Generative Landscape Modeling in Urban Open Space Design : An Experimental Approach

Digital Landscape Architecture Conference '19 // Anhalt

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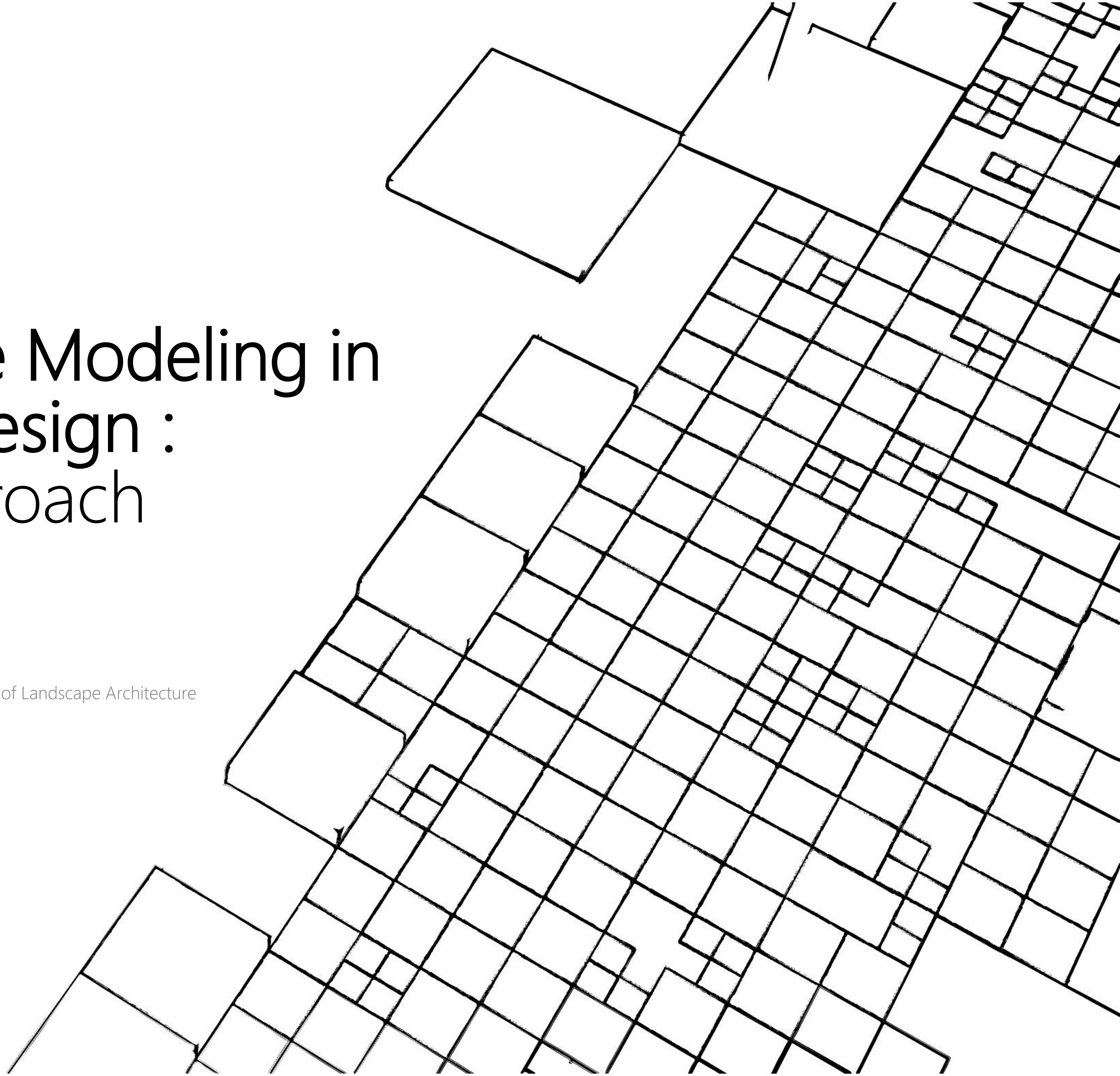


Ecology

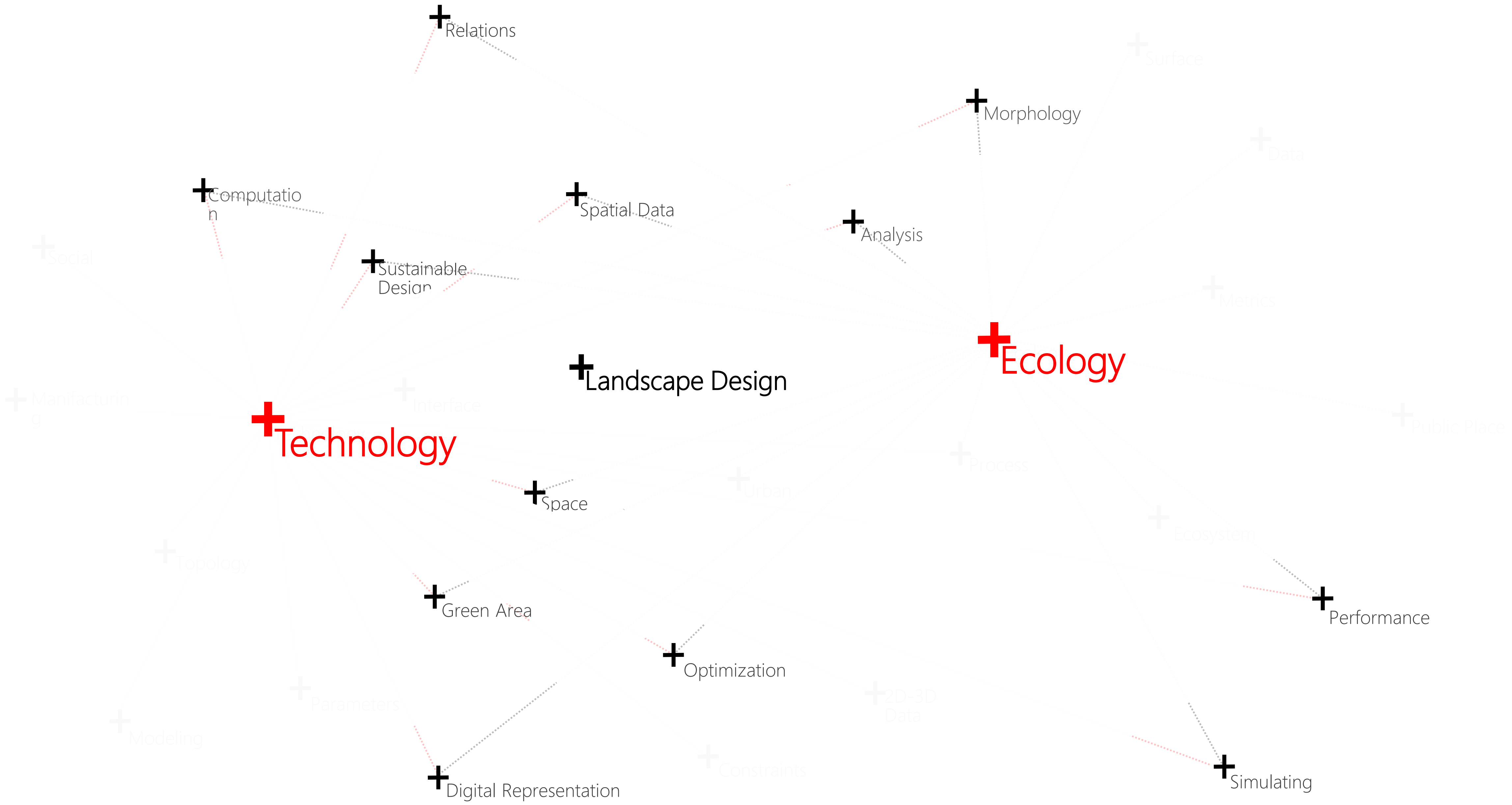
+ How can we improve the ecological values and social integration of existing urban open spaces by re-designing ?

Technology

+ What would be the new digital methodologies to indicate this re-designing process, and how to integrate to landscape design ?

“ … Design paradigms recently have an agenda that is based on ecological and environmental concerns. The dynamic, operational and even physical aspects of this situation have brought the landscape to the center of design generation, including architecture and urbanism practices. … ”

Chris Reed, 2018
Codify |



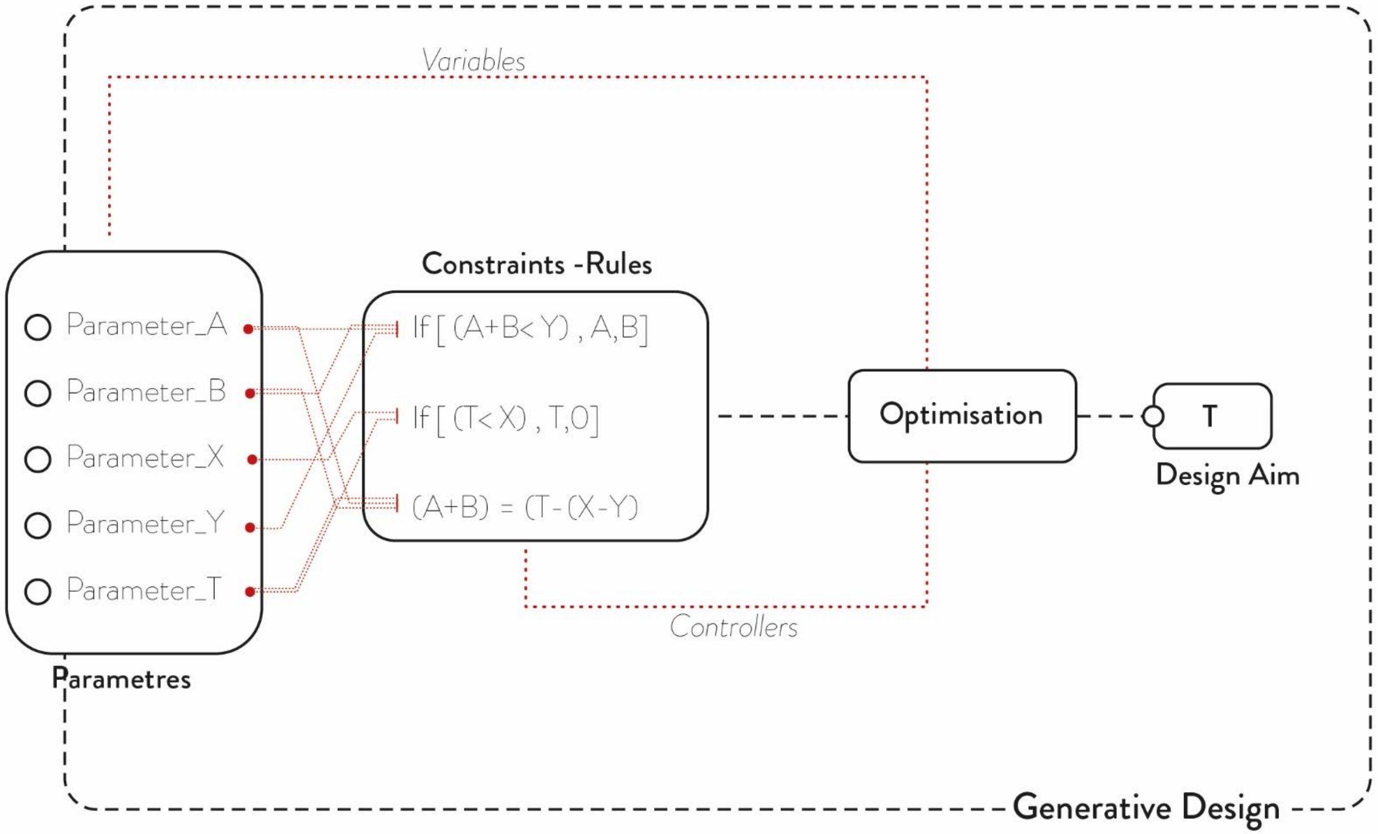
Relations
Morphology
Computation
Spatial Data
Analysis
Sustainable Design
Ecology
Landscape Design
Technology
Space
Green Area
Optimization
Performance
Digital Representation
Simulating
Surface
Data
Social
Metrics
Interface
Public Place
Process
Urban
Ecosystems
Topology
Parameters
Modeling
2D-3D Data
Constraints

This paper aims to explore the algorithmic design thinking for the landscape by generative modeling approach in urban open space. Focusing on dynamic and reciprocal interactions between social(human movement), physical(hard-soft structures) and ecological(surface radiation and microclimate analysis) parameters.

