Urban climates information at the service of planning and management of the planning and sustainable development of Latin American cities

Hugo Romero, Faculty of Architectural and Urbanism,
University of Chile

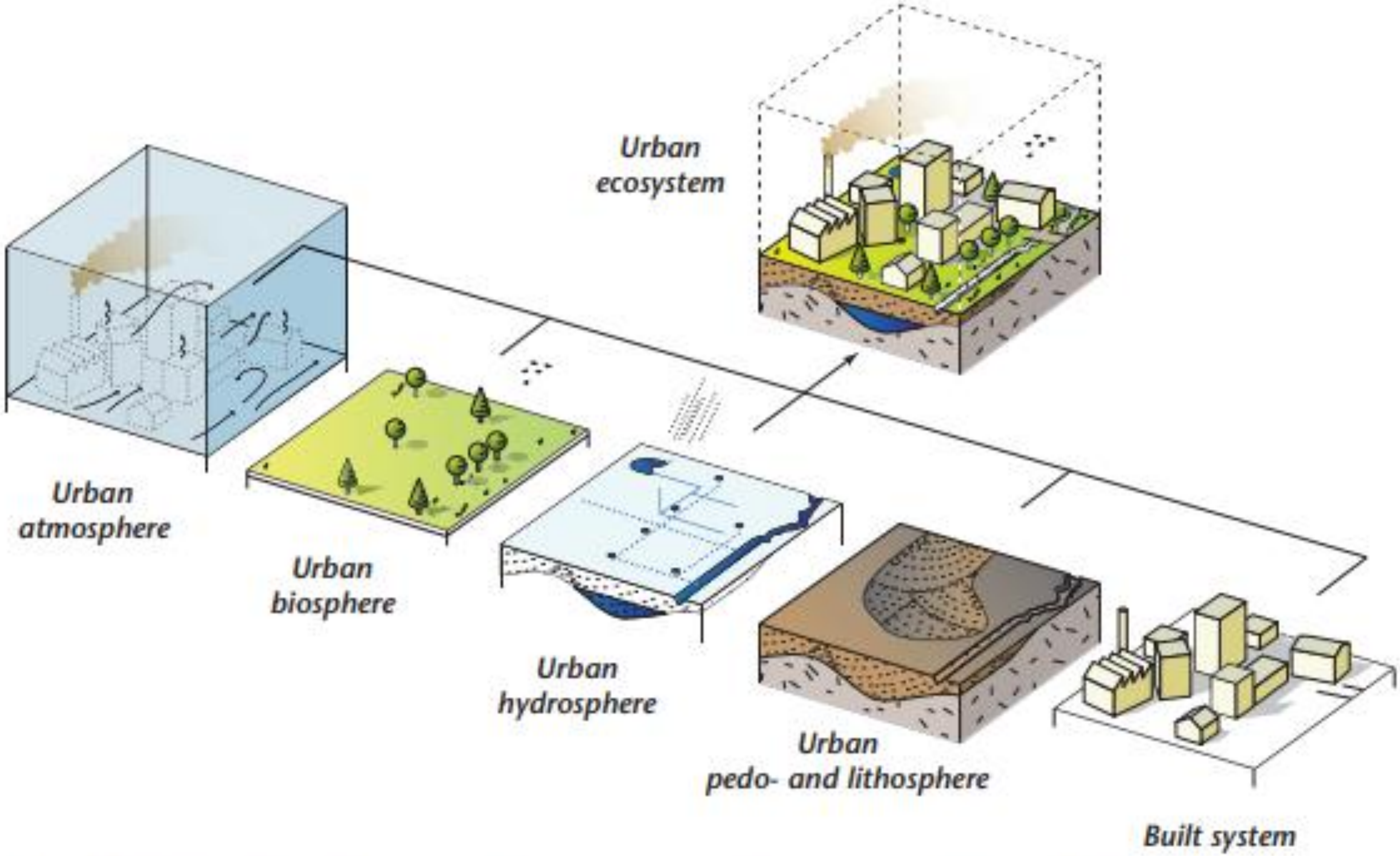

Figure 1.3 The biophysical components that comprise an urban ecosystem. They include all aspects of the preurban natural environment subsequently modified by the introduction of built infrastructure.

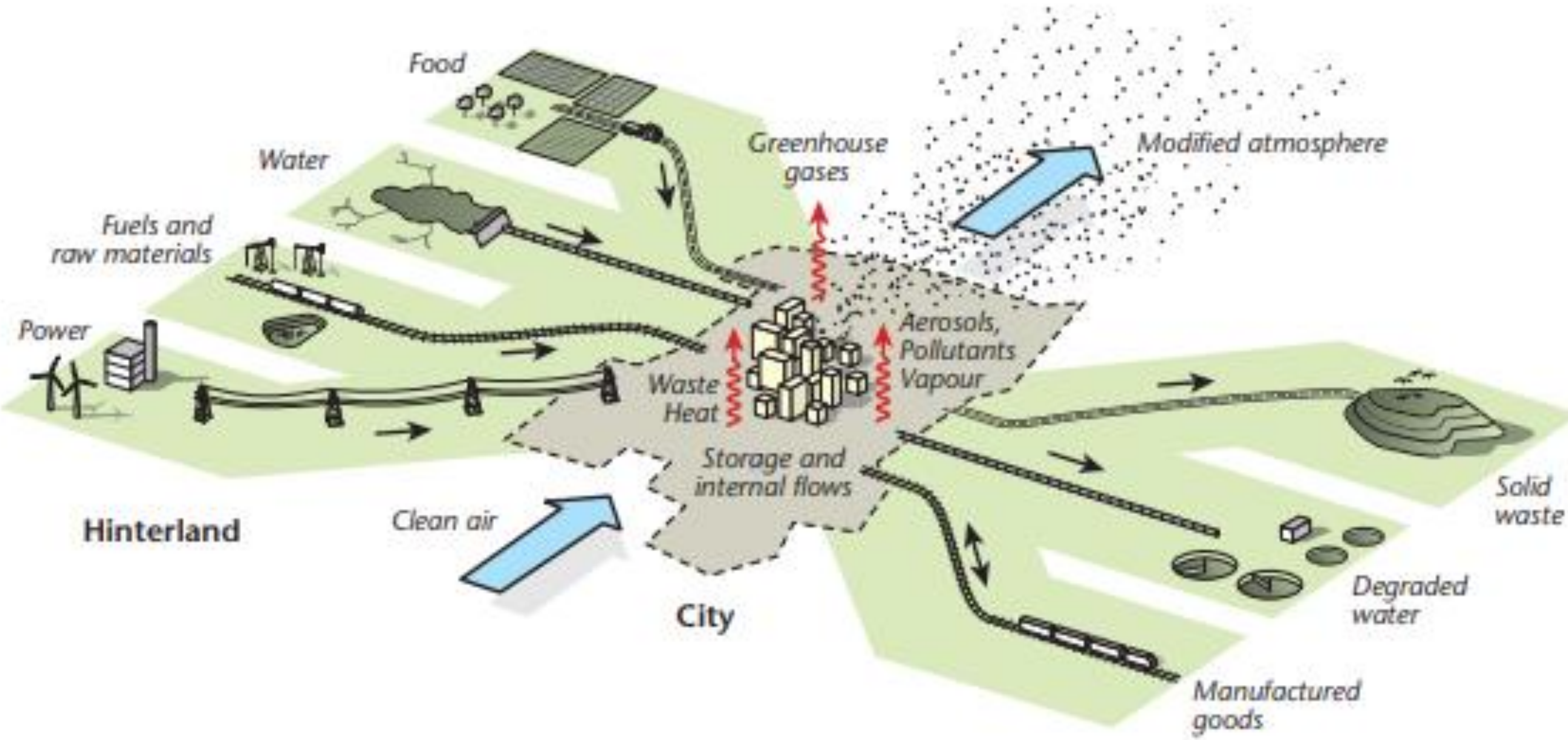

Figure 1.4 Representation of inputs to, and outputs from, an urban ecosystem (Modified after Christen 2014; © Elsevier, used with permission).

Table 2
Distinctive physical features of cities: The urban fabric.

Physical features	Distinctive urban characteristics
Population densities	○ Population densities and overpopulation (increased) ○ Access to marginal areas (reduced)
Land coverage and vegetation	○ Built-up surface area (increased) ○ Size, location and distribution of green and recreational areas (reduced) ○ Tree coverage (reduced) ○ Access to affordable space (reduced) ○ 'Consumption' of land (including rural land) (increased)
Architectural details	○ Building heights (increased) ○ Differences in building heights (more varied) ○ Construction materials and colours (different; more influential e.g. of streets) ○ Construction techniques (less traditional, more advanced) ○ Shape of dwellings (more varied, in parts more restricted)
Organization of structures in space	○ Distance between buildings (reduced) ○ Concentration and interdependence of buildings, services and technical infrastructure (increased) ○ Concentration and interdependence of political and economic centres (increased) ○ Orientation of dwellings (more restricted) ○ Street layout and street orientation (denser, more restricted)
Relation of dwellings to topographic features	○ Proximity to large bodies of water (reduced) ○ Relation to nearby hills and valleys (more difficult to account for) ○ Terrain inclinations (more difficult to account for)
Infrastructure	○ Infrastructure network density and connectivity (increased, more congested) ○ Dependency on infrastructure network (increased)

Table 3
Distinctive environmental features of cities: The urban climate.

Environmental features	Distinctive urban characteristics
Precipitation	○ Rainfall (increased) ○ Snowfall (reduced)
Wind	○ Wind speed and exchange (reduced) ○ Local wind circulation, gusts and turbulences (increased)
Temperature	○ Temperature (increased)
Air quality	○ Emissions (increased) ○ Dust particles (increased)
Humidity	○ Air humidity (reduced) ○ Fog and cloudiness (increased) ○ Evaporation (reduced)
Solar radiation	○ Length of natural lightning (reduced) ○ Intensity of solar radiation (reduced)
Soil	○ Ground sealing and compression (increased) ○ Soil quality (reduced)
Water bodies	○ Ground water level (reduced) ○ Ground water quality (reduced) ○ Surface water quality (reduced) ○ Water flows (more regulated) ○ Dependency on other (rural) areas for ecosystem services
Flora	○ Vegetation cover (reduced) ○ Biodiversity of vegetation (reduced, specific city vegetation) ○ Growing season (increased) ○ Vegetation forms (specific forms developed on facades, roofs, etc.) ○ Dependency on other (rural) areas for ecosystem services
Fauna	○ Biodiversity of species (generally reduced, overpopulation of some species)
Noise	○ Noise (increased)
Waste and waste water	○ Amount of waste (increased) ○ Type of waste (more hazardous)

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Noise	○ Noise (increased)
Waste and waste water	○ Amount of waste (increased)
	○ Type of waste (more hazardous)
	○ Waste water (increased; increased mix of rainwater and backwater)

Source: Adapted from Wamsler (2013).

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Distinctive physical features of cities: The urban fabric.

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Infrastructure	○ Infrastructure network density and connectivity (increased, more congested) ○ Dependency on infrastructure network (increased) ○ Flows (e.g. material and people) (increased)

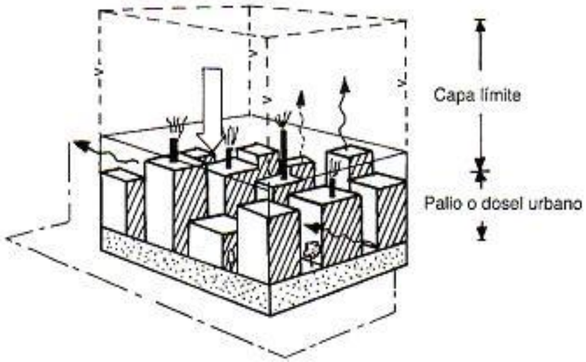
Source: Adapted from Wamsler (2013).

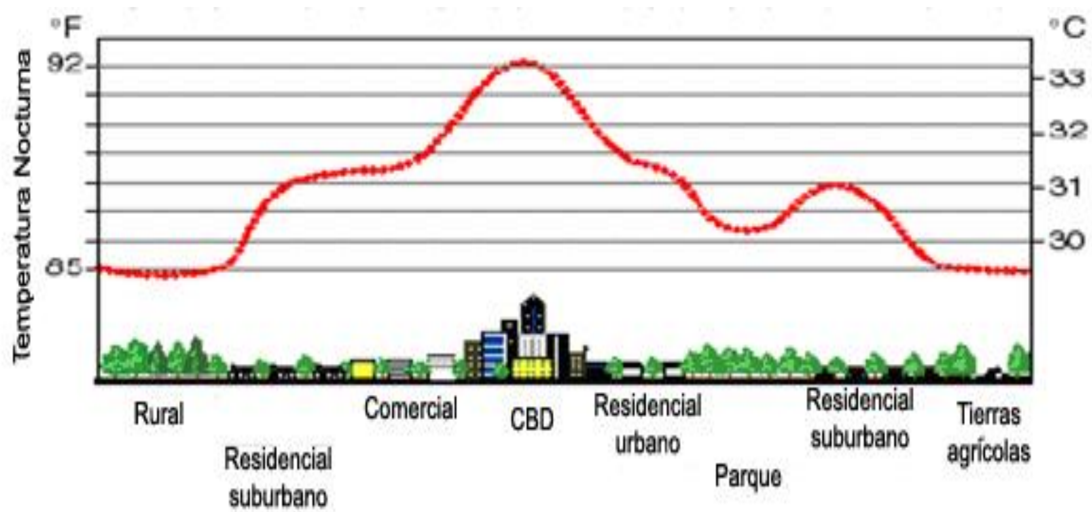
Table 1. Case study summaries.

