Center for Geographic Analysis
Institute for Quantitative Social Sciences
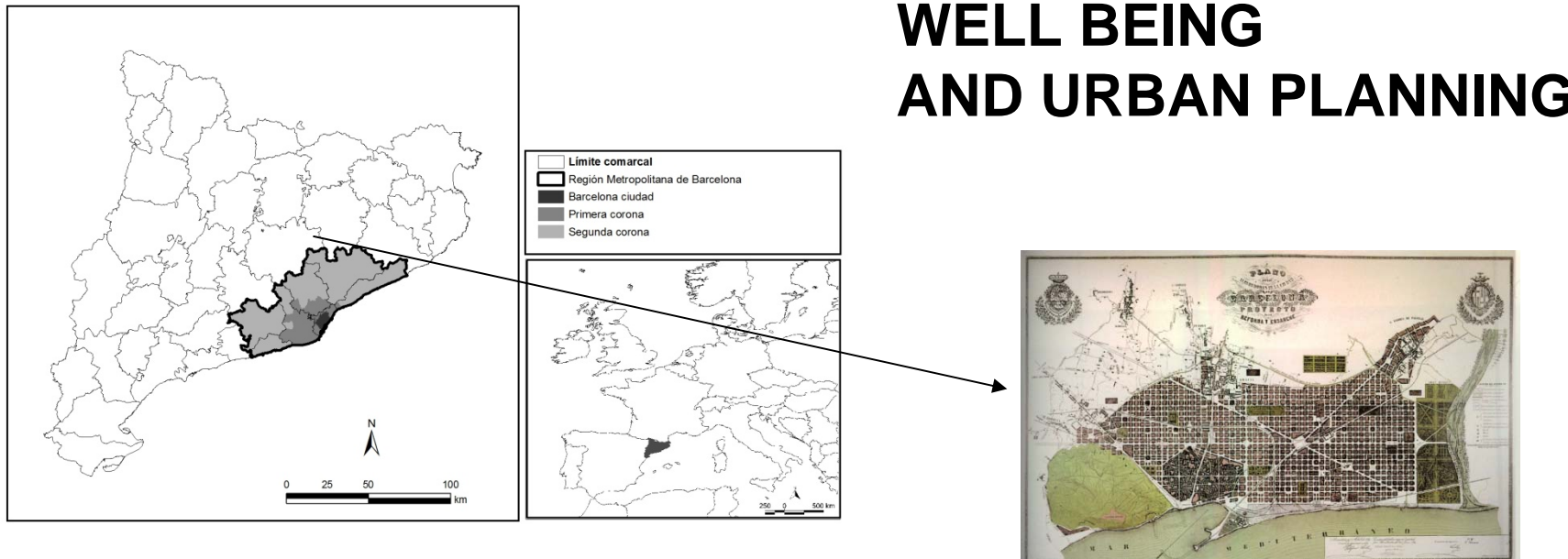**Harvard University**

CERDÀ AND BARCELONA.

ABCD-GIS Meeting <u>March 16, 2011</u>
Presenter: Montserrat Pallares-Barbera, Ph.D., Visiting Scholar at the CGA
Presentation: "CERDÀ AND BARCELONA. A DISCUSION ON SPATIAL WELL BEING AND URBAN PLANNING"
When: Wednesday, March16. Noon - 1:30
Where: Room S050 in the CGIS South building at 1730 Cambridge St.

WELL BEING
AND URBAN PLANNING

Límite comarcal
Región Metropolitana de Barcelona
Barcelona ciudad
Primera corona
Segunda corona

MONTSERRAT PALLARES-BARBERA,
ANNA BADIA, JORDI DUCH

mpallares@cga.harvard.edu

Parts of the talk

- How normative urban planning could be used as a tool to redistribute well being across individuals

- How to optimize the use of resources such as schools, markets, parks and hospitals

- Case study, the Cerdà's urban expansion of Barcelona done in 1860

- Methodology from location theory, such as spatial location-allocation models and GIS for data capturing and analysis

Public goods

- Assumption that services are public goods
- The use of a pure public good do not affect other people's utility in using them
- Pure public good is not subject to congestion
- I.e., allocation of people to schools do not decrease the utility for other people,
- Choosing a service location depends on individual's distance to a service

OUR OBJECTIVES

- We want to get further elements to incorporate in planning practices
- We want to study the distribution of well being over the space
- To study Cerdà's proposal and current methodology from location theory and GIS

- Our working hypotheses are the following:

  – Cerdà's proposal for the expansion of Barcelona had the aim to improve the population living standards
  – He used urbanism as a redistribution tool
  – He emphasize the access of population to services as an important mechanism of improving social well being
  – Cerdà's proposal is normative urban planning which differed from real situations; and we can learn from this for future strategies of governance

CERDÀ AND HIS PRECONDITIONS AS URBAN PLANNER

- Technology
- "social order" need a container (Cerdà 1869, p. 6)
- movement and communicability (Cerdà 1869, p. 8)
- Strength to do it
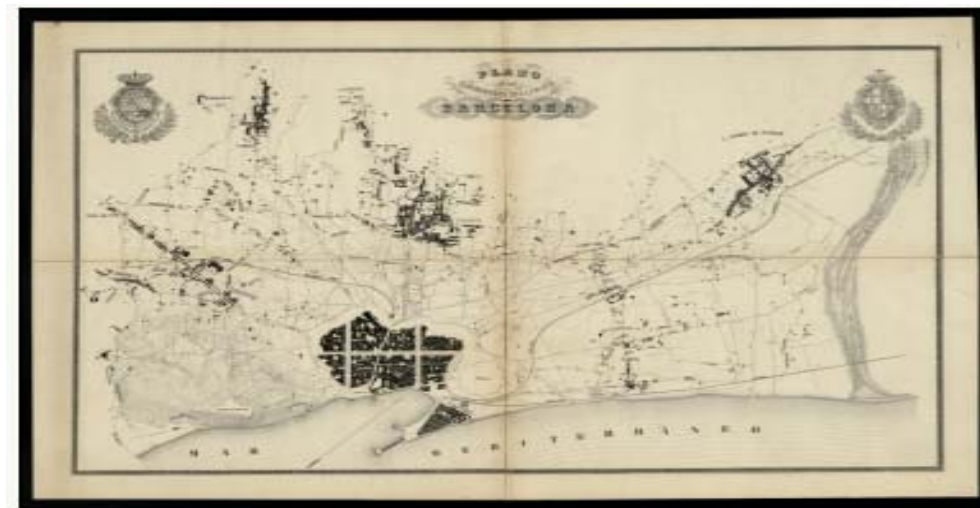- "social philosophy and the urbanization concept" (started in 1849 p. 9); "la idea urbanizadora"