Ground Notion Relations

In order to make the design computable, new methods arose out to parametrize the design via CAD programs. These systems have attractive effects in terms of defining parametric design over ***constraints*** *because many design alternatives can be generated with several modifications(Jabi, 2013).*

Therewithal, one-step further, algorithmic coding and iterative process-based design methods make it possible to generate more complex design variations from a set of design rules and parameters(Petras, Mitasova, Petrasova, & Harmon, 2016; Sanjuán & Ramirez, 2016). ***The algorithms*** *are designed to produce these alternatives within the framework of* ***design rules (constraints)*** *and to achieve the* ***optimal scenario*** *called* ***generative systems****.*



The Study Area

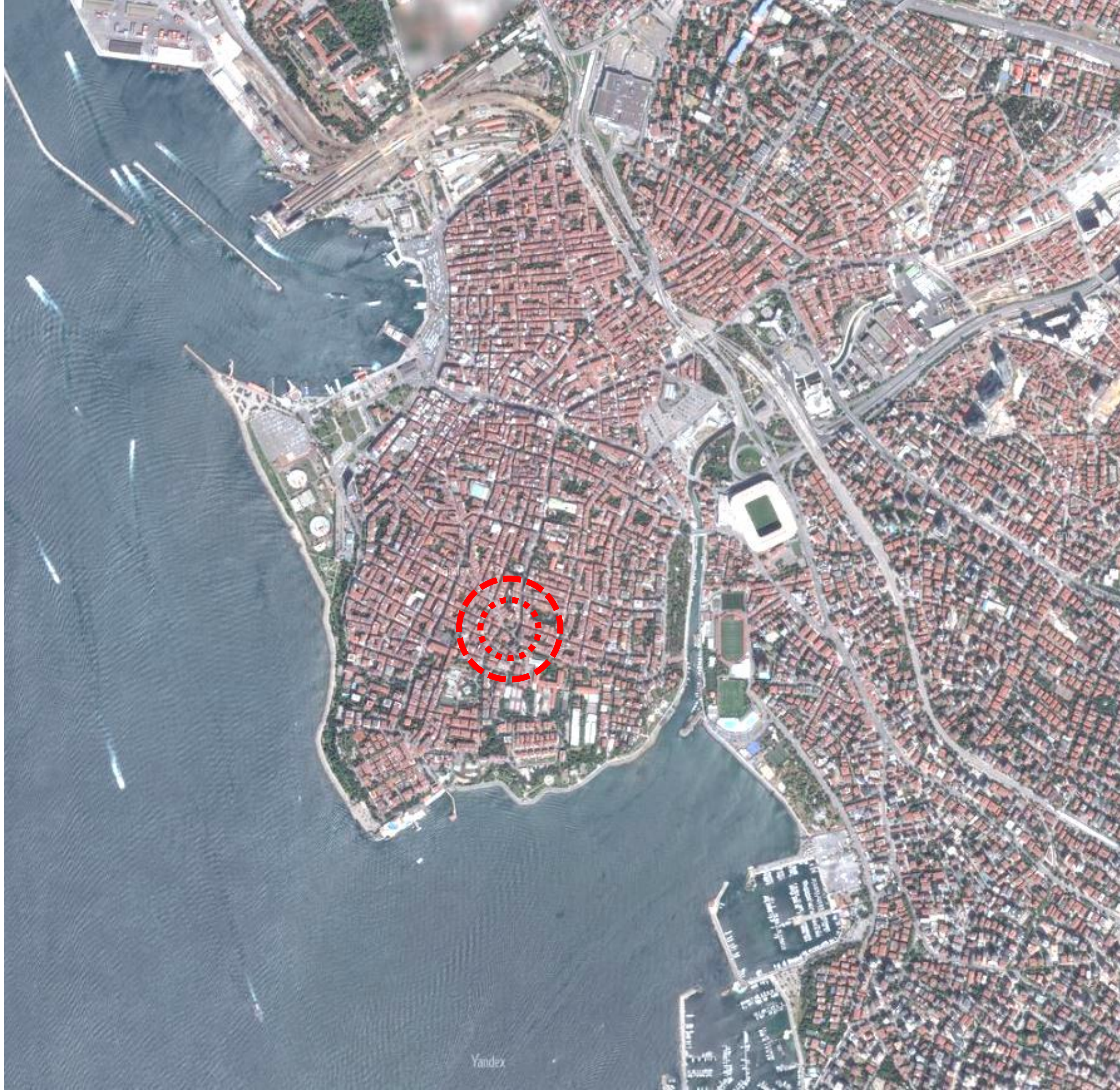
Istanbul / Kadıköy

Moda Square

sun exposure value // 11 days/hour

average radiation value // 6.6 Kwh/m²-day

average temperature values reaches // 28 degrees



The Study Area

Istanbul / Kadıköy

Moda Square

Design Thinking Workflow

1 Data Gathering / Digitalization

Field Observations
Base map
Arial Photo

- Area boundaries
- Building heights
- Vegetation type-count
- Vegetation location
- Human usage patterns
- Attraction spots

2 Definning Parameters

Rhinoceros(5.0)
Grasshopper

○ **Design Parameters**
[Populate Tree modeling]

- Tree type-count
- Max-min sizes
- Selection randomization
- Positioning seeds

Rhinoceros(5.0)
Grasshopper
Ladybug add-on

○ **Restraining Parameters**
[Microclimatic and Radiation Matrix]

- Buildings
- Trees
- Surface
- Epw wether file

Rhinoceros(5.0)
Grasshopper
Quelea add-on

○ **Restraining Parameters**
[Human Movement Simulation]

- Movement Environment
  (Buildings-street)
- Boid algorithm
- Predominnatly usage
  (start-target points)
- Attraction points
- Obstacles
  (trees,surface types)
- Seek force
  (to shaded areas)

3 Constraints

Rhinoceros(5.0)
Grasshopper
Functions and Values

○ **Main Constraint**
Minimizing sun exposed area value

○ **Neutral Conditions**
- Tree type selection randomization value
- Tree max-min size values
- Tree cap min proximity function
  (to overlap max %30)
- Tree proximity max funtion
  (to design elements coexistence)
- Human usage axes and tree positioning funtion
  (to keep open predominanly usage axes)
- Movement area limiting function
  (to keep the design elements inside the site with 2 m pavement)

4 Evolutionary Solver and Generative Modeling

Rhinoceros(5.0)
Grasshopper
Galapagos Solver Algorithm

○ **Main Objective**
Minimizing sun exposed areas

- **Controllers**
  All values and Funtion definitions

Rhinoceros(5.0)
Grasshopper
Quadtree Algorithm

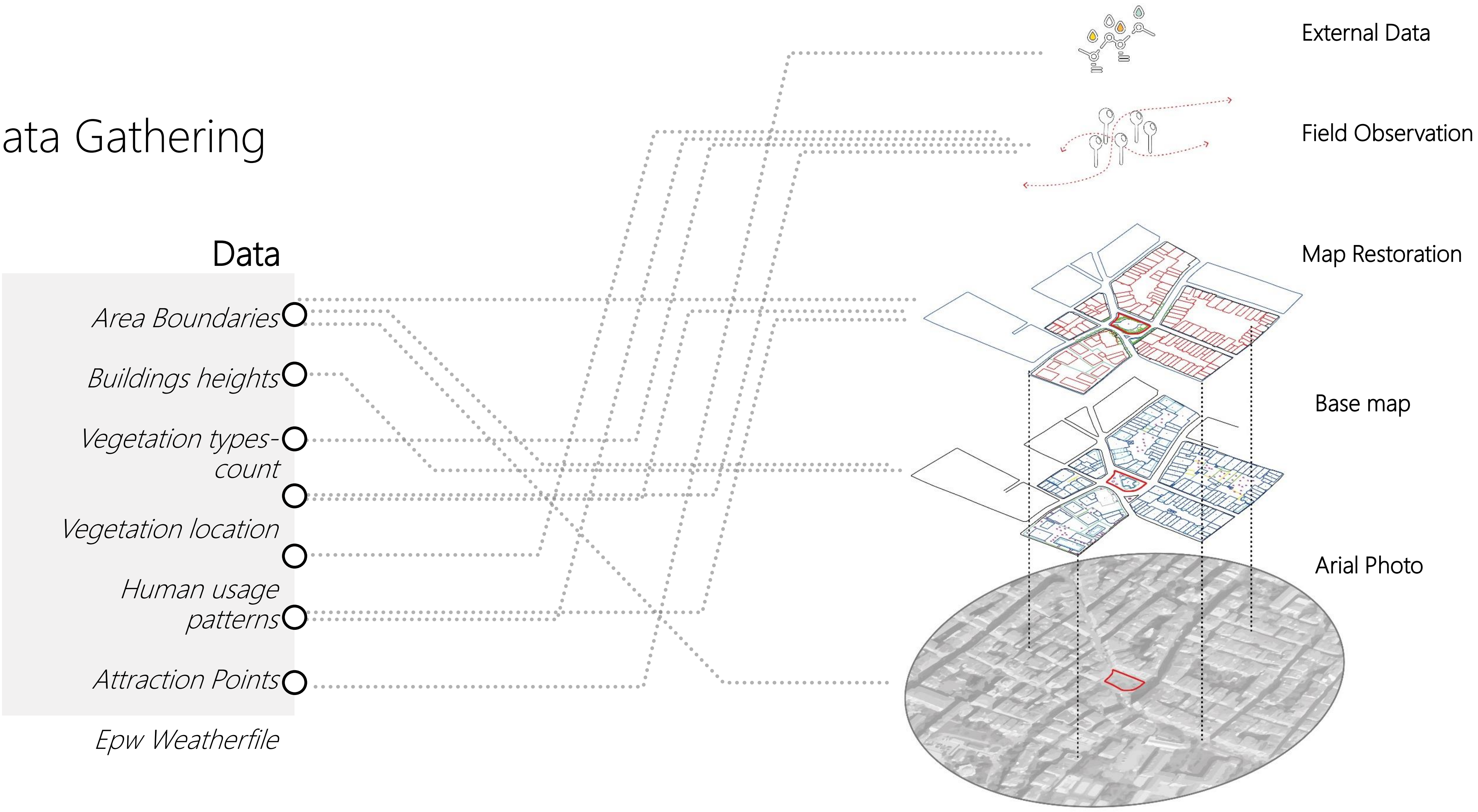
○ **İnputs**
- Tree positioning point data
- Movement axes point data

○ **Outputs**
- Vegetation covered areas — "-" unit vector
- Walking path ways — "0" unit vector
- Sitting places — "+" unit vector