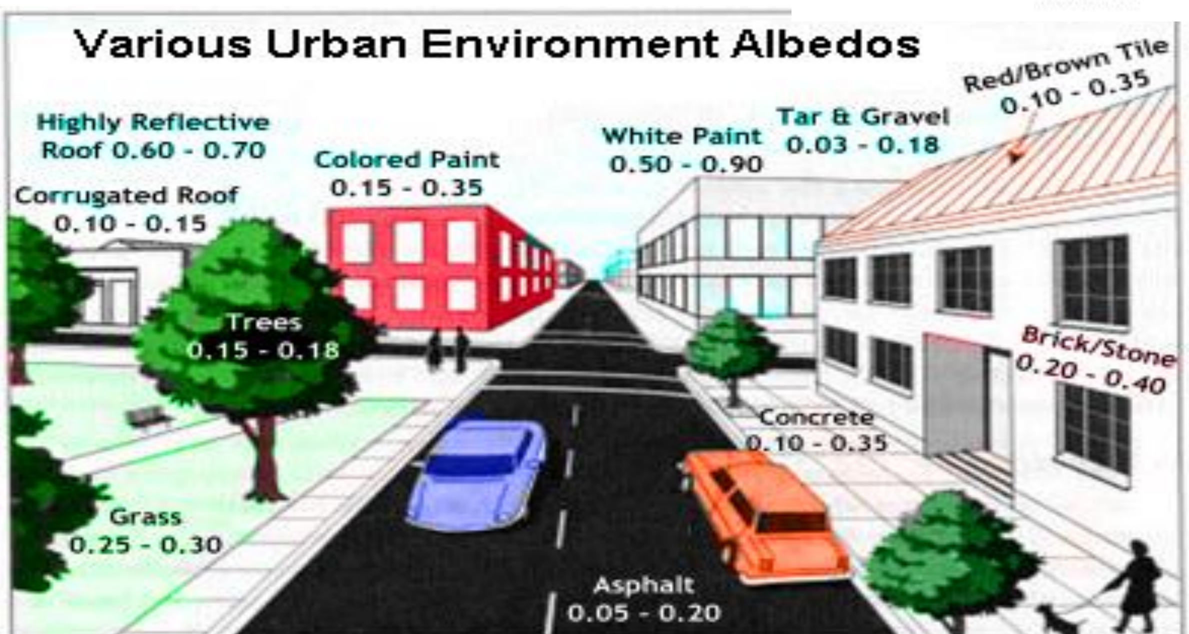
	Stuttgart	Tokyo	New York	Manchester
The impact of global climate change at the local level and perception of risks	- Long established use of urban climatology has been reoriented to manage urban heat island effects; Acute local and cultural weather awareness	- Urban heat island effects worsening due to climate change and tall buildings; Strong public awareness of issue and need to manage impacts	- Impact largely ignored until recently with focus on greenhouse gas reductions and adaptation; Perception of risk heightened by energy demands, flooding, and extreme weather	- Local-scale climate change impacts poorly understood; Perception of risk relatively low and impetus to combat originally driven from central government
Competences, authority, and capacity to regulate climate-relevant issue areas	- Utilises regulatory powers to link urban climatology knowledge to planning, development, and infrastructure provision; Institutionalized urban climatology unit within city government to advise on policy issues	- Focus on generic standards, guidelines, and market forces rather than regulatory and localized measures; Environmental assessments generally undertaken by consultants but some policy developed with researchers	- Wide range of regulatory measures updated and detailed outcomes set; Relies on the aggregate impact of measures implemented by multiple agencies and city departments in cooperation with researchers, consultants, and NGOs	- Largely lacks authority to regulate or set standards without national government approval; Limited in-house capacity, largely relies on researchers and consultants for analytical capacity
National programmes that support local initiatives	- Bottom-up implementation of local government approaches to urban climate management through changes to federal legislation	- National involvement related to the mitigation of urban heat island effects; Some support for academic research projects due to strong national awareness of urban heat island	- Limited national programmes Bespoke initiatives with federal agencies and departments exist however	- Top-down setting of targets by national government for local government; Previously mandatory but no longer, leading to less impetus for action

Table 1. Case study summaries.

	Stuttgart	Tokyo	New York	Manchester
The involvement of cities in national and transnational networks	- Extensive involvement in knowledge exchange with other cities in Germany and around the world Involvement in a range of transnational networks	- Well established network between Tokyo and Stuttgart as well as within and between academic researchers in the two cities; Strong involvement in national level discussions on the urban heat island	- Tri-State regional cooperation; Involvement in the C40 cities network as well as other international networks on climate change resilience	- Knowledge exchange largely left to academics to expand national and international networks; Coordination difficulties exist between the local authorities that make up the region
The coproduction of urban climate science and local climate change policy	- Scientists and policy-makers are highly integrated within local government creating a long-term institutionalized concern for urban climatology issues	- Scientists have long contributed to the identification of the urban heat island effect but city lacks an in-house group of urban climatologists to advise on policy development	- New commitment to multi-stakeholder engagement of scientists, consultants, other stakeholders, and government departments but lack of explicit integration of urban climatology concerns into policy-making process	- Piecemeal engagement with scientists and consultants leading to overall lack of recent institutionalization of urban climatology


Capa límite
Palio o dosel urbano


°F
°C
92
85
33
32
31
30
Temperatura Nocturna
Rural
Residencial suburbano
Comercial
CBD
Residencial urbano
Parque
Residencial suburbano
Tierras agrícolas


Various Urban Environment Albedos
Highly Reflective Roof 0.60 - 0.70
Corrugated Roof 0.10 - 0.15
Colored Paint 0.15 - 0.35
White Paint 0.50 - 0.90
Tar & Gravel 0.03 - 0.18
Red/Brown Tile 0.10 - 0.35
Trees 0.15 - 0.18
Brick/Stone 0.20 - 0.40
Concrete 0.10 - 0.35
Grass 0.25 - 0.30
Asphalt 0.05 - 0.20

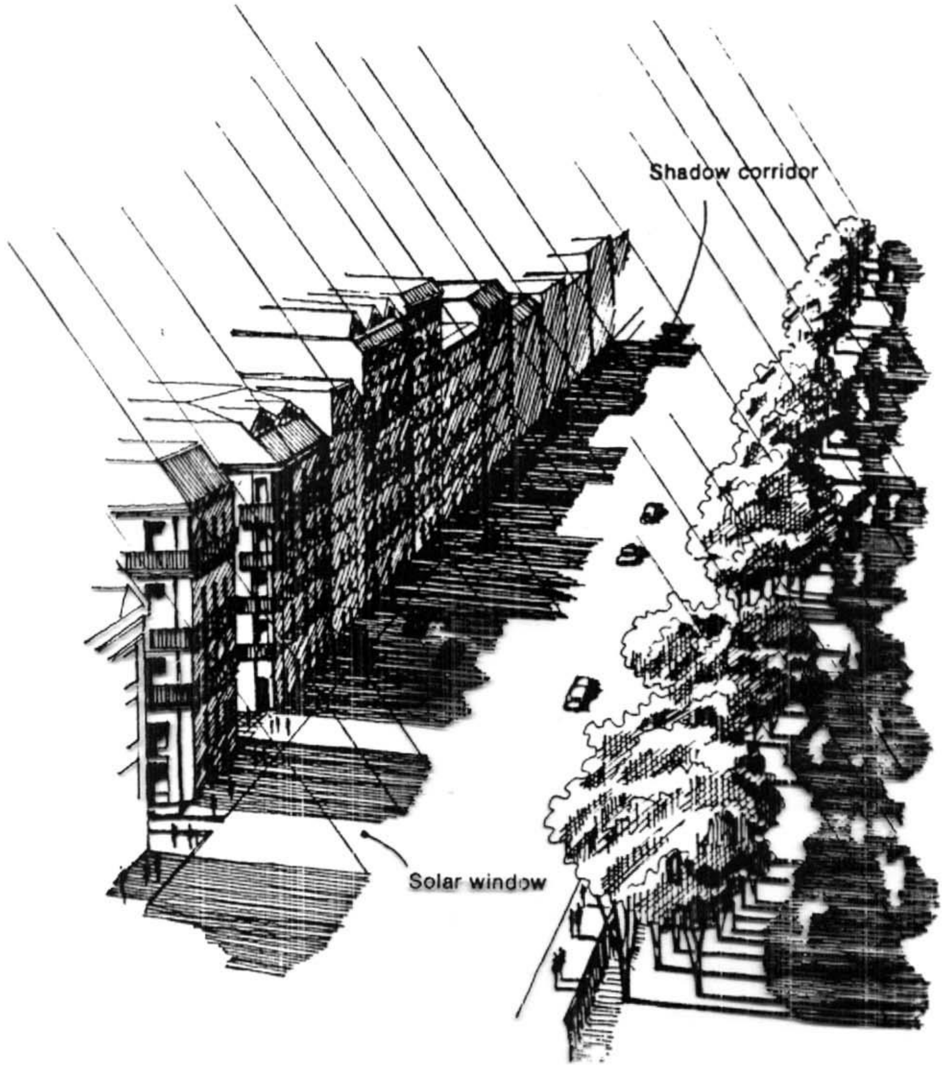


Fig. 14.8 The pattern of solar radiation in the urban environment as altered by tall buildings.

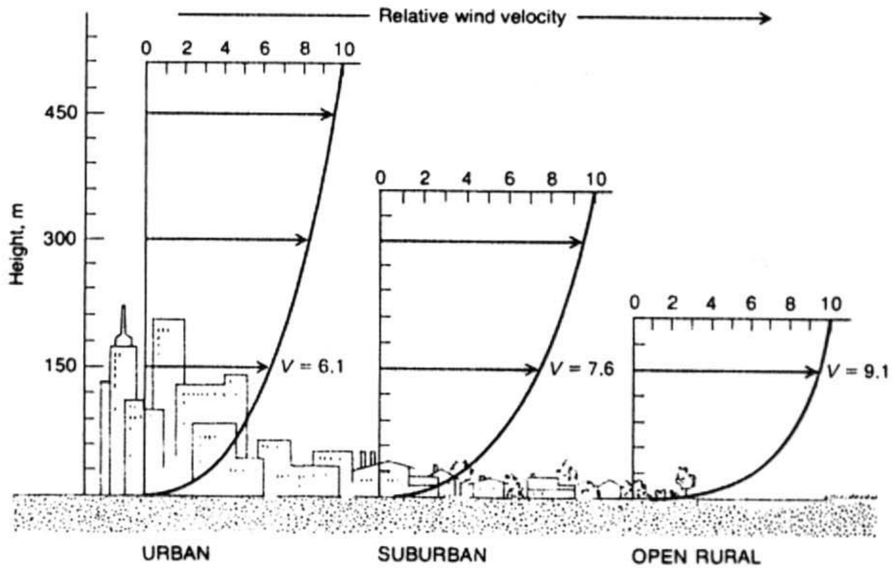


Fig. 15.5 Profile of wind velocity over urban and rural landscapes. Although ground-level wind velocities are markedly lower in cities, turbulence tends to be higher because of tall buildings.

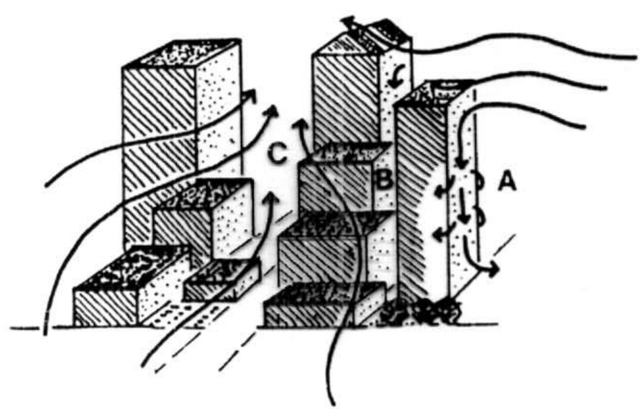


Fig. 15.6 Airflow over and around buildings. Highest velocities are reached on the windward brow and across the roof of the tallest building. A strong flow of air is also deflected down the building face (A), but a calm zone develops in the space between the buildings (B). C refers to accelerated flow associated with the canyon between large buildings.