BASIC FACTS ABOUT BARCELONA 1860: a boiling pot

- Increasing population
- 182 factories, 54272 workers (41% women) (Cerdà 1869, p. 206)
- Workers' strikes 1855 (Engels, Toynbee p. 118)
- "The wall" a political reason
- Plagues
- 802 inhab/ha

Barcelona's Old City
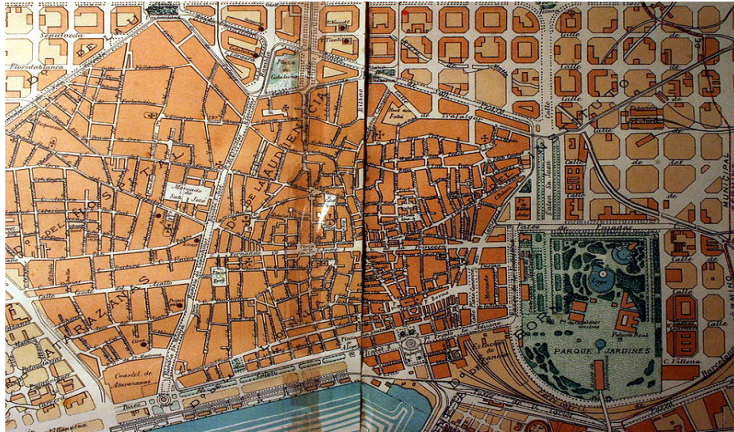
Topographic map of Barcelona 1958

# Cerdà and the Old City. the unbearable urban density

- "Monograph about statistics of the working class of Barcelona" (1856): living conditions
- "social statistics" as action tool
  - Density 11.44 sq m/person; 183,877 inhabitants (Garriga i Roca 1857-1858)
  - Mortality as dependent variable
    - food intake
    - family budget
    - working conditions
  - House dimension-house density

The Inside-wall city: density and mortality in the **first** (second) floor

Density inh/house (1859)

Mortality rate/1,000 people (1856-1865)

≡ From less than 3, to more than 4.

≡ From less than 20, to more than 30.
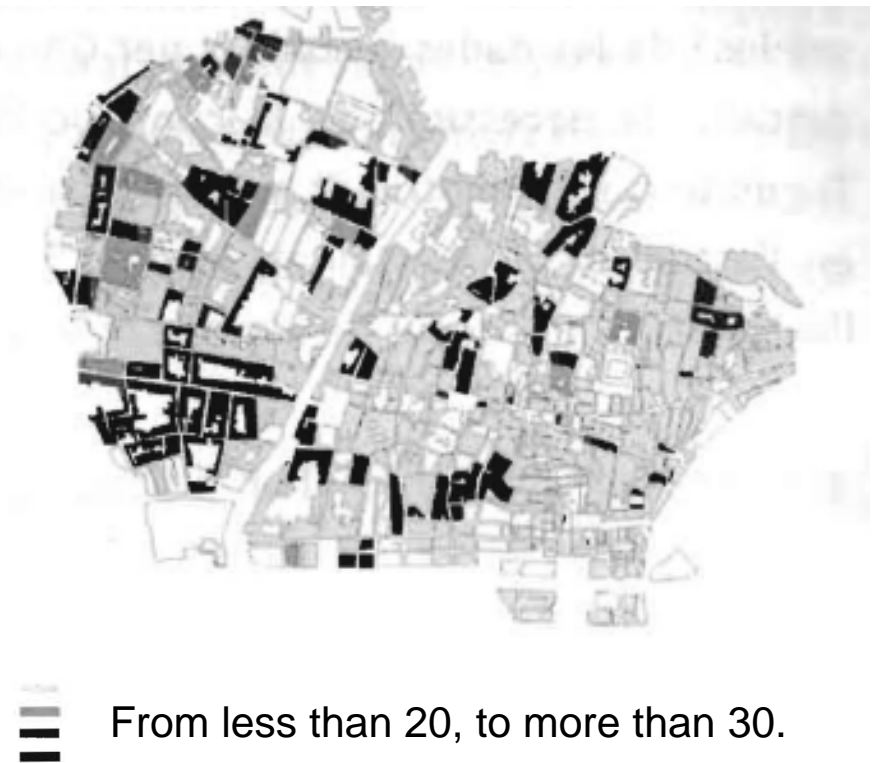
Source. Canedo Arnedo, M. **Geohistòria ambiental de la Barcelona del segle XIX**. Master Research Project. Universitat Autònoma de Barcelona. Geography Department, 2010.

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"The house is the coffin of the living human" (Monlau in García Fària 1894)(1)

Density inh/house (1859)