Solver Definition Chain

Parameter Definition Chain

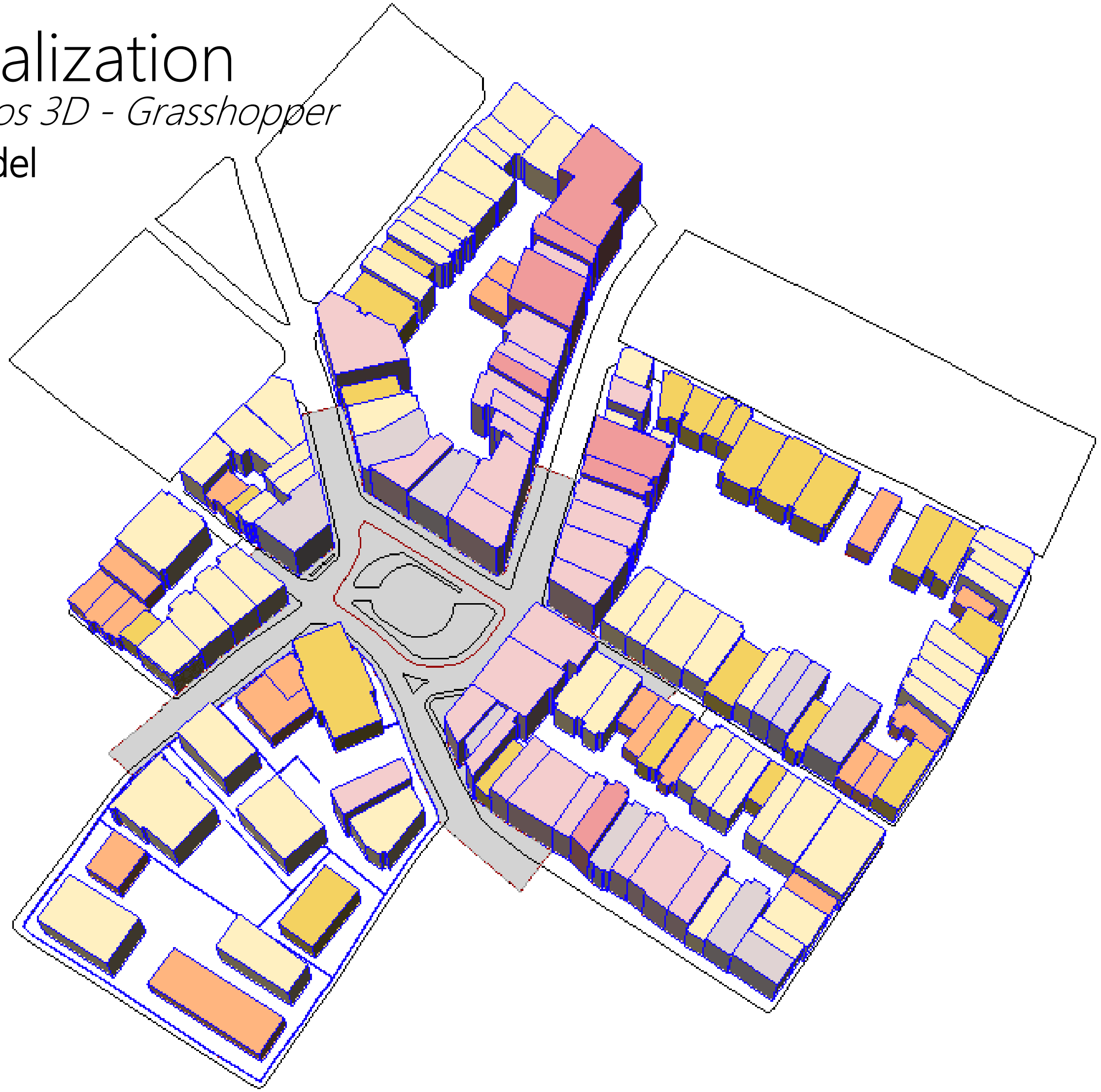
1 _ Data Gathering



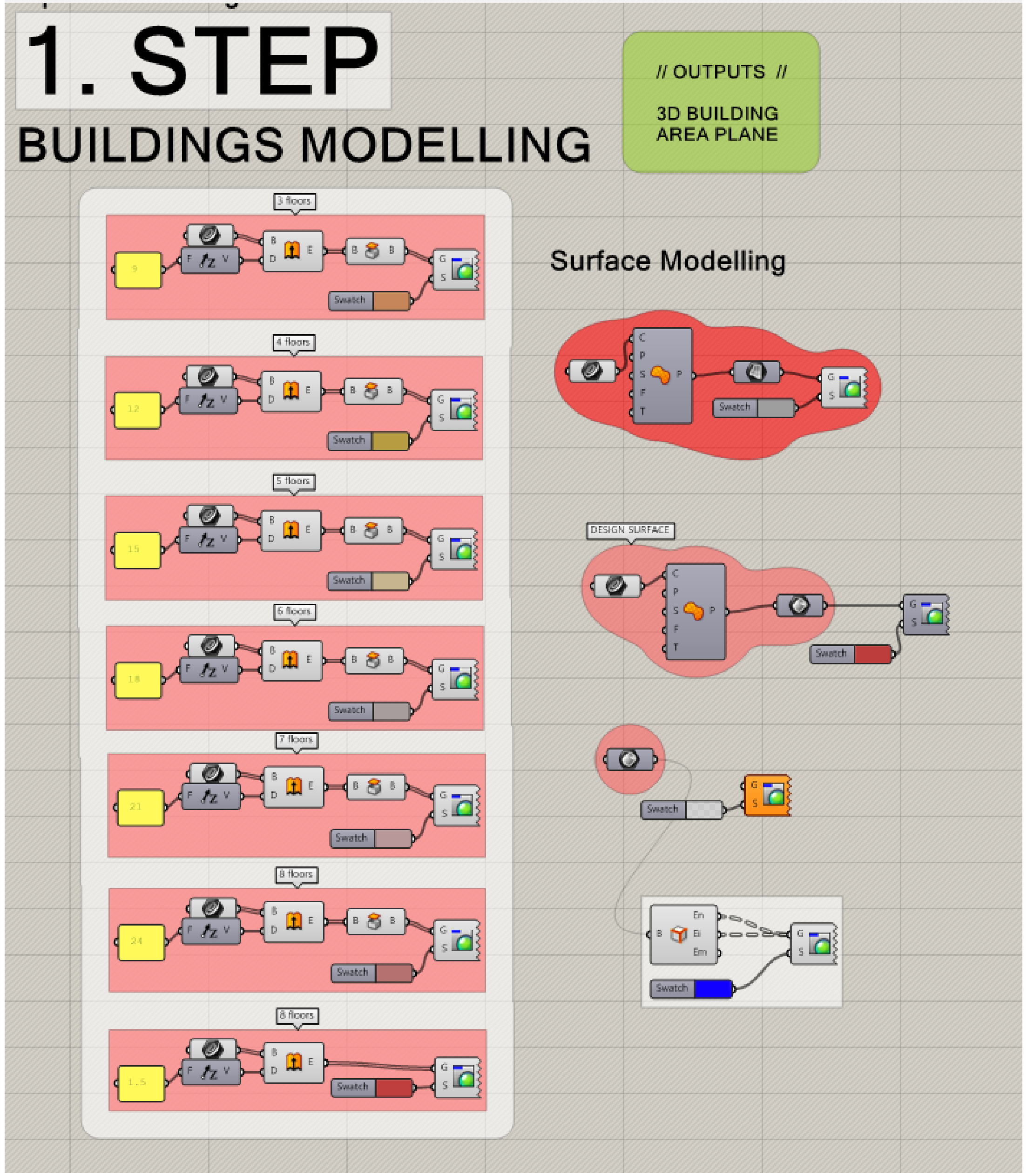
1 _ Digitalization

Rhinoceros 3D - Grasshopper

Base model



Rhinoceros view



Grasshoper view

2 _ Defining Parameters

Rhinoceros 3D - Grasshopper

Design Parameters //

Tree modelling

Tree types- Counts
Max-min sizes
Selection
randomization
Positioning

Restraining Parameters //

Microclimatic analysis
Solar Radiation

Buildings
Trees
Surface
Epw weatherfile

Ladybug Add-on

User simulation

Base model
Boild algorithim
Predominantly usage axes
Attraction Points (start-end points)
Obstacles (trees,surface types)
Seek force (to shaded areas)

Quela Add-on

2 _ Defining Parameters

Rhinoceros 3D - Grasshopper

Design Parameters //

Tree modelling

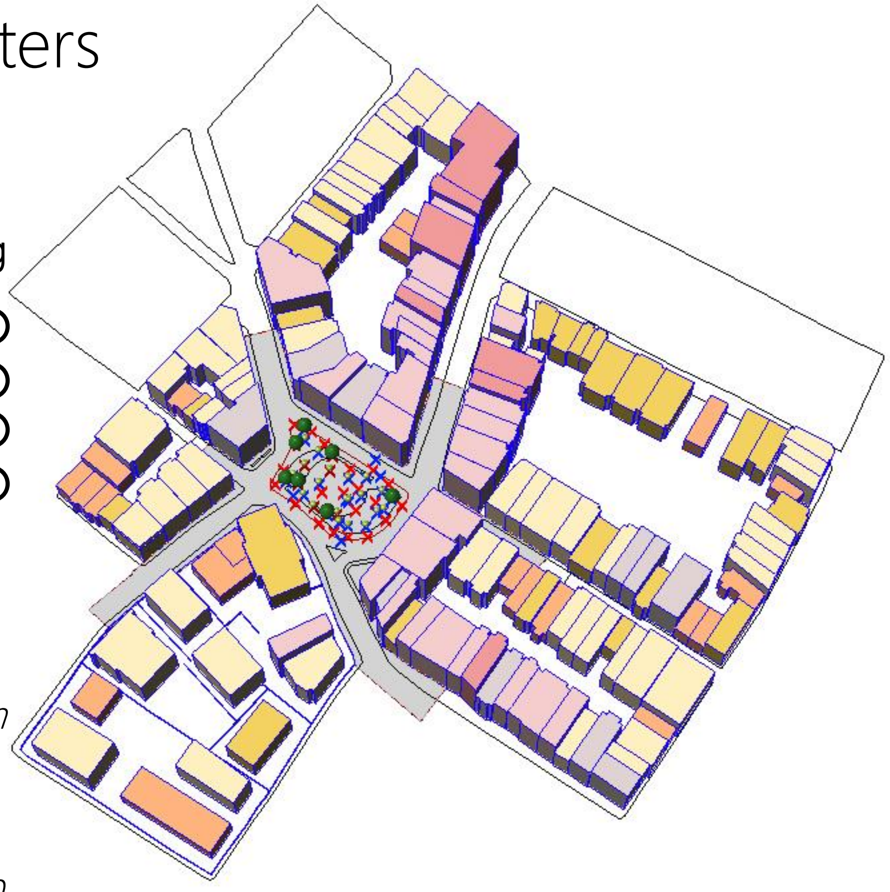
Tree types- Counts
Max-min sizes
Selection
randomization
Positioning

Tree types
Melia azedarach
Ligustrum japonica excelsum

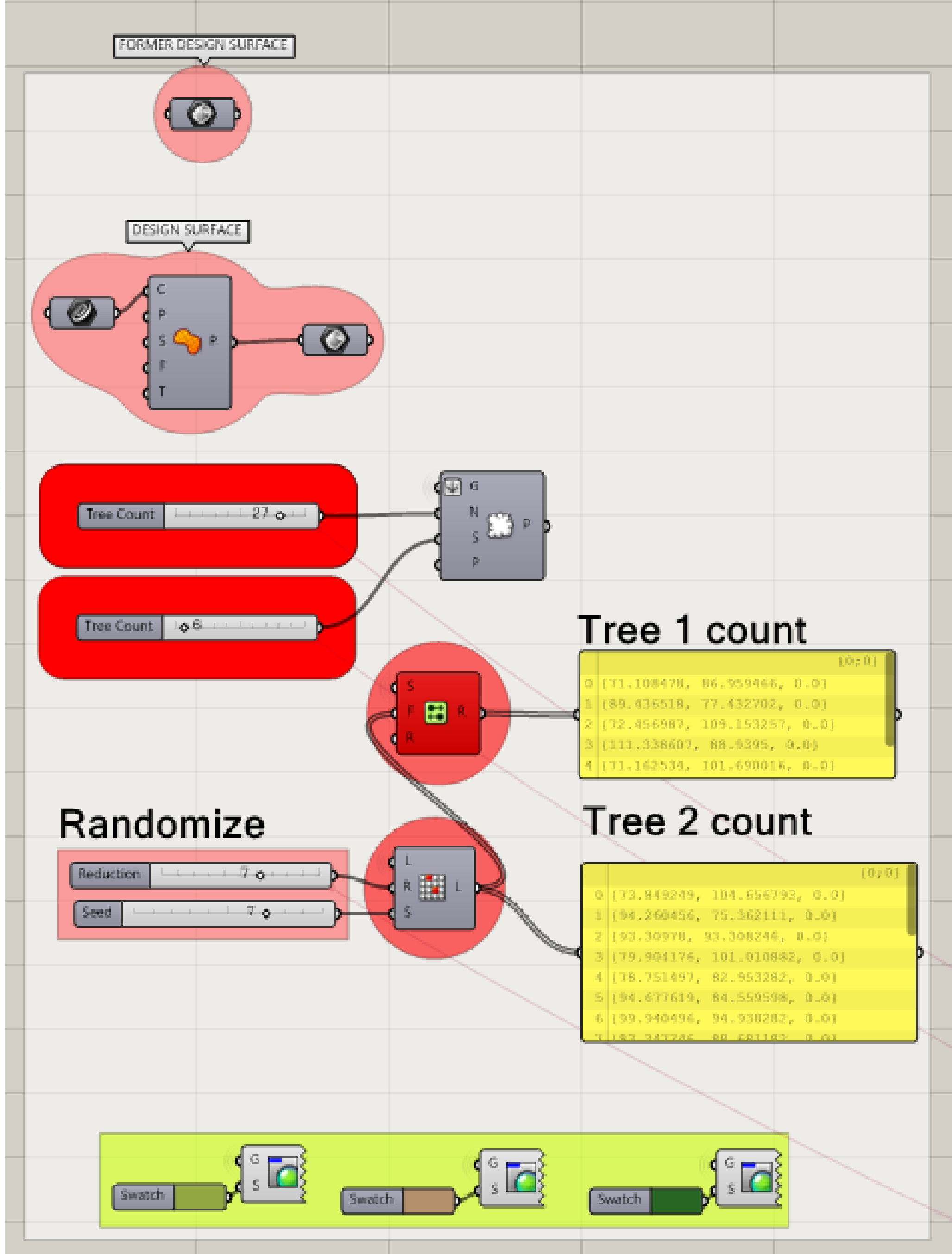
Total tree count
Existing : 25
Projected : min 15 – max -30