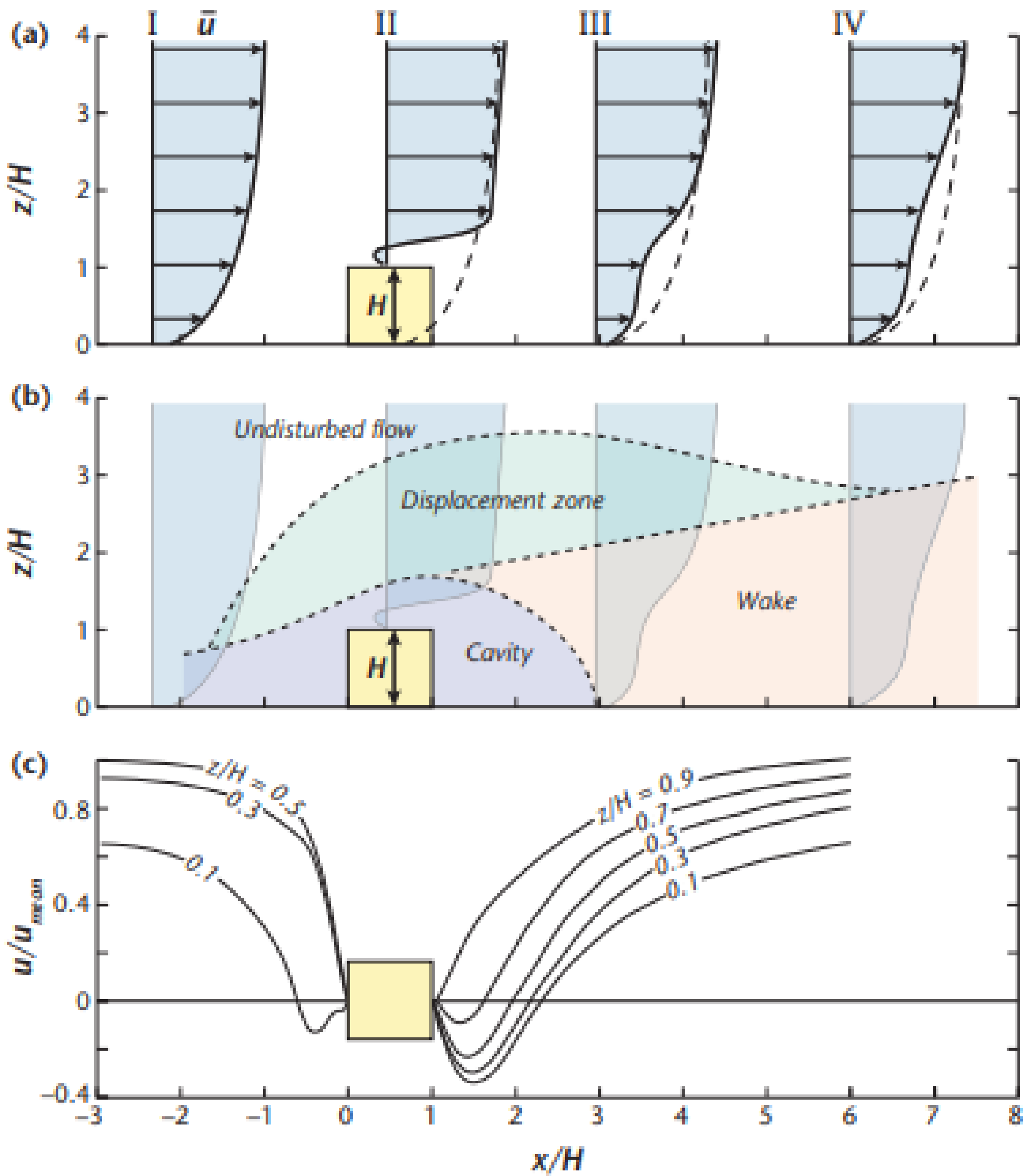


Figure 4.6 Side view of profiles of **(a)** velocity upwind (I), over (II) and downwind (III and IV) of an isolated cubical building with approach flow from left and normal to front face. **(b)** Zones of the flow (Modified after: Meroney, 1982). **(c)** Time-averaged u-velocity at different heights along the centre-line of the building, with u_{mean} the mean undisturbed wind speed at given height (Modified after: Yakhot et al., 2006).

Figure 4.7 Clouds that visualize flow displacement over high-rise buildings in Panama City Beach, United States. Wind is from the ocean (Credit: J. R. Hott, Panhandle Helicopters; with permission).

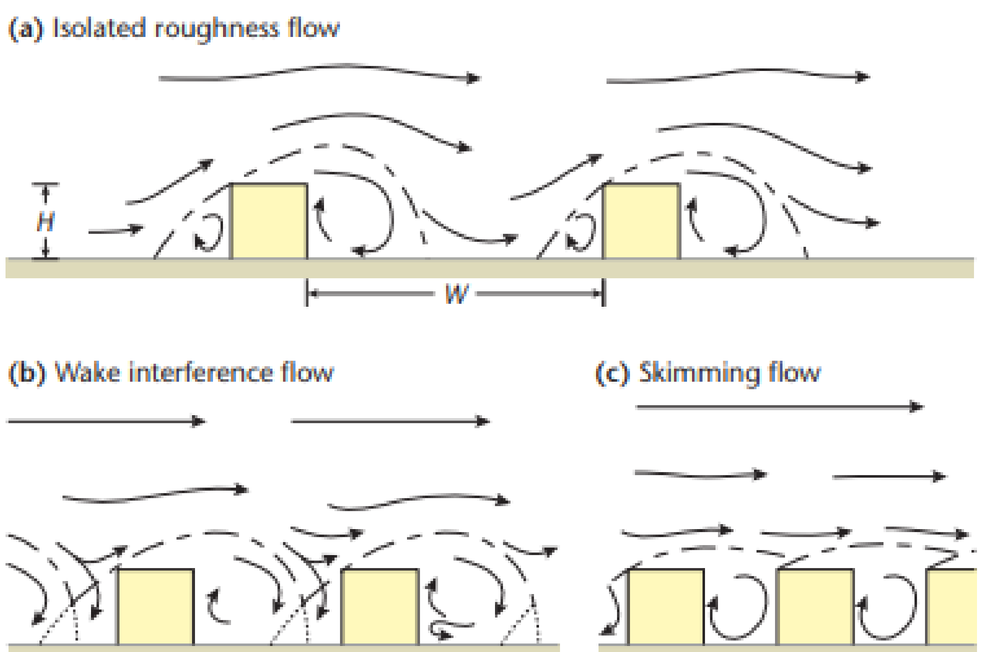


Figure 4.9 Effect of packing density (H/W) on flow régimes over urban-like 'building' arrays in a wind tunnel (Modified after: Oke, 1988 constructed using data of Hussain and Lee, 1980).

Table 4.2 Typical values of properties related to surface roughness including: mean height of roughness elements (z_H), roughness length (z_0), zero-plane displacement (z_d), power law exponent (α) for neutral conditions and normalized friction velocity (u_*/u_{ref}) for natural and urban terrain. The categories are consistent with the Davenport classification scheme that is used in wind engineering (Data sources: Oke, 1987; Wieringa, 1993; Grimmond and Oke, 1999a and Davenport et al., 2000).

Surface or terrain	Mean height of roughness elements z_H (m)	Roughness length z_0 (m)	Zero-plane displacement z_d (m)	Power law exponent α	Normalized friction velocity u_*/u_{ref}
Rural					u_{ref} at 10 m
Mud flats, ice, tarmac		0.001–0.01 mm		0.08	0.03
Snow, water (average state)[1]		0.1–1 mm		0.09	0.03
Desert sand		0.3–0.5 mm		0.10	0.04
Bare soil, cut grass[1]	0.02–0.05	0.01–0.02 m		0.10–0.11	0.04–0.06
Grass[1], stubble field	0.2–0.5	0.03–0.06 m	0.1–0.3	0.11–0.13	0.06–0.07
Farmland, crops[1]	0.4–1	0.05–0.15 m	0.2–0.7	0.14–0.18	0.07–0.10
Bushland[1], orchards[1], savannah	2–4	0.4–1 m	1.3–2.5	0.18–0.24	0.1–0.17
Forest[1]– range from temperate to tropical	12–30	0.8–2 m	9–24	0.23–$>$ 0.27	$>$ 0.16
Urban					u_{ref} at 30 m
Low height and density — houses, gardens, trees; warehouses	5–8	0.3–0.8 m	2–4	0.2–0.25	0.09–0.12
Medium height and density — row and close houses, town centres	7–14	0.7–1.5 m	3.5–8	0.23–0.27	0.11–0.14
Tall and high density — less than six floors, row and block buildings	11–20	0.8–2 m	7–15	0.26–0.29	0.13–0.16
High-rise — office and apartment tower clusters[2]	$>$ 20	$>$ 2 m	$>$ 12	0.29–0.35	$>$ 0.16

[1] Values depend on wind speed as vegetation is flexible.
[2] Estimates have little field support.

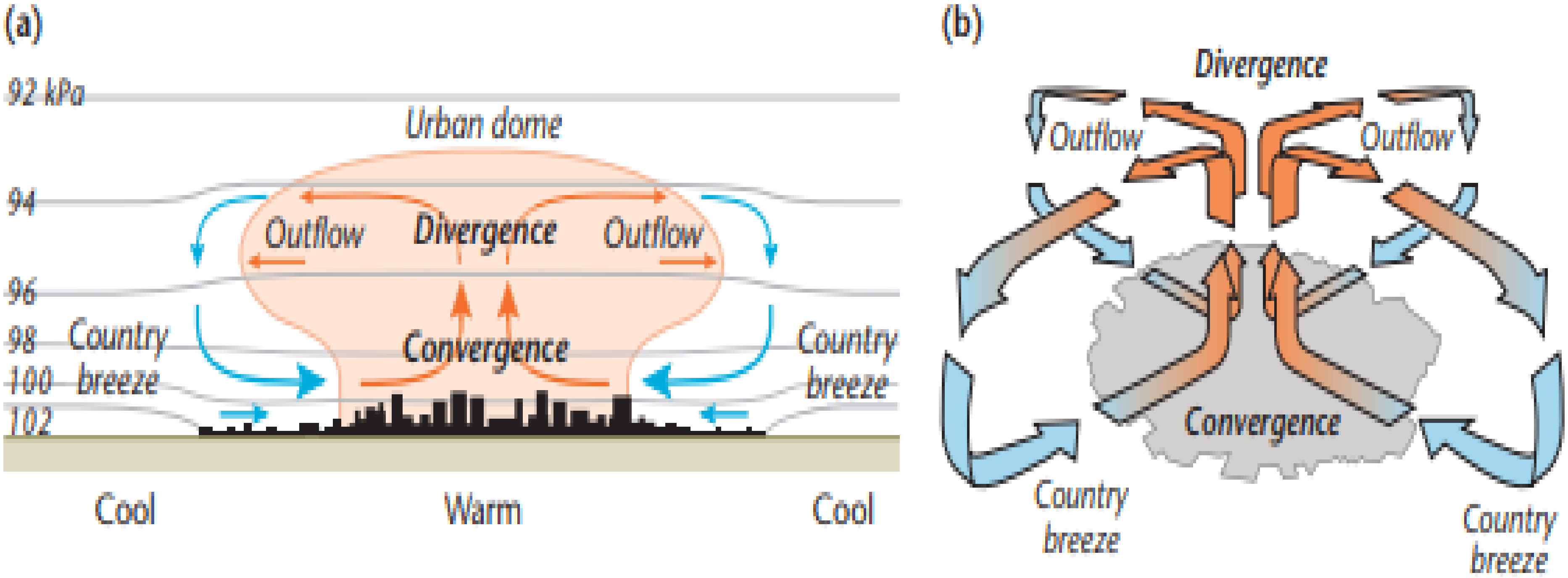
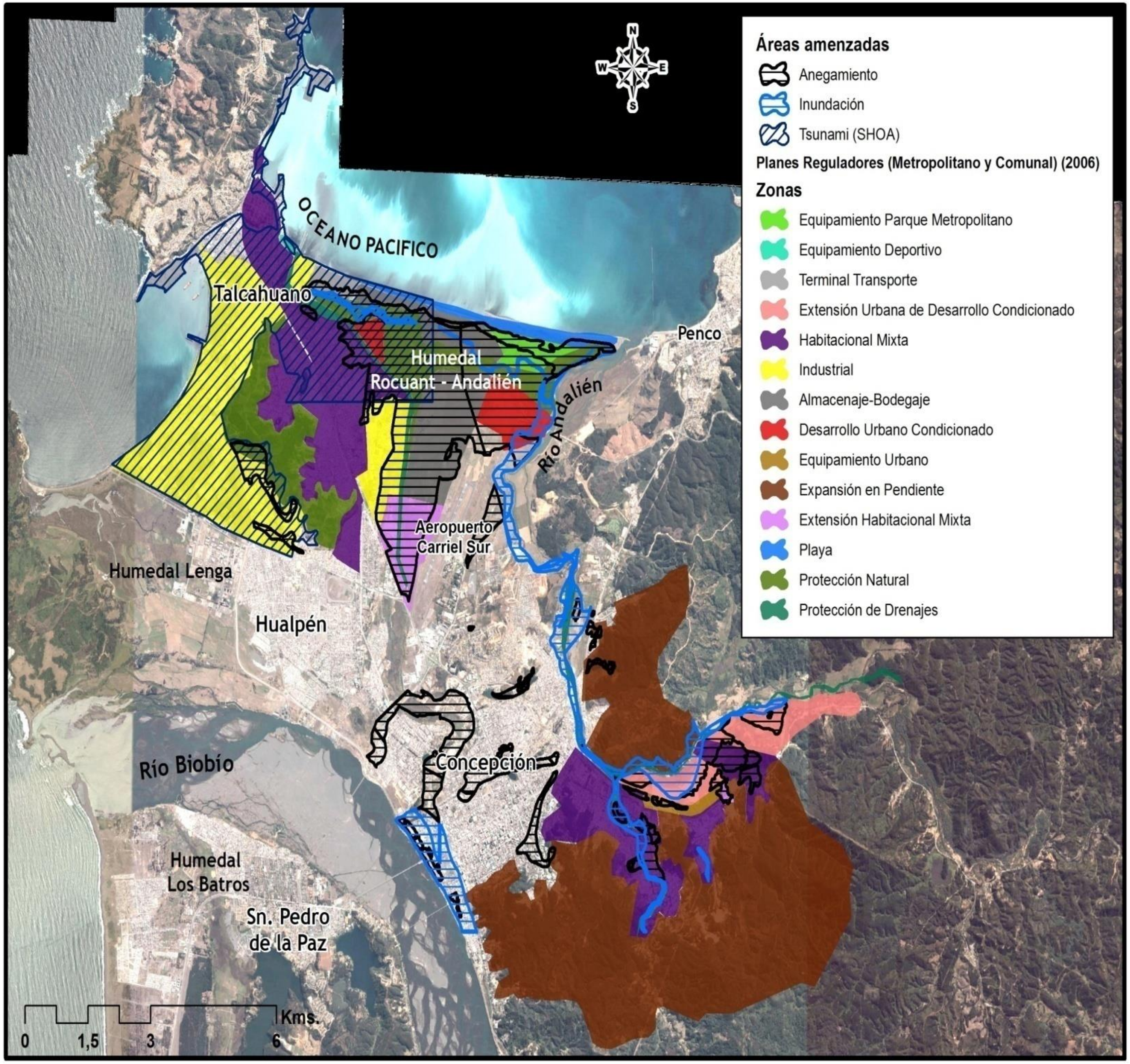


