IMM®

AN INTERNATIONAL DESIGN LABORATORY FOR URBAN SUSTAINABILITY

Urban Form and Environmental Performances via Integrated Modification Methodology (IMM) methodology.

www.immdesignlab.com

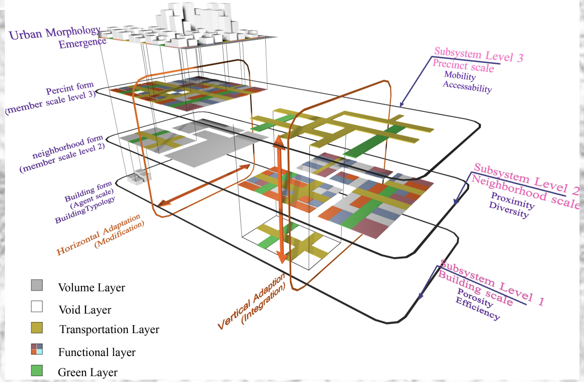
INDEX

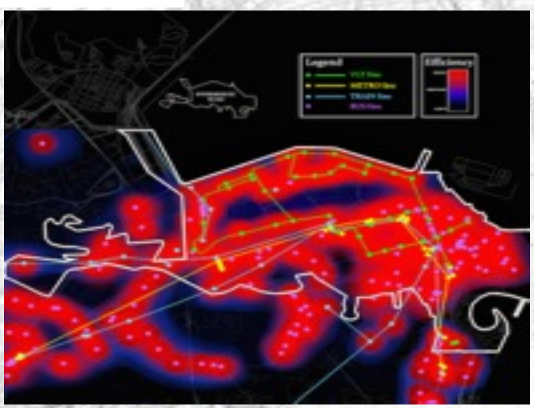
Part 1. Today's glossary.

Part 2. IMM Methodology.

Part 3. Study case. (Tehran)

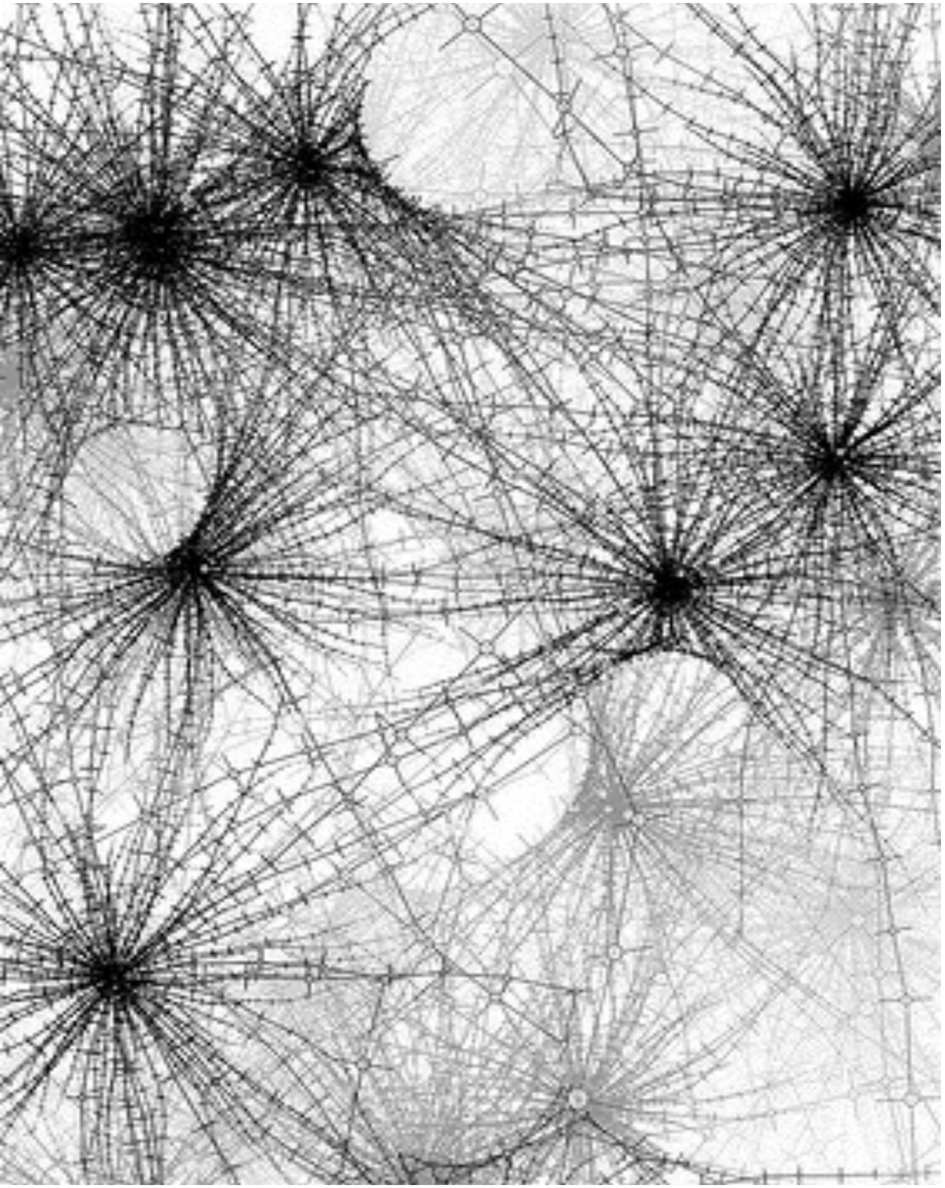
Part 4. References.





TODAY’S GLOSSARY

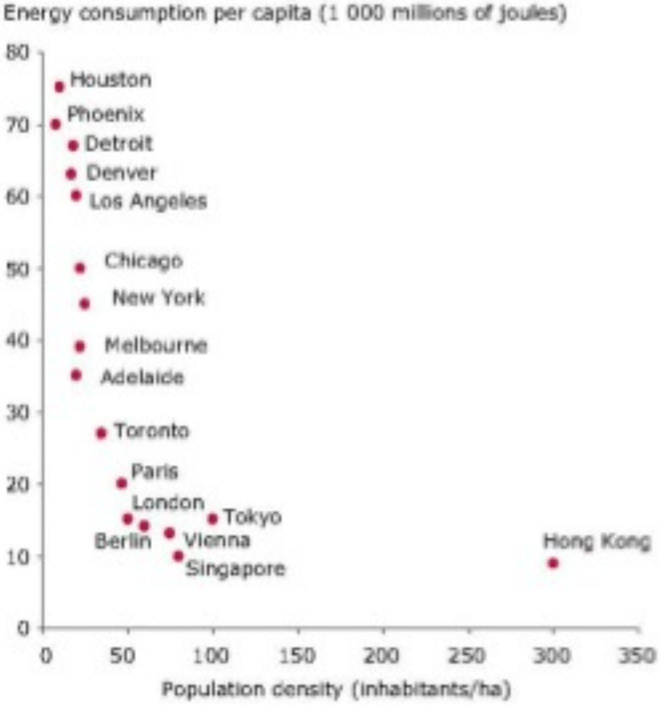
Terms you will encounter today



Holism:

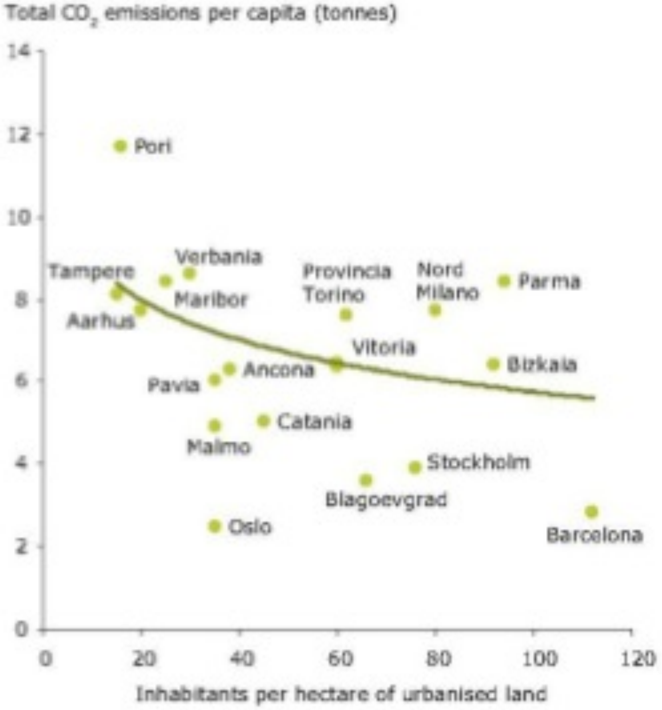
the theory that parts of a whole are in intimate interconnection, such that they cannot exist independently of the whole, or cannot be understood without reference to the whole, which is thus regarded as greater than the sum of its parts.

Figure 9 Population density and energy consumption, selected World cities



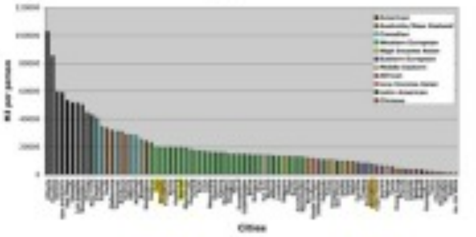
Source: Adopted from Newman, P. and Kenworthy, J., 1999.

Figure 10 Population density and CO_2 emissions, selected European cities

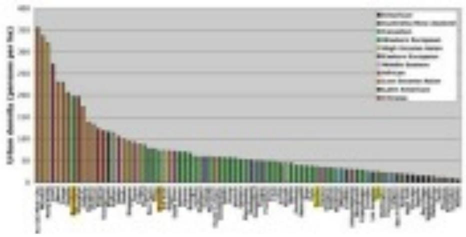


Source: Adopted from Ambiente Italia, 2003

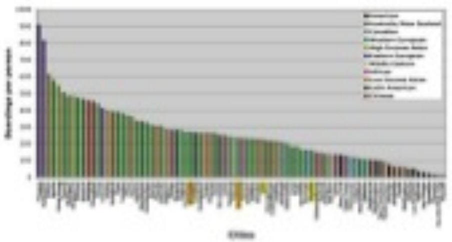
Private Passenger Transport Energy Use per Person, 1995



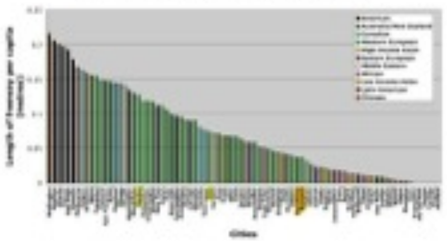
Urban Density, 1995 (Persons/Ha)



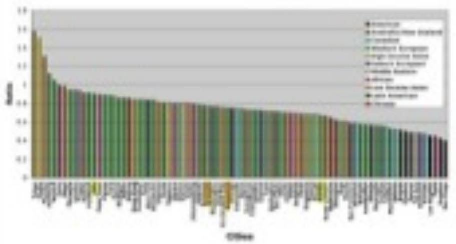
Public Transport Boardings per Person, 1995

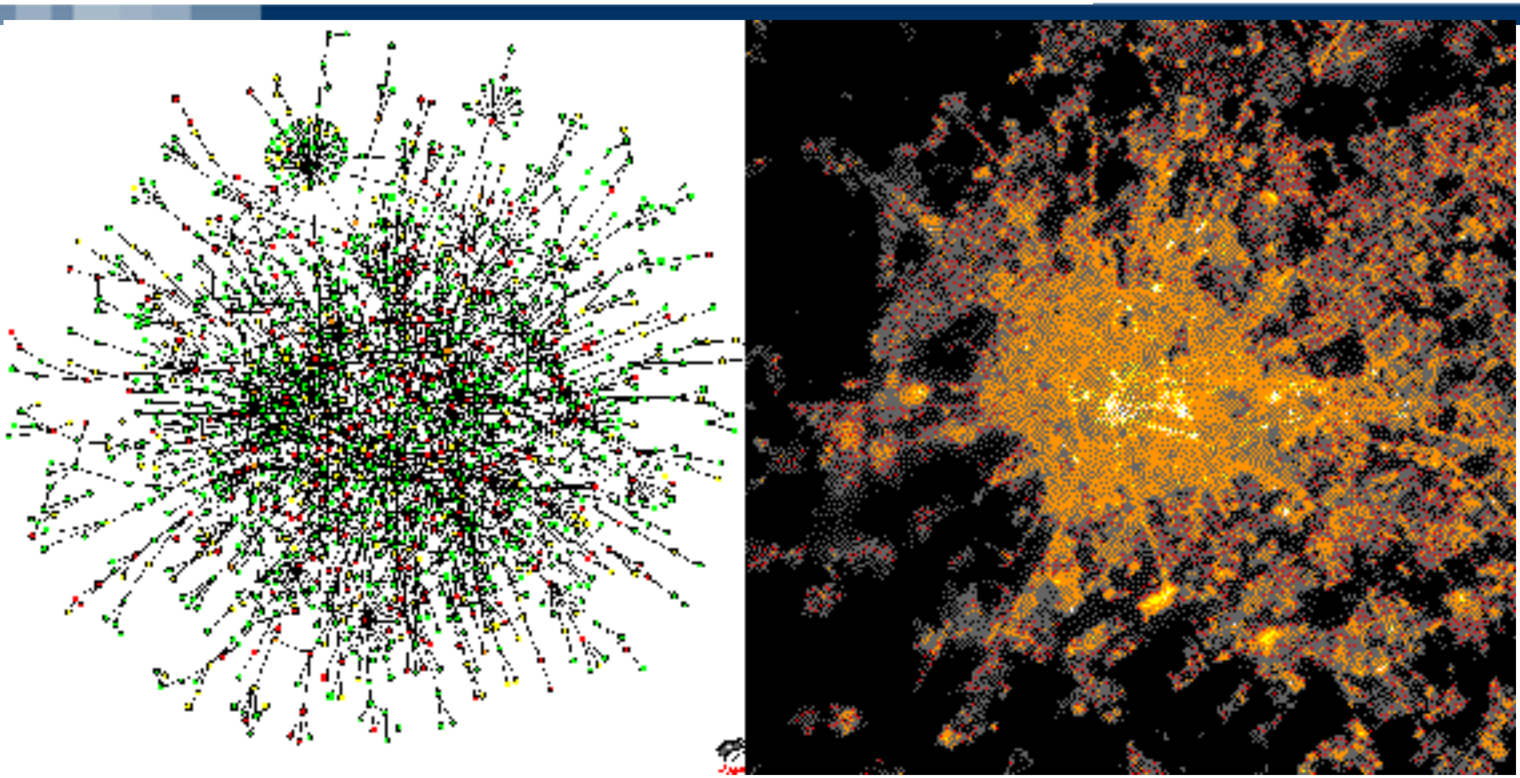


Length of Freeway per Capita, 1995 (metres)



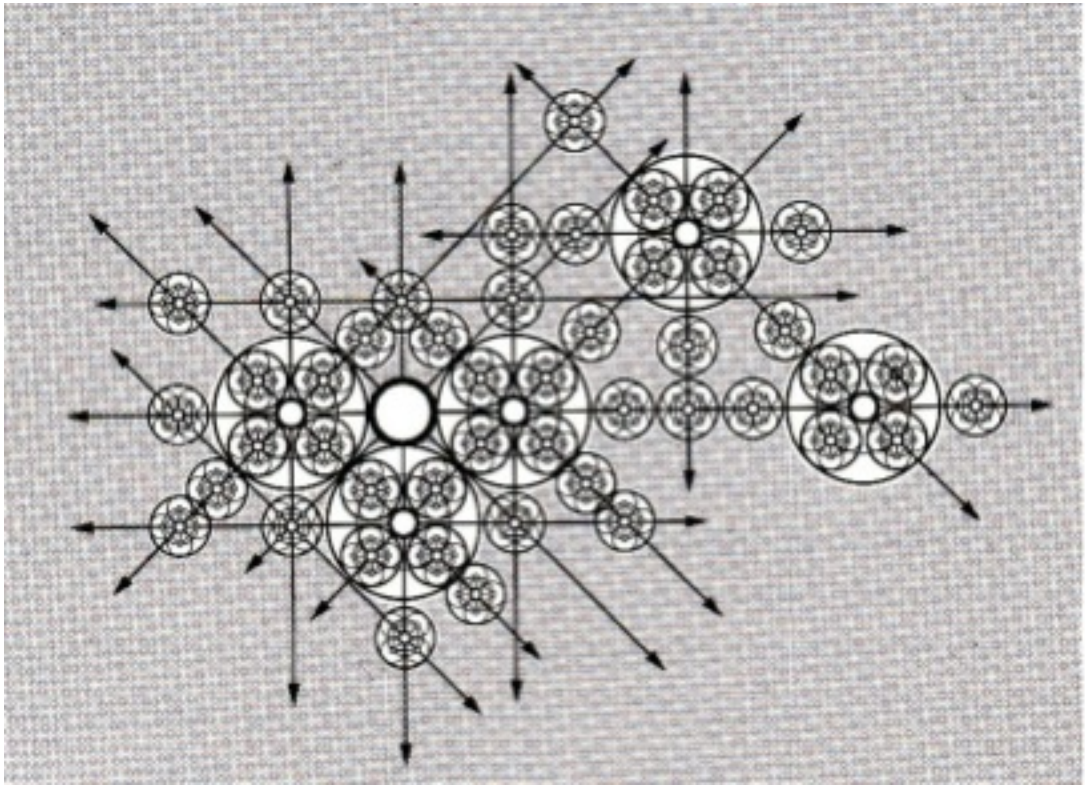
Ratio of Public to Private Transport Speed, 1995





Complex systems:

Consisting of many diverse and autonomous but interrelated components which they exhibit properties that emerge from their interaction and cannot be predicted from the properties of the parts.

