Evolutionary Computing for Multi-Objective Spatial Optimisation

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Prof. Richard Dawson

Background

- Need to move towards more Resilient and Sustainable Urban areas.

- Conflicting Sustainability Objectives

- Need for localized evidence

- Analytical appreciation of trade-offs.

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- Need to move towards more Resilient and Sustainable Urban areas.

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Table 1. Examples of Potential Conflicts between Risk and Sustainability efforts (adapted from Dawson, 2011)

Response	Potential Benefit	Potential Negative Impact
Urban Densification	Reduce public transport emissions and better accessibility	Increased urban heat islands and surface run off responsible for flooding
Air conditioning	Reduced heat stress	Increases energy use and consequently emissions
Raising flood defences	Reduce flood frequency	Encourages development in riskier areas
Dispersed development	Reduce flood damage and better quality of life	Increased private vehicle emissions

Dawson, R. J. (2011). "Potential pitfalls on the transition to more sustainable cities and how they might be avoided." Carbon Management, 2(2), 175–188.

Background

- Need to move towards more resilient

And sustainable urban areas.

- Conflicting Sustainability Objects

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Spatial Optimisation Framework

- Simultaneous Optimization of multiple Sustainability Objectives

- Evolutionary Approach
  - Selection
  - Crossover
  - Mutation

- Pareto-optimal Spatial Plans
  - Domination

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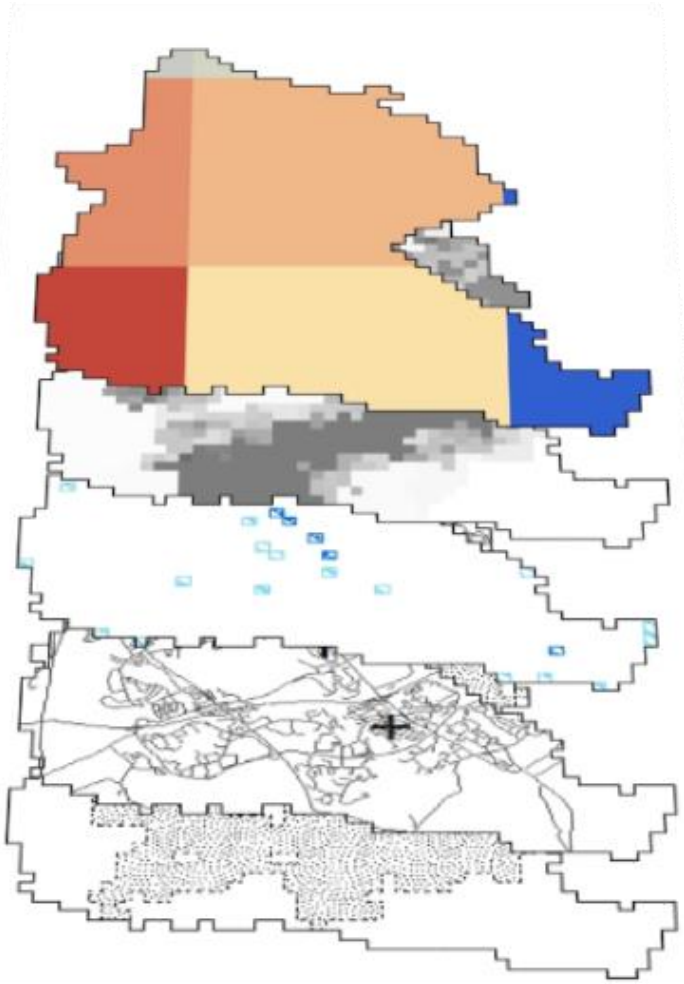

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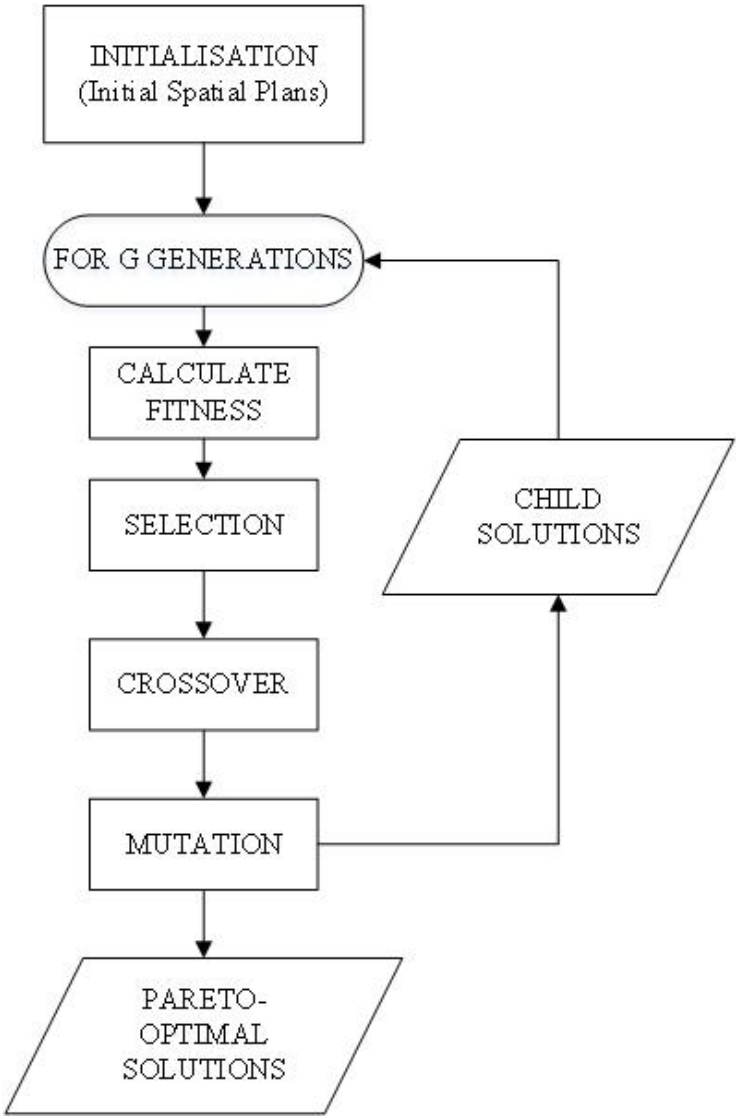

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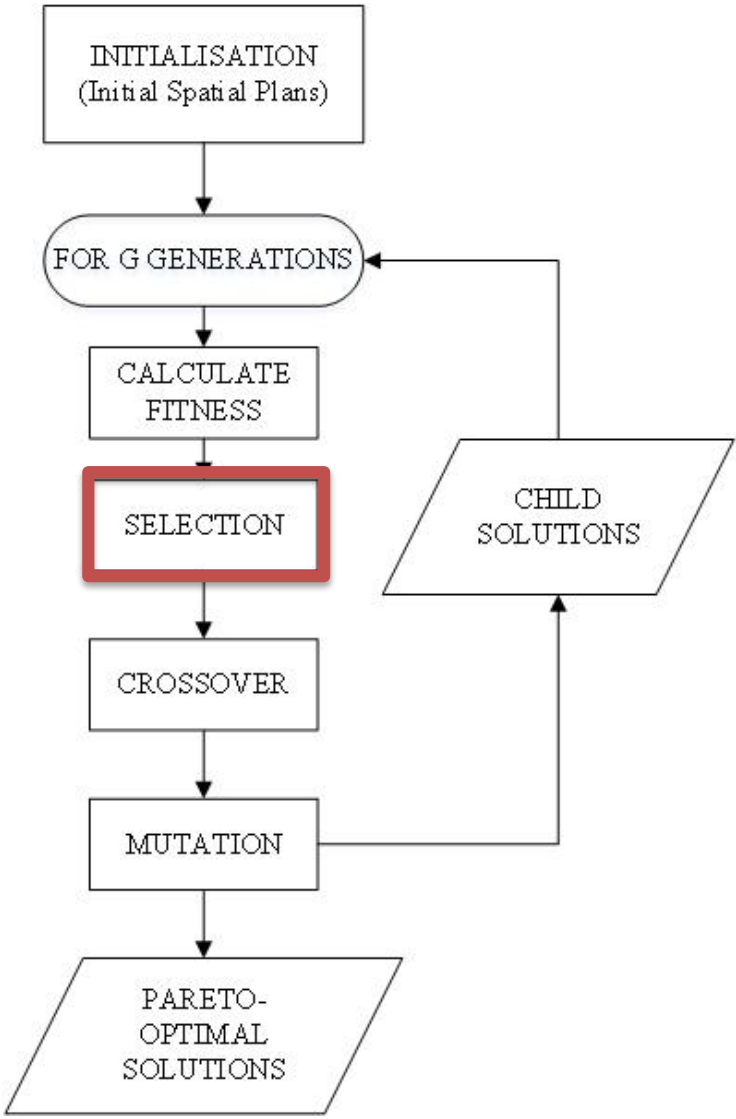
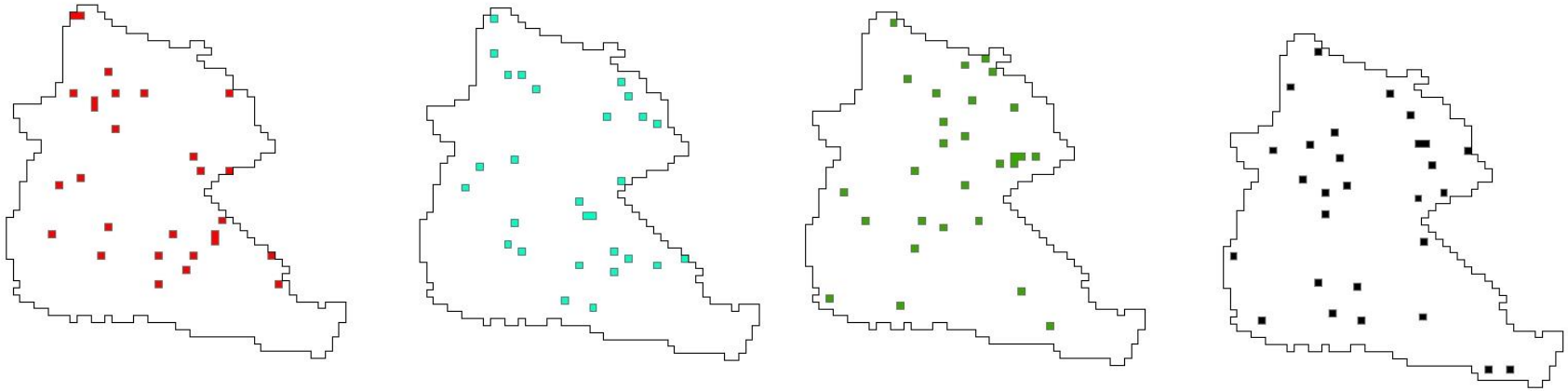
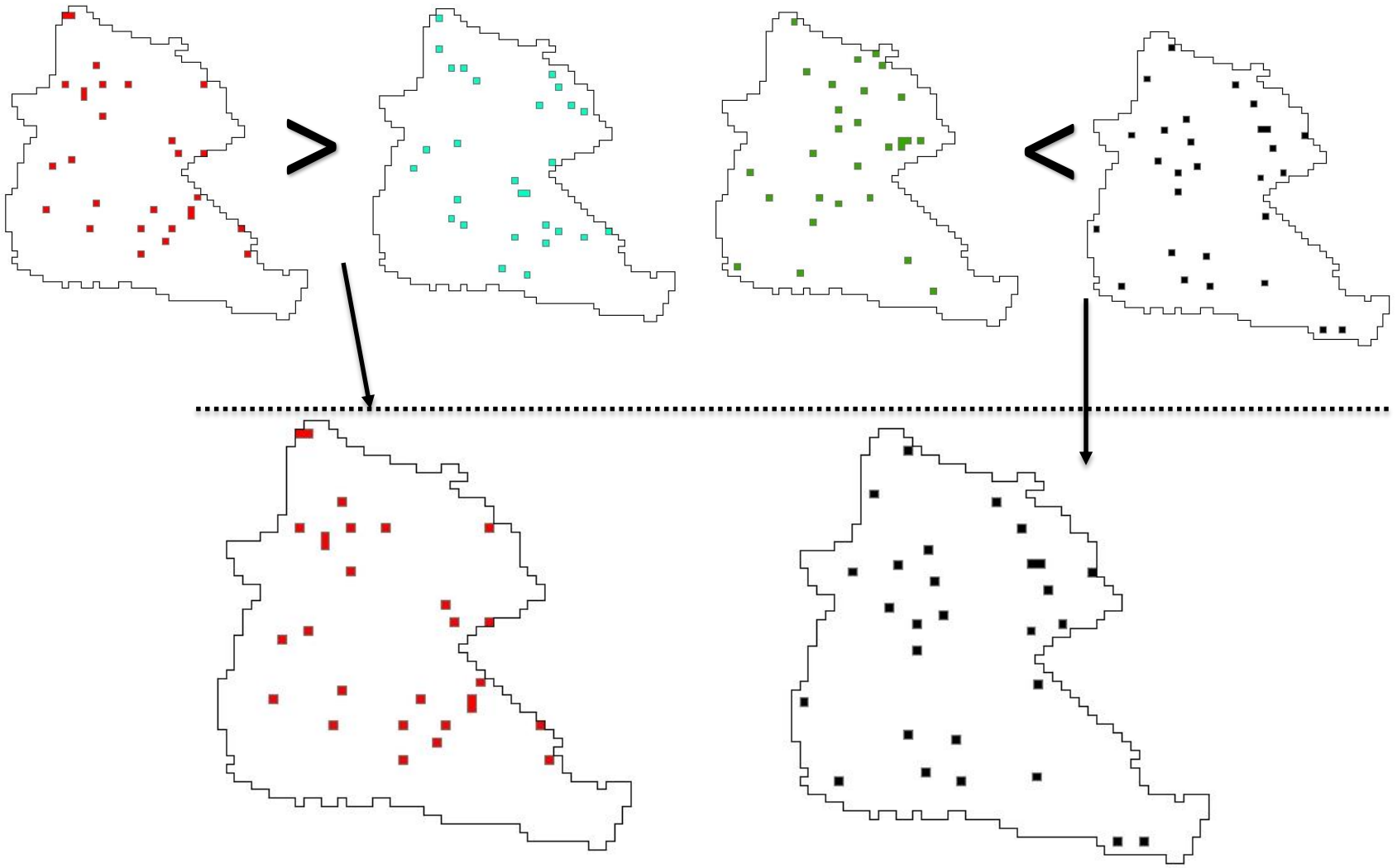