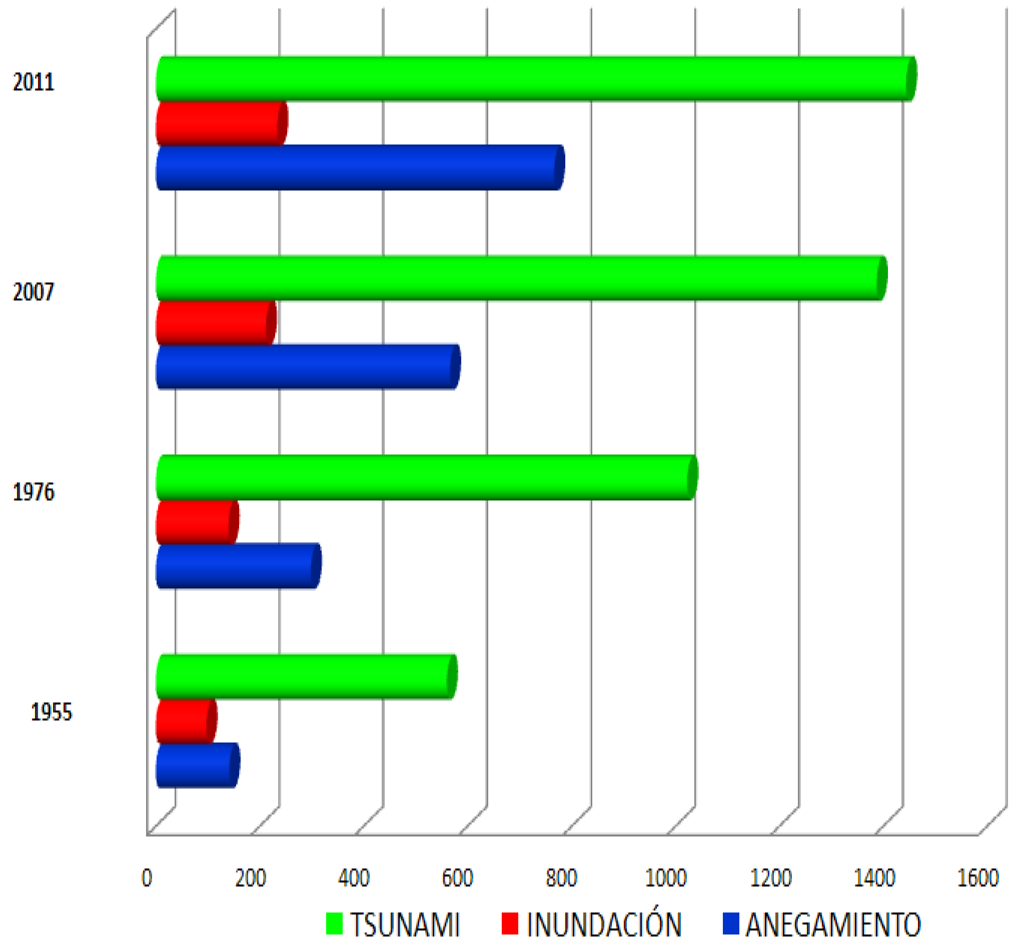
Figure 4.31 Schematic of the urban heat island circulation (UHIC). **(a)** Idealized 2D air pressure distribution (thin horizontal arrows represent horizontal pressure gradient forces), and dotted lines are isobars (lines of equal atmospheric pressure in kPa). The thick lines are the resulting circulation. **(b)** Highly simplified view of the 3D circulation pattern (neglecting the Coriolis force).


Inundación Julio 2006
Humedal Lenga

Áreas de amenaza natural



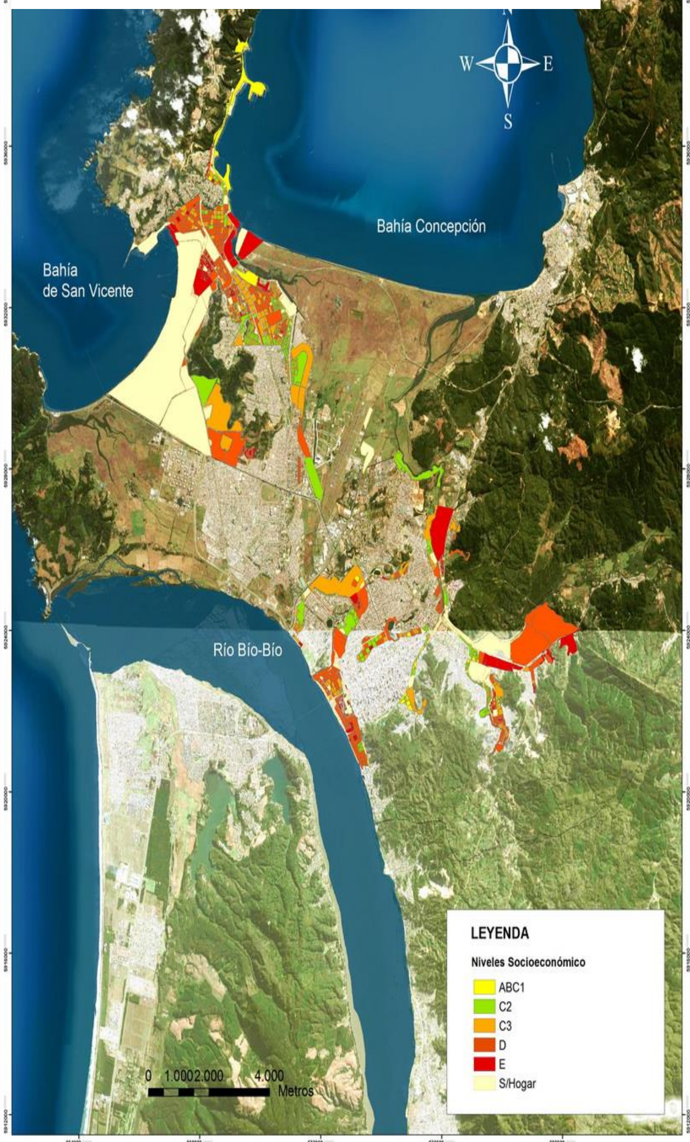
Superficie Urbana en áreas de amenaza natural (hás)



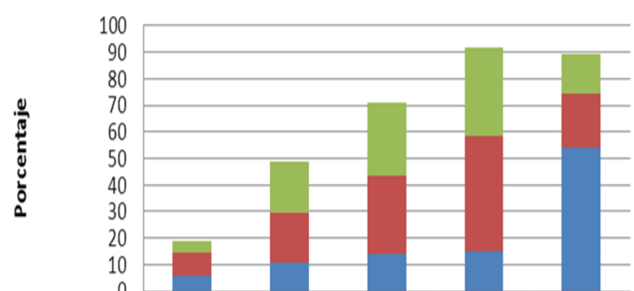
RIESGO	1955	1976	2007	2011
ANEGAMIENTO	142	299	567	766
INUNDACIÓN	98	140	212	234
TSUNAMI	561	1023	1388	1444
TOTAL GENERAL	800	1461	2166	2445

Expansión urbana, riesgos naturales y vulnerabilidad socioterritorial

Distribución grupos socioeconómicos



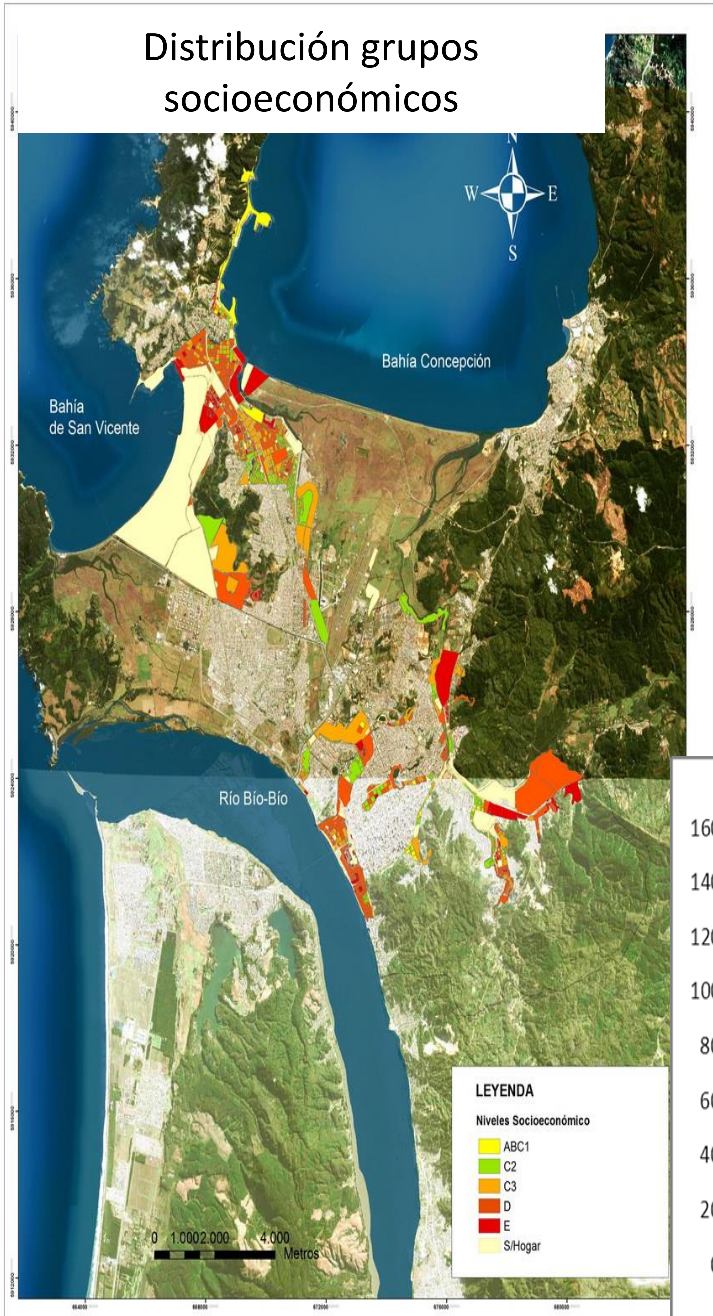
Zonas de peligrosidad natural



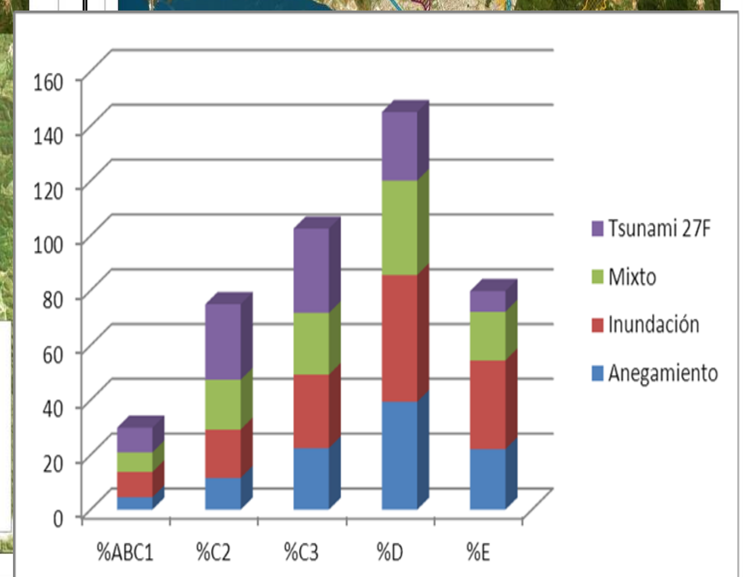
	%ABC1	%C2	%C3	%D	%E
Tsunami	5	19	28	33	15
Inundación	8	19	30	43	20
Anegamiento	6	11	14	15	54