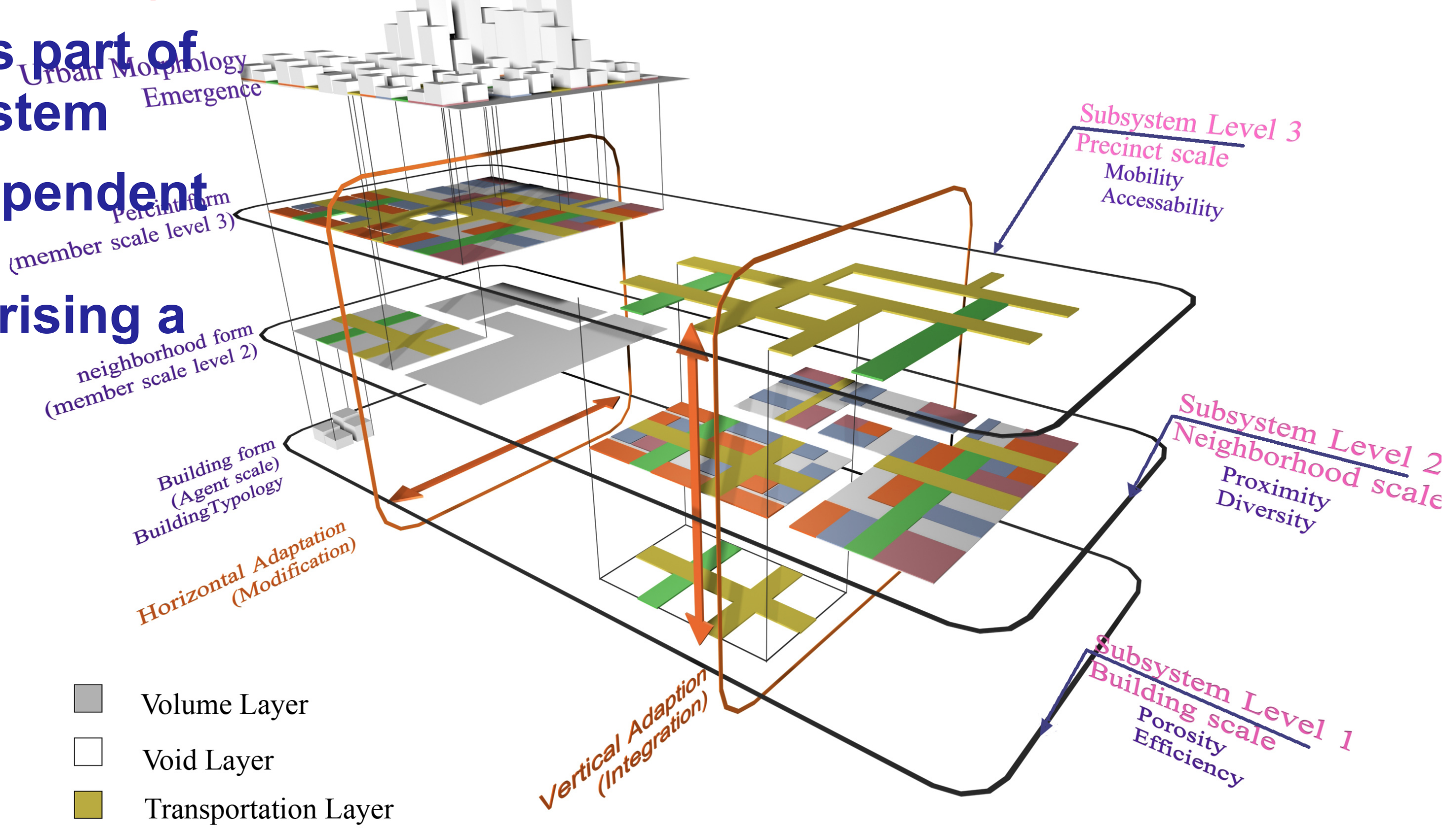


HIERARCHICAL STRUCTURE A hierarchy (Greek: hierarchia (ἱεραρχία), is an arrangement of items in which the items are represented as being "above," "below," or "at the same level as" one another.

SUBSYSTEM (LAYER):

A system that is part of some larger system

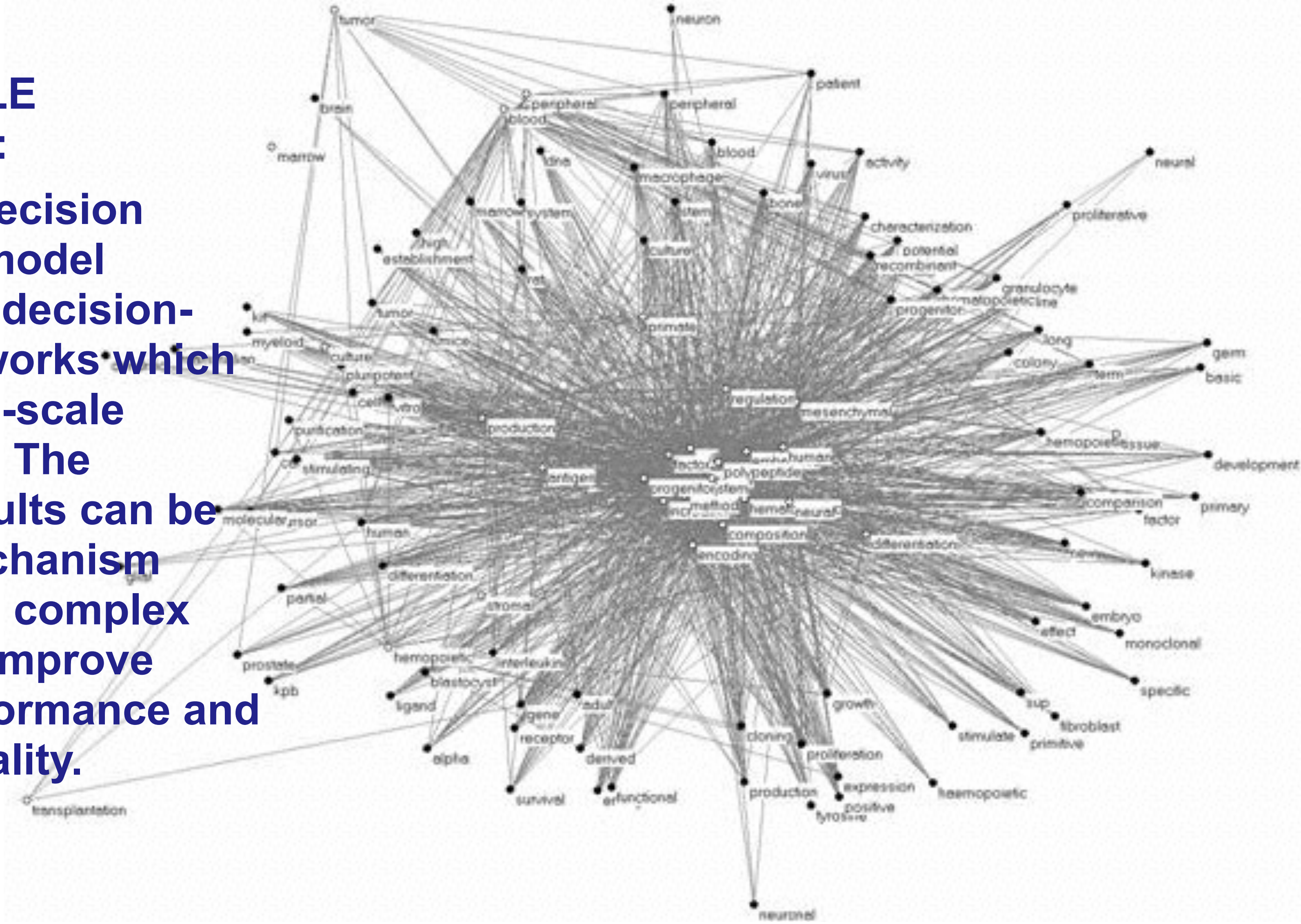
A group of independent but interrelated elements comprising a unified whole



- ▨ Volume Layer
- ⬜ Void Layer
- 🟨 Transportation Layer
- ▦ Functional layer
- 🟩 Green Layer

MULTI-SCALE APPROACH:

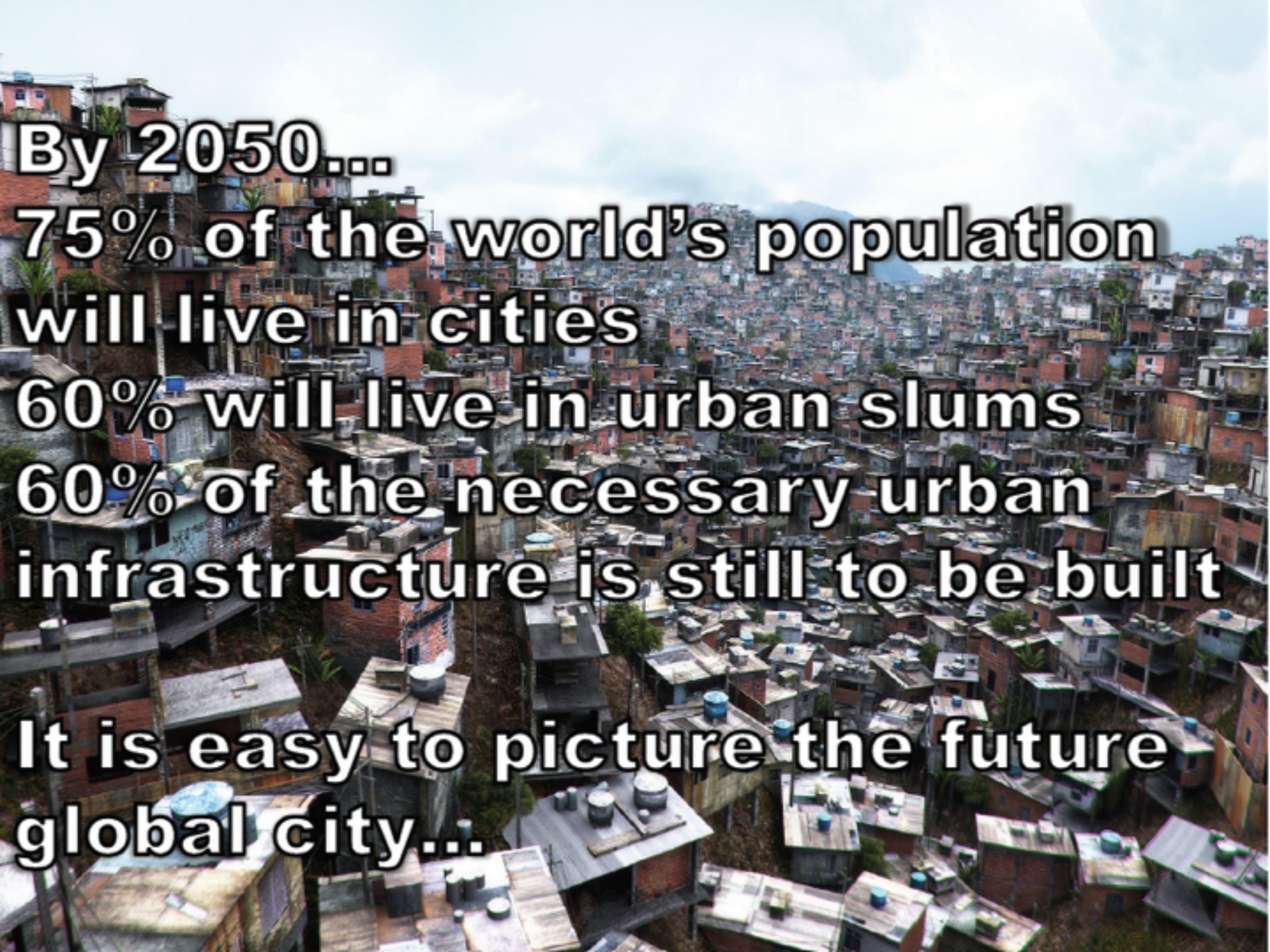
Multiscale decision theory can model hierarchical decision-making networks which exhibit multi-scale phenomena. The theory's results can be used by mechanism designers in complex systems to improve system performance and decision quality.



Every single project, depends on the size, scale and level of complexity. In fact, multidisciplinary design is a symbiotic relation between the layers.

“The only problems that have simple solutions are simple problems. The world is a complex place, facing complex problems that have complex solutions, and we need to make complex decisions everyday”. P. Ortiz.

According to the UN as the population on the planet ***doubles*** to its high estimate of **15 billion** by the end of this century the number of occupants will *halve* from **4** people per household in **1990** to 1.97 by 2050.



By 2050...

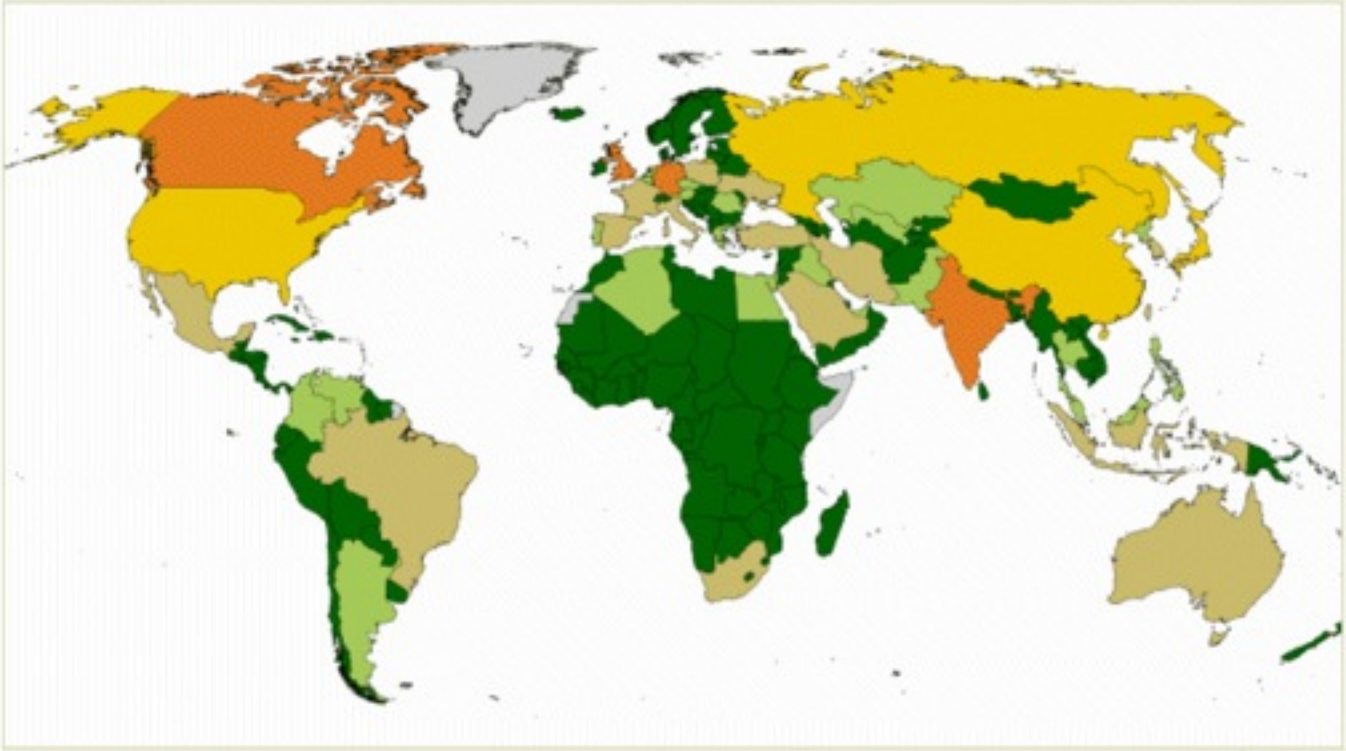
75% of the world's population will live in cities

60% will live in urban slums

60% of the necessary urban infrastructure is still to be built

It is easy to picture the future global city...

Total CO2 Emissions, Excluding Land Use Change, 2000



Total CO2 Emissions
(thousands of tons of carbon dioxide)

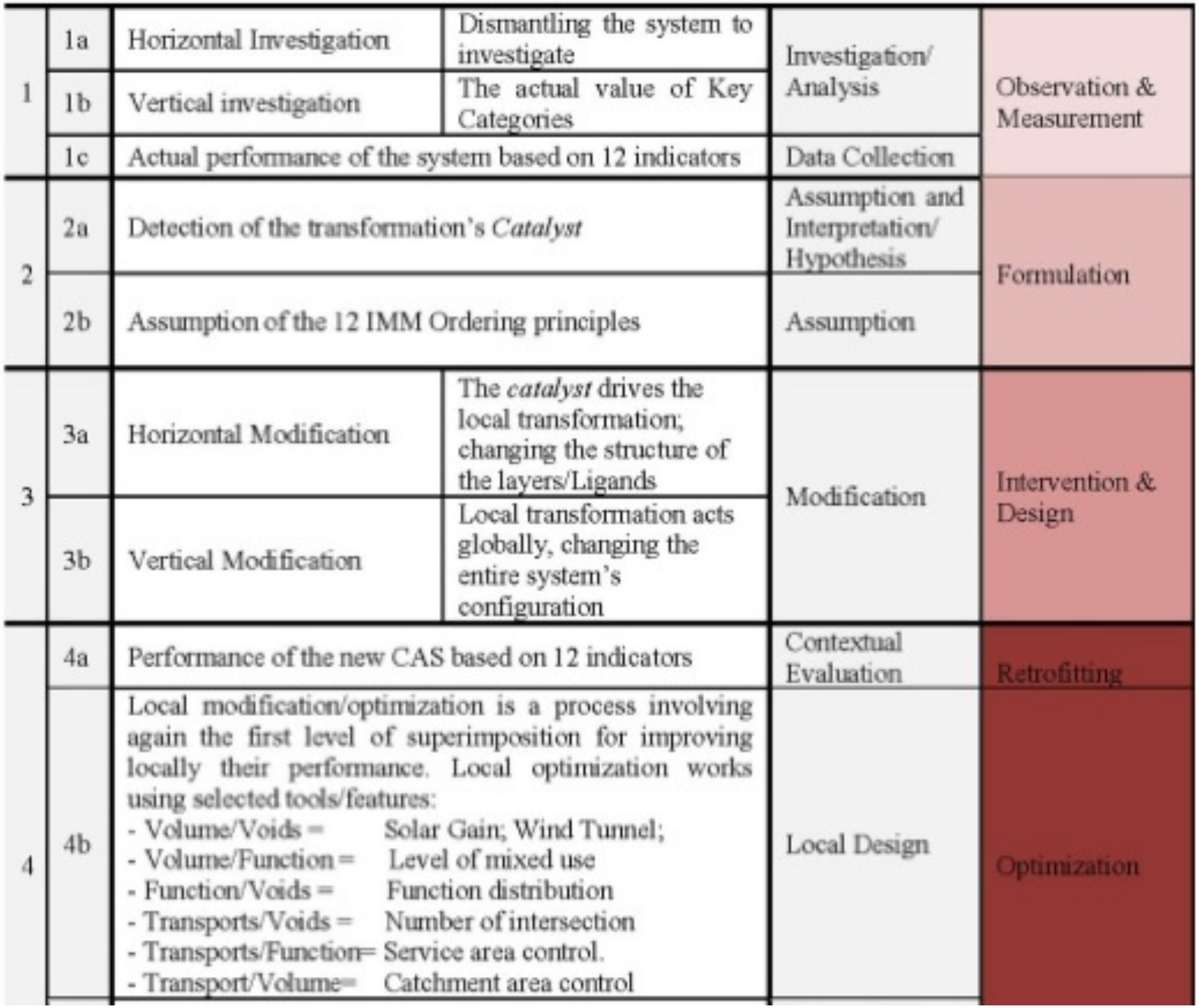
- 🟨 > 1,200,001
- 🟧 1,200,000 - 500,001
- 🟫 500,000 - 200,001
- 🟩 200,000 - 60,001
- 🟩 < 60,000
- ⬜ No Data

Map Projection: Robinson

IMM® is a method to improve the performance of a city as an existing system via modification of its costituents.