Selection Operator



Selection Operator



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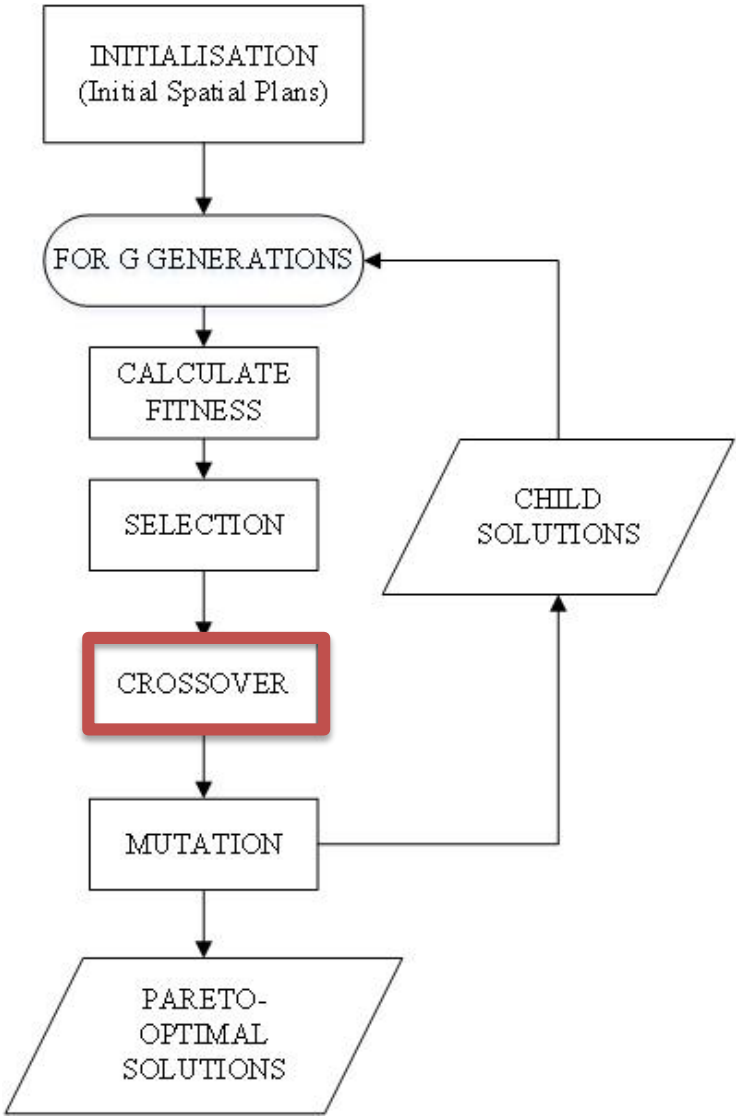

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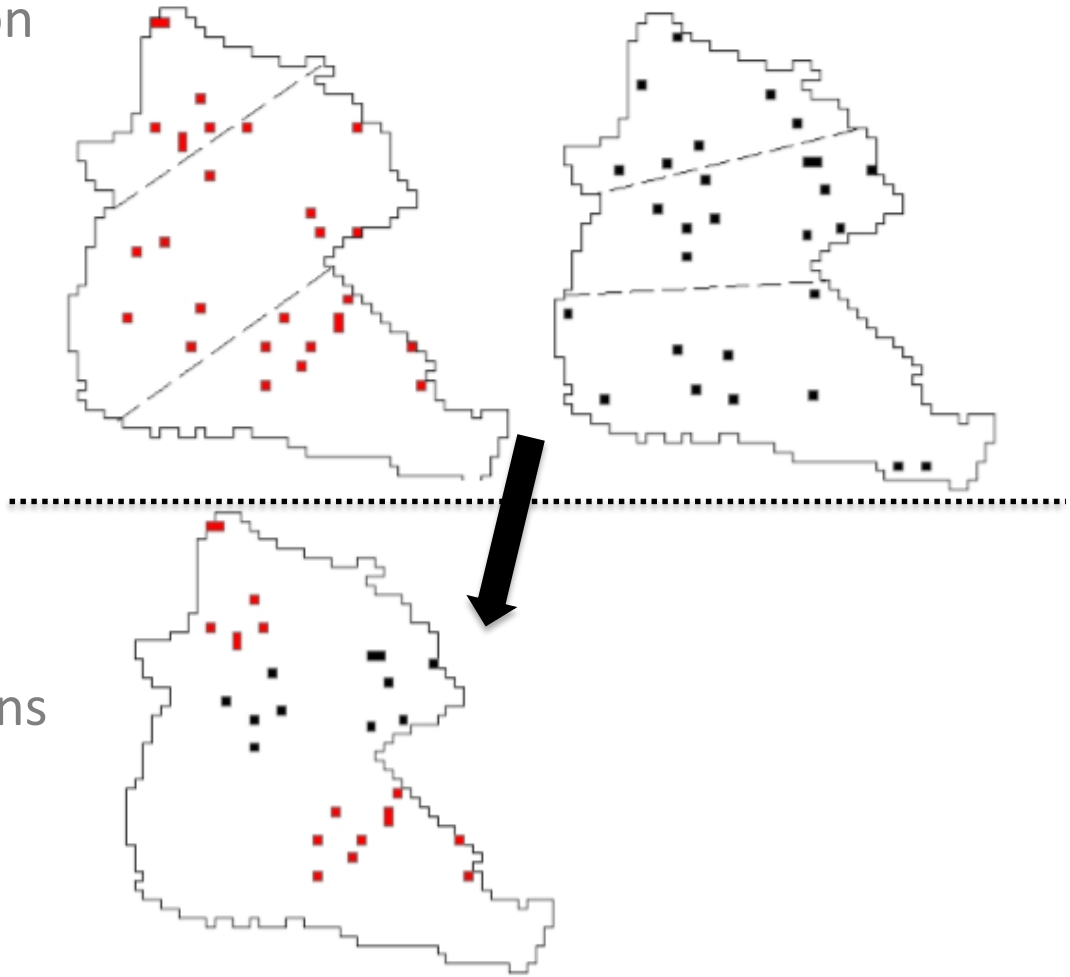

Spatial Optimisation Framework

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  - **Mutation**

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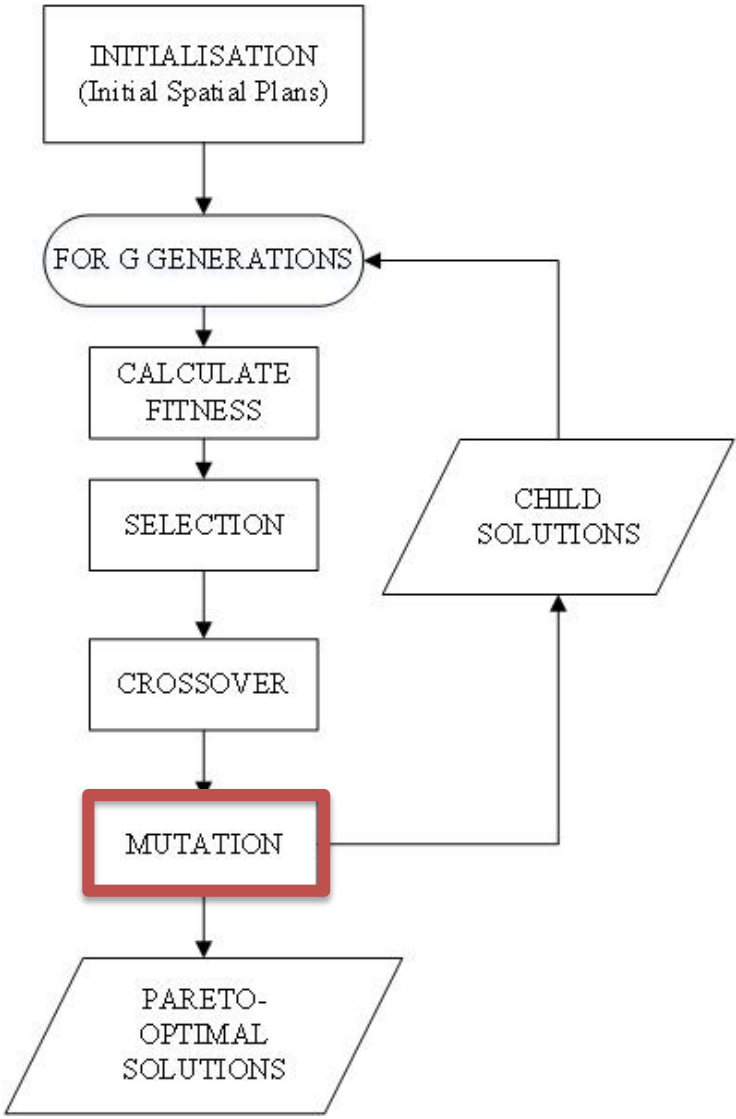

