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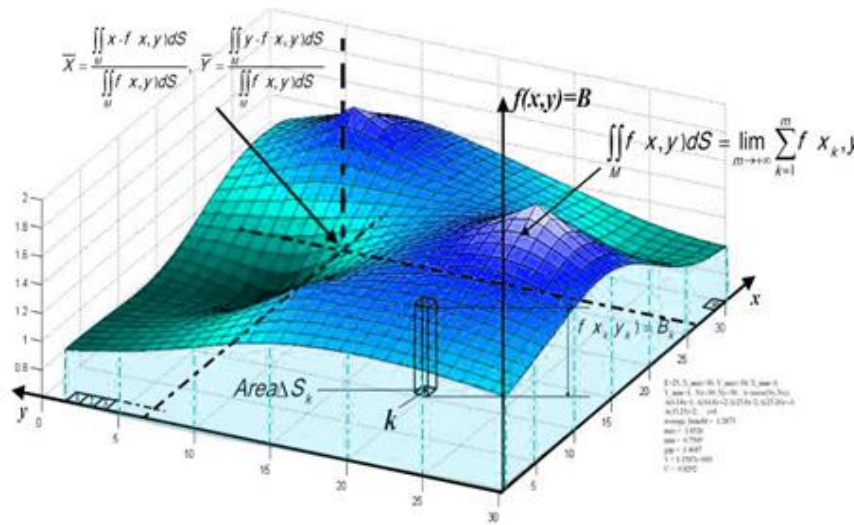
Luca D'Acci

Head of Urban Environment and Climate Change
at IHS [Erasmus University Rotterdam](http://www.ihs.nl)

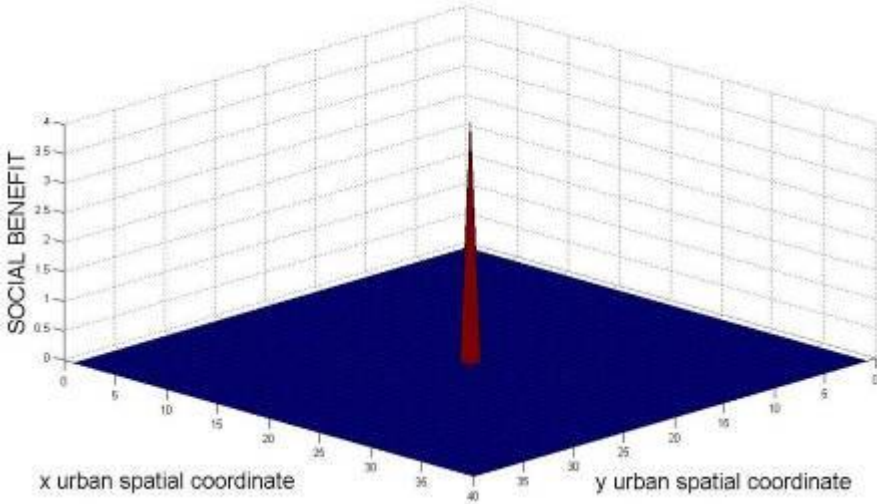
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ISOBENEFIT LINES



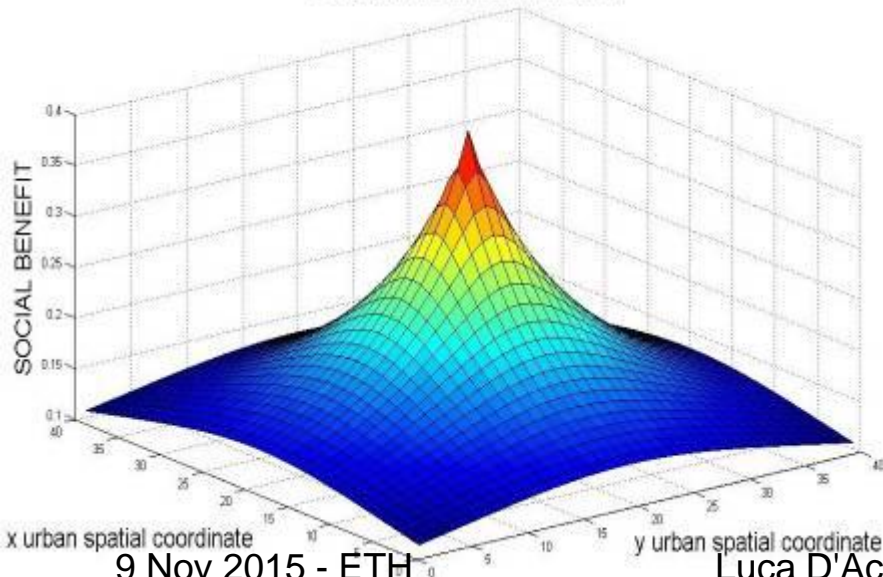
PUNCTUAL BENEFIT



the benefit you receive when you are **directly** enjoying the amenity

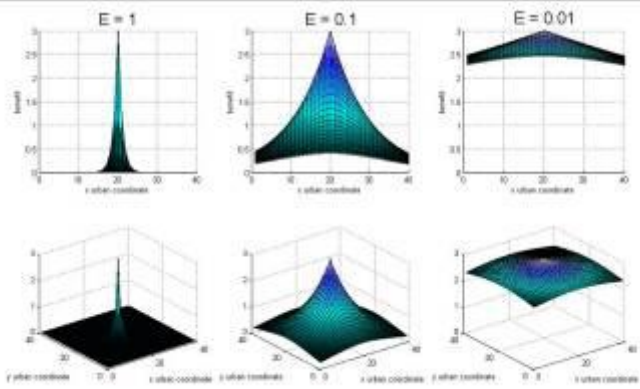


DISTRIBUTED BENEFIT



... how this benefit **flows** throughout the city: how easy, cheap, pleasant is to reach the amenity





$$B_t = \sum_{i=1}^n \sum_{k=1}^m B_{i,k} = \sum_{i=1}^n \sum_{k=1}^m A_i \cdot M_e / (d_{i-k} + M_e)$$

$$B_t = \sum_{i=1}^n B_i = \sum_{i=1}^n \int_{a_i}^{b_i} \int_{c_i}^{d_i} \left\{ (A_i \cdot M_e) \cdot [((x - x_i)^2 + (y - y_i)^2)^{1/2} + M_e]^{-1} \right\} dx dy$$

$$a_i = x_{\min} - x_i \quad b_i = x_{\max} - x_i$$

$$c_i = y_{\min} - y_i \quad d_i = y_{\max} - y_i$$

$$Bd_i = \sum_{k=1}^m (A_i \cdot M_e) \cdot [((x_k - x_i)^2 + (y_k - y_i)^2)^{1/2} + M_e]^{-1} = \sum_{k=1}^m \{z | z = f(x_k, y_k) | x_k \in X_i, y_k \in Y_i\}$$

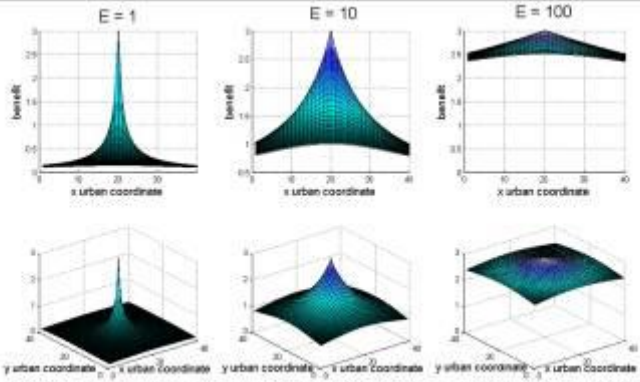
$$f(x_k, y_k) = (A_i \cdot M_e) \cdot [((x_k - x_i)^2 + (y_k - y_i)^2)^{1/2} + M_e]^{-1}$$

$$X_i = (1 - x_i, x_{k \max} - x_i)$$

$$Y_i = (1 - y_i, y_{k \max} - y_i)$$

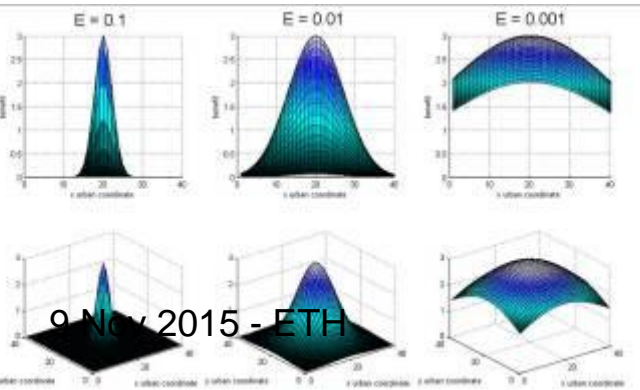
$$x_k, y_k \in \mathbb{N}$$

$$x_i, y_i = n \in \mathbb{N} | n > 0$$



$$m_{xy} = B_k = \sum_{i=1}^n (A_i \cdot M_e) \cdot [((x_k - x_i)^2 + (y_k - y_i)^2)^{1/2} + M_e]^{-1}$$

$$B_t = \sum_{i=1}^n \sum_{k=1}^m (A_i \cdot M_e) \cdot [((x_k - x_i)^2 + (y_k - y_i)^2)^{1/2} + M_e]^{-1}$$



$$SB_t = \sum_{j=1}^r D_j \cdot B_{t,j} = \sum_{j=1}^r \sum_{i=1}^n D_j \cdot \int_{a_j}^{b_j} \int_{c_j}^{d_j} \left\{ [A_i \cdot M_e] \cdot [((x - x_i)^2 + (y - y_i)^2)^{1/2} + M_e]^{-1} \right\} dx dy$$

$$DBC = \sigma M / \bar{M} = \sqrt{\frac{\sum_{k=1}^m (B_k - \bar{B})^2}{m-1}} \bigg/ \frac{1}{n} \sum_{i=1}^n B_i$$

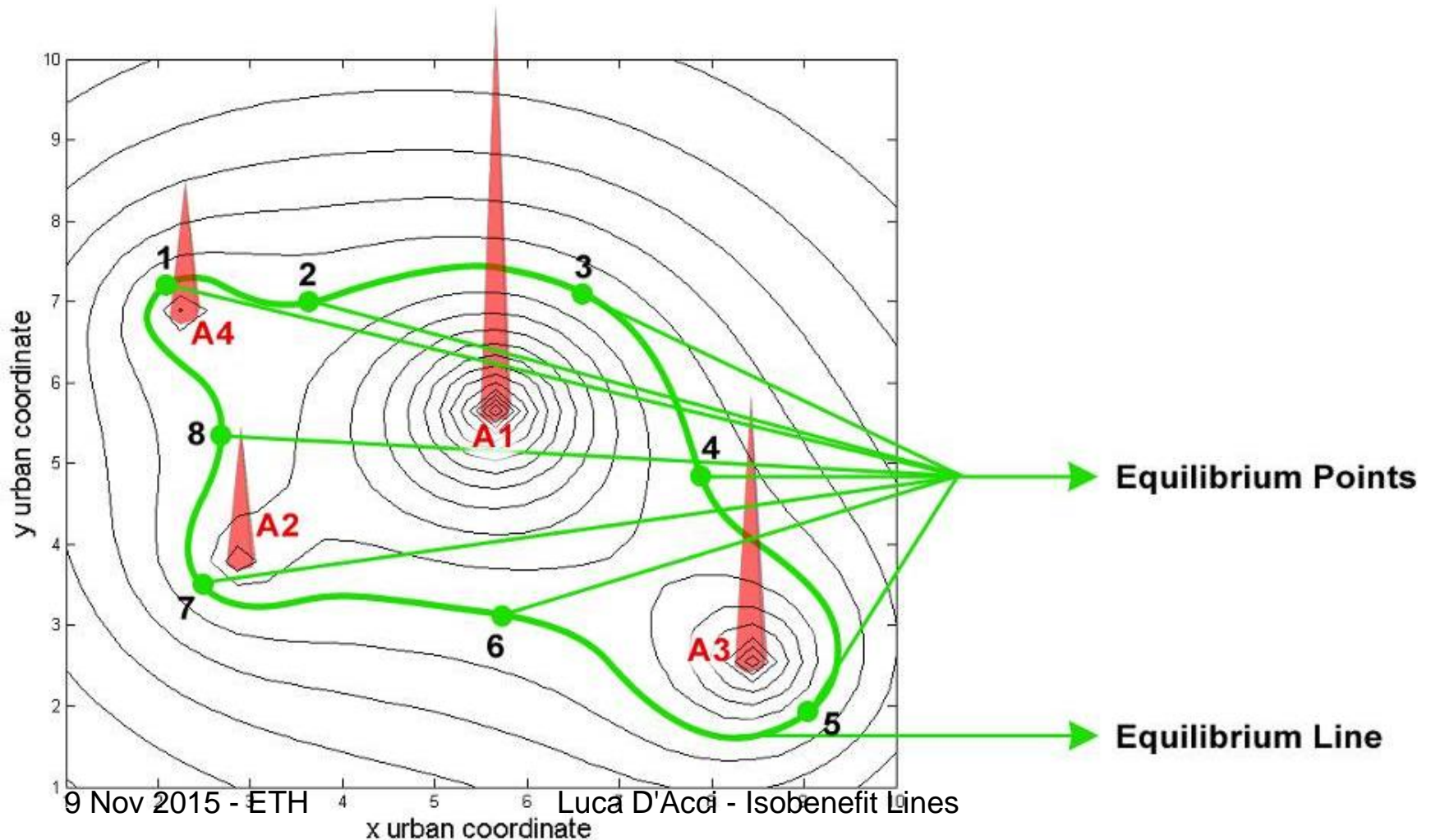
$$P = \sum_{k=1}^{m^*} v_k$$

$$m^* = x \% m, m^* \in \mathbb{N}$$

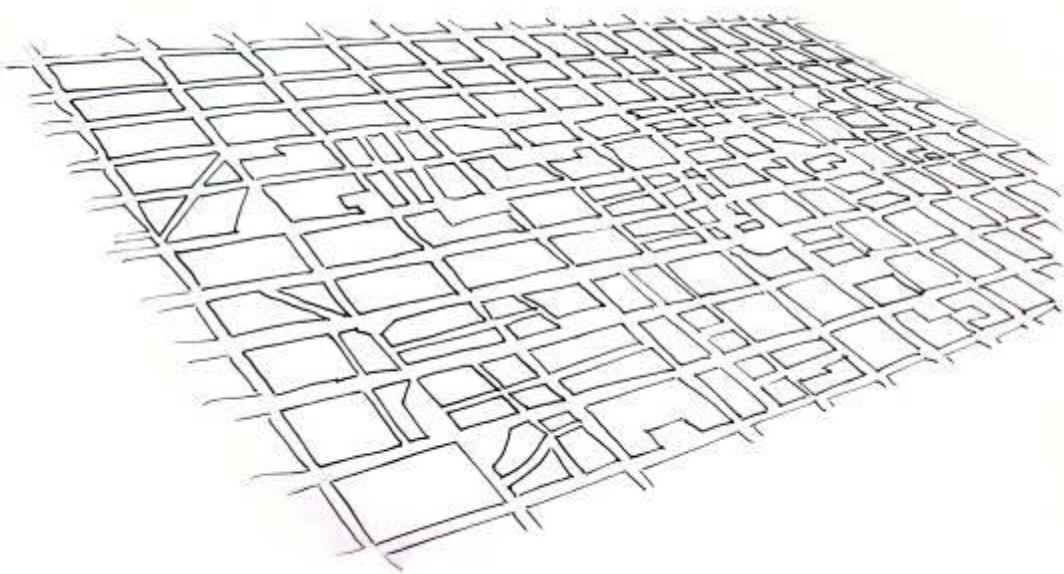
The benefit of a point k received from an amenity i distant d , and with a level A of attractiveness, is given by:

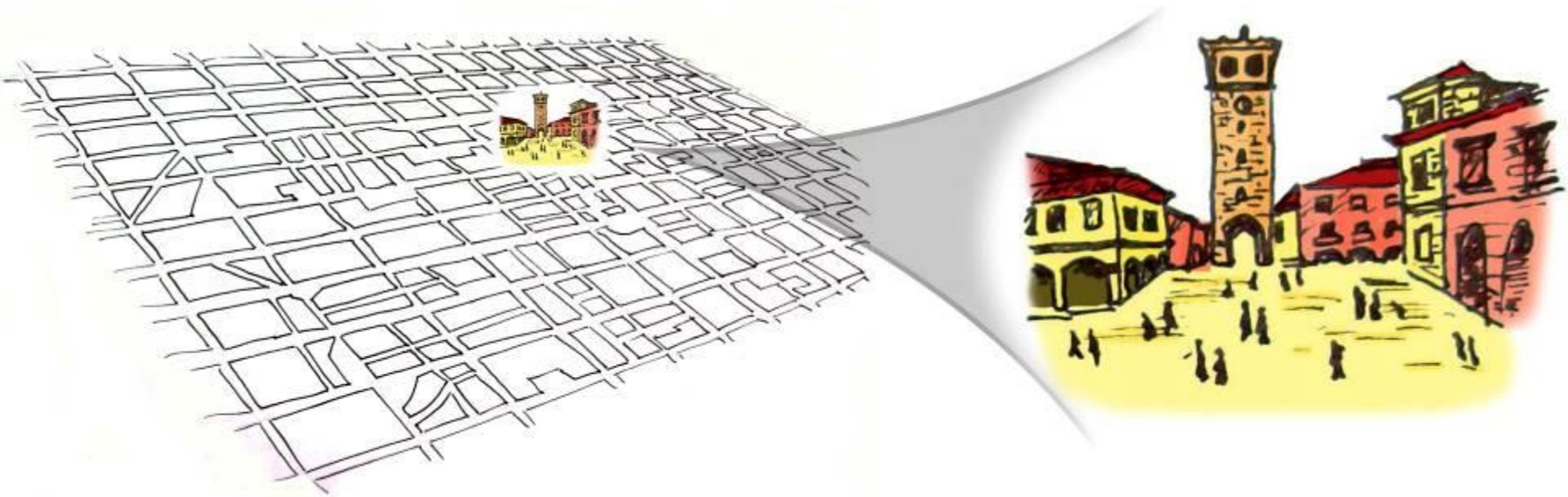
$$B_{i,k} = \frac{A_i}{1 + (d_{i-k} / E)}$$