2004

Distribución grupos socioeconómicos



Zonas afectadas: Tsunami 27F 2010 y evento pluviométrico 2006



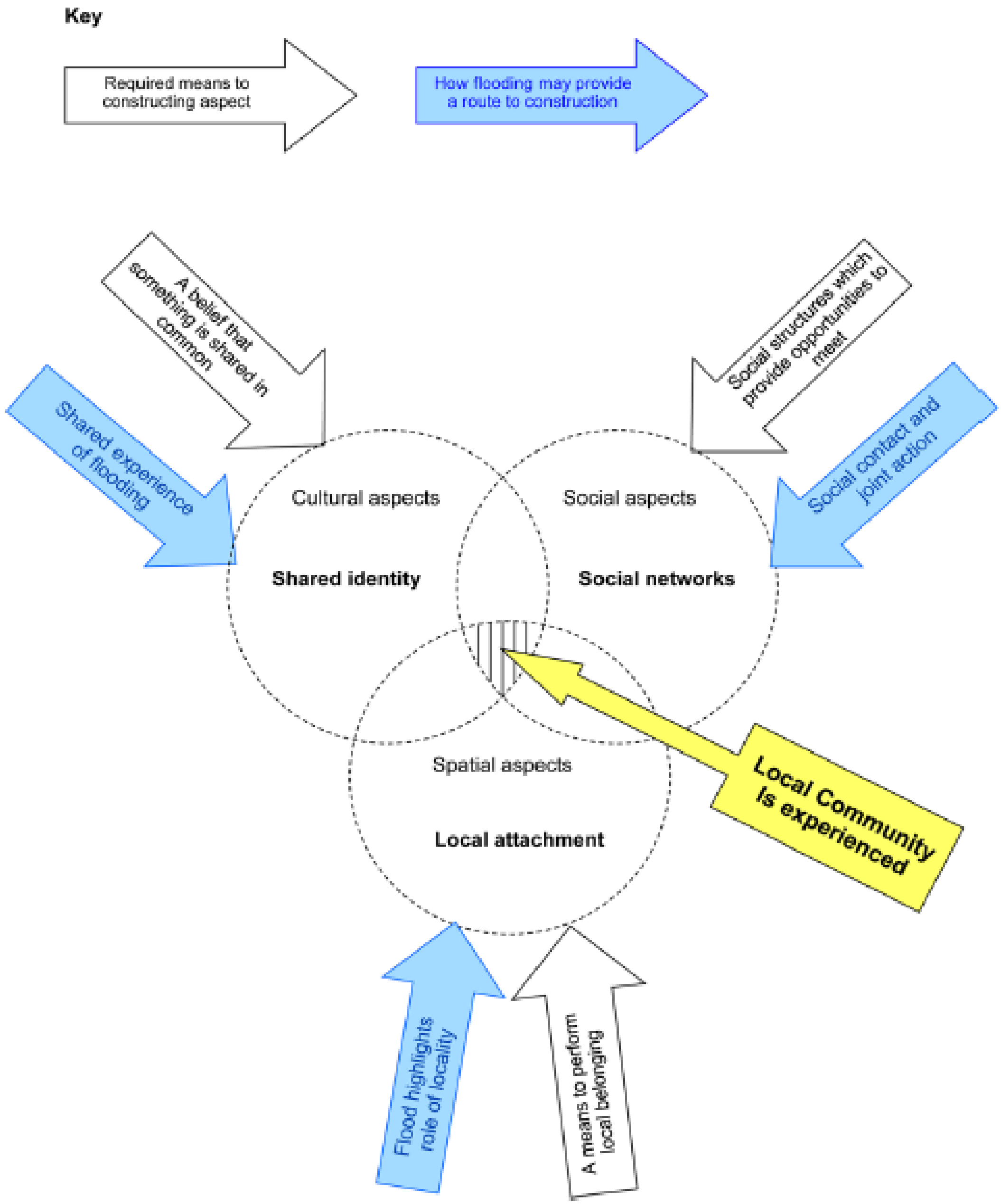
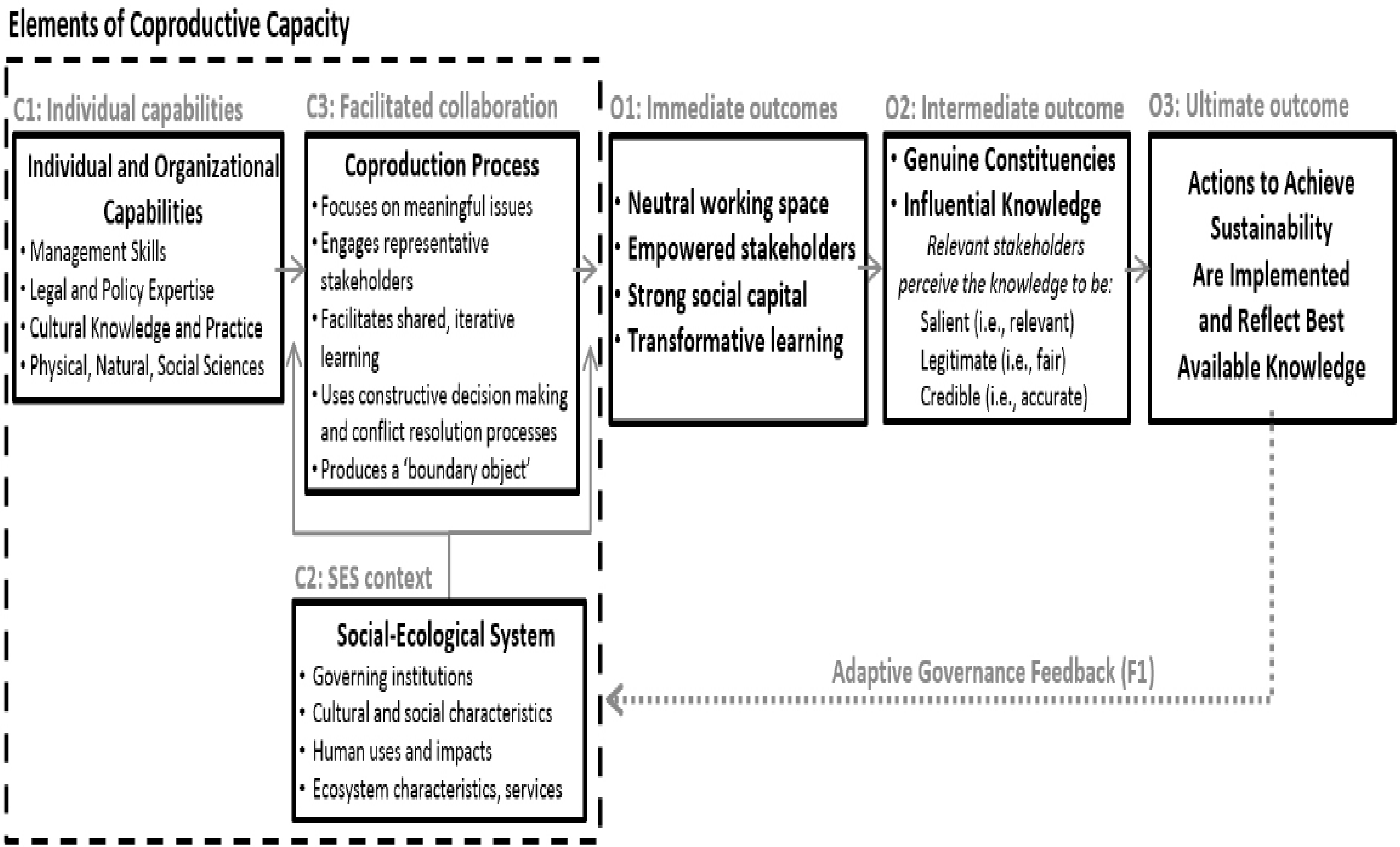


Figure 1 The construction of the conscious community and the role of flooding

Fuente: Understanding local community construction through flooding: the 'conscious community' and the possibilities for locally based communal action. Tracey Coates. Página 6

Fig. 1. Conceptual framework that specifies the sequential goals of knowledge coproduction (identified as O1-O3) and potential sources of coproductive capacity (C1-C3).



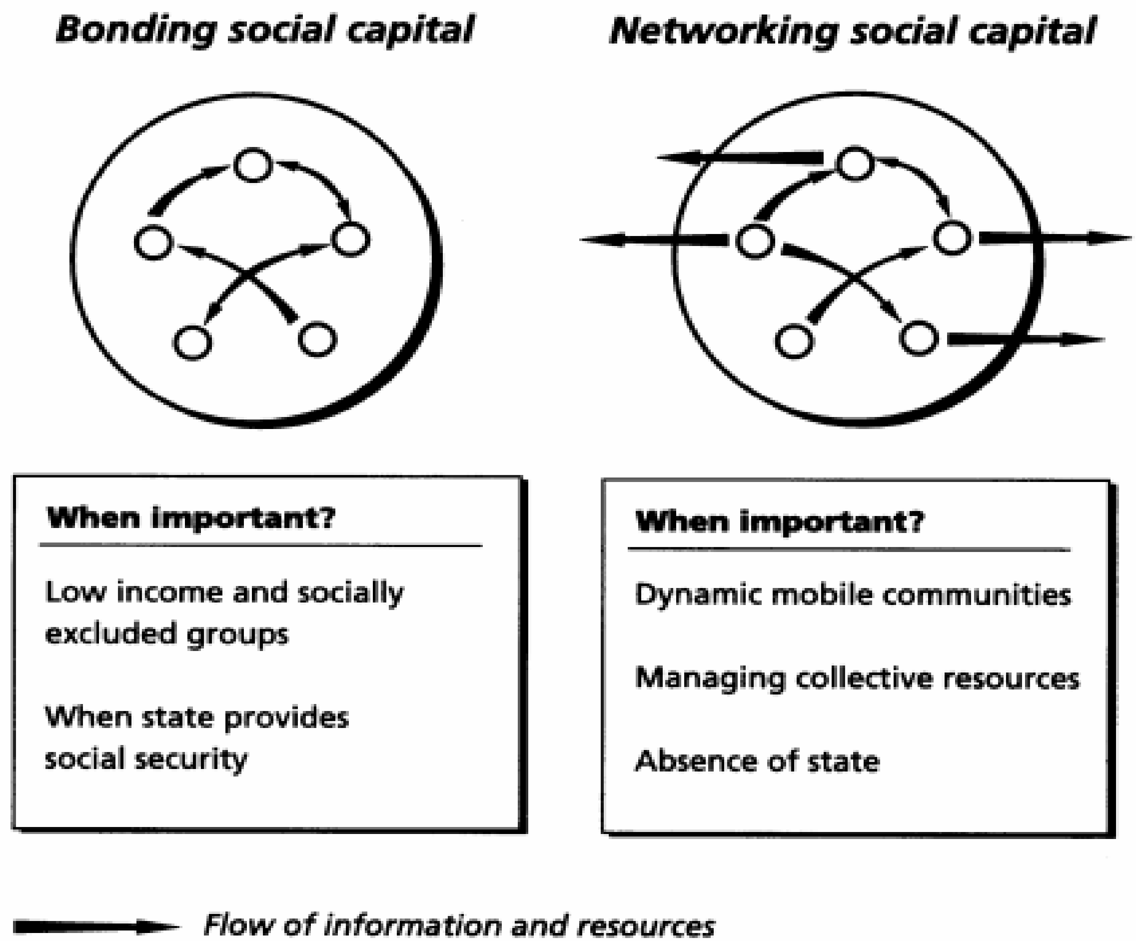


Figure 1. Circumstances in which bonding and networking social capital are important for adaptive capacity.

Fuente: ADGER, 2003.

