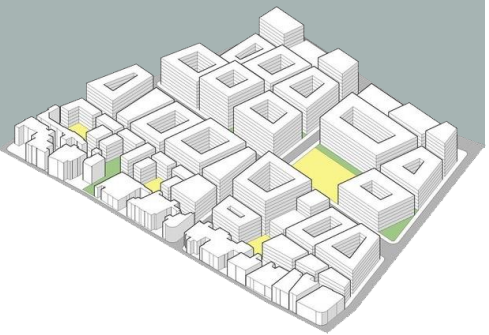


Generative Design for Spatial Layout of Urban Neighborhood

By: Abhishek Palit
Scholar No. 19510002
Guided By: Prof. Saptarshi Kolay

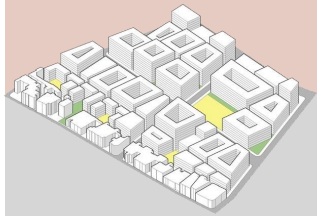
Synopsis

Aim

To create a generative design methodology for spatial layout of neighborhood, that incorporates different variables and parameters as a set of defined measurable goals and generates different design options that can be evaluated to achieve the optimum solution.

Objectives

1. *Literature Review of the Generative Design Approach.*
2. *Site Study and Analysis.*
3. *Identification of parameters and goals and creation of a generative algorithm that integrates a rule-based geometric system and a series of measurable goals and parameters and generates multi variate scenarios.*
4. *To evaluate the generated scenarios and select the optimum design option.*



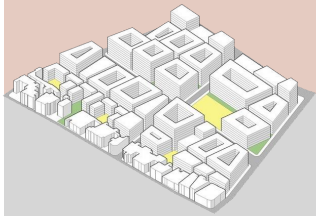
Synopsis

Scope

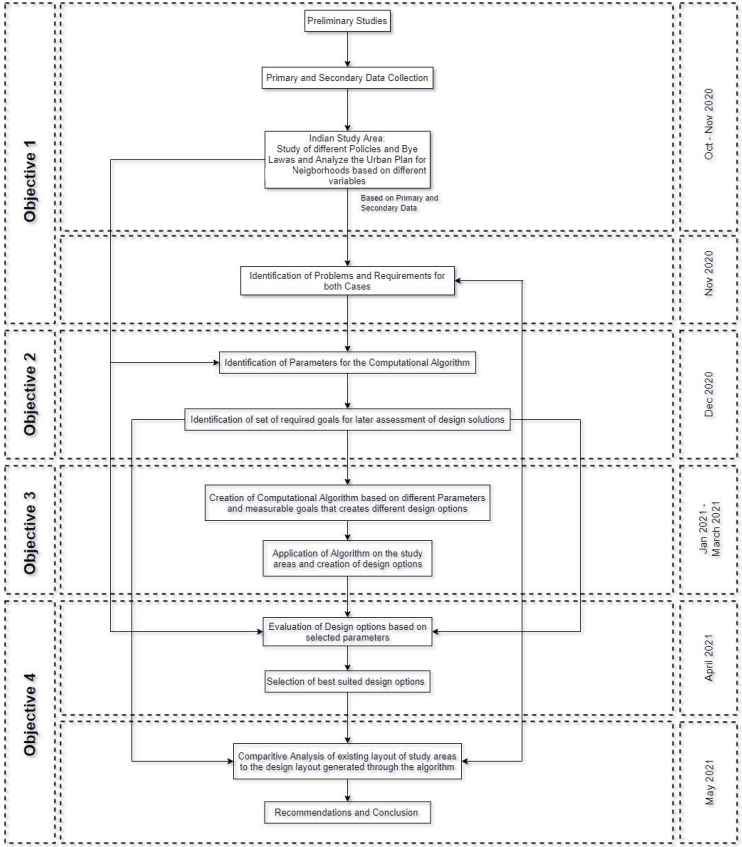
- *Includes the scale of a neighbourhood in two selected cities.*
- *The tools for the computation will include parametric software Revit Dynamo.*
- *Computational algorithm thus generated would output automated layouts of the neighbourhood for the selected study area.*
- *The study will also compare the computer-generated layouts to the existing layout of the neighbourhoods of the study area.*

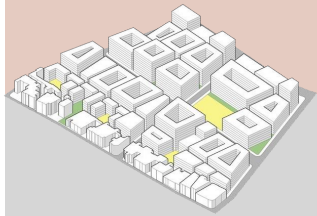
Limitations

- *Limited to a general statement by one city, for validation of the computational algorithm.*
- *The generative algorithm will be based on the parameters and goals majorly identified through the analysis of the study areas.*



Methodology



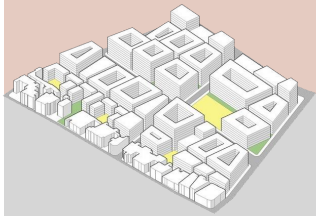


Neighborhood Design Concepts

Radburn Model
by Clarence Stein and Henry Wright

- Four to six superblocks commonly formed a neighbourhood that was bounded by major roads or natural features.
- At one end of the parkway there could be a small school with community rooms.
- Roads in the neighbourhood were to be hierarchical - major through traffic roads to border each neighbourhood, distributor roads to surround each superblock, and culs-de-sac to provide access to individual property lots.

Neighborhood Concept - Radburn Model
by Clarence Stein and Henry Wright

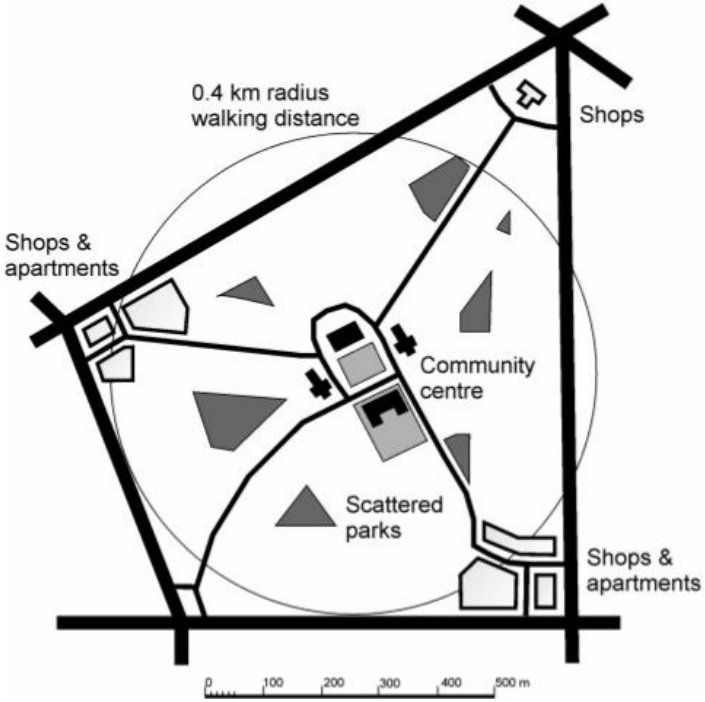


Neighborhood Design Concepts

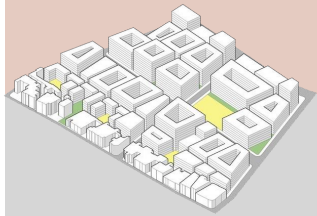
Neighborhood Unit
by Clarence Perry

Perry identified six neighbourhood unit design principles.

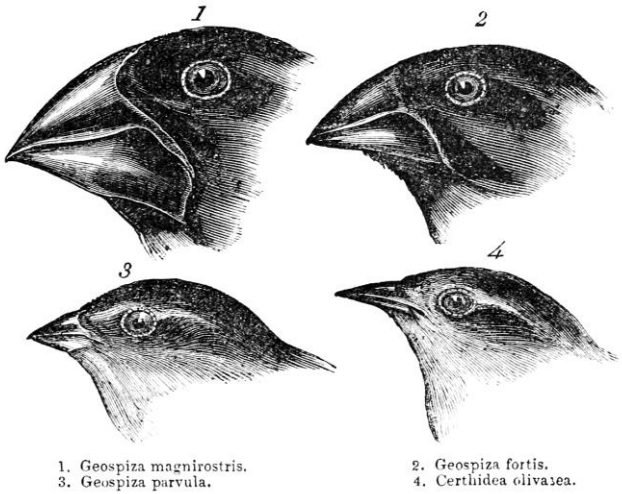
- First, the unit was to be ideally a shape in which all sides were equidistant from the centre, and its size was to be fixed.
- Secondly, a central neighbourhood or community centre was to contain various institutional sites, including a school, grouped round a central green space.
- Thirdly, local shops or shops and apartments were to be located at the outer corners of the neighbourhood.
- Fourthly, scattered small parks and open spaces, located in each quadrant of the neighbourhood, were to form 10 per cent of the total area.
- Fifthly, arterial streets were to bound each side of the neighbourhood while ,
- sixthly, the layout of the internal street was to be a combination of curvilinear and diagonal roads to discourage through traffic. Vehicular and pedestrian traffic was to be segregated.



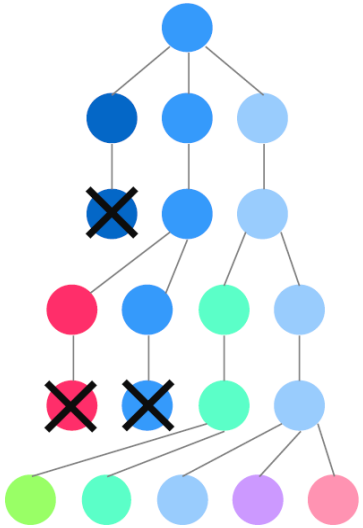
Neighborhood Unit Concept by Clarence Perry



Nature's evolutionary design approach.



The evolutionary process in nature (Darwin's finches or Galapagos finches. Darwin, 1845)



Mutation creates variation

Unfavorable mutations selected against

Reproduction and mutation occur

Favorable mutations more likely to survive

and reproduce

The evolutionary process in the nature. (Nagy, 2017a)

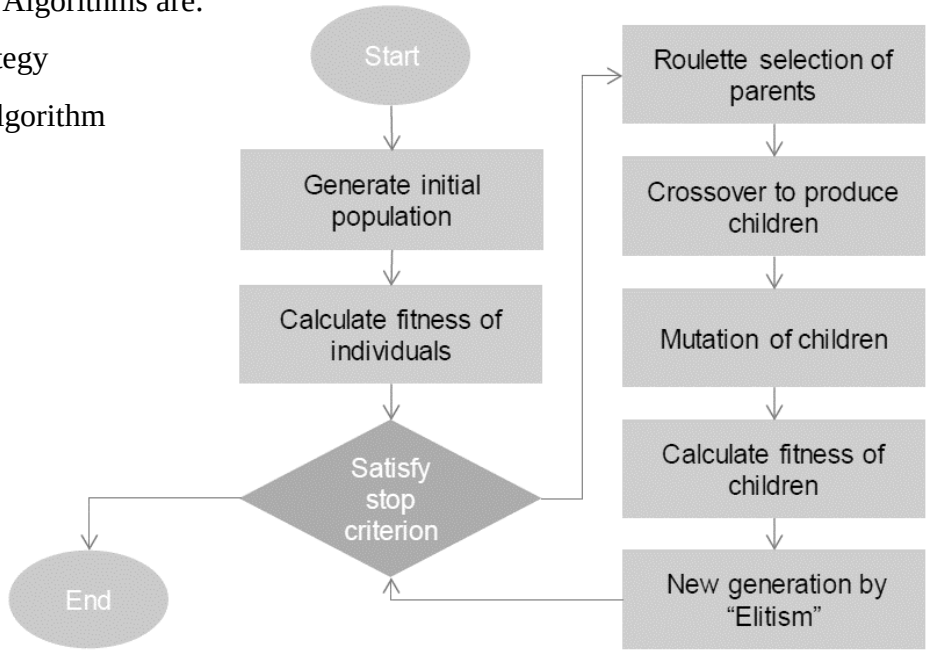
Selection → **Breeding** → **Mutation**

Genetic Algorithm

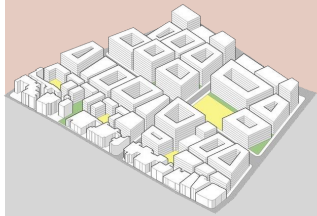
- Genetic Algorithm is a ***metaheuristic used to solve multi-objective optimization problems.***
- The method of rating the population of children along with the population of parents is called ***Elitism.***

The three commonly known elitist Genetic Algorithms are:

- ✓ PAES – Pareto Archived Evolution Strategy
- ✓ SPEA – Strength Pareto Evolutionary Algorithm
- ✓ NSGA – Non-Dominated Sorting GA



Basic workflow of a Genetic Algorithm (GA) (Nagy D. ,2017)



Non-Dominated Sorting Genetic Algorithm II (NSGA – II)

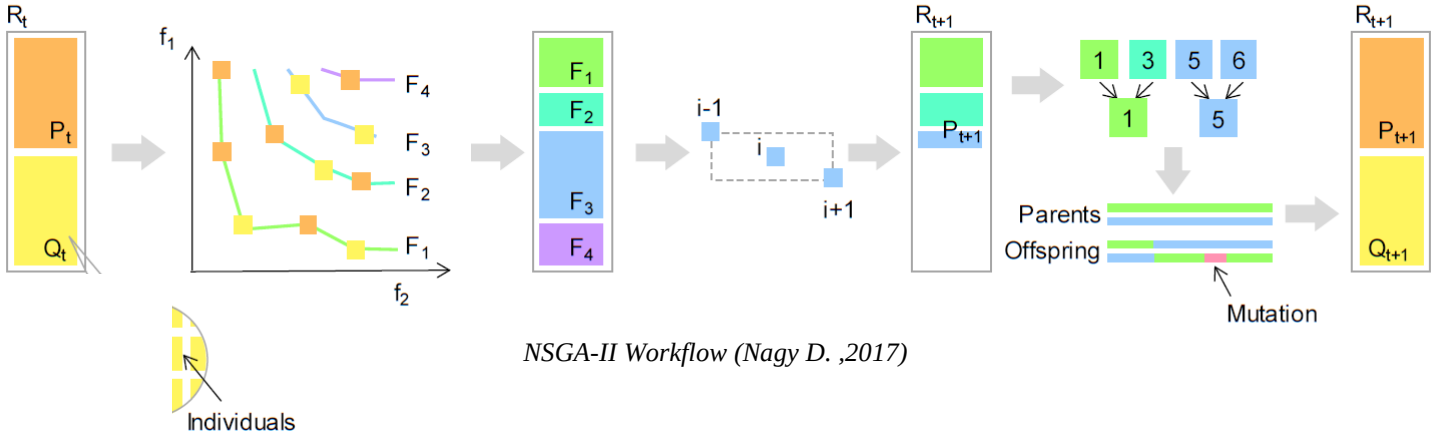
Fast Nondominated Sorting → ***Crowding Distance Computation*** → ***Crossover and Mutation***

Generation R_t consisting of parent population P_t and offspring population Q_t

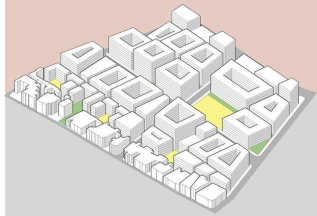
Individuals of both populations are sorted into fronts according to non-dominated sorting

Parent population of the next generation is filled up with fronts. In case of a front needed to be split, crowded distance sorting is used to determine rank within front

Tournament selection, crossover and mutation creates the new offspring population



NSGA-II Workflow (Nagy D. ,2017)



Multi Objective Optimization

Design Decisions

Street Network

Block Design

Number of Blocks

Size of Plots

Bye Laws of Neighborhood

Open Spaces

Objectives

Spatial Configuration

Attain Policy Requirements

Environmental Objectives

Density Requirements

Proximity of Amenities

Urban Quality of Life

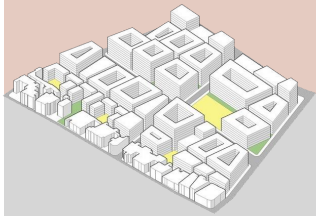
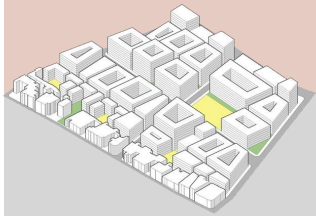


Image Source: https://architectus.com.au/projects/urban-typologies-and-stormwater-management/

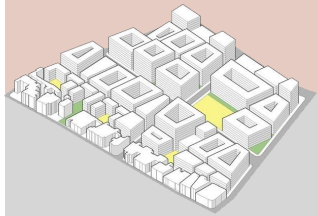
Case Study 1 – Computational Urban Design Prototyping: Interactive Planning Synthesis Methods – A case study in Cape Town.

- **Project Type – Urban Neighbourhood (Research Project)**
- **Research Partners:**
  - a) Future Cities Laboratory, Singapore
  - b) Department of Energy, Austrian Institute of Technology, Vienna, Austria
  - c) Departement Architektur, Eidgenössische Technische Hochschule Zürich, Zürich, Switzerland
- **Authors – Yufan Miao, Reinhard Koenig, Katja Knecht, Kateryna Konieva, Peter Buš and Mei-Chih Chang.**
- **Project Location – Cape Town, South Africa**
- **Year of Research – 2018**
- **Tools Used:**
  - a) Rhino 3D for Modelling
  - b) Grasshopper for Visual Scripting
  - c) Empower Shack Project for Live interaction with the Model on Browser.



Aims of the Project

- Development of Data structure for Spatial configuration of Streets, Blocks and Parcels.
- Translation of stakeholder requirements into parameters for the Computational Algorithm.
- Generation of spatial configuration for: Optimized use of land for dense housing configuration; Efficient space allocation; Neighbourhood preferences of the community.
- Maximize the spatial qualities, level of details and geometric precision of the automated design.
- The Computational Urban Design Prototyping Project is carried out for the city of Cape Town, South Africa. The city accommodates around 7.5 million people living in informal settlements.
- The city has a need of 2.5 million housing units. The research aims to develop new design and analysis tools for a comprehensive urban spatial design that can be implemented on different sites.
- The tools developed in the project is adaptable to meet site specific requirements and needs of different stakeholders.
- The CUDP project developed in the Research study has two major characteristics:
  a. The project allows designers to create multiple design options by adjusting parameter values.
  b. Application allows the designers to change the geometric constrains of the project, making it more interactive.



