (x0.5)
1.1						
2						

1.1



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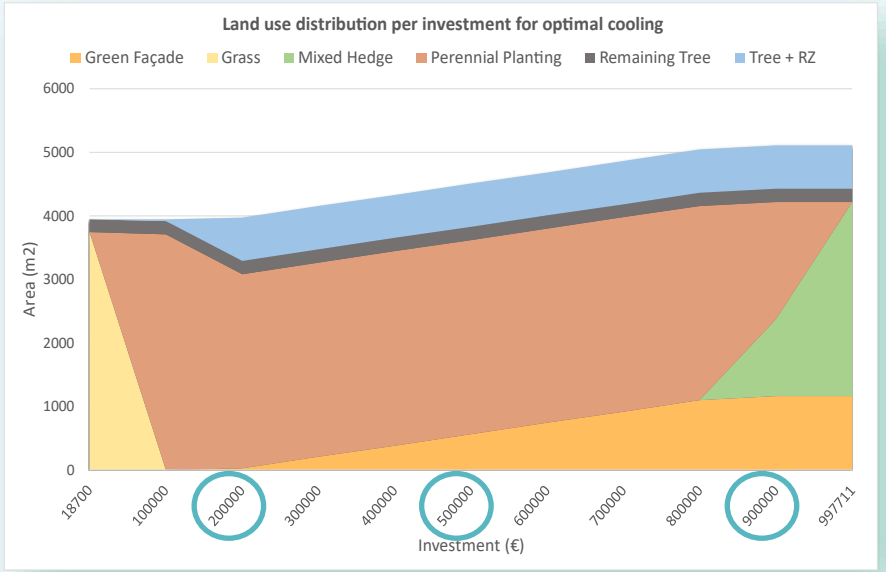
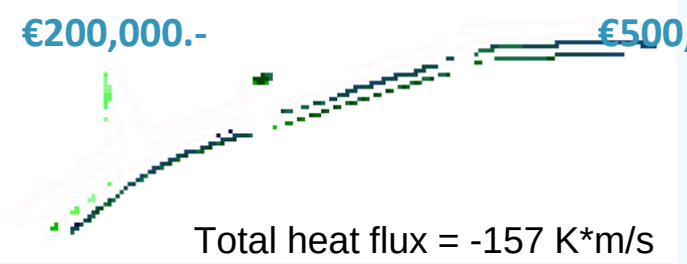


Simulatie

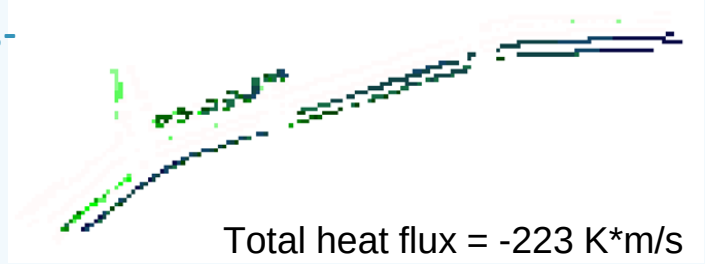
Scenario 1: Heat flux (K*m/s)