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- **Pareto-optimal Spatial Plans**
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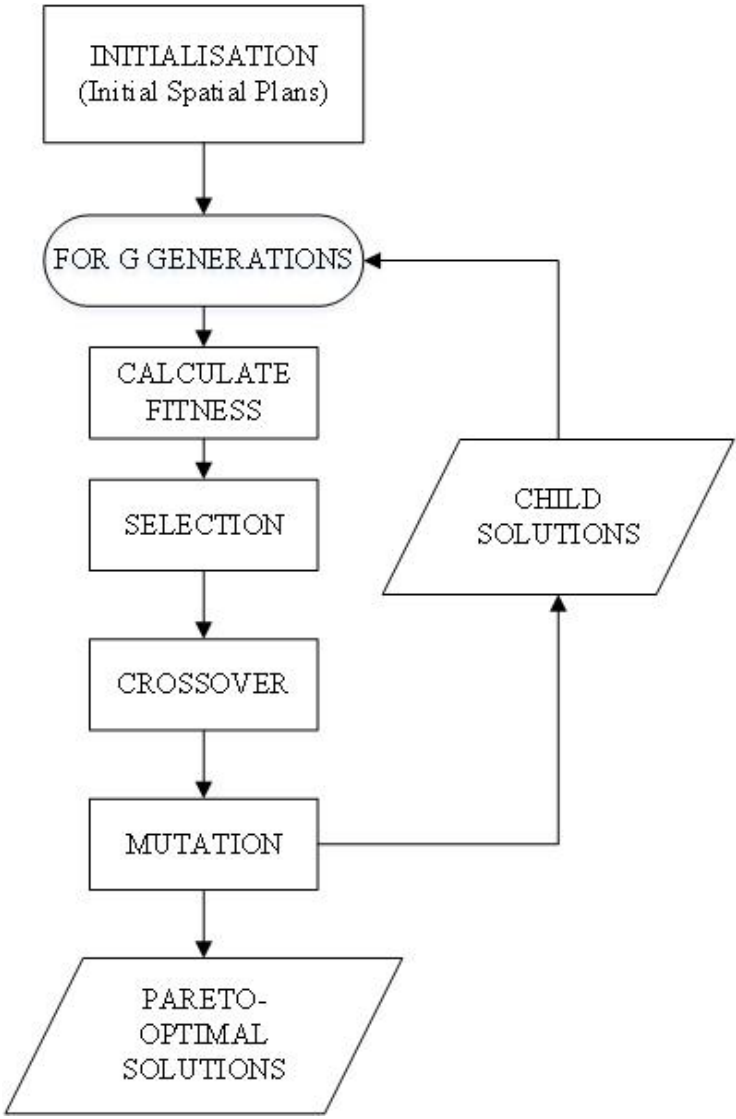
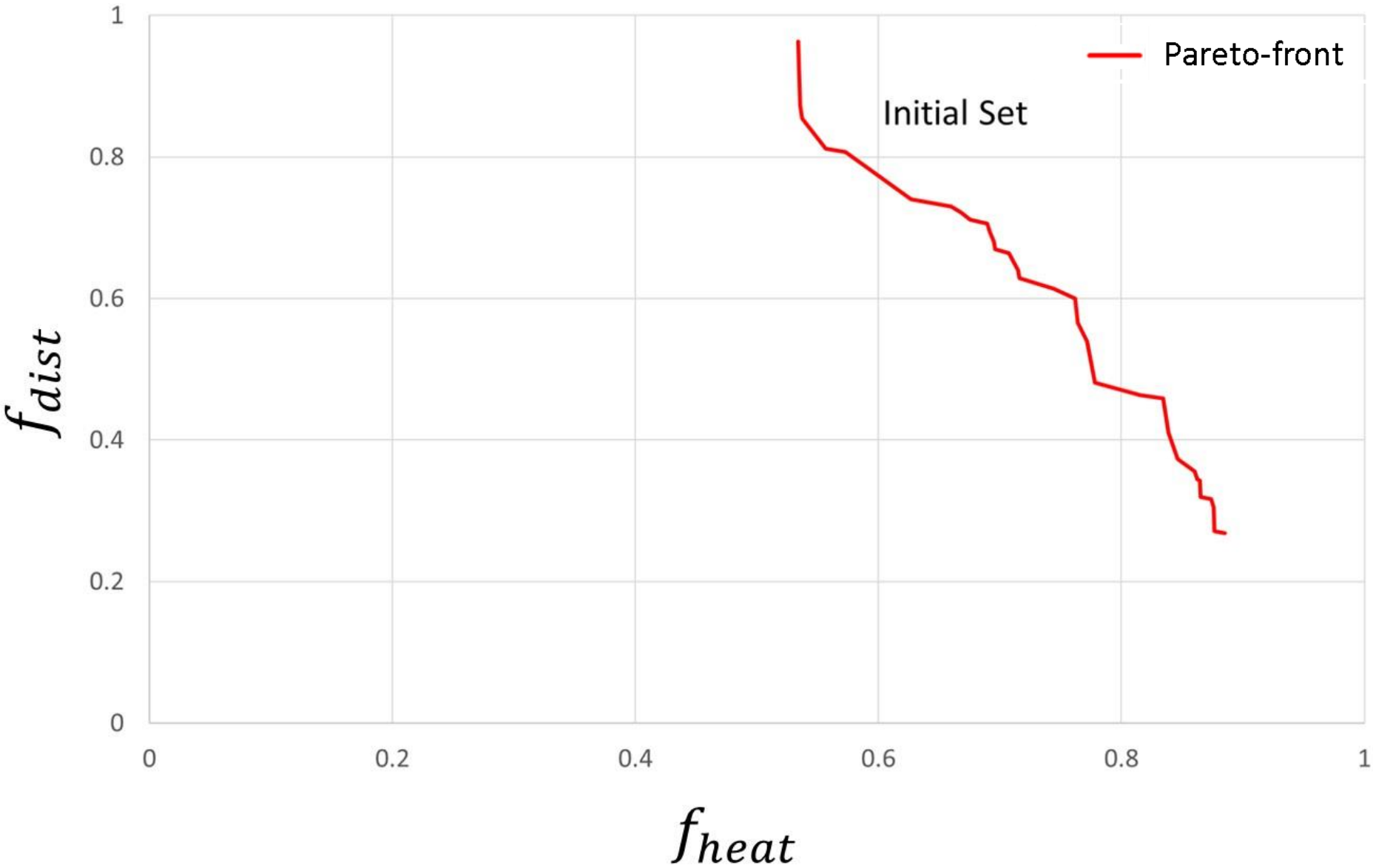


Pareto-Optimisation



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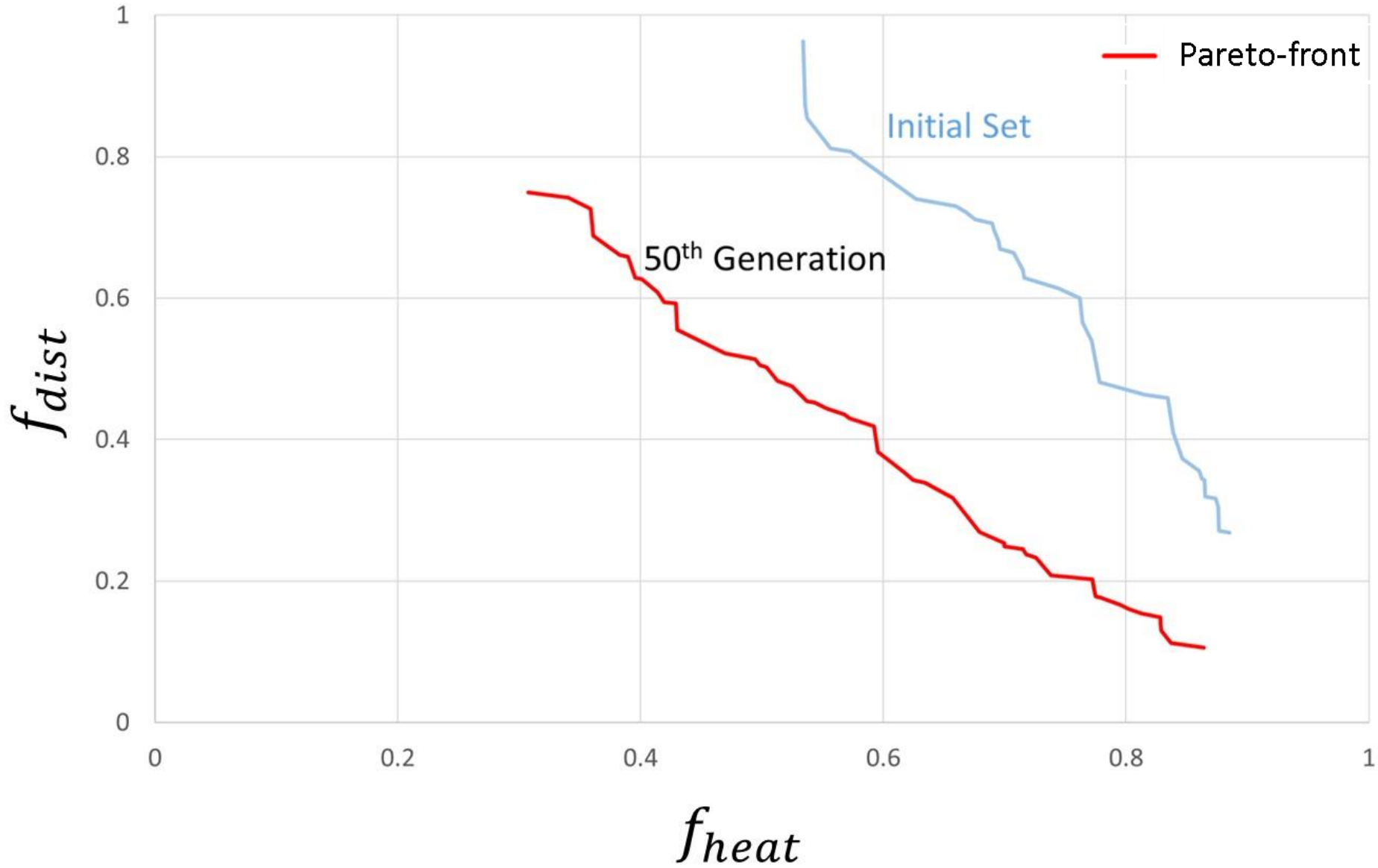

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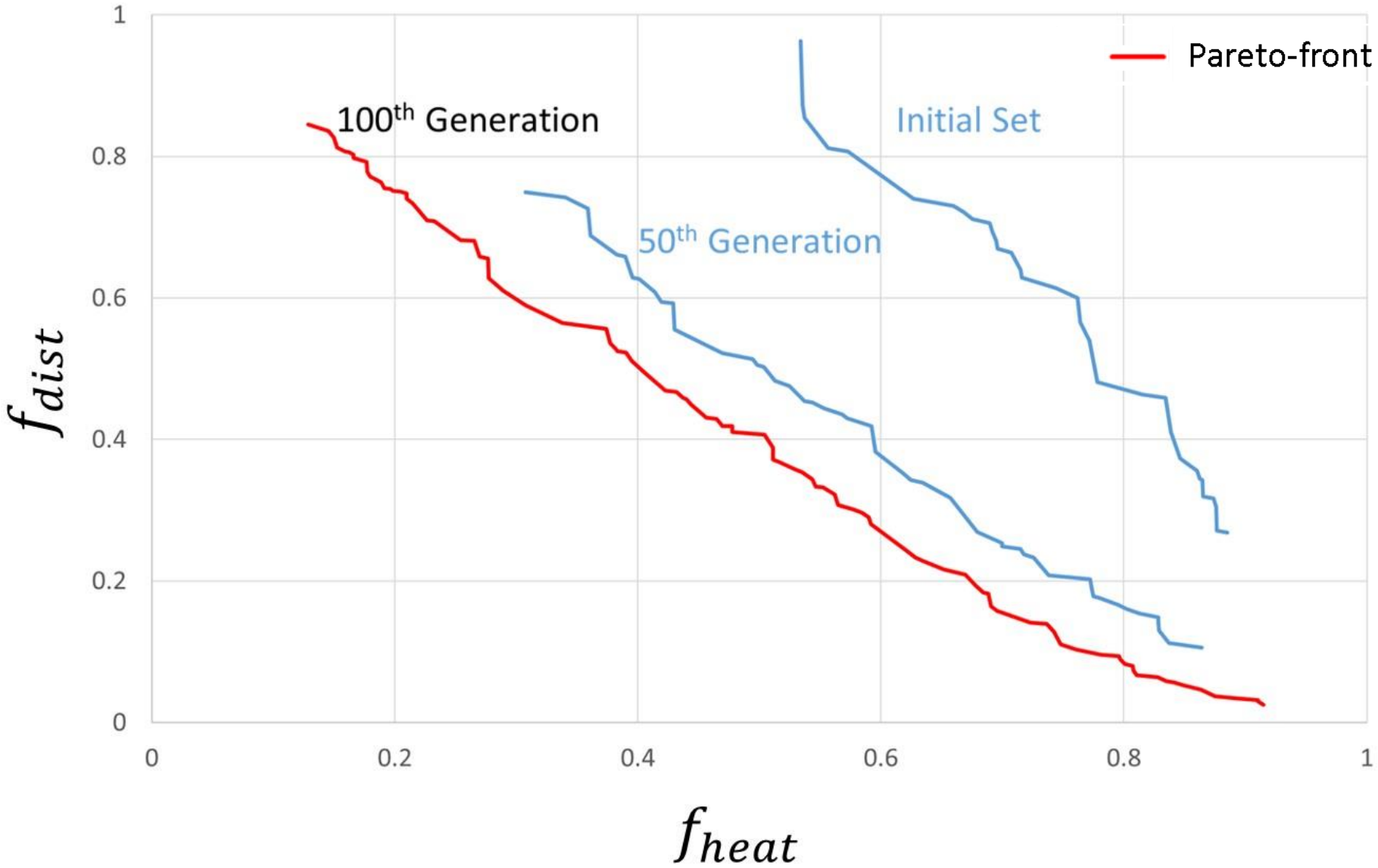