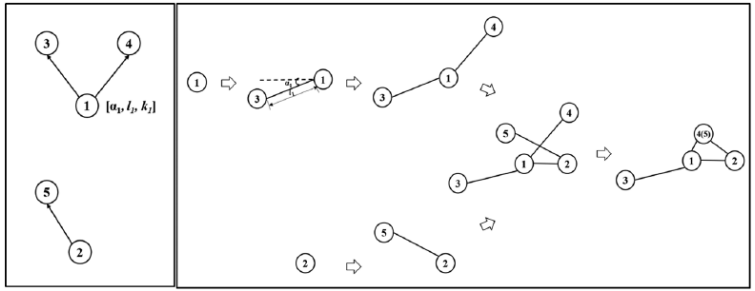
Methods Adopted

Street Networks represented as instruction trees. → ***Slicing Tree representation of Parcels.*** → ***Evolutionary Multi Objective Optimization***

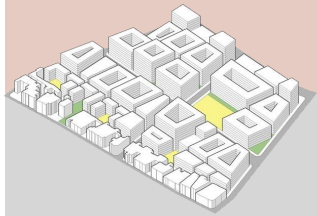
a. Street Networks represented as instruction trees.

The Figure represents the instruction tree for the generation of street networks. Nodes are used to contain the information for addition of street segments.

Each node contains the information of length, angle, and degree of connectivity. The edges between the nodes define the relationship of two nodes and the parent node.

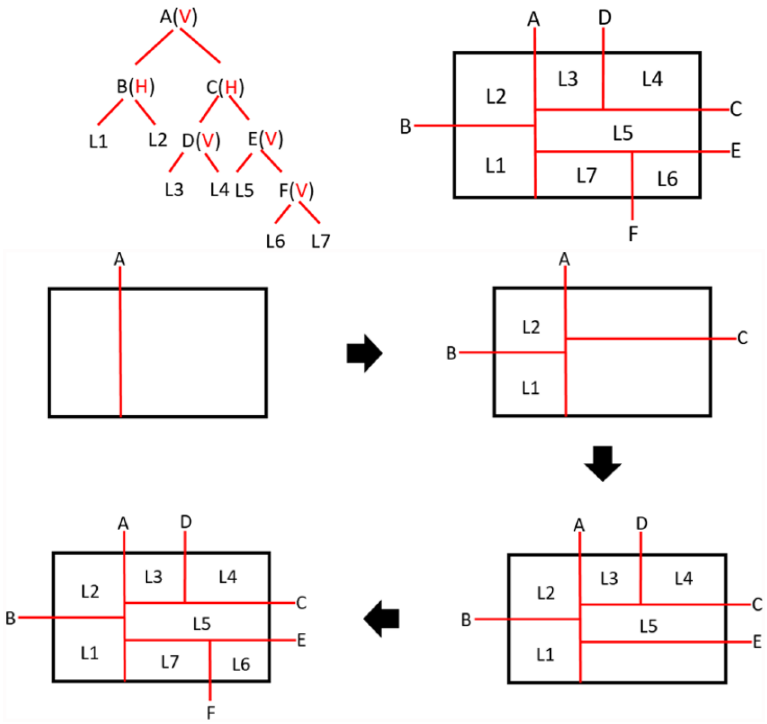


Street Network Instruction Tree

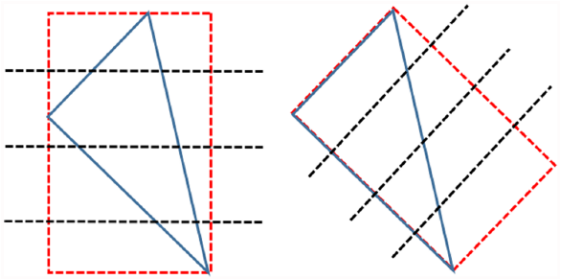


Methods Adopted

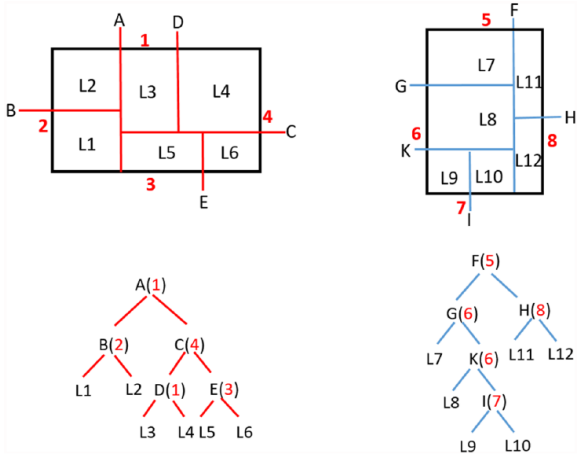
b. Slicing Tree representation of Parcels.



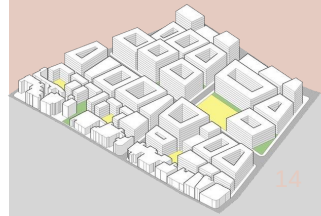
Method of land parcellation using slicing tree.



Bounding Box for irregular site geometry.



Updated Slicing Tree data structure to include edge identity.

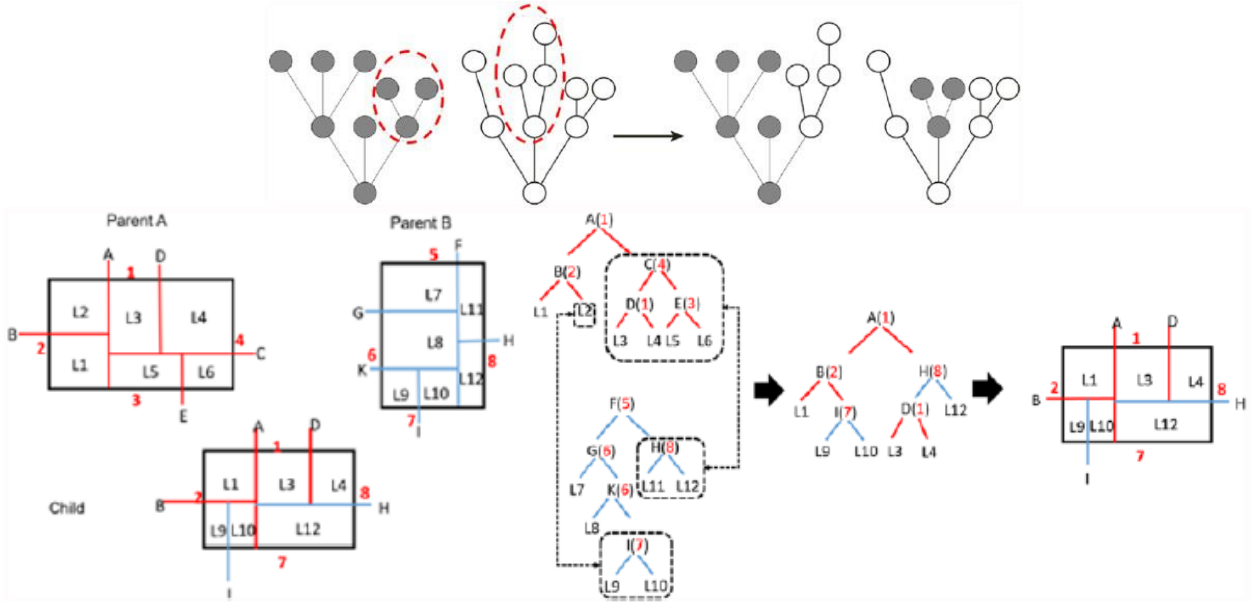


Methods Adopted

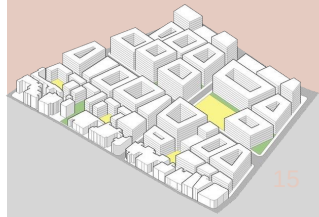
c. ***Evolutionary Multi Objective Optimization (EMO)***

The Parent population is crossed over and mutated to create offspring solutions that are better optimized for street networks.

The process continues until the goals of the design is achieved.



Crossover process for Evolutionary Multi Objective Optimization.



Implementation on Site

The project requirements had been identified together by the local stakeholders, urban planners, and the project team.

The major requirements were:

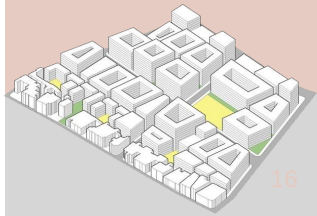
i. Creation of a tool that provides efficient densely packed urban design.

ii. Accessibility to facilities

iii. Fair allocation of Private and Public spaces.

iv. Involvement of the community into the design process through interactive 3D Design.

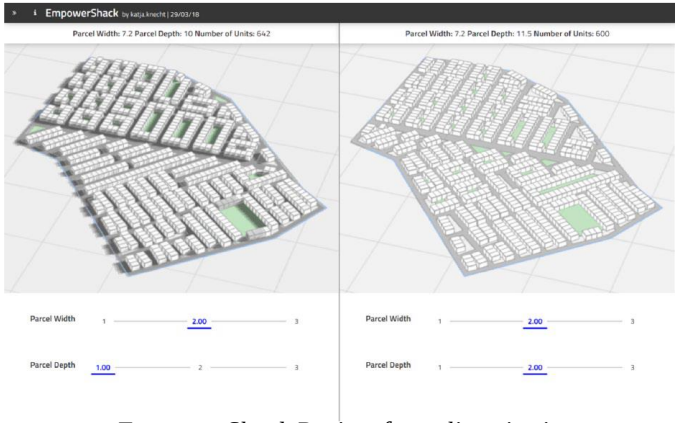
Study Area - Enkanini in Cape Town City, South Africa



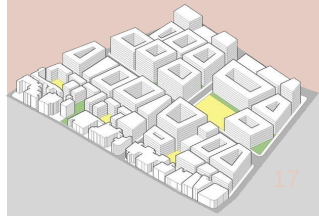
Design Variants

- The project team used Speckle plug-in for Grasshopper to make the generated layouts available online for different stakeholders.
- It also permits the stakeholders to interact with the model by allowing them to change the dimension (width and depth) of the parcels using number sliders.
- The resulting geometry can update based on the inputs given for the width and depth.

Urban Layouts generated by the algorithm. Left: Without any specified street segment. Right: With specified Street segment.

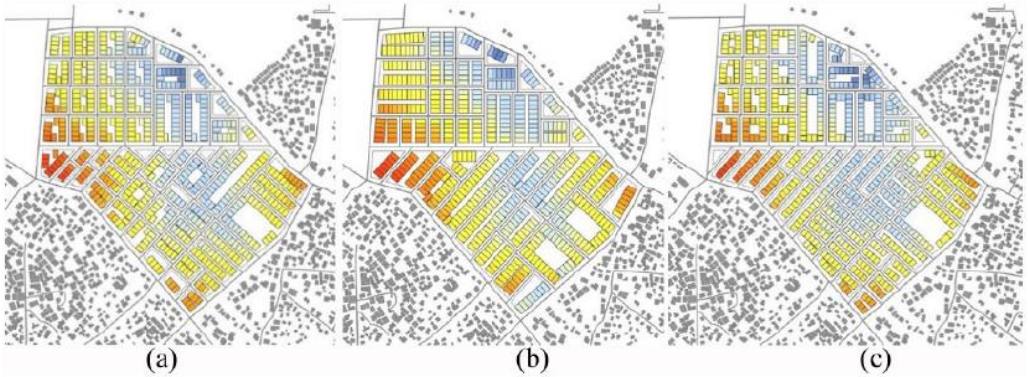


Empower Shack Project for online viewing and interaction with the model.

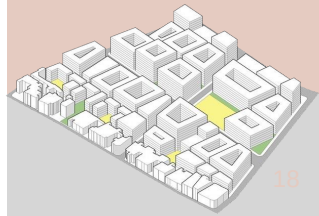


Design Evaluation for Pedestrian Accessibility

- ❑ The Urban Layouts have also been evaluated for Pedestrian accessibility by gravity-based methods.
- ❑ The distance along the street networks is calculated from each housing unit.
- ❑ The number of accessible facilities is identified is inverse to the travel cost. In this project, only educational facilities have been considered.
- ❑ Figure below shows the pedestrian access map. The warm colours in the map represent high access, while cold colours represent low access.



Pedestrian Accessibility Map.

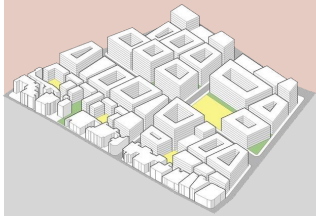


Case Study 2 – Integrating Urban Analysis, Generative Design, and Evolutionary Optimization for Solving Urban Design Problems

- **Project Type – Urban Neighbourhood (Research Project)**
- **Research Partners:**
  - a) Singapore-ETH Centre, Singapore
  - b) Austrian Institute of Technology (AIT), Austria
  - c) Bauhaus-University Weimar, Germany;

Authors – Reinhard Koenig, Yufan Miao, Anna Aichinger, Katja Knecht and Kateryna Konieva

- **Project Location – Centre of Weimar, a medium-sized town in Germany.**
- **Year of Research – 2018**
- **Tools Used:**
  - a) Rhino 3D for Modelling
  - b) Grasshopper for Visual Scripting
  - c) Decoding Spaces Toolbox

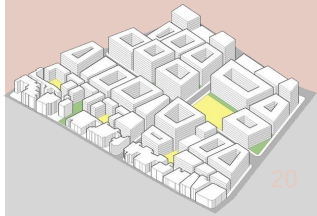


Aim of the Project

To provide an ***explorable set of urban design solutions***, leveraging different design goals during the urban design process. The main objectives of this study are
(i) to ***develop and demonstrate a data structure*** that can accommodate a flexible representation of urban design problems and
(ii) to prove that we can ***generate satisficing urban design variants*** by integrating state of the art ***urban analysis and EMO methods.***

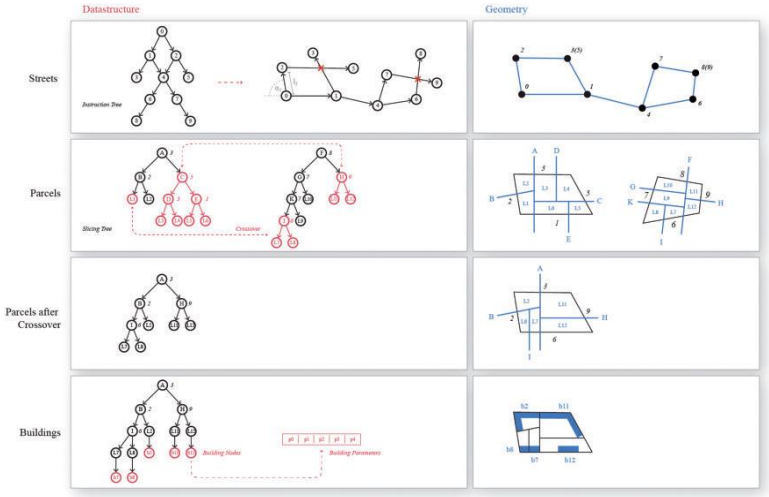
To ***optimize the arrangement of streets, parcels, and buildings—spatial configurations—***developed an evolutionary strategy, in combination with a ***selection mechanism using the HypE algorithm*** from the PISA framework.

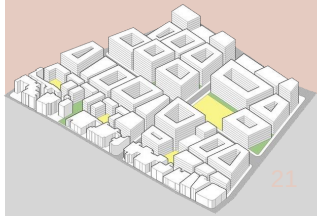
HypE is especially designed for considering many-objectives, since most of the multi-objective algorithms are developed for solving problems with two or three contradictory objectives.



Data Structure

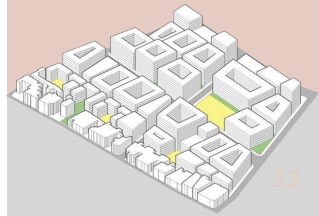
- The basic instruction tree structure (top row) controls the ***generation of street networks including some adaptations.***
- The network generation is guided by three parameters that are stored in each node—***length, angle, and connectivity.***
- The data structure of the instruction tree is extended by a ***slicing tree structure (second row),*** which controls the subdivision of the ***street blocks into parcels***. In addition, the second and third rows show how we use the data structure for the crossover operator.
- The ***bottom row shows how the information for the building generation*** is appended to the data structure in the form of additional nodes, containing the building parameters.





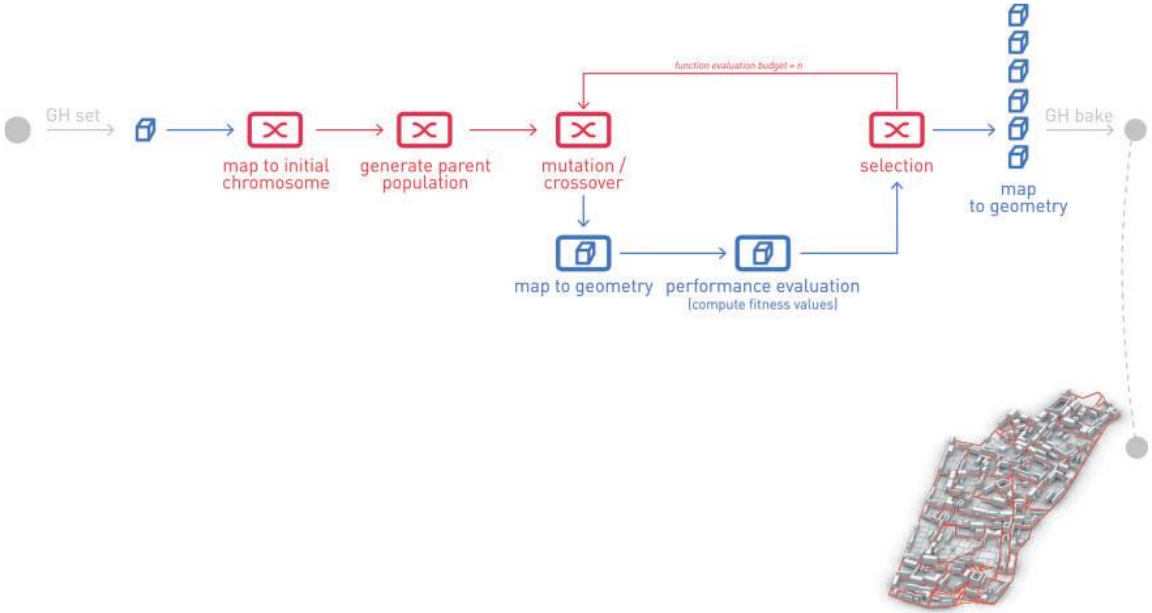
Implementation on Site

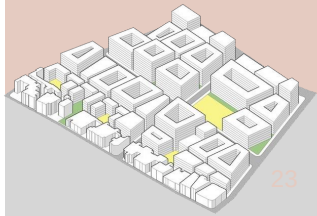
- The case study site in the town of Weimar. Left: The boundary with the initial street segments that inform the new street network.
- Centre: One hundred randomly generated street networks show the possible variations that can be generated with the defined parameter ranges.
- Right: A selected urban design variant for the case study site in Weimar with the detailed results of a centrality analysis.



Optimization Procedure

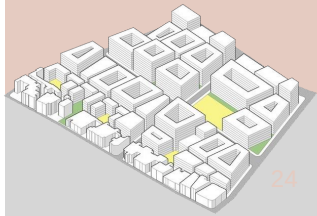
- The optimization procedure with our Grasshopper components. Red are the components with the data structure and the operators of the EMO.
- Blue are the components that deal with the geometry, whereas the “performance evaluation component” is a placeholder for many possible Grasshopper definitions that may be used to compute an objective value.