What Is IMM?

PHASING



1	1a	Horizontal Investigation	Dismantling the system to investigate	Investigation/ Analysis	Observation & Measurement
	1b	Vertical investigation	The actual value of Key Categories		
	1c	Actual performance of the system based on 12 indicators		Data Collection	
2	2a	Detection of the transformation's *Catalyst*		Assumption and Interpretation/ Hypothesis	Formulation
	2b	Assumption of the 12 IMM Ordering principles		Assumption	
3	3a	Horizontal Modification	The *catalyst* drives the local transformation; changing the structure of the layers/Ligands	Modification	Intervention & Design
	3b	Vertical Modification	Local transformation acts globally, changing the entire system's configuration		
4	4a	Performance of the new CAS based on 12 indicators		Contextual Evaluation	Retrofitting
	4b	Local modification/optimization is a process involving again the first level of superimposition for improving locally their performance. Local optimization works using selected tools/features: - Volume/Voids = Solar Gain; Wind Tunnel; - Volume/Function = Level of mixed use - Function/Voids = Function distribution - Transports/Voids = Number of intersection - Transports/Function= Service area control. - Transport/Volume= Catchment area control		Local Design	Optimization

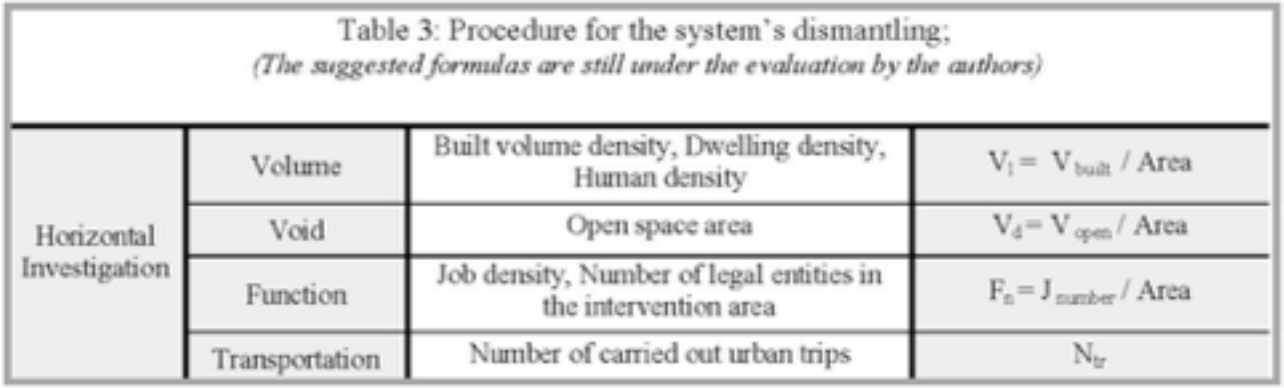


Table 3: Procedure for the system's dismantling;
(The suggested formulas are still under the evaluation by the authors)

Horizontal Investigation	Volume	Built volume density, Dwelling density, Human density	$V_1 = V_{built} / Area$
	Void	Open space area	$V_d = V_{open} / Area$
	Function	Job density, Number of legal entities in the intervention area	$F_n = J_{number} / Area$
	Transportation	Number of carried out urban trips	N_{tr}

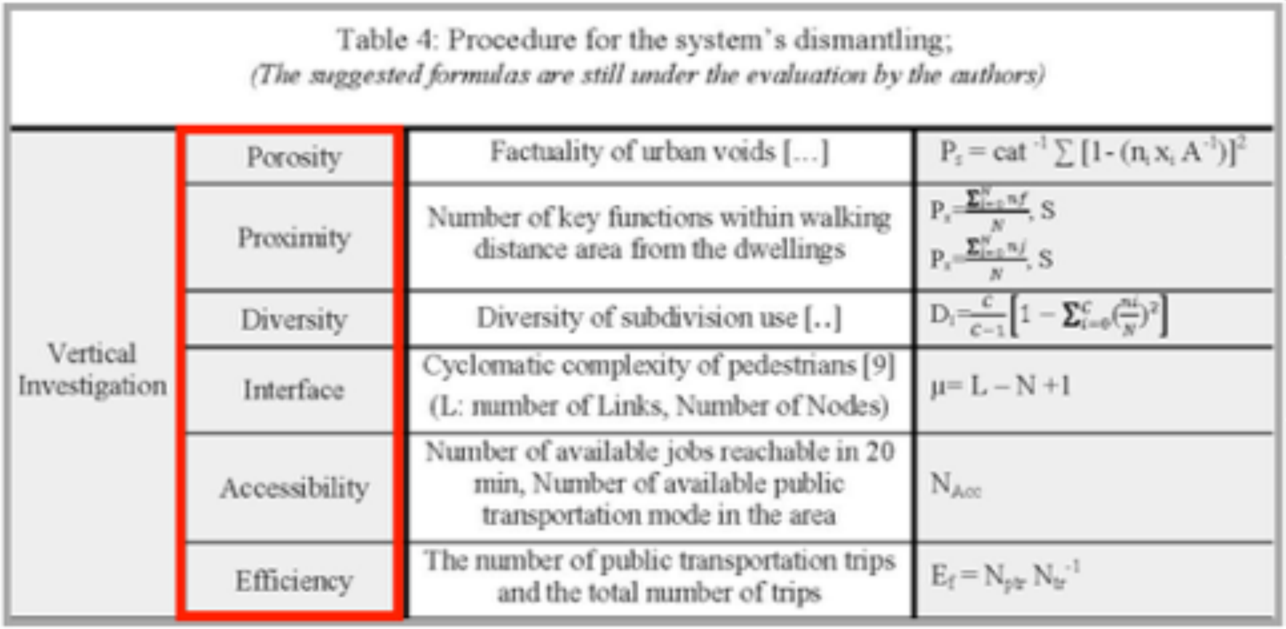


Table 4: Procedure for the system's dismantling;
(The suggested formulas are still under the evaluation by the authors)

Vertical Investigation	Porosity	Factuality of urban voids [...]	$P_z = cat^{-1} \sum [1 - (n_i x_i A^{-1})]^2$
	Proximity	Number of key functions within walking distance area from the dwellings	$P_x = \frac{\sum_{i=1}^{N} nf}{N}, S$ $P_x = \frac{\sum_{i=1}^{N} nj}{N}, S$
	Diversity	Diversity of subdivision use [..]	$D_i = \frac{c}{c-1}\left[1 - \sum_{i=0}^{c}(\frac{ni}{N})^2\right]$
	Interface	Cyclomatic complexity of pedestrians [9] (L: number of Links, Number of Nodes)	$\mu = L - N + 1$
	Accessibility	Number of available jobs reachable in 20 min, Number of available public transportation mode in the area	N_{Acc}
	Efficiency	The number of public transportation trips and the total number of trips	$E_f = N_{ptr} N_{tr}^{-1}$

Porosity Volume and Void layer defines the Porosity of the city as a solid porous Volume, sponge like, with various sizes of holes linked by linear Void layer

Proximity is the number of different type of key functions in a predetermined area walk able.

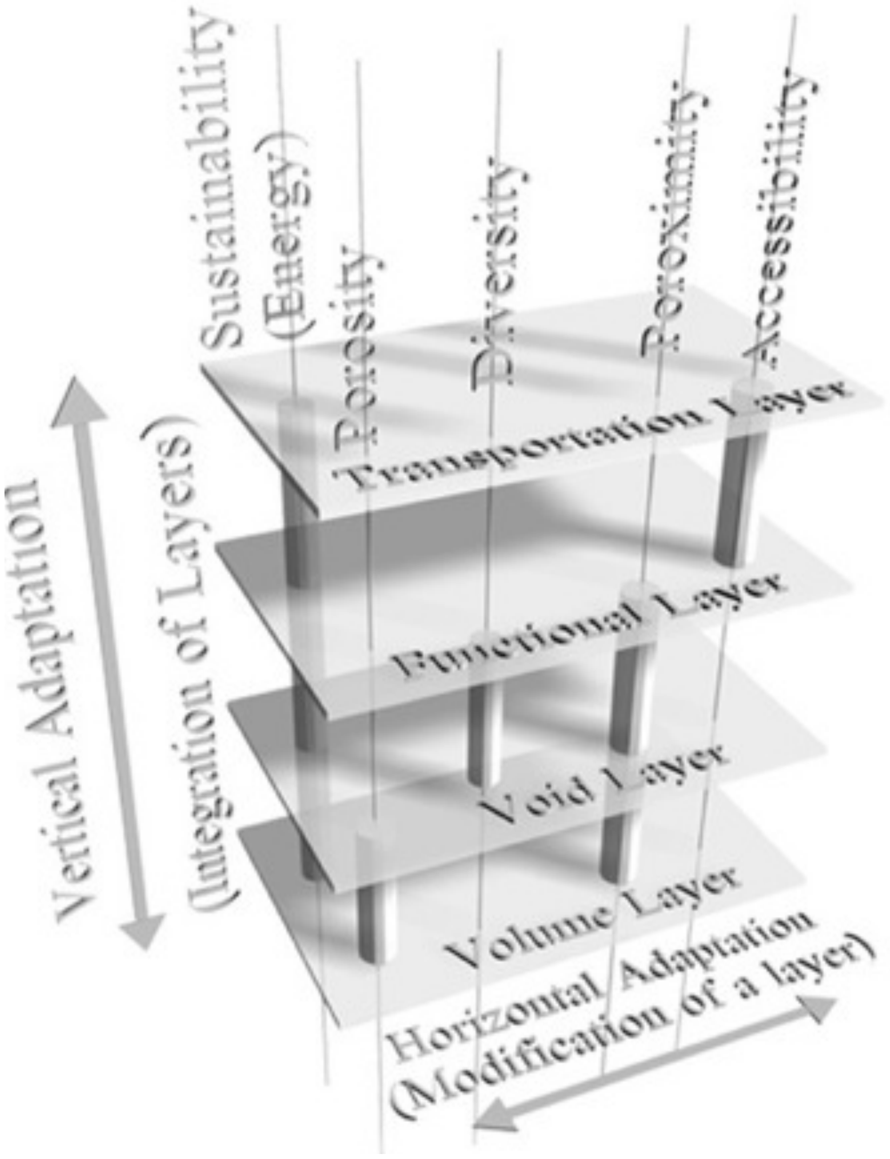
Diversity is the number of interactions between nodes within a network; it's the number and the distribution of the different type of key functions in a predetermined distance.

Interface is about movability inside the urban voids and it defines how complex they are. it increases the complexity of the system, by increasing the number of possible Links to connect two nodes

Accessibility is a distance independent parameter that relies on a time factor. it refers to the ease of reaching destinations.

Efficiency is the ratio between the number of trips operated by public transport and the total transportation demands of the study area.

HORIZONTAL INVESTIGATION



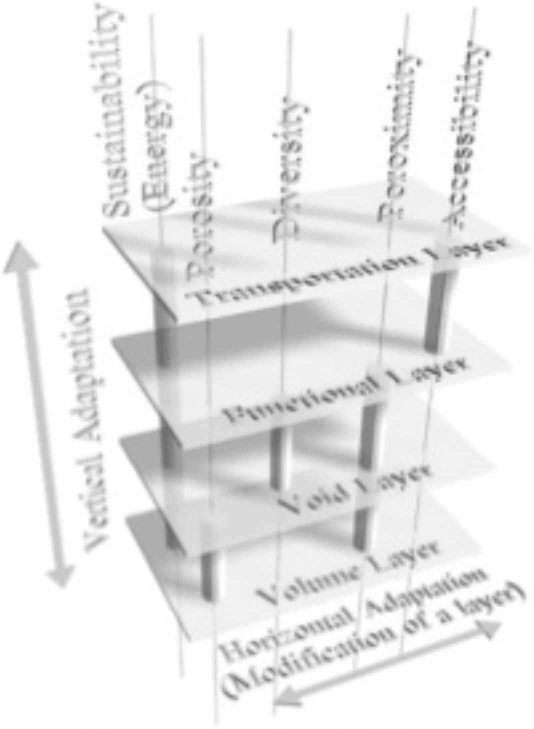
VERTICAL INVESTIGATION

The second step of the Investigation phase is an investigation of the comprehensive configuration of the CAS. For this reason it is requested a particular attention to describe the correlation between the different subsystems (Global configuration) in order to assign a proper role and specific characteristics to each one.

Key Categories, First Level of Integration

Porosity:
The city as a solid **porous volume**, sponge like, with various sizes of holes linked by linear Void layer.

Poroximity:
the Proximity is the number of different type of key functions in a predetermined **walkable scale distance;**



Layers' superimposition	First level (Key Catagories)	Second level	Determinants	
Volume / Function	Proximity	Compactness	Morphology	Energy efficient form
Volume / Void	Porosity			
Function / Void	Diversity	Complexity	Typology	
Transport / Void	Interface			
Transport / Function	Accessibility	Connectivity	Technology	
Transport / Volume	Efficiency			

Key Categories, First Level of Integration

Diversity:
Direct relationship with the **number of the nodes and Links.** The diversity, the distribution of the different functions in urban spaces. Diversity is **dependent on the number and type of the functions and independent from the distance.**

Interface:
direct relationship to movability and **permeability** inside the urban morphological **cavities**.

Layers' superimposition	First level (Key Catagories)	Second level	Determinants	
Volume / Function	Proximity	Compactness	Morphology	Energy efficient form
Volume / Void	Porosity			
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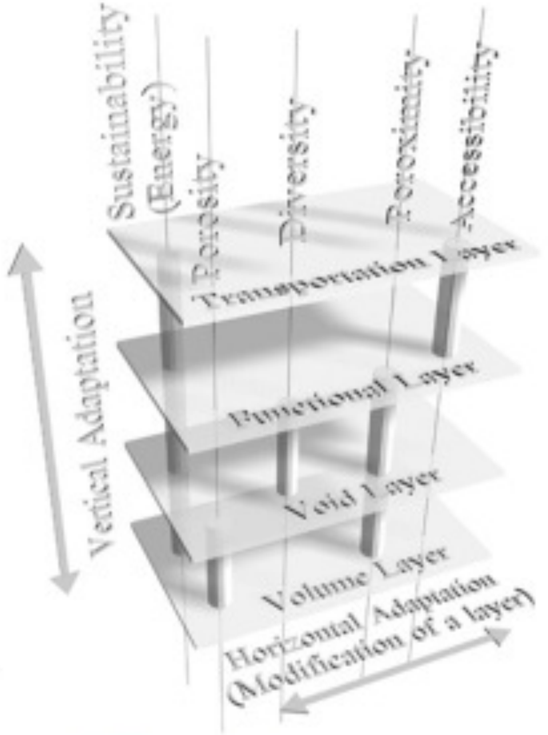
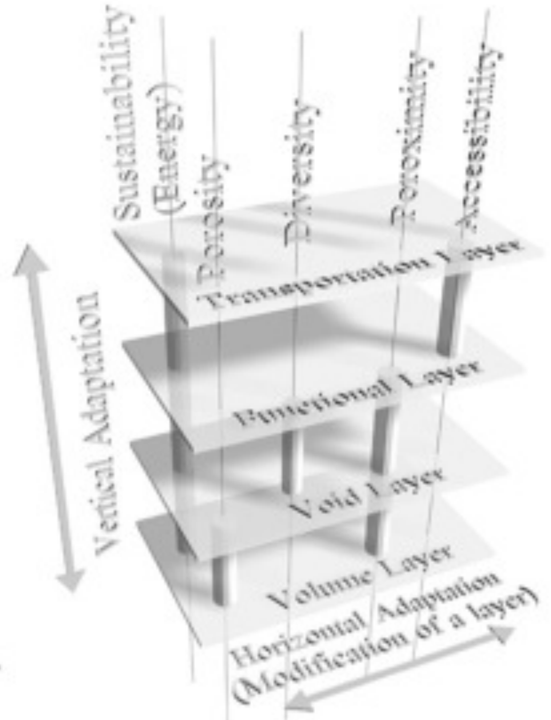


Key Categories, First Level of Integration

Accessibility:
refers to the ease of reaching destinations. Accessibility is a distance independent parameter that simply relies on a **time factor**.

Efficiency:
the ratio between the number of trips operated by **public transport** and the total transportation demands of the study area.