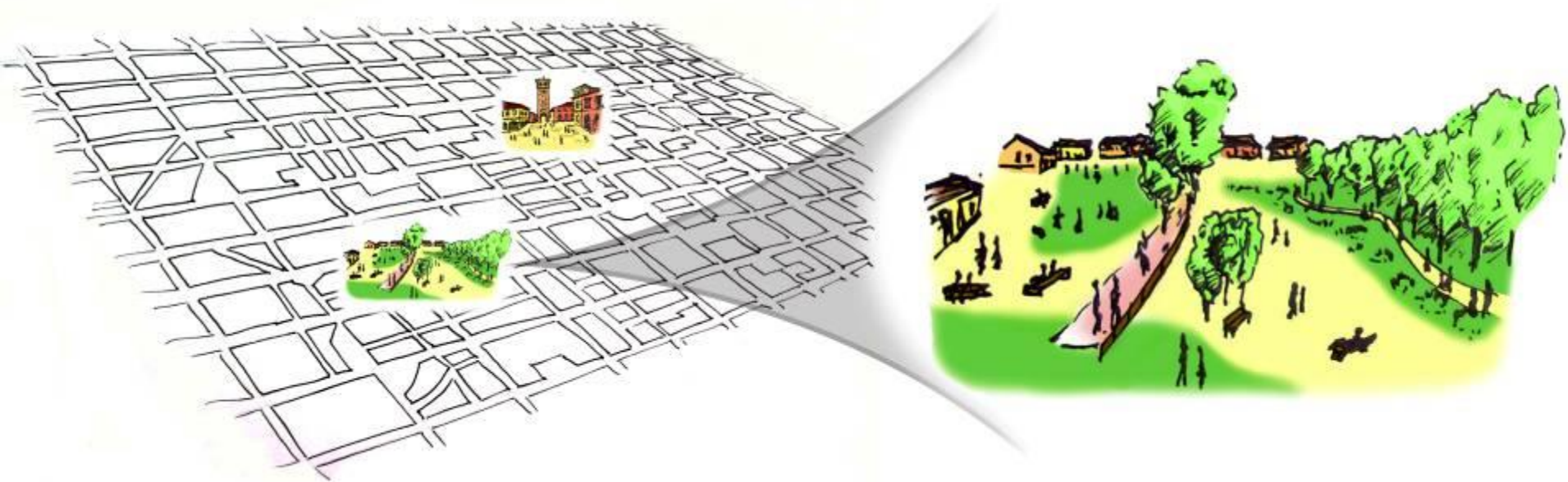
The Isobenefit Lines join the urban points with equal levels of benefit given from urban amenities

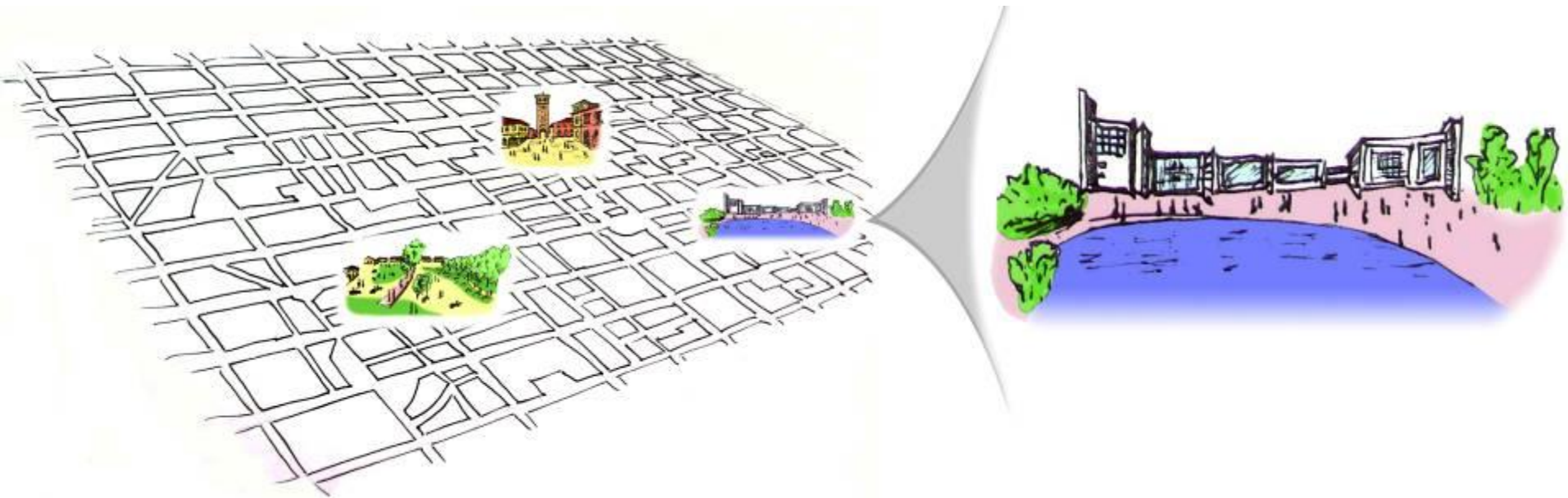


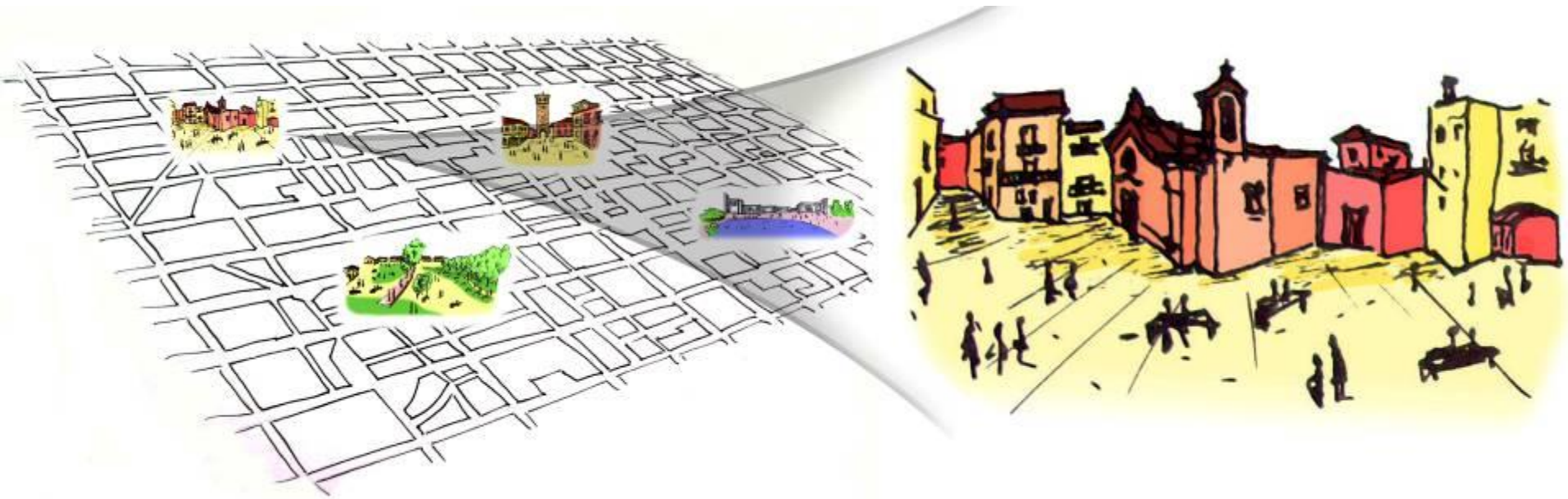
The change of city structures and of personal preferences/needs imply a change of the isobenefit city landscape which is the map of the benefit given from amenities and which depends from the benefit you receive when you are directly enjoying amenities and from how this benefit flows throughout the city.



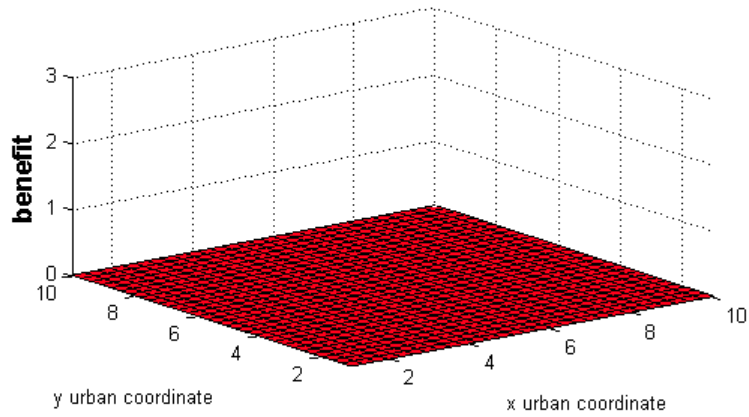




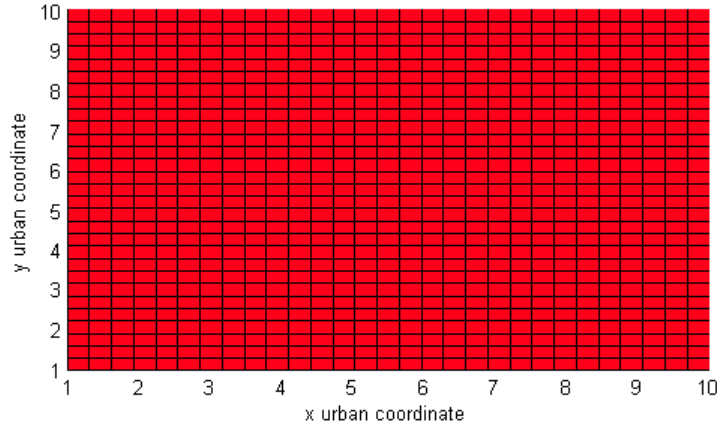
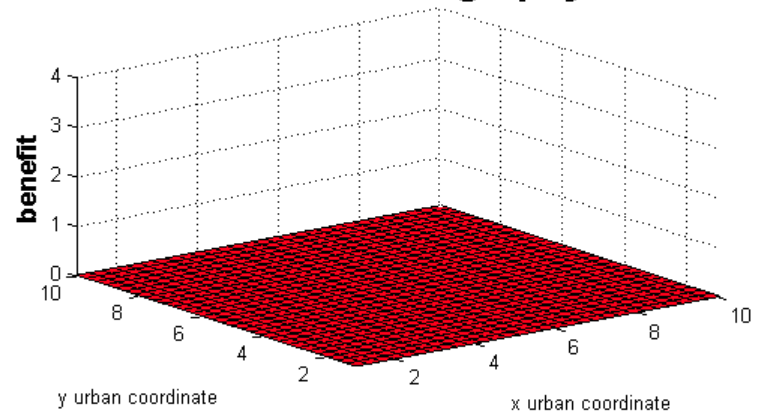




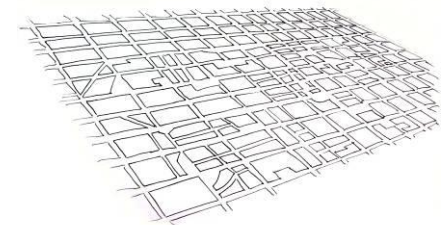
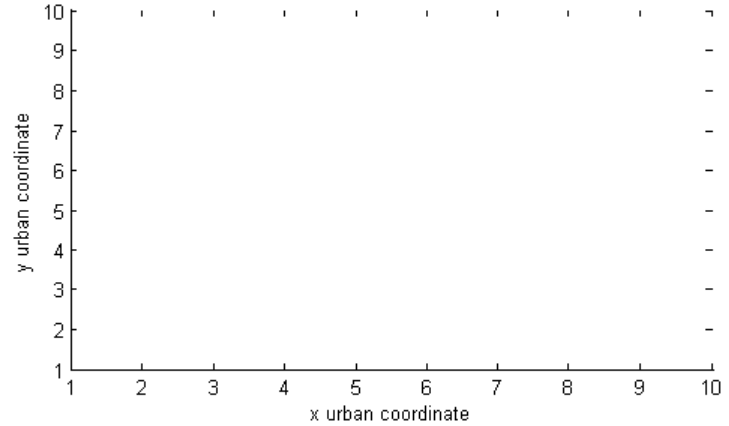
SCENARIO 0



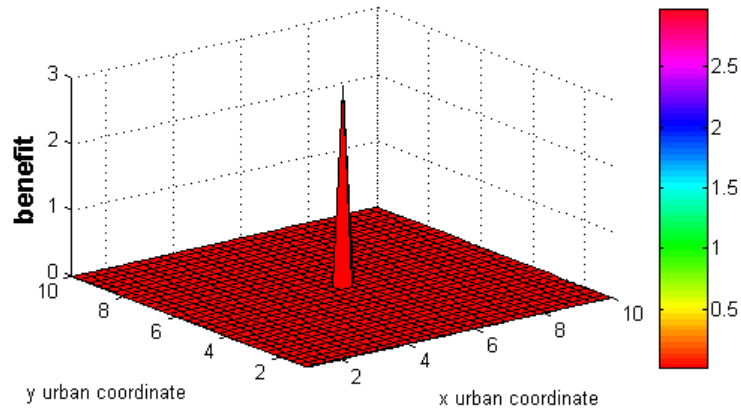
isobenefit orography



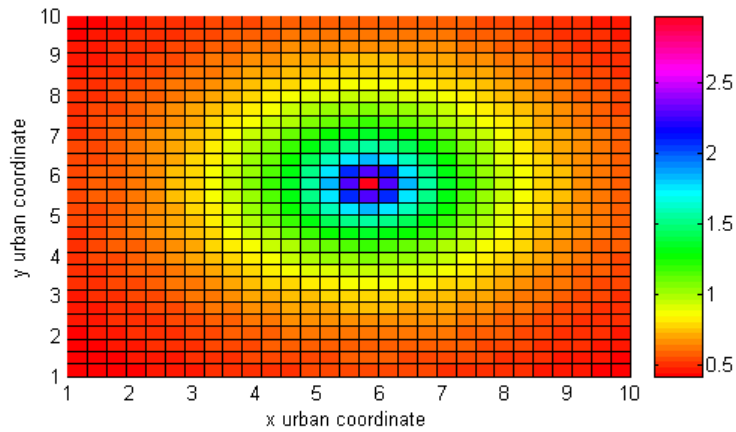
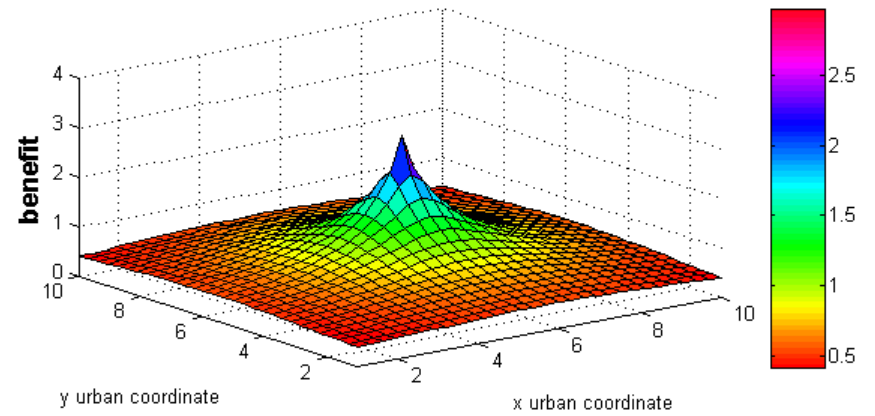
isobenefit curves



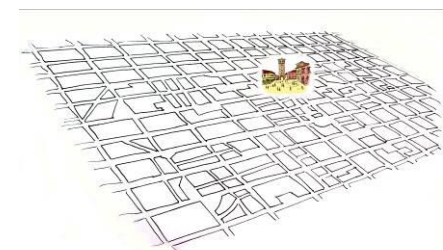
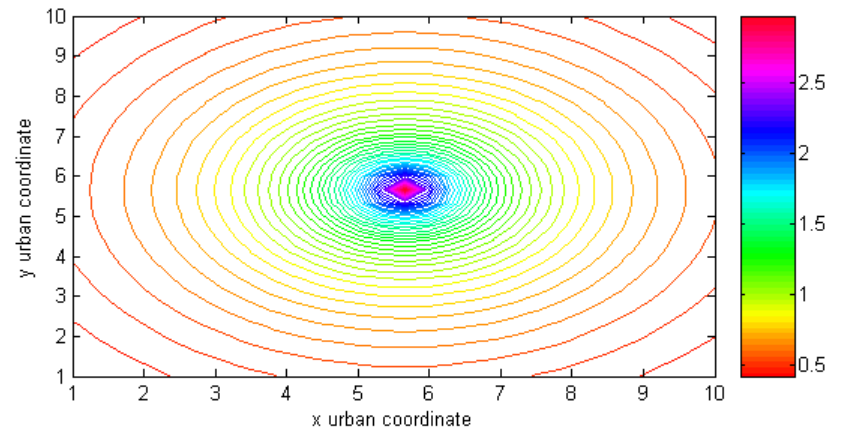
SCENARIO 1



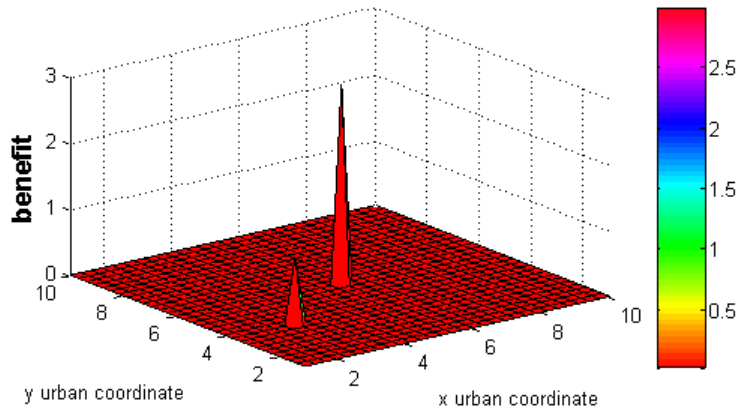
isobenefit orography



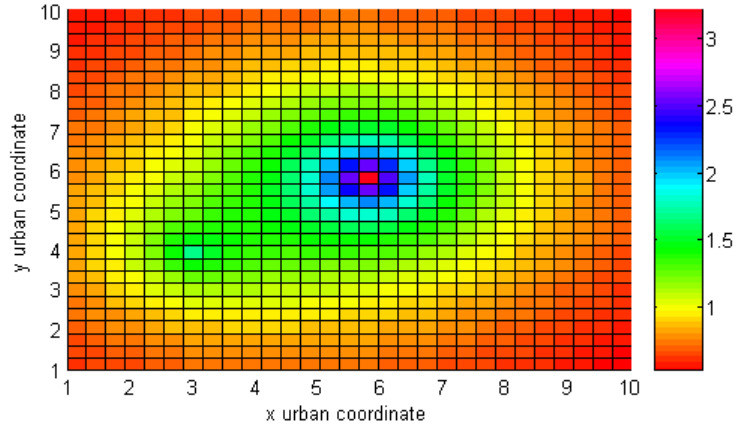
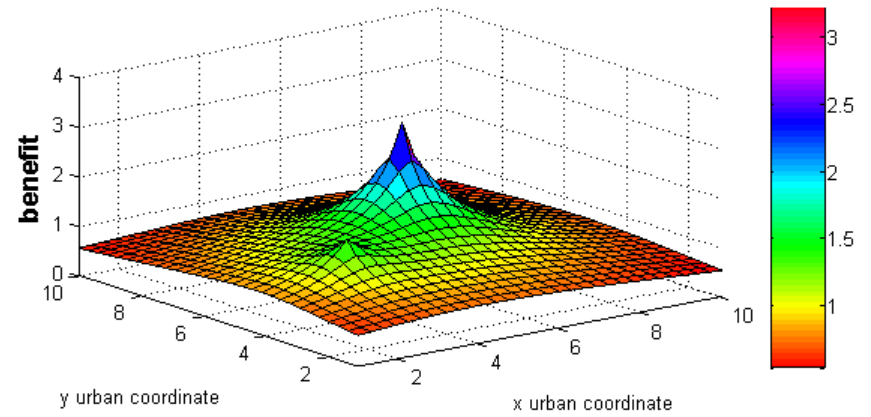
isobenefit curves