Selection randomization

Positioning - Point data



TREE MODELLING



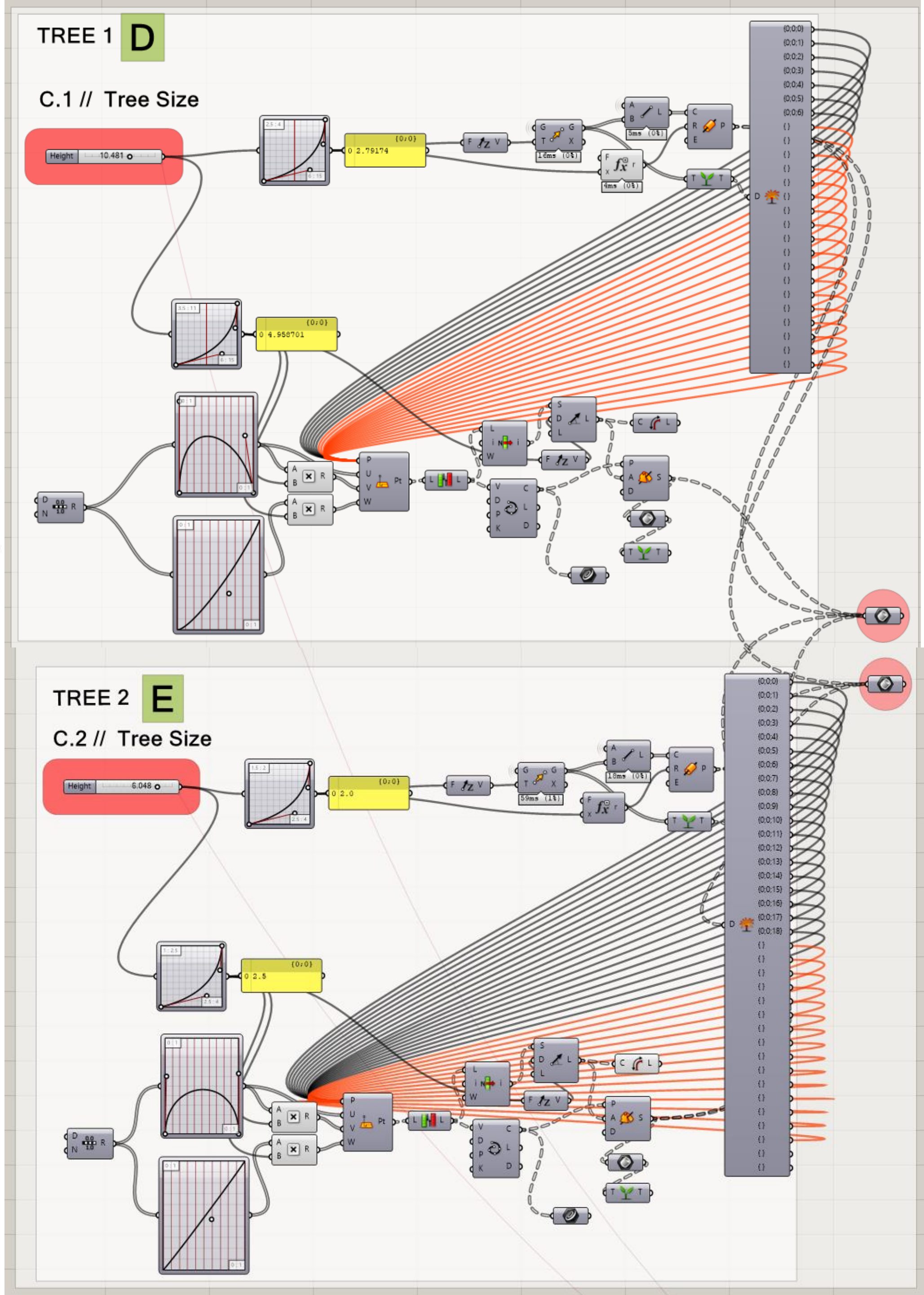
2 _ Defining Parameters

Rhinoceros 3D - Grasshopper

Design Parameters //

Tree modelling

Tree types- Counts
Max-min sizes
Selection
randomization
Positioning



Max-Min Size

2 _ Defining Parameters

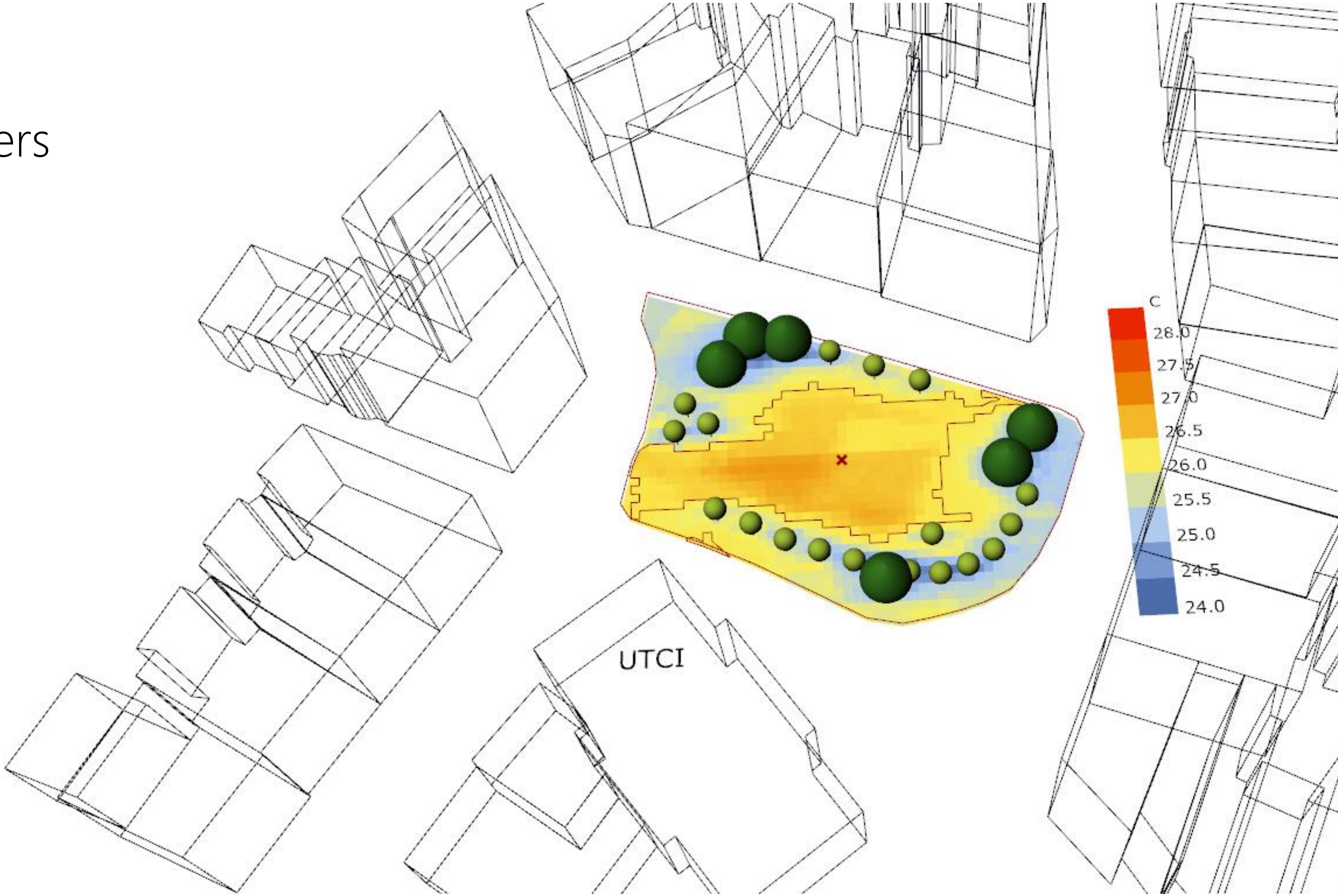
Rhinoceros 3D - Grasshopper

Restraining Parameters //

Microclimatic analysis

Buildings ○
Trees ○
Surface ○
Epw weatherfile ○

Sun exposure
Wind Effect
Aspect etc.



2 _ Defining Parameters

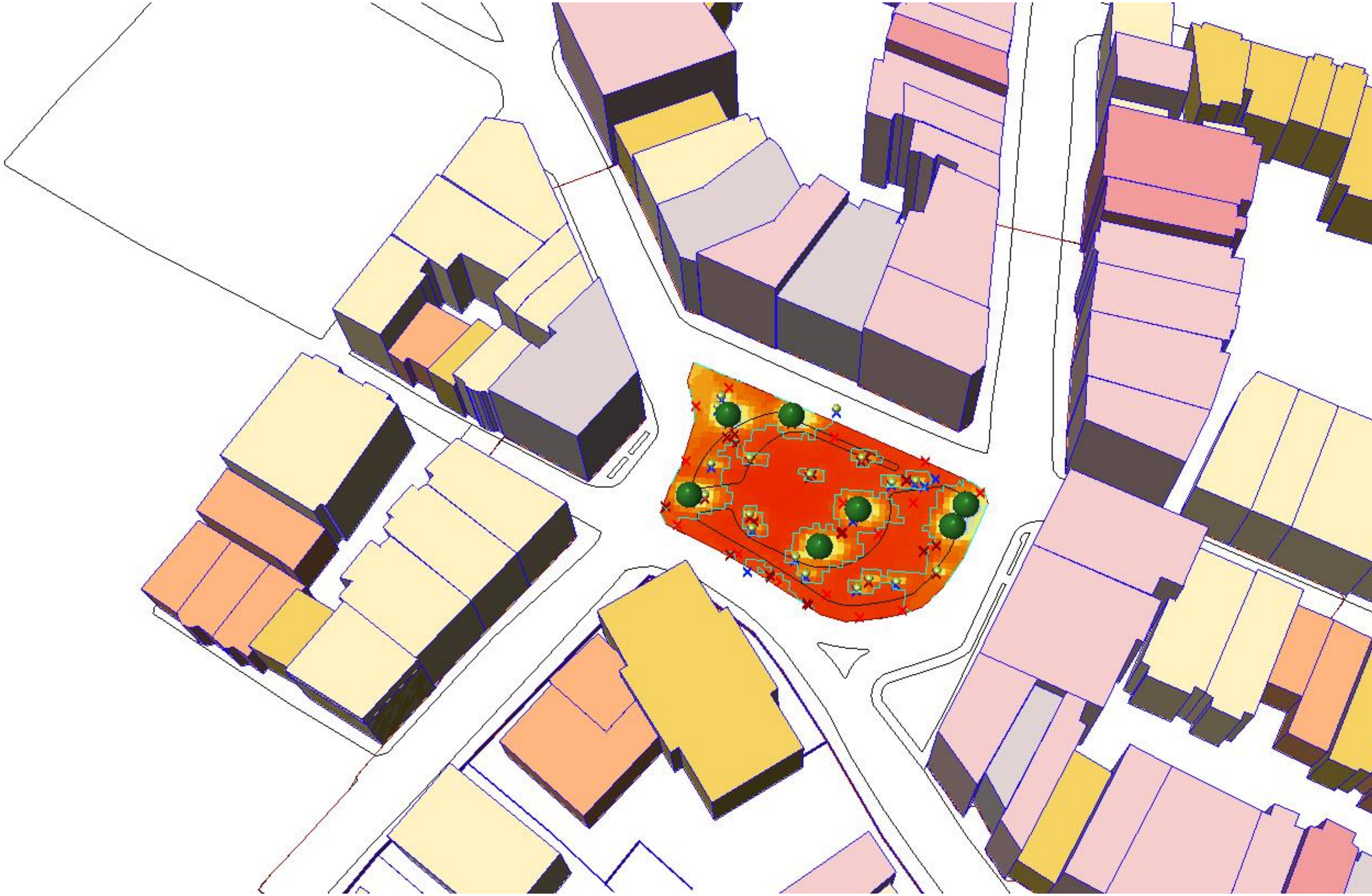
Rhinoceros 3D - Grasshopper

Restraining Parameters //

Solar Radiation

Buildings
Trees
Surface
Epw weatherfile

Solar radiation matrix



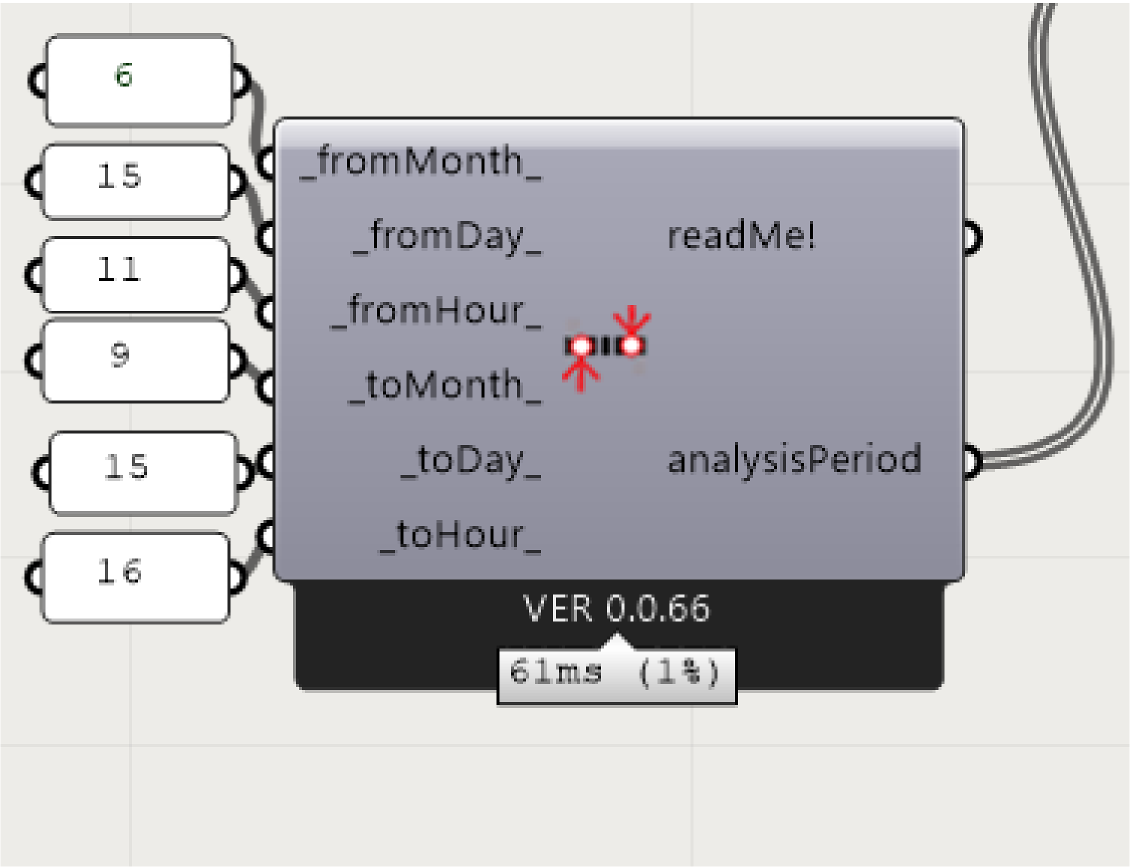
2 _ Defining Parameters

Rhinoceros 3D - Grasshopper

Restraining Parameters //

Solar Radiation

Buildings
Trees
Surface
Epw weatherfile



https://www.energyplus.net/weather-download/europe_wmo_region_6/TUR//TUR_Istanbul.170600_IWEC/all