Mortality rate/1,000 people (1856-1865)
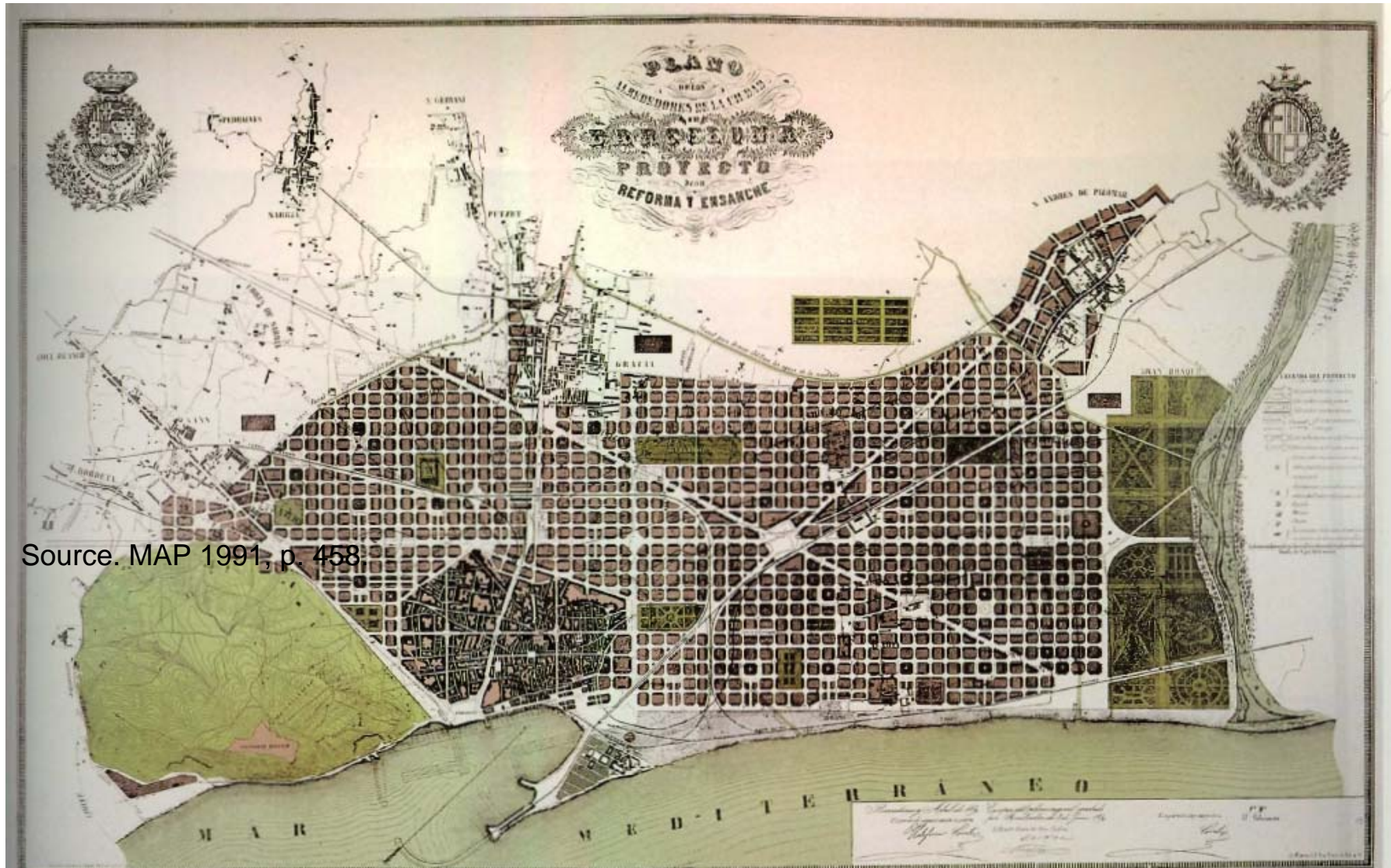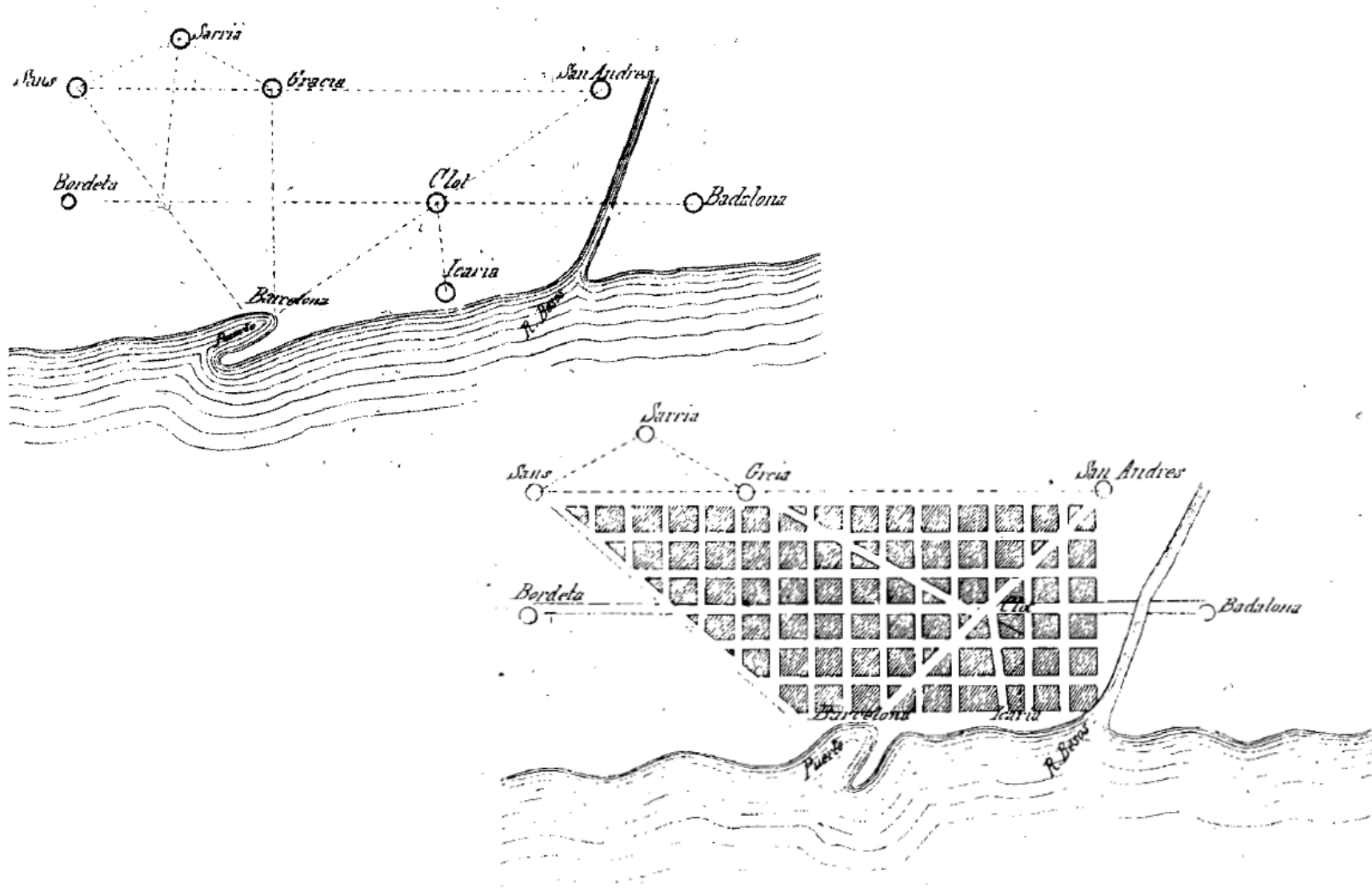

From less than 3, to more than 4.

From less than 20, to more than 30.