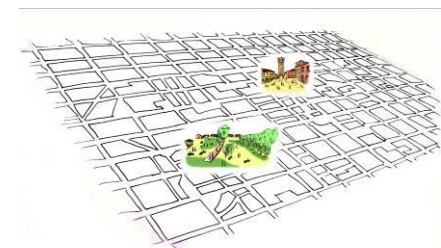
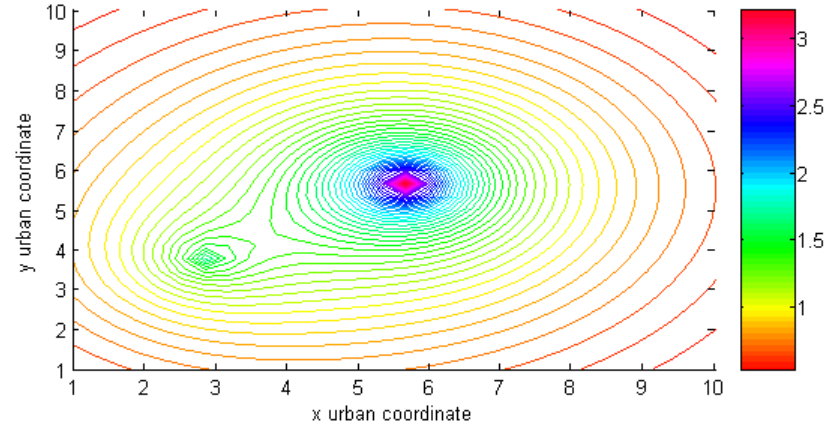
SCENARIO 2



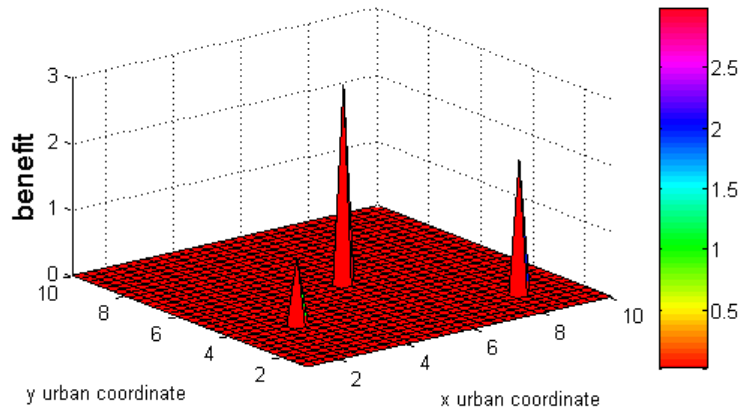
isobenefit orography



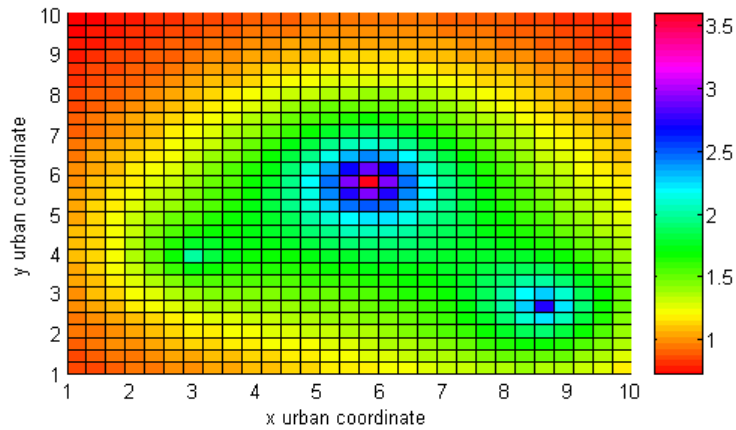
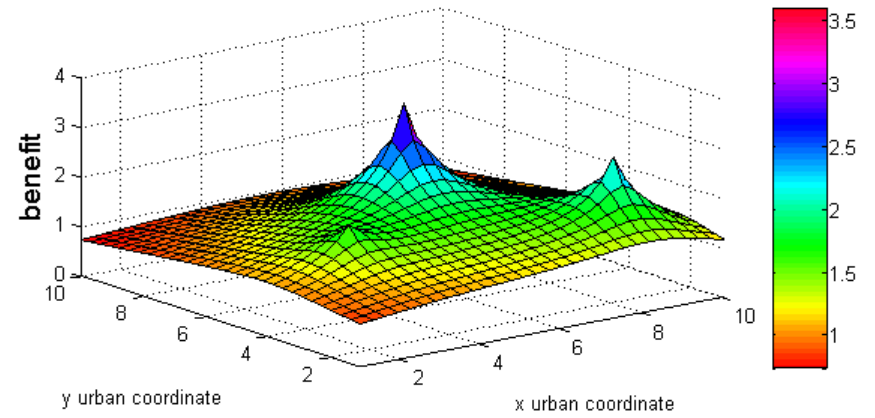
isobenefit curves



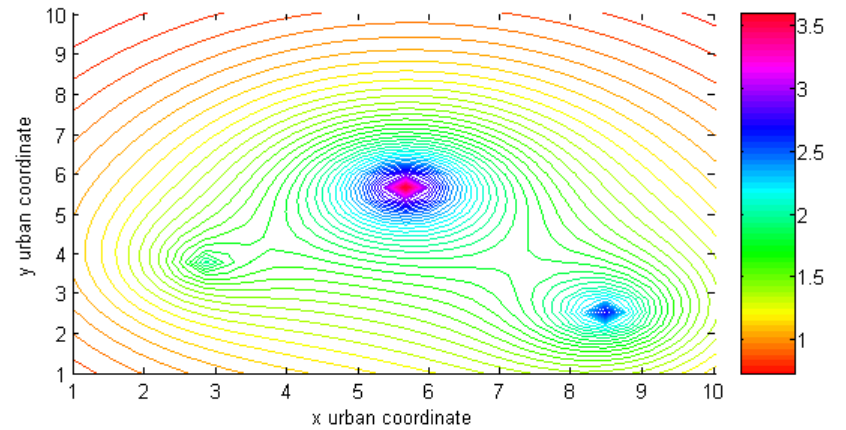
SCENARIO 3



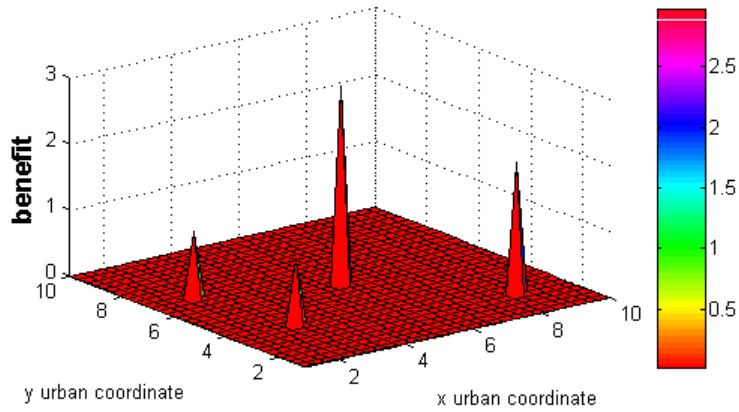
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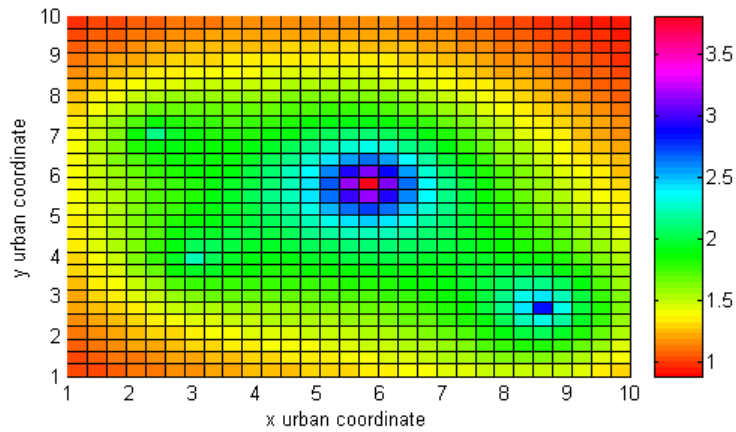
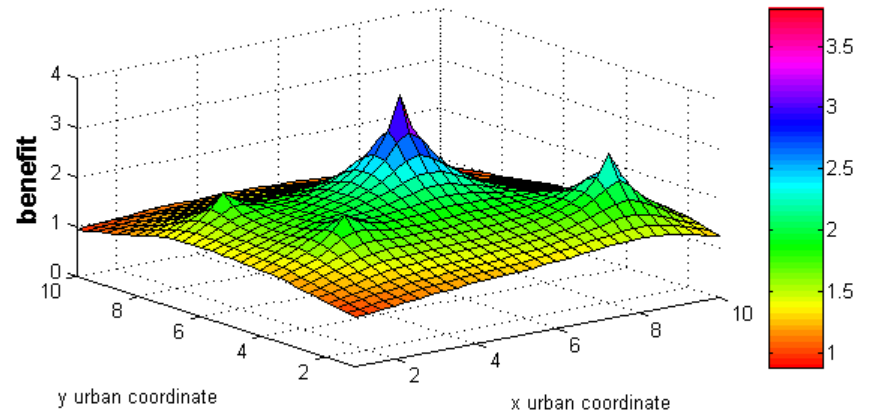
isobenefit curves



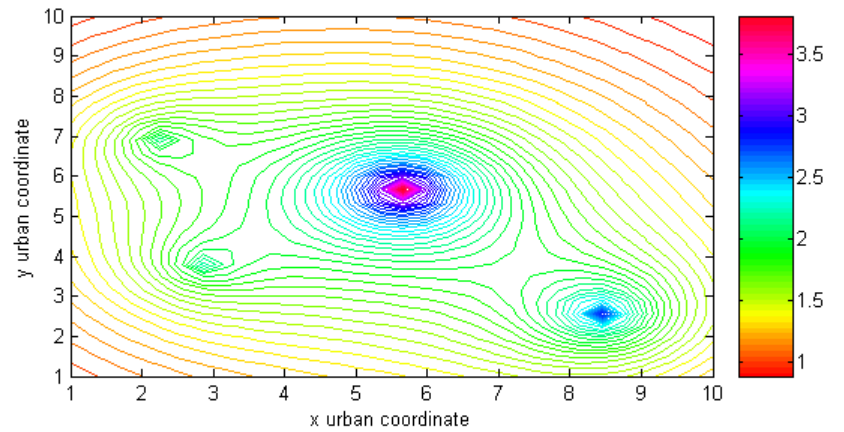
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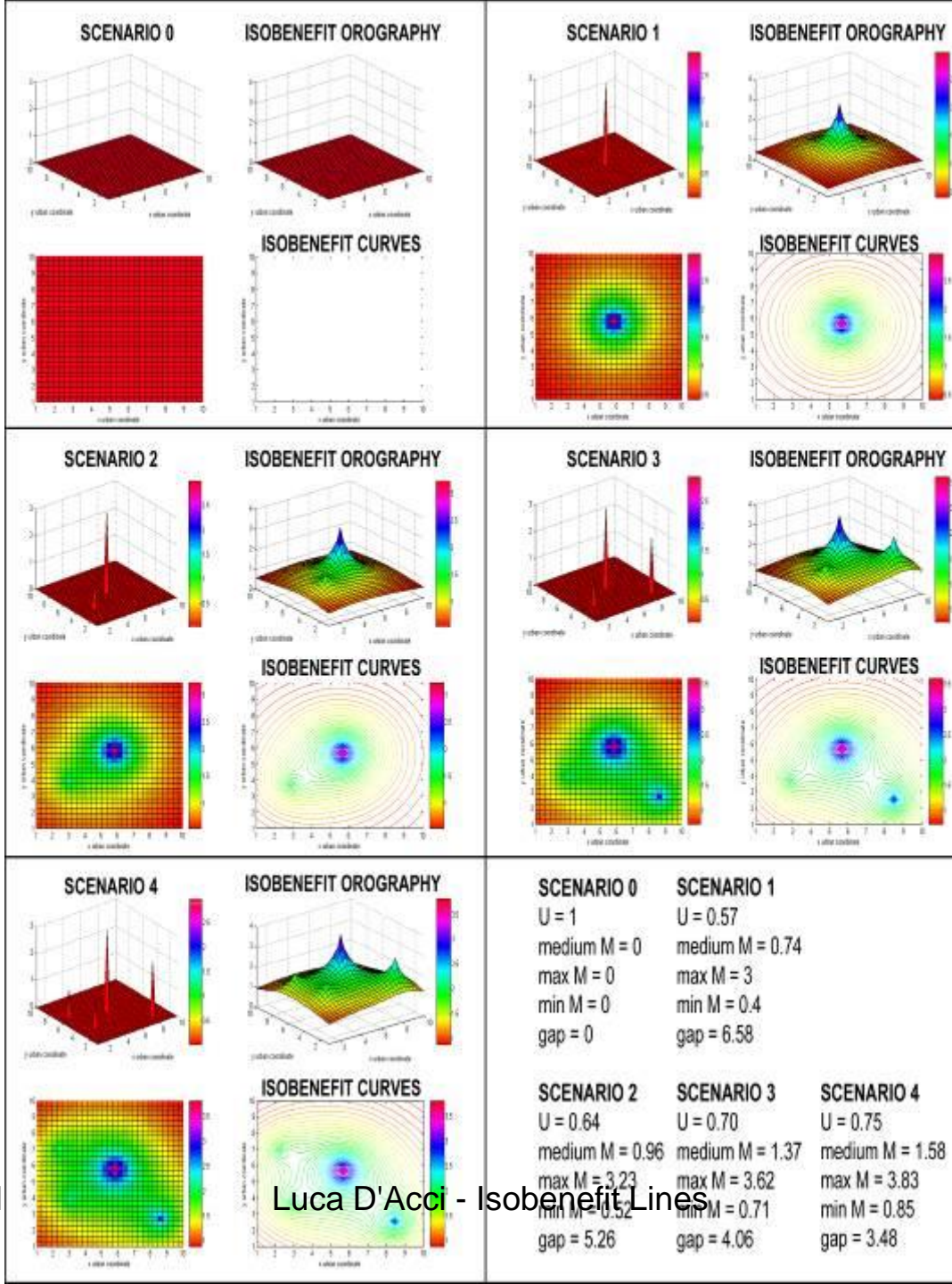


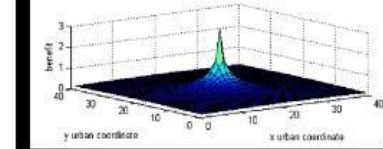
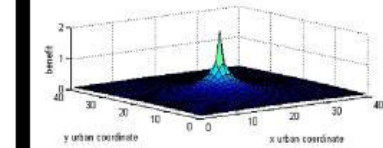
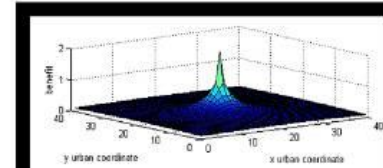
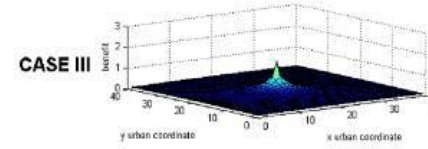
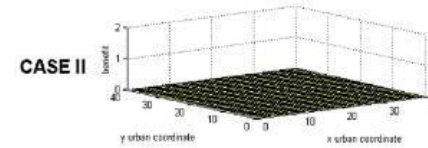
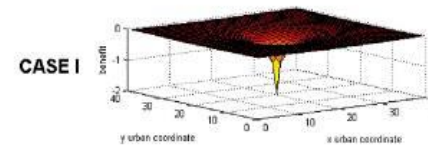
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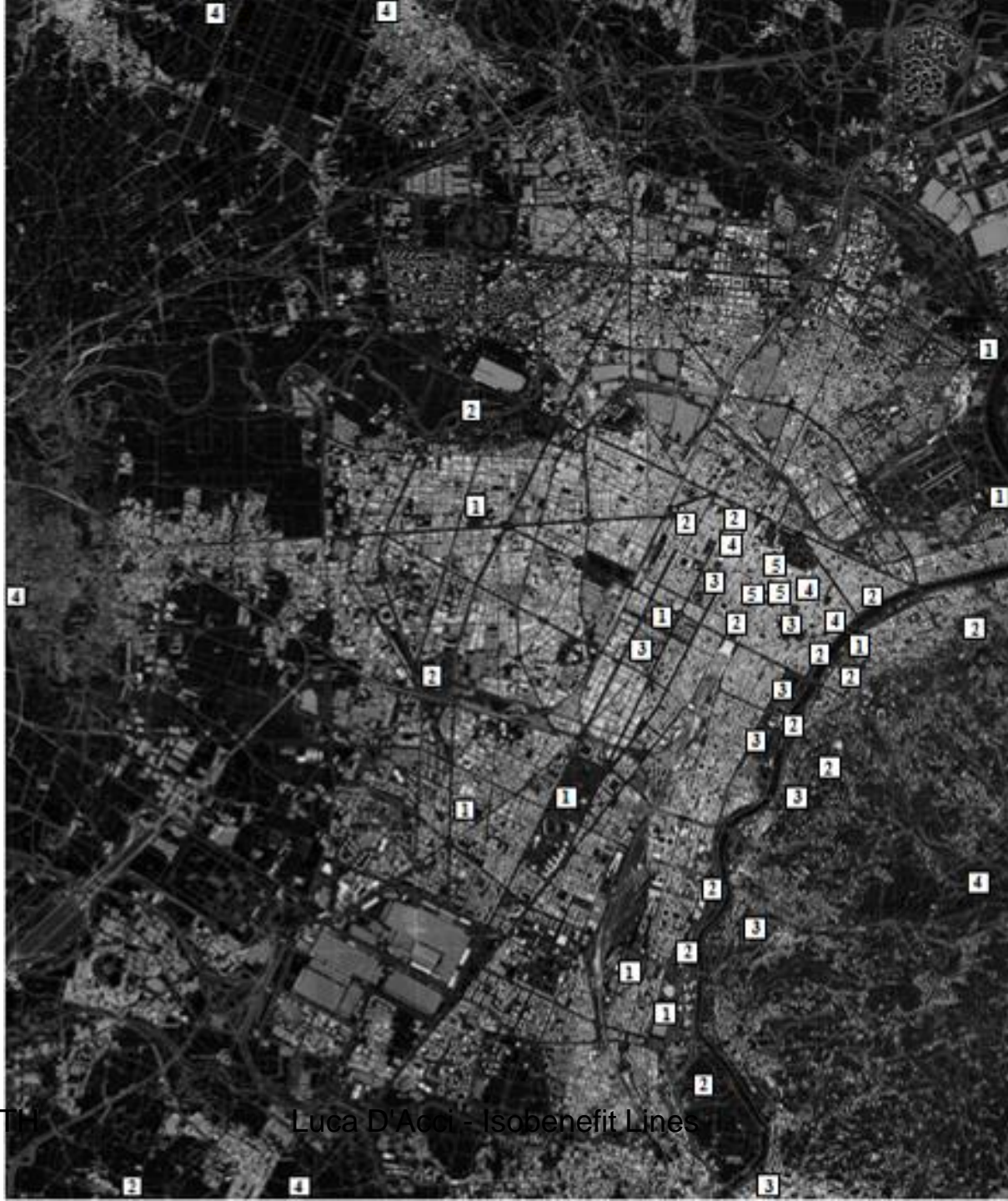