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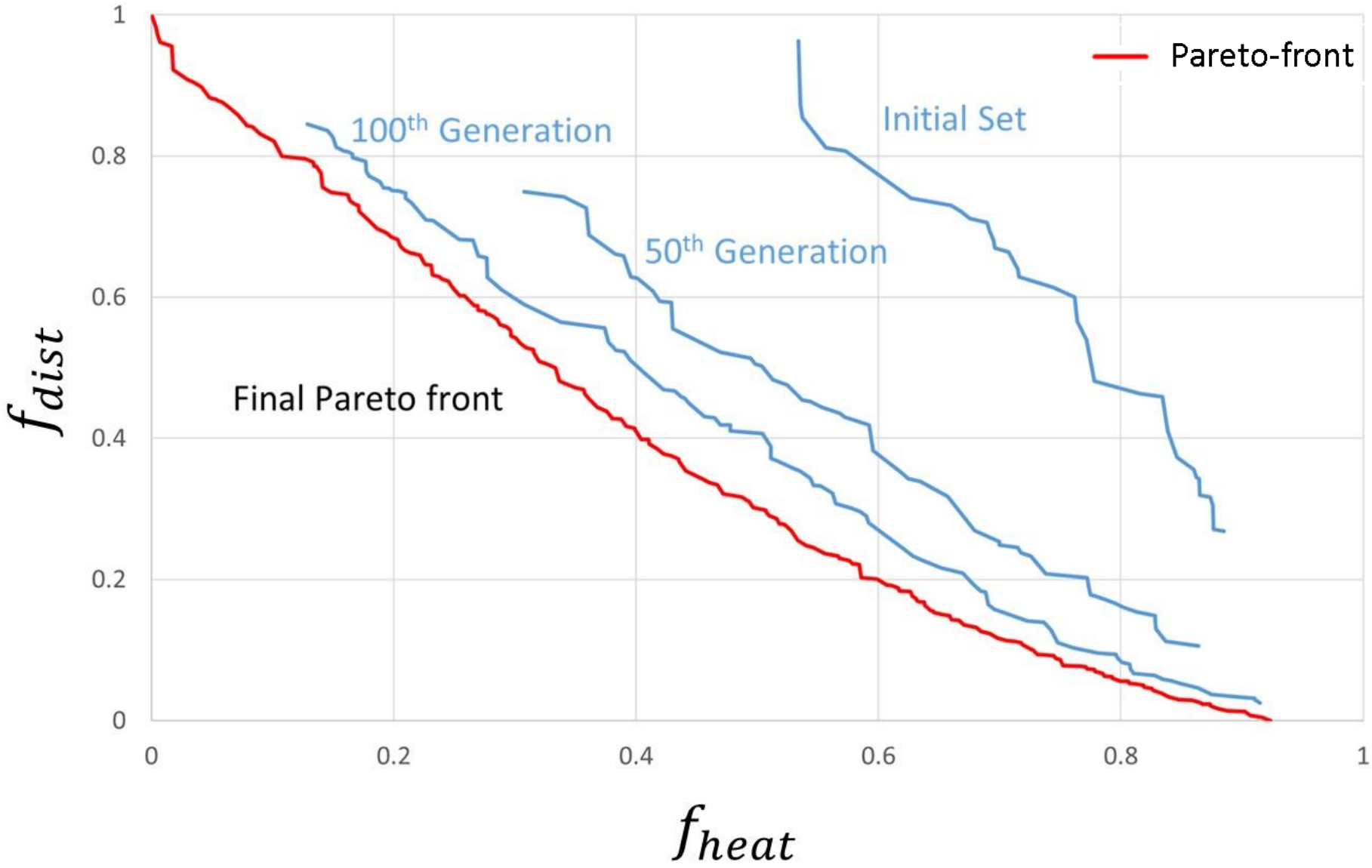

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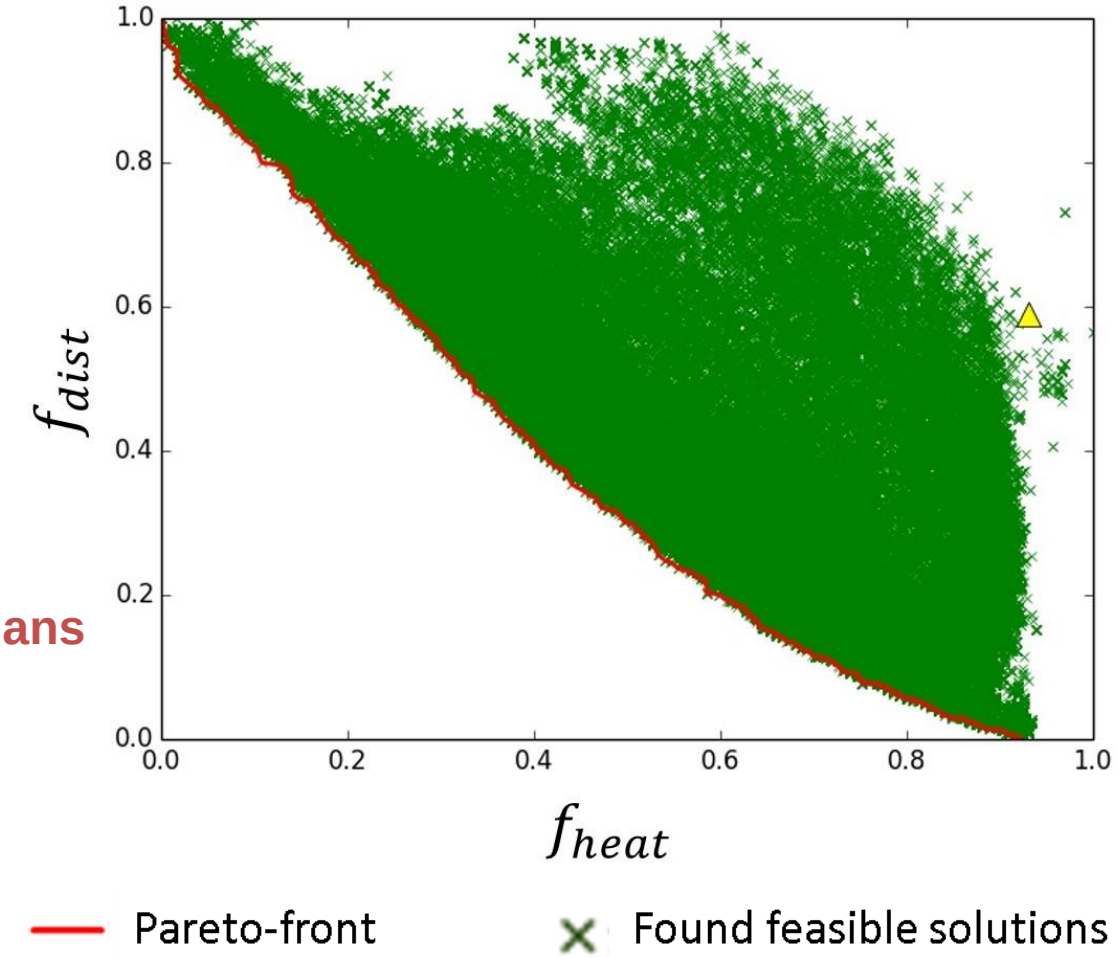
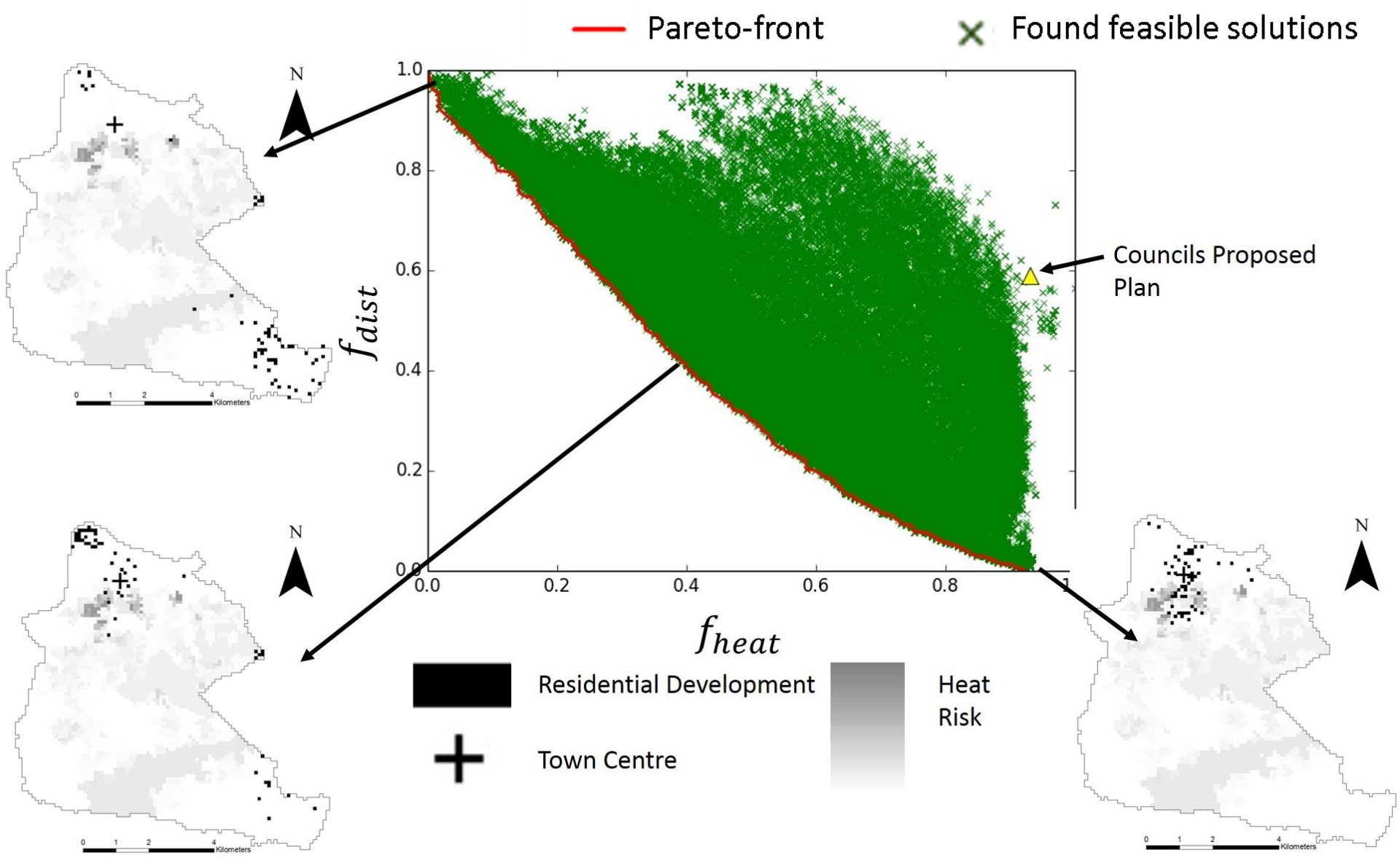
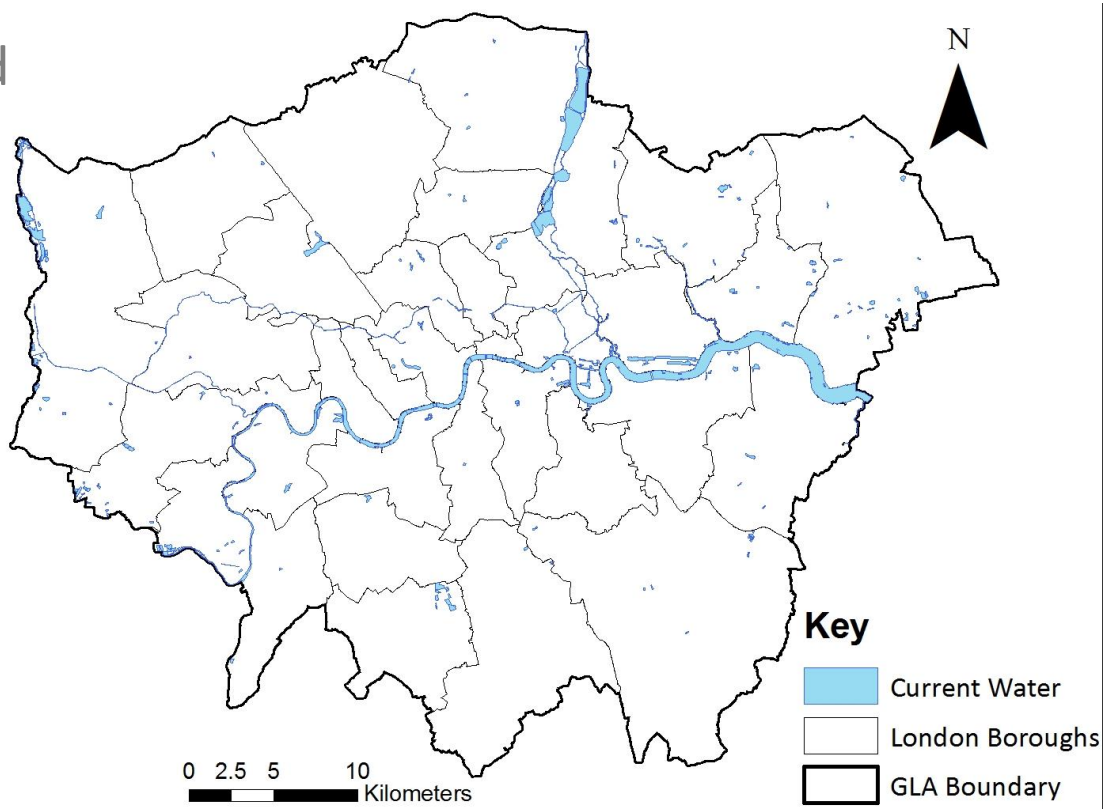


Pareto-optimal Front



London Case Study

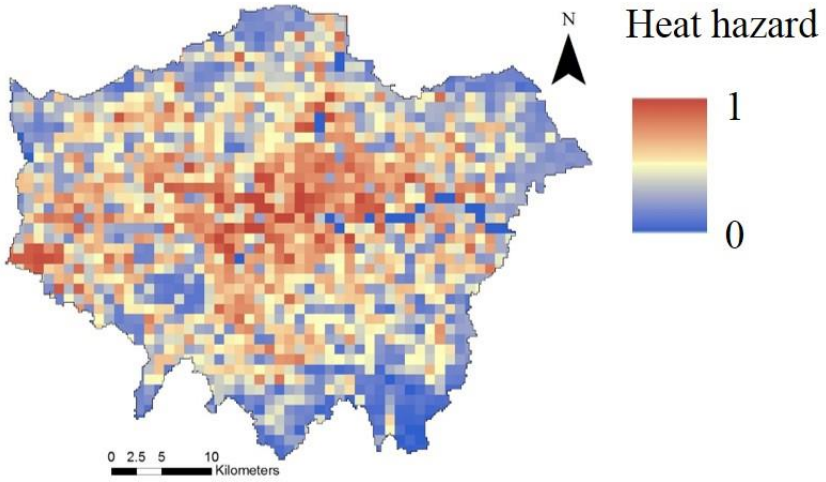
- Complex system
- Increasing Population
- Multiple climate induced Hazards
- Large GHG emitter