The Inside-wall city: density and mortality in the **fourth** floor

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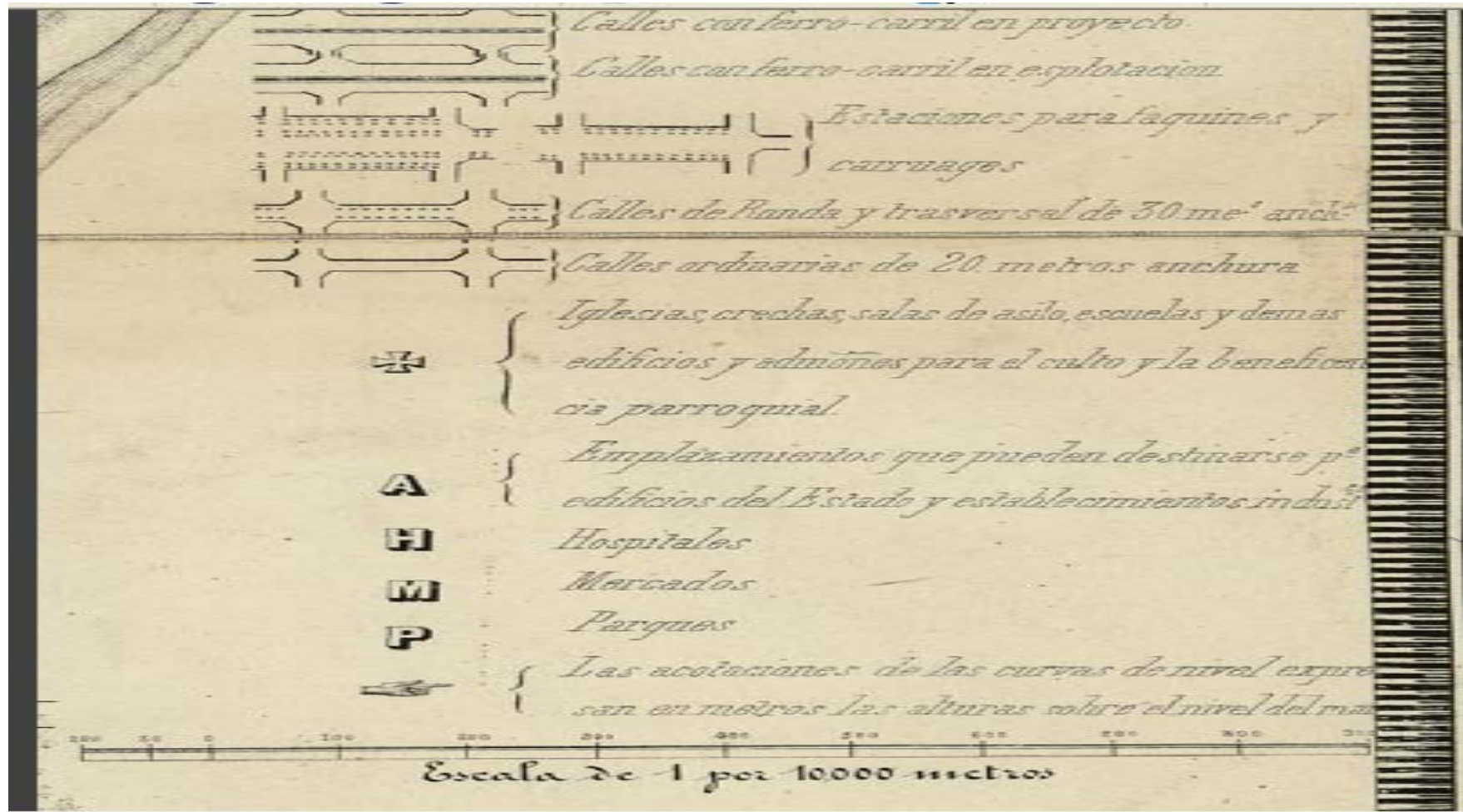
Cerdà's Map of Urban Expansion of Barcelona 1861

Source. MAP 1991, p. 458.

New city center and first approaches to new Barcelona

Cerdà's Map legend

His main variables

Espresión general del lado de las manzanas

Para formular ahora de una manera general la espresion del lado de las manzanas, en funcion de todas las variables que en ella deben figurar, supondrémos que sea:

x...... Lado de la manzana
2b.... Anchura de la calle
f ...... Fondo del solar de construcción
d...... Fachada del solar de construccion
v...... Número de habitantes por casa
p...... Número de metros de superficie que han de tocar por individuo de la total de la poblacion

Se tendrá para las manzanas:

$$\text{Cerradas} \begin{cases} \text{con chaflanes } x = \dfrac{2pv - 2bd}{d} \pm \sqrt{\dfrac{4pv\,(pvf - 2bdf - b^2d - df^2)}{d^2f}} \\[2em] \text{sin chaflanes } x = \dfrac{2pv - 2bd}{d} \pm \sqrt{\dfrac{4pv\,(pv - 2bd - df)}{d^2}} \end{cases}$$

$$\text{Abiertas} \begin{cases} \text{con chaflanes } x = \dfrac{pv - 2bd}{d} \pm \sqrt{\dfrac{pv\,(pvf - 4bdf - 4b^2d)}{d^2f}} \\[2em] \text{sin chaflanes } x = \dfrac{pv - 2bd}{d} \pm \sqrt{\dfrac{pv\,(pv - 4bd)}{d^2}} \end{cases}$$

Aplicando ahora a estas fórmulas los siguientes valores constantes:

2b = 20   y suponiendo ademas que los valores de V sean   71
f = 20   57
d = 20   43
p = 40   29

Obtendremos los dos siguientes estados:

Source. Cerdà 1861 (transcribed 1991).

Typology of blocks in the Cerdà Map (1)

- Block with housing built at two of the faces. Area: 12.500 sq meters.
    - Building occupation: 40% of total block

- Block with housing built at one of the faces. Area: 10.901 sq meters.
    - Building occupation: 20%

- Block with alley in the center. Area: 4.021 sq meters.
    - Building occupation: 50%

- Block with two housing rows intersected. Area: 12.500 sq meters

- Block with three housing rows, one of them smaller. Area: 12.500 sq meters

- Block with three housing rows connected. Area: 9.800 sq meters
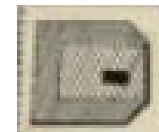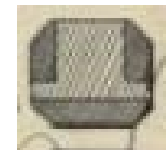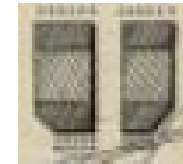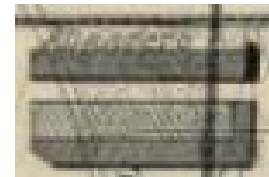
Typology of blocks in the Cerdà Map (2) Unusual types

- Larger blocs with 4 rows of housing. Area 24,250 sq meters

- Larger blocs with 2 rows of housing. Area 23,100 sq meters

- Larger blocs with 2 rows of housing. Area 10.220 sq meters.