Between
2003 – 2017 weather data

Analyse periods //

From mid June to mid September
At high noon (11 am – 4 pm)

+ 2 _ Defining Parameters

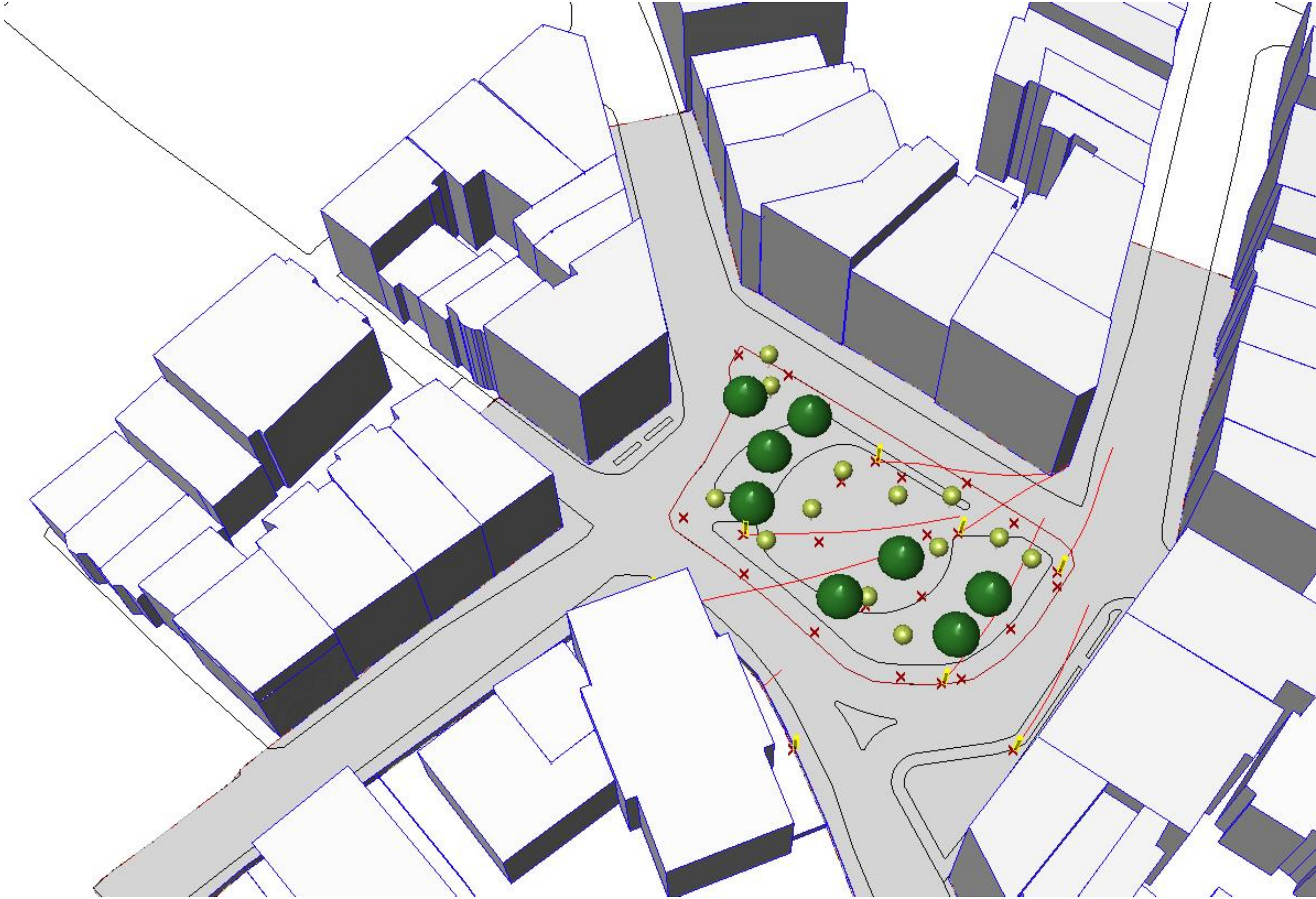
Rhinoceros 3D - Grasshopper

Restraining Parameters //

User simulation

Base model
Boild algorithim
Predominantly usage axes
Attraction Points (start-end points)
Obstacles (trees,surface types)
Seek force (to shaded areas)

Human usage pattern
Simulation was run
By using **Quela Add-on**



2 _ Defining Parameters

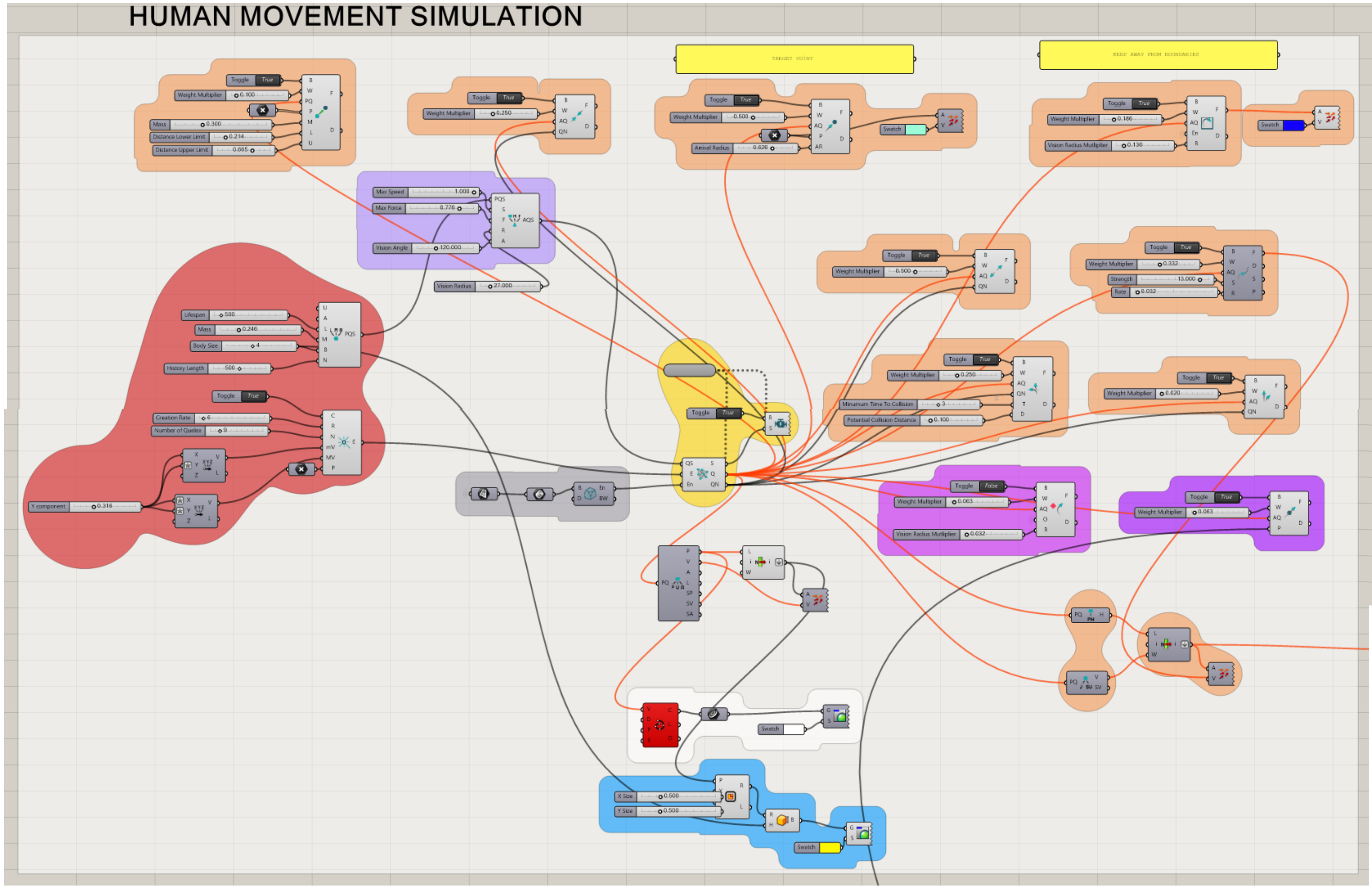
Rhinoceros 3D - Grasshopper

Restraining Parameters //

User simulation

Base model
Boild algorithim
Predominantly usage axes
Attraction Points (start-end points)
Obstacles (trees,surface types)
Seek force (to shaded areas)

*To mimic the behavior of the queleas as people in the open spaces, such as walking around was provided with **wonder force**, and making shaded areas more preferred as walking axes was defined with **seek force**. In addition to these point data and additional forces, the simulation was created based on **swarm behavior** rules from the Boids algorithm with **separation, alignment** and **cohesion forces.***



2 _ Defining Parameters

Rhinoceros 3D - Grasshopper

Restraining Parameters //

User simulation

Base model
Boild algorithim
Predominantly usage axes
Attraction Points (start-end points)
Obstacles (trees,surface types)
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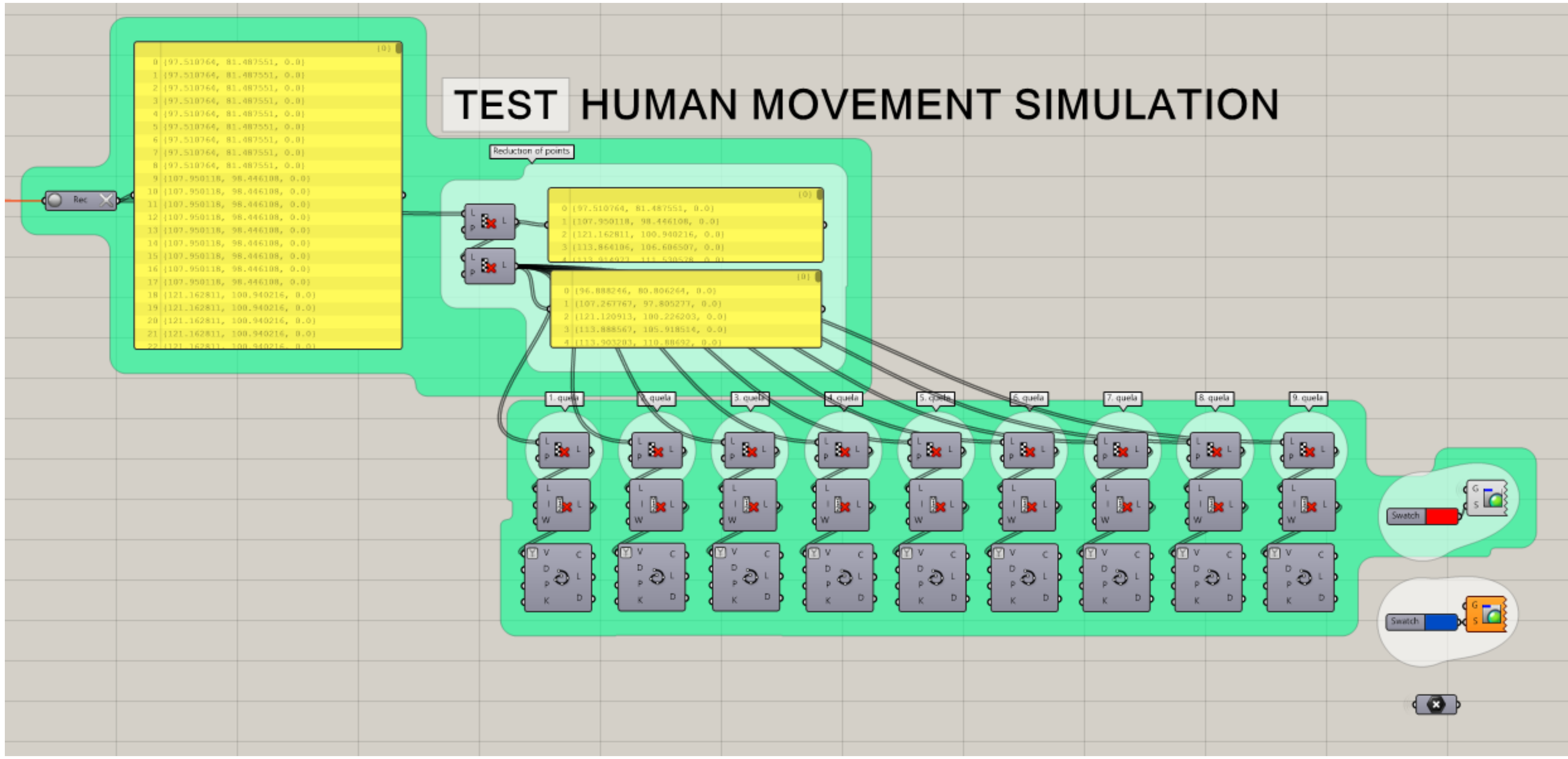


Recording the point data and converting to line data as walking pathways.