London Case Study

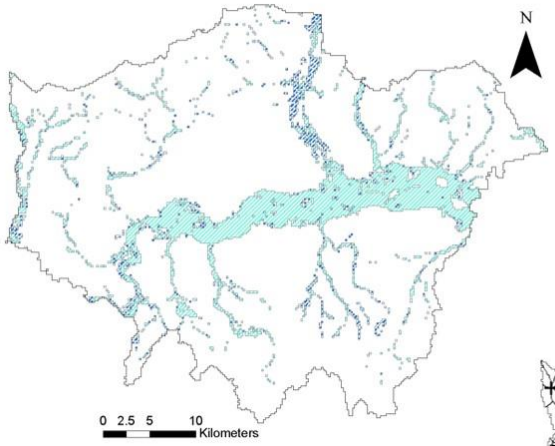
Minimising exposure to extreme heat

- f_{heat}



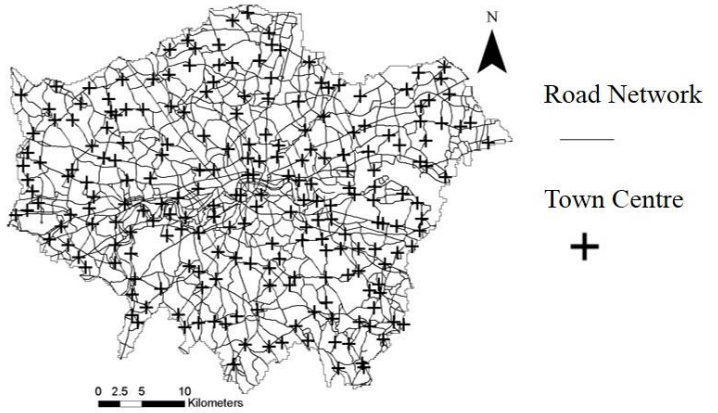
Minimise flood risk

- f_{flood}



Minimise transport emissions

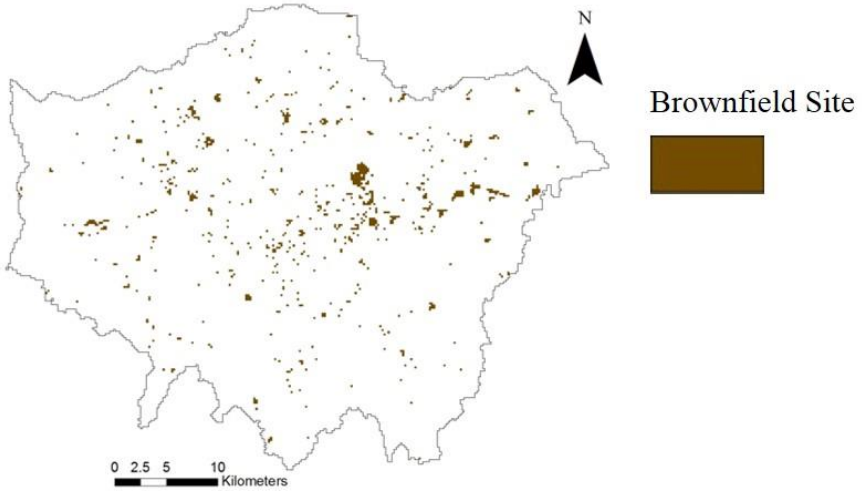
- f_{dist}



London Case Study

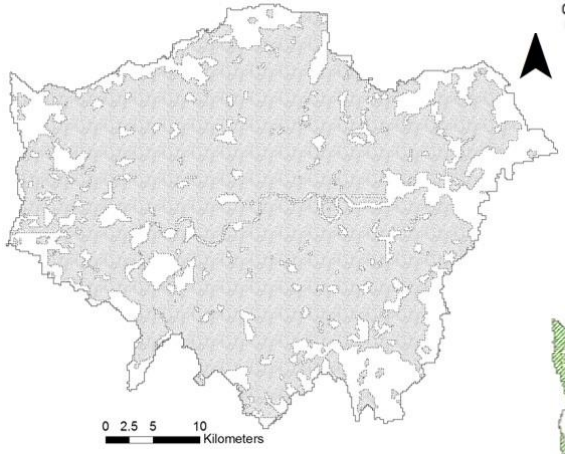
Maximise brownfield development

- $f_{brownfield}$

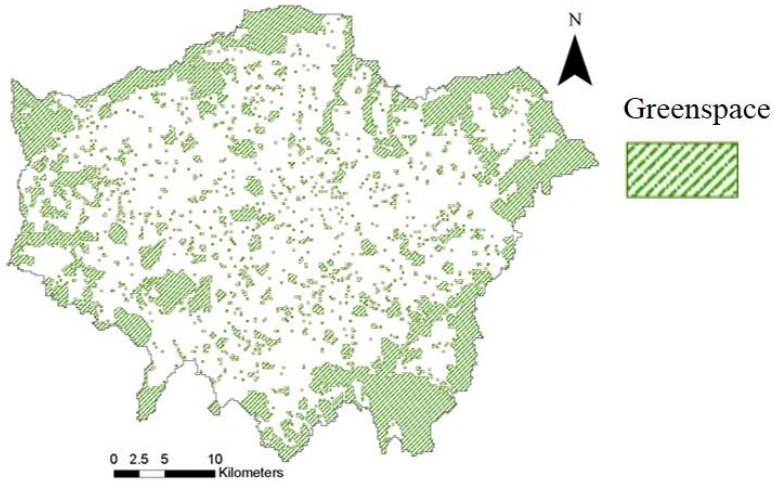


Minimise Urban Sprawl

- f_{sprawl}



Prevent development of greenspace

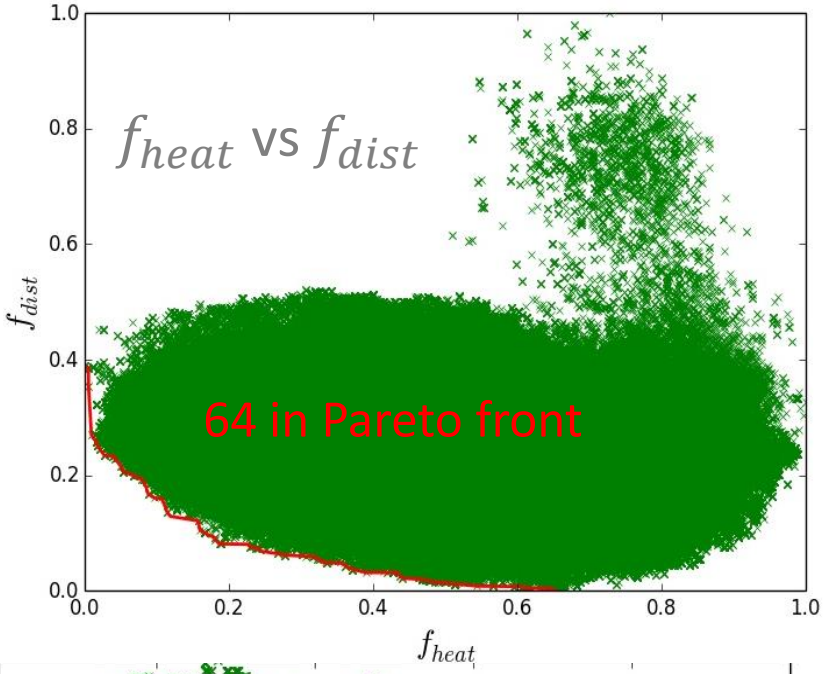


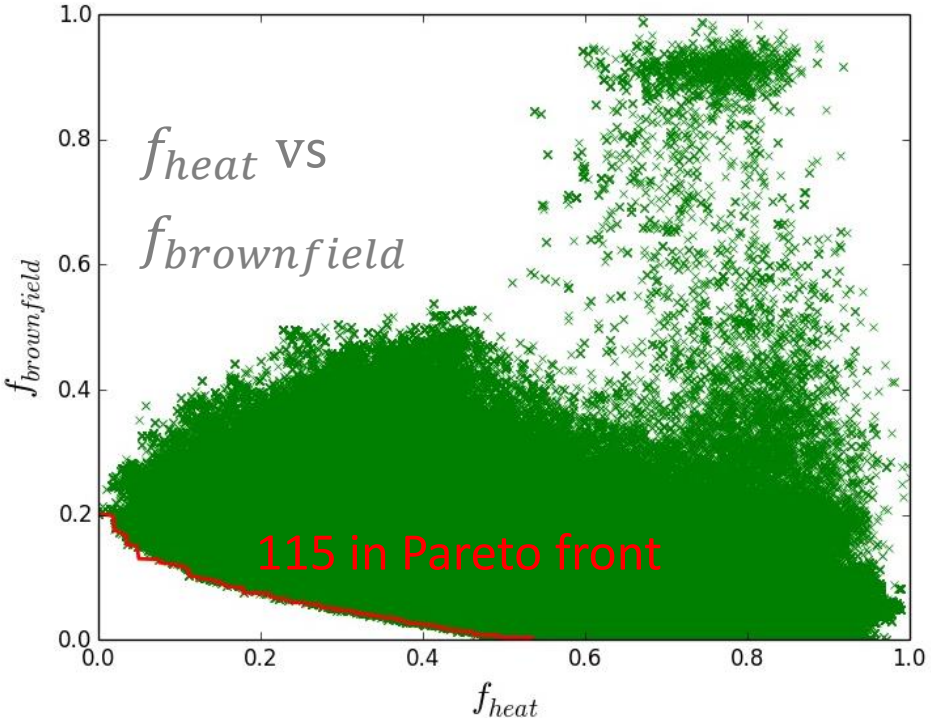
Pareto Fronts

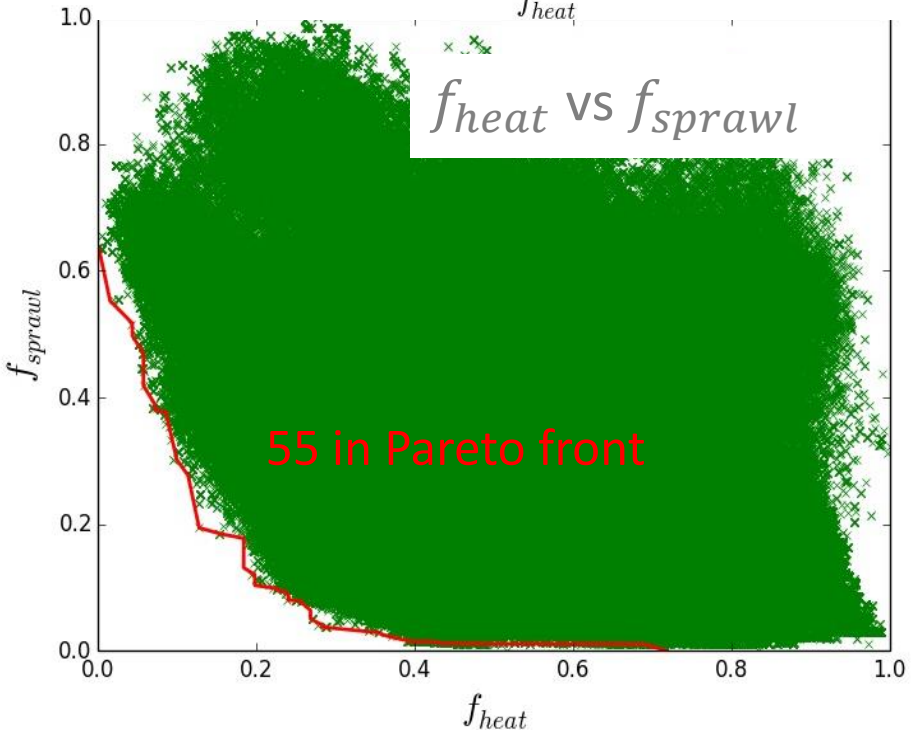
- 890233 Solutions found

Pareto-front

Found feasible solutions

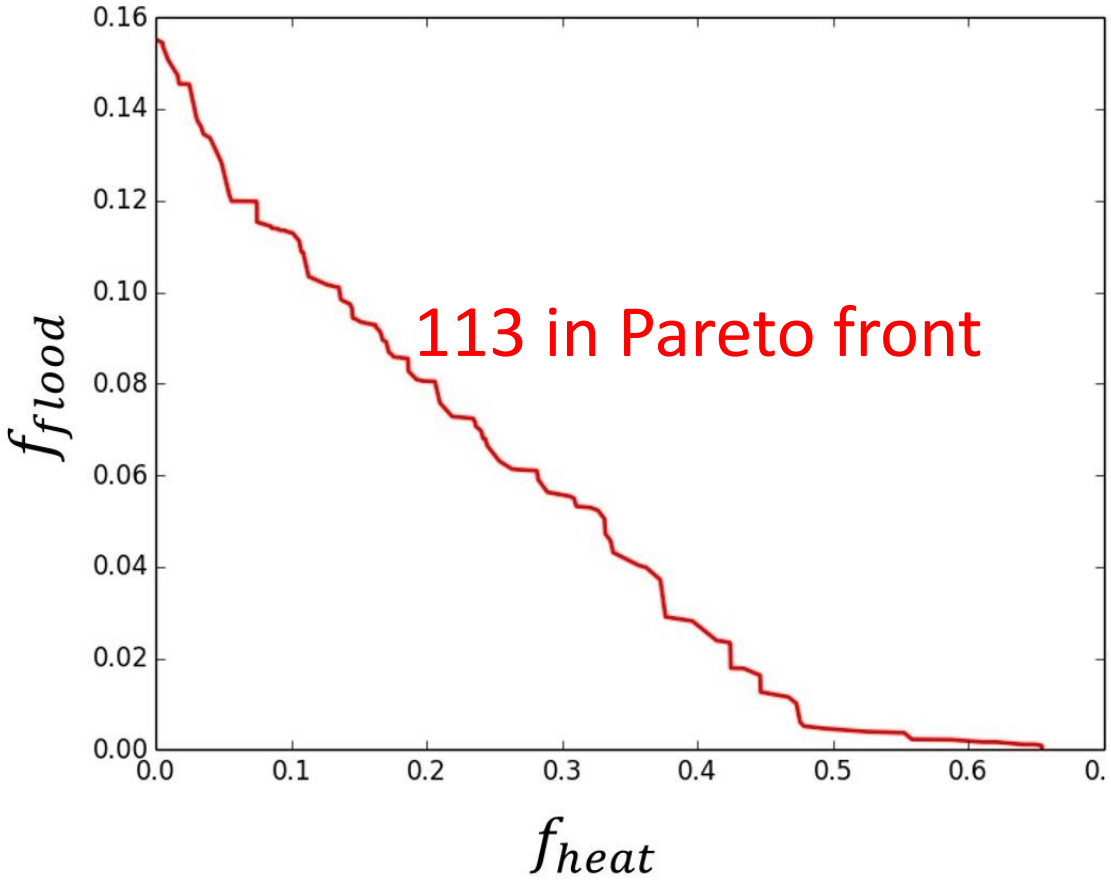