Irregular blocks found in the South of the Map. Areas: 9,920, 7,370 and 3,876 sq meters

Irregular blocks found in Sant Andreu. Areas: 14,794 and 12,700 sq meters

Triangular block found in the Diagonal. Area: 4,202 sq meters

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Methodology

- **1. Spatial-optimization** models implemented in GIS and SDSS
- **2. Test and analyze the optimal** and suboptimal objectives and generate a number of compromised spatial solutions that can be both feasible and different from one another
- **3. Data capturing and spatial analysis: ArcGIS Network Analyst**
    - Spatial data:
        - Georeferentiation of the base map (Spatial referencing data)
        - Digitalization: arcs, nodes, polygons, blocks
        - Distance
    - Alphanumeric data:
        - Population
        - Income

The optimization model

Choose x_{ij} in order to minimize:

$$Z = \sum_{i=1}^{n}\sum_{j=1}^{p} a_i d_{ij} x_{ij}$$

subject to

$$x_{ij} \in \{0,1\}$$

$$\sum_{j=1}^{p} x_{ij} = 1$$

Where,
a_i = quantity of population in node i,
i = origin of population,
j = possible service location,
n = number of nodes,
p = number of services,
d_{ij} = the shortest distance between node i and node j,
x_{ij} = 1 if population of node i is assigned to j, 0 otherwise.

Imposing more constraints....

- Constraints:
  - All population is suppose to have the same amount of income
  - Schools and services have unlimited capacity. It is limited by the quantity of population allocated to service
  - Facilities offer the same type of service, product, or quality