Layers' superimposition	First level (Key Catagories)	Second level	Determinants	
Volume / Function	Proximity	Compactness	Morphology	Energy efficient form
Volume / Void	Porosity			
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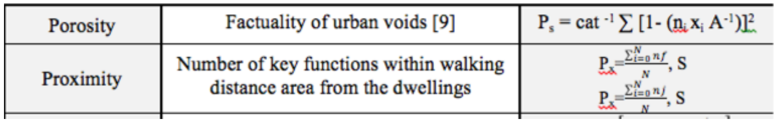
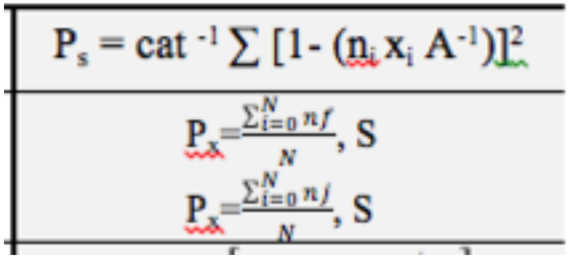
Transport / Void	Interface			
Transport / Function	Accessibility	Connectivity	Technology	
Transport / Volume	Efficiency			

VERTICAL INVESTIGATION

Comprehension of the CAS configuration



Porosity	Factuality of urban voids [9]	$P_s = cat^{-1} \sum [1-(n_i x_i A^{-1})]^2$
Proximity	Number of key functions within walking distance area from the dwellings	$P_x = \frac{\sum_{i=0}^{N} nf}{N}, S$ $P_x = \frac{\sum_{i=0}^{N} nj}{N}, S$



$$P_s = cat^{-1} \sum [1-(n_i x_i A^{-1})]^2$$

$$P_x = \frac{\sum_{i=0}^{N} nf}{N}, S$$

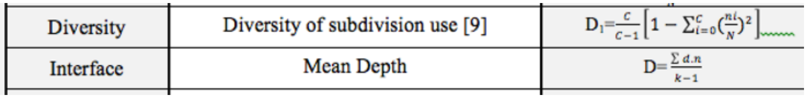
$$P_x = \frac{\sum_{i=0}^{N} nj}{N}, S$$

Volume/Function = PROXIMITY **Volume/Voids = POROSITY**

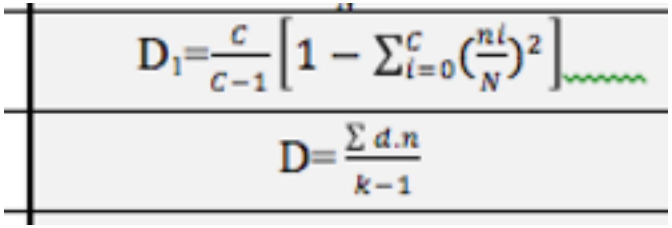
COMPACTNESS

VERTICAL INVESTIGATION

Comprehension of the CAS configuration

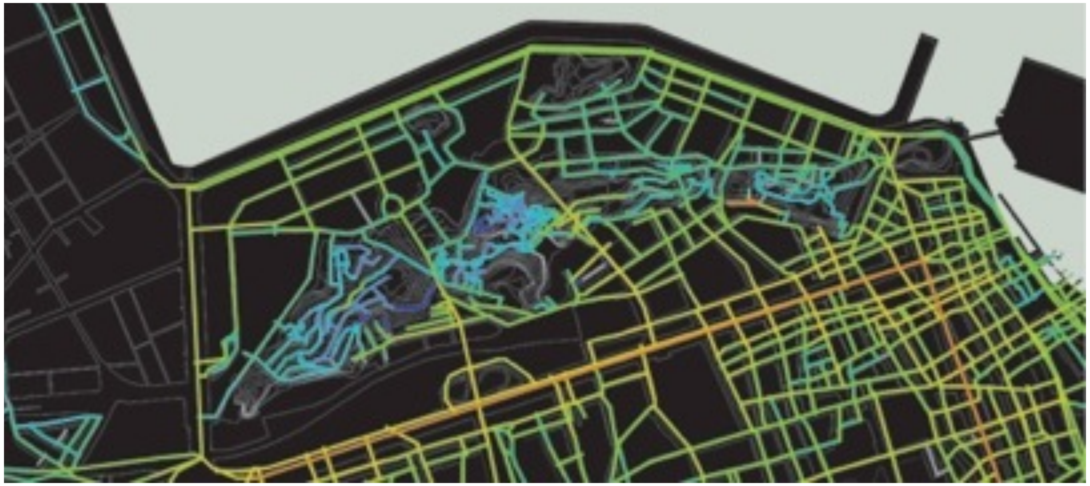


Diversity	Diversity of subdivision use [9]	$D_1 = \frac{c}{c-1}\left[1 - \sum_{i=0}^{c}\left(\frac{ni}{N}\right)^2\right]$
Interface	Mean Depth	$D = \frac{\sum d.n}{k-1}$



$$D_1 = \frac{c}{c-1}\left[1 - \sum_{i=0}^{c}\left(\frac{ni}{N}\right)^2\right]$$

$$D = \frac{\sum d.n}{k-1}$$



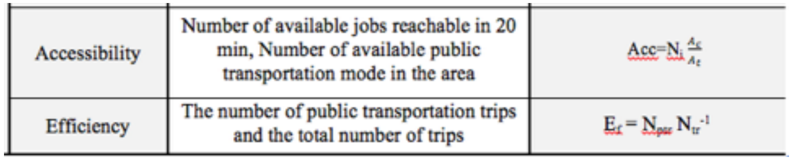
Transportation/Voids = INTERFACE

Function/Voids = DIVERSITY

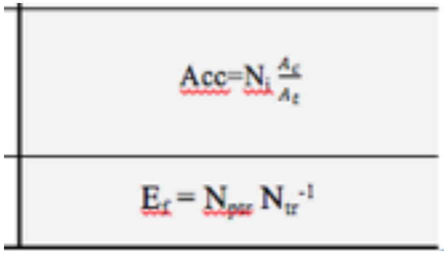
COMPLEXITY

VERTICAL INVESTIGATION

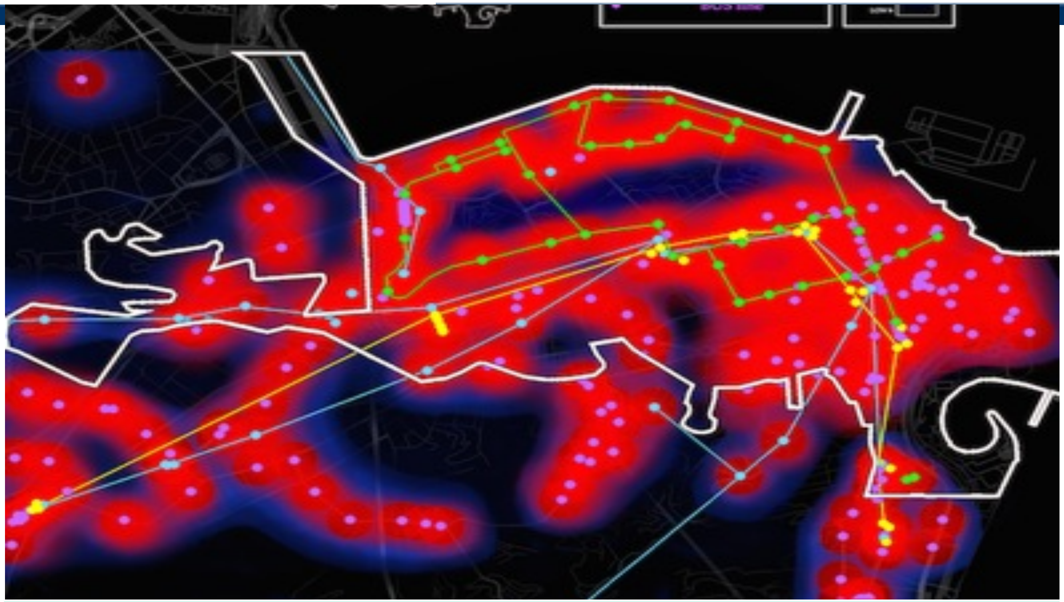
How does the actual CAS work?



Accessibility	Number of available jobs reachable in 20 min, Number of available public transportation mode in the area	$Acc = N_i \frac{A_c}{A_t}$
Efficiency	The number of public transportation trips and the total number of trips	$E_f = N_{ptr} N_{tr}^{-1}$



$Acc = N_i \frac{A_c}{A_t}$
$E_f = N_{ptr} N_{tr}^{-1}$

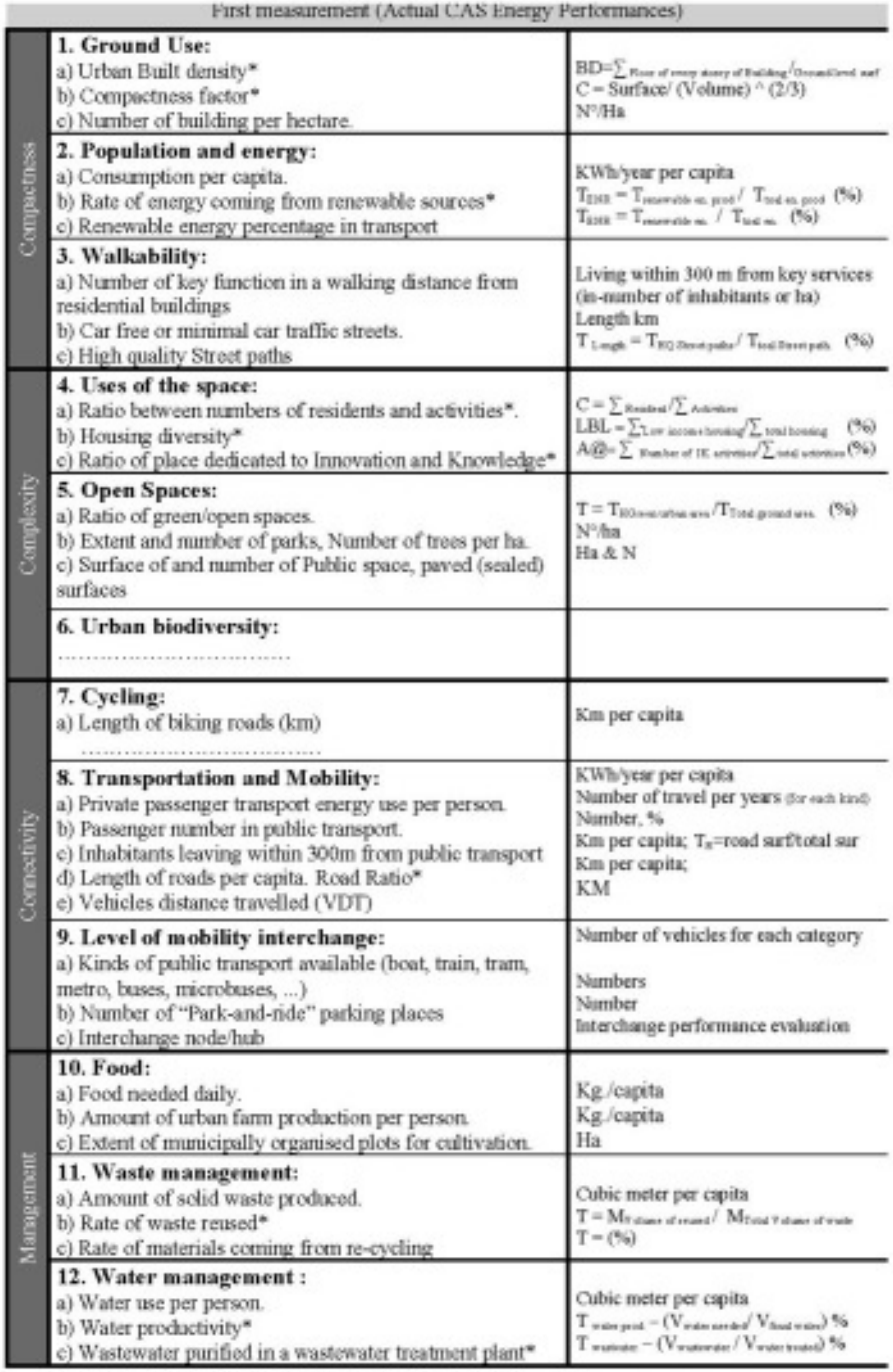


Transportation/Volumes
EFFICIENCY
Transportation/Function = ACCESSIBILITY

CONNECTIVITY

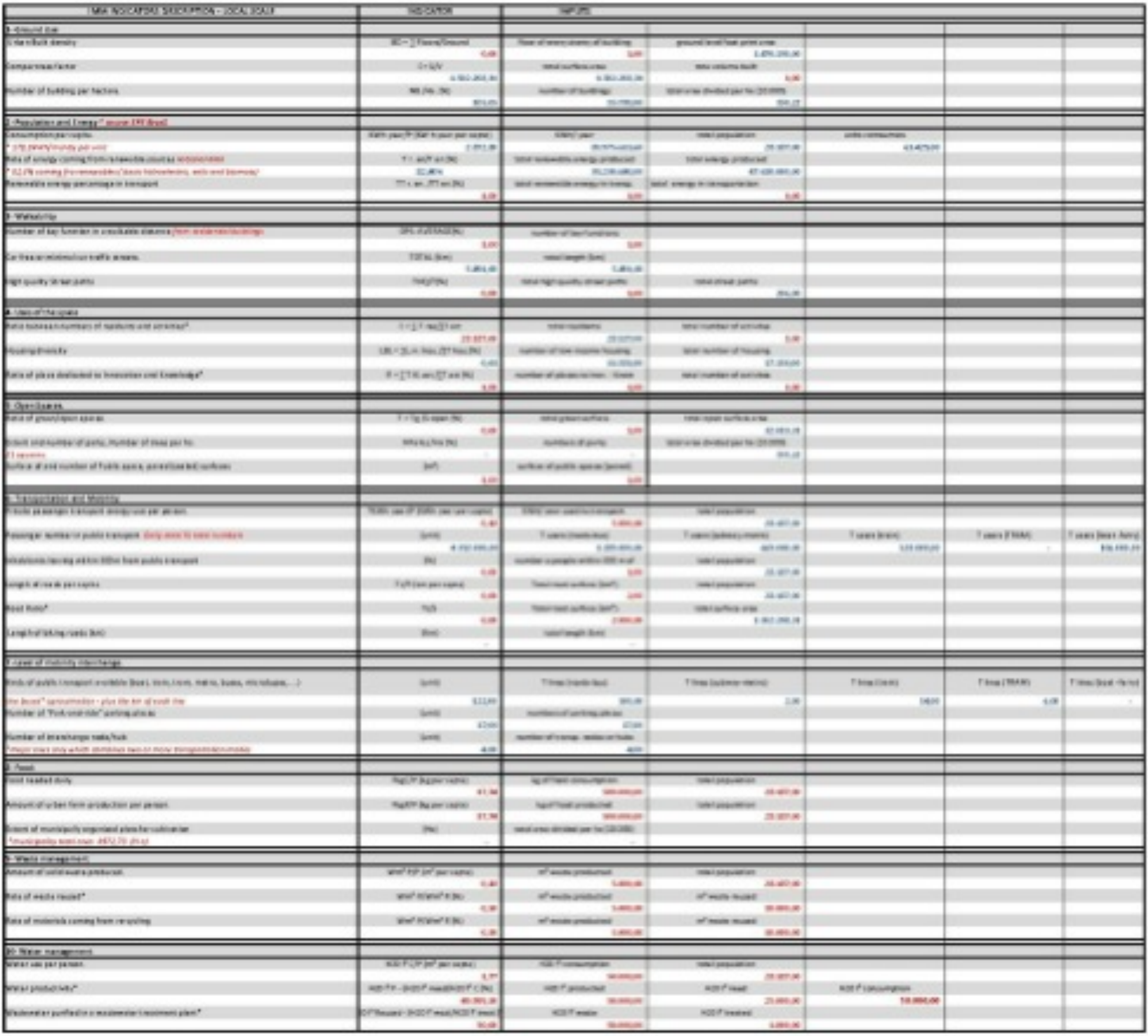
First CAS Measurement

Comprehension of the CAS performance.