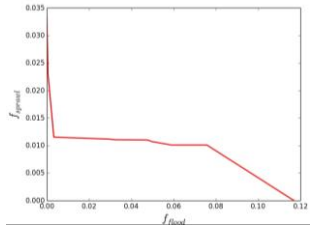


Pareto fronts

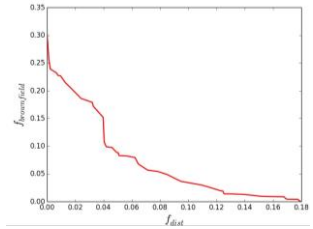
f_{heat} vs f_{flood}



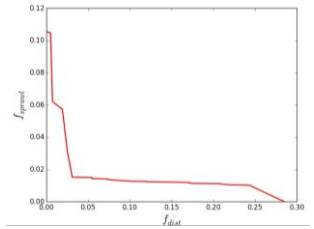
f_{flood} vs f_{sprawl}



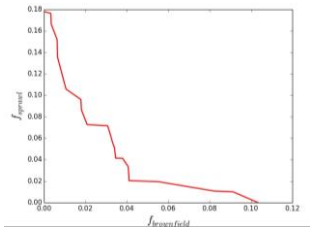
f_{dist} vs $f_{brownfield}$



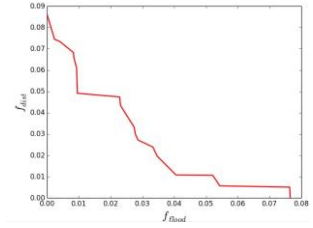
f_{dist} vs f_{sprawl}

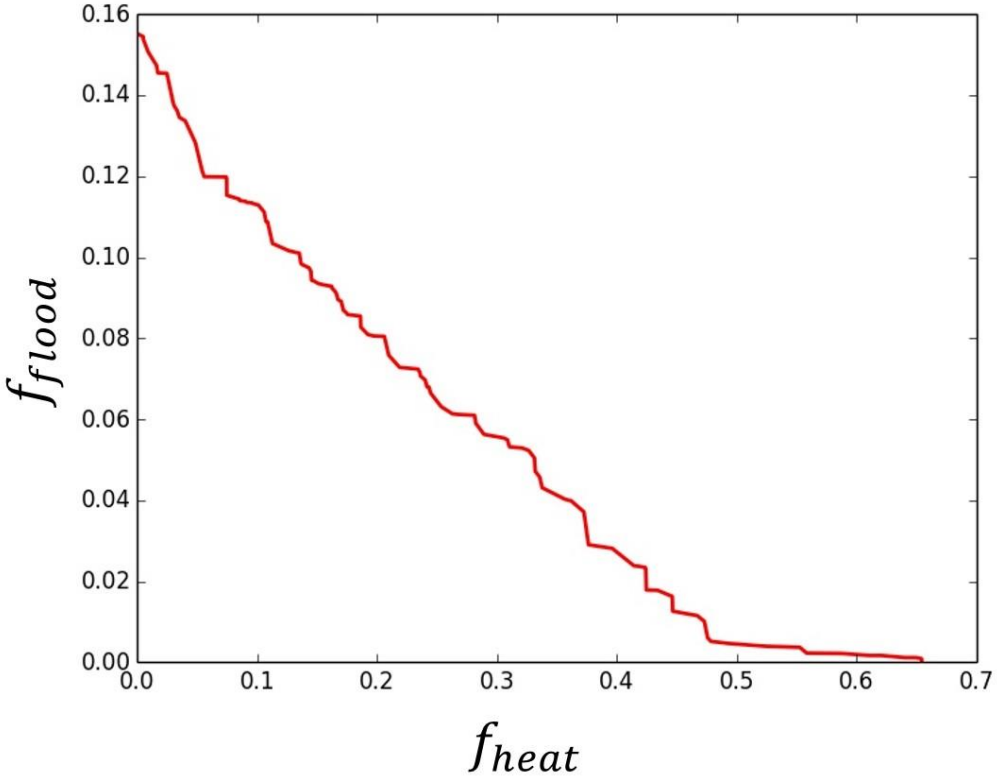


f_{sprawl} vs $f_{brownfield}$

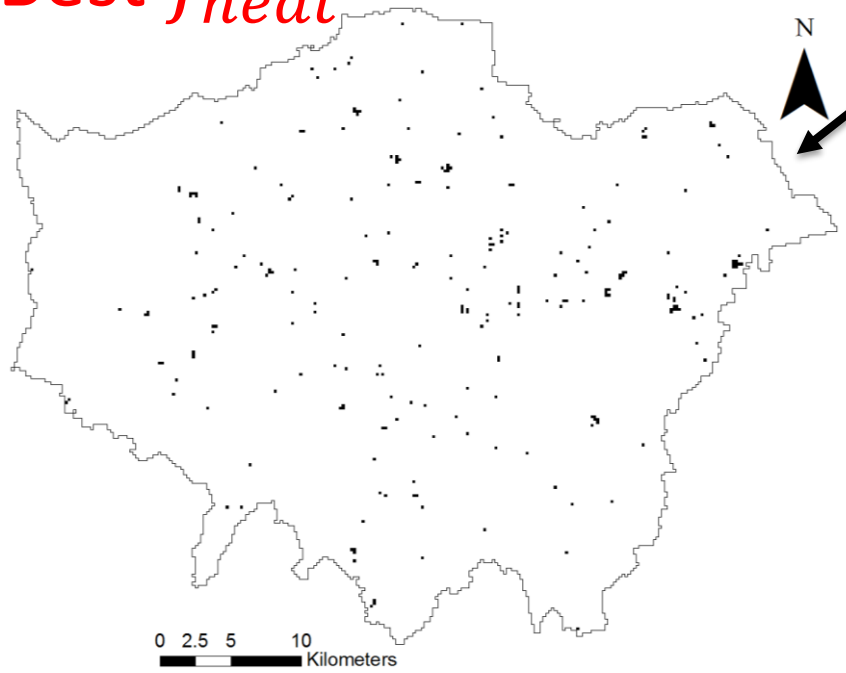


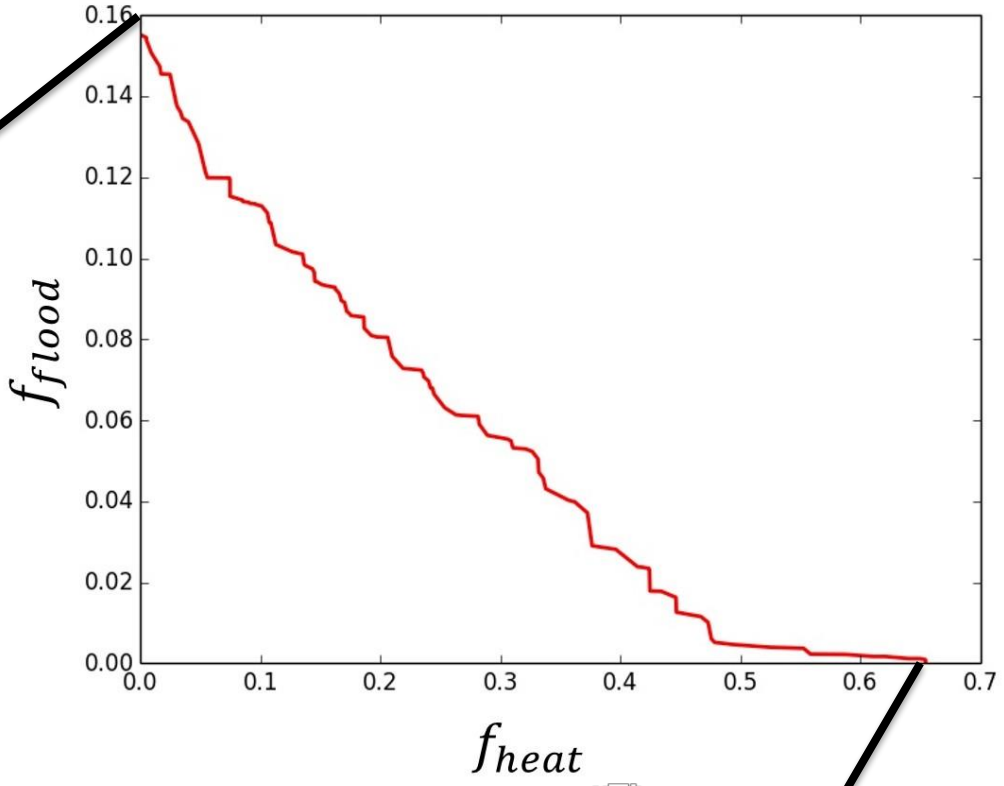
f_{flood} vs f_{dist}

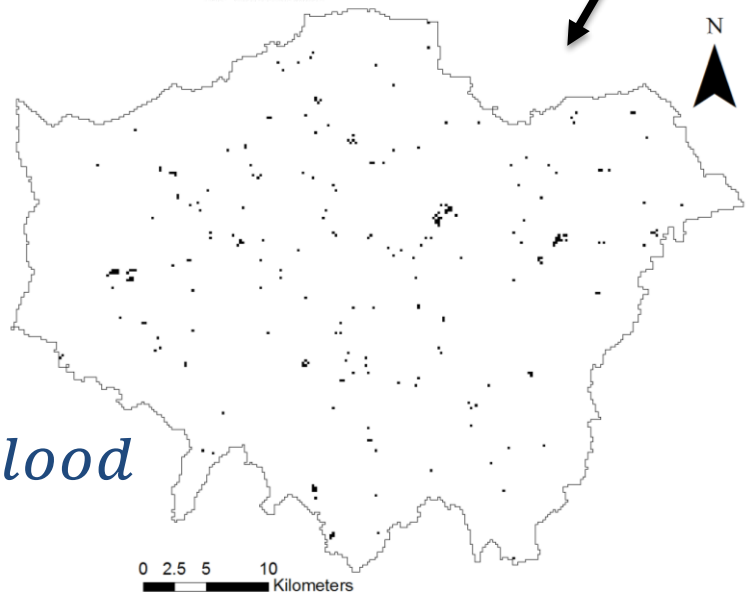



0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
f_{flood}
f_{heat}

Best f_{heat}

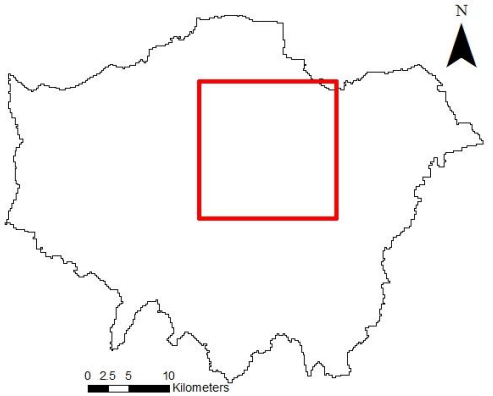






Best f_{flood}

Proposed residential development (d_{ij}) (varying densities)