€200,000.-



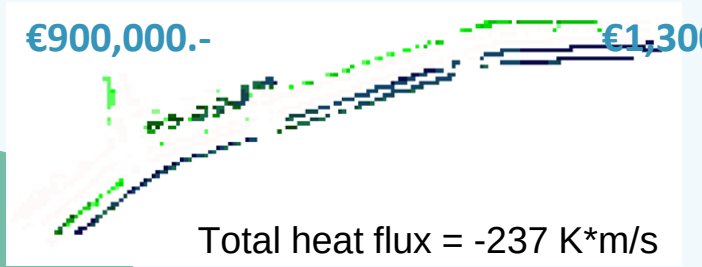
Total heat flux = -157 K*m/s

€500,000.-



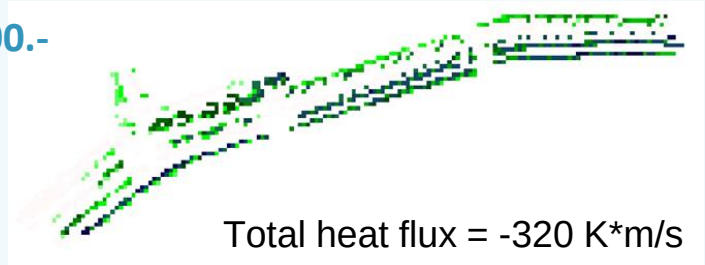
Total heat flux = -223 K*m/s

€900,000.-

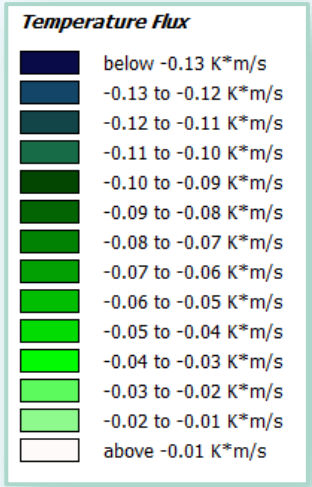


Total heat flux = -237 K*m/s

€1,300,000.-



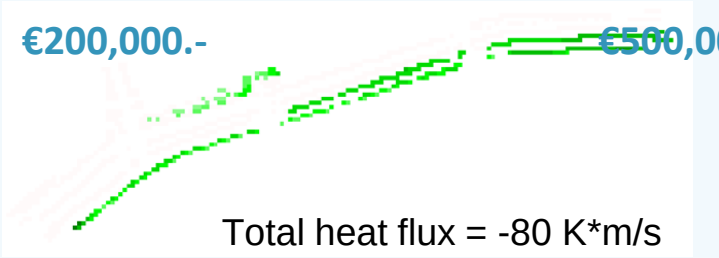
Total heat flux = -320 K*m/s



Simulatie

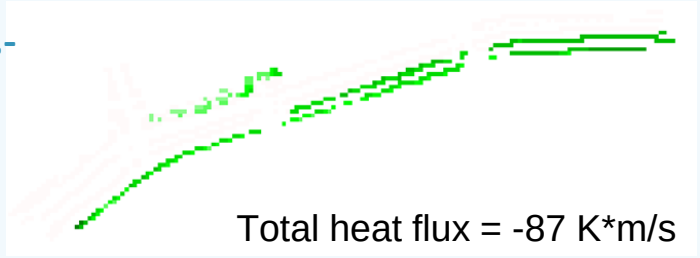
Scenario 2: Heat flux (K*m/s)