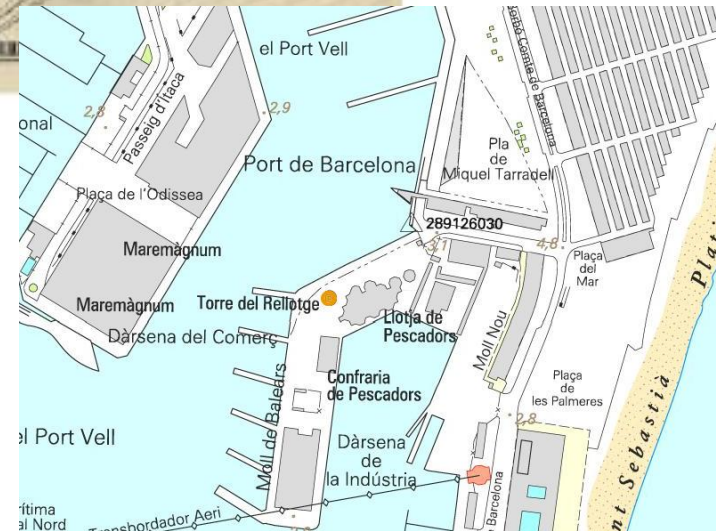# Figure 2. Capturing geospatial data. Rotating and scaling the Map
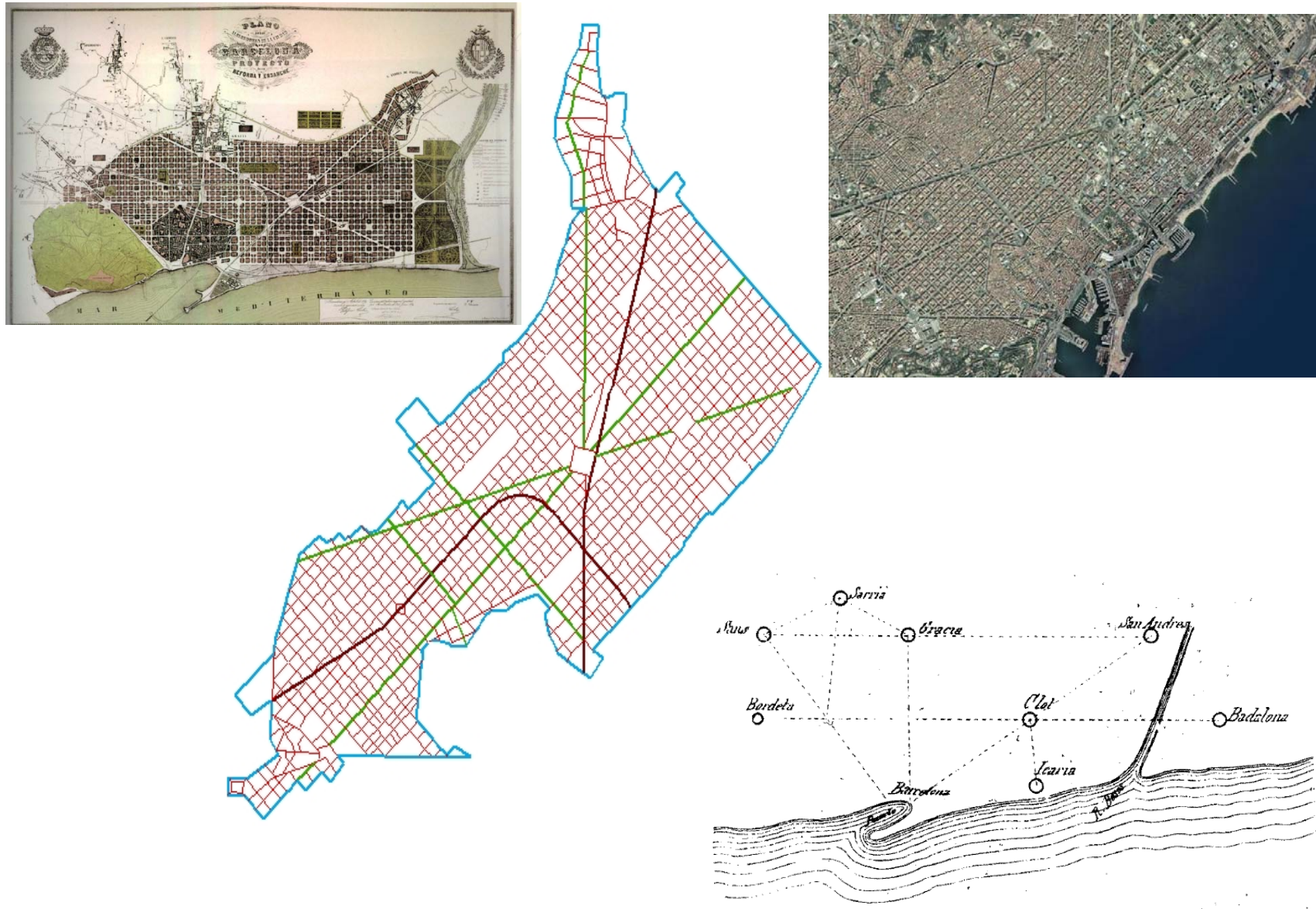
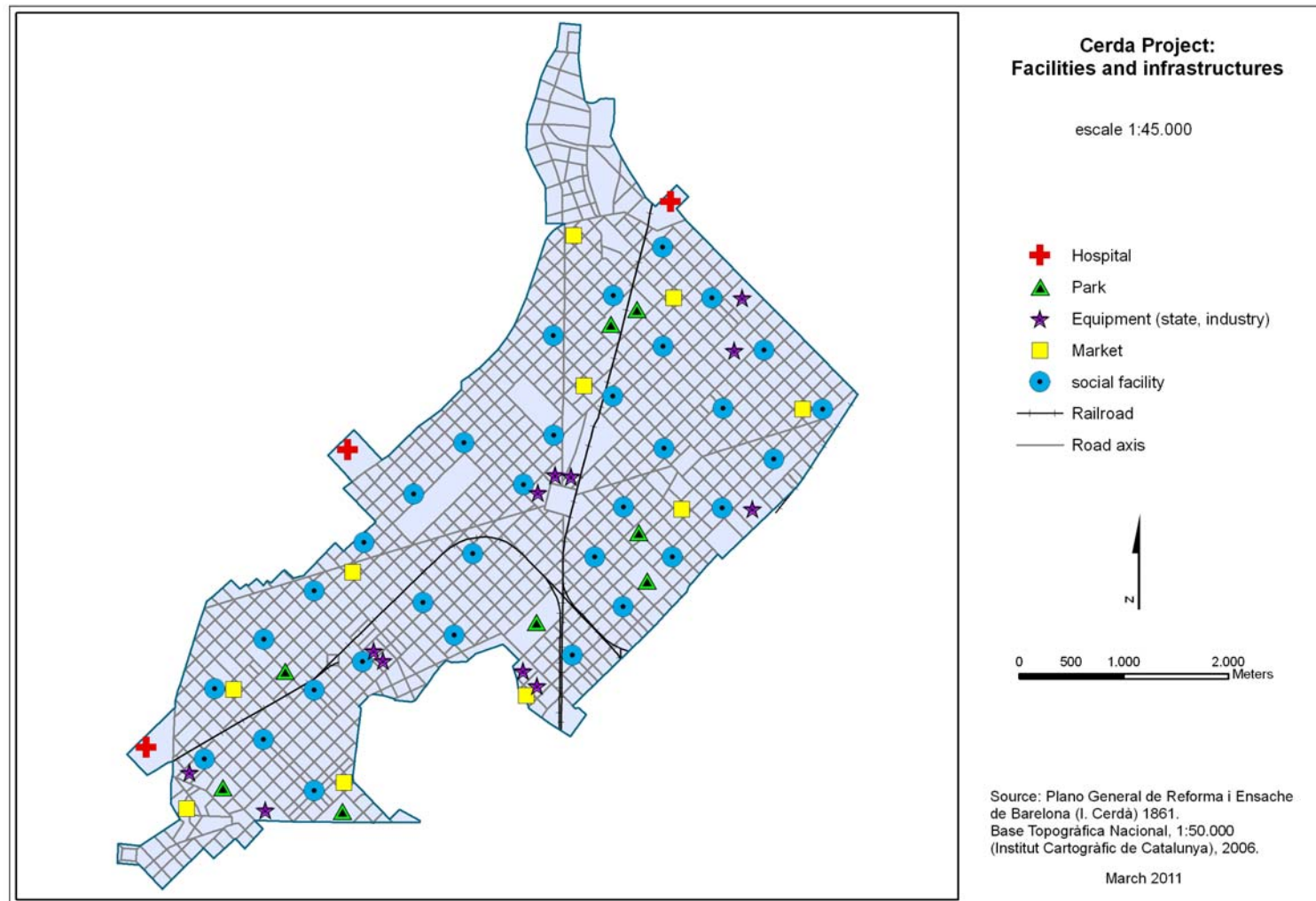# Figure 3. Control points used in the georectification of the image Map Cerdà
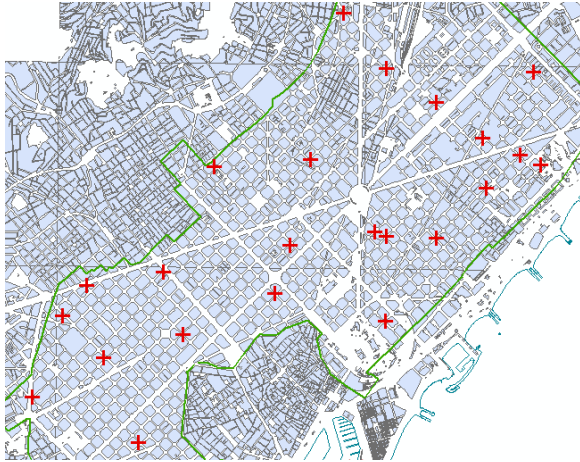
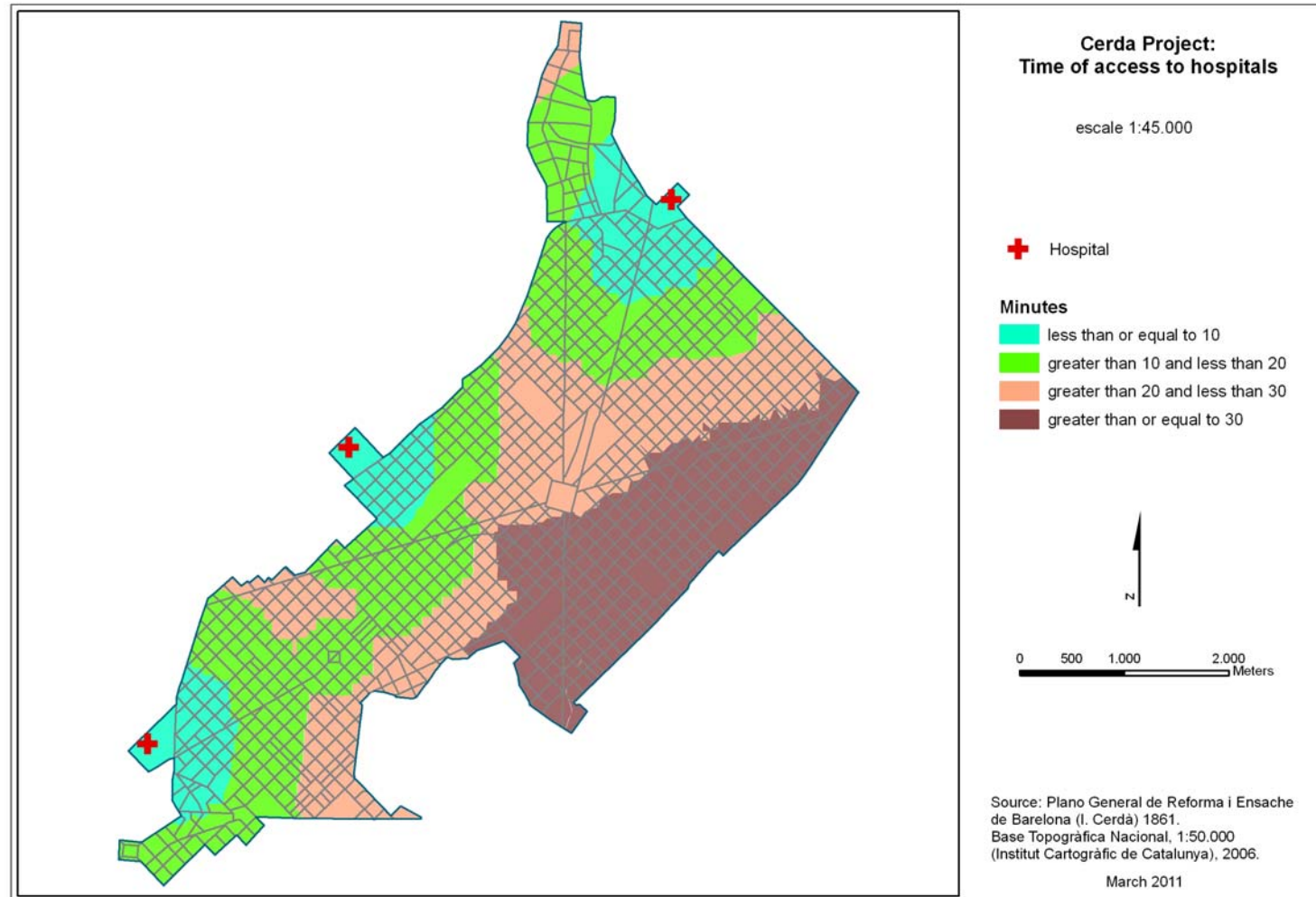Intersection of Meridiana and Parallel Avenues. The Clock Tower