First measurement (Actual CAS Energy Performances)

Compactness	**1. Ground Use:** a) Urban Built density* b) Compactness factor* c) Number of building per hectare.	$BD=\sum_{\text{Floor of every storey of Building}}/_{\text{Ground land surf}}$ C = Surface/ (Volume) ^ (2/3) N°/Ha
	2. Population and energy: a) Consumption per capita. b) Rate of energy coming from renewable sources* c) Renewable energy percentage in transport	KWh/year per capita $T_{ERR} = T_{\text{renewable en. prod}} / T_{\text{total en. prod}}$ (%) $T_{ERR} = T_{\text{renewable en.}} / T_{\text{total en.}}$ (%)
	3. Walkability: a) Number of key function in a walking distance from residential buildings b) Car free or minimal car traffic streets. c) High quality Street paths	Living within 300 m from key services (in-number of inhabitants or ha) Length km $T_{\text{Length}} = T_{\text{HQ Street paths}} / T_{\text{total Street path}}$ (%)
Complexity	**4. Uses of the space:** a) Ratio between numbers of residents and activities*. b) Housing diversity* c) Ratio of place dedicated to Innovation and Knowledge*	$C = \sum_{\text{Resident}} / \sum_{\text{Activities}}$ $LBL = \sum_{\text{Low income housing}} / \sum_{\text{total housing}}$ (%) A@= $\sum_{\text{Number of IK activities}} / \sum_{\text{total activities}}$ (%)
	5. Open Spaces: a) Ratio of green/open spaces. b) Extent and number of parks, Number of trees per ha. c) Surface of and number of Public space, paved (sealed) surfaces	$T = T_{\text{HQ green urban area}} / T_{\text{Total ground area}}$ (%) N°/ha Ha & N
	6. Urban biodiversity: ………………………………	
Connectivity	**7. Cycling:** a) Length of biking roads (km) ………………………………	Km per capita
	8. Transportation and Mobility: a) Private passenger transport energy use per person. b) Passenger number in public transport. c) Inhabitants leaving within 300m from public transport d) Length of roads per capita. Road Ratio* e) Vehicles distance travelled (VDT)	KWh/year per capita Number of travel per years (for each kind) Number, % Km per capita; T_R=road surf/total sur Km per capita; KM
	9. Level of mobility interchange: a) Kinds of public transport available (boat, train, tram, metro, buses, microbuses, ...) b) Number of "Park-and-ride" parking places c) Interchange node/hub	Number of vehicles for each category Numbers Number Interchange performance evaluation
Management	**10. Food:** a) Food needed daily. b) Amount of urban farm production per person. c) Extent of municipally organised plots for cultivation.	Kg./capita Kg./capita Ha
	11. Waste management: a) Amount of solid waste produced. b) Rate of waste reused* c) Rate of materials coming from re-cycling	Cubic meter per capita $T = M_{\text{Volume of reused}} / M_{\text{Total Volume of waste}}$ T = (%)
	12. Water management : a) Water use per person. b) Water productivity* c) Wastewater purified in a wastewater treatment plant*	Cubic meter per capita $T_{\text{water prod.}} = (V_{\text{water needed}} / V_{\text{food water}})$ % $T_{\text{wastewater}} = (V_{\text{wastewater}} / V_{\text{water treated}})$ %



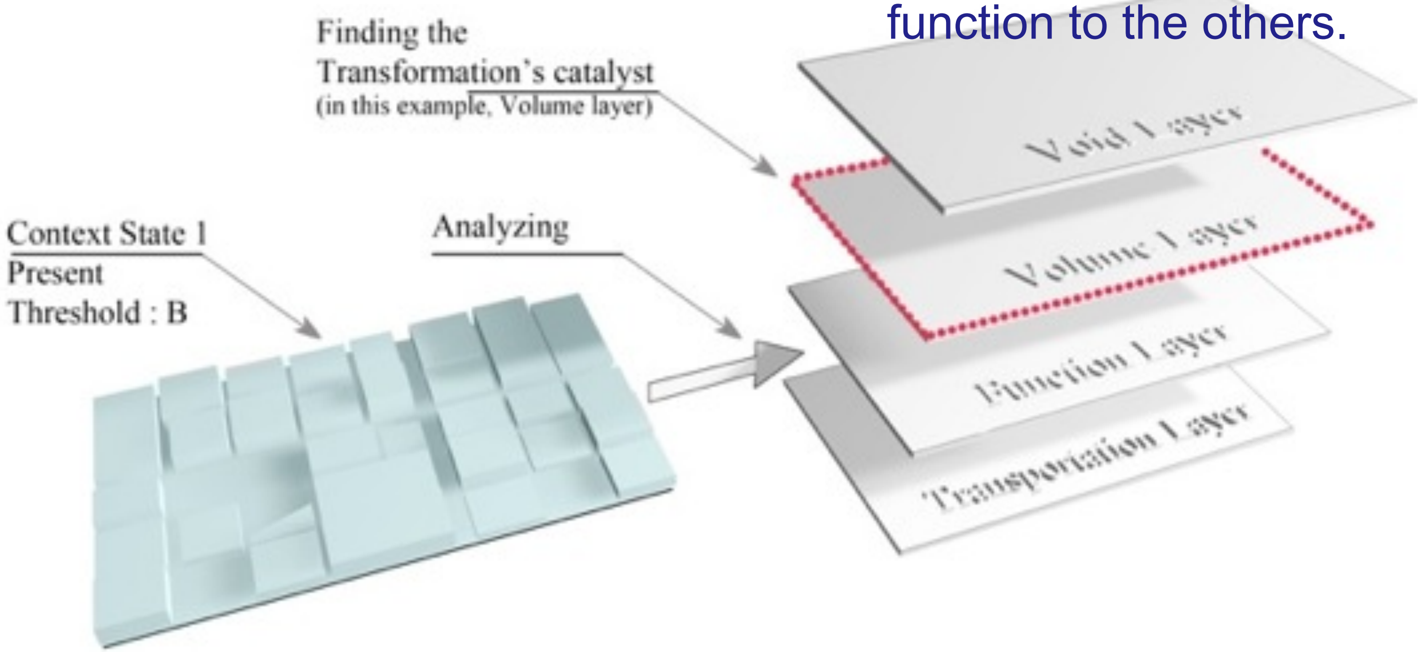
First CAS Measurement

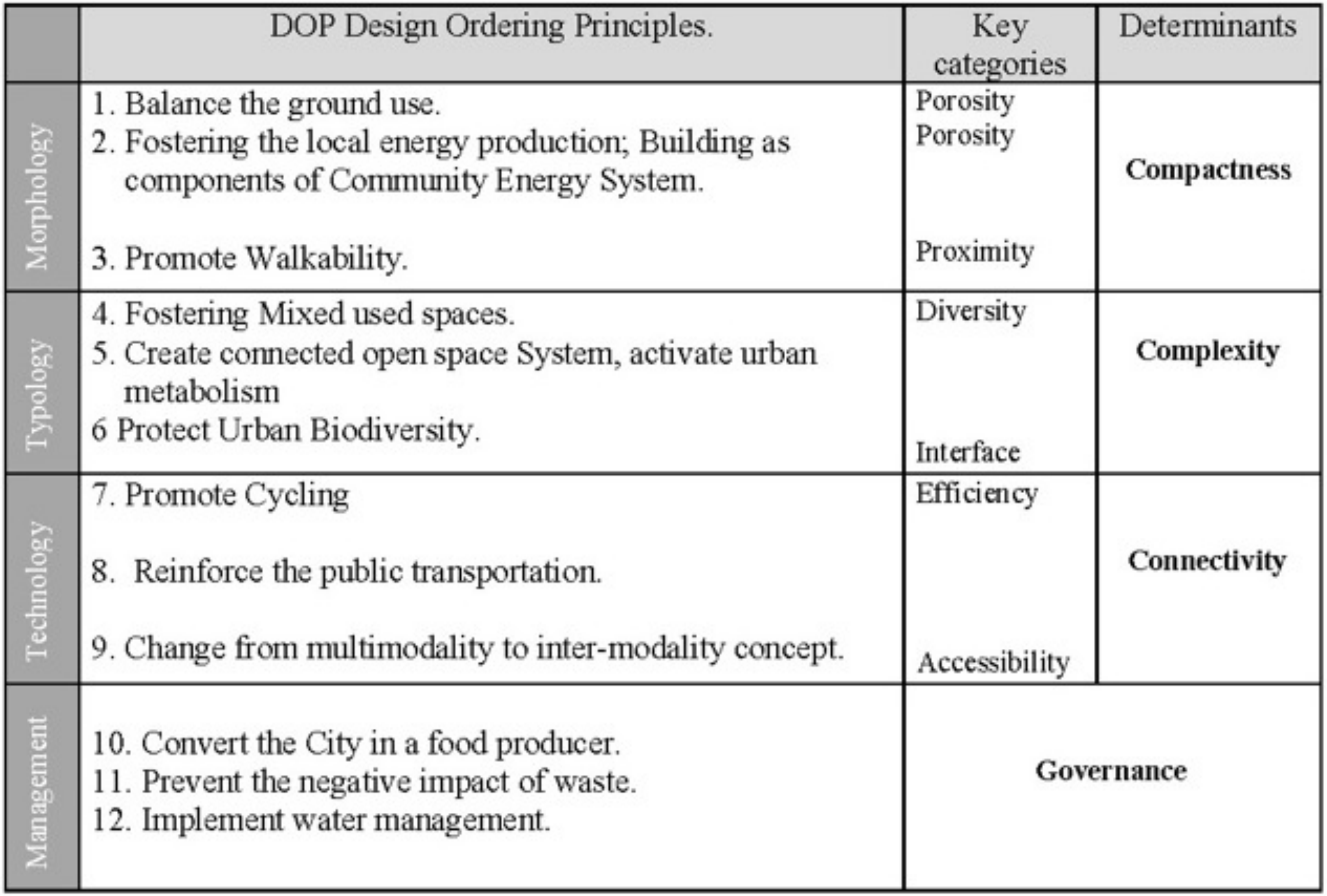
Comprehension of the CAS performance.

How to transform/optimize the actual CAS?

Detecting transformation catalyst:

The choice of one subsystem (layer) as a first driver of the transformation is the main goal of this phase, assigning respectively the Catalyst role to the selected Subsystem and the Reactants function to the others.

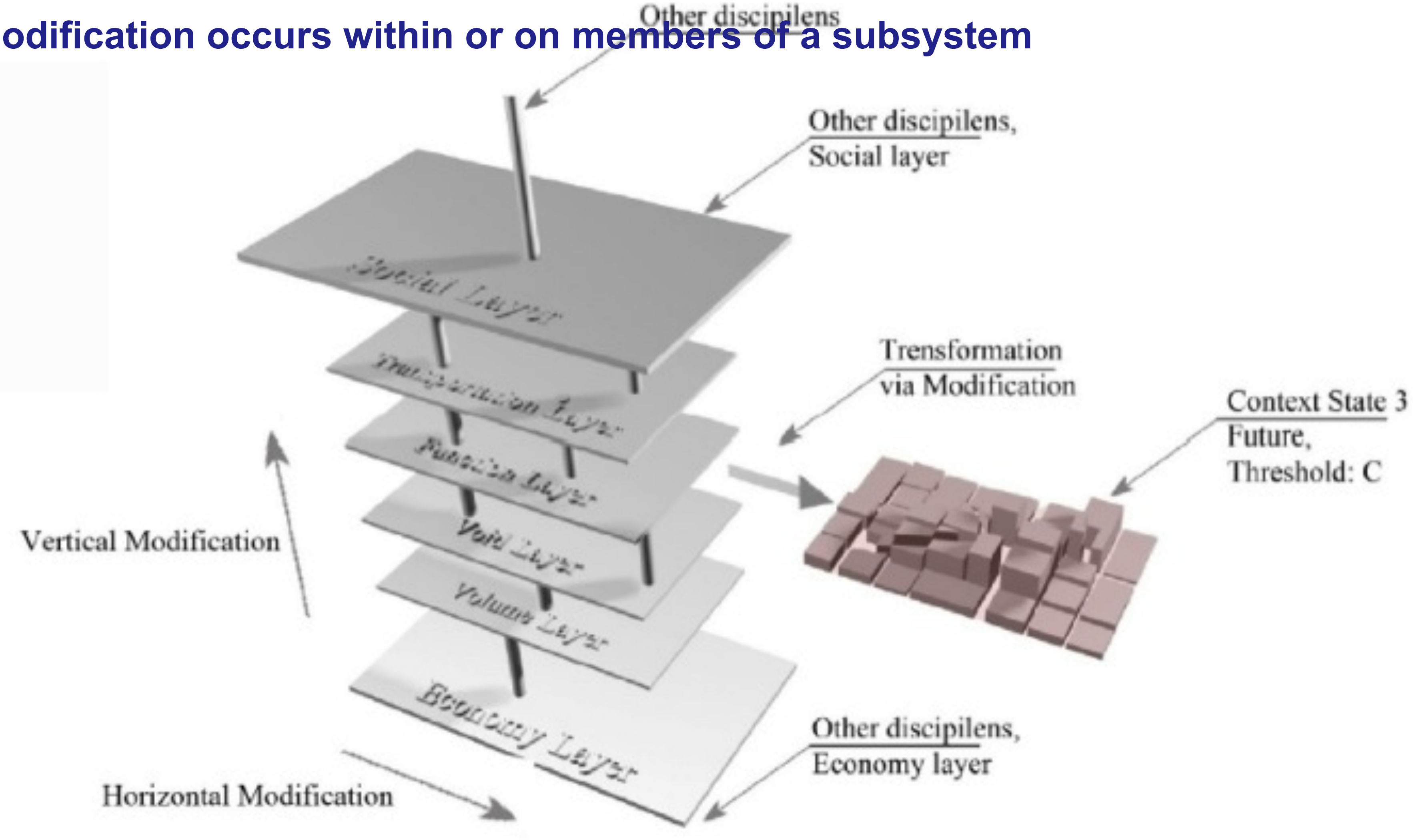


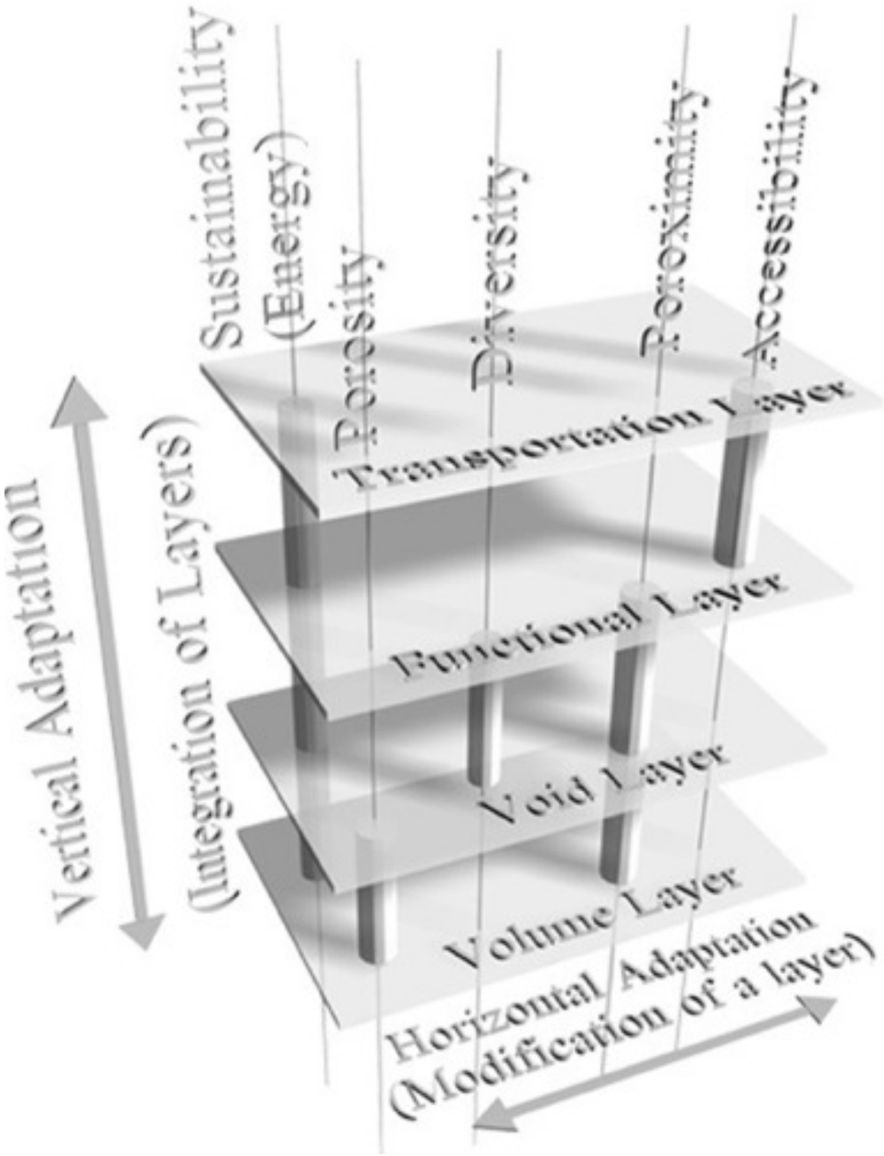


	DOP Design Ordering Principles.	Key categories	Determinants
Morphology	1. Balance the ground use. 2. Fostering the local energy production; Building as components of Community Energy System. 3. Promote Walkability.	Porosity Porosity Proximity	**Compactness**
Typology	4. Fostering Mixed used spaces. 5. Create connected open space System, activate urban metabolism 6 Protect Urban Biodiversity.	Diversity Interface	**Complexity**
Technology	7. Promote Cycling 8. Reinforce the public transportation. 9. Change from multimodality to inter-modality concept.	Efficiency Accessibility	**Connectivity**
Management	10. Convert the City in a food producer. 11. Prevent the negative impact of waste. 12. Implement water management.	**Governance**	

HORIZONTAL MODIFICATION.