isobenefit curves



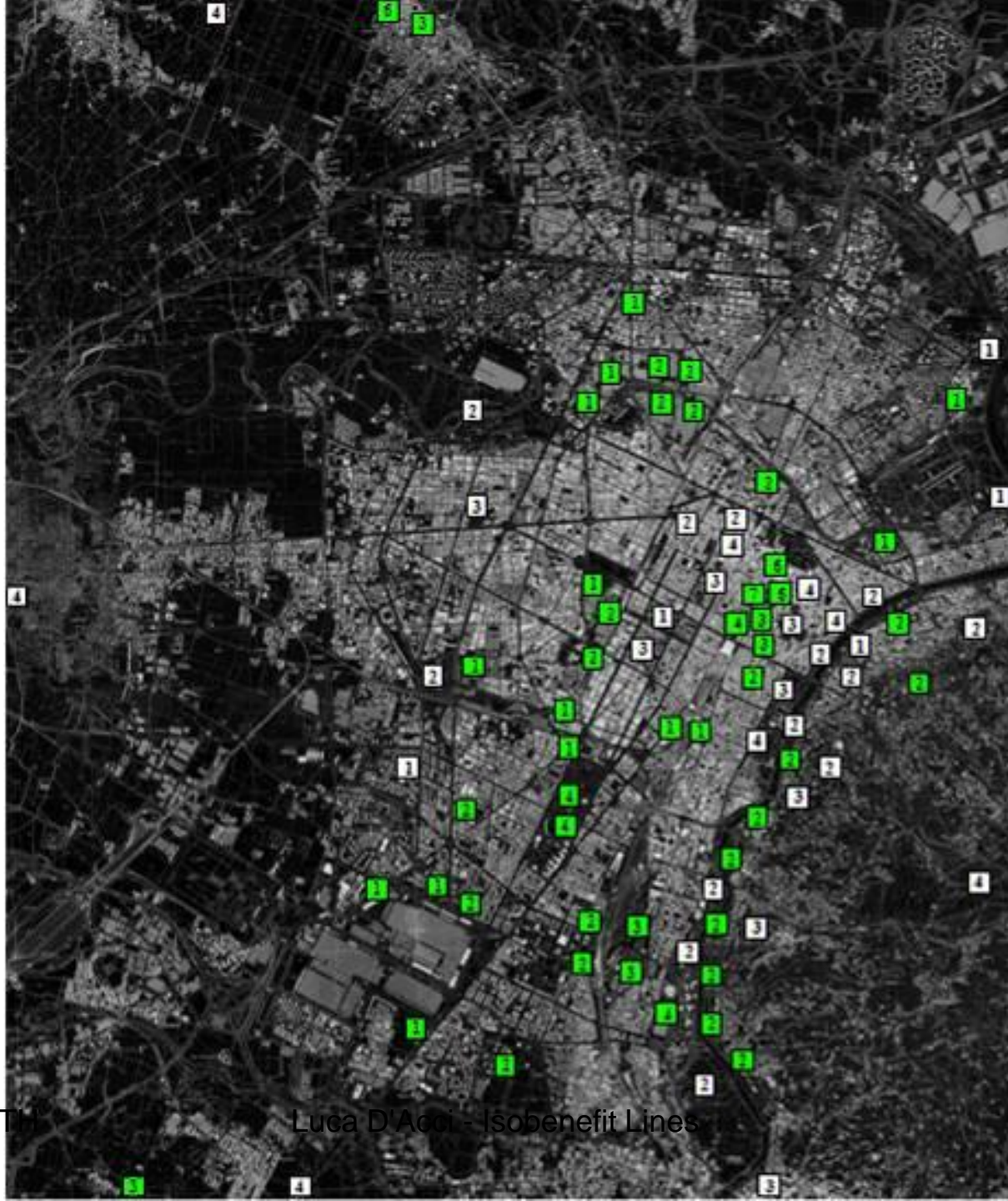






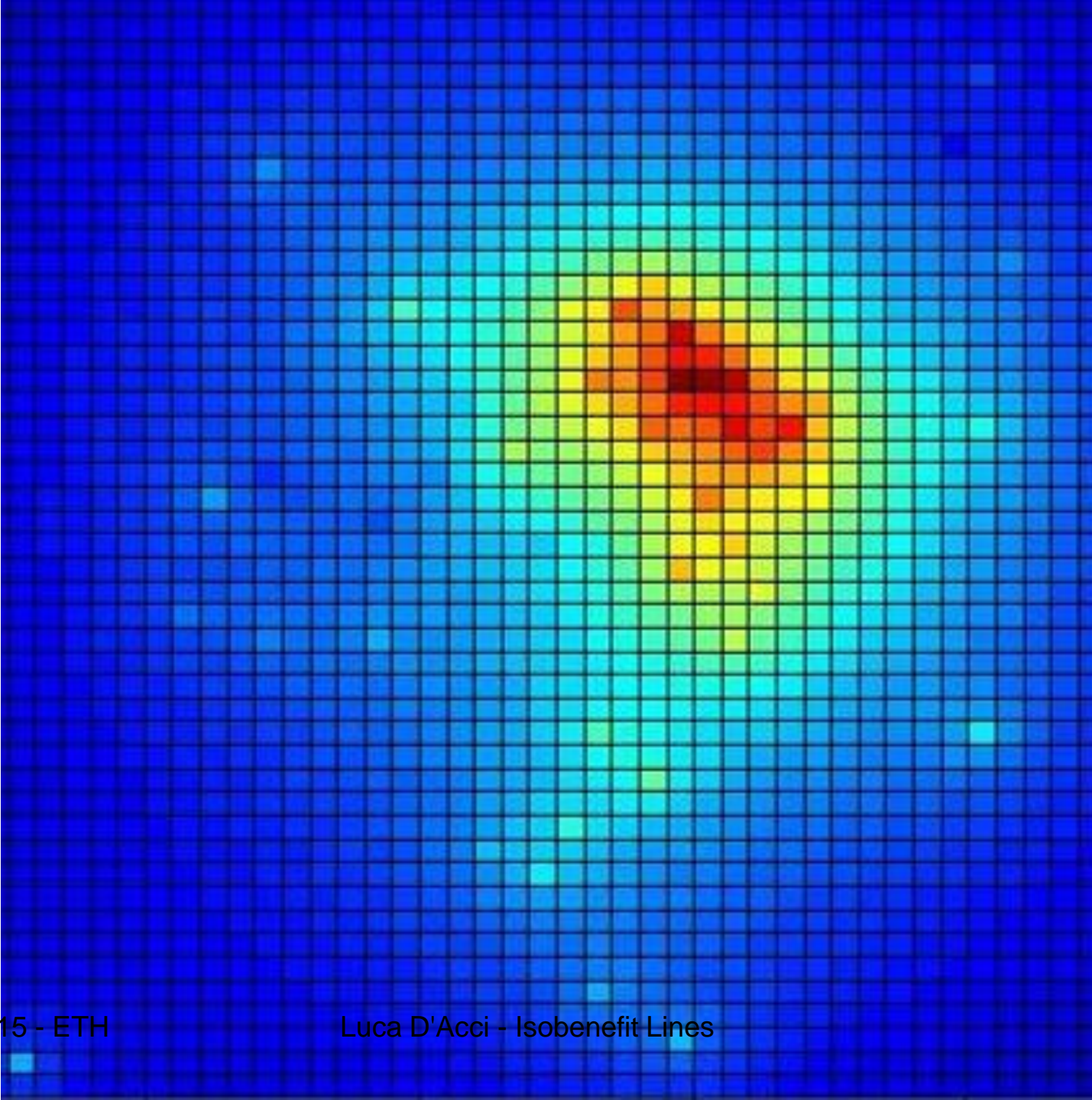
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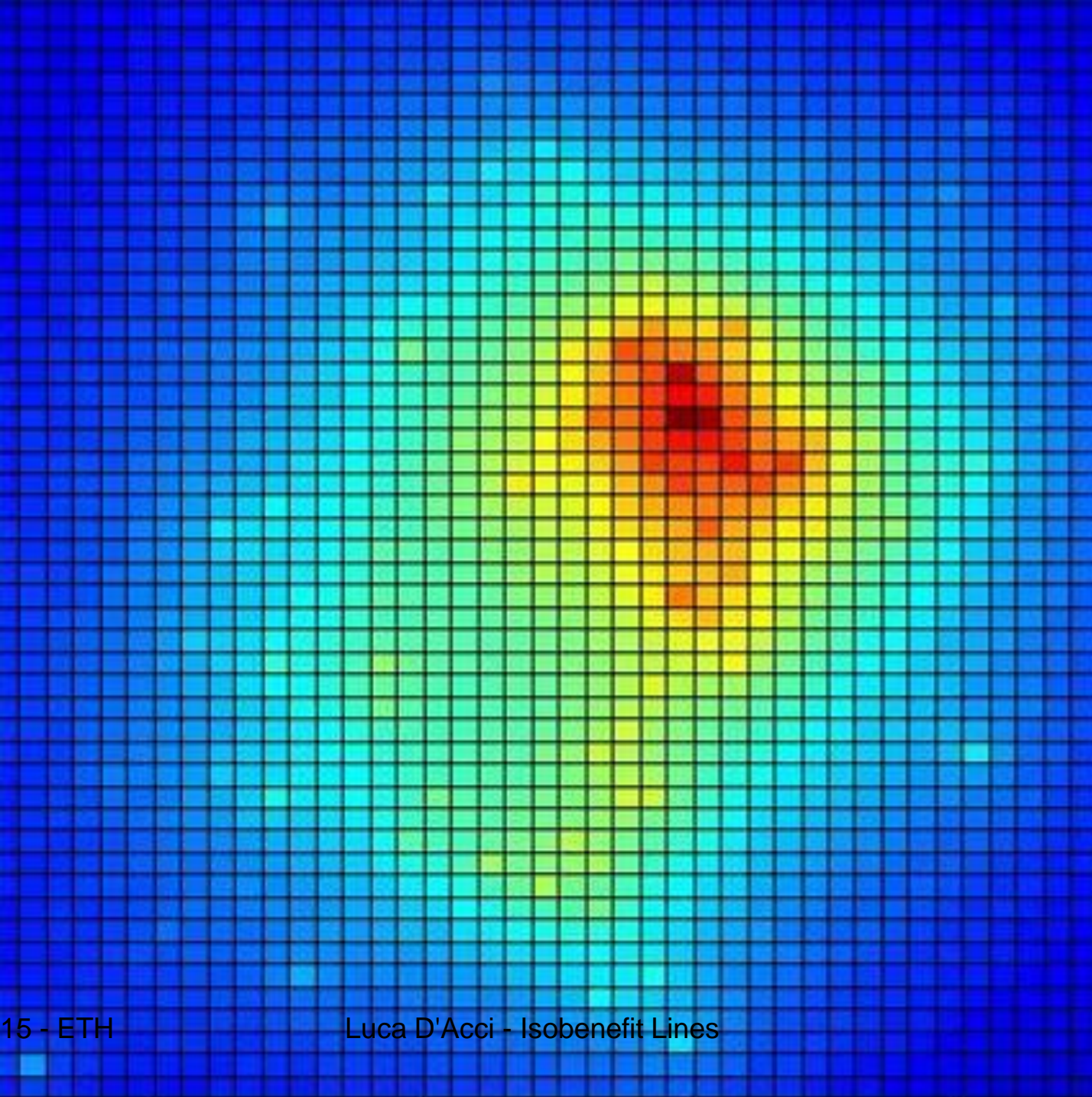
Luca D'Acci - Isobenefit Lines



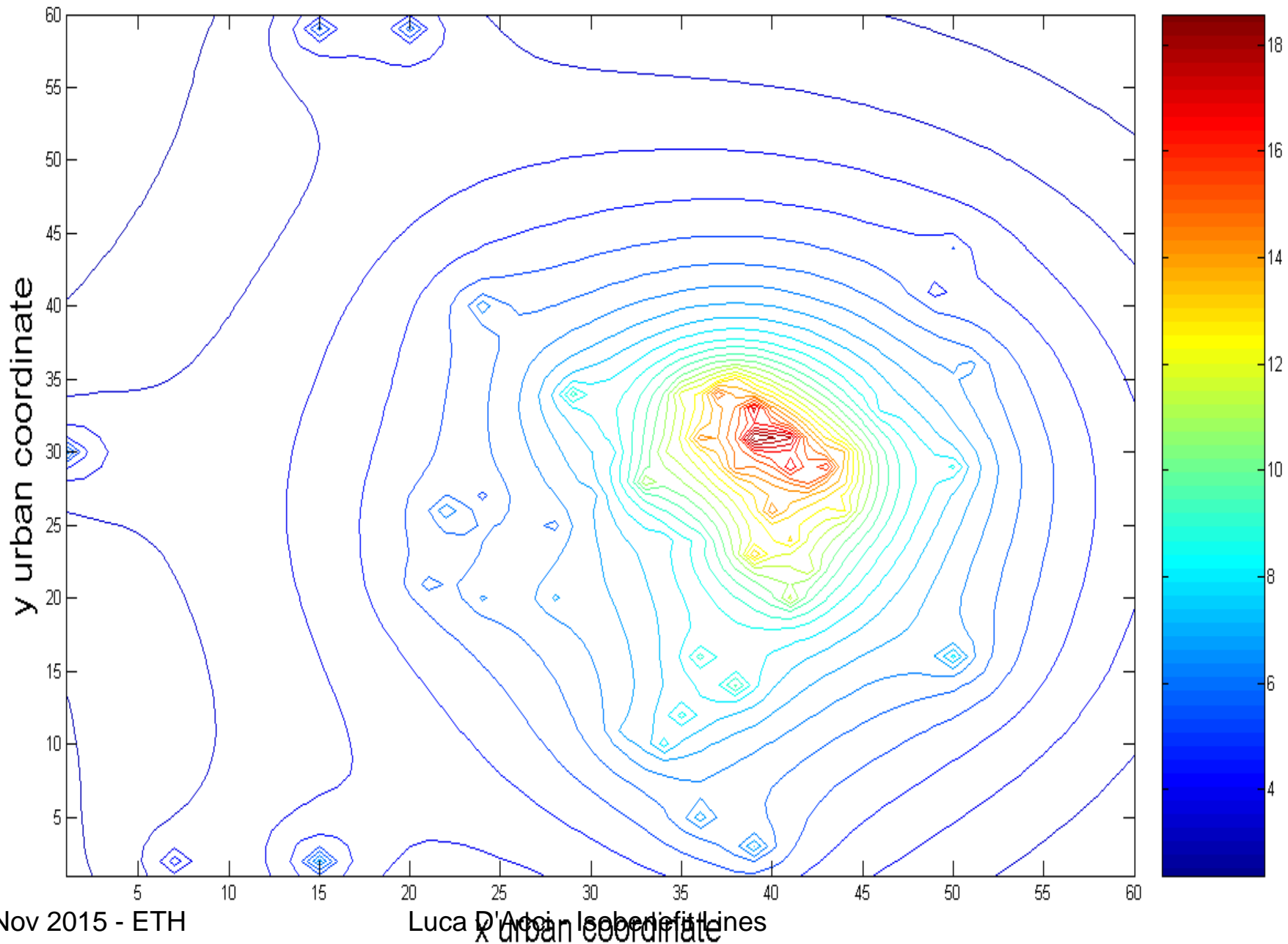
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Luca D'Adda - Isobenefit Lines