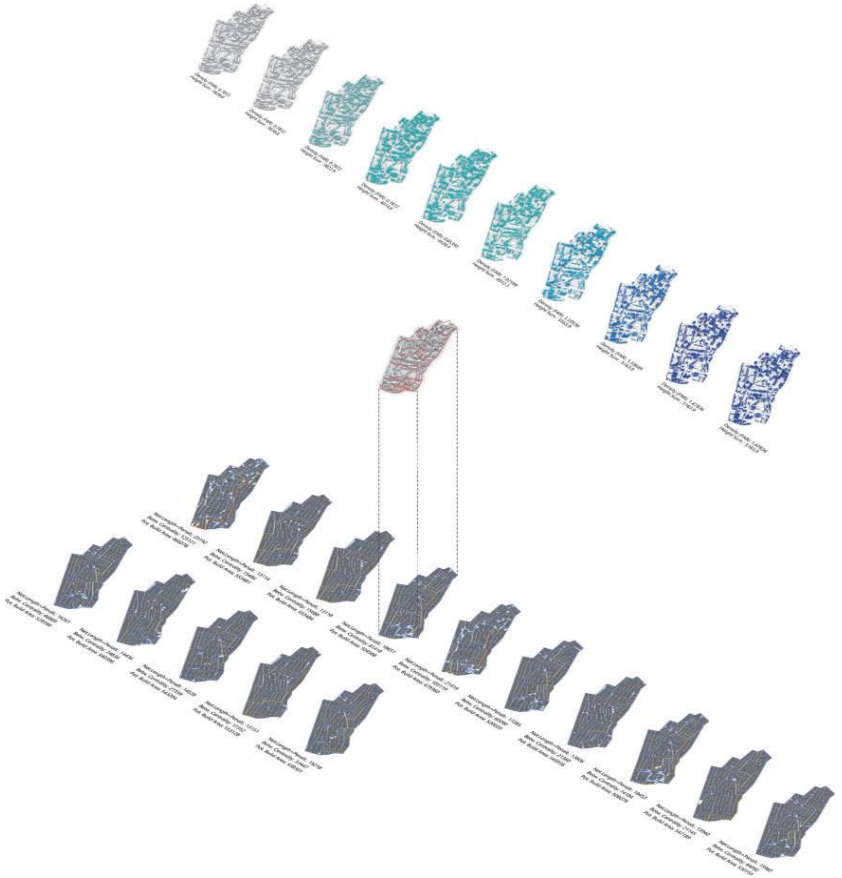
Results

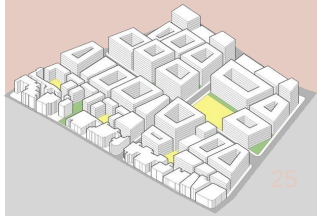
- Set of non-dominated spatial configurations after 200 iterations of the EMO using four objectives (listed below each variant).
- The empty street blocks are above the defined maximum of 40,000 square meters.
- The colored street segments show the betweenness centrality (where red means high and blue low centrality).
- The objective values are stated below each variant. Orthogonality is highest for values closer to 0.



Results

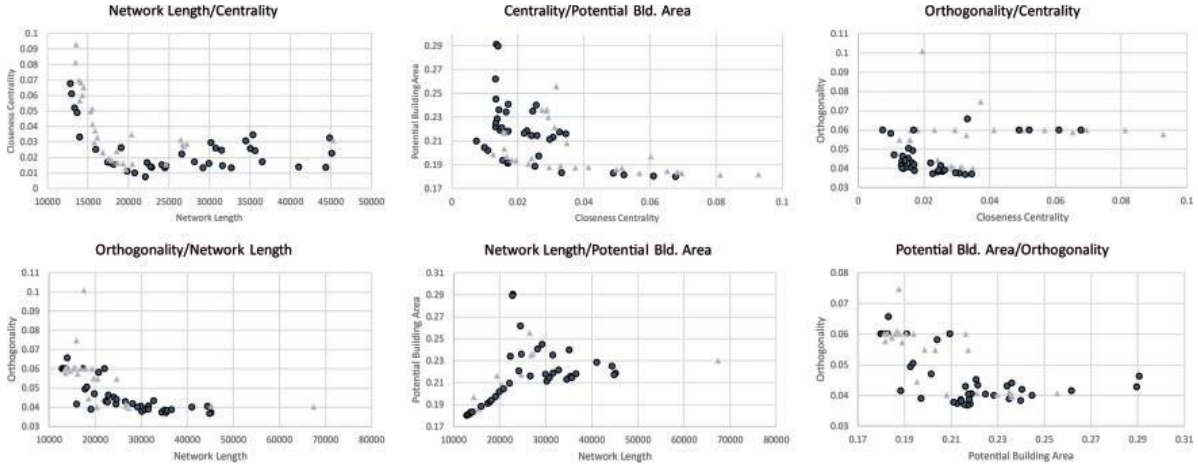
- Optimizing the building typologies in the second optimization phase based on a street network and plot configuration selected from the first phase.
- The top row shows a set of non-dominated spatial building configurations after 200 iterations of EMO using two objectives.
- The building configurations are ranked based on their fitness values ascending from left to right.

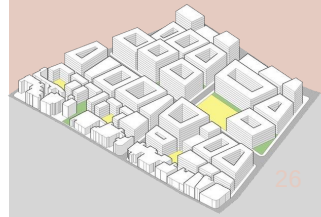




Results

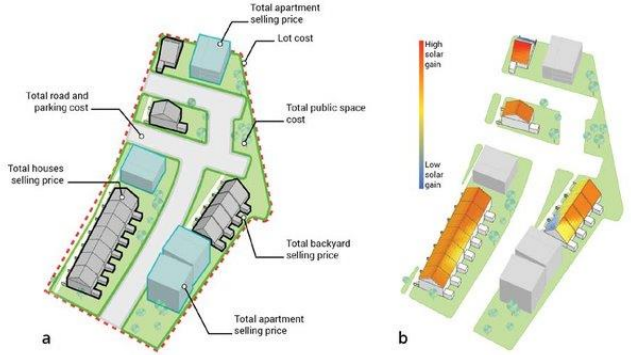
- The scatter plots show two-dimensional views on the four-dimensional Pareto-front.
- Each plot includes the objective values of the Pareto-optimal solutions that we found after 200 iterations with 100 variants per iteration with our optimization process (dark circles) and with a random search process with the same amount of generated variants (gray triangles).
- The hypervolume value for the Pareto-front of the random search is 813.902 and for the optimization 809.403



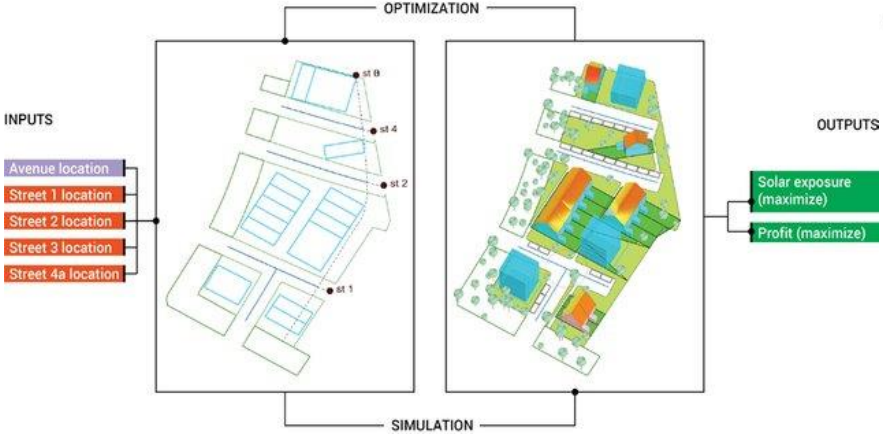


Case Study 3 - Alkmaar Residential Neighbourhood, Netherlands – Parametric Urban Design

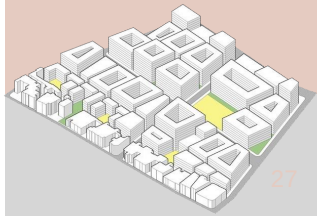
Integrating Financial and Energy Goals for Automated Neighbourhood Layout



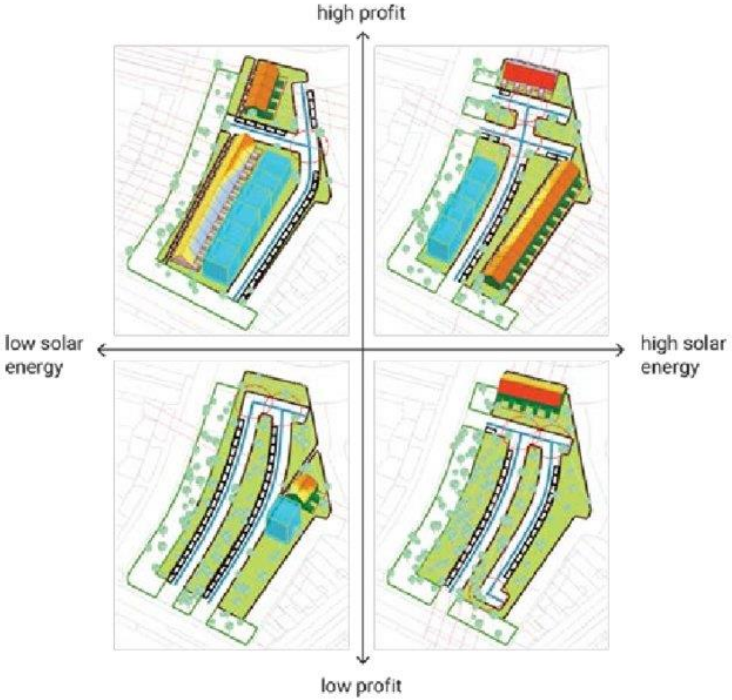
Description of two metrics, development profitability (a) and potential for solar gain (b).



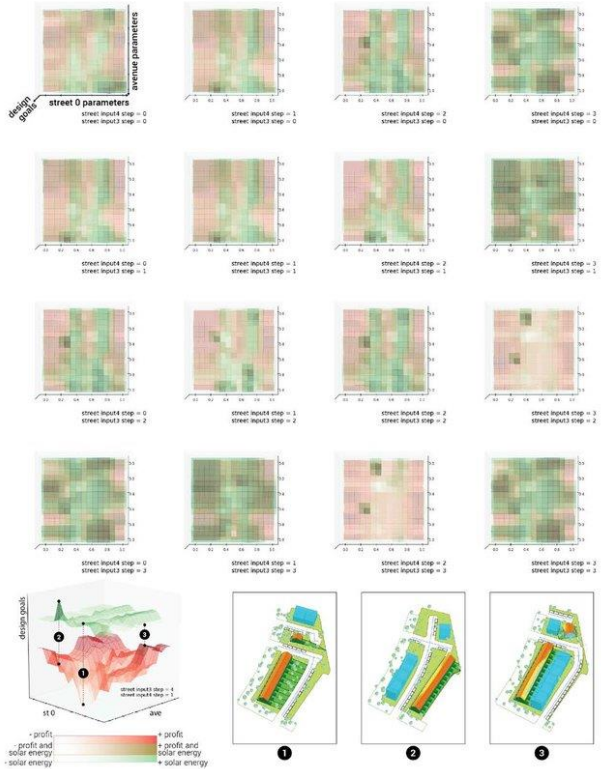
Design space showing five input parameters, definition of a single design's geometry, evaluation of design through simulation, and two output metrics.



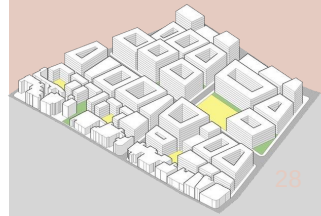
Case Study 3 - Alkmaar Residential Neighbourhood, Netherlands – Parametric Urban Design



Comparison of designs at performance extremes.



Design space visualization with plot x and y axes representing input parameters and z-axis and color representing averaged values of output metrics.



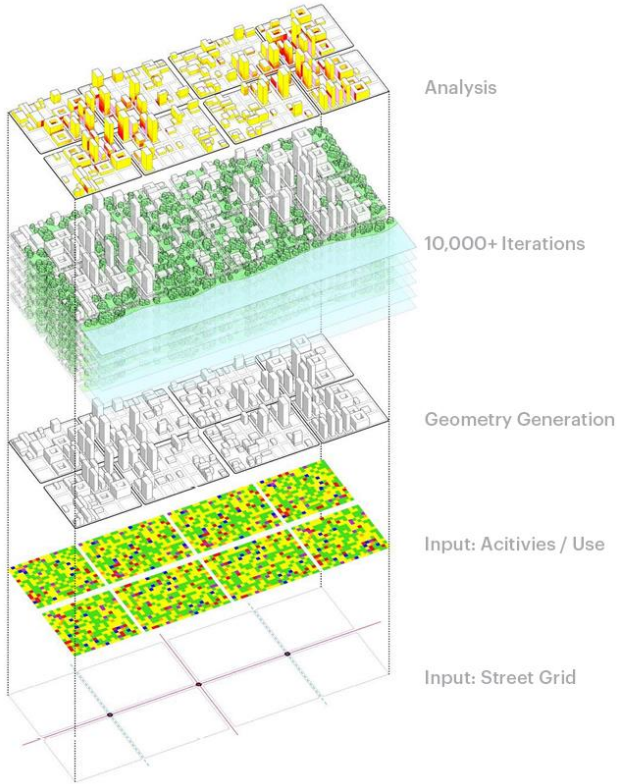
Research Labs around Globe

Parametric/ Generative Urban Design and Planning Research Labs around Globe

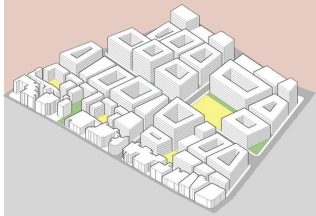
1. *School of Architecture, Georgia Tech (Atlanta USA)*
2. *Autodesk, USA*
3. *Delft University of Technology (TU Delft) , Netherlands*
4. *Bauhaus-University Weimar, Germany*
5. *Technical University, Munich, Germany*
6. *ETH, Zurich*
7. *Austrian Institute of Technology (City Intelligence Lab), Austria*
8. *Lodz University of Technology, Poland*
9. *German Jordanian University, SABE, Jordan*
10. *National university of Singapore, Singapore*
11. *Beijing Jiaotong University, China*
12. *Dubai Municipal corporation, Dubai*
13. *Cape Town City Council, Cape Town*

Structure of the Presentation.

- *Synopsis of the Study*
- *Literature Review*
- *Site Analysis*
- *Project Development*
- *Implementation*
- *Results*
- *Conclusion*



Process of Generative Urban Design

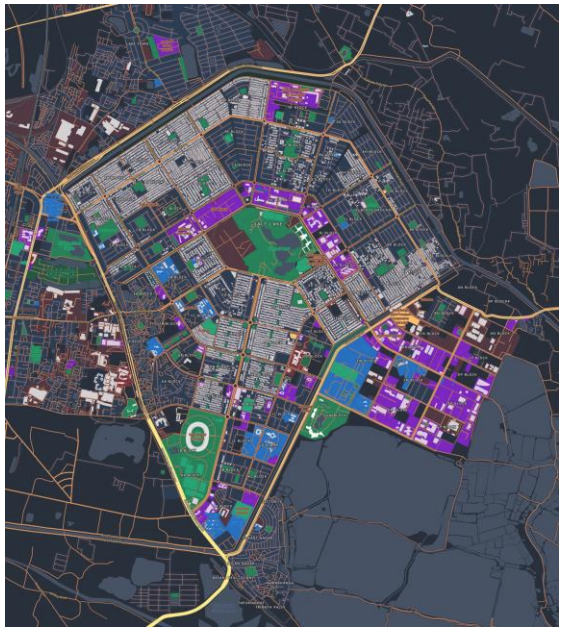


Salt Lake City, Kolkata

- The site for the study has been selected as the CD Block of Salt Lake City, Kolkata.
- The Generative Algorithm for automated neighbourhood layout has been developed based on the existing dimensions of the site.

Location of Salt Lake City

Sectoral map of Salt Lake City, Kolkata with BD and CD Block highlighted.



Satellite Map of Salt Lake City, Kolkata with site marked.

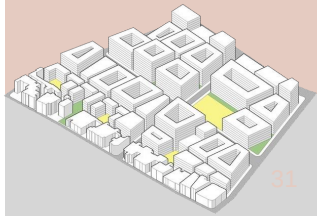
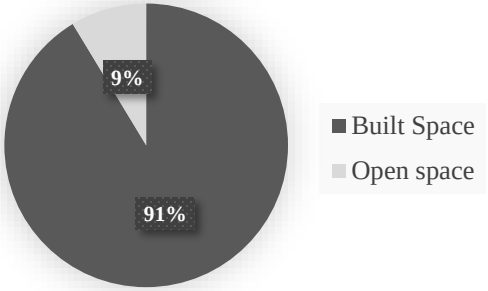


Figure Ground Map

- The map shows that the neighborhood has a Fine-Grained structure with row housing and Grid Iron Road pattern.
- There are three open spaces in the Blocks BD and CD at center.
- The total number of residential buildings of the neighborhood is 378, and 3 open spaces.