Modification occurs within or on members of a subsystem

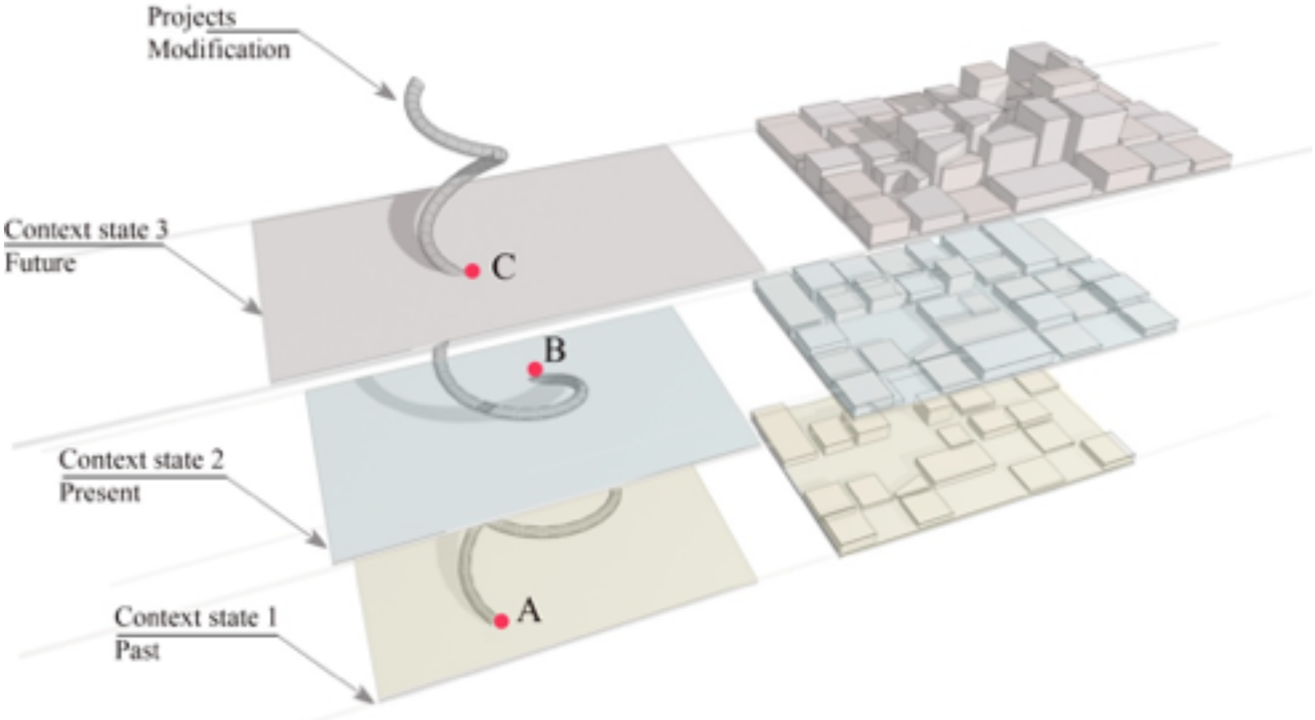


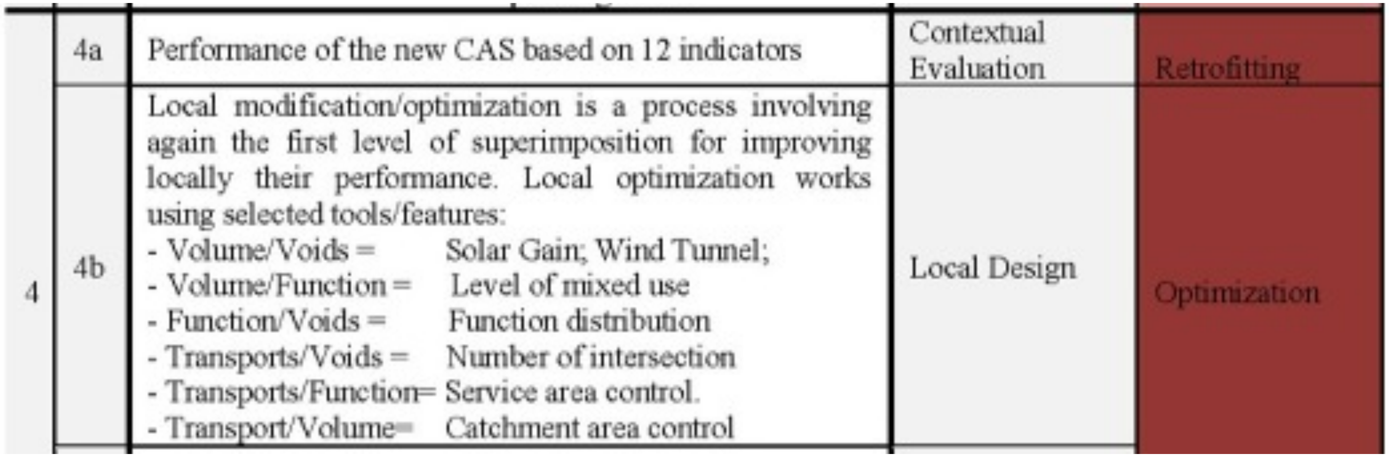


VERTICAL MODIFICATION

The Vertical modification is a chain reaction of the system propelled by the project. The aim of this step is to make possible the propagation of local changes towards the distant parts of the system as a consequence of connectivity, and making this propagation the cause a global change

PHASING



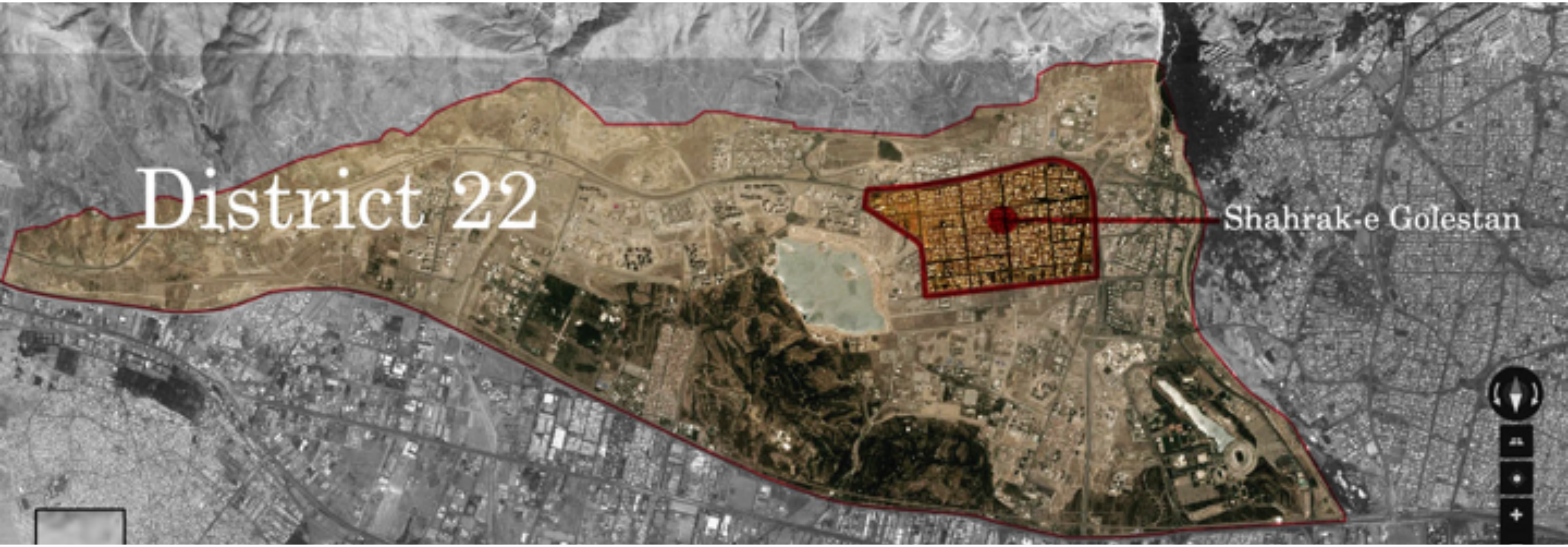


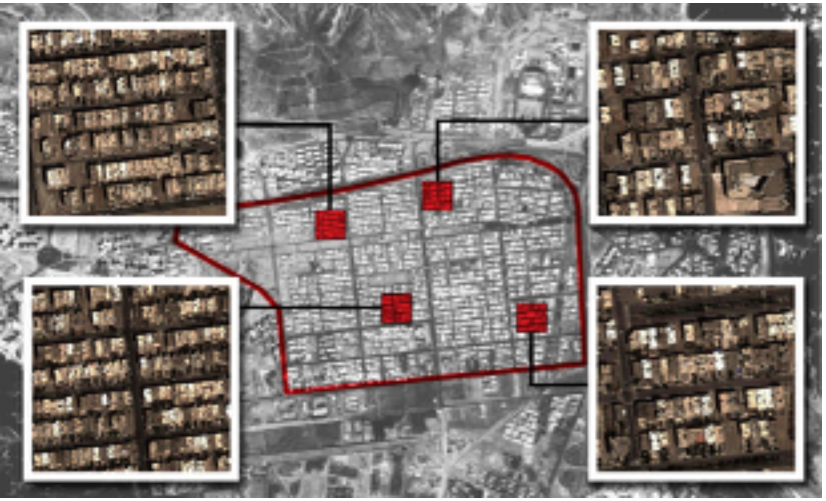
4	4a	Performance of the new CAS based on 12 indicators	Contextual Evaluation	Retrofitting
	4b	Local modification/optimization is a process involving again the first level of superimposition for improving locally their performance. Local optimization works using selected tools/features: - Volume/Voids = Solar Gain; Wind Tunnel; - Volume/Function = Level of mixed use - Function/Voids = Function distribution - Transports/Voids = Number of intersection - Transports/Function= Service area control. - Transport/Volume= Catchment area control	Local Design	Optimization

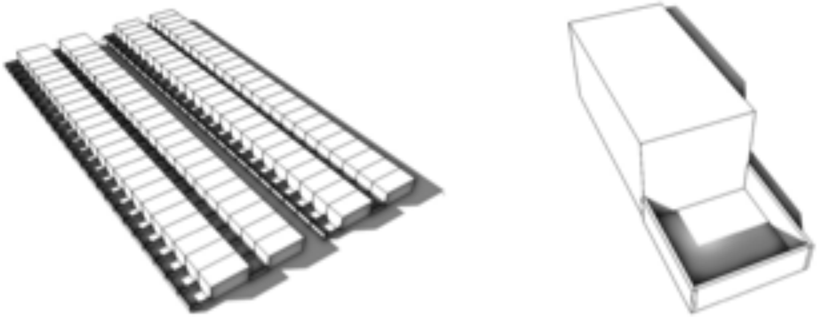
PART III

- **Case study: Environmental and energy performances optimization of a neighbourhood in Tehran via IMM methodology**


District 22
2 mi
5 km

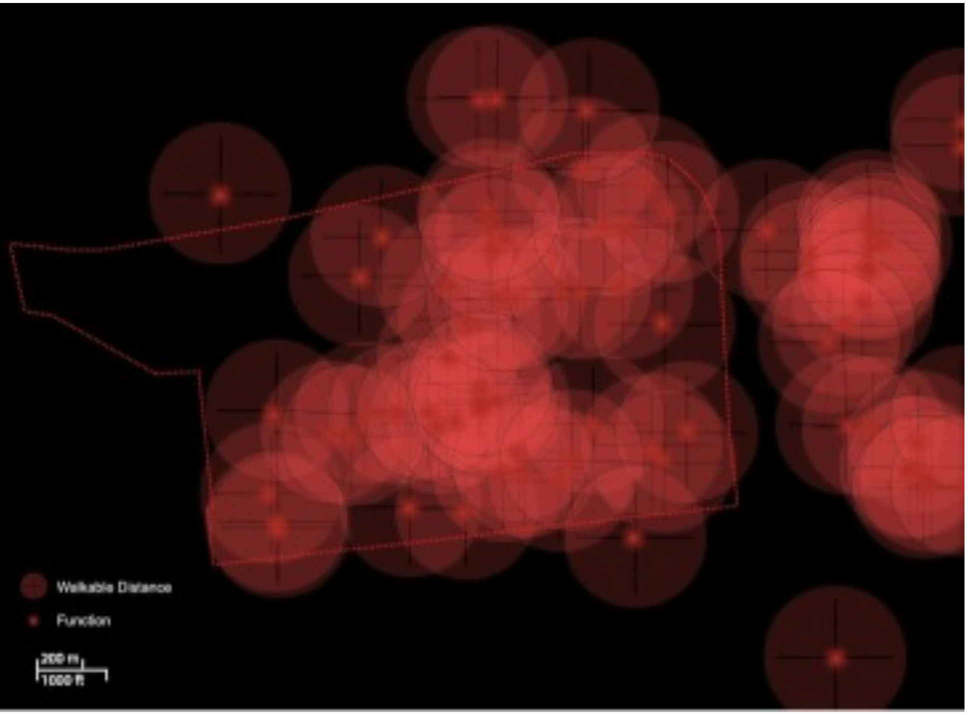

District 22
Shahrak-e Golestan



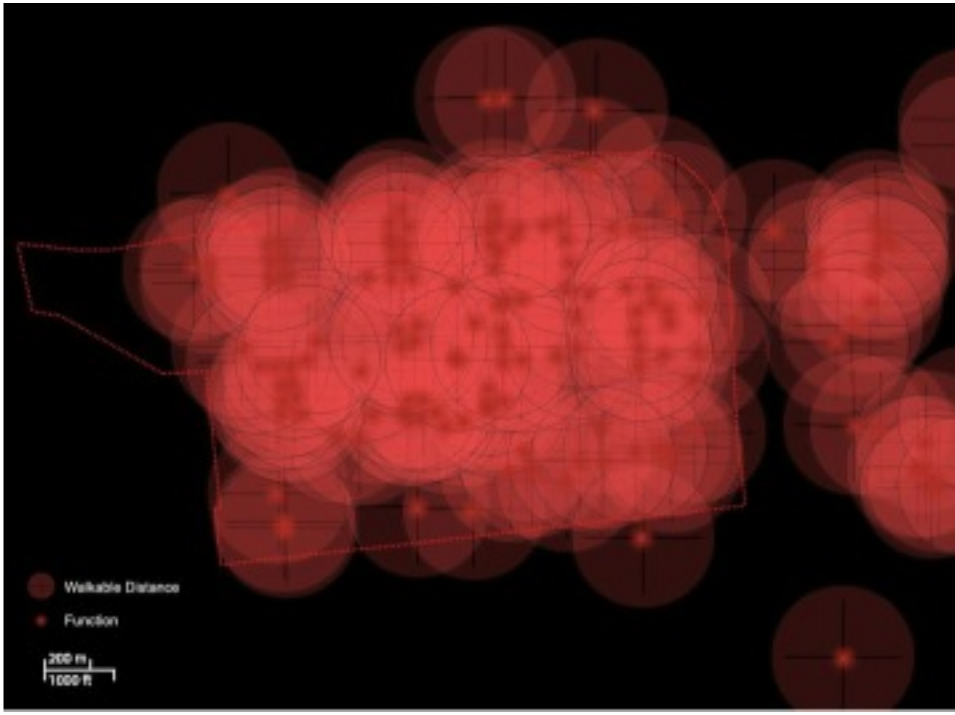


Layer	Description	Formula	Value
Volume	Built volume density, Dwelling density, Human density	$V_l = V_{built}$ / Area	3.60
Void	Open space/area	$V_d = V_{open}$ / Area	1.86
Function	Job density, Number of legal entities in the intervention area	$F_n = J_{number}$ / Area	2E-4
Transportation	Number of carried out urban trips (daily)	N_{tr}	57,178

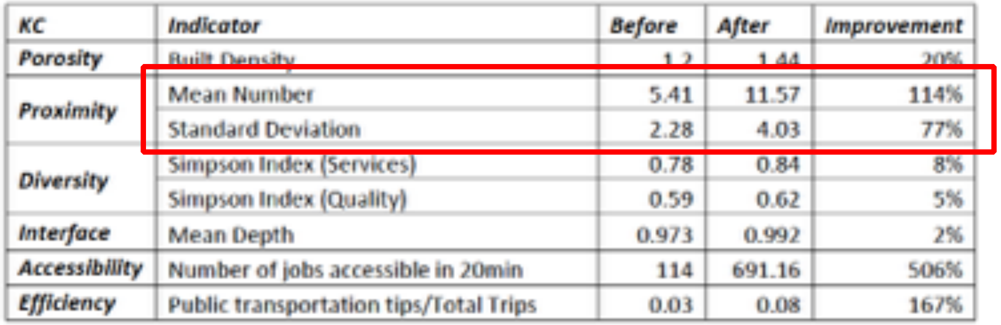
Table 3-1 Horizontal investigation



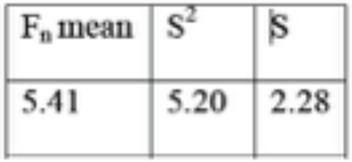
Before



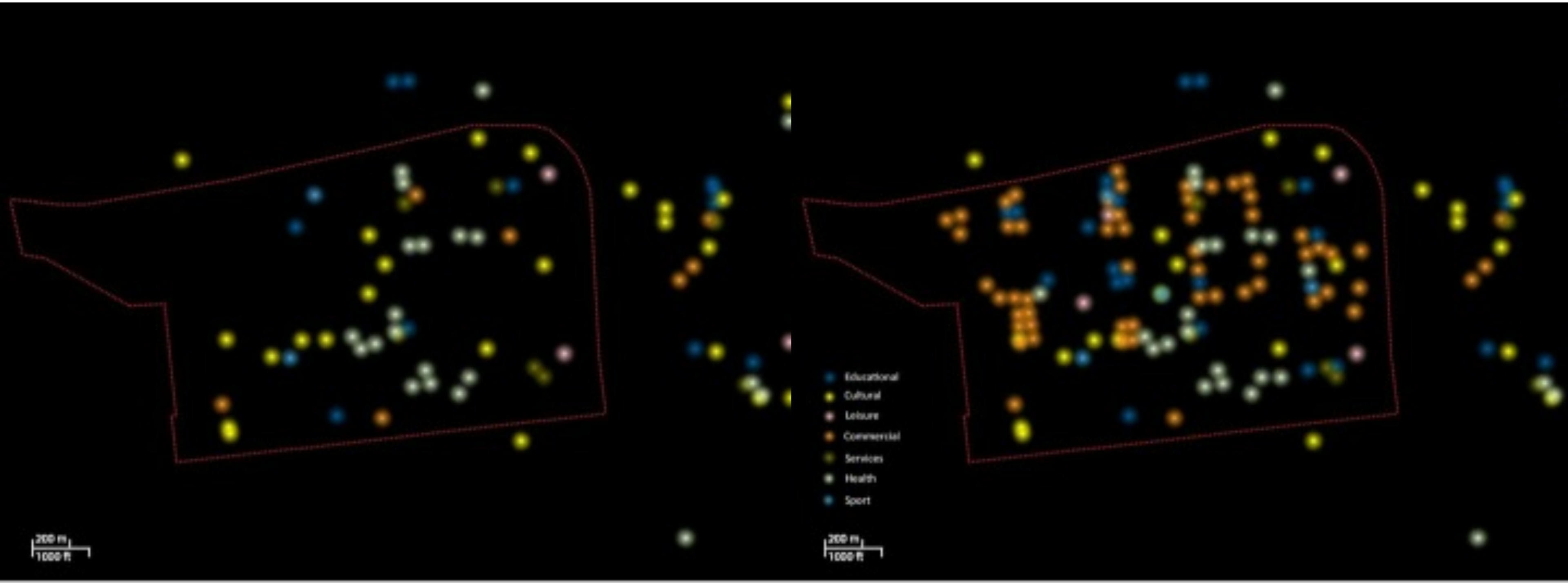
After



KC	Indicator	Before	After	Improvement
Porosity	Built Density	1.2	1.44	20%
Proximity	Mean Number	5.41	11.57	114%
	Standard Deviation	2.28	4.03	77%
Diversity	Simpson Index (Services)	0.78	0.84	8%
	Simpson Index (Quality)	0.59	0.62	5%
Interface	Mean Depth	0.973	0.992	2%
Accessibility	Number of jobs accessible in 20min	114	691.16	506%
Efficiency	Public transportation tips/Total Trips	0.03	0.08	167%