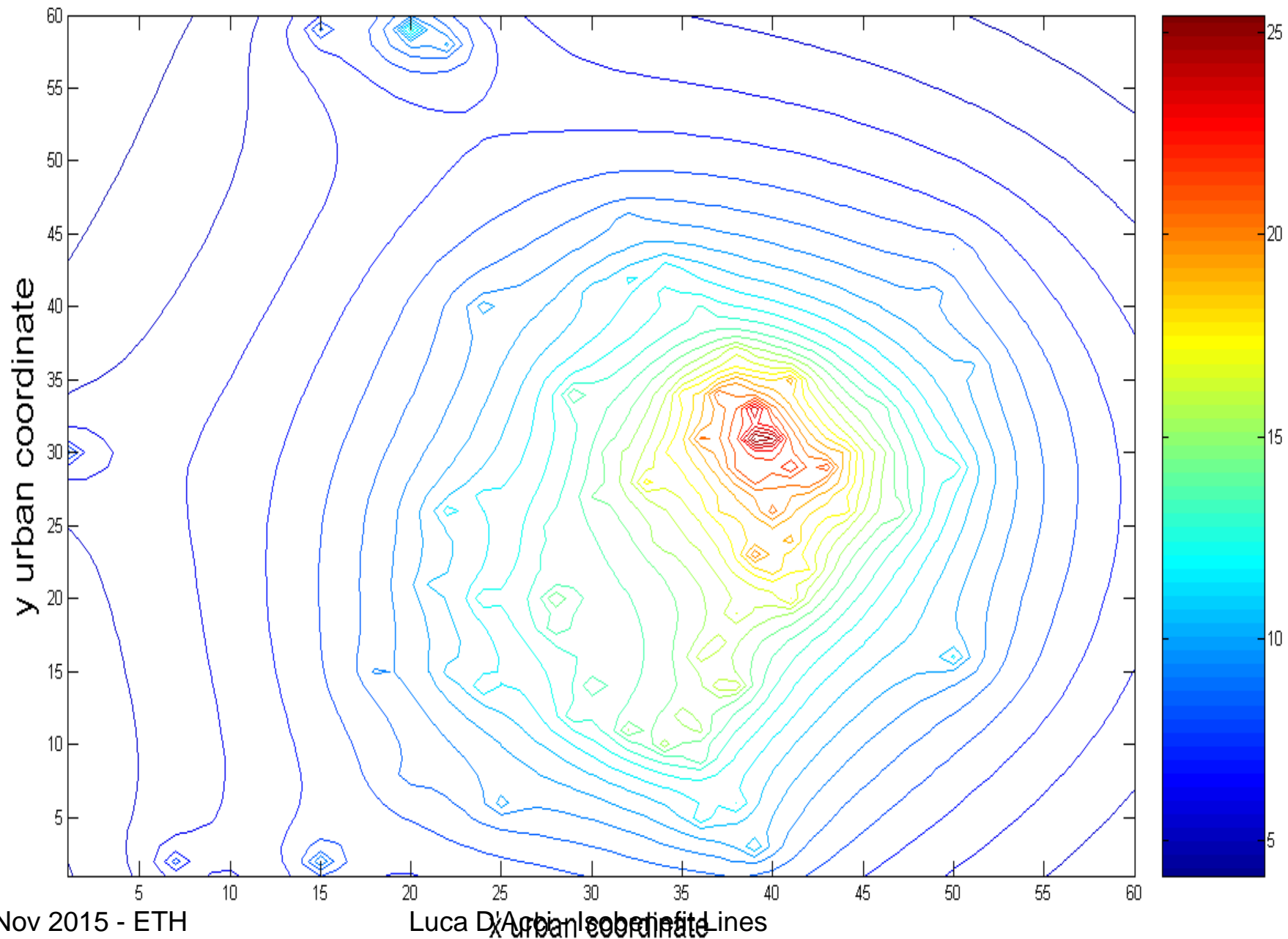




TURIN ISOBENEFIT LINES BEFORE THE URBAN TRANSFORMATIONS



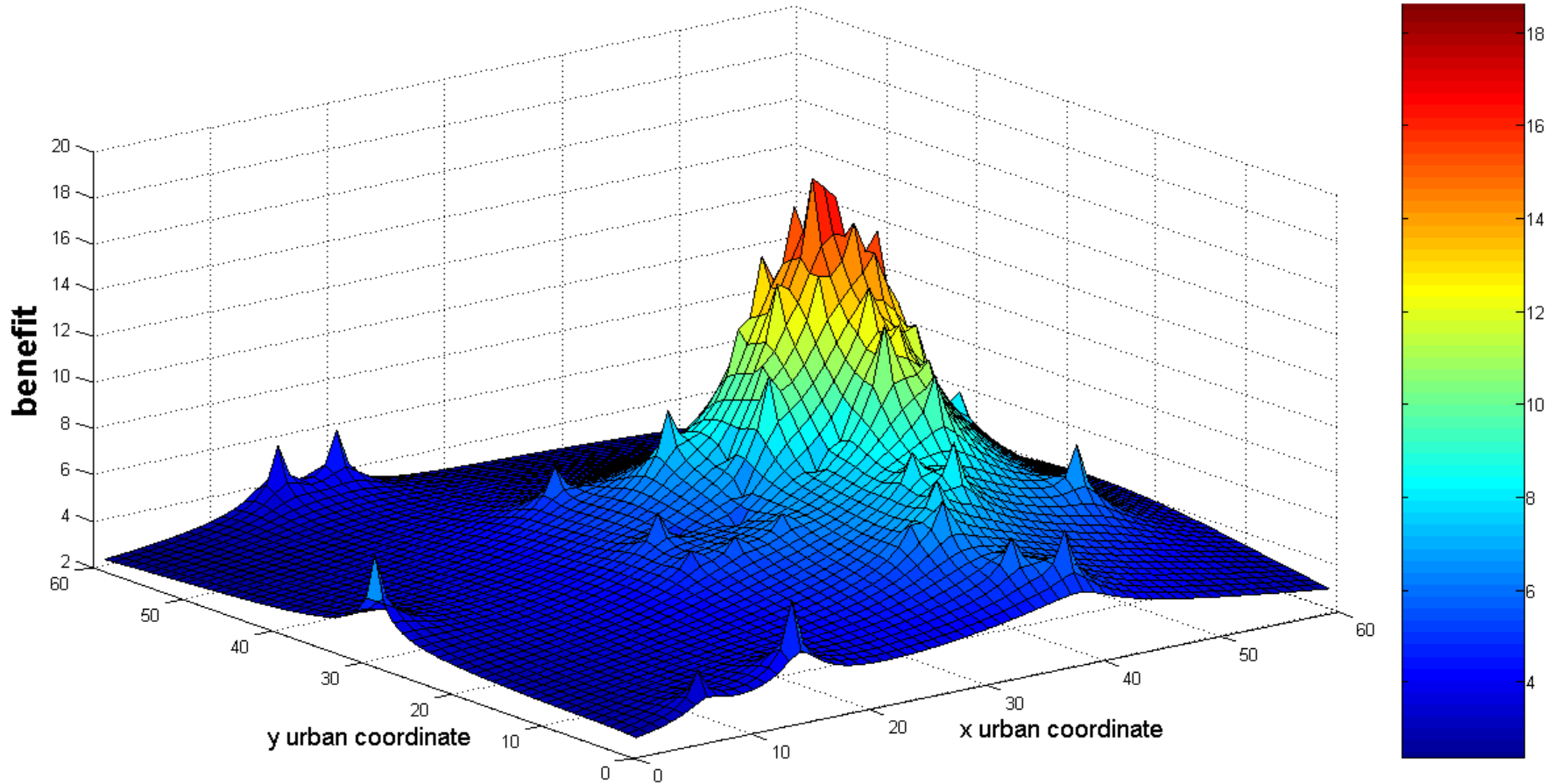
TURIN ISOBENEFIT LINES AFTER THE URBAN TRANSFORMATIONS



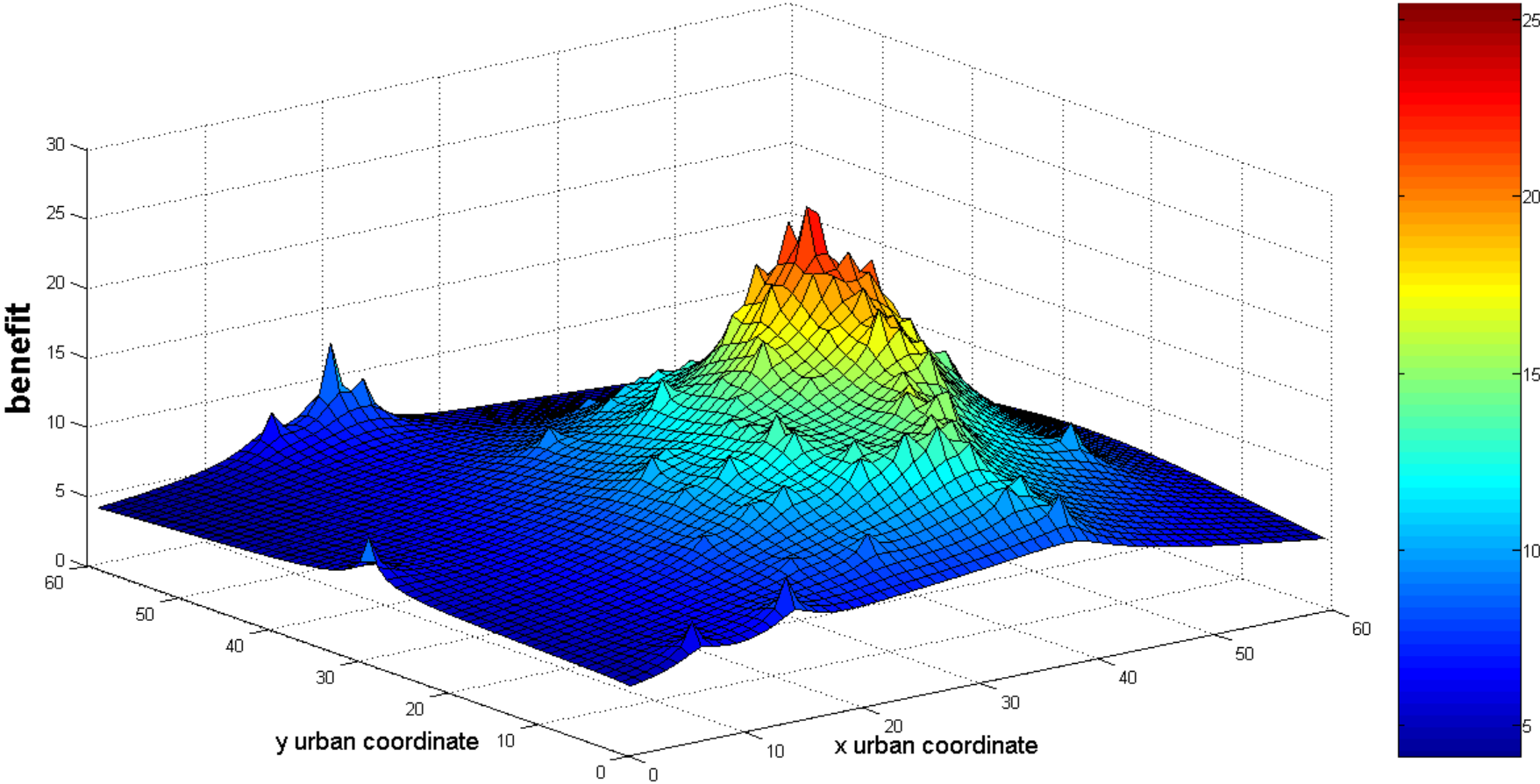
9 Nov 2015 - ETH

Luca D'Adda Urban coordinate lines

TURIN ISOBENEFIT OROGRAPHY BEFORE THE URBAN TRANSFORMATIONS



TURIN ISOBENEFIT OROGRAPHY AFTER THE URBAN TRANSFORMATIONS



The benefit of a point k received from an amenity i distant d , and with a level A of attractiveness, is given by:

$$B_{i,k} = \frac{A_i}{1 + (d_{i-k}/E)}$$

Where E is the variable which allows to transform the distances into ***Psycho-Economical*** distances.

$$E = \varepsilon \cdot E_{i-k}$$

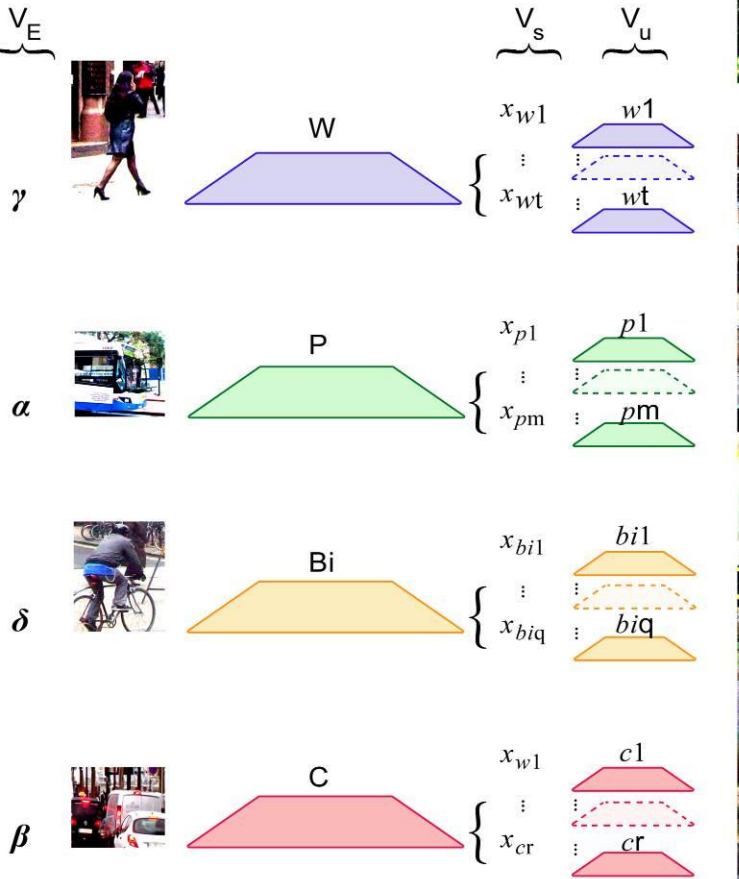
$$E_{i-k} = \alpha P_{i-k} + \beta C_{i-k} + \gamma W_{i-k} + \delta B_i$$

Calculating equation 1 for all the n amenities present in the city:

$$B_k = \sum_{i=1}^n B_{i,k}$$



The **objective** status of movement possibilities offered by the city is expressed by v_u .
 The **subjective** status, 'transducer' of the preferences heterogeneity of citizens, is expressed by v_E , v_S and ε



Therefore v_E , v_S and ε

transform the Euclidean distance (d) into a **Psycho-Economical Distance**, where we think about time in monetary terms.

If we formulate A and E on aggregate statistics and habits by observing the majority of the citizens rather than each of them, we talk of **Isobenefit Lines**.

When A and the full set of parameters of E are formulated on *personal* habits and preferences, we pass from *Isobenefit Lines* to **Personal Isobenefit Lines**

$$P = x_{p1}p_1 + x_{p2}p_2 + \dots + x_{pz}p_z + \dots + x_{pm}p_m; \quad v_p = (x_{p1}, x_{p2}, \dots, x_{pz}, \dots, x_{pm})$$

$$C = x_{c1}c_1 + \dots + x_{cr}c_r; \quad v_c = (x_{c1}, \dots, x_{cr})$$

$$W = x_{w1}w_1 + \dots + x_{wt}w_t; \quad v_w = (x_{w1}, \dots, x_{wt})$$

$$Bi = x_{bi1}bi_1 + \dots + x_{biq}bi_q; \quad v_{bi} = (x_{bi1}, \dots, x_{biq})$$

$$v_S = (v_p, v_c, v_w, v_{bi})$$



For example, a person can give more importance to libraries, parks and pedestrian areas, another to shopping malls and parking, another to hospitals and public transport, etcetera. In the same way, a person could give more value to aesthetics and silence, another more about speed and time, another more about costs, etcetera.

Also, a same person can change her/his needs/preferences along the years, as the daily life of children, teenagers, adults and seniors are different.

Again, a same person could change his/her habits when becomes richer or poorer, or get married or divorced, or have babies, or memories, etcetera.

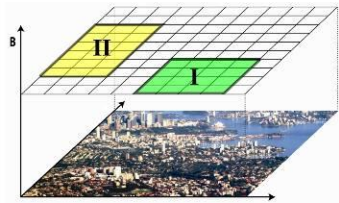
To change needs, habits, preferences means to change the values of the parameters, which in turn means to modify personal *Benefit Orography* (the 3-dimensional visualization of equation 4, of the city, which we call also *Benefit Landscape*).

Person 1 and Person 2;
 Person 3 and Person 4:
 = v_s and qualitative criteria
 $\neq v_E$

Person 1



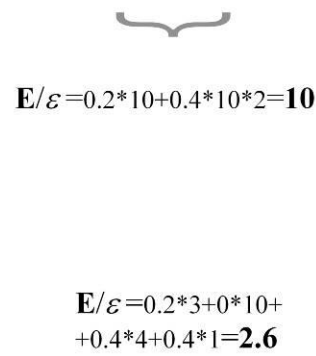
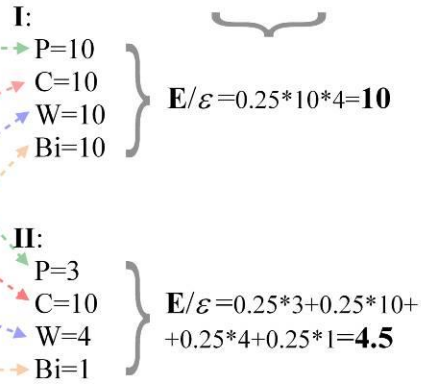
Person 2



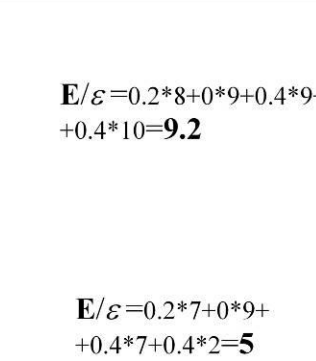
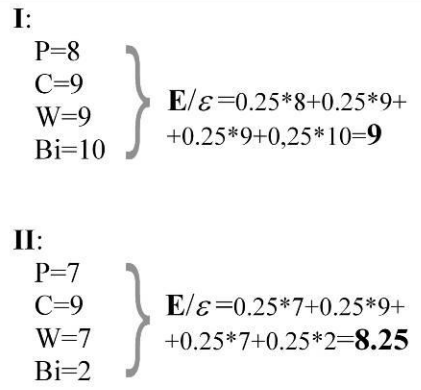
$$\alpha = \beta = \gamma = \delta = 0.25$$



$$\alpha = 0.2; \beta = 0; \gamma = \delta = 0.4$$



Person 3 and Person 1;
 Person 4 and Person 2
 $\neq v_s$ and qualitative criteria
 $= v_E$



Person 4 and Person 1;
 Person 3 and Person 2
 $\neq v_s$ and qualitative criteria
 $\neq v_E$