€200,000.-



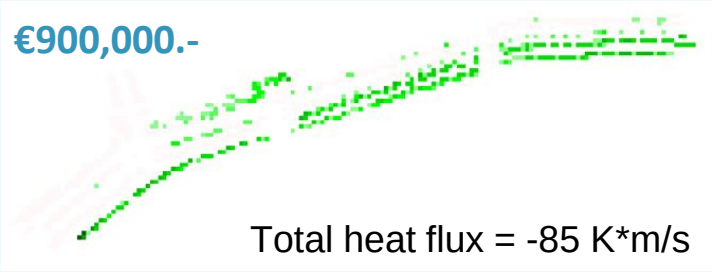
Total heat flux = -80 K*m/s

€500,000.-

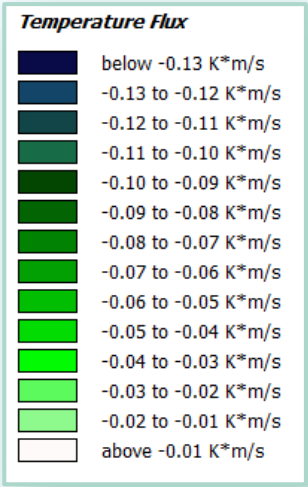


Total heat flux = -87 K*m/s

€900,000.-



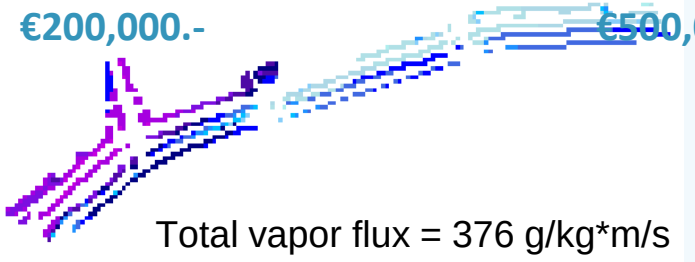
Total heat flux = -85 K*m/s



Simulatie

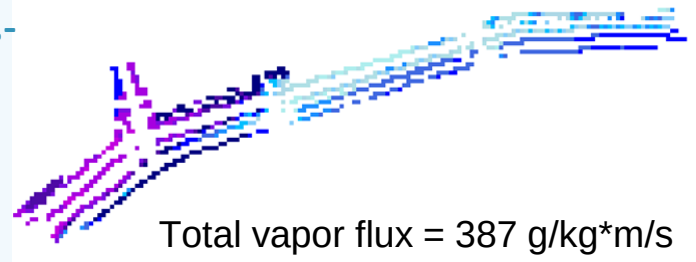
Scenario 1: Vapor flux (g/kg*m/s)

€200,000.-



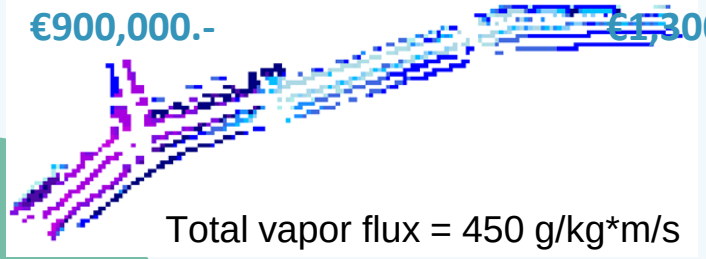
Total vapor flux = 376 g/kg*m/s

€500,000.-



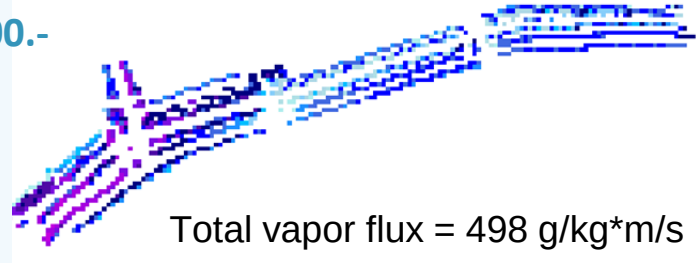
Total vapor flux = 387 g/kg*m/s

€900,000.-

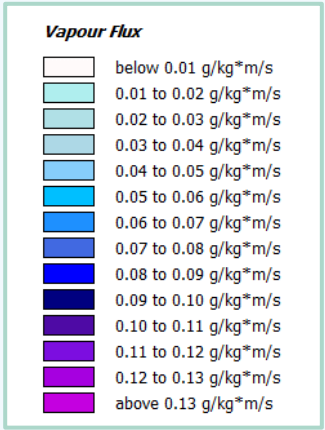


Total vapor flux = 450 g/kg*m/s

€1,300,000.-



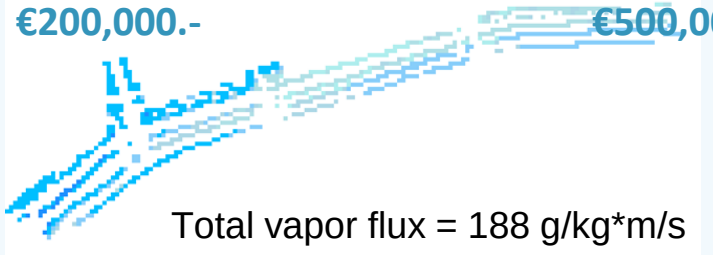
Total vapor flux = 498 g/kg*m/s



Simulatie

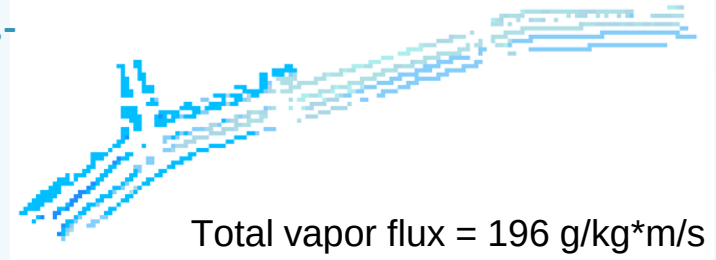
Scenario 2: Vapor flux (g/kg*m/s)