Best f_{heat}

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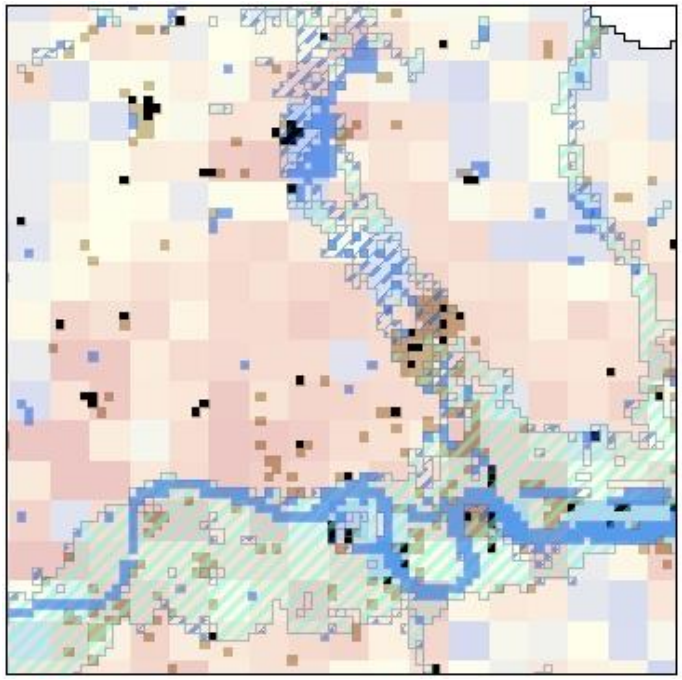
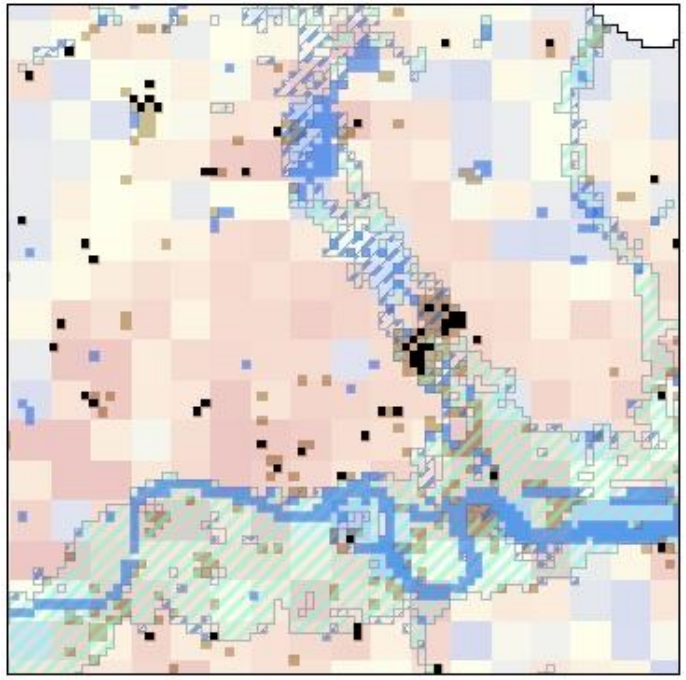




1 in 1000 year Flood zone (z_j)

1 in 100 year Flood zone (Z_j)

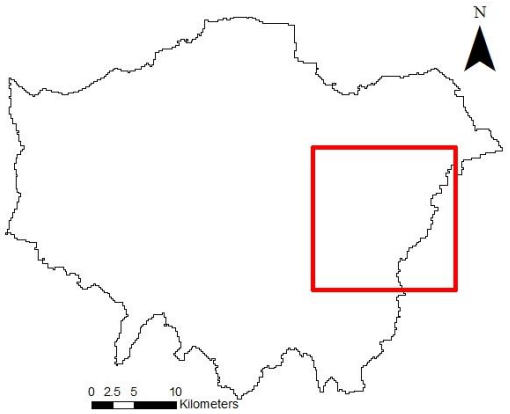
Brownfield (b_j)

Proposed residential development (d_{ij}) (varying densities)

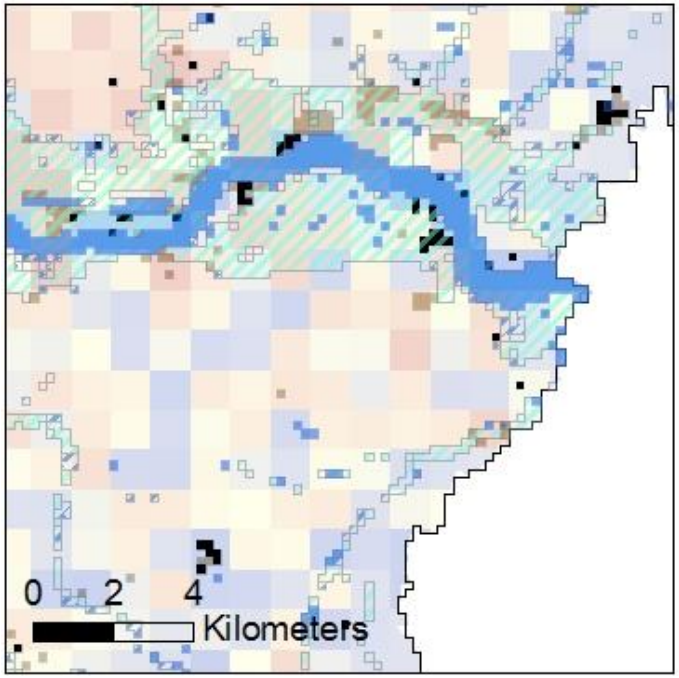
Hazard (h_{ij})

1

0



Best f_{heat}



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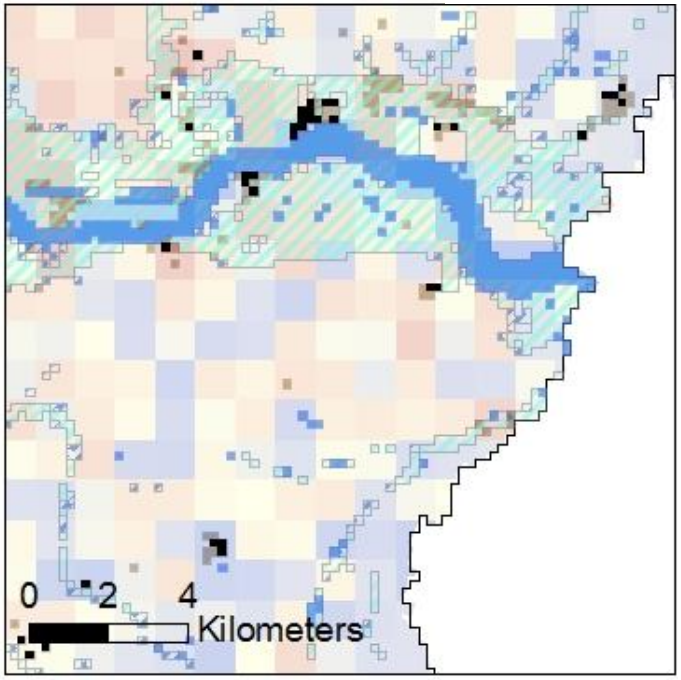

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Hazard (h_{ij})

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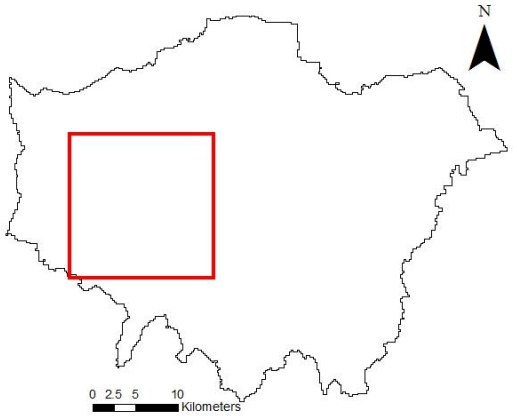
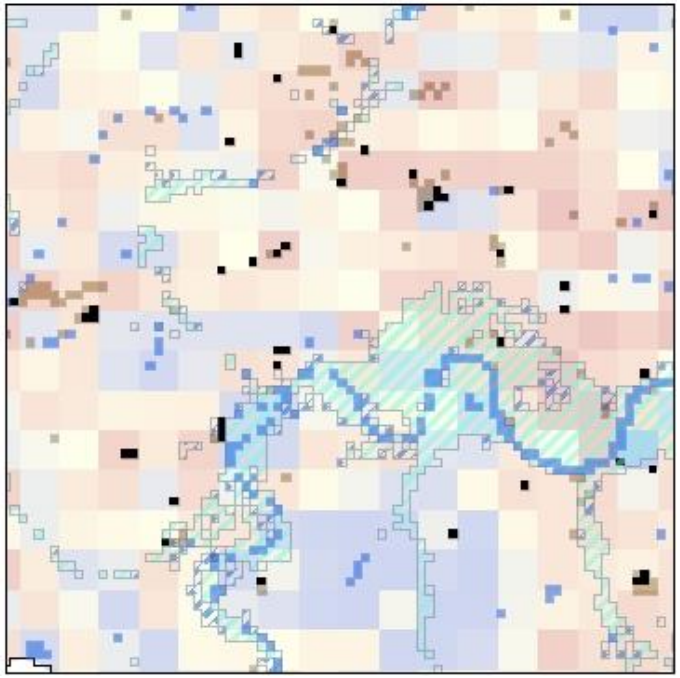
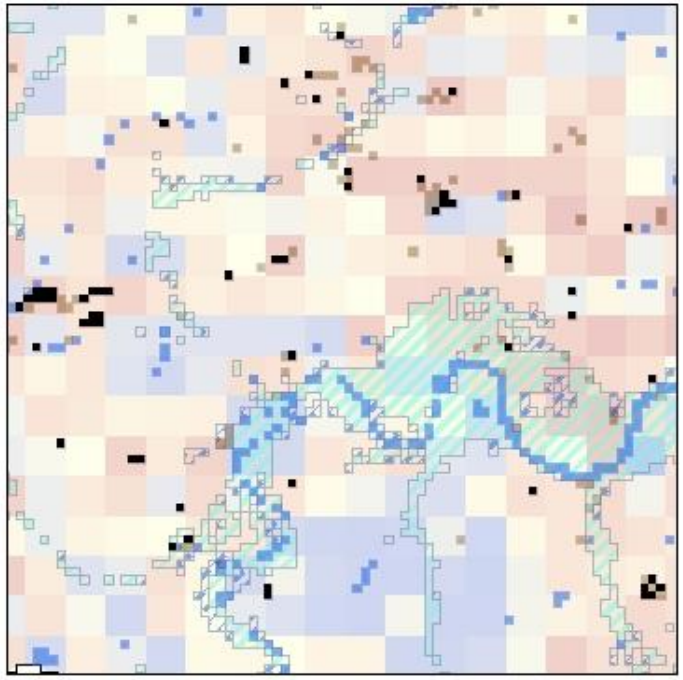
0



Best f_{heat}

Best f_{flood}





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1 in 100 year Flood zone (Z_j)

Brownfield (b_j)

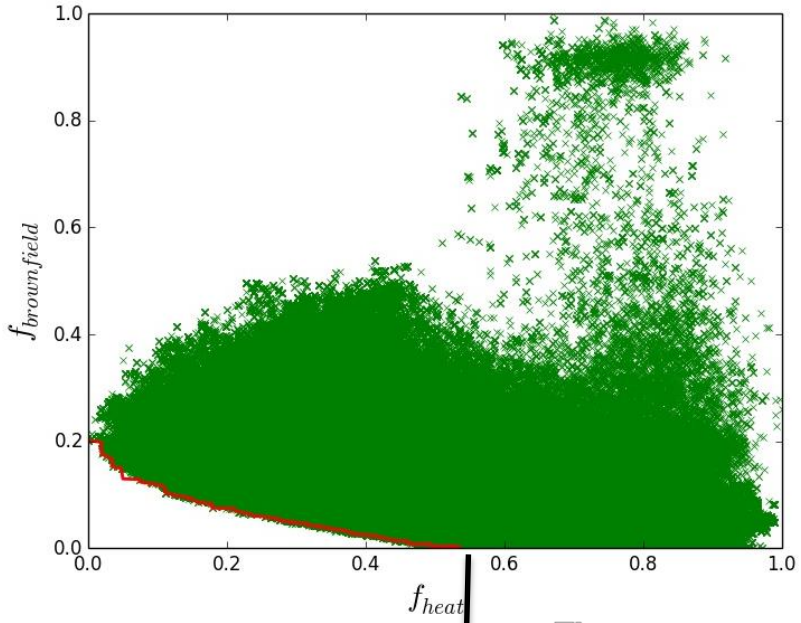
Proposed residential development (d_{ij}) (varying densities)