Total no. of Residential Plots = 378

No. of Open Spaces = 3



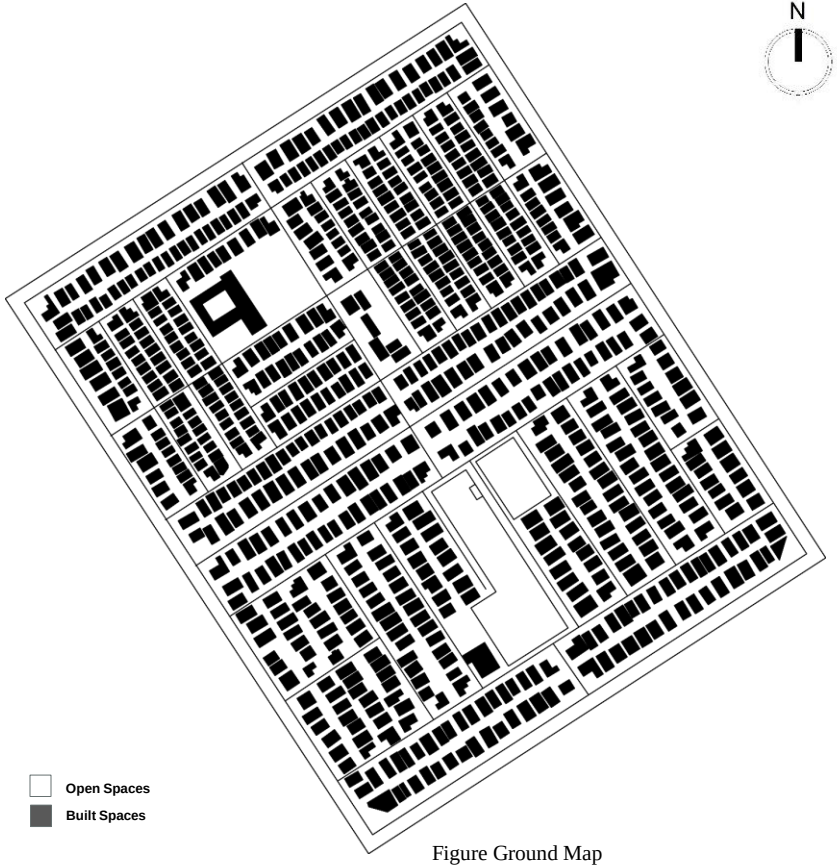
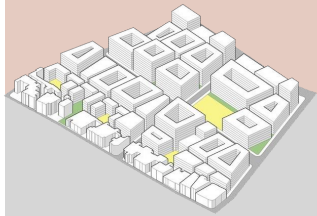
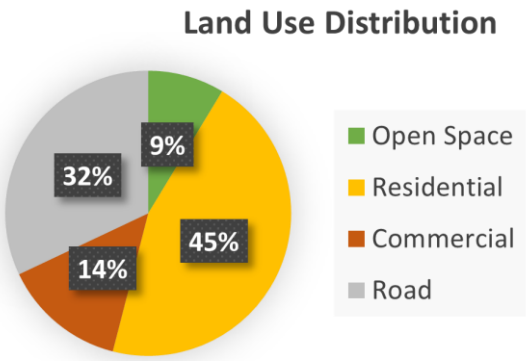


Figure Ground Map

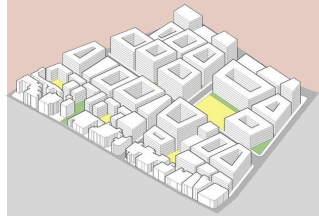


Land Use Map

- The Neighborhood BD block and CD Block have a mixed-use typology of Land usage.
- The neighborhood has a combination of commercial and residential spaces with two institutional usages of schools. The total residential land-use is 45%, commercial is 14%, open space is 9% and Roads is 32%.

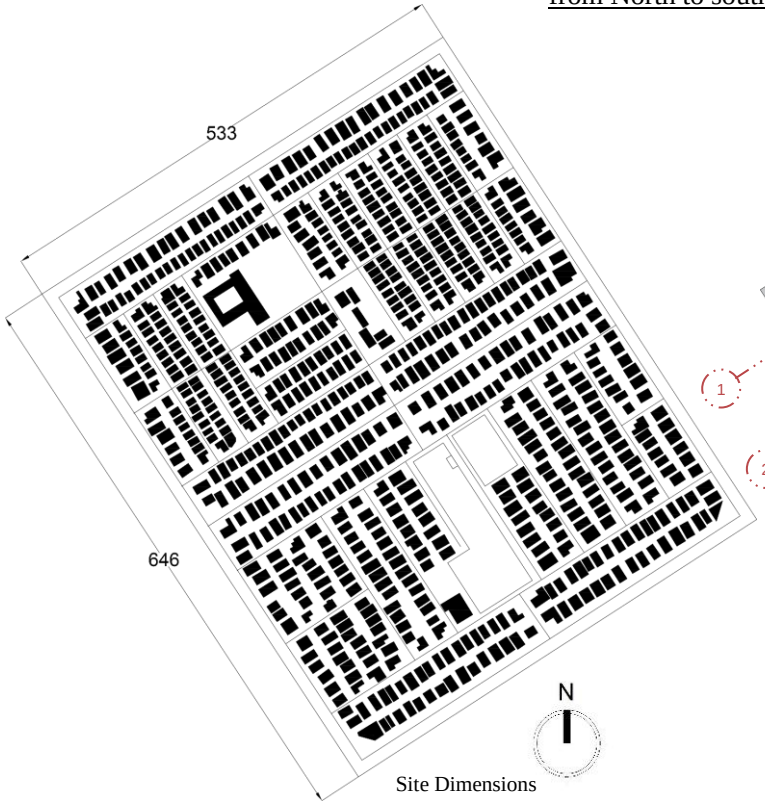


Land Use Map



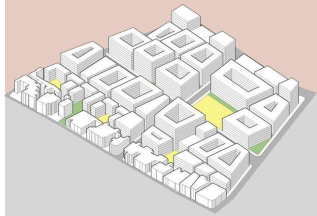
Block Spatial Design Analysis

There are 6 Major Roads that cut the site from West to East and 1 major road that cuts from North to south. The Road network divides the site into 38 Secondary Plots



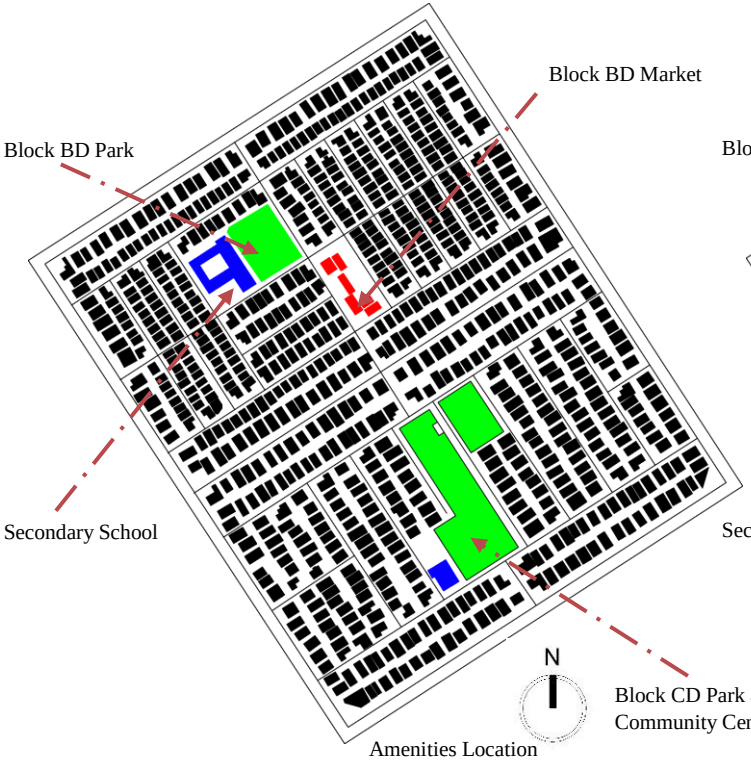
Site Dimensions

Major Roads and Secondary Plots



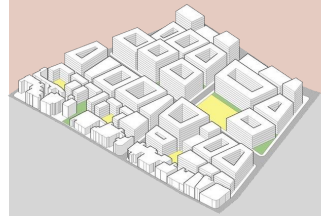
Site Amenities

The site has three basic amenities – Open spaces, School and Market complex.
Maximal Radial Distance to Park = 283m, School = 592m.



Amenities Location

Major Roads and Secondary Plots

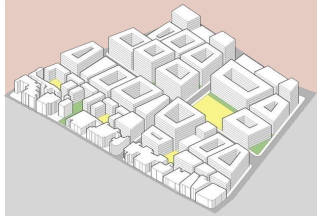


Shading Analysis

On a typical summer day, 26th June, 2pm.,
The 17% of the road surface receives shadow.

Axonometric View of
Site with shadows.

Shading Analysis



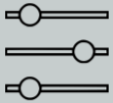
Project Development

Create Parametric Model

Parametric model used in design is composed of a variety of modules that combine computation with geometric operations

Specify Input Parameters

Fixed and Variable input parameters have been used in the study.



Specify Design Goals

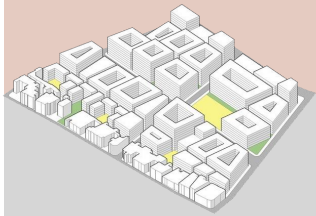
Six Design goals comprise of project ambitions and targets that the algorithm has to meet.

Generate Design solutions

The Generative Design algorithm creates multiple design options based on the parameters and goals.

Evaluation of Generated Solutions

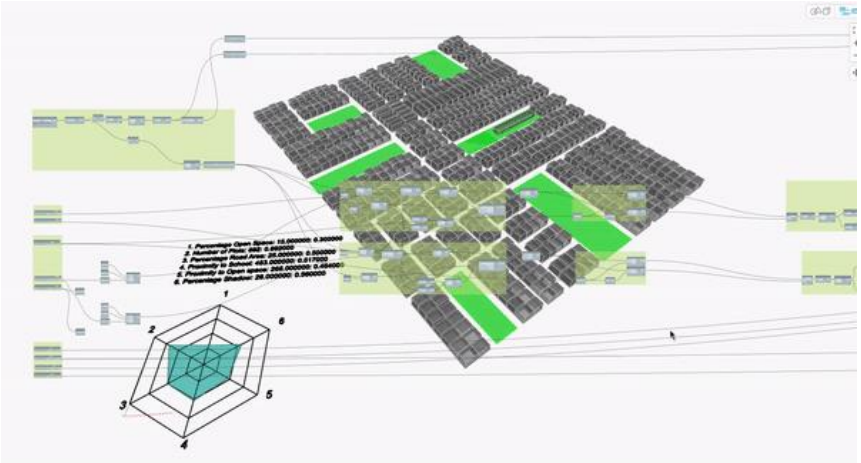
The generated design solutions are evaluated based on a normalized metric.



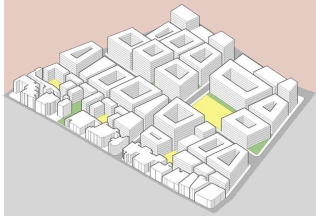
Parametric Model

"Parametric models used in design are composed of a variety of modules that combine computation with geometric operations, none of which are easily differentiable." (Nagy D. , Learning from nature, 2017a)

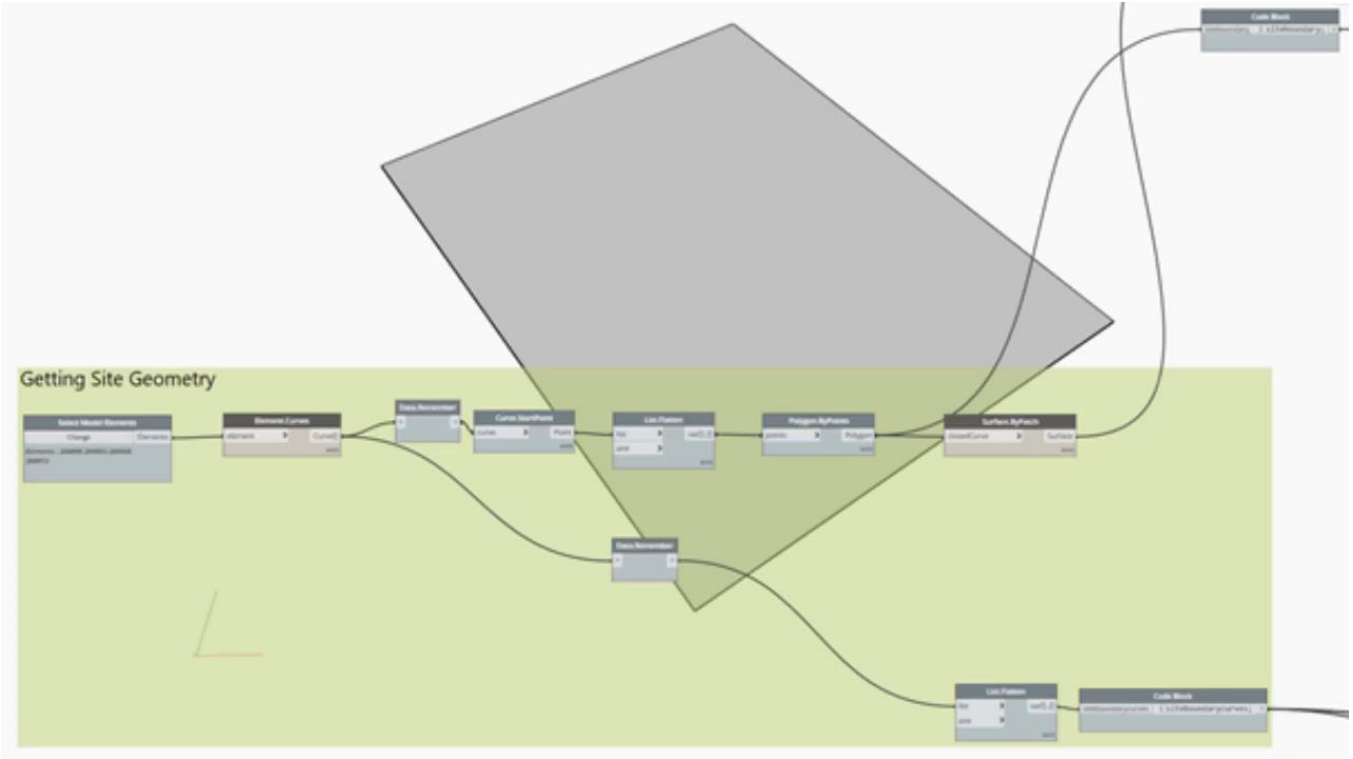
1. ***Creating Site Boundary***
2. ***Creating Major Roads – Through Streets***
3. ***Creating Major Plots***
4. ***Creating Secondary Roads – Local Streets***
5. ***Creating Secondary Plots***
6. ***Locating Site Amenities***
7. ***Adding Building Blocks***

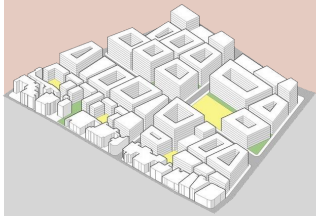


Autodesk Dynamo script for the project.



Parametric Model





Specifying Input Parameters

1. Fixed Input Parameters

The fixed input parameters are used as the constraints or the fixed values. These are user specific parameters. The fixed input parameters of this study include:

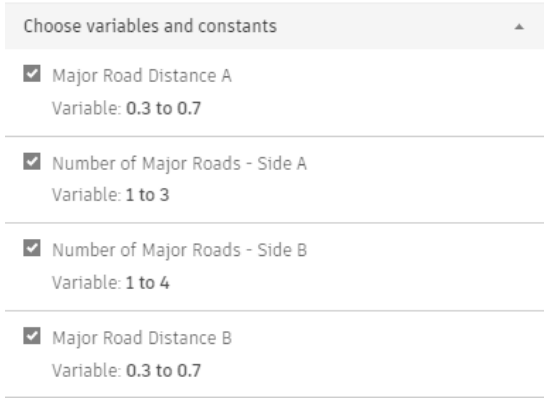
- Site Boundary
- Road Widths (Local Street and Through street width)
- Plot Dimensions (Length and Width) – The individual blocks
- Plot Offset – Offsets of one plot to other
- Amenity Area (School) – The total plot size for the school.
- Building heights – Individual unit heights.

2. Variable Input Parameters

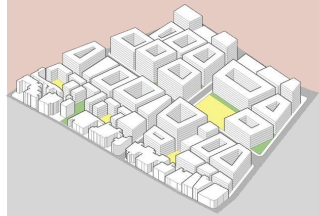
The generative algorithm changes the values and finds different combinations of the variable parameters to generate different design options.

The variable parameters include:

- Road Position on X and Y Axis (Through street)
- Number of Roads (Through streets)



Variable Input Parameters



Specifying Design Goals

Maximizing no. of Plots

The profit of the project depends on maximizing the no. of Plots at the same site.

Minimizing the Road Area

The project cost or developer cost is less with less road development.

Maximizing the Open Space Areas

The Quality of Life of a Neighborhood increases when all people have nearby open spaces

Maximizing Proximity to School

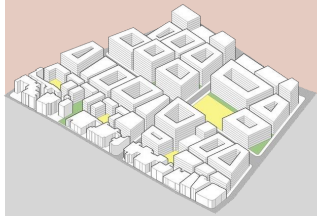
The distance to school must be minmum to add to the safety of children.

Maximizing Proximity to Open Spaces

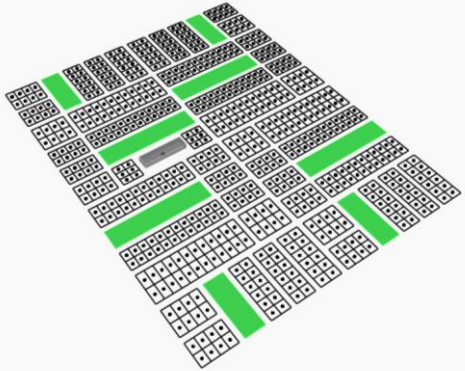
The distance to open spaces has to be less, for each age group to have access to it.

Maximizing Shadow Areas

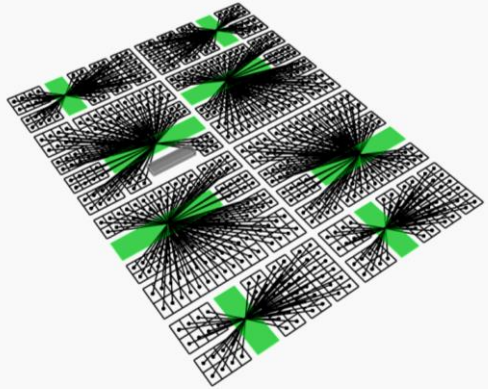
Shadows ensure thermally comfortable neighborhoods. Study has been done for one summer day – June 26th



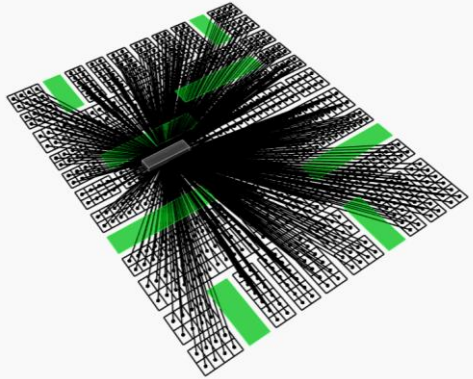
Design Goals



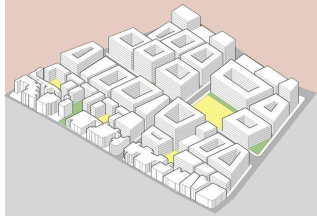
Creating Center points of all Plots



Finding Longest distance to Open Space



Finding Longest distance to School



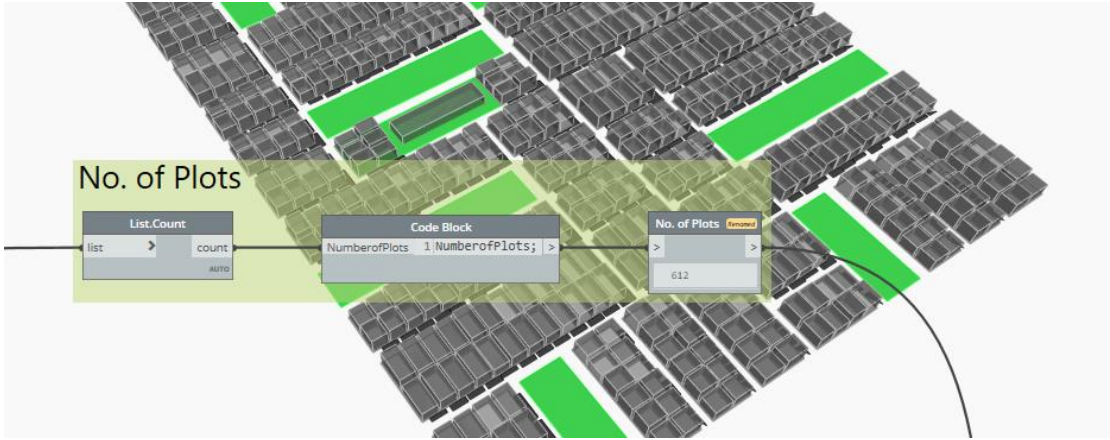
Normalized Metrics for Design Goals

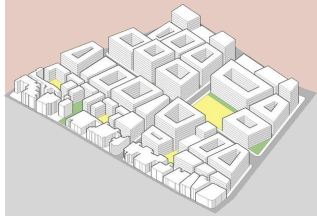
Design Goal 1 - Maximizing Number of Plots.