F_n mean	S^2	S
5.41	5.20	2.28



Before **After**

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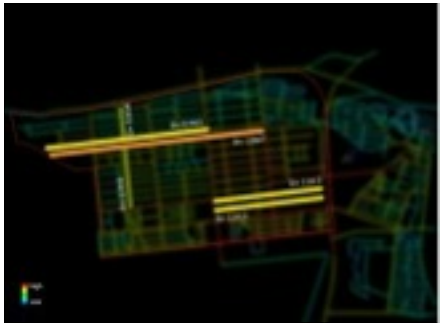
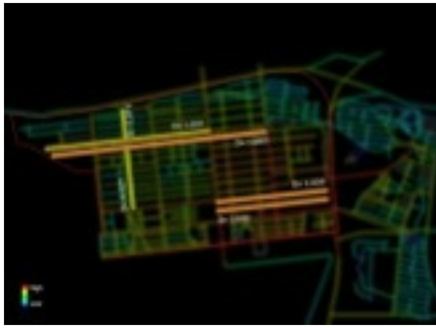
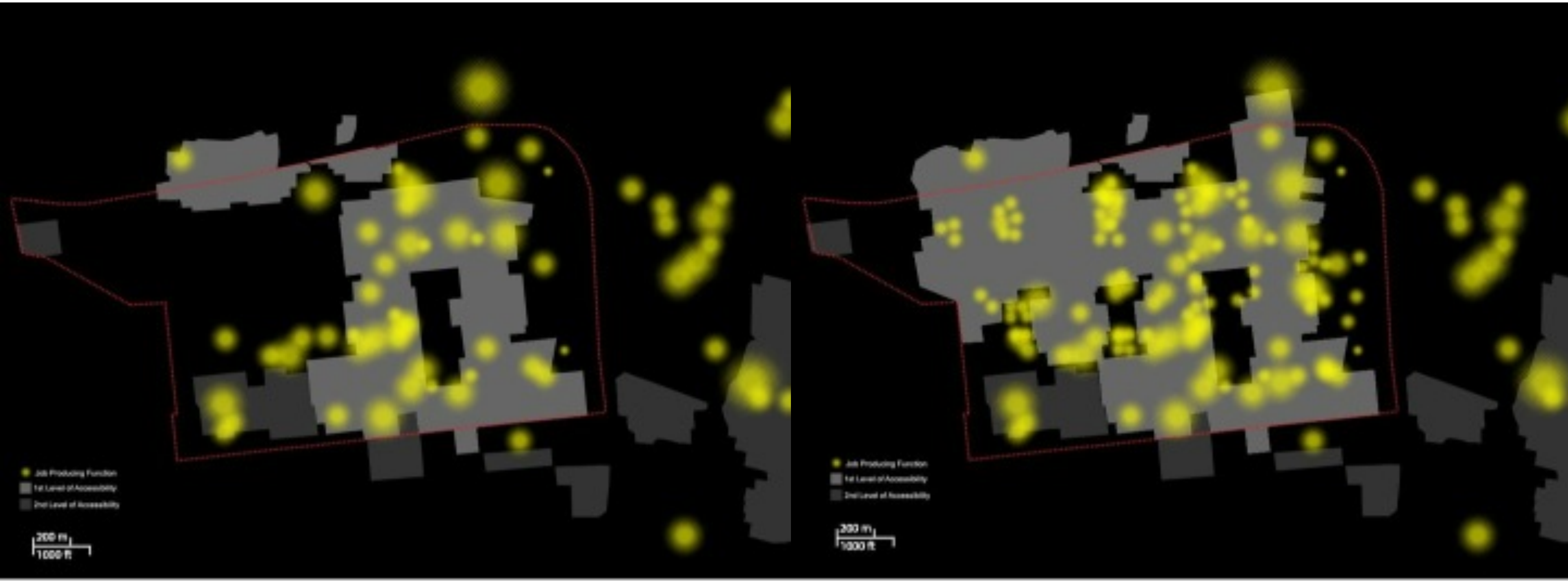
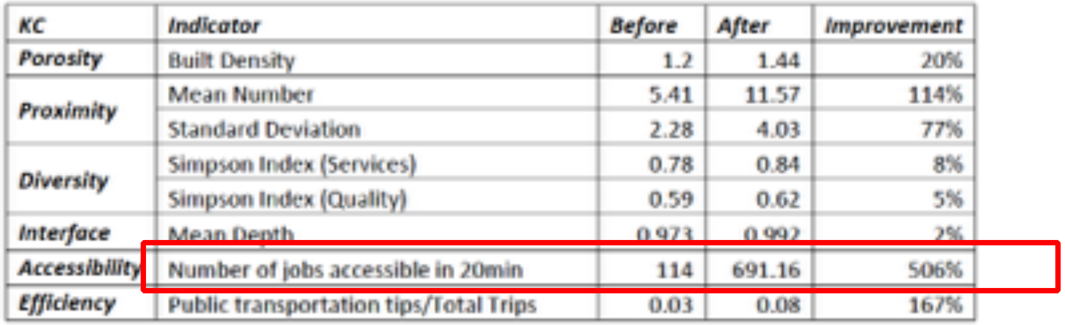






Before

After



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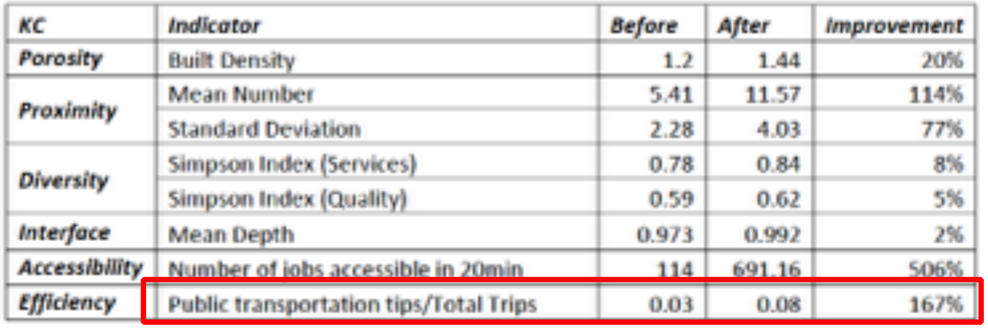

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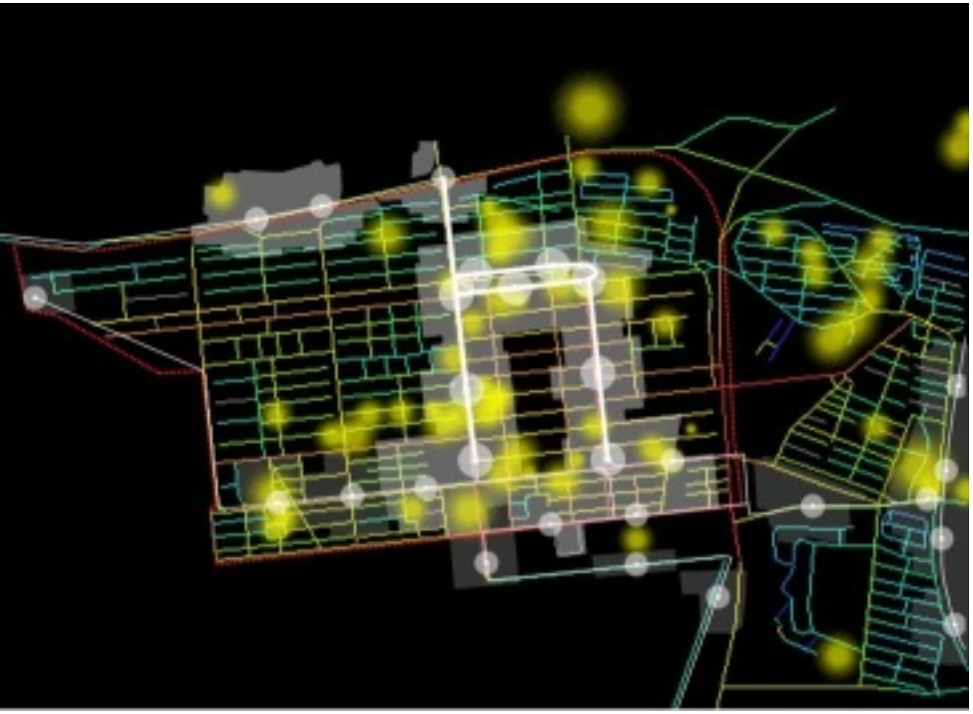
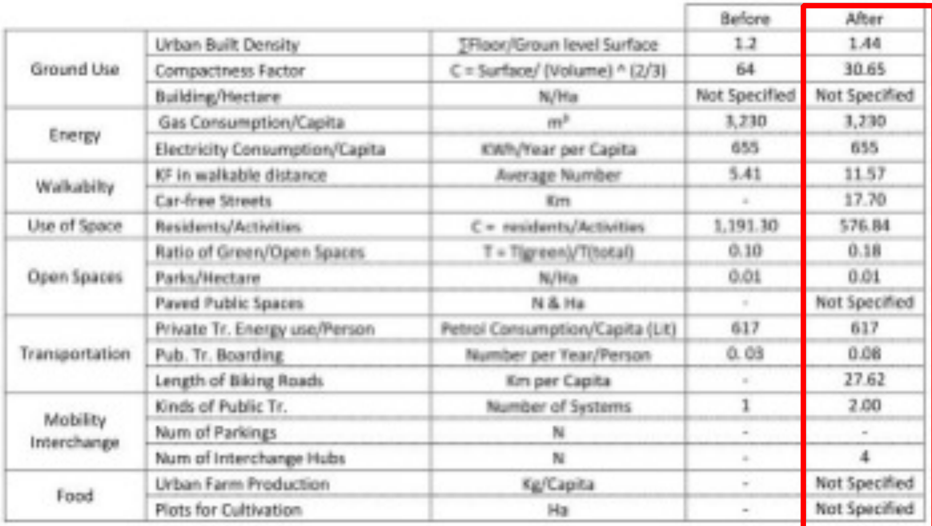
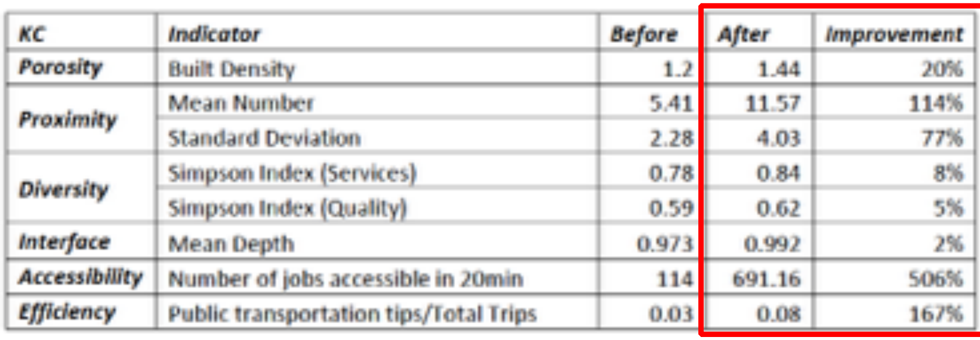




			Before	After
Ground Use	Urban Built Density	∑Floor/Groun level Surface	1.2	1.44
	Compactness Factor	C = Surface/ (Volume) ^ (2/3)	64	30.65
	Building/Hectare	N/Ha	Not Specified	Not Specified
Energy	Gas Consumption/Capita	m³	3,230	3,230
	Electricity Consumption/Capita	KWh/Year per Capita	655	655
Walkability	KF in walkable distance	Average Number	5.41	11.57
	Car-free Streets	Km	-	17.70
Use of Space	Residents/Activities	C = residents/Activities	1,191.30	576.84
Open Spaces	Ratio of Green/Open Spaces	T = T(green)/T(total)	0.10	0.18
	Parks/Hectare	N/Ha	0.01	0.01
	Paved Public Spaces	N & Ha	-	Not Specified
Transportation	Private Tr. Energy use/Person	Petrol Consumption/Capita (Lit)	617	617
	Pub. Tr. Boarding	Number per Year/Person	0. 03	0.08
	Length of Biking Roads	Km per Capita	-	27.62
Mobility Interchange	Kinds of Public Tr.	Number of Systems	1	2.00
	Num of Parkings	N	-	-
	Num of Interchange Hubs	N	-	4
Food	Urban Farm Production	Kg/Capita	-	Not Specified
	Plots for Cultivation	Ha	-	Not Specified

Before

After



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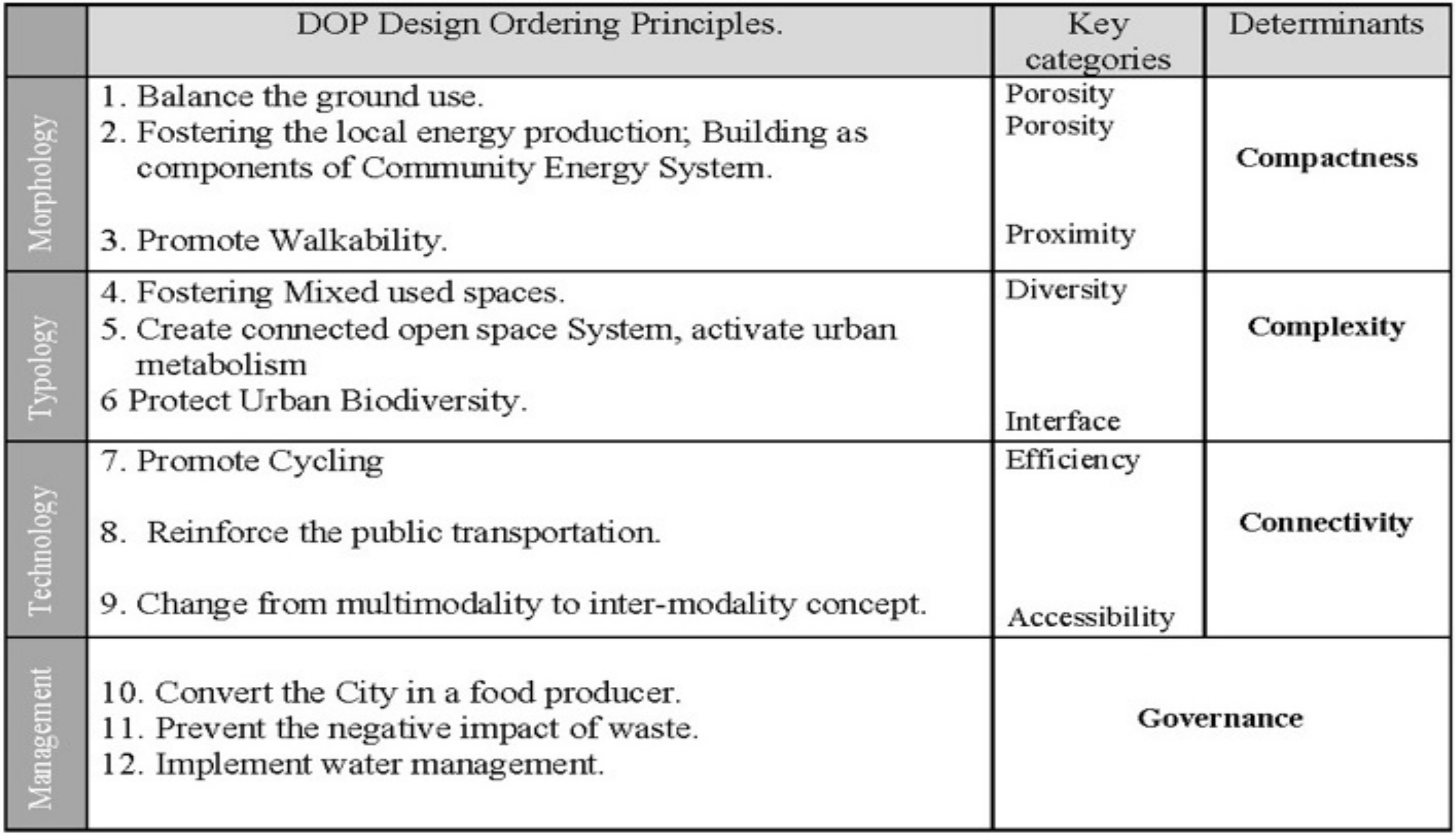

	DOP Design Ordering Principles.	Key categories	Determinants
Morphology	1. Balance the ground use. 2. Fostering the local energy production; Building as components of Community Energy System. 3. Promote Walkability.	Porosity Porosity Proximity	**Compactness**
Typology	4. Fostering Mixed used spaces. 5. Create connected open space System, activate urban metabolism 6 Protect Urban Biodiversity.	Diversity Interface	**Complexity**
Technology	7. Promote Cycling 8. Reinforce the public transportation. 9. Change from multimodality to inter-modality concept.	Efficiency Accessibility	**Connectivity**
Management	10. Convert the City in a food producer. 11. Prevent the negative impact of waste. 12. Implement water management.	**Governance**	

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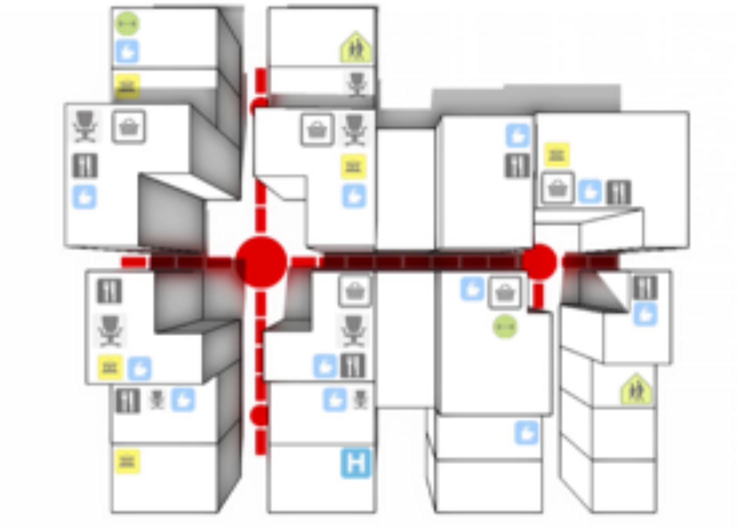