€200,000.-



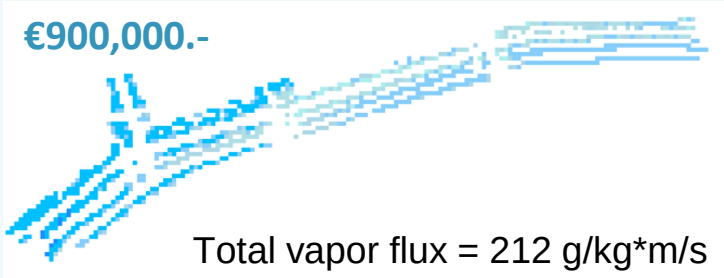
Total vapor flux = 188 g/kg*m/s

€500,000.-

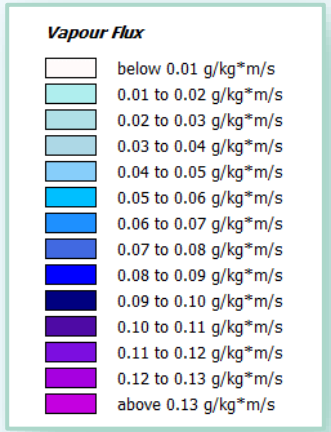


Total vapor flux = 196 g/kg*m/s

€900,000.-



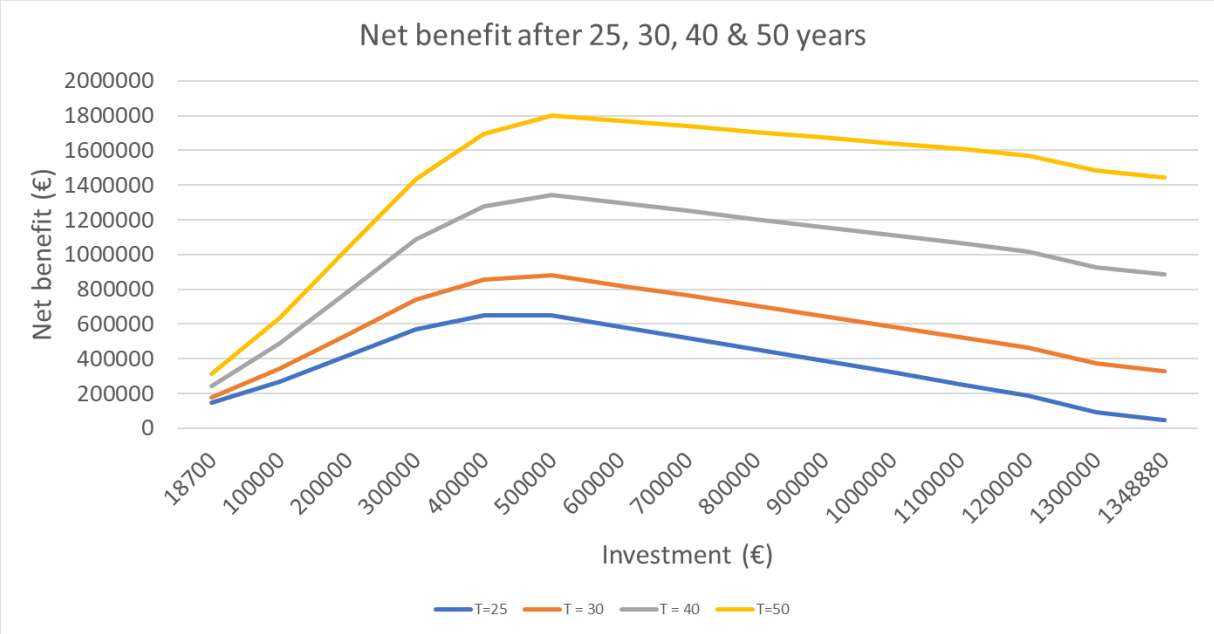
Total vapor flux = 212 g/kg*m/s



Scenario 4

Scenario	Max cooling	Max benefits	Max net benefits	Saturated zone	Water retention	Evapotranspiration factor (x0.5)
4						