Normalized Metric for No. of Plots = **No. of Plots /1000**

For example: The number of plots for the below design option is 612.

The normalized metric for the No. of Plots would be **612/1000 = 0.612**





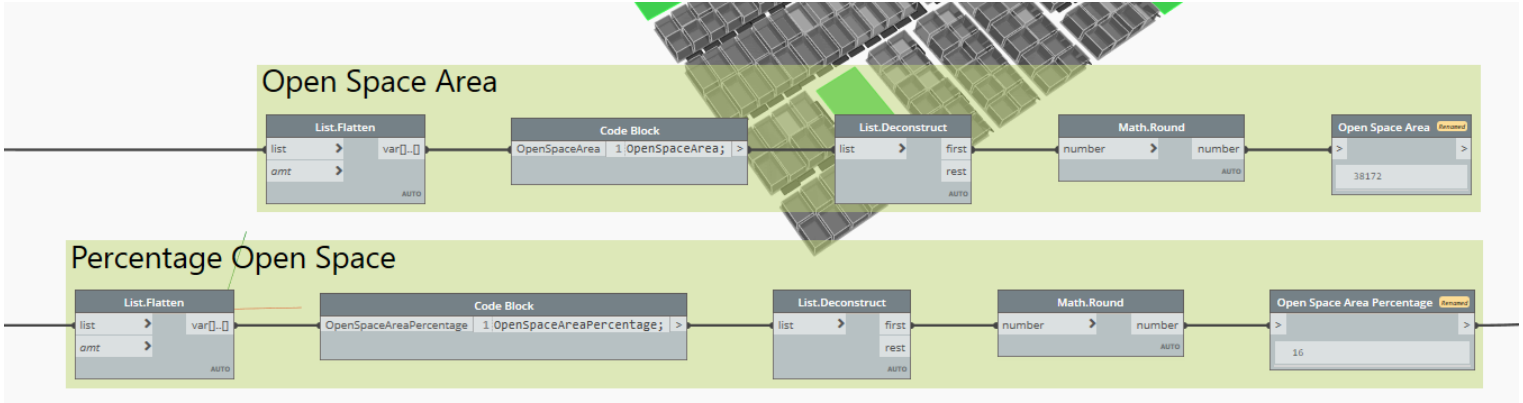
Normalized Metrics for Design Goals

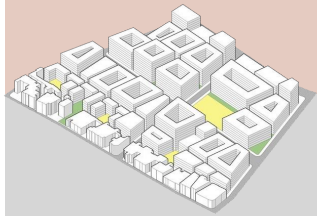
Design Goal 2 - Maximizing Open Space Area.

Normalized metric for open space percentage = **(Open Space Area Percent * 2) / 100**

For example, the open space area percentage of the below design option is 16%.

The normalized metric for the Open space area percentage would be **(16*2)/100 = 0.32**





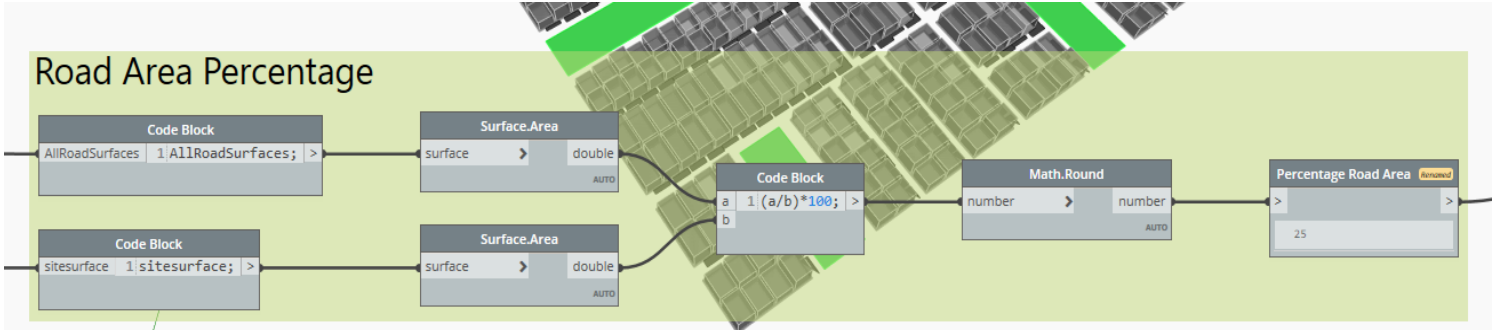
Normalized Metrics for Design Goals

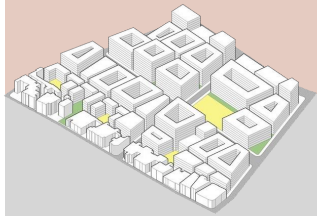
Design Goal 3 – Minimizing Road Area.

Normalized metric for road area percentage = **(1- (total road area percent * 2) /100)**

For example, in the below design, the total road area percentage is 25%.

The normalized metric would be **(1 - (25*2)/100) = 0.5**





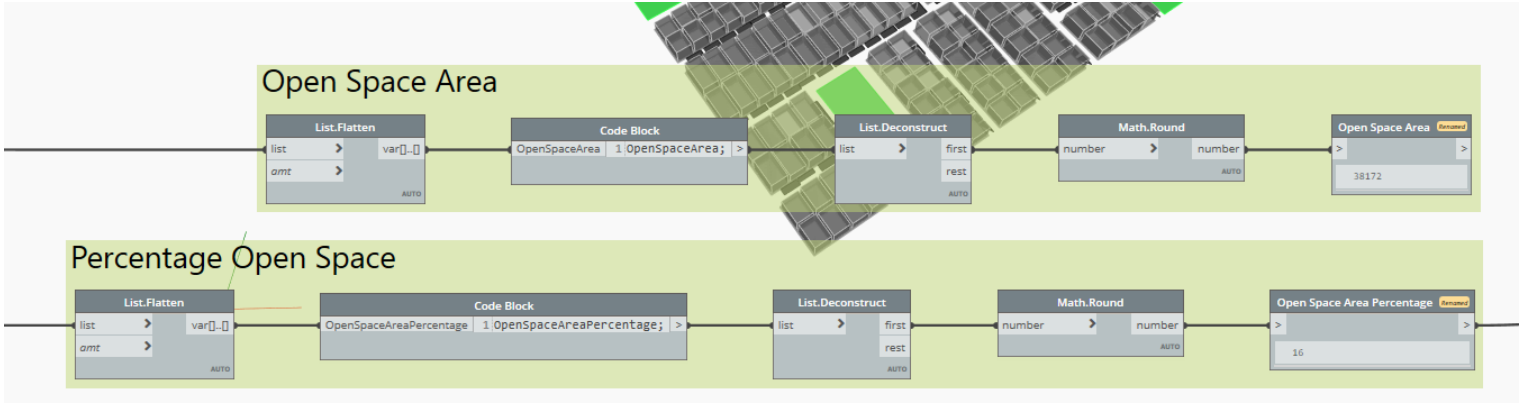
Normalized Metrics for Design Goals

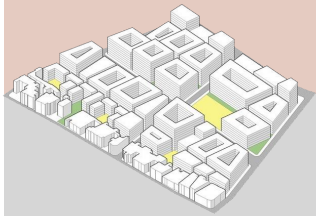
Design Goal 4 - Maximizing Proximity to School.

Normalized Metric for Proximity to school = **(1 - (Longest radial distance / 1000))**

For example, in the below design, the maximum distance to school is 469m.

The Normalized metric for the Proximity to school is **(1 – (469/1000)) = (1 - 0.469) = 0.541**





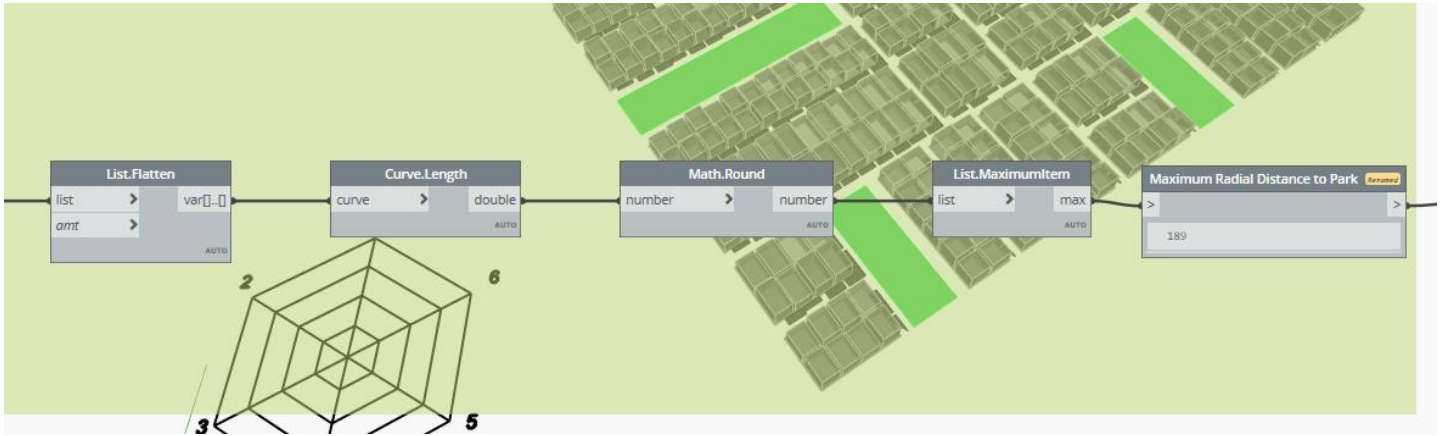
Normalized Metrics for Design Goals

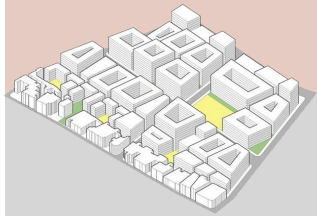
Design Goal 5 - Maximizing Proximity to Open Spaces.

Normalized Metric for Proximity to open spaces = (1 - (Longest radial distance * 2) / 1000))

For example, in the below design, the maximum distance to school is 189m.

The normalized metric would be = **(1 – ((189 * 2)/1000)) = 1 – 0.378 = 0.622**





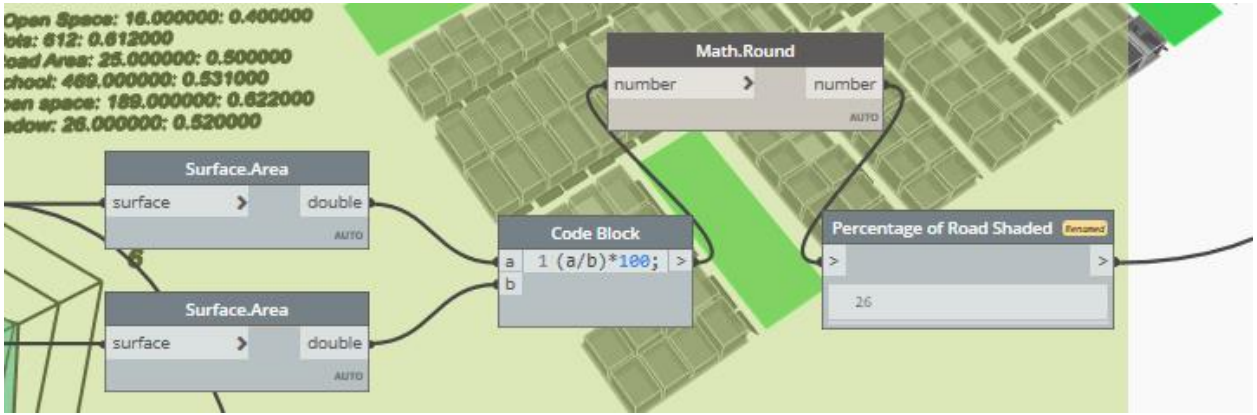
Normalized Metrics for Design Goals

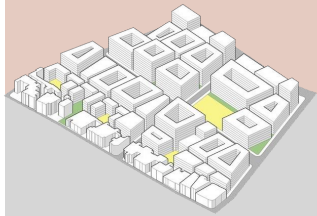
Design Goal 6 - Maximizing percentage of Road Shaded.

Normalized Metric for Shading Percentage: (Total Shading Percentage * 2) / 100

For example, for the design below the shading percent is 26 %.

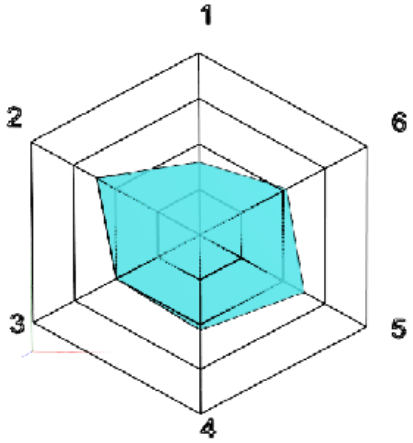
The normalized metric for the Shading would be **(26 * 2)/ 100 = 0.52**

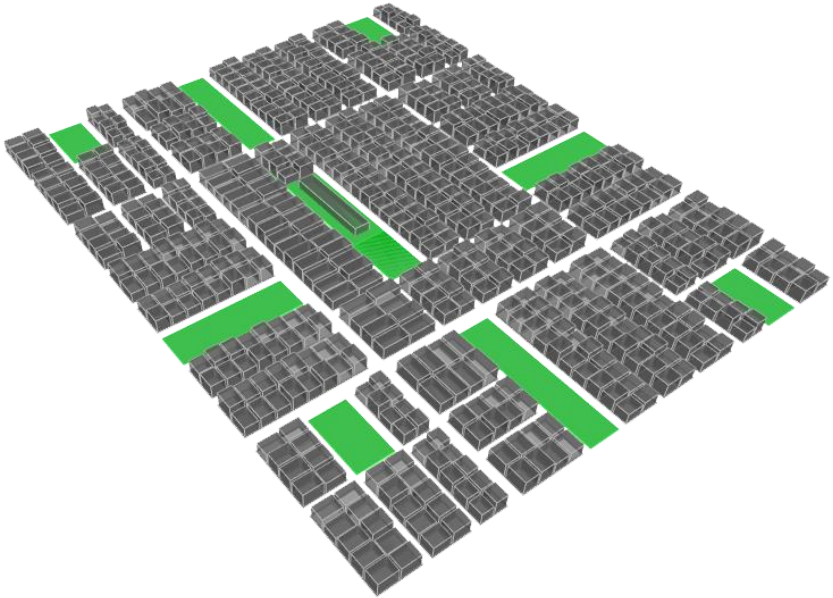


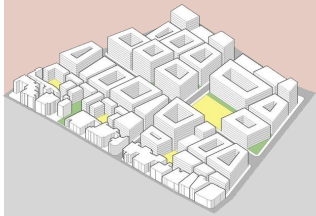


Radar Chart for Analysis

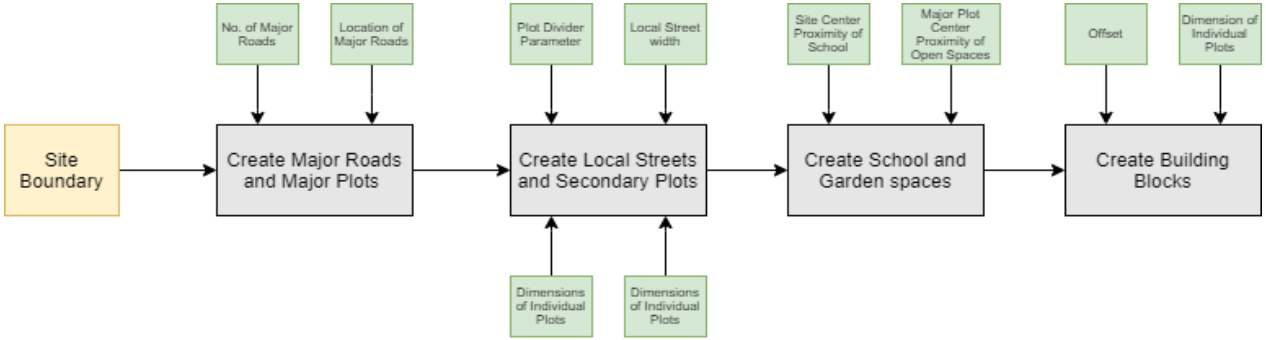
1. Percentage Open Space: 16.000000: 0.400000
2. Number of Plots: 612: 0.612000
3. Percentage Road Area: 25.000000: 0.500000
4. Proximity to School: 469.000000: 0.531000
5. Proximity to Open space: 189.000000: 0.622000
6. Percentage Shadow: 26.000000: 0.520000