Person 3

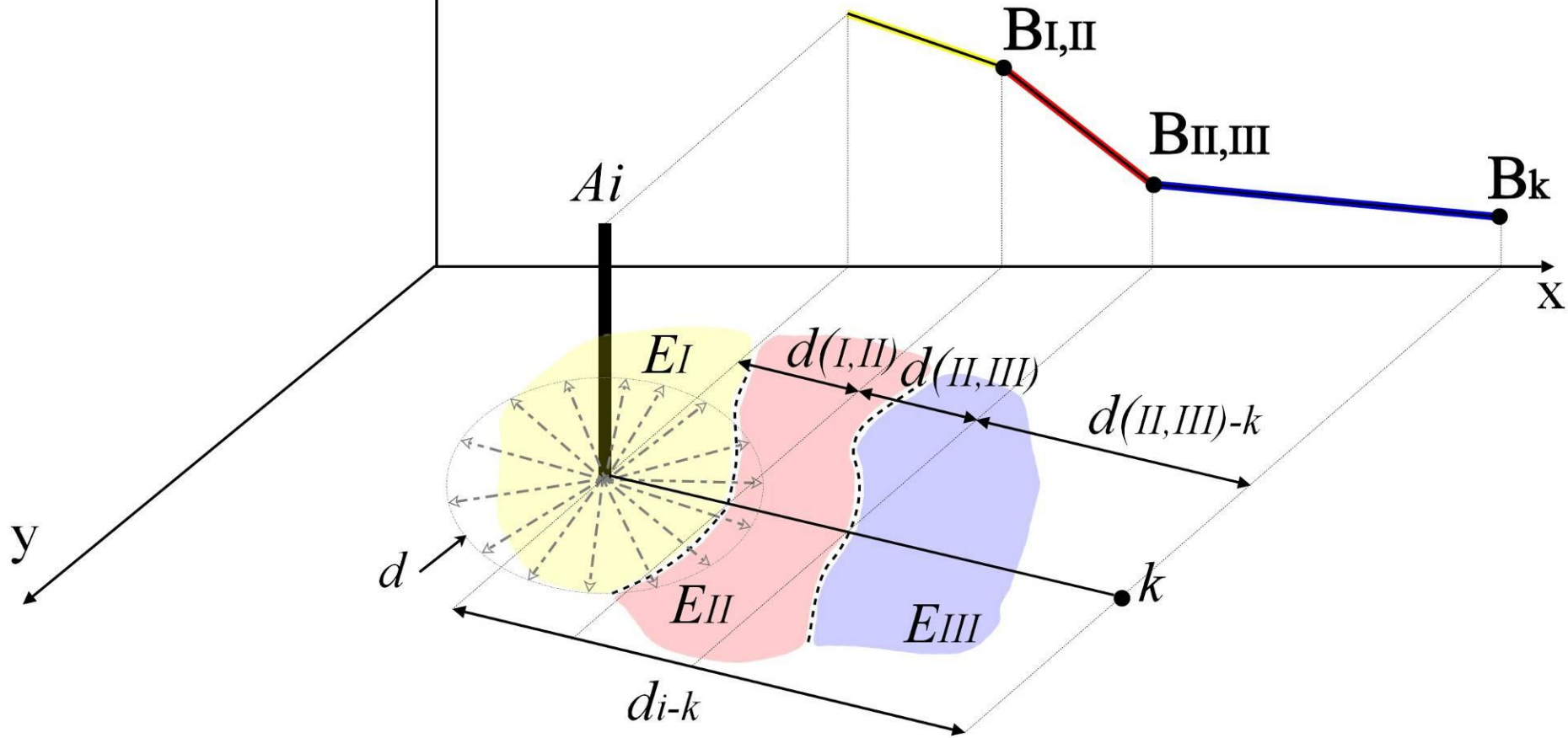


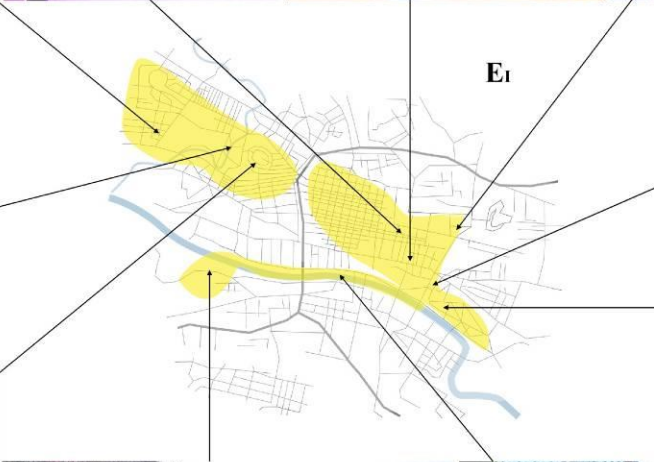
Luca D'Acciolo
 Accionis
 benefit Lines



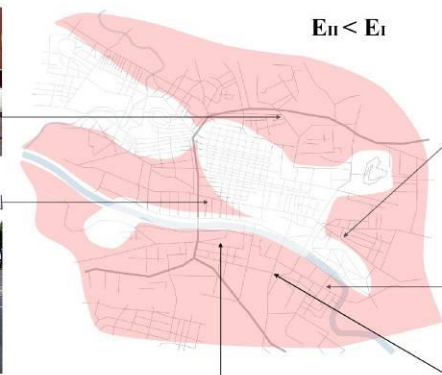
Benefit

$$E_{III} > E_I > E_{II}$$



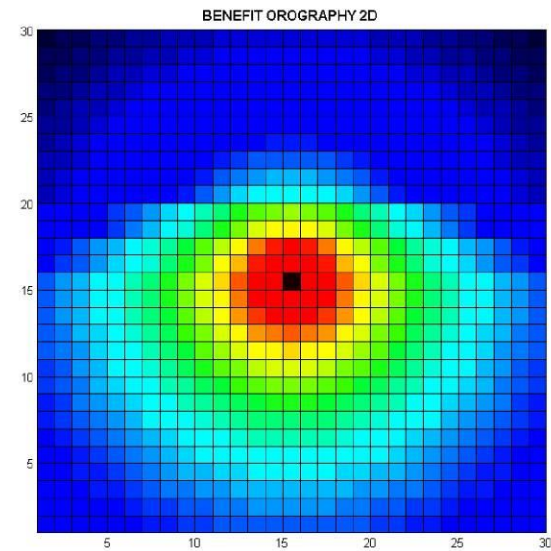
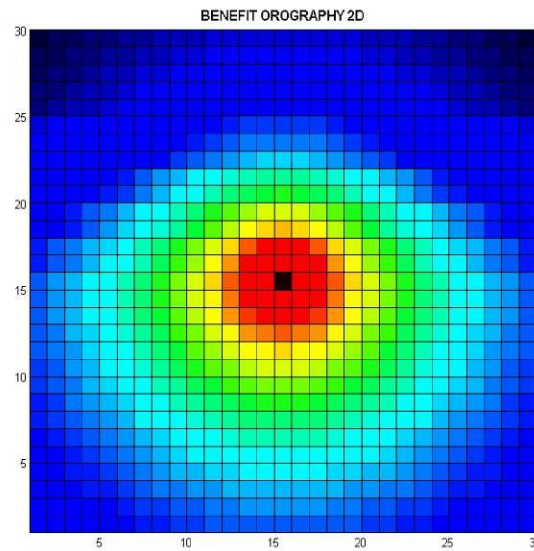
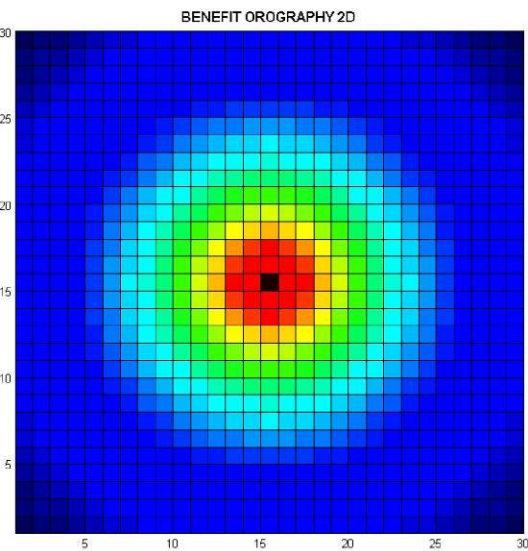


E_1



$E_{II} < E_I$

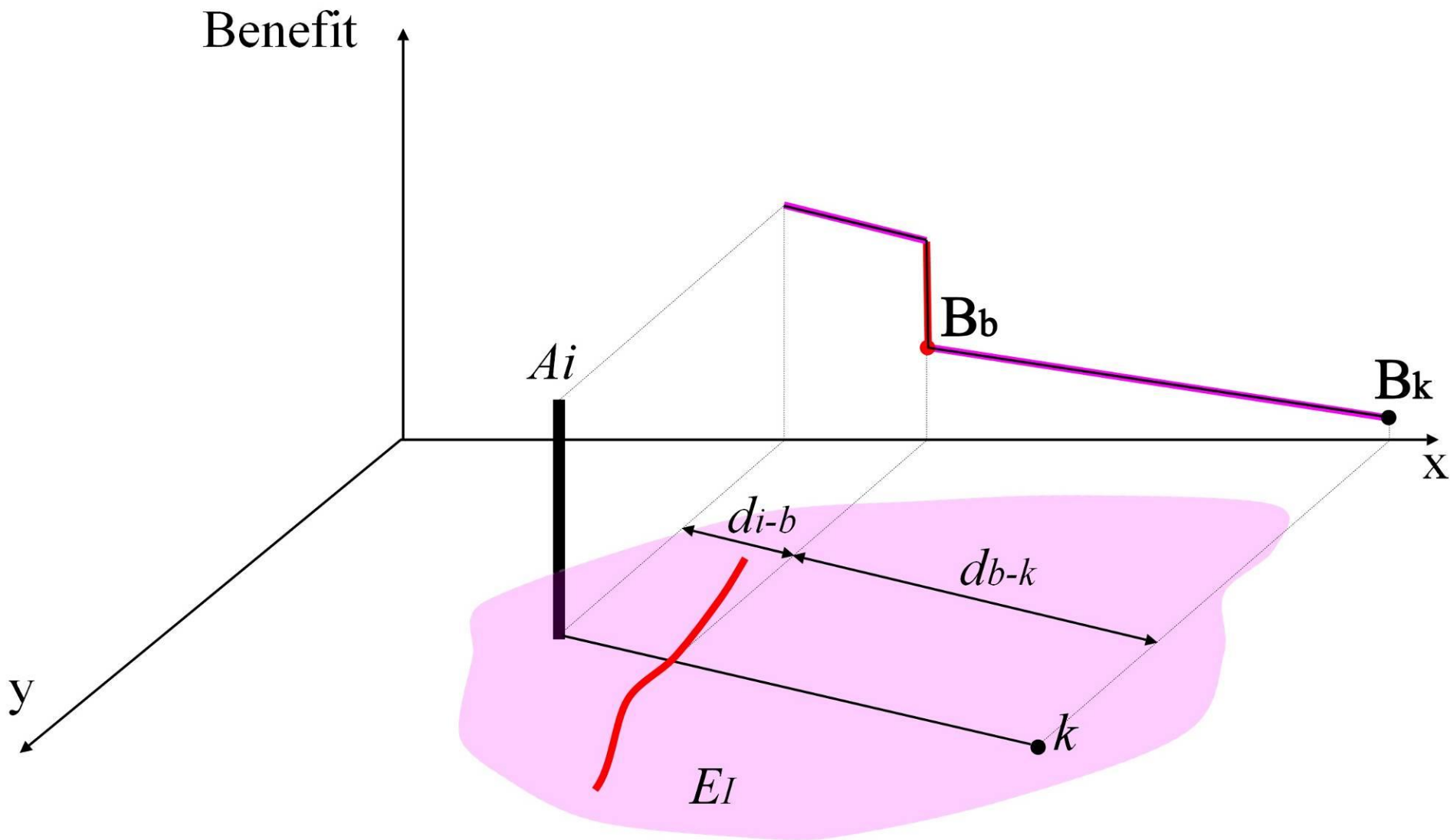


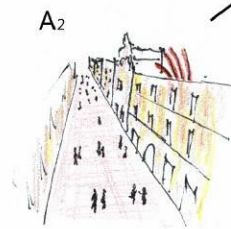
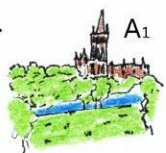


Left: example of one amenity in an isotropic area ($E = \text{constant}$).

Middle: the same amenity but in un-isotropic area with a lower E on the north area of the city.

Right: same example of the "Middle" but with an even lower E .

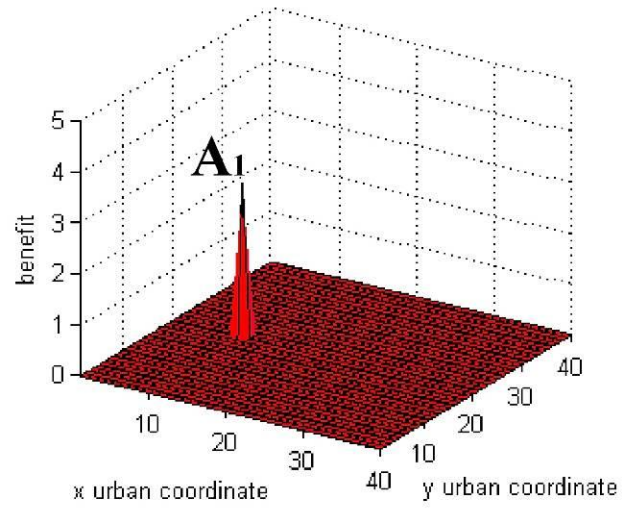




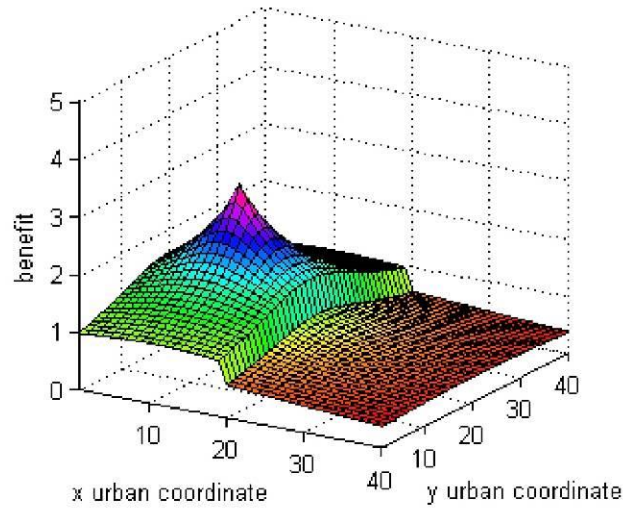
b



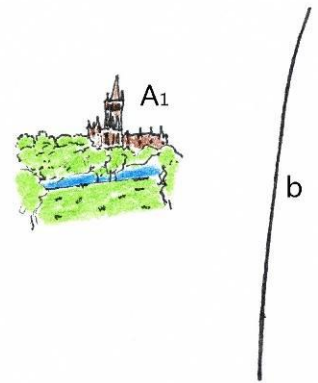
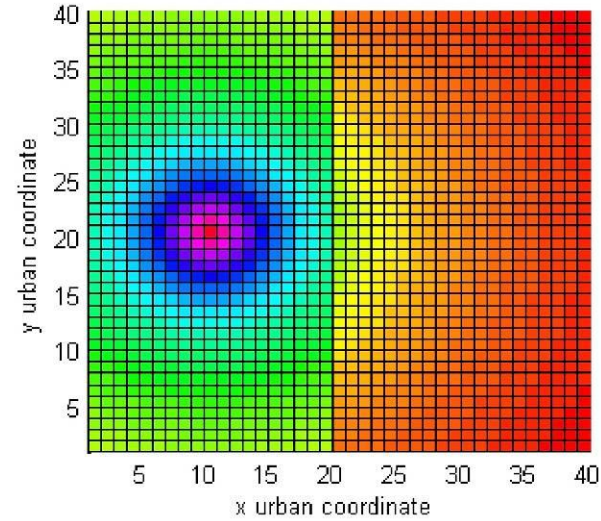
PUNCTUAL BENEFIT