+ 3 _ Constraints

Rhinoceros 3D - Grasshopper

Functions and Values //

Neutral Conditions // Tree Relations

Tree type selection randomization value
Tree max-min size values
Tree cap min proximity function
(to overlap max %30)
Tree proximity max funtion
(to design elements coexistence)

Neutral Conditions // Spatial relations

Human usage axes and tree
positioning funtion
(to keep open predominanly usage
axes)
Movement area limiting function
(to keep the design elements inside the
site
with 2 m pavement)

Main Condition

Minimizing sun exposed area value

3 _ Constraints

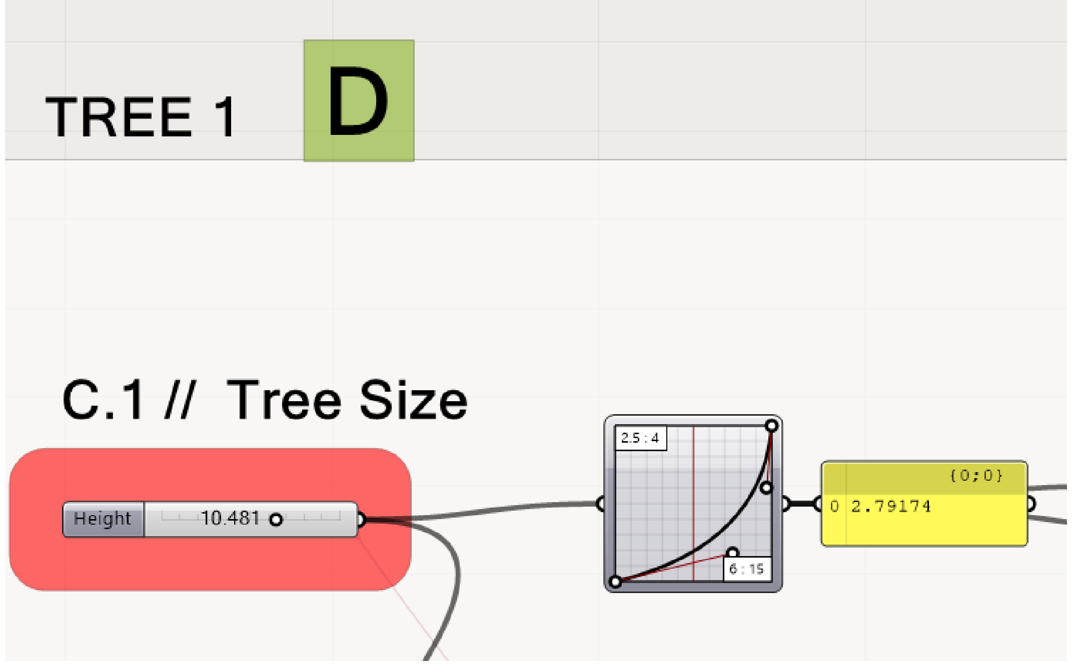
Rhinoceros 3D - Grasshopper

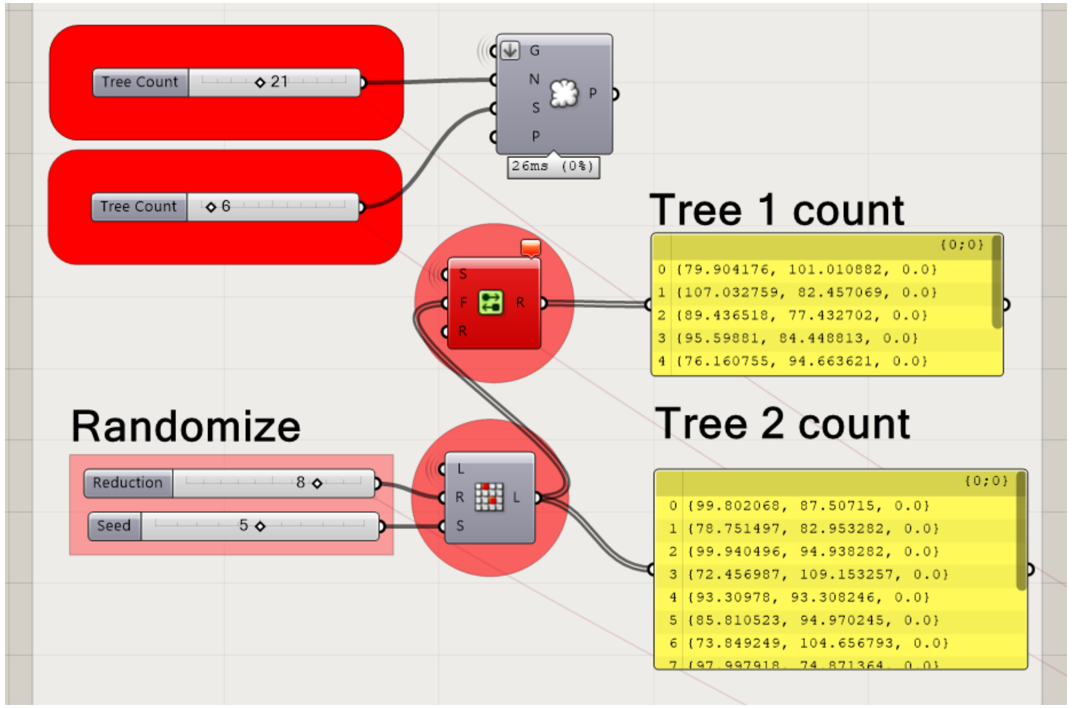
Functions and Values //

Neutral Conditions // Tree Relations

Tree type selection randomization value
Tree max-min size values
Tree cap min proximity function
(to overlap max %30)
Tree proximity max funtion
(to design elements coexistence)

These values defined with tree modeling stage.





3 _ Constraints

Rhinoceros 3D - Grasshopper

Functions and Values //

Neutral Conditions // Tree Relations

Tree type selection randomization value
Tree max-min size values
Tree cap min proximity function
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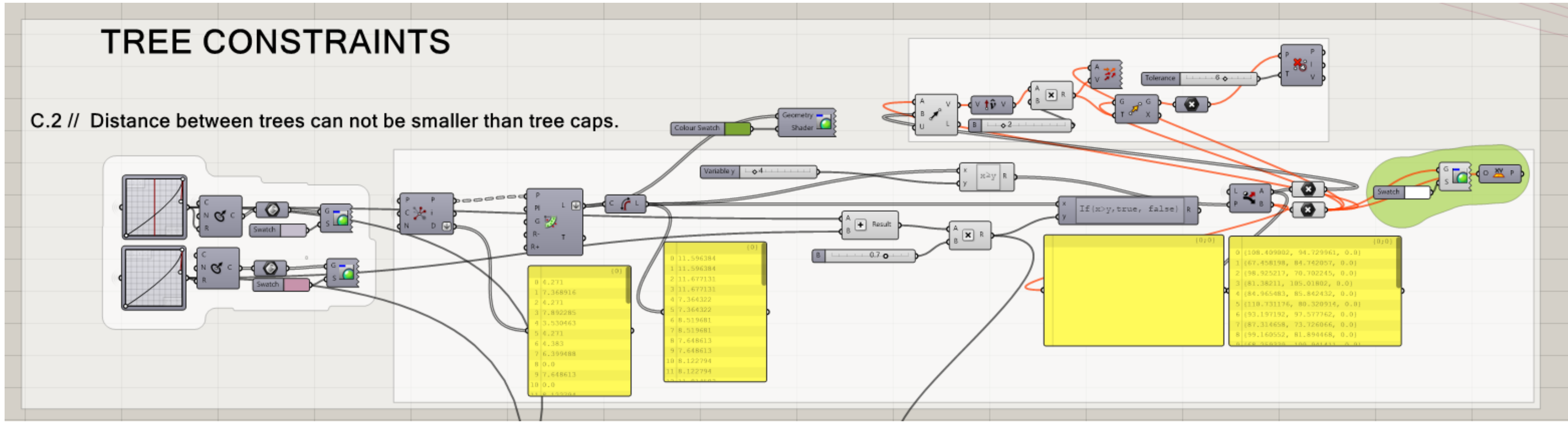
Tree proximity max funtion
(to design elements coexistence)



Min proximity – caps overlap max %30
Max proximity – area boundary

3 _ Constraints

Rhinoceros 3D - Grasshopper

Functions and Values //

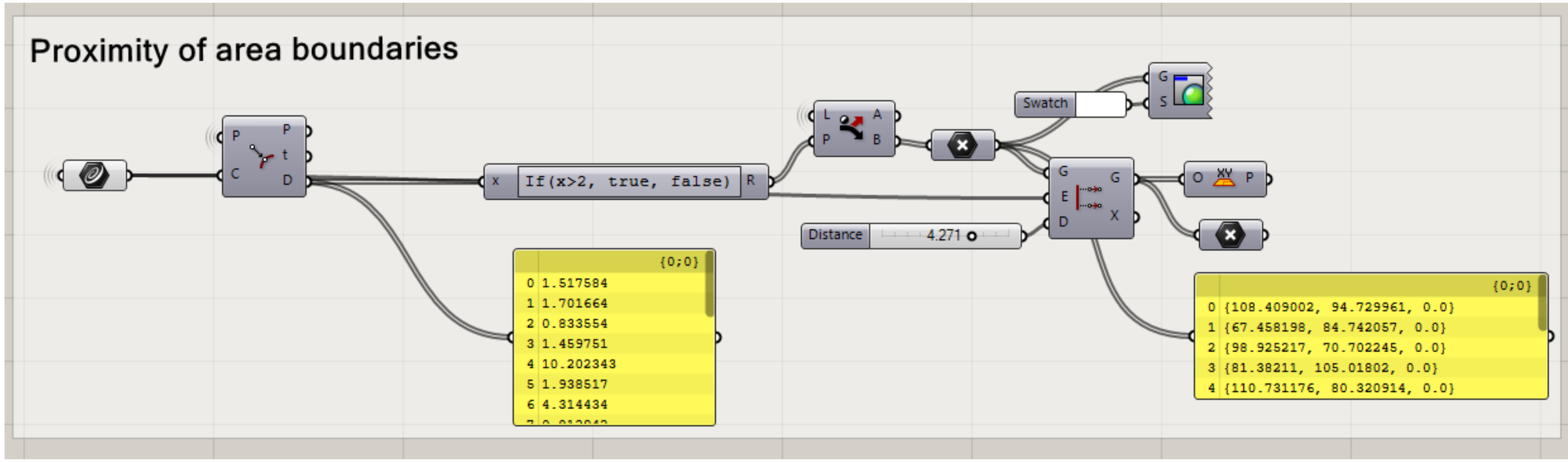
Neutral Conditions // Spatial relations

Human usage axes and tree positioning funtion
(to keep open predominanly usage axes)

Movement area limiting function
(to keep the design elements inside the site
with 2 m pavement)

Inside area that close to maximum 2 m to reach the area boundary.

With 3 main predominantly usage axes emerge acceptance, tree positionings was restricted to keep open usage pattern.



4 _ Evolutionary Solver and Generative Modelling

Rhinoceros 3D - Grasshopper

Constraint Function //

Controllers
Tree positioning point data

Main Objective
Provide tree constraints

Galapagos Solver Algorithm //

Controllers
All values and Funtion definitions

Main Objective

Minimizing sun exposed areas

Quadtree Algorithm//

Inputs
Tree positioning point data
Movement axes point data

Outputs
Vegetation covered areas
Walking path ways
Sitting places

"- " unit vector
"0 " unit vector
" +" unit vector

Optimizations
By using Galapagos Grasshopper Evolutionary Solver,
And constarint functions that defined.