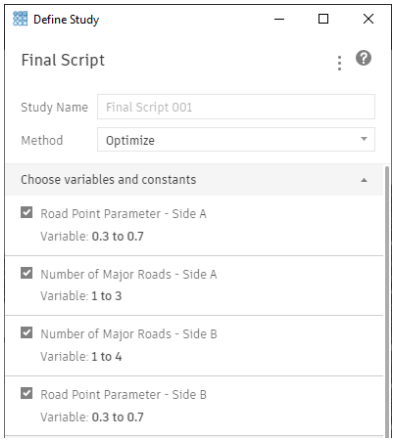


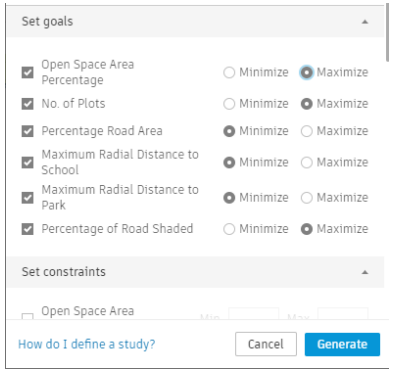




Generating design solutions

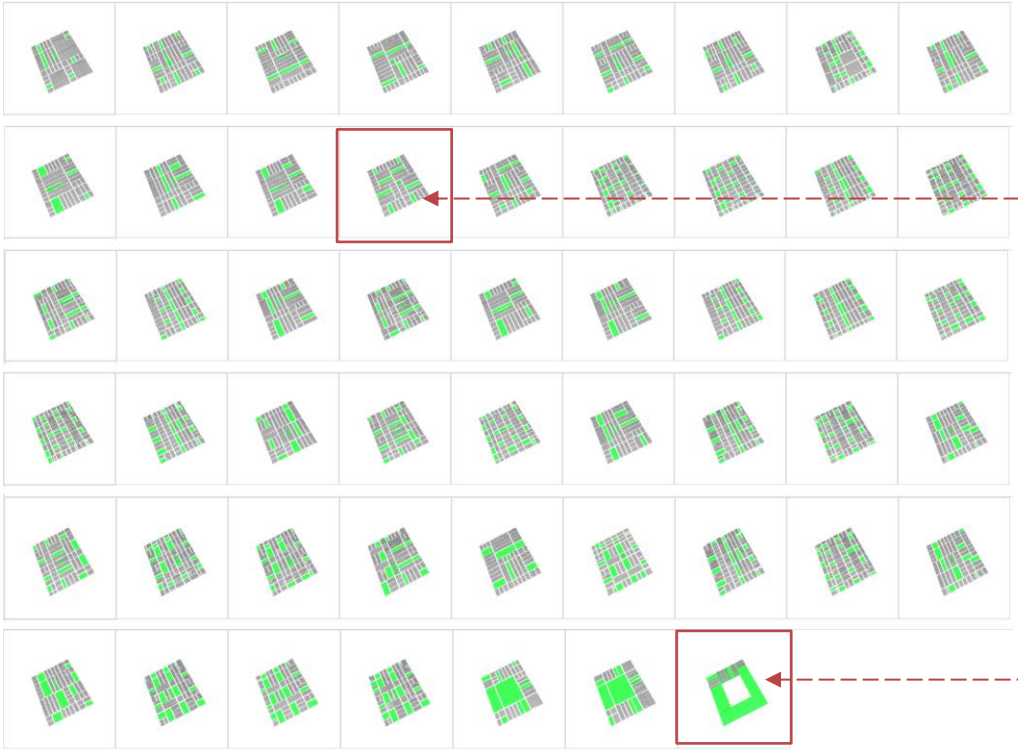






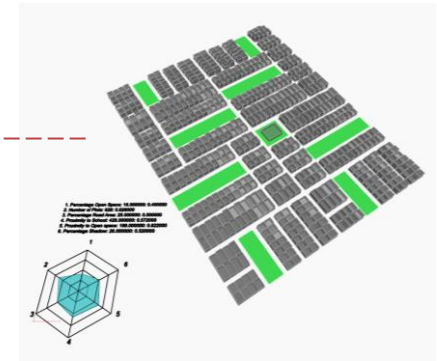
Generating design solutions

20 Sets of Outcomes with 40 solutions each = Total of 800 Solution

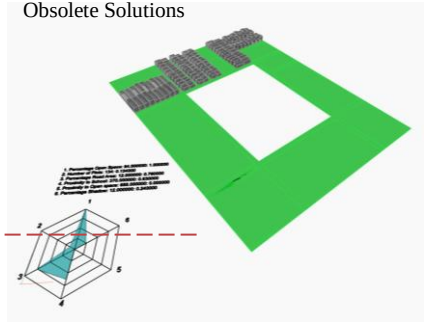


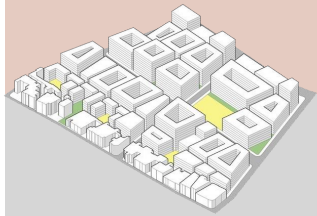
Generated Design Solutions

Performing Solutions

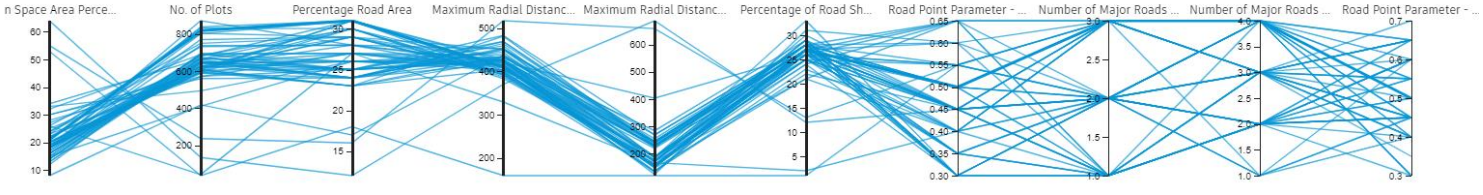


Obsolete Solutions

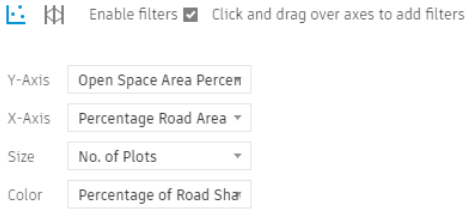


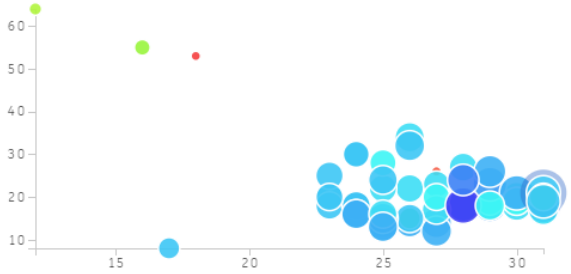


Results

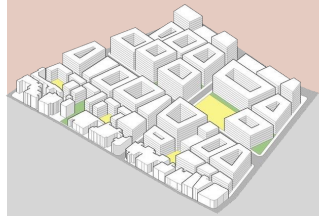


Parallel coordinates graph

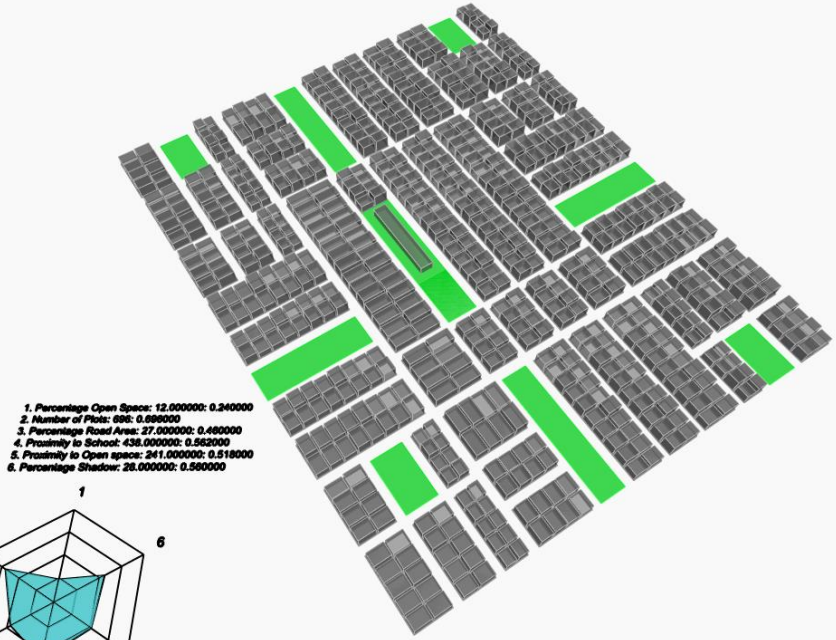




Scatter Plot

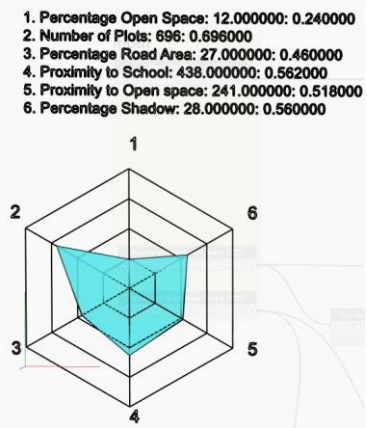


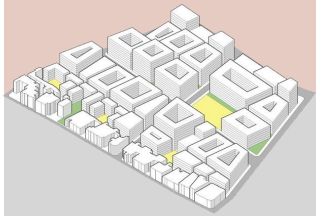
#Solution 1 – Highest No. of Plots



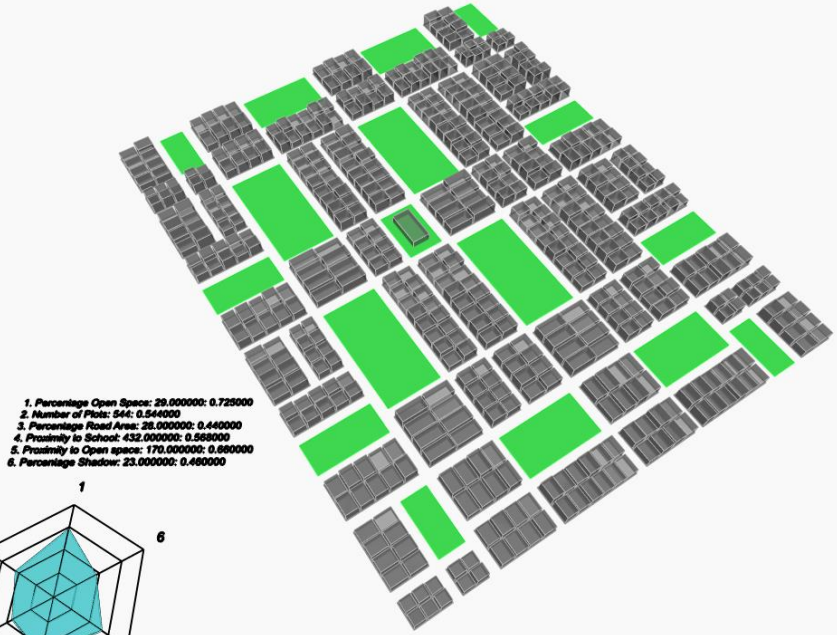
Outputs	
Open Space Area Percentage	12.0
No. of Plots	696.0
Percentage Road Area	27.0
Maximum Radial Distance to School	438.0
Maximum Radial Distance to Park	241.0
Percentage of Road Shaded	28.0

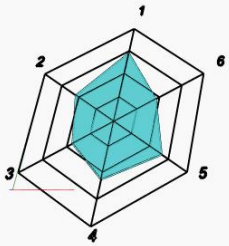
Variables	
Road Point Parameter - Side A	0.500
Number of Major Roads - Side A	2
Number of Major Roads - Side B	2
Road Point Parameter - Side B	0.500





#Solution 2 – Maximum Open Area

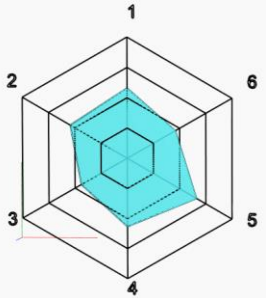




Outputs	
Open Space Area Percentage	29.0
No. of Plots	544
Percentage Road Area	28
Maximum Radial Distance to School	432
Maximum Radial Distance to Park	170
Percentage of Road Shaded	23

Variables	
Road Point Parameter - Side A	0.500
Number of Major Roads - Side A	3
Number of Major Roads - Side B	3
Road Point Parameter - Side B	0.500

1. Percentage Open Space: 29.000000: 0.580000
2. Number of Plots: 544: 0.544000
3. Percentage Road Area: 28.000000: 0.440000
4. Proximity to School: 432.000000: 0.568000
5. Proximity to Open space: 170.000000: 0.660000
6. Percentage Shadow: 23.000000: 0.460000



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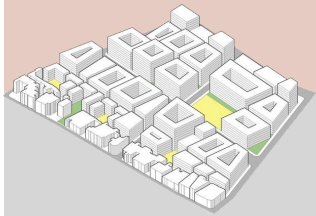
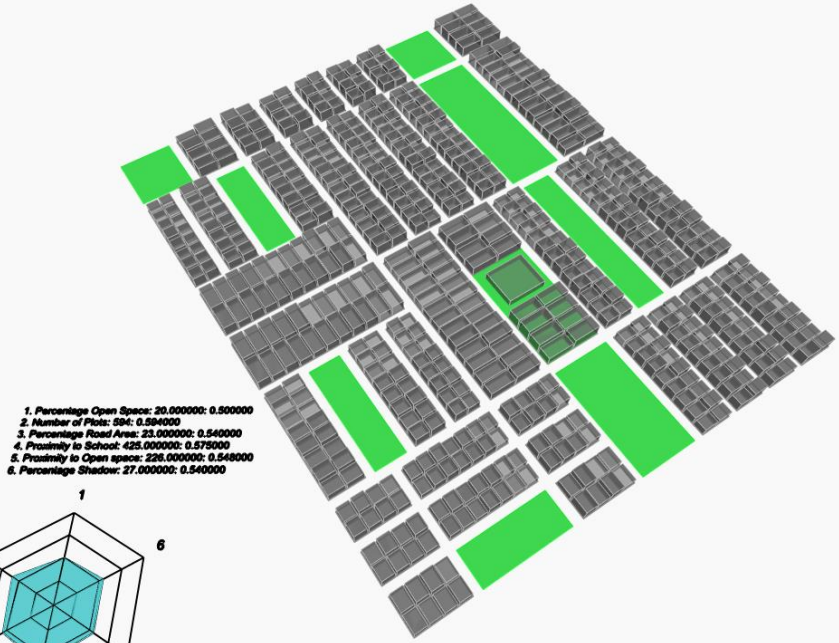


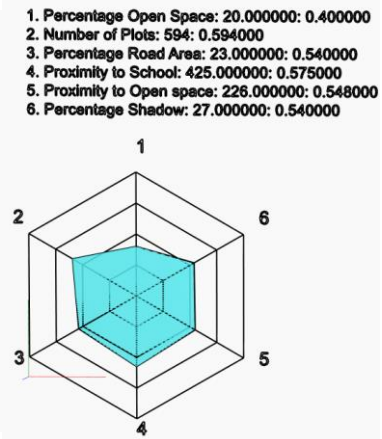
By : Abhishek Palit

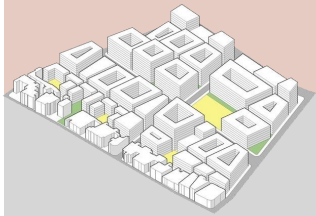
#Solution 3 – Minimum Road Area



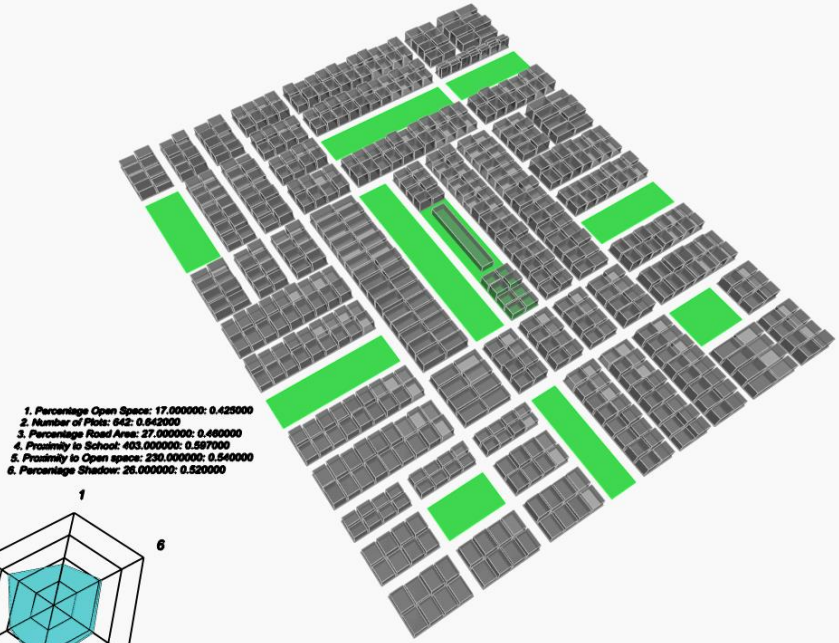
Outputs	
Open Space Area Percentage	20.0
No. of Plots	594.0
Percentage Road Area	23.0
Maximum Radial Distance to School	425.0
Maximum Radial Distance to Park	226.0
Percentage of Road Shaded	27.0

Variables	
Road Point Parameter - Side A	0.650
Number of Major Roads - Side A	1
Number of Major Roads - Side B	3
Road Point Parameter - Side B	0.650



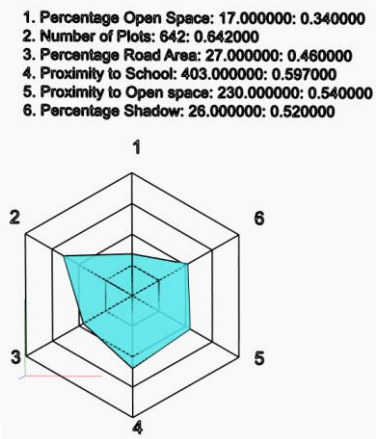


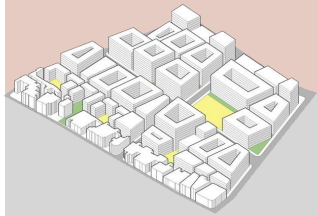
#Solution 4 – Maximum Proximity to School



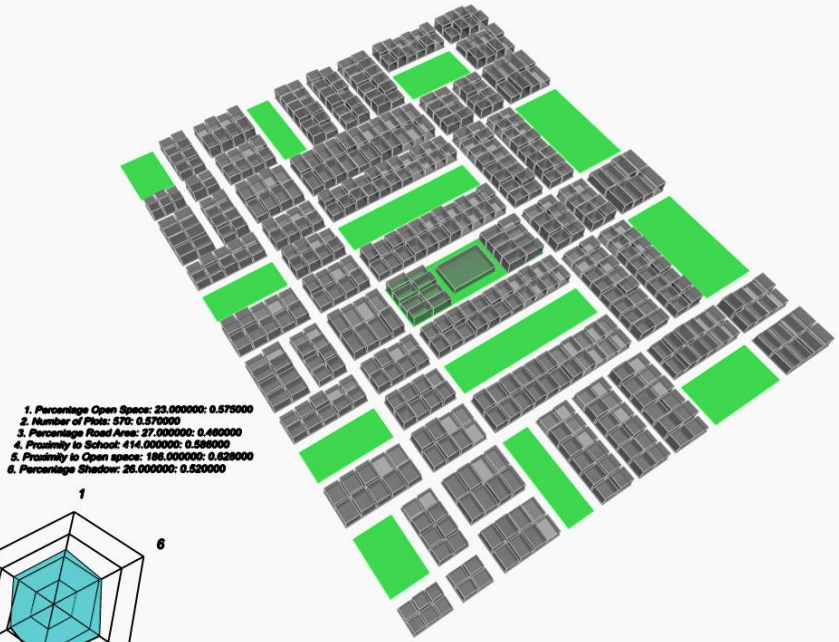
Outputs	
Open Space Area Percentage	17.0
No. of Plots	642.0
Percentage Road Area	27.0
Maximum Radial Distance to School	403.0
Maximum Radial Distance to Park	230.0
Percentage of Road Shaded	26.0