Original Map and the current Barcelona's grid
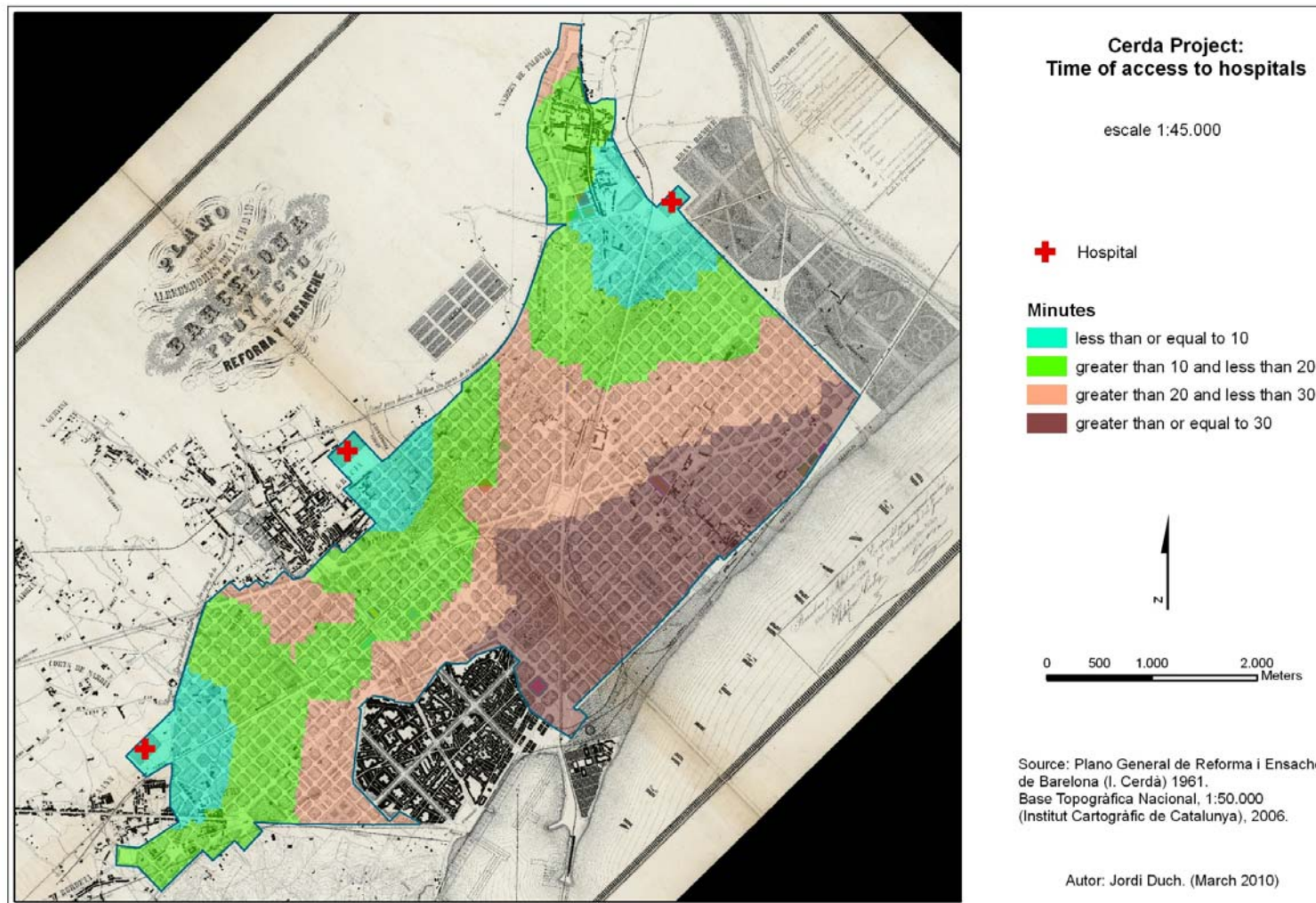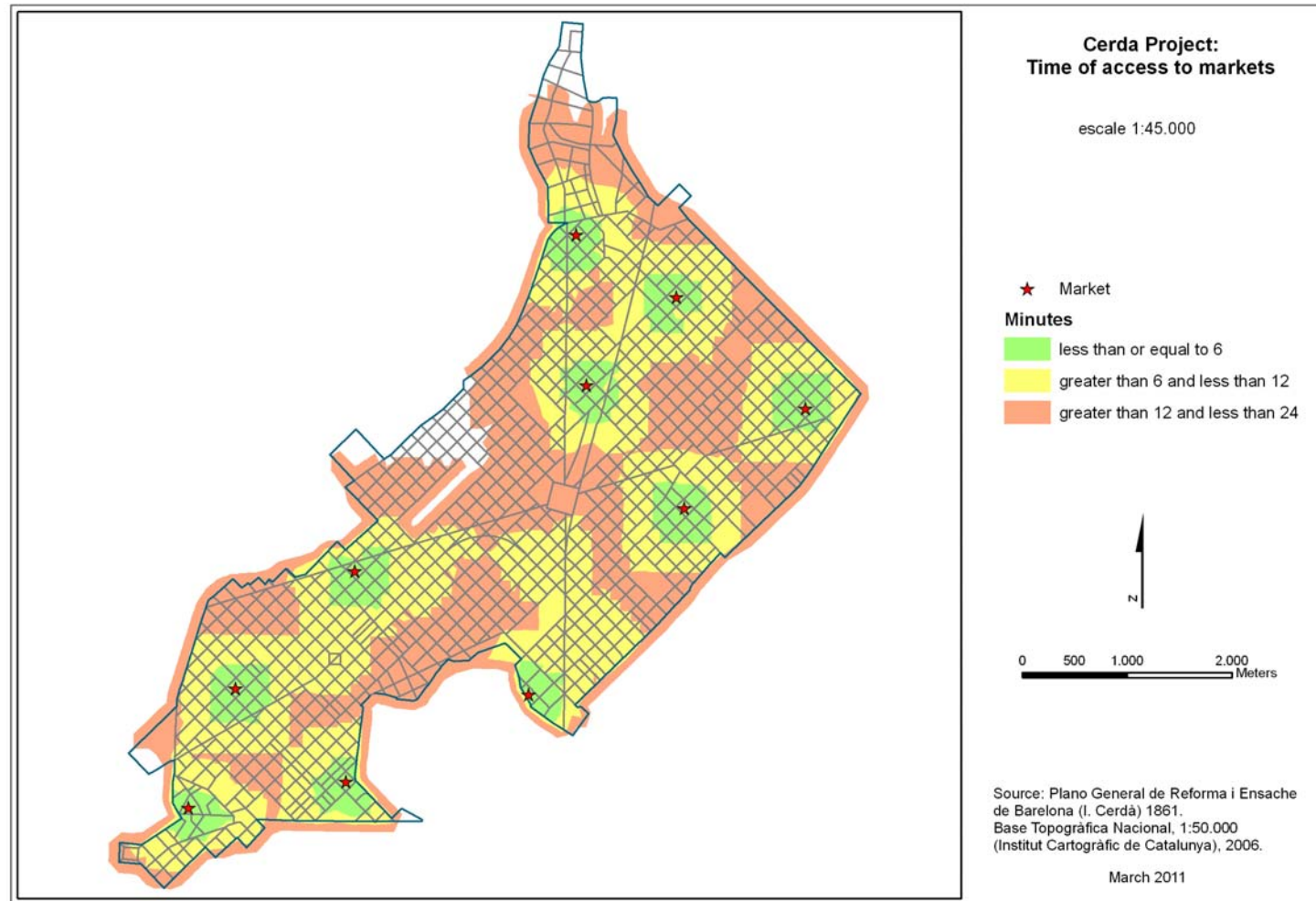
Spatial analysis: Cerdà's locational pattern