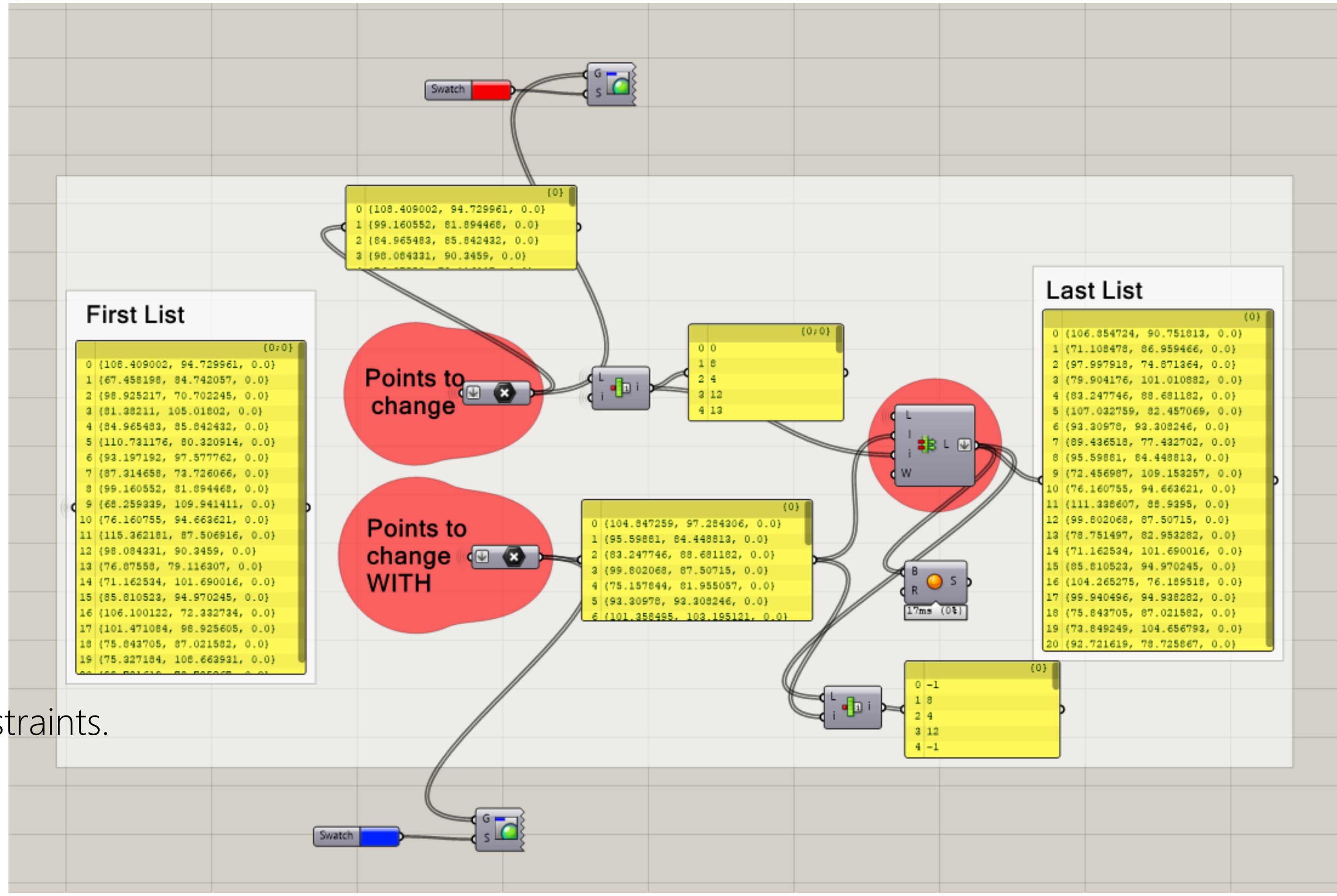
4 _ Evolutionary Solver and Generative Modelling

Rhinoceros 3D - Grasshopper

Constraint Function //

Controllers
Tree positioning point data

Main Objective
Provide tree constraints



Optimizations
By using “ move function” that defined via tree constraints.

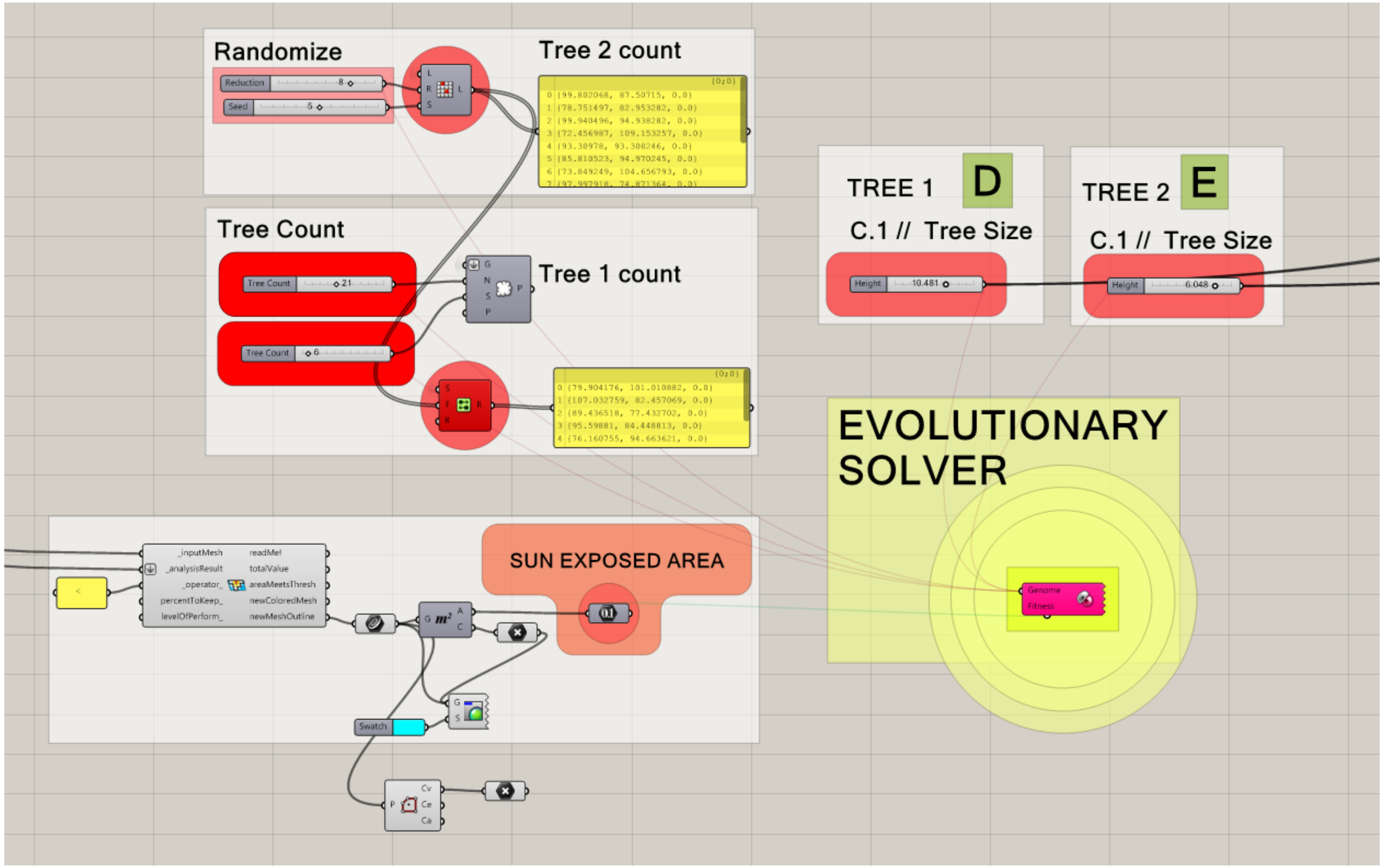
4 _ Evolutionary Solver and Generative Modelling

Rhinoceros 3D - Grasshopper

Galapagos Solver Algorithm //

Controllers
All values and Funtion definitions
Main Objective

Minimizing sun exposed areas



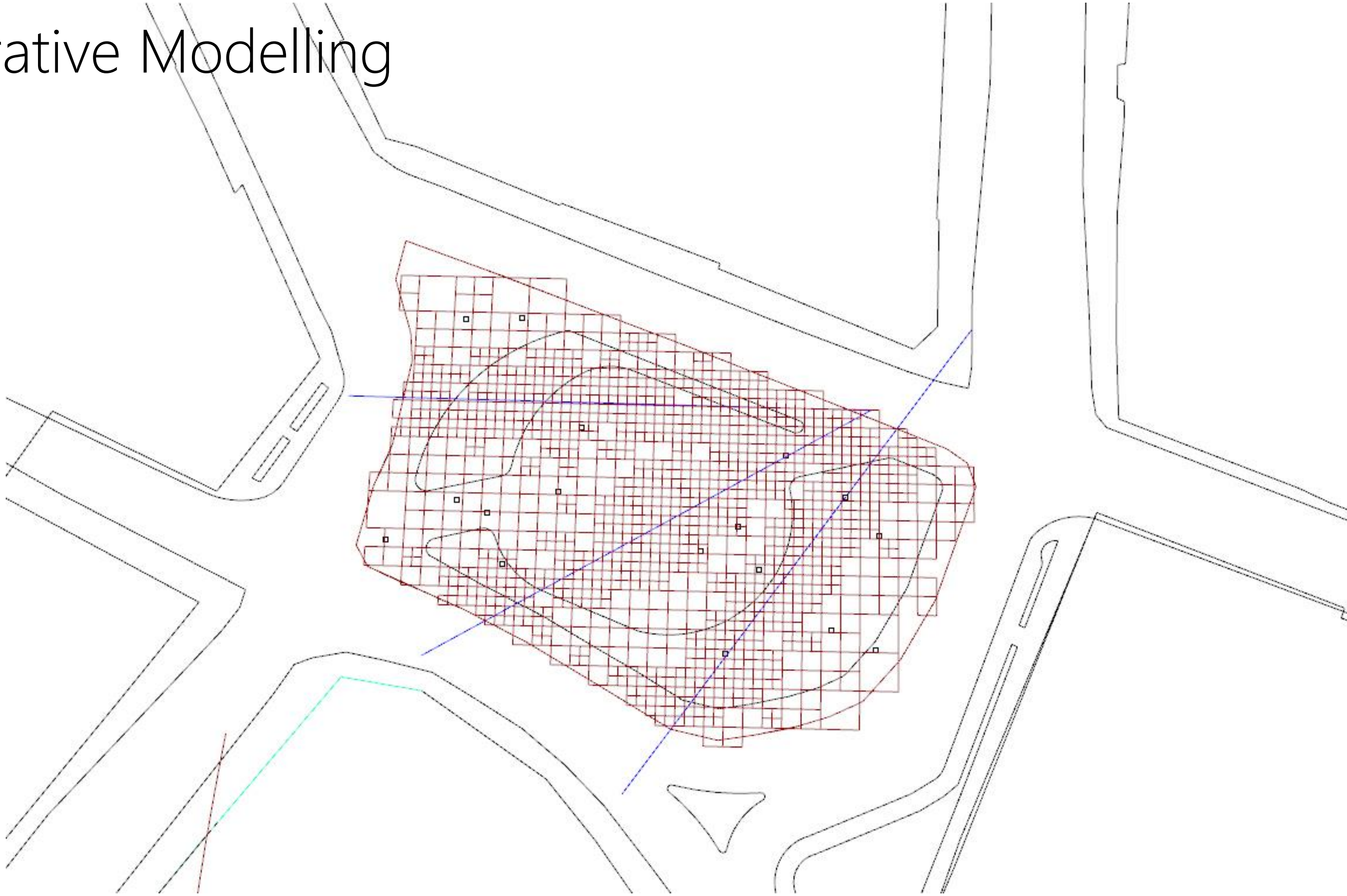
4 _ Evolutionary Solver and Generative Modelling

Rhinoceros 3D - Grasshopper

Quadtree Algorithm//

Inputs
Tree positioning point data
Movement axes point data

Outputs
Vegetation covered "- " unit vector
areas "0 " unit vector
Walking path ways " +" unit vector
Sitting places

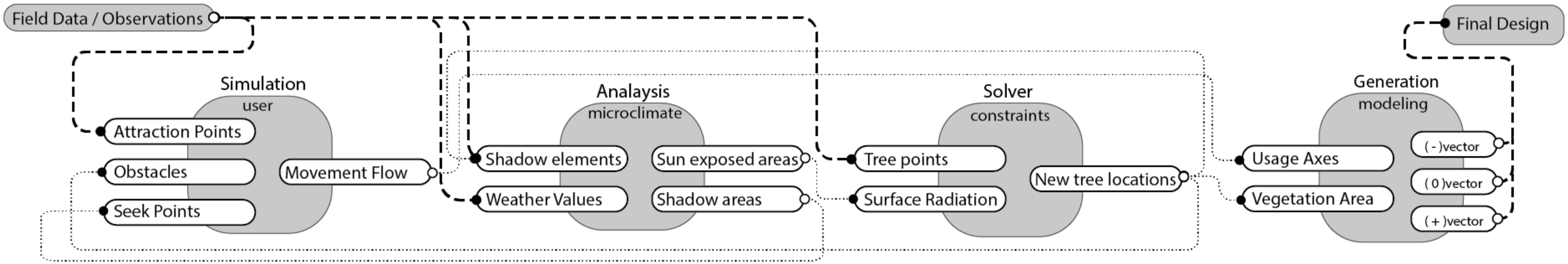


Findings

Walking pathways

Plan "0" vector force

Model Workflow



Findings

Evolutionary Solver Algorithm

	Emty	Existing	Evolutionary Solver Algorithm	Generative Algorithm
Design Surface // Consist of boundaries that shaped by roads.			Surface // **% 34** impermable. After the surface manipulation. **849 m²** Tree count 26 T1 | 8 T2 | 18	Surface // **% 95** impermable **1279m²** Before the surface manipulation. Tree count 26 T1 | 8 T2 | 18
Solar Radiation Matrix // Sun Exposure depends on only sun rays and building positioning.			Surface radiation // maximum **% 26** of the area was directly sun exposed	Surface radiation // maximum **% 34** of the area was directly sun exposed
Usage patern // Spread around the Side Recorded 30 sec.			Human usage pattern // Environmental interaction is high and also because of the fractality of designed area usage interaction is high. **4 unit** inside the area.	Human usage pattern // Sepreaded , environmental interaction is high.
Microclimatic Analysis// (with wind and sun exposure direction) Open space feeling Condition value			Area microclimatic condition // open space usage is high **%12** of the area' s degree **higher than 27° C** Users could reach only impermable surfaces.	Area microclimatic condition // open space usage is high **%17,5** of the area' s degree **higher than 27° C** Users could reach only impermable surfaces.