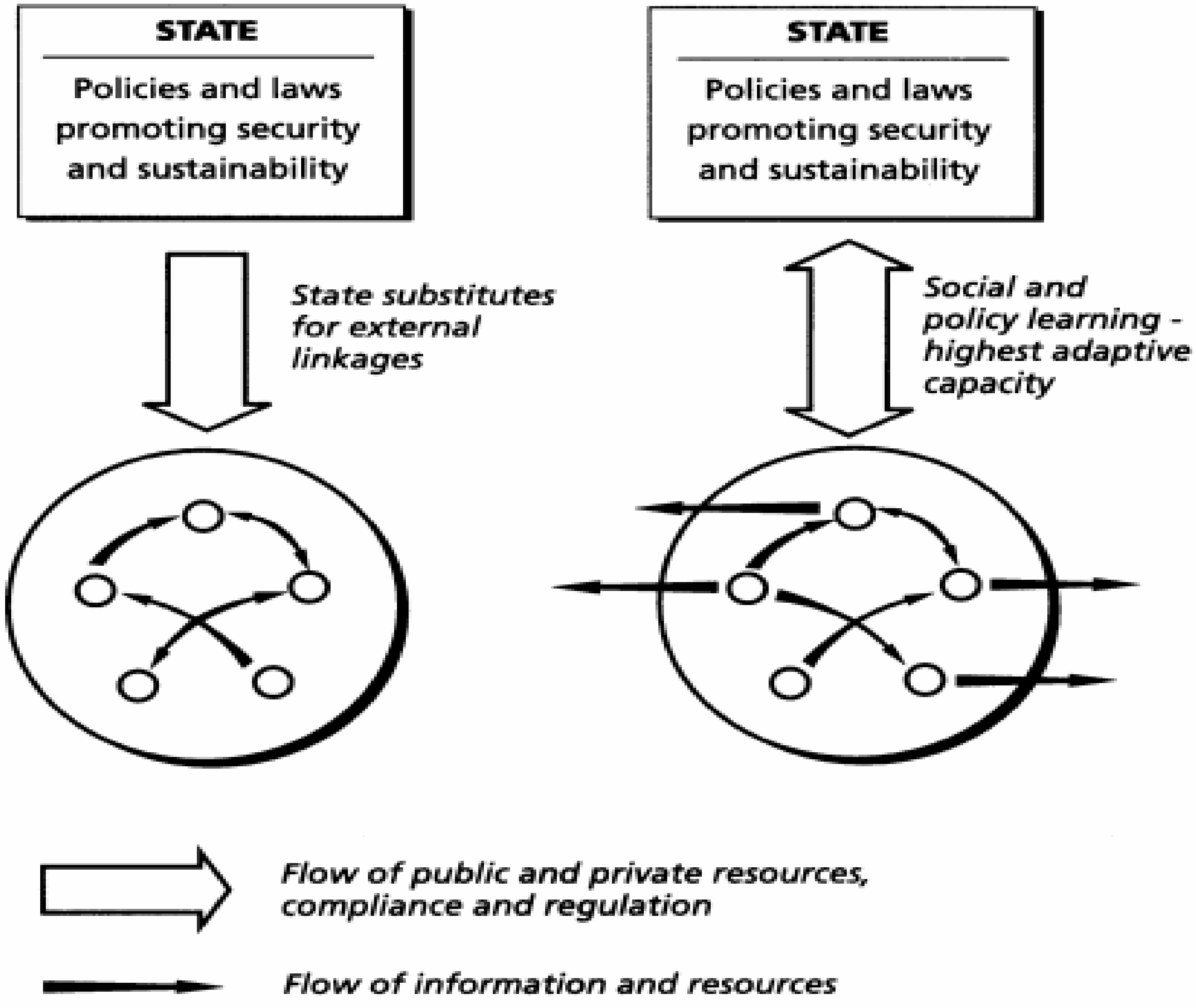


Figure 2. Vertical linkages between state and society with a "well-functioning" state.

Fuente: ADGER, 2003.

Operational definitions of the four proposed dimensions of place attachment.

Pole	Construct	Definition	Supporting literature
Personal	Place identity	Those dimensions of self, such as the mixture of feelings about specific physical settings and symbolic connections to place, that define who we are.	Proshansky et al., 1983; Williams et al., 1992; Williams & Vaske, 2003.
	Place dependence	Functional connection based specifically on the individual physical connection to a setting; for example, it reflects the degree to which the physical setting provides conditions to support an intended use.	Schreyer et al., 1981; Williams et al., 1992; Williams & Vaske, 2003.
Community	Social bonding	Feelings of belongingness or membership to a group of people, such as friends and family, as well as the emotional connections based on shared history, interests or concerns.	Kasarda & Janowitz, 1974; Hay, 1998a; Perkins & Long, 2002; Hidalgo & Hernandez, 2001; Stedman et al., 2004; Kyle & Chick, 2007; Sampson & Goodrich, 2009; Trentelman, 2009.
Environment	Nature bonding	Implicit or explicit connection to some part of the non-human natural environment, based on history, emotional response or cognitive representation (e.g., knowledge generation).	Kals et al., 1999; Clayton, 2003; Schultz, 2001; Schultz et al., 2004.

After Reymon at al. (2010):416

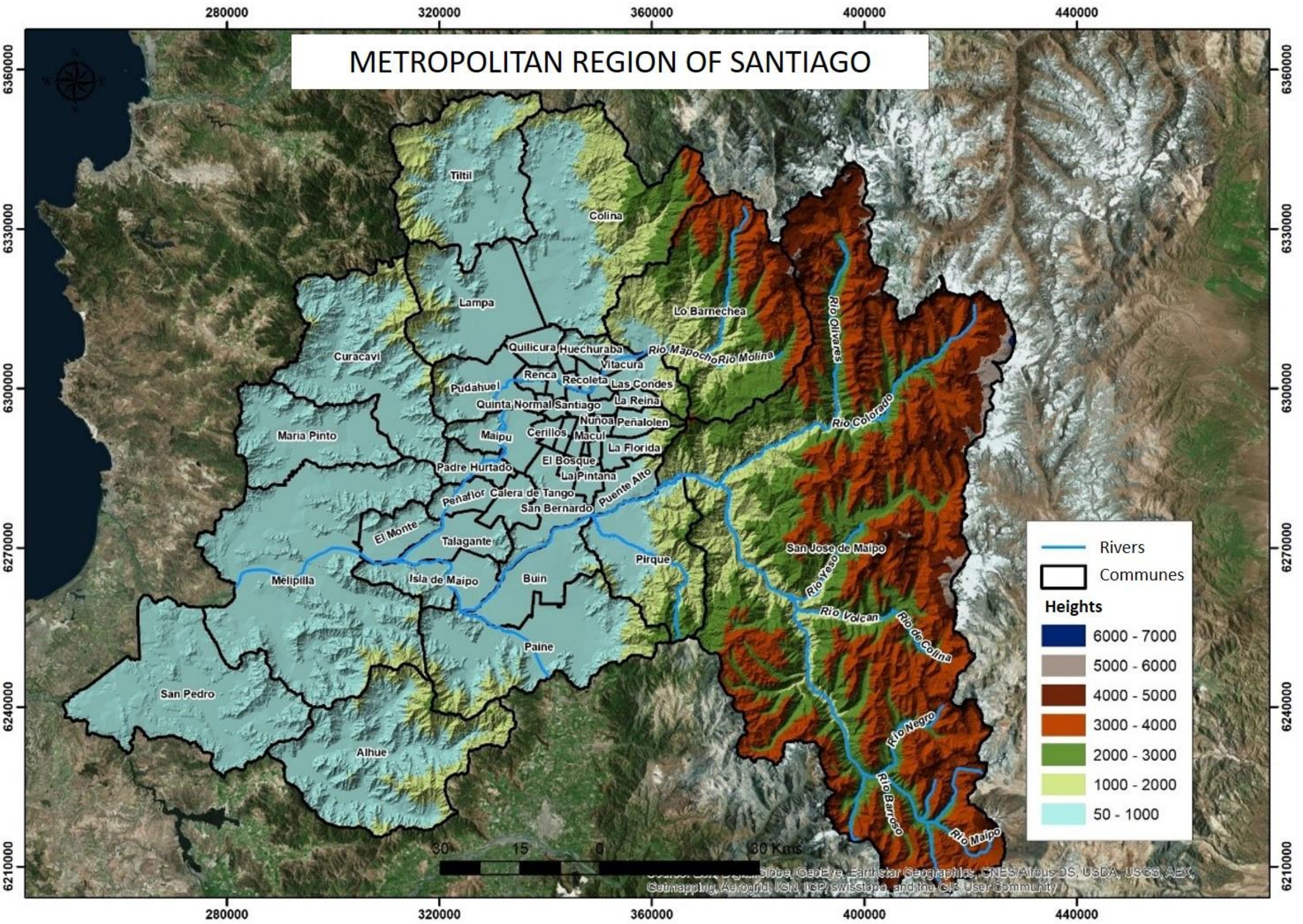
Table 1. Descriptive Statistics for Place-Meanings Scale Items and Dimensions.

Dimension and Statements	*M*	SD	α	Δα	λ
Individual identity			0.92		
I am very attached to the forest	4.01	1.11		0.91	0.85
I feel this forest is a part of me	3.70	1.11		0.90	0.87
I identify strongly with the forest	3.89	1.11		0.86	0.92
Family identity			0.90		
I have pride in my heritage because of the forest	3.86	1.15		0.89	0.79
The forest is a special place for my family	3.89	1.12		0.84	0.87
Important family memories are tied to the forest	3.75	1.18		0.83	0.88
Self-efficacy			0.90		
The forest is best for the activities I like to do	3.60	1.12		0.86	0.88
I have satisfying experiences when I visit the forest	4.05	1.05		0.88	0.83
No other place can compare to the forest	3.78	1.13		0.89	0.77
The forest is my first choice for outdoor recreation	3.60	1.16		0.87	0.84
Self-expression			0.93		
I feel that I can really be myself at the forest	3.87	1.07		0.91	0.87
Visiting the forest allows me to express myself	3.57	1.05		0.87	0.92
Visiting the forest says a lot about who I am	3.67	1.11		0.91	0.87
Community identity			0.93		
The forest contributes to the community's character	4.24	1.00		0.91	0.89
The community's history is defined by the forest	4.14	1.01		0.88	0.93
The forest has helped put the community on the map	4.10	1.03		0.92	0.86
Economic meanings			0.90		
The community's economy depends on the forest	3.79	1.02		—	0.86
Appalachia's economy depends on the forest	3.95	1.02		—	0.86
Ecological meanings			0.97		
The forest is important in conserving the landscape	4.48	0.94		0.96	0.92
The forest is important in providing wildlife habitat	4.59	0.95		0.95	0.95
The forest is important in protecting water quality	4.57	0.95		0.94	0.96

Table 2. Descriptive Statistics for Perceived Resilience Scale Items and Dimensions.