Cerda Project:
Facilities and infrastructures

escale 1:45.000

➕ Hospital
🔺 Park
★ Equipment (state, industry)
🟨 Market
🔵 social facility
—+— Railroad
—— Road axis

N

0   500   1.000   2.000
                        Meters

Source: Plano General de Reforma i Ensache
de Barelona (I. Cerdà) 1861.
Base Topogràfica Nacional, 1:50.000
(Institut Cartogràfic de Catalunya), 2006.

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Spatial analysis: hospital service areas

Cerda Project:
Time of access to hospitals

escale 1:45.000

✚ Hospital

Minutes
- less than or equal to 10
- greater than 10 and less than 20
- greater than 20 and less than 30
- greater than or equal to 30

N

0   500   1.000   2.000
                        Meters

Source: Plano General de Reforma i Ensache
de Barelona (I. Cerdà) 1861.
Base Topogràfica Nacional, 1:50.000
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Spatial analysis: hospital service areas

Spatial analysis: market service areas

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Future research

- Service location
- Taking into account capacity of services
- Introducing different population densities
- Introducing different typology of services
- Considering different levels of income
  - Spatial justice

Transferable utility

- Distance versus willingness to pay for it
- Public utility everyone gets the service; but
- Assuming different level of income. People would be willing to pay differently to get a service closer
- Who should get the service's benefit, the person who pays more or the person who pays less? How to allocate stratified demand?

Questions about spatial justice

- Is this situation always possible?
- Could we have transferability without any strategic policy to guide where and who gets wellbeing?
- How does livability can be increased in cities?
- Can urban policies be transformed and adjusted to fulfill population needs?
- Might mechanisms to distribute resources in space help to achieve a more even spatial justice?

Alphanumeric data: Population

Housing category	Floor number	Number of people living in each floor	Area sq meters	sq meters/ Inhab	Length x depth
1rst. Project A	PB (Ground)	0	400		20x20
	1rs	13	400		
	Total	13	800	61,54	
1rst. Project B	PB (Ground)	0	400		20x20
	1rs	13	400		
	2nd	9	400		
	Total	22	1200	54,55	
2nd. Project A	PB (Ground)	0	320		10,95x10,95
	1rs	12	320		
	Total	12	640	53,33	
2nd. Project B	PB (Ground)	0	320		
	1rs	12	320		
	2nd	9	320		
	Total	21	960	45,71	10.95x10.95
3rd. Project A	PB (Ground)	0	225		
	1rst	11	225		
	Total	11	450	40,91	15x15
3rd. Project B	PB (Ground)	0	225		
	1rs	11	225		

the end...

Source: Busquets 1992.

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