Variables	
Road Point Parameter - Side A	0.450
Number of Major Roads - Side A	2
Number of Major Roads - Side B	2
Road Point Parameter - Side B	0.400





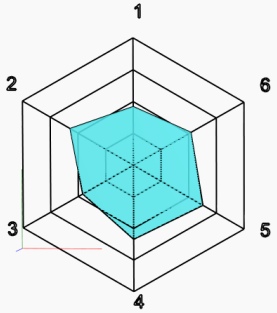
#Solution 5 – Maximum Proximity to Open Spaces



Outputs	
Open Space Area Percentage	23.0
No. of Plots	570.0
Percentage Road Area	27.0
Maximum Radial Distance to School	414.0
Maximum Radial Distance to Park	186.0
Percentage of Road Shaded	26.0

Variables	
Road Point Parameter - Side A	0.650
Number of Major Roads - Side A	2
Number of Major Roads - Side B	3
Road Point Parameter - Side B	0.500

1. Percentage Open Space: 23.000000: 0.460000
2. Number of Plots: 570: 0.570000
3. Percentage Road Area: 27.000000: 0.460000
4. Proximity to School: 414.000000: 0.586000
5. Proximity to Open space: 186.000000: 0.628000
6. Percentage Shadow: 26.000000: 0.520000



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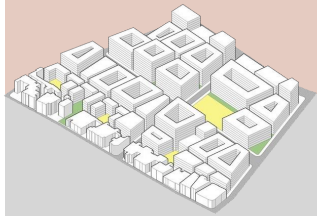
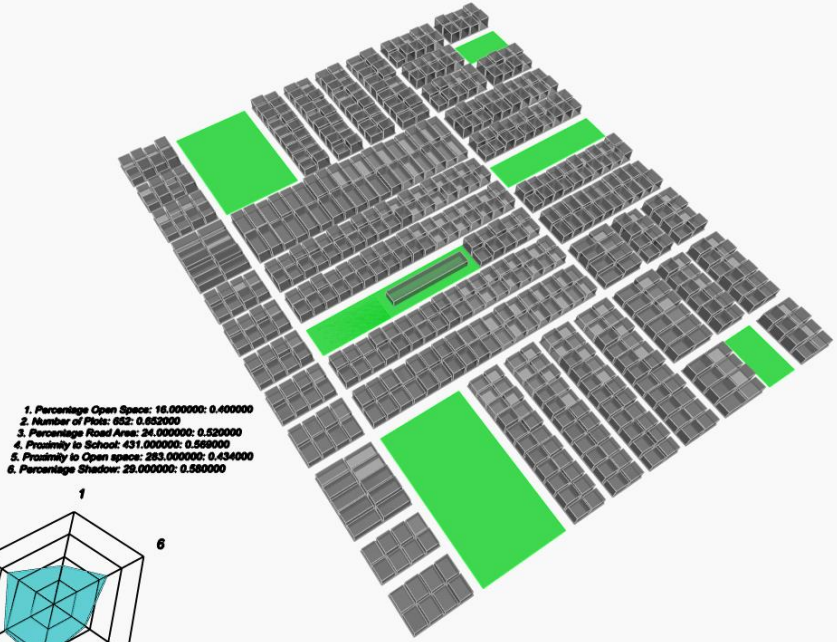


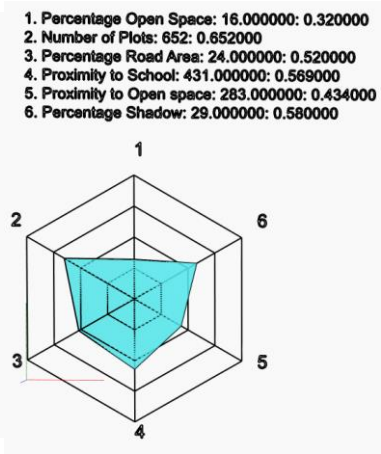
By : Abhishek Palit

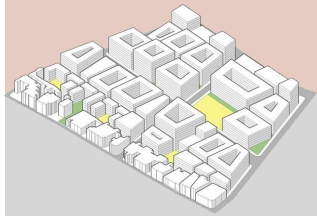
#Solution 6 – Maximum Road Area Shaded



Outputs	
Open Space Area Percentage	16.0
No. of Plots	652.0
Percentage Road Area	24.0
Maximum Radial Distance to School	431.0
Maximum Radial Distance to Park	283.0
Percentage of Road Shaded	29.0

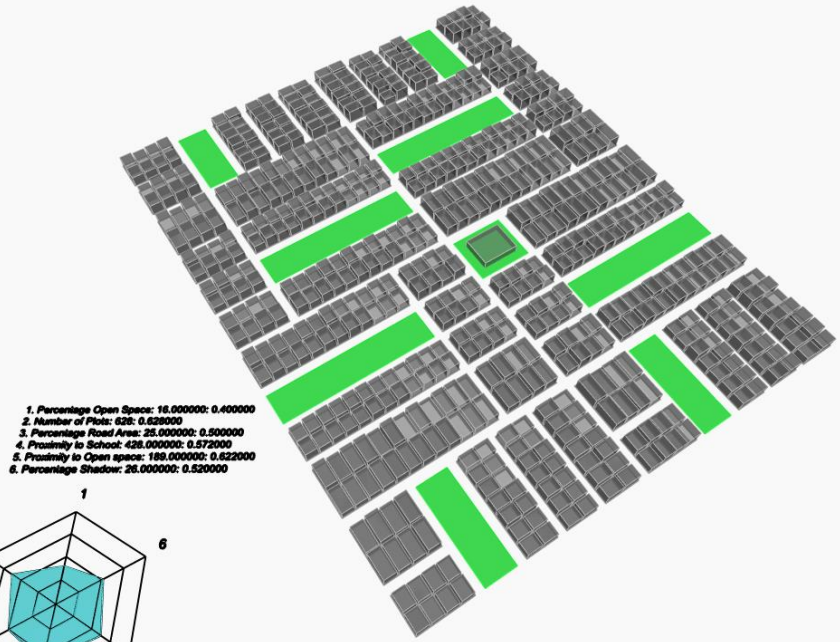
Variables	
Road Point Parameter - Side A	0.300
Number of Major Roads - Side A	1
Number of Major Roads - Side B	2
Road Point Parameter - Side B	0.550





Results

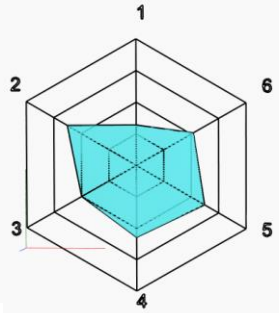
#Solution 7

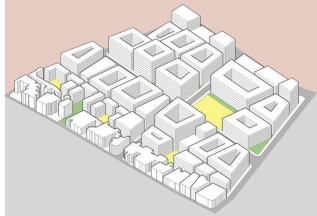


Outputs	
Open Space Area Percentage	16.0
No. of Plots	628.0
Percentage Road Area	25.0
Maximum Radial Distance to School	428.0
Maximum Radial Distance to Park	189.0
Percentage of Road Shaded	26.0

Variables	
Road Point Parameter - Side A	0.500
Number of Major Roads - Side A	1
Number of Major Roads - Side B	3
Road Point Parameter - Side B	0.550

1. Percentage Open Space: 16.000000: 0.320000
2. Number of Plots: 628: 0.628000
3. Percentage Road Area: 25.000000: 0.500000
4. Proximity to School: 428.000000: 0.572000
5. Proximity to Open space: 189.000000: 0.622000
6. Percentage Shadow: 26.000000: 0.520000





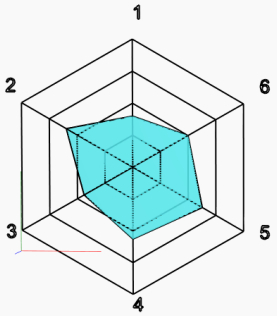
Results

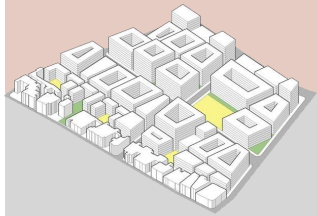
#Solution 8

Outputs	
Open Space Area Percentage	20.0
No. of Plots	598
Percentage Road Area	28.0
Maximum Radial Distance to School	435
Maximum Radial Distance to Park	186
Percentage of Road Shaded	25

Variables	
Road Point Parameter - Side A	0.50
Number of Major Roads - Side A	2
Number of Major Roads - Side B	3
Road Point Parameter - Side B	0.50

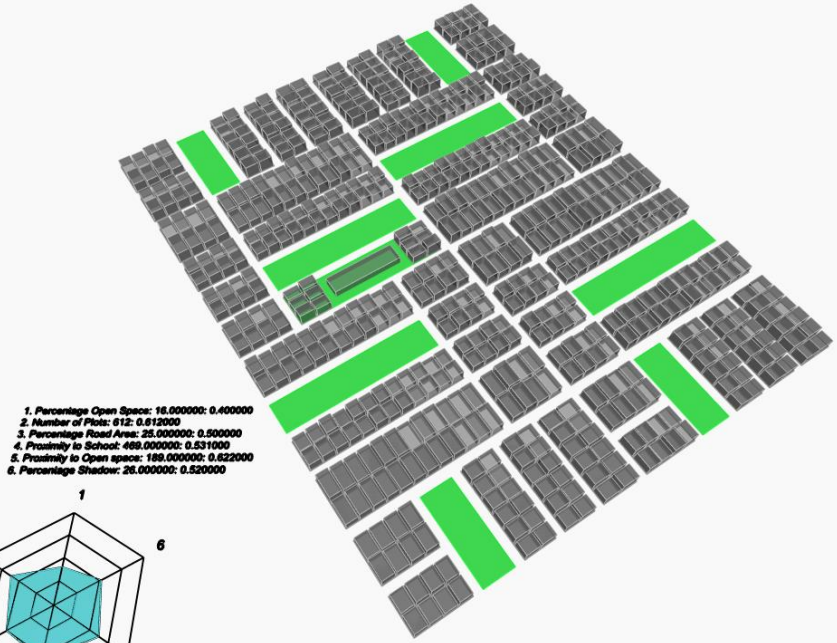
1. Percentage Open Space: 20.000000: 0.400000
2. Number of Plots: 598: 0.598000
3. Percentage Road Area: 28.000000: 0.440000
4. Proximity to School: 435.000000: 0.565000
5. Proximity to Open space: 186.000000: 0.628000
6. Percentage Shadow: 25.000000: 0.500000





Results

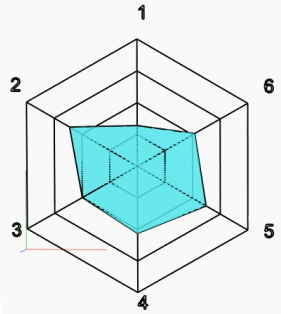
#Solution 9

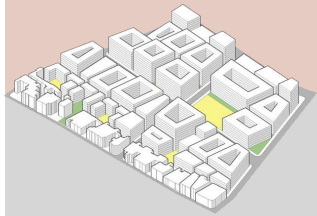


Outputs	
Open Space Area Percentage	16.0
No. of Plots	612
Percentage Road Area	25.0
Maximum Radial Distance to School	469
Maximum Radial Distance to Park	189
Percentage of Road Shaded	26

Variables	
Road Point Parameter - Side A	0.50
Number of Major Roads - Side A	1
Number of Major Roads - Side B	3
Road Point Parameter - Side B	0.50

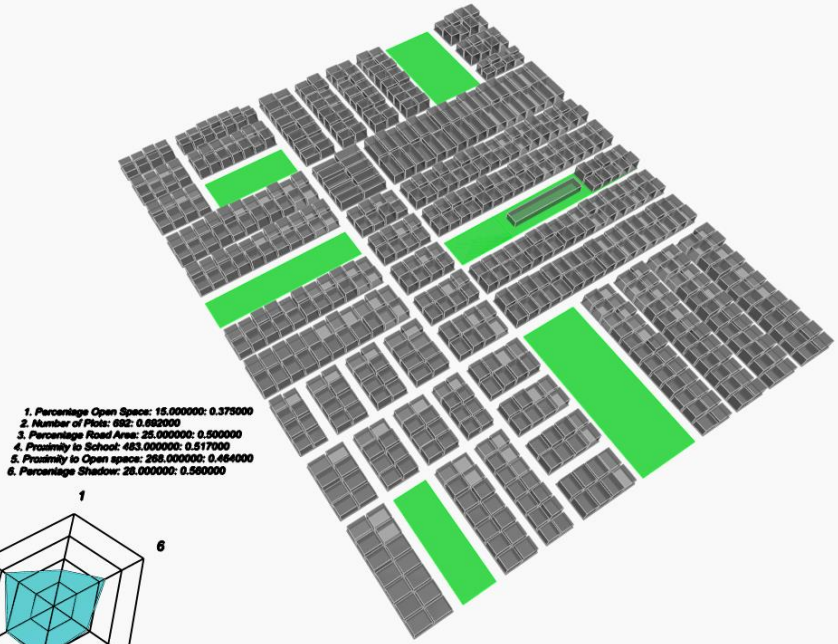
1. Percentage Open Space: 16.000000: 0.320000
2. Number of Plots: 612: 0.612000
3. Percentage Road Area: 25.000000: 0.500000
4. Proximity to School: 469.000000: 0.531000
5. Proximity to Open space: 189.000000: 0.622000
6. Percentage Shadow: 26.000000: 0.520000





Results

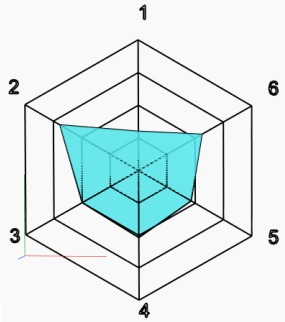
#Solution 10

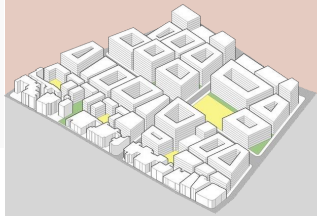


Outputs	
Open Space Area Percentage	15.0
No. of Plots	692.0
Percentage Road Area	25.0
Maximum Radial Distance to School	483.0
Maximum Radial Distance to Park	268.0
Percentage of Road Shaded	28.0

Variables	
Road Point Parameter - Side A	0.650
Number of Major Roads - Side A	1
Number of Major Roads - Side B	2
Road Point Parameter - Side B	0.600

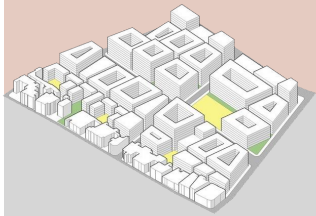
1. Percentage Open Space: 15.000000: 0.300000
2. Number of Plots: 692: 0.692000
3. Percentage Road Area: 25.000000: 0.500000
4. Proximity to School: 483.000000: 0.517000
5. Proximity to Open space: 268.000000: 0.464000
6. Percentage Shadow: 28.000000: 0.560000





Summary of Selected Solutions

	Normalized Metrics						
	Goal 1 - Max No. of Plots	Goal 2 - Max Open Area %	Goal 3 - Min Road Area %	Goal 4 - Proximity to School	Goal 5 - Proximity to open space	Goal 6 - Max Shading %	Average
Solution 1	0.696	0.300	0.460	0.562	0.518	0.560	0.516
Solution 2	0.544	0.580	0.440	0.568	0.660	0.460	0.542
Solution 3	0.594	0.500	0.540	0.575	0.548	0.540	0.550
Solution 4	0.624	0.425	0.460	0.597	0.540	0.520	0.528
Solution 5	0.570	0.575	0.460	0.586	0.628	0.520	0.557
Solution 6	0.520	0.400	0.520	0.569	0.434	0.580	0.504
Solution 7	0.628	0.400	0.500	0.572	0.622	0.520	0.540
Solution 8	0.598	0.500	0.440	0.565	0.626	0.500	0.538
Solution 9	0.612	0.400	0.500	0.531	0.622	0.520	0.531
Solution 10	0.692	0.375	0.500	0.517	0.464	0.580	0.521

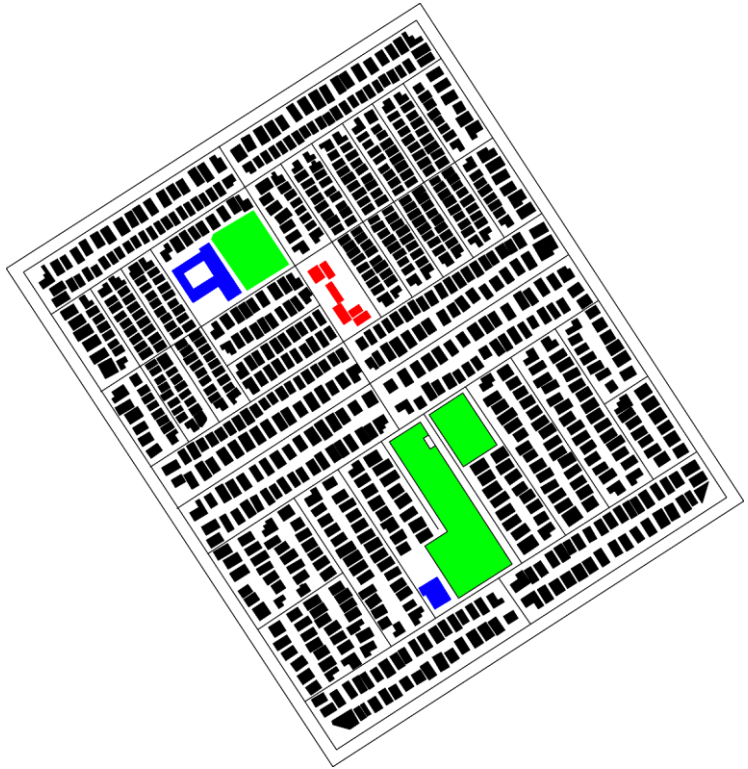


Comparative Analysis of Existing Design with Generative Design solutions

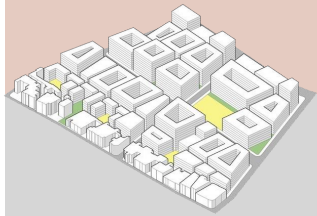
#Existing Case

The existing site parameter values include:

a. No. of Plots = 378
b. Site Open Space Area Percentage = 9%
c. Area Covered by Roads = 34%
d. Maximum Radial Distance to school = 592m
e. Maximal radial Distance to Park = 283m
f. Shading Percentage = 17%