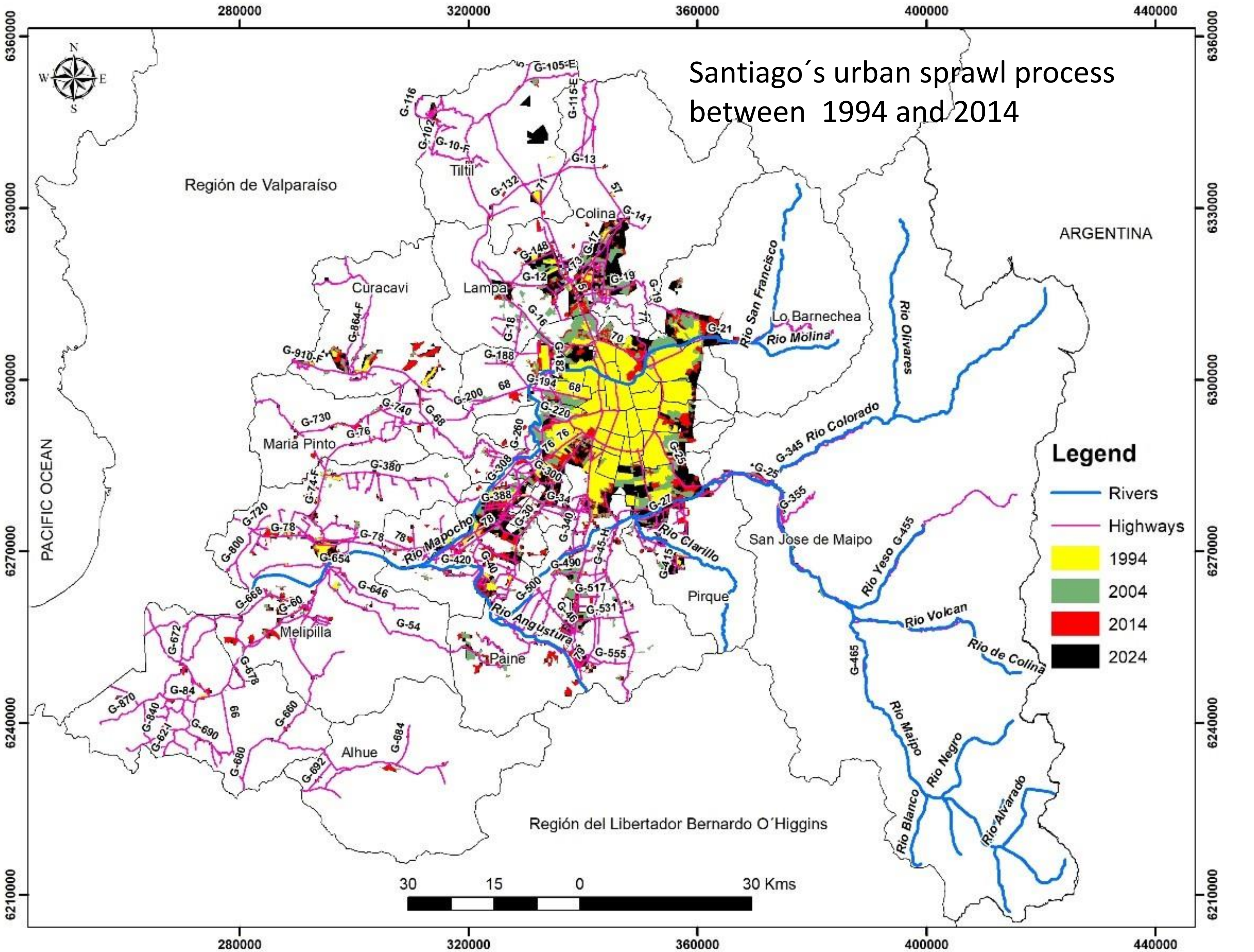
Dimension and Scale Items	*M*	SD	α	Δα	Rotated Factor Loadings[a]			
					λ_1	λ_2	λ_3	λ_4
Risk perception			0.93					
I would be at risk if increasingly severe storms altered forest conditions	3.54	1.05		0.92	**0.826**	0.118	0.085	−0.061
I would be at risk if increasingly severe droughts altered forest conditions	3.84	1.05		0.86	**0.930**	0.141	0.008	−0.050
I would be at risk if changing climatic conditions altered forest conditions	3.77	1.02		0.89	**0.945**	0.145	−0.016	0.001
Ability to learn			0.86					
Information about how changing environmental conditions impact the forest is easy to find	2.82	1.00		—	0.083	0.115	**0.851**	0.038
Information about how forest conditions affect my community is easy to find	2.73	0.96		—	−0.026	0.050	**0.910**	0.068
Ability to plan			0.89					
I could plan for increasingly severe weather conditions	3.64	0.96		—	0.190	**0.836**	0.087	0.066
I could make plans if forest conditions changed	3.56	0.91		—	0.203	**0.890**	0.068	0.125
Ability to adapt			0.63					
I could adapt to increasingly severe weather conditions	3.47	1.00		0.56	0.034	0.444	0.092	**0.496**
Things will turn out the same for me, regardless of forest changes	2.45	1.10		0.63	−0.331	−0.103	0.235	**0.386**
I could adapt to altered forest conditions	3.16	0.91		0.41	−0.092	0.182	0.074	**0.819**
I could cope with small changes in forest-related industries	3.42	0.91		0.59	0.079	0.165	0.071	**0.445**
Proportion of variance explained (92.1% of total)					34.3	24.3	21.3	16.2

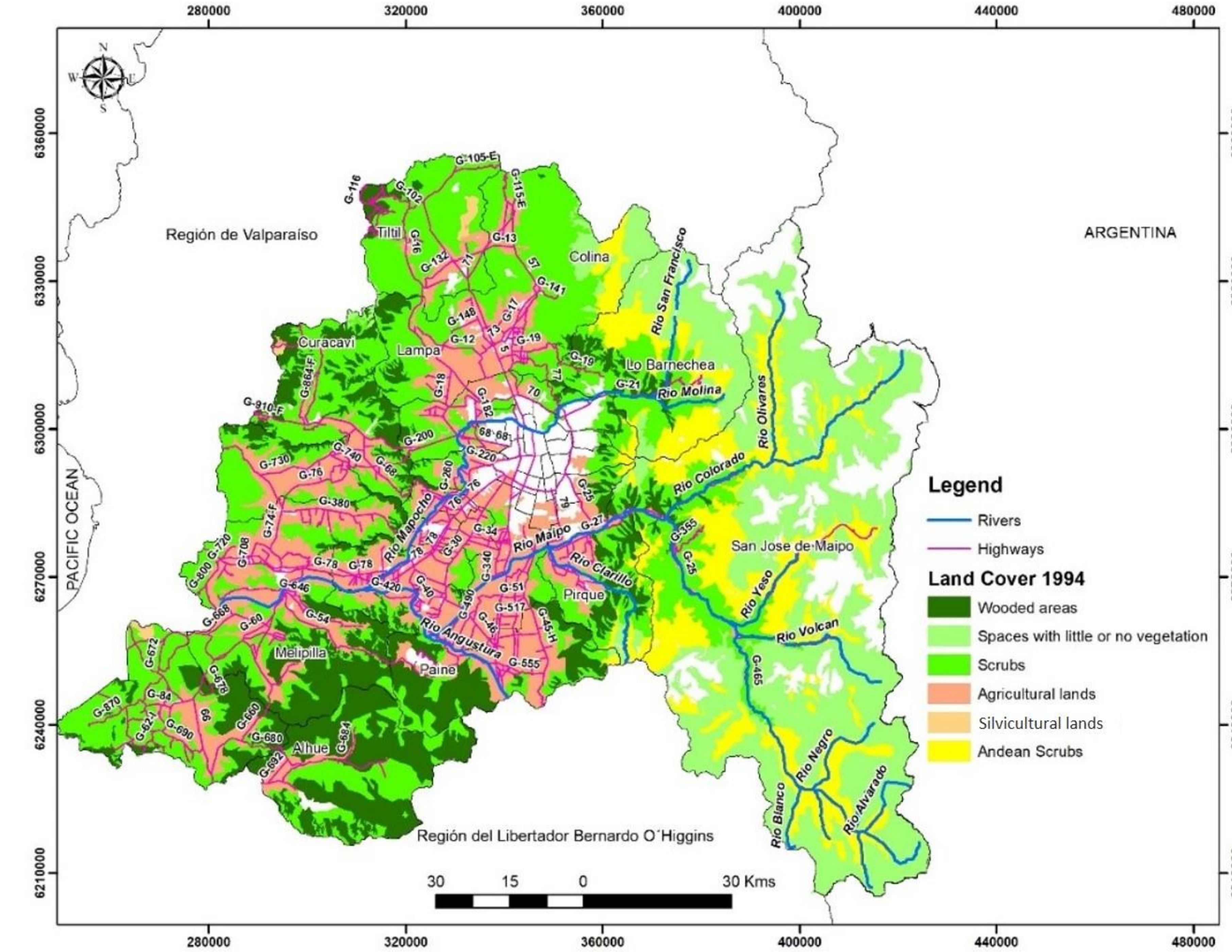
[a] Maximum-likelihood factor method with Varimax rotation used to extract factors.
Note. Each statement item's highest factor loading is indicated by boldface type.



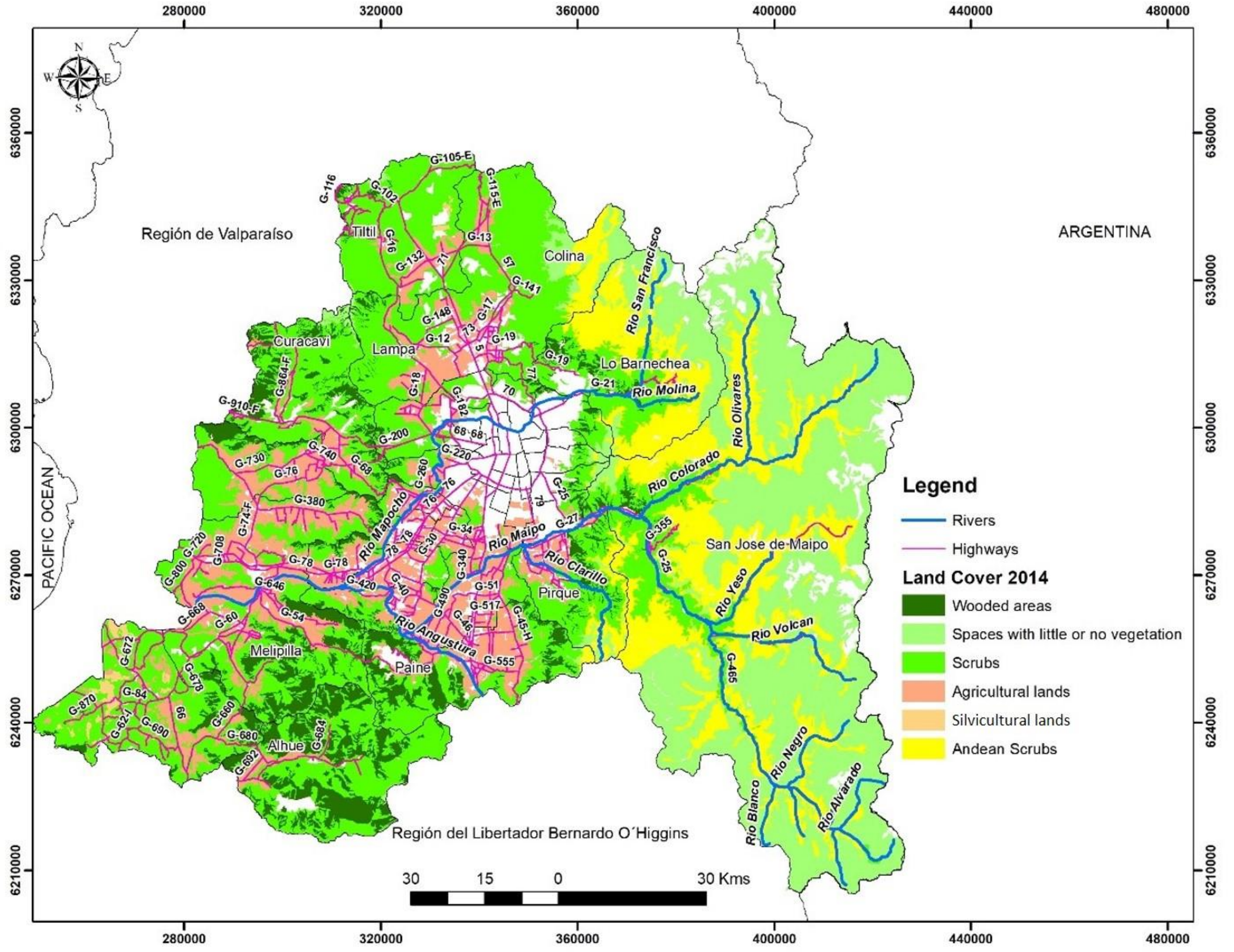
METROPOLITAN REGION OF SANTIAGO
280000
320000
360000
400000
440000
6360000
6330000
6300000
6270000
6240000
6210000
Tiltil
Colina
Lampa
Curacavi
Lo Barnechea
Quilicura
Huechuraba
Vitacura
Rio Mapocho
Rio Molina
Renca
Recoleta
Las Condes
Pudahuel
Quinta Normal
Santiago
La Reina
Ñuñoa
Peñalolen
Maria Pinto
Maipu
Cerillos
Macul
La Florida
El Bosque
Padre Hurtado
La Pintana
Peñaflor
Calera de Tango
San Bernardo
Puente Alto
El Monte
Talagante
Melipilla
Isla de Maipo
Buin
Pirque
San Jose de Maipo
Paine
San Pedro
Alhue
Rio Olivares
Rio Colorado
Rio Yeso
Rio Volcan
Rio de Colina
Rio Negro
Rio Barroso
Rio Maipo
Rivers
Communes
Heights
6000 - 7000
5000 - 6000
4000 - 5000
3000 - 4000
2000 - 3000
1000 - 2000
50 - 1000
30
15
0
30 Kms