Findings

Impermable Surface // % 68

Microclimatic effect // %33

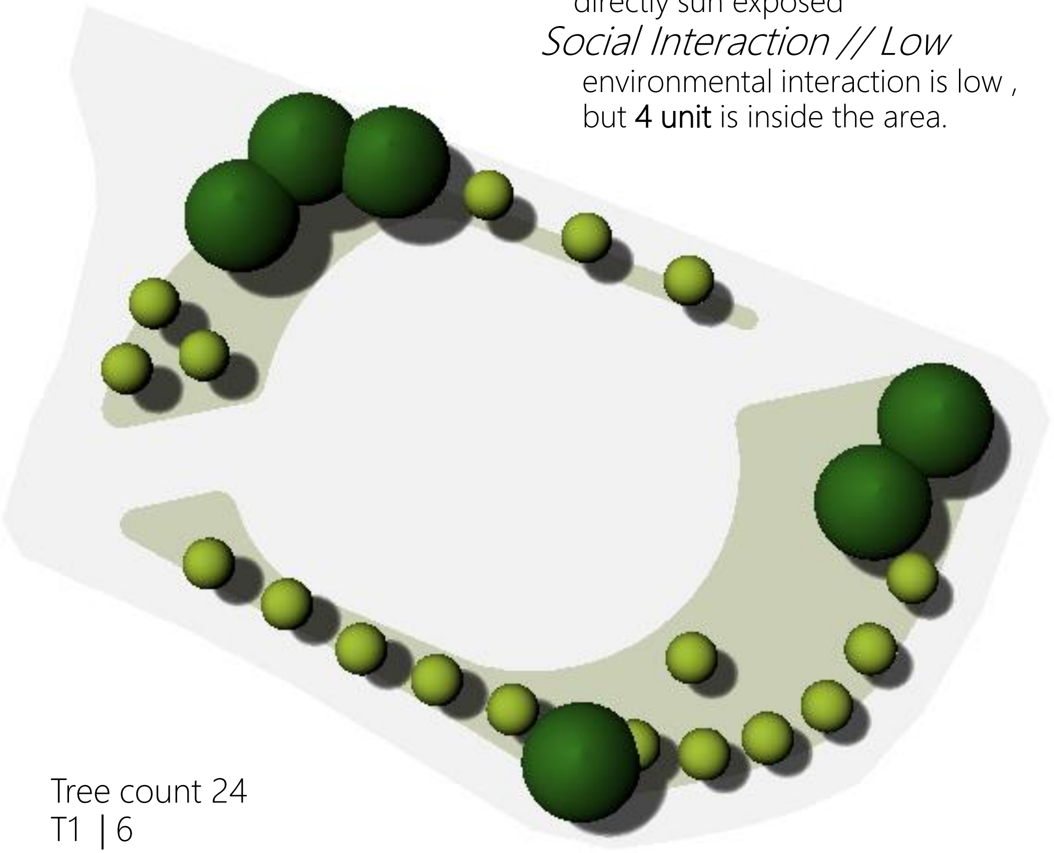
higher than 27° C

Solar Radiation // % 47

directly sun exposed

Social Interaction // Low

environmental interaction is low , but **4 unit** is inside the area.



Tree count 24
T1 | 6
T2 | 18

Existing Situation

Impermable Surface // % 34

Microclimatic effect // %12

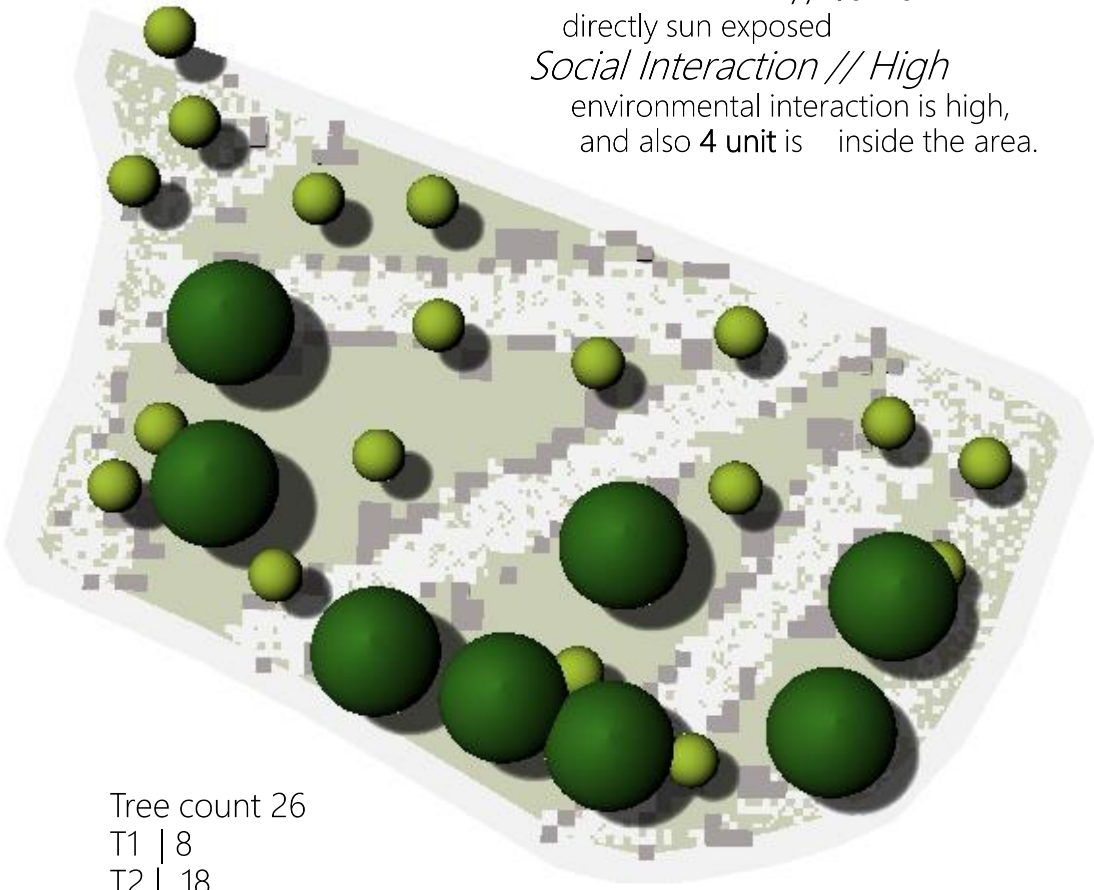
higher than 27° C

Solar Radiation // % 26

directly sun exposed

Social Interaction // High

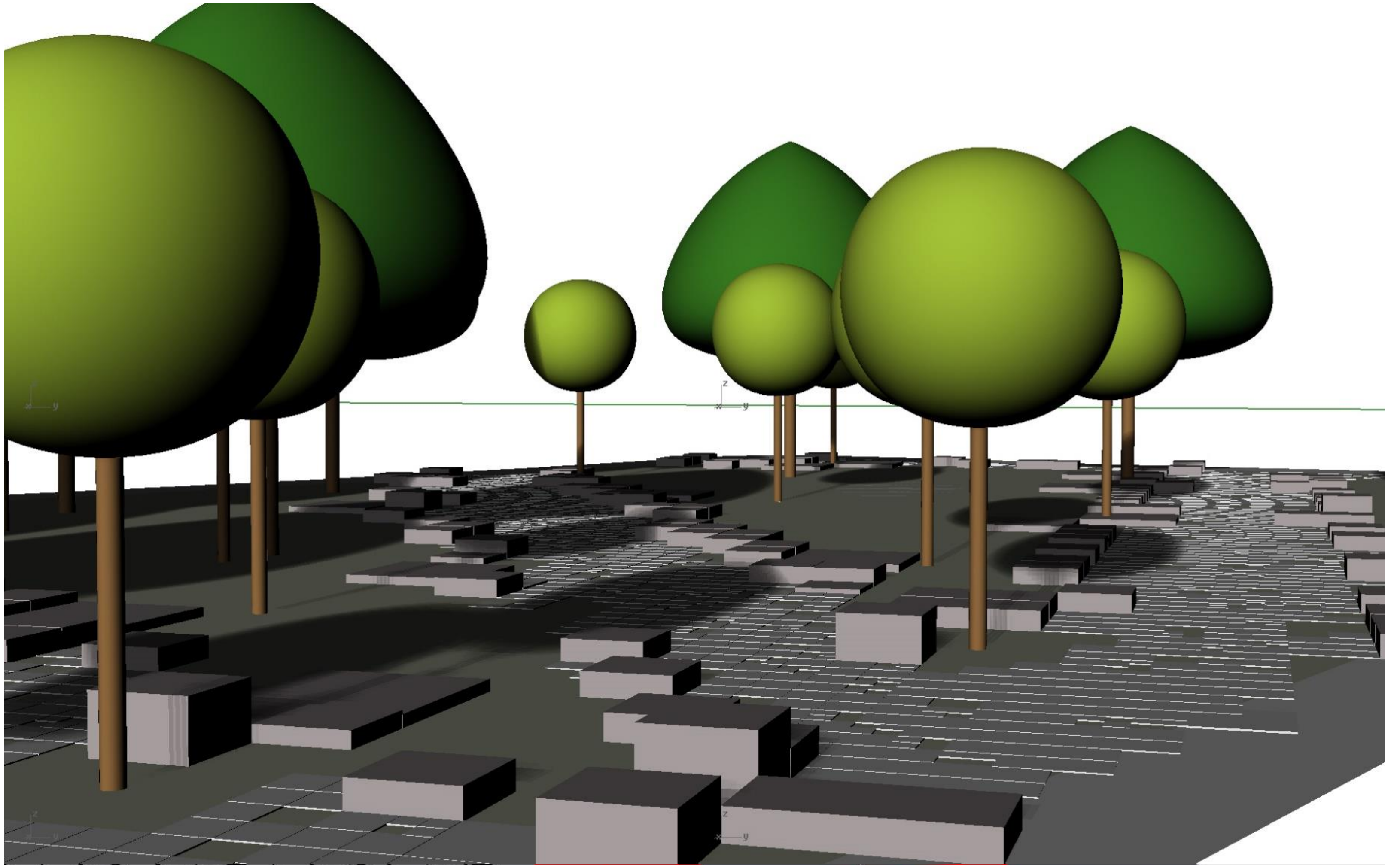
environmental interaction is high, and also **4 unit** is inside the area.



Tree count 26
T1 | 8
T2 | 18

Generated Situation

Findings



The generated design surface has different features like sitting walls, vegetation patches, and walking pathways.

Conclusion

- While this study proposed a design outcome, it was tested the effects of landscape elements by the instrumentality of algorithmic design process.
- This model was intended to be produced in a single and integrative definition so that it can be seen instantly how inputs and outputs affect each other.
- Parameters that used in the model, can describe the conditions that provide the appropriate environment for the creation of landscape design; however, the model can be developed by defining more and detailed parameters.
- However constraints and rule functions works, tree positionings and identified usage areas creation should be defined more precisely because one tree and also some sitting areas were loctaed too close to the edge and sidewalk.

Future Works

- The tree features, which were used as the design parameters, can be introduced into the model in a way that carries all the characteristics of the field.
- A model can be developed with more detailed and variated microclimatic analysis outputs
- New definitions can be developed through ecological cycles by evaluating the material properties of the design surface.
- In order to make the simulation more consistent, input data which were collected from the location-based observations can be used as more statistical and recorded data.
- Generative design stage should be consider to create different method to acheive more soft design lines.

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[1] http://www.heatherwick.com/projects/buildings/moganshan/

[2] https://www.mvrdv.nl/projects/295/zhangjiang-future-park

[3] http://jdsa.eu/slc/

[4] https://www.stefanoboeriarchitetti.net/project/ca-delle-alzaie/

[5] https://big.dk/#projects-arc

[6] http://emrearolat.com/gallery/zorlu-center-mixed-use-complex/

[7] https://www.architectmagazine.com/project-gallery/jewel-changi-airport_o

[8] https://www.mvrdv.nl/projects/17/hongqiao-cbd?photo=18347

[9] https://www.commercialinteriordesign.com/thoughts/woods-bagot-designed-sharjah-masterplan-to-encourage-active-lifestyle

[10] https://www.zaha-hadid.com/masterplans/kartal-pendik-masterplan/

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Thank You !