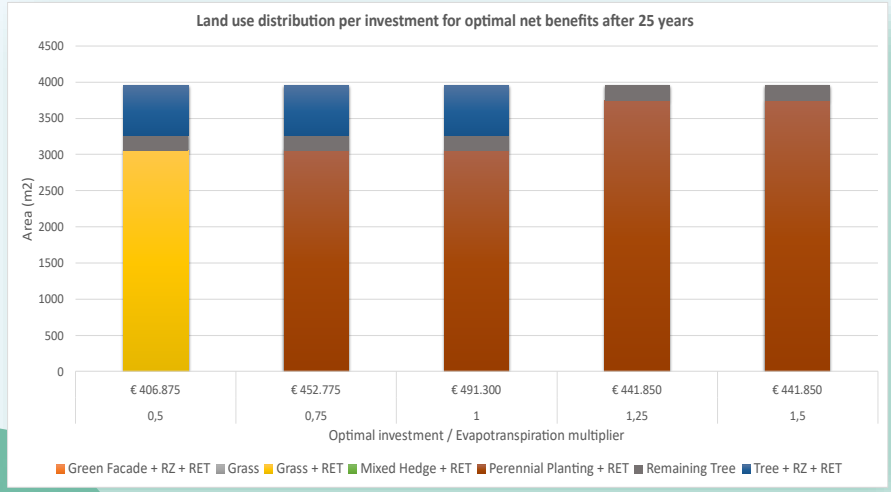
$$Net\ benefit = T * (Benefit\ cooling + Benefit\ water\ retention - Maintenance\ costs\ ) - investment\ costs$$

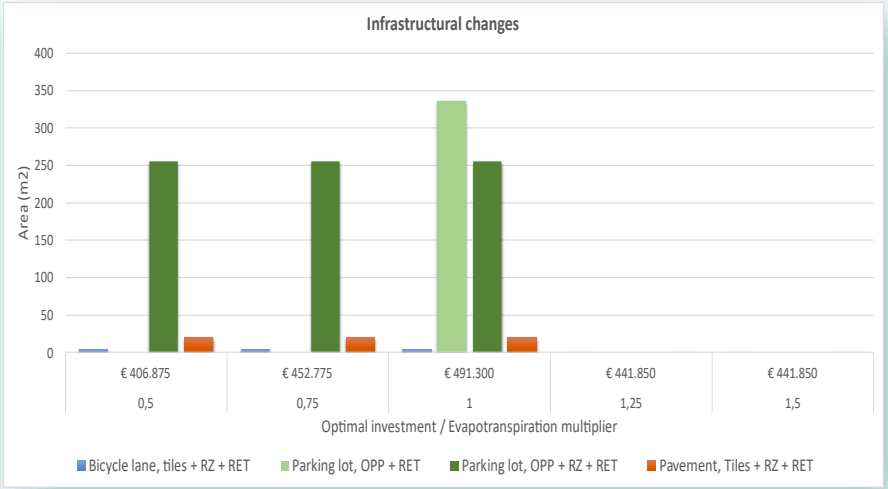


Gevoeligheidsanalyse

Scenario	Max cooling	Max benefits	Max net benefits	Saturated zone	Water retention	Evapotranspiration factor (x0.5)
5						

The optimal distribution with an uncertain evapotranspiration





Discussie/limitatie

1. De tool is gebasseerd op aannames
2. Sommige kaders zijn specifiek tot Arnhem

3. De gemengde haag heeft een groter effect op de heat flux dan verwacht.
4. Het atmosferisch verkoelend effect van een groene gevel is minimaal.
5. Wanneer verdamping een minder grote rol speelt zijn meerjarige grassen/kruiden minder effectief.

6. De tool heeft zeker waarde als startpunt van discussie voor een ontwikkeling.
7. Er zijn slechts enkele keuze variabelen gekozen, de gemeente miste heesters.
8. In deze vorm met name geschikt voor interne communicatie, hoewel de boodschap extern ook waardevol is.

Conclusies

1. De tool kan op een objecieve manier de optimale verdeling van BGI berekenen per investering.
2. De simulatie valideert deels de input data betreft investeringen en verkoelend effect.
3. De tool kan een rol spelen in de interne communicatie/ startpunt van discussie.

“There is no green design without a blue design”

Follow-up research

- Input verder valideren, meer kwantitatieve data vergaren (iterair proces ENVI-met).
- Neem ook andere relevante factoren mee (groeiperiode, de windflux).
- Neem andere ecosysteemvoordelen mee in de kostenbaten functie.
- Verbeter de communicatiemethode

Thank you for your attention

Are there any questions?