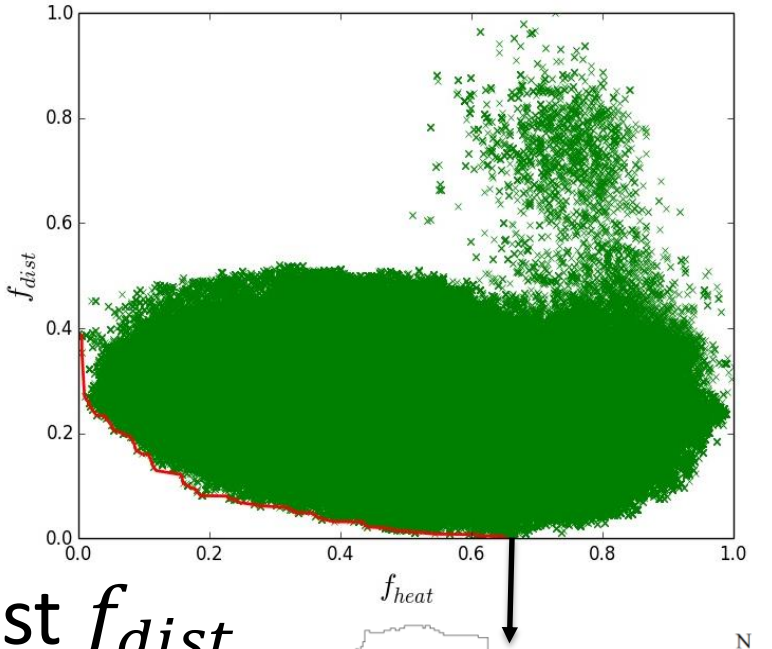
Hazard (h_{ij})

1

0

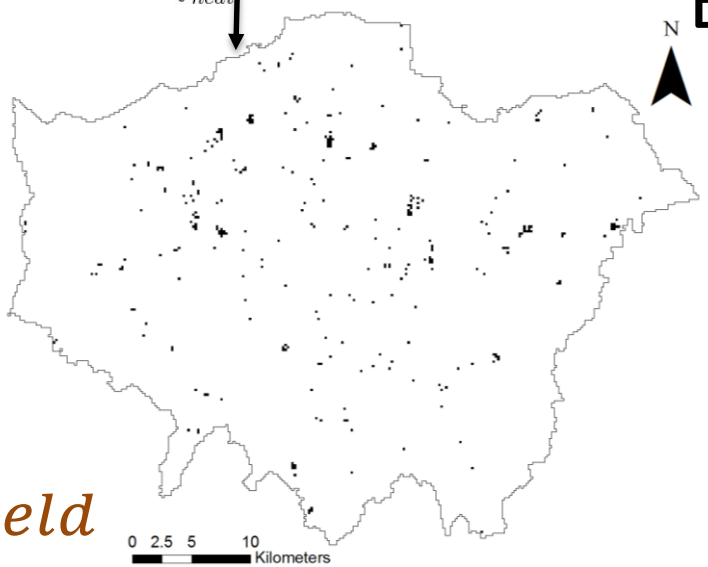
Pareto-Optimal Plans



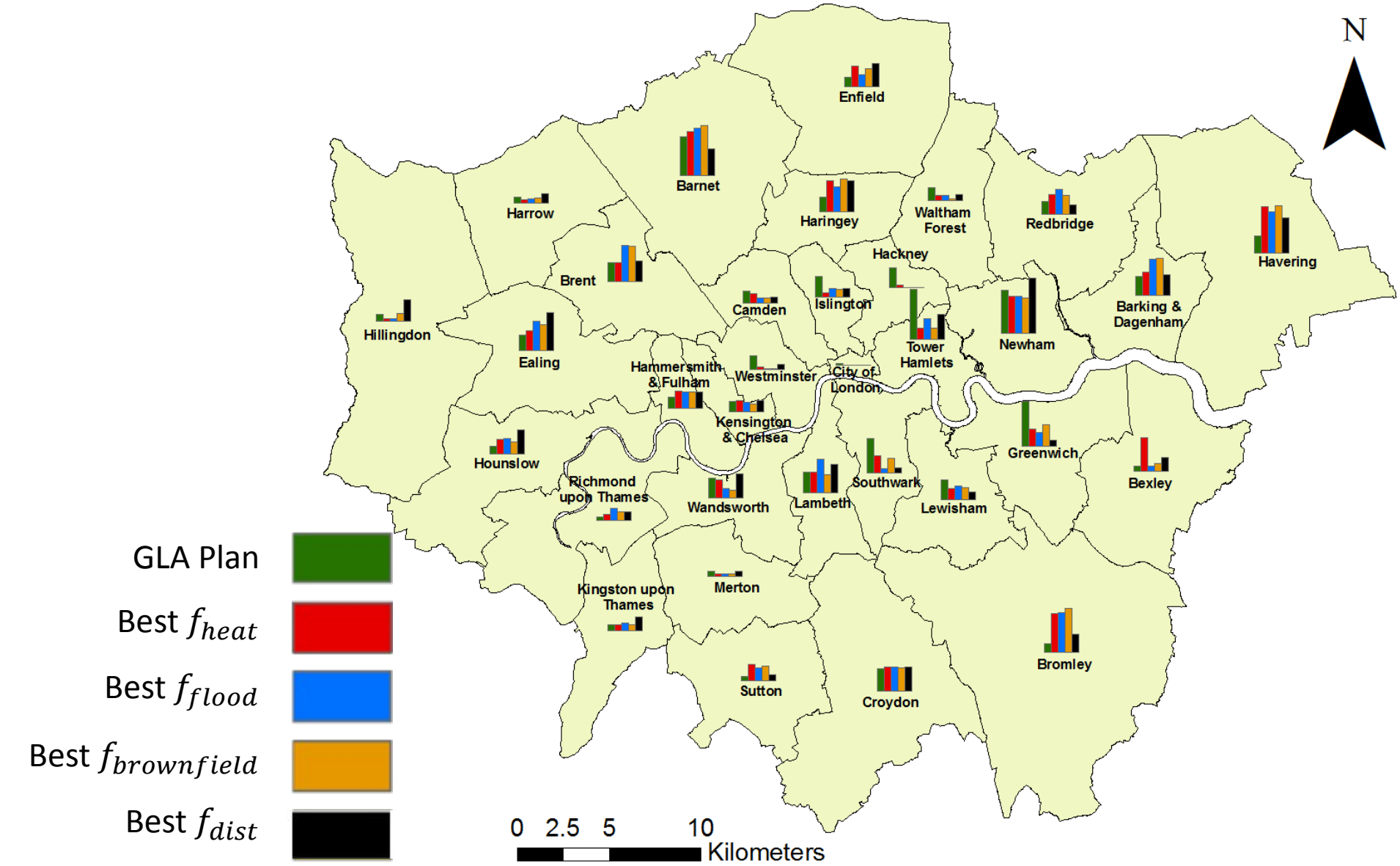


Best f_{dist}

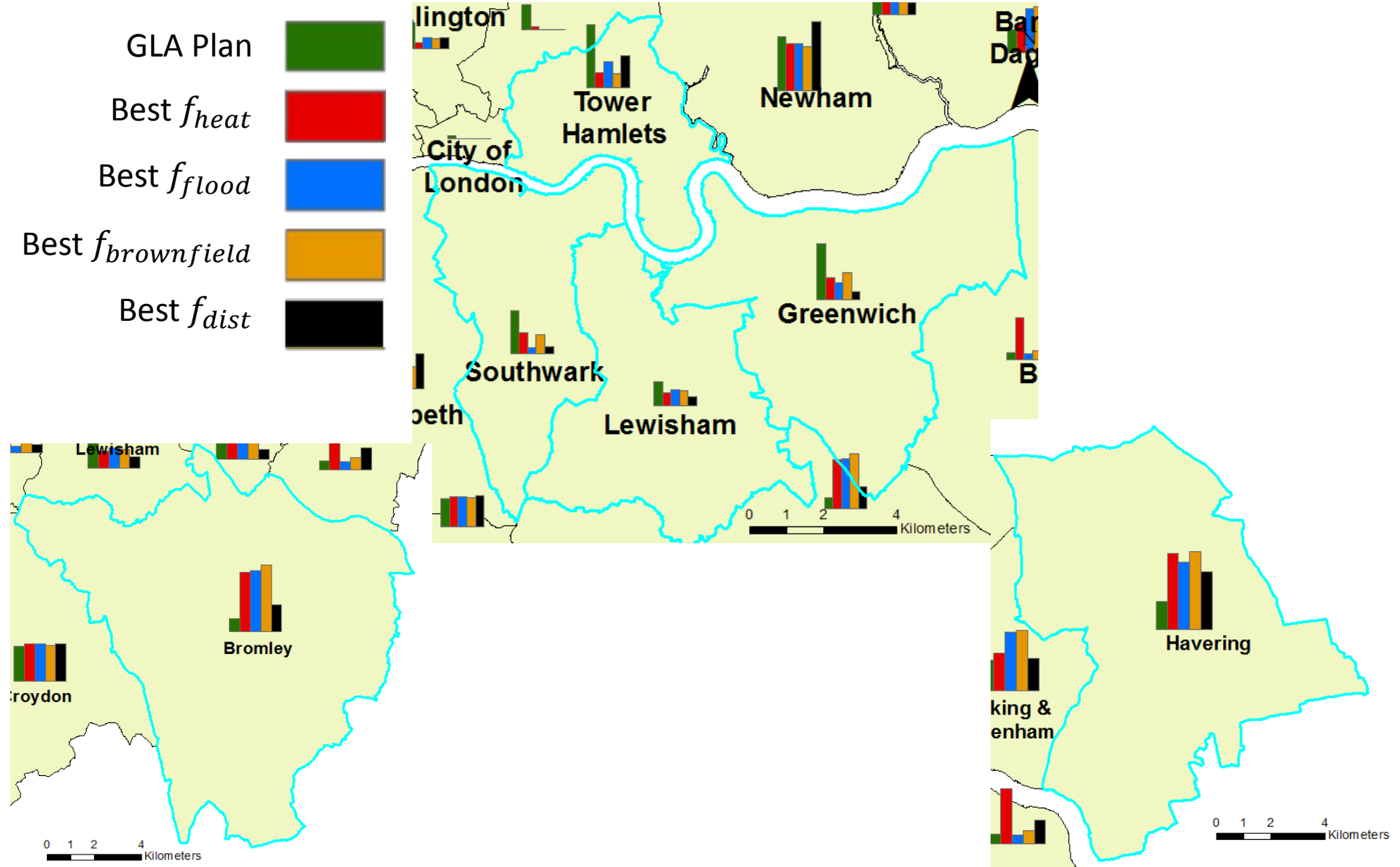
Best $f_{brownfield}$



Borough Comparison



Borough Comparison



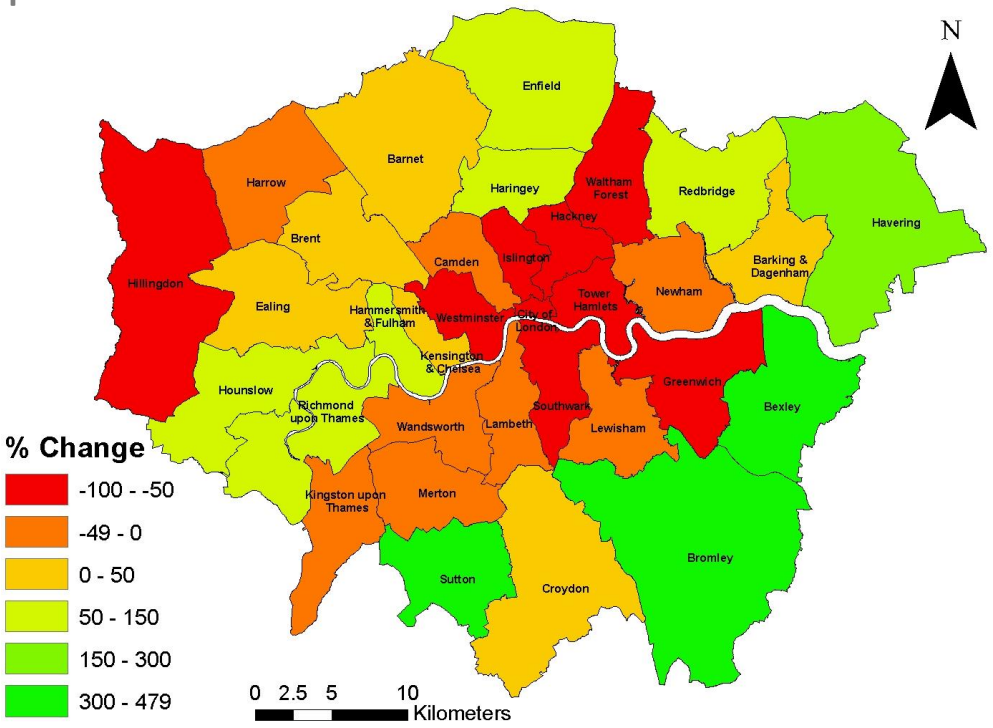
Conclusion

- Robust spatial plans in presence of conflicting risk and sustainability objectives

- Ability to recognise best trade-offs for conflicts and point towards optimal trends

- Further risk and sustainability objectives
    - Potential to form decision support tool

% Change from current plan to optimise f_{heat}



Evolutionary Computing for Multi-Objective Spatial Optimisation

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