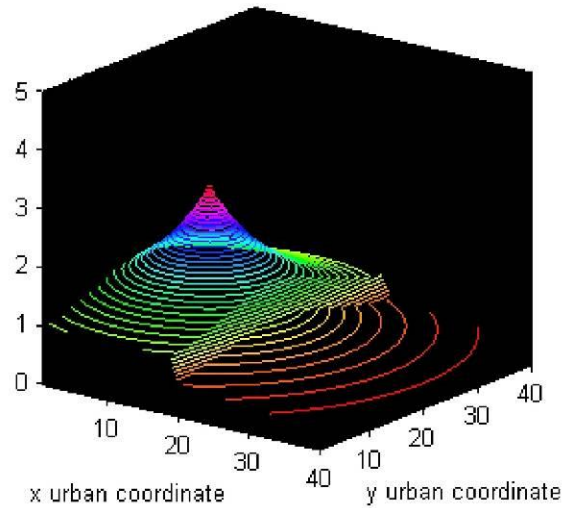
BENEFIT OROGRAPHY 3D



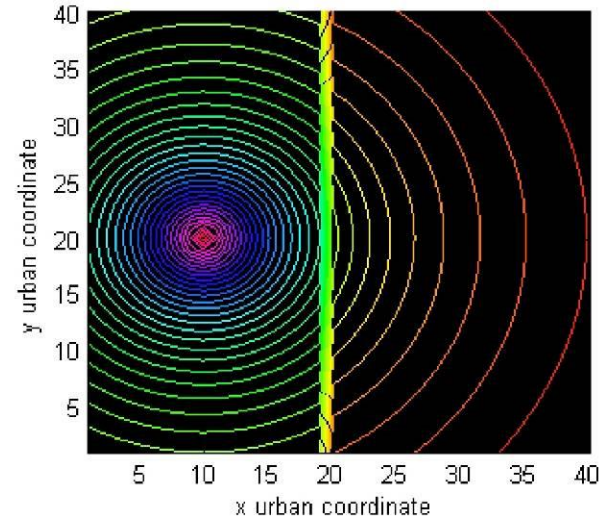
BENEFIT OROGRAPHY 2D



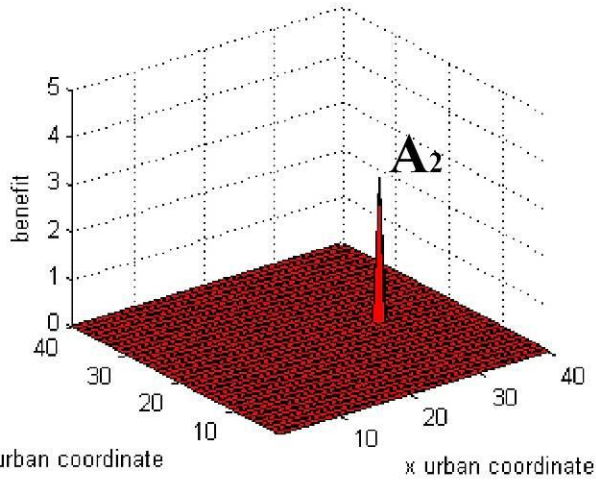
ISOBENEFIT LINES 3D



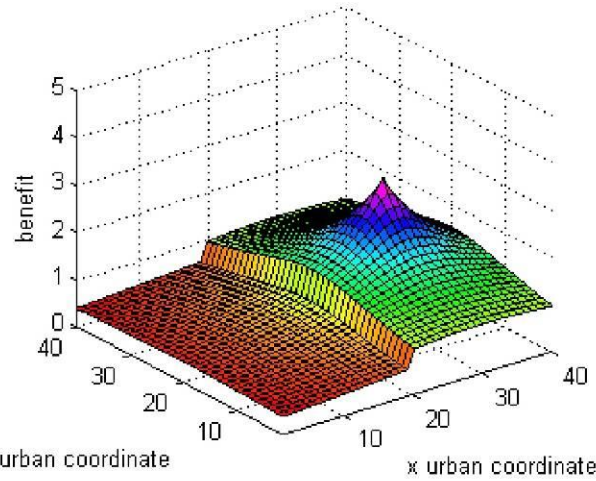
ISOBENEFIT LINES 2D



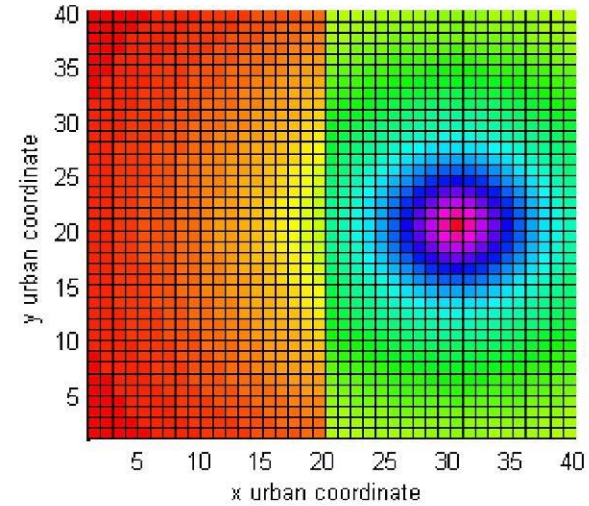
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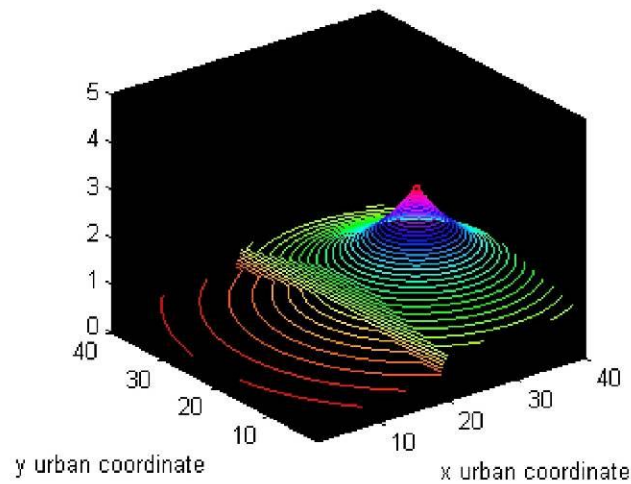
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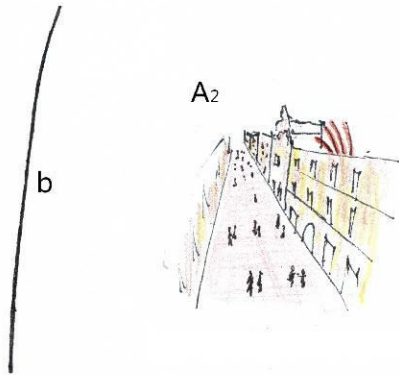
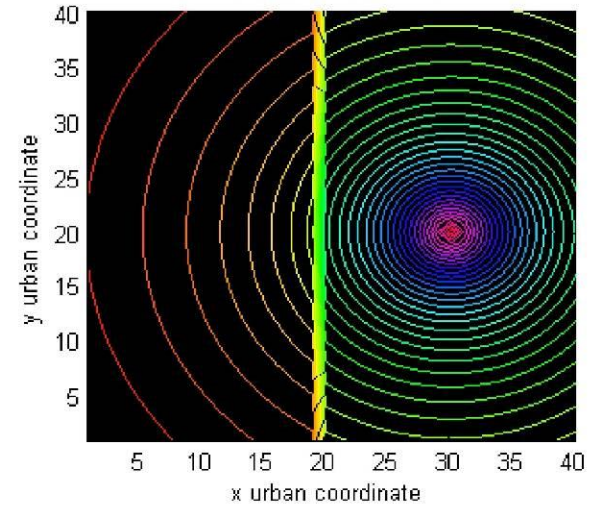
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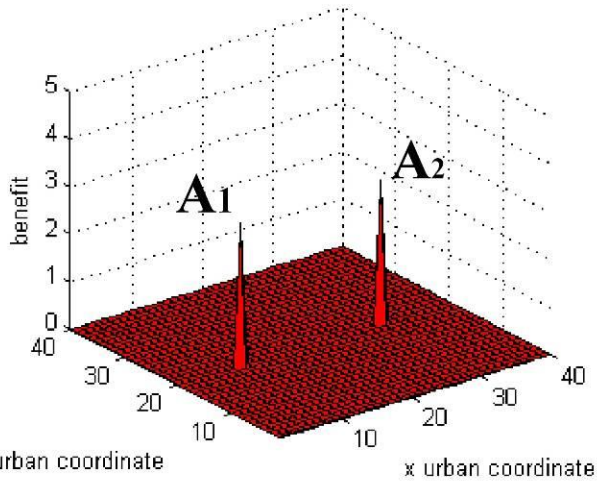
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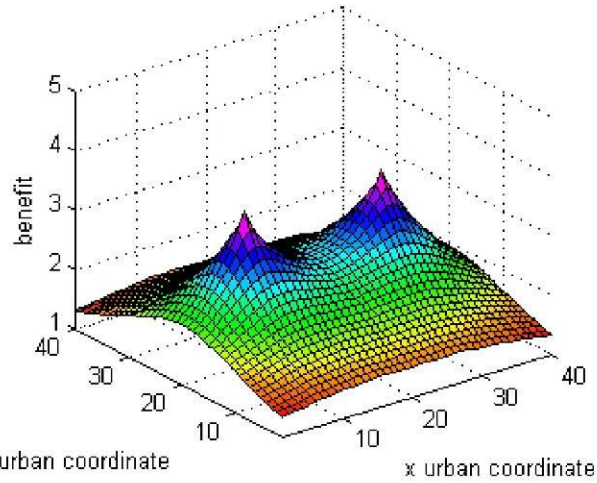
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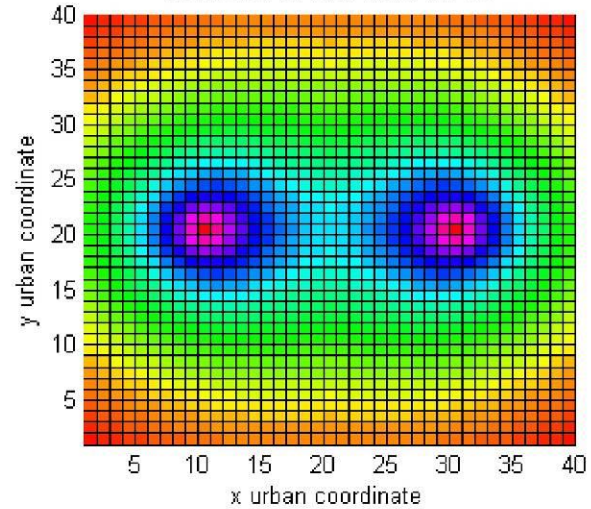
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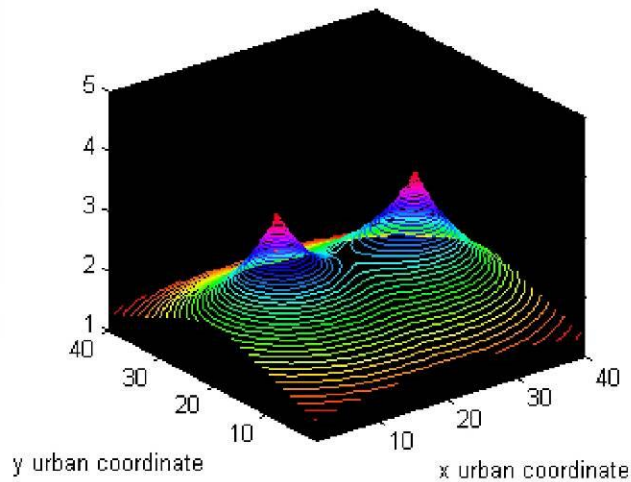
ISOBENEFIT OROGRAPHY 3D



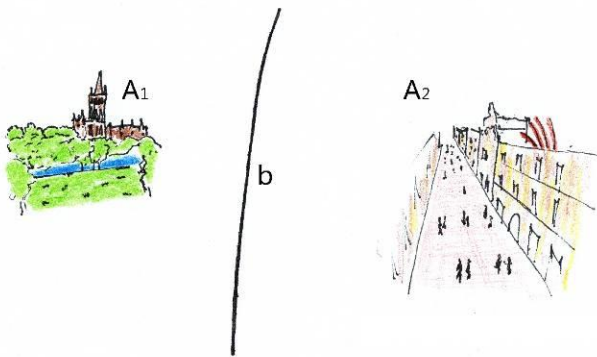
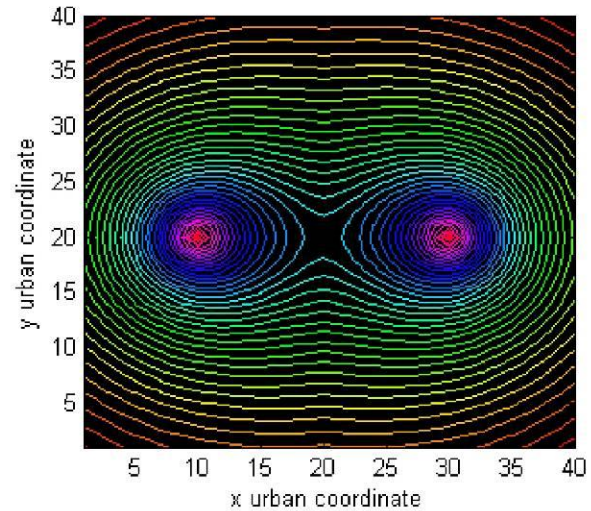
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ISOBENEFIT LINES 3D

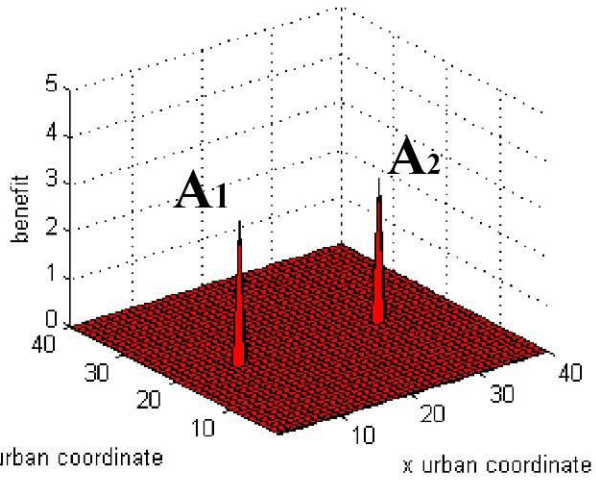


ISOBENEFIT LINES 2D

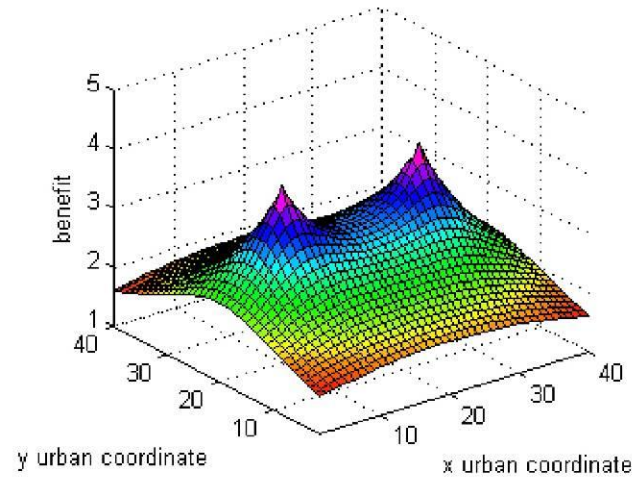


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 U=0.7820

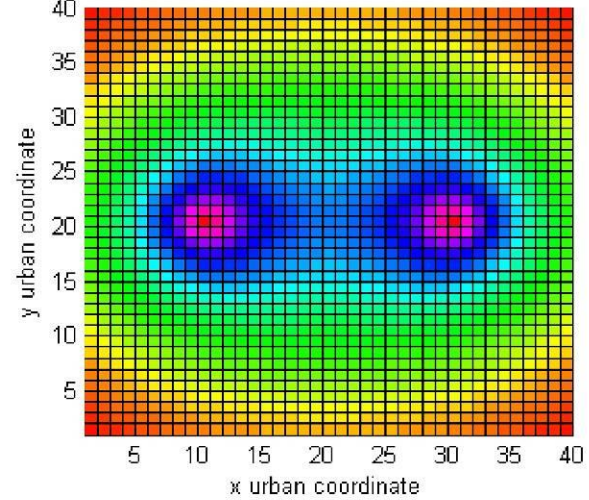
PUNCTUAL BENEFIT



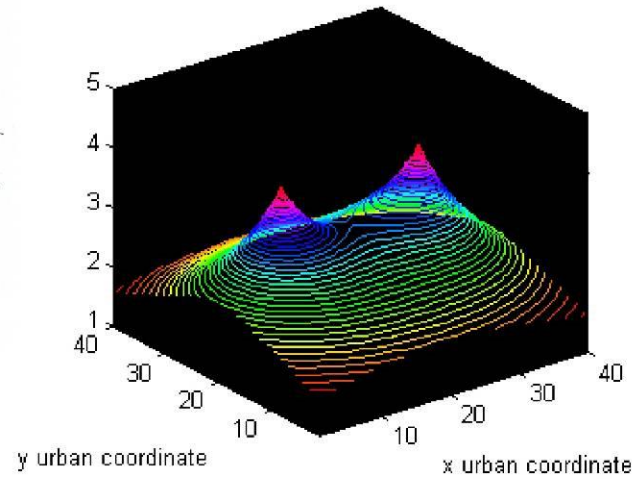
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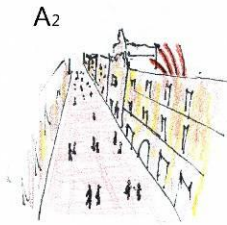
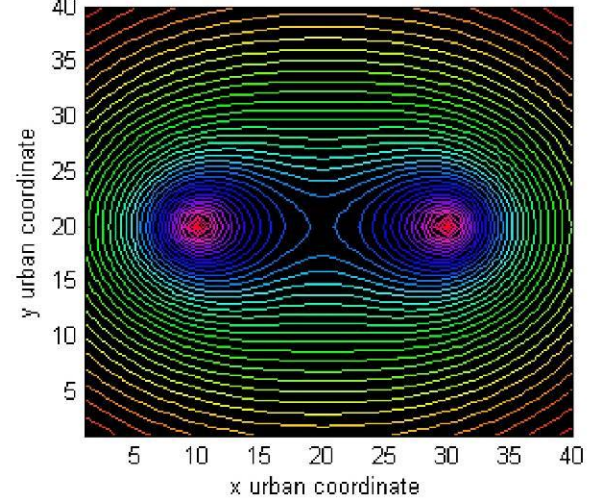
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ISOBENEFIT LINES 3D



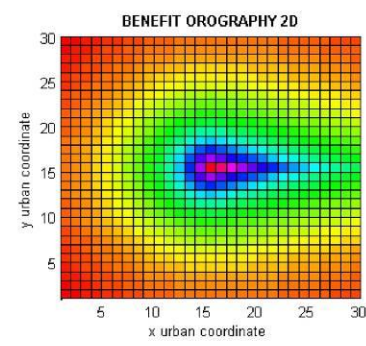
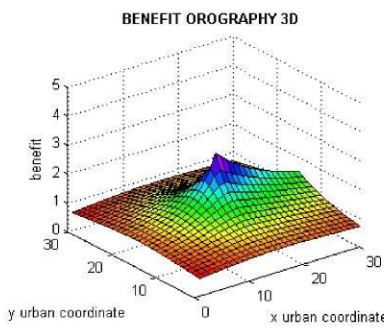
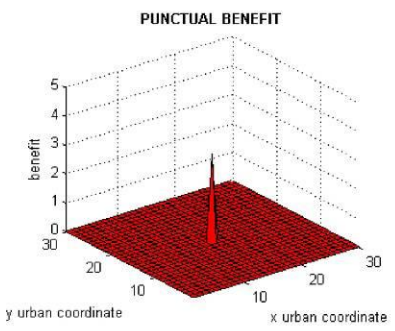
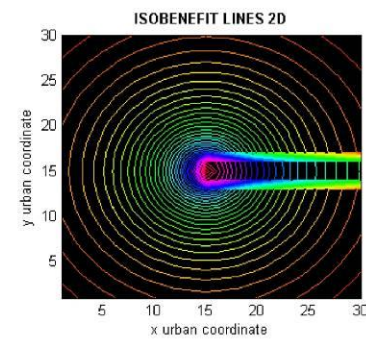
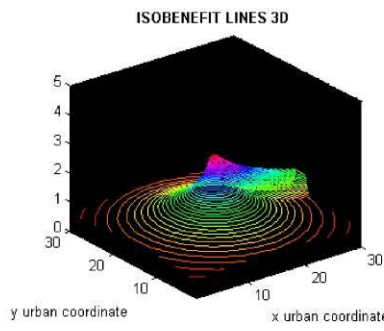
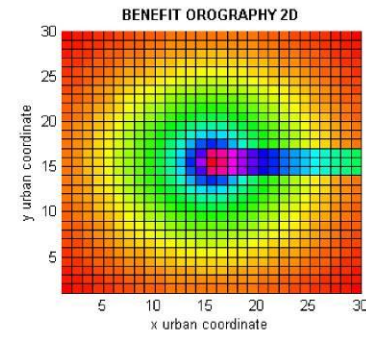
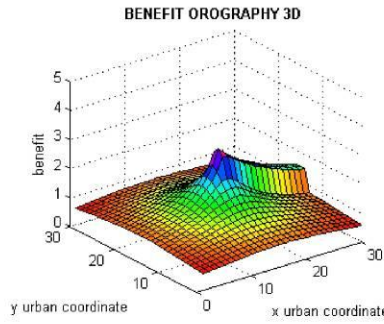
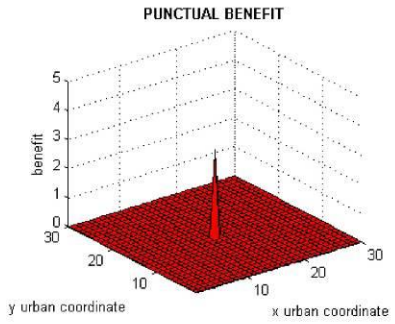
ISOBENEFIT LINES 2D



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 U=0.8033

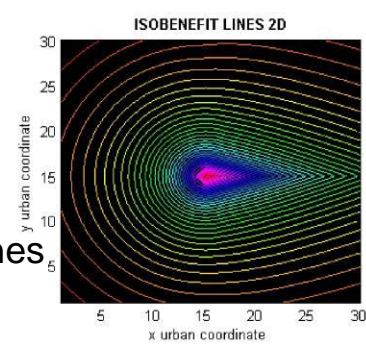
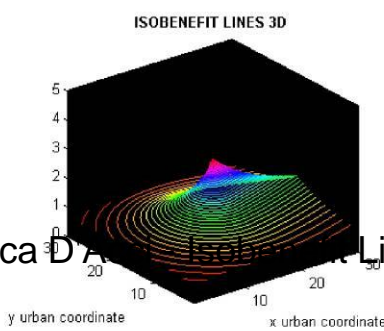
Preferential Pathways (pedestrian and cycle paths, underground, fast streets, etc.)