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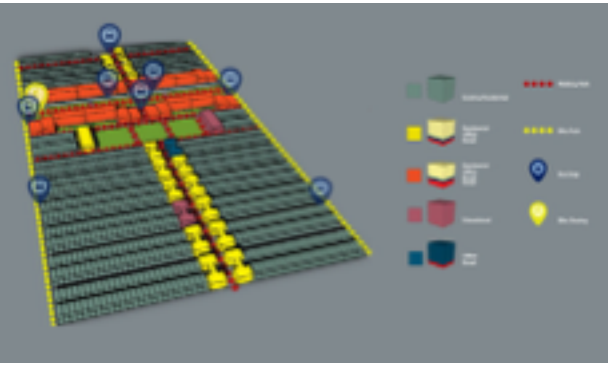

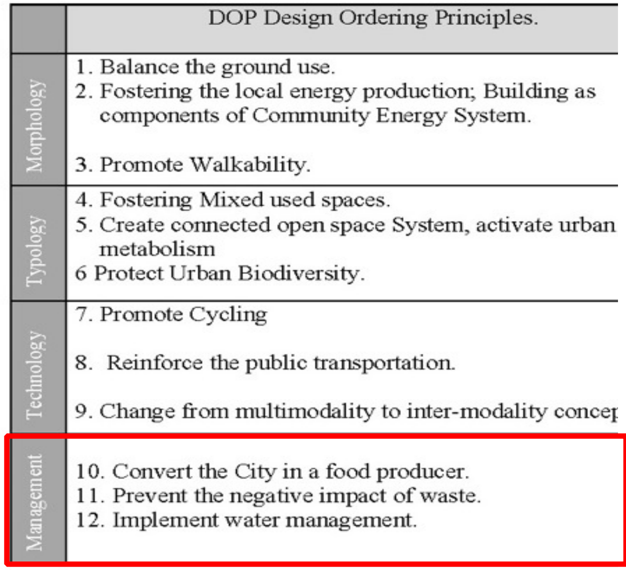

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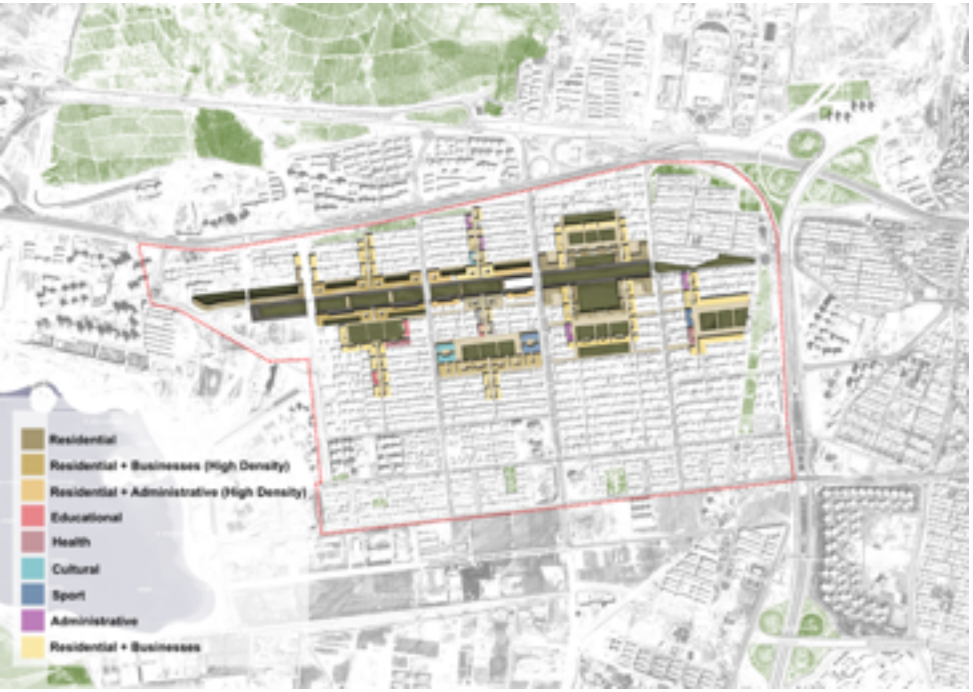

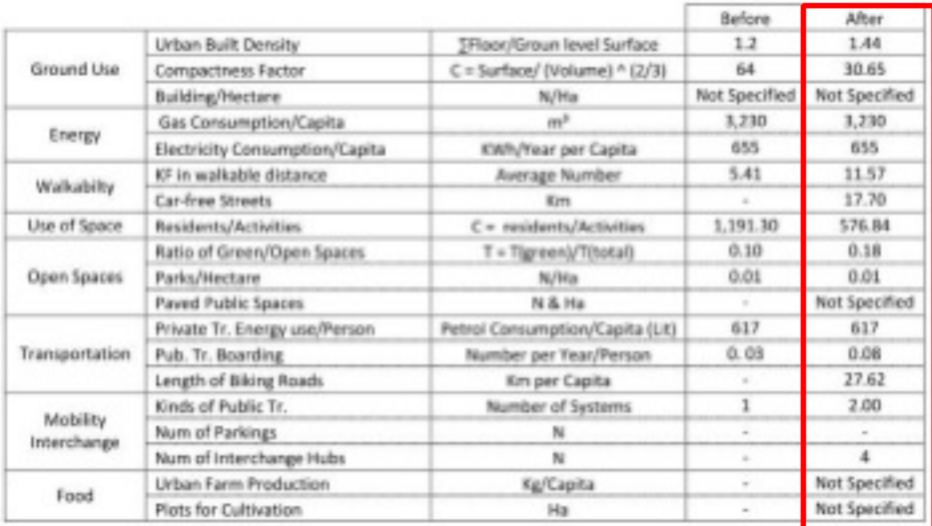

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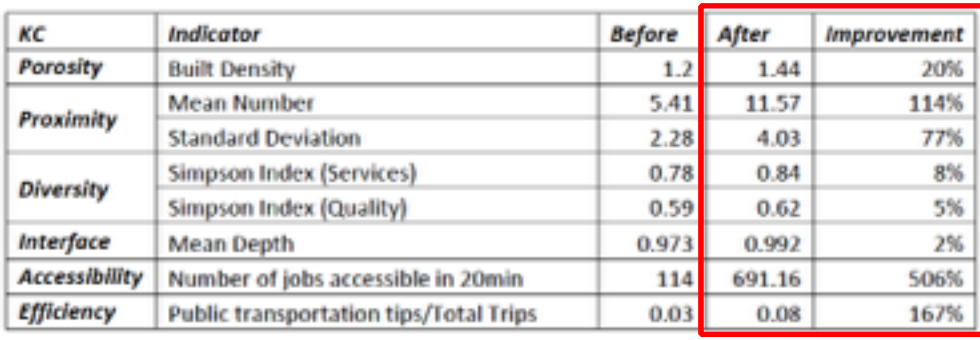
	Plots for Cultivation	Ha	-	Not Specified

Before

After



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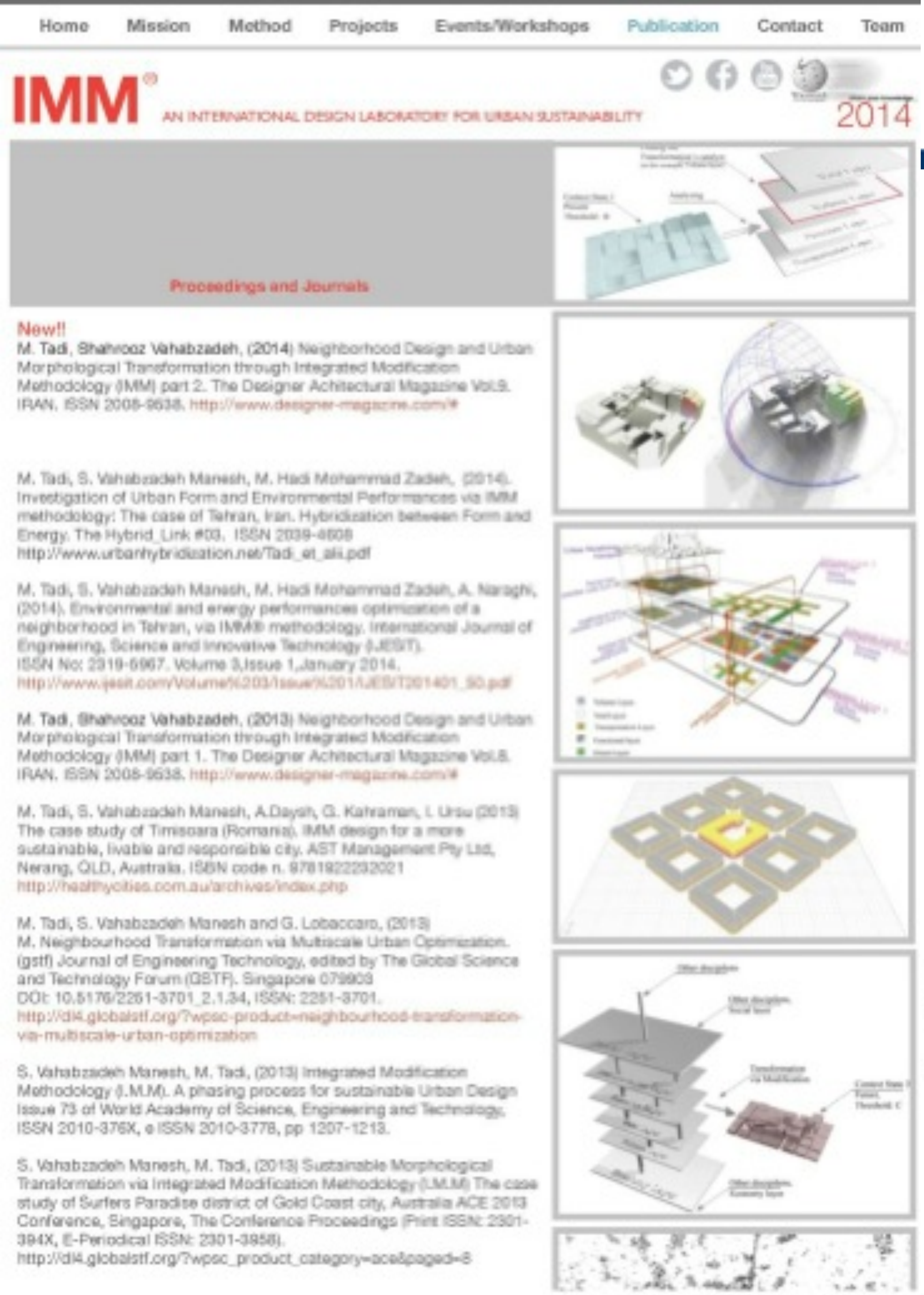
Integrated Modification Methodology

From Wikipedia, the free encyclopedia

Integrated Modification Methodology (IMM)[1] is a design methodology based on a specific process with the main goal of improving the urban energy performance, through the modification of its constituents and optimization of the architecture of their ligands. According to this view, the city, considered as a Complex Adaptive System (CAS),[2] is not solely a mere aggregation of disconnected energy consumers and the total energy consumption of the city is different from the sum of the all of the buildings consumption. This considerable gap between the total energy consumption of the city and the sum of all consumers is concealed from the urban morphology and urban form of the city. IMM is a multi-stage, iterative process, applied to urban components, for improving their environmental and energy performances is fundamentally Holistic, Multi-Layer, Multi-scale, it investigates the relationships between urban morphology [3] and energy consumption by focusing mostly on the 'Subsystems' characterized by physical characters and arrangement. In this methodology, city consists of the superimposition of an enormous number of interrelated components, categorized in different Layers or 'Subsystems', which through their inner arrangement and the architecture of their ligands provide a certain physical and provisional arrangement. The constituents of the CAS adapt themselves to react to the newly imposed constraints, in order to improve upon the entire system's performance. The complex adaptive system is composed of heterogeneous elements, linked together either directly or indirectly, and the final system performance emerges from all of the elements as a whole. This adaptation occurs within or on members of a single subsystem, known as Horizontal Adaptation, and between the different subsystems, termed Vertical Adaptation.[4] In other words, the adaptation of existing members in a subsystem, or horizontal adaptation, as a response to the newly imposed conditions and constraints, changes the subsystem's performance, which will be the cause of the entire system's transformation over time.

Complex Adaptive System (CAS) is composed of four or more subsystems, it is considered to be a superposition of products of the subsystems' states. Superimposition is a process of integration of two or more Sub-systems. Once the subsystems interact, their states are no longer independent.

Contents [hide]
1 Background
2 Theory
3 A Phasing process
3.1 Phase 1. Investigation/Analysis.



Proceedings and Journals

New!!

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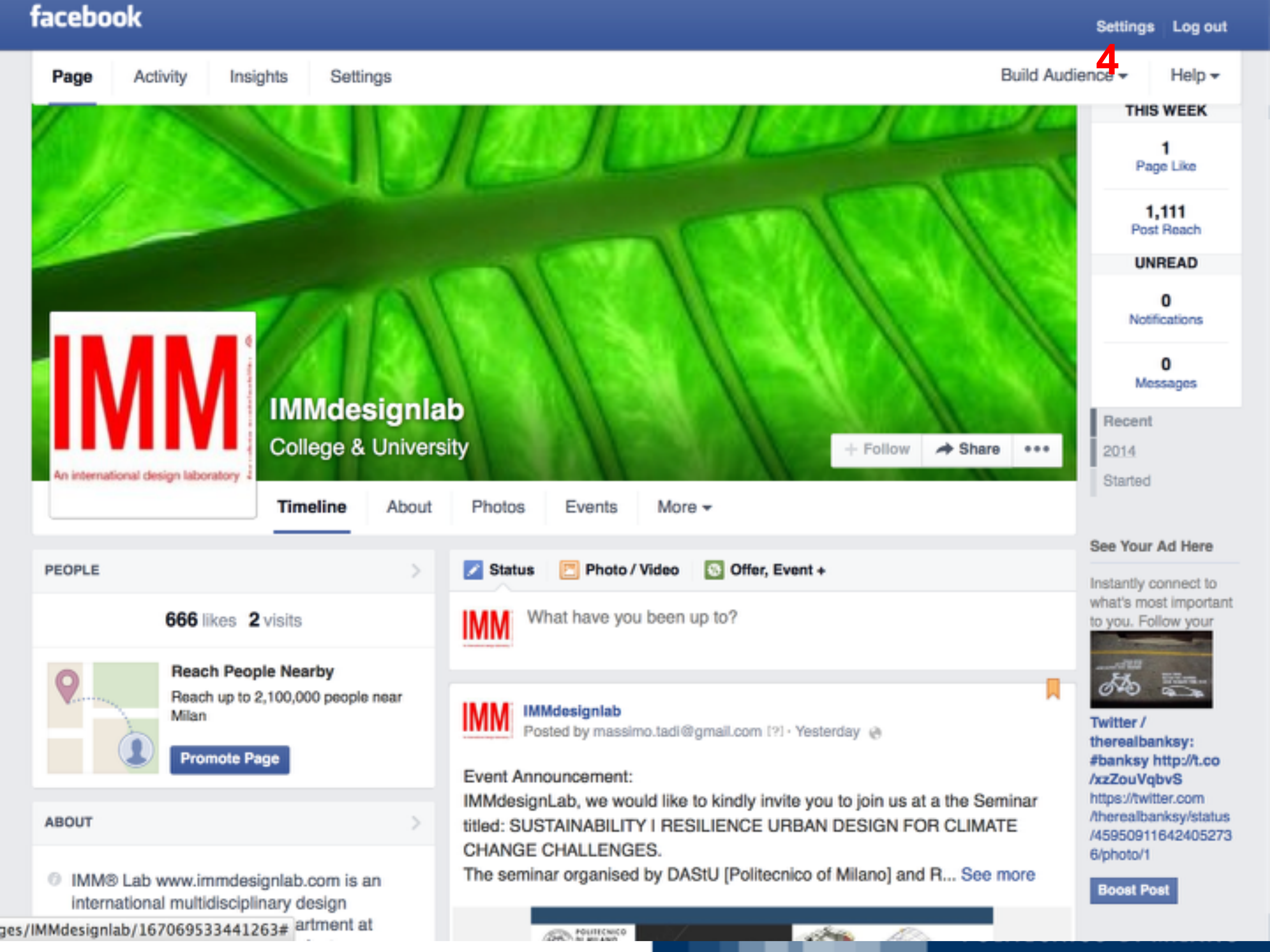

IMMdesignlab
Posted by massimo.tadi@gmail.com [?] · Yesterday

Event Announcement:
IMMdesignLab, we would like to kindly invite you to join us at a the Seminar titled: SUSTAINABILITY I RESILIENCE URBAN DESIGN FOR CLIMATE CHANGE CHALLENGES.
The seminar organised by DAStU [Politecnico of Milano] and R... See more

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4

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AN INTERNATIONAL DESIGN LABORATORY FOR URBAN SUSTAINABILITY

2013

According to this theory, the city, is not solely a mere aggregation of disconnected energy consumers and the total energy consumption of the city is different from the sum of the whole building's consumption.

The whole is more than the sum of its parts. *Aristotle, Metaphysic*

IMM™ is International and multidisciplinary Design Laboratory for Urban Sustainability. Our work is driven by the principle that urban design can directly affect the quality of our environment, improve the energy performances as well as the quality of our lives making our future more sustainable and responsible. IMM™ - the acronym of Integrated Modification Methodology, an innovative design methodology based on a specific process with the main goal of improving the CAS' (complex adaptive systems) energy performance, through the modification of its constituents and optimization the architecture of their ligands. Its approach is fundamentally Holistic, Multi-Layer, Multi-scale. In this methodology, the city is considered to be a dynamic Complex Adaptive System comprised of the superimposition of an enormous number of interrelated components, categorized in different Layers or 'Subsystems', (also complex adaptive systems) which through their inner arrangement and the architecture of their ligands provide a certain physical and provisional arrangement of the CAS. The