Existing Layout of the BD and CD Block Neighborhood

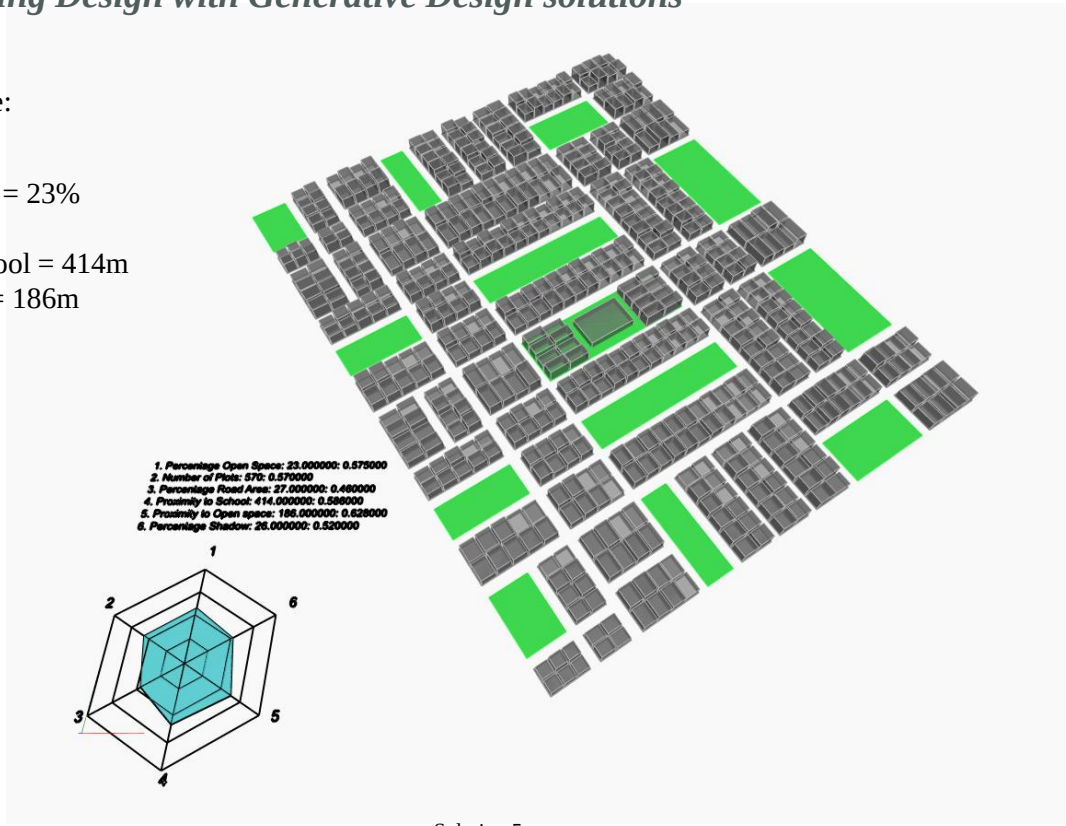


Comparative Analysis of Existing Design with Generative Design solutions

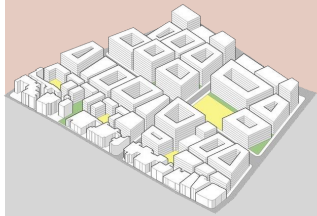
#Solution 5

The Solution 5 parameter values include:

a. No. of Plots = 570
b. Site Open Space Area Percentage = 23%
c. Area Covered by Roads = 27%
d. Maximum Radial Distance to school = 414m
e. Maximal radial Distance to Park = 186m
f. Shading Percentage = 26%



Solution 5

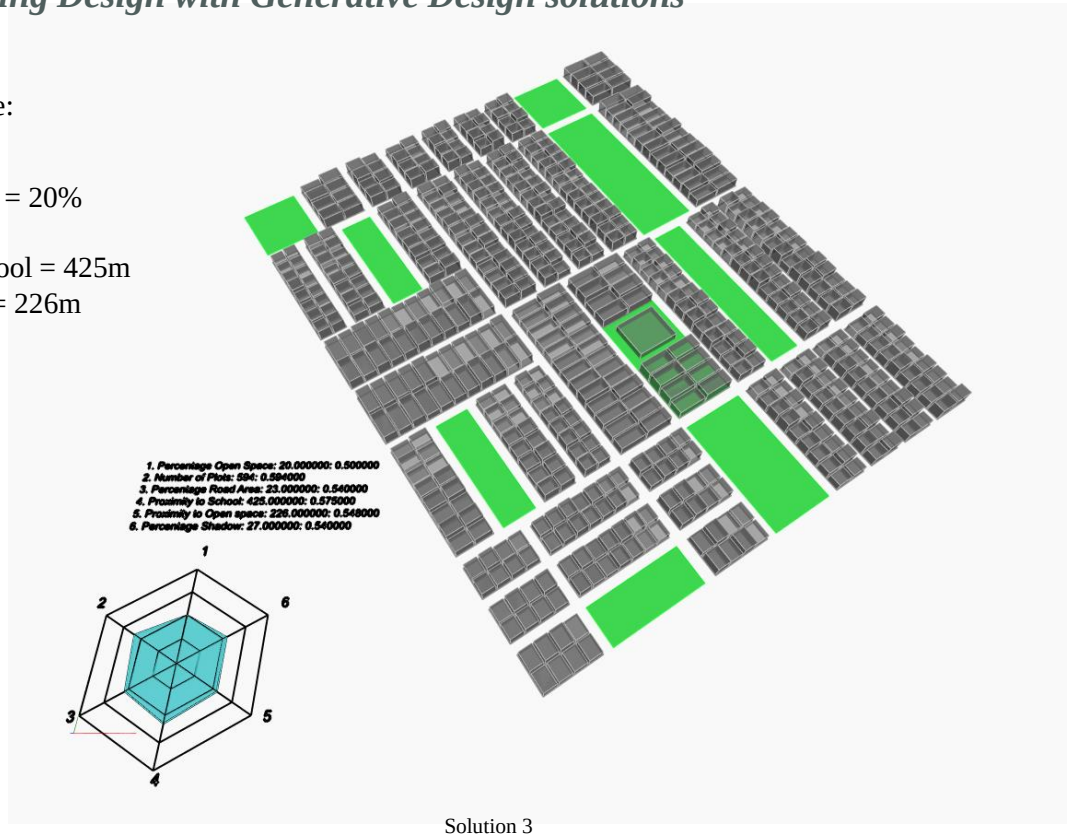


Comparative Analysis of Existing Design with Generative Design solutions

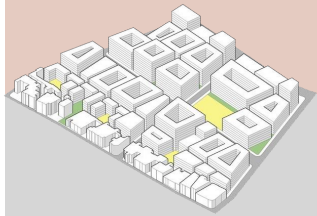
#Solution 3

The Solution 3 parameter values include:

a. No. of Plots = 594
b. Site Open Space Area Percentage = 20%
c. Area Covered by Roads = 23%
d. Maximum Radial Distance to school = 425m
e. Maximal radial Distance to Park = 226m
f. Shading Percentage = 27%



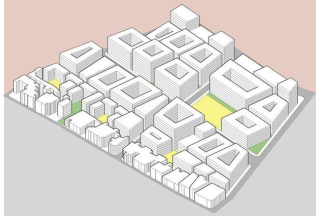
Solution 3



Comparative Analysis of Existing Design with Generative Design solutions

	Output Parameters					
	No. of Plots	Open Space Area %	Total road Area %	Highest Radial Distance to school	Highest Radial Distance to Open Space	Shading %
Existing case	378.000	9.000	34.000	592.000	283.000	17.000
Solution 5	570.000	23.000	27.000	414.000	186.000	26.000
Solution 3	594.000	20.000	23.000	425.000	226.000	27.000

	Normalized Metrics						
	Goal 1 - Max No. of Plots	Goal 2 - Max Open Area %	Goal 3 - Min Road Area %	Goal 4 - Proximity to School	Goal 5 - Proximity to open space	Goal 6 - Max Shading %	Average
Existing Case	0.378	0.180	0.320	0.408	0.717	0.340	0.391
Solution 5	0.570	0.460	0.460	0.586	0.814	0.520	0.568
Solution 3	0.594	0.400	0.540	0.575	0.774	0.540	0.571

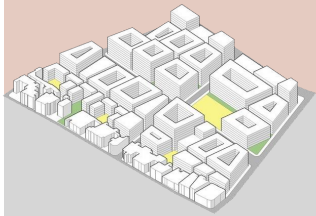


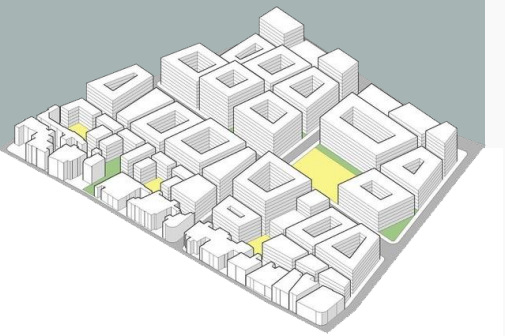
Conclusion

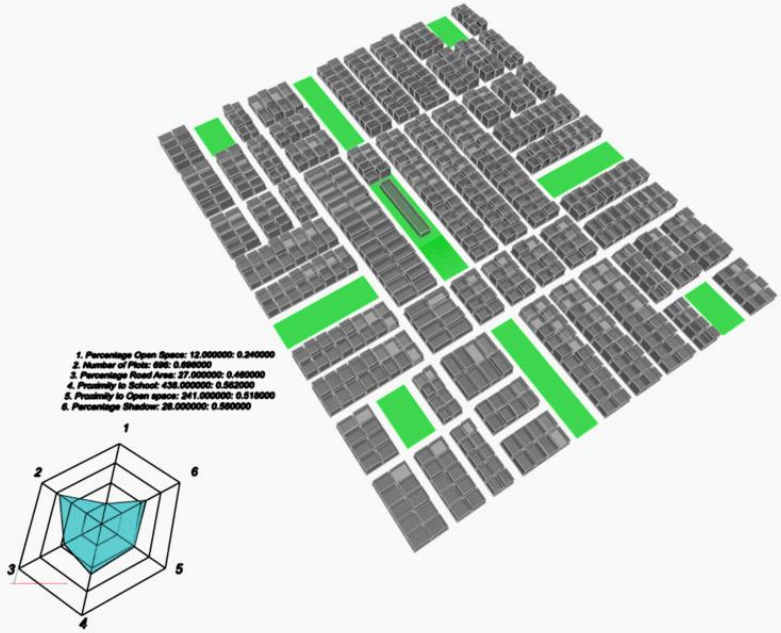
- In India, cities are expanding at an extremely high pace, with municipal boundaries being expanded, and new agricultural land use change, the **Generative Design tool can be used prior to design, so that better informed iterations of the same neighborhood can be found.**
- The Generative Design process allows the architects and planners to take **opinions of stakeholders and incorporate them in design, at an early stage of the project.**
- **Changing the set of goals and requirements of the Project is easier in the Generative Design workflow.**
- **Generative Design in an Architect and Urban Planner's friend.**

Future Scope of Work

- The further research is required **for more comprehensive Urban design parameters such as climate, safety, comfort, traffic, behaviour, etc**.
- These parameters **can add more complexity of the Urban design to the generative design** and help to create more functional design solutions that incorporate a magnitude of urban design parameters.






1. Percentage Open Space: 12.000000: 0.340000
2. Number of Plots: 896: 0.699000
3. Percentage Road Area: 27.000000: 0.460000
4. Proximity to School: 438.000000: 0.562000
5. Proximity to Open space: 241.000000: 0.518000
6. Percentage Shadow: 28.000000: 0.580000
1
2
3
4
5
6

Thankyou..

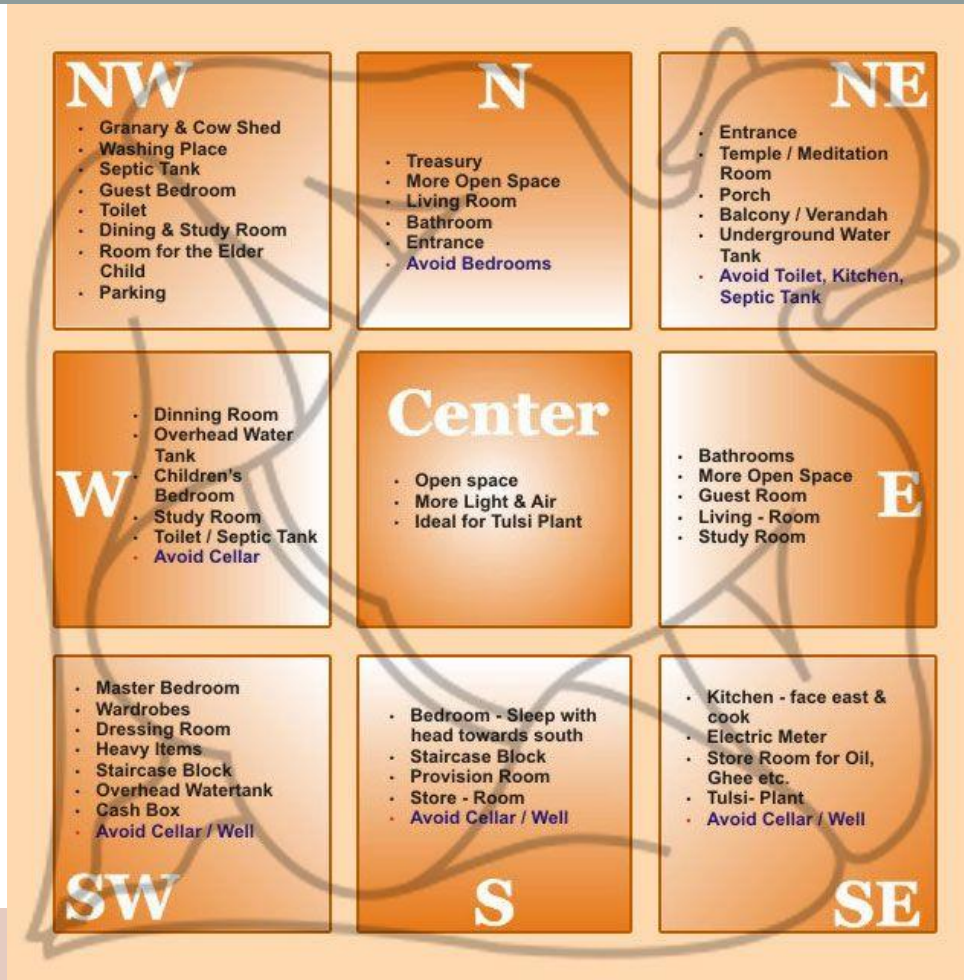
Next Steps: Generative Design and Vaastu

Vaastu

Vaastu shastra are texts on the traditional Indian system of architecture.

These texts describe **principles of design, layout, measurements, ground preparation, space arrangement, and spatial geometry.**

The designs aim to integrate architecture with nature, the relative functions of various parts of the structure, and ancient beliefs **utilizing geometric patterns (yantra), symmetry, and directional alignments.**



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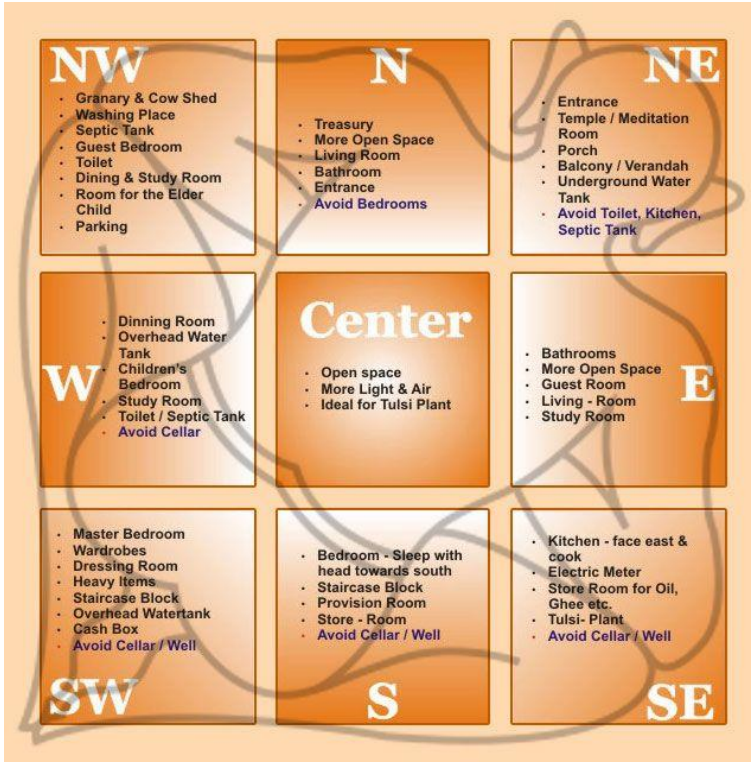
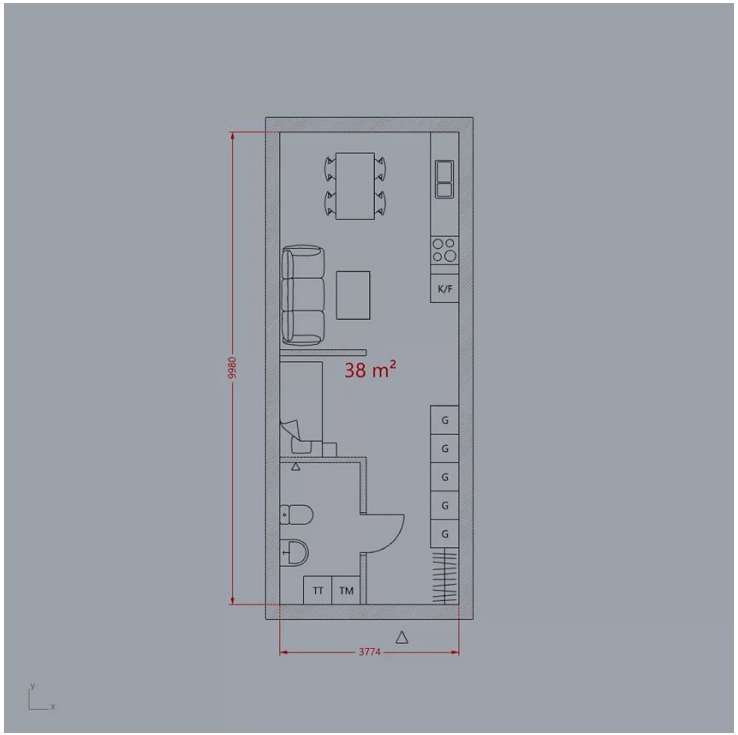
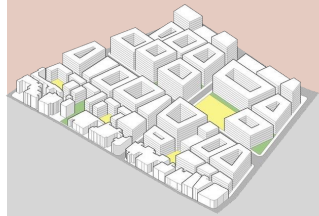
Next Steps: Generative Design and Vaastu

Vaastu ??





Automatic Floor Plan Generator by Finch



By : Abhishek Palit