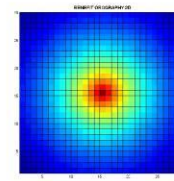
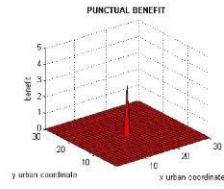


$$B_{i,z} = \frac{B_{i,l}}{1 + d_{i,j)-z} / (\varphi E_l)}$$

$$B_{i,k} = f(B_{i,z}, d_{z-k}, E_{k-z})$$

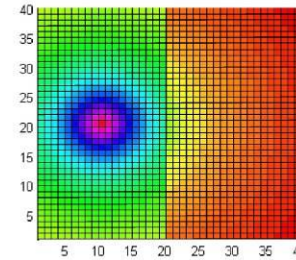


Amenity

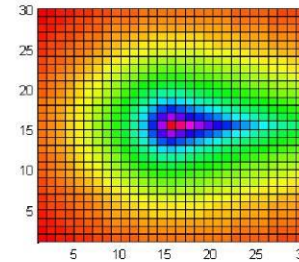


Psycho-temporal-economical alteration of distances and amenity diffusion

BARRIERS

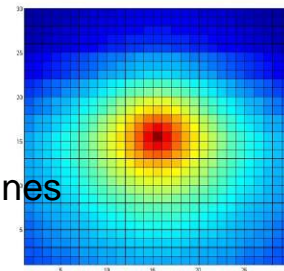


PREFERENTIAL PATHWAYS

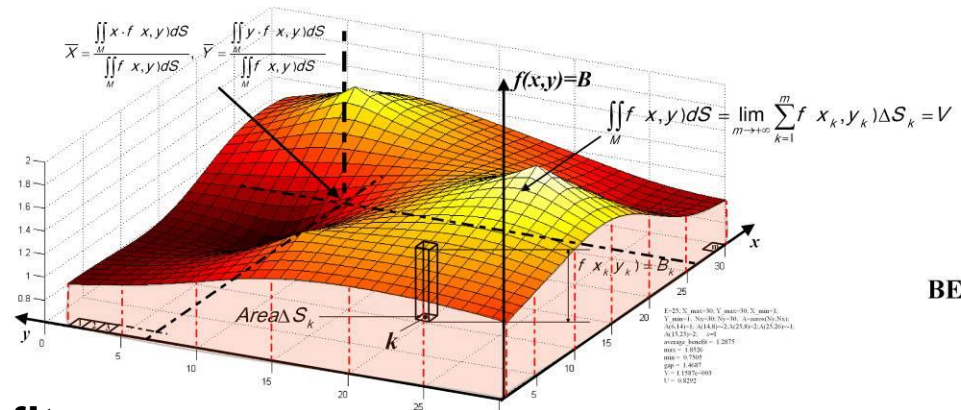


DIFFERENT E

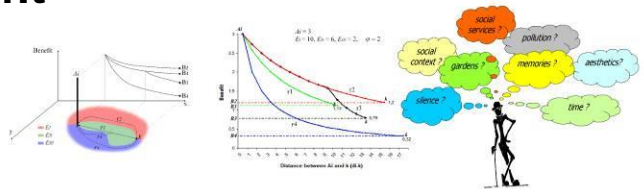
i.e. different general urban quality
(fuzzy urban quality + number and distribution of city centralities),
and/or streets/transport efficiency)



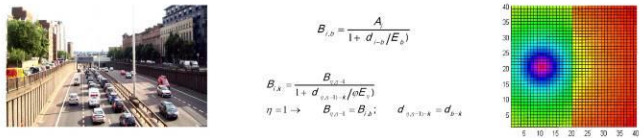
Cities as Maths Volumes of Benefit



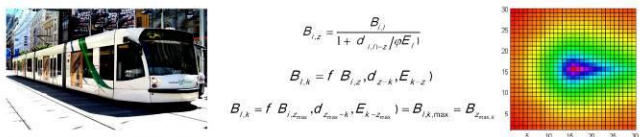
BENEFIT LANDSCAPE



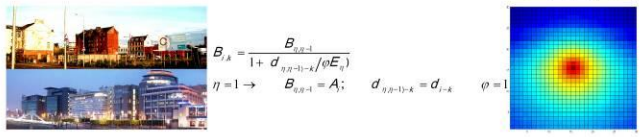
↑
Route choice



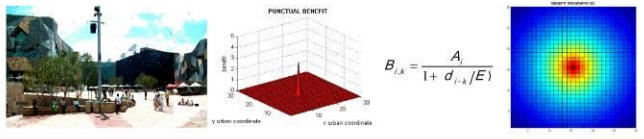
Barriers (Psychological and/or Physical)



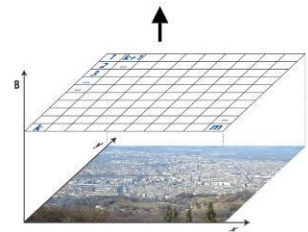
Preferential Paths
(Psychologically and/or Temporally and/or Economically)



Urban Fuzzy Quality, Social Context,
Transports and Streets Efficiency,
Personal Memories and Preferences, etc.



Amenities
quantified on Personal Preferences (*Personal Isobenefit Lines*)
or, if exist, on the "ordinary" Preferences

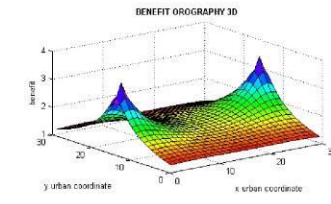
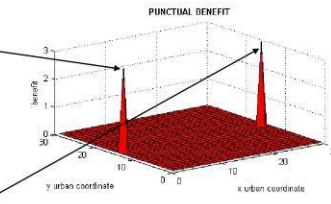


CITY

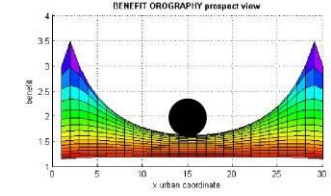
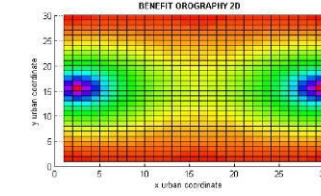




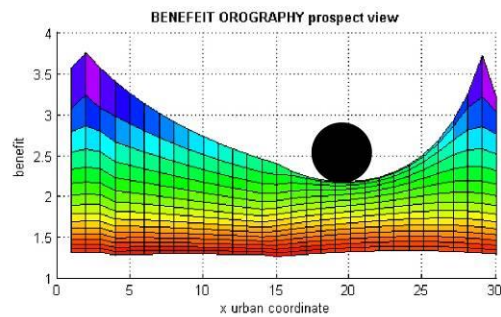
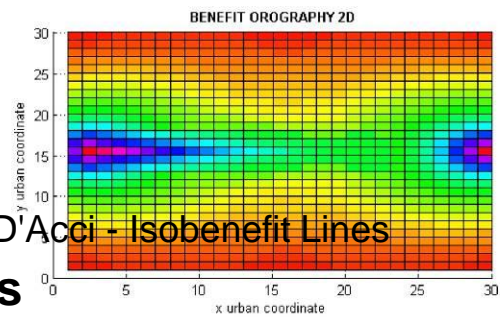
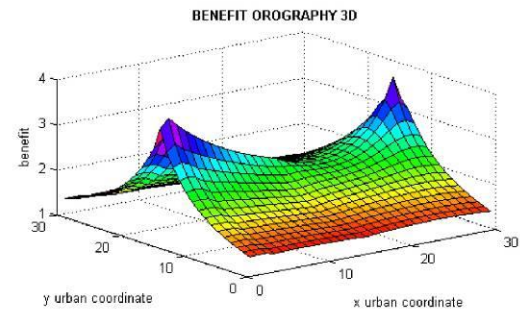
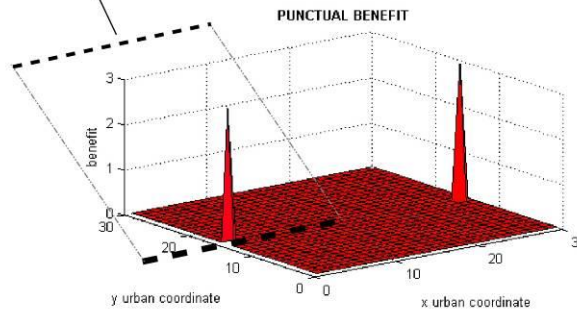
A1



A2



Preferential Pathway

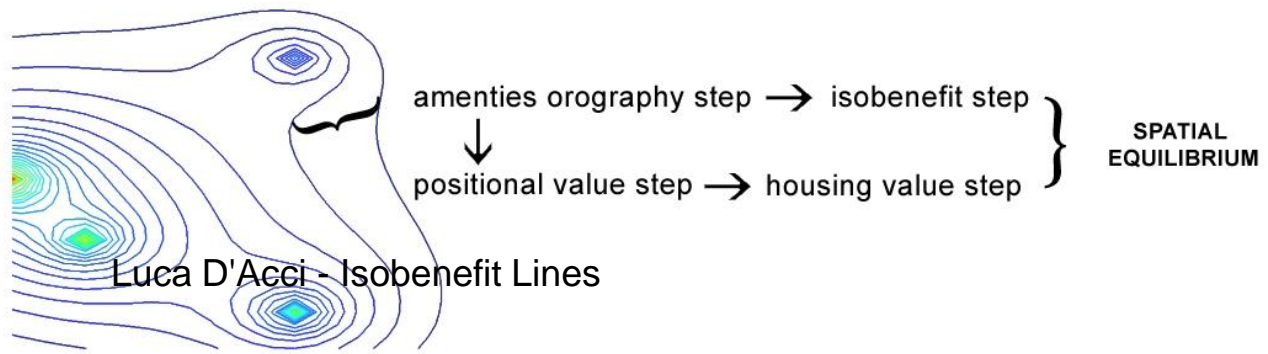
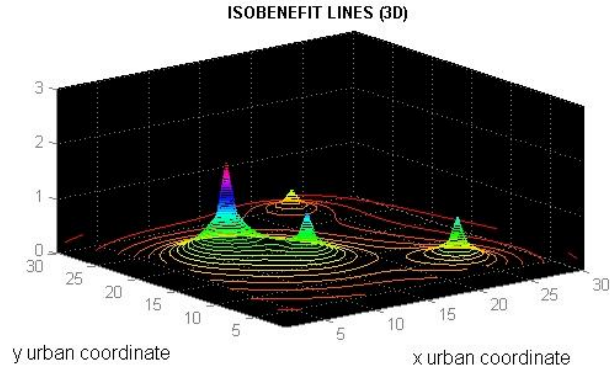
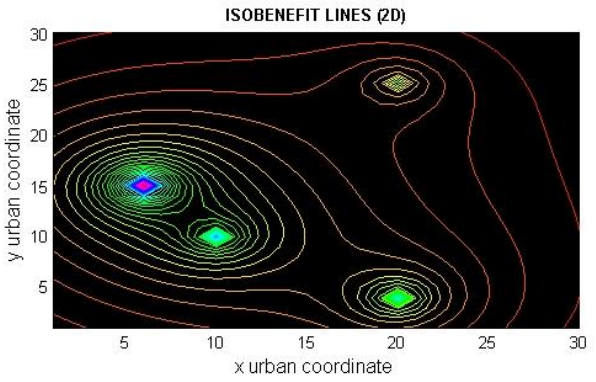
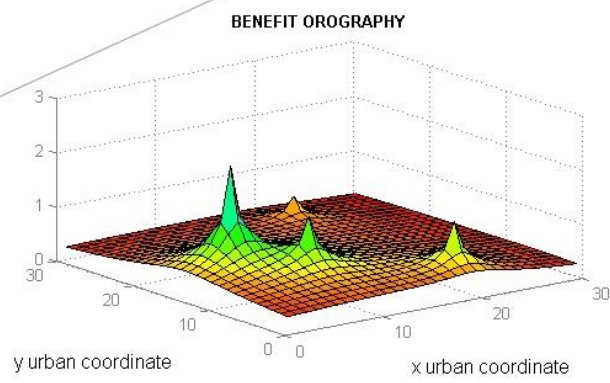
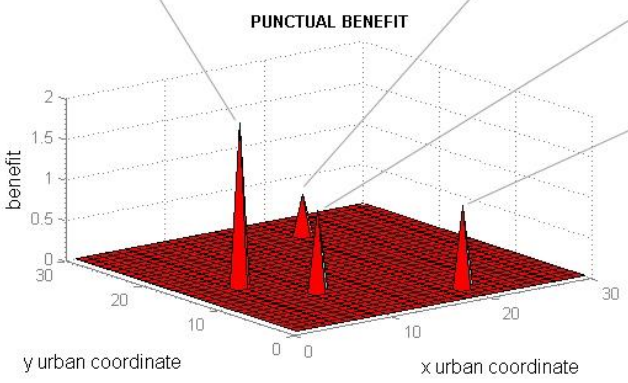


9 Nov 2015 - ETH

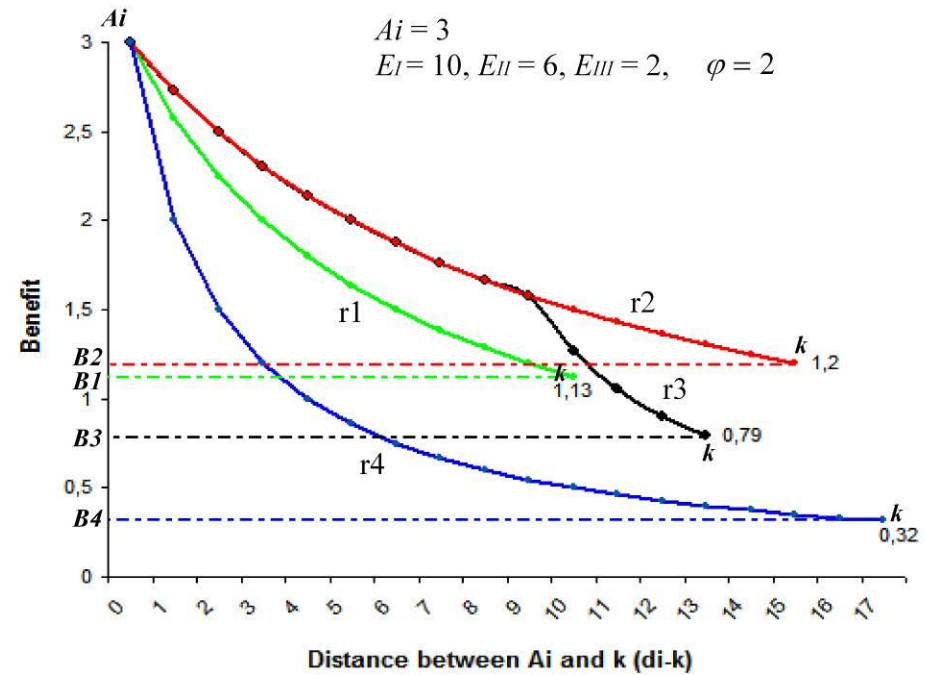
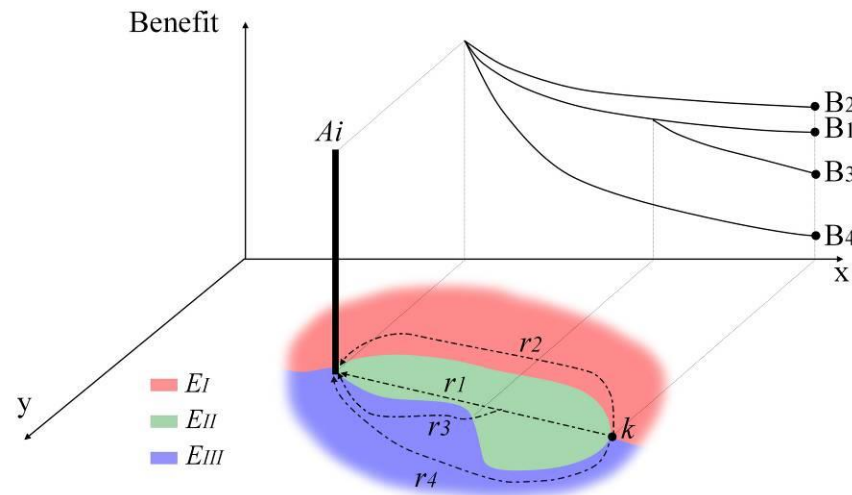
Luca D'Acci - Isobenefit Lines

Breaking points of equal attractions

Spatial Equilibrium & Isobenefit Lines



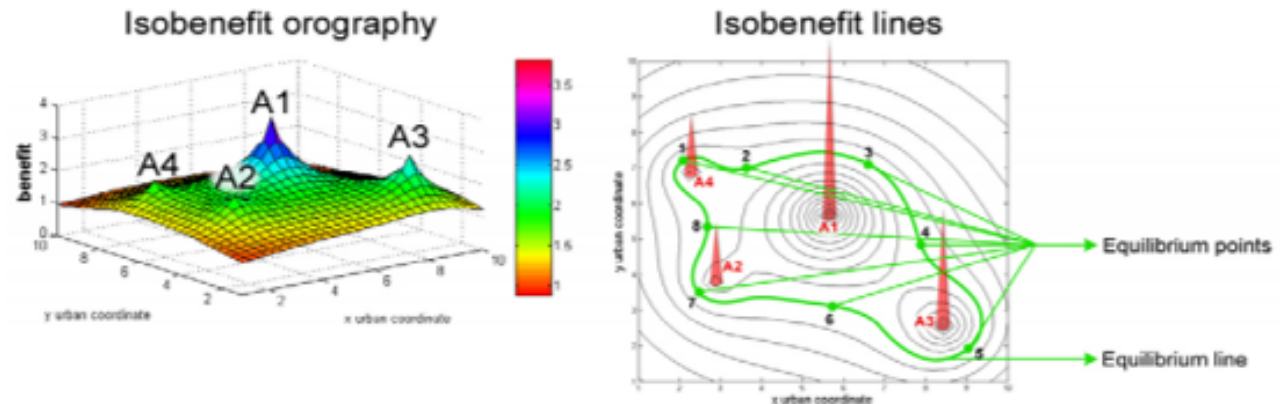
Citizens movement within cities



Isobenefit Lines Rewrite Rules for Understanding City Life

A new way of mapping cities according to the benefit they give residents has the potential to change the way planners think about city design

From MIT Technology Review, published by MIT, Massachusetts Institute of Technology
www.technologyreview.com/view/429679/isobenefit-lines-rewrite-rules-for-understanding/



Cities are vast, dynamic entities that are complex on a multitude of different scales. A visitor to any city can usually gauge within hours whether it “works” on a human level. But it is famously hard to quantify the factors that make one city better than another.

D'Acci L. (2013). [Simulating Future Societies in Isobenefit Cities.](#) *Futures*. Volume 54, pp 3-18

D'Acci L. (2015). [Urban DNA for cities evolution.](#)
<http://arxiv.org/abs/1408.2874>

D'Acci L. (2015). [Mathematize urbes by humanizing them. Cities as Isobenefit Landscapes: Psycho-Economical distances and Personal Isobenefit Lines.](#) *Landscape and Urban Planning*, Volume 139, July 2015, Pages 63–81.

www.urem.eu/isobenefit

www.urem.eu/isobenefit/lectures.html

references:

- D'Acci L., (2013). Monetary, Subjective and Quantitative Approaches to Assess Urban Quality of Life and Pleasantness in Cities. *Social Indicators Research*, January 2014, Volume 115, Issue 2, pp 531-559
- D'Acci L., (2013). Hedonic inertia and underground happiness. *Social Indicators Research*, September 2013, Vol 113, n.3, pp 1237-1259.
- D'Acci L., (2013). Simulating Future Societies in Isobenefit Cities. *Futures*. Volume 54, November 2013, Pages 3–18.
- D'Acci L., (in press 2015). Mathematize urbes by humanizing them. *Landscape and Urban Planning*.