Santiago´s urban sprawl process between 1994 and 2014

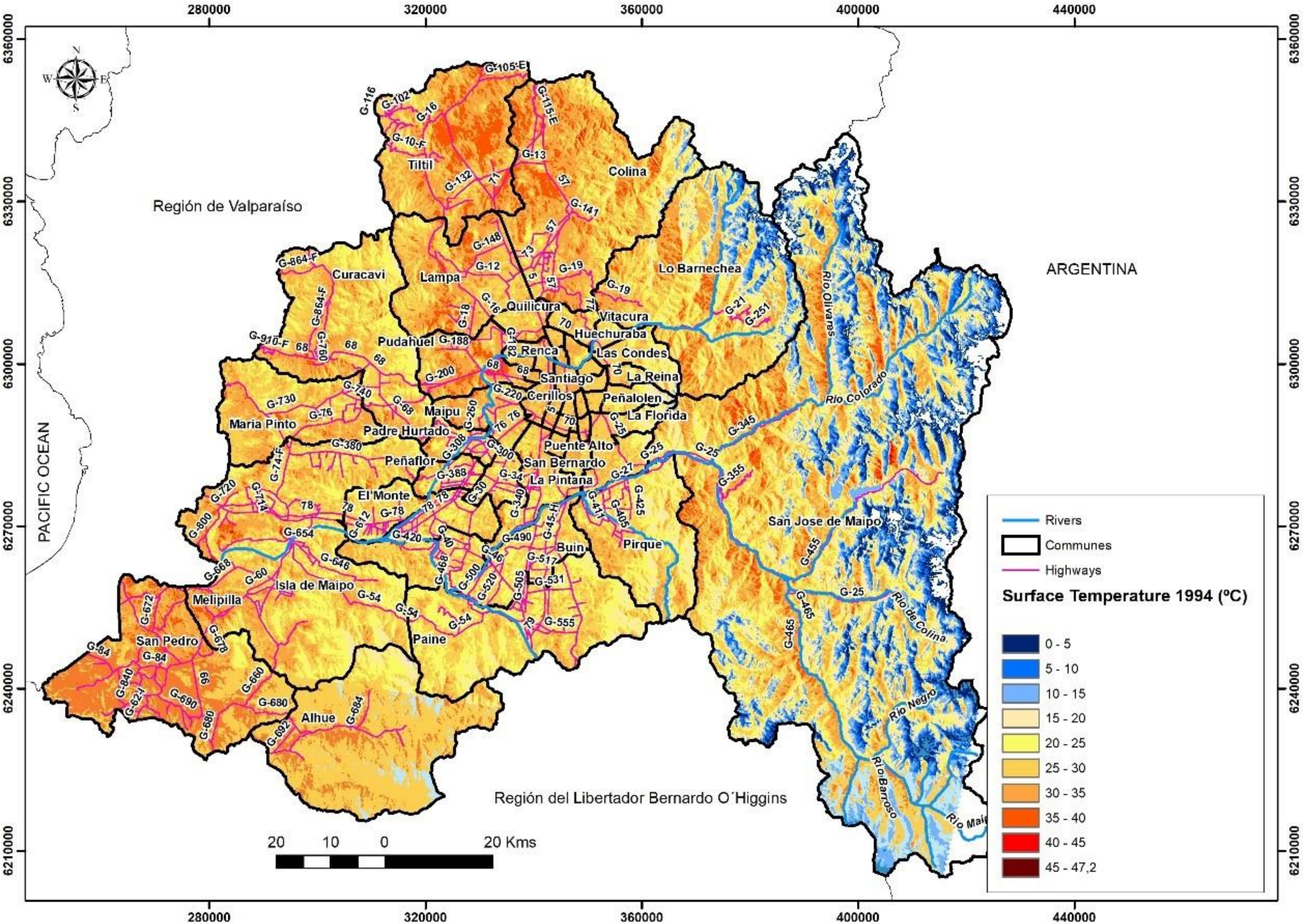




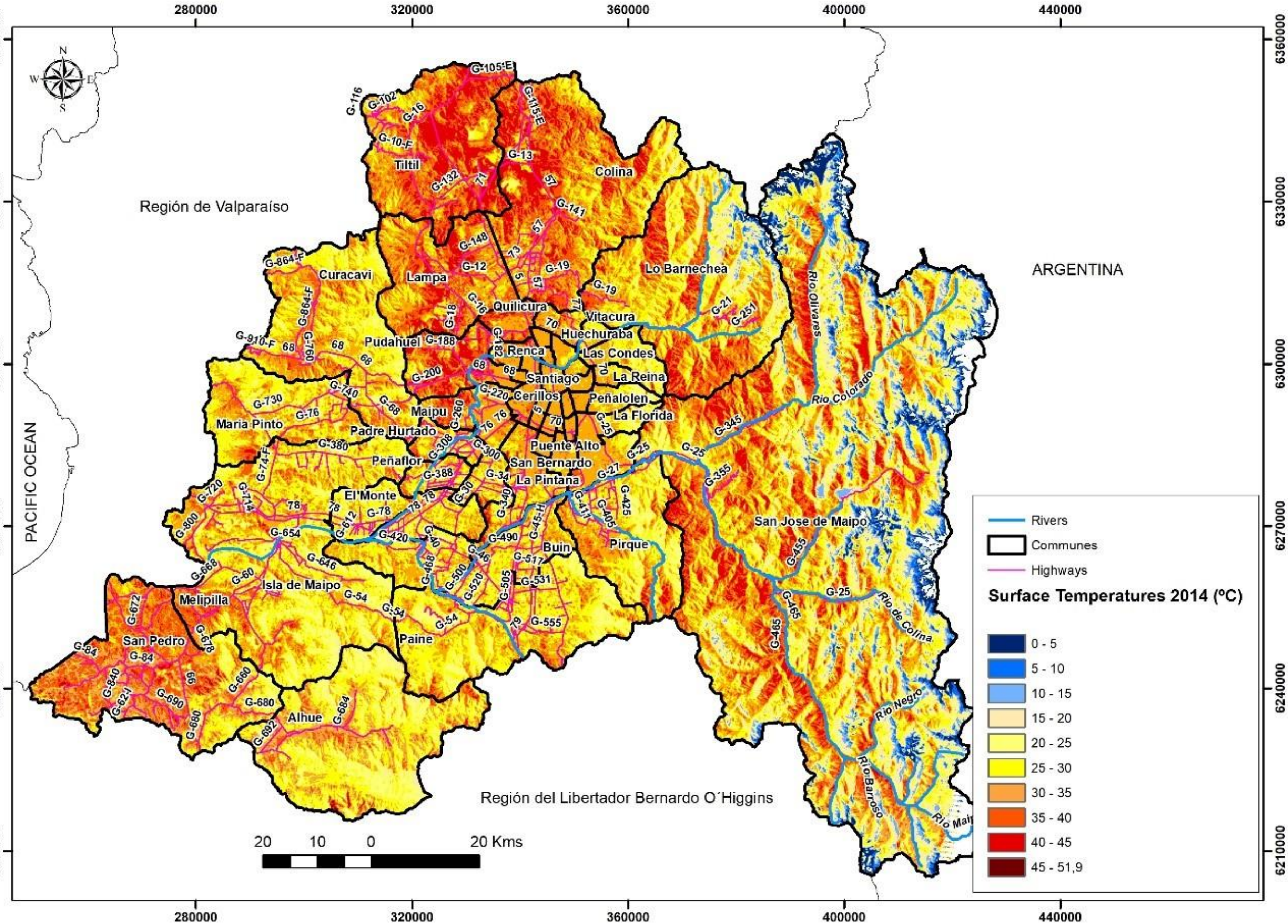
Legend
Rivers
Highways
Land Cover 1994
Wooded areas
Spaces with little or no vegetation
Scrubs
Agricultural lands
Silvicultural lands
Andean Scrubs
Región de Valparaíso
ARGENTINA
PACIFIC OCEAN
Región del Libertador Bernardo O´Higgins
Colina
Tiltil
Lampa
Curacavi
Lo Barnechea
San Jose de Maipo
Pirque
Paine
Melipilla
Alhue
Rio Mapocho
Rio Maipo
Rio Angustura
Rio Clarillo
Rio Colorado
Rio Molina
Rio San Francisco
Rio Olivares
Rio Yeso
Rio Volcan
Rio Negro
Rio Blanco
Rio Alvarado
30 15 0 30 Kms
N
S
W
E
280000
320000
360000
400000
440000
480000
6360000
6330000
6300000
6270000
6240000
6210000



Región de Valparaíso
ARGENTINA
PACIFIC OCEAN
Región del Libertador Bernardo O´Higgins
Tiltil
Colina
Curacaví
Lampa
Lo Barnechea
San Jose de Maipo
Pirque
Melipilla
Paine
Alhue
Rio San Francisco
Rio Molina
Rio Olivares
Rio Colorado
Rio Mapocho
Rio Maipo
Rio Clarillo
Rio Yeso
Rio Volcan
Rio Angustura
Rio Negro
Rio Blanco
Rio Alvarado
Legend
Rivers
Highways
Land Cover 2014
Wooded areas
Spaces with little or no vegetation
Scrubs
Agricultural lands
Silvicultural lands
Andean Scrubs
30 15 0 30 Kms
280000
320000
360000
400000
440000
480000
6360000
6330000
6300000
6270000
6240000
6210000

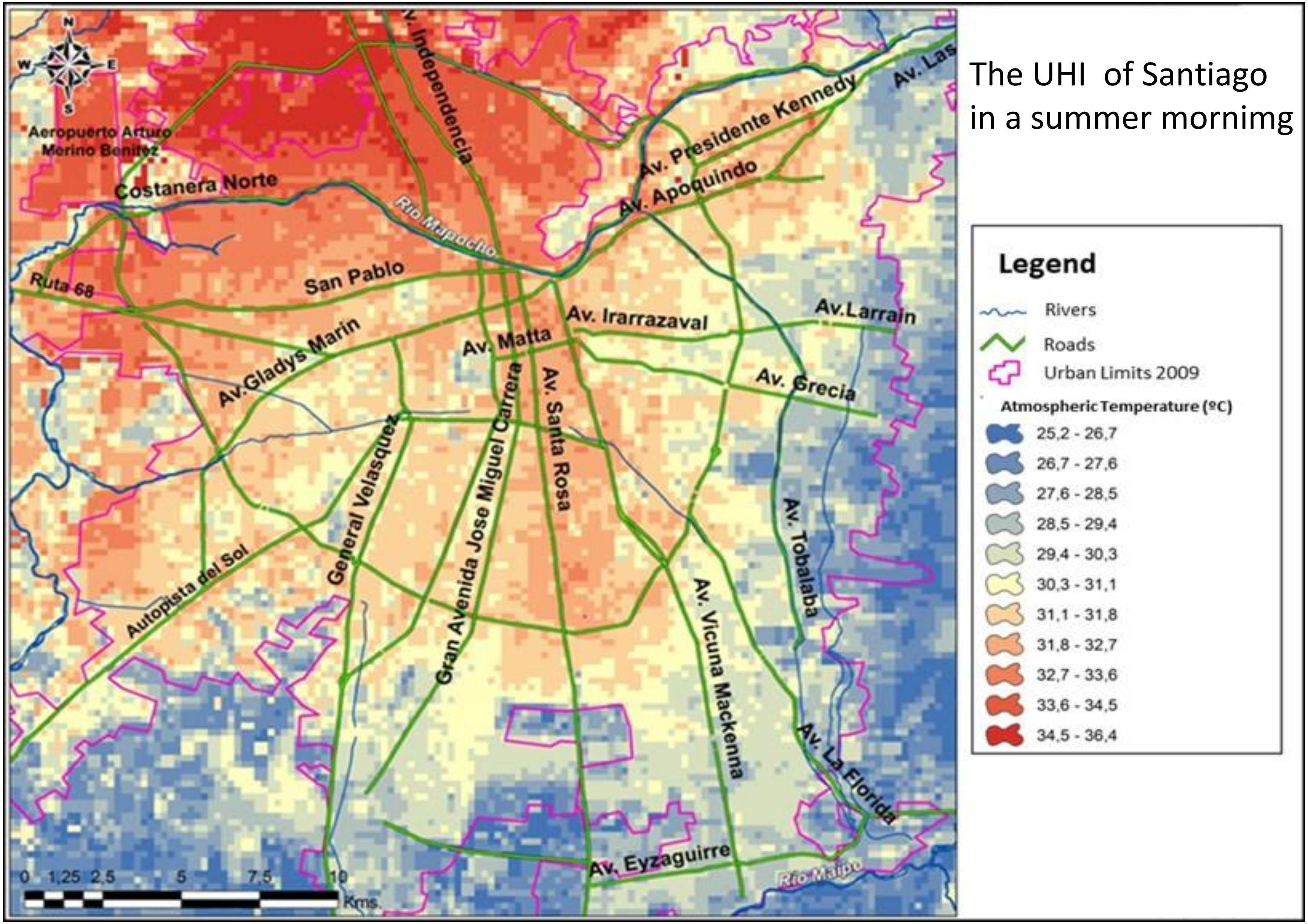


280000
320000
360000
400000
440000
6360000
6330000
6300000
6270000
6240000
6210000
N
S
W
E
PACIFIC OCEAN
Región de Valparaíso
ARGENTINA
Región del Libertador Bernardo O´Higgins
Tiltil
Colina
Lampa
Curacavi
Lo Barnechea
Quilicura
Vitacura
Huechuraba
Pudahuel
Renca
Las Condes
Santiago
La Reina
Cerillos
Peñalolen
Maipu
La Florida
Maria Pinto
Padre Hurtado
Puente Alto
Peñaflor
San Bernardo
La Pintana
El Monte
San Jose de Maipo
Pirque
Buin
Isla de Maipo
Melipilla
Paine
San Pedro
Alhue
Rio Olivares
Rio Colorado
Rio de Colina
Rio Negro
Rio Barroso
Rio Maipo
20 10 0 20 Kms
Rivers
Communes
Highways
Surface Temperature 1994 (ºC)
0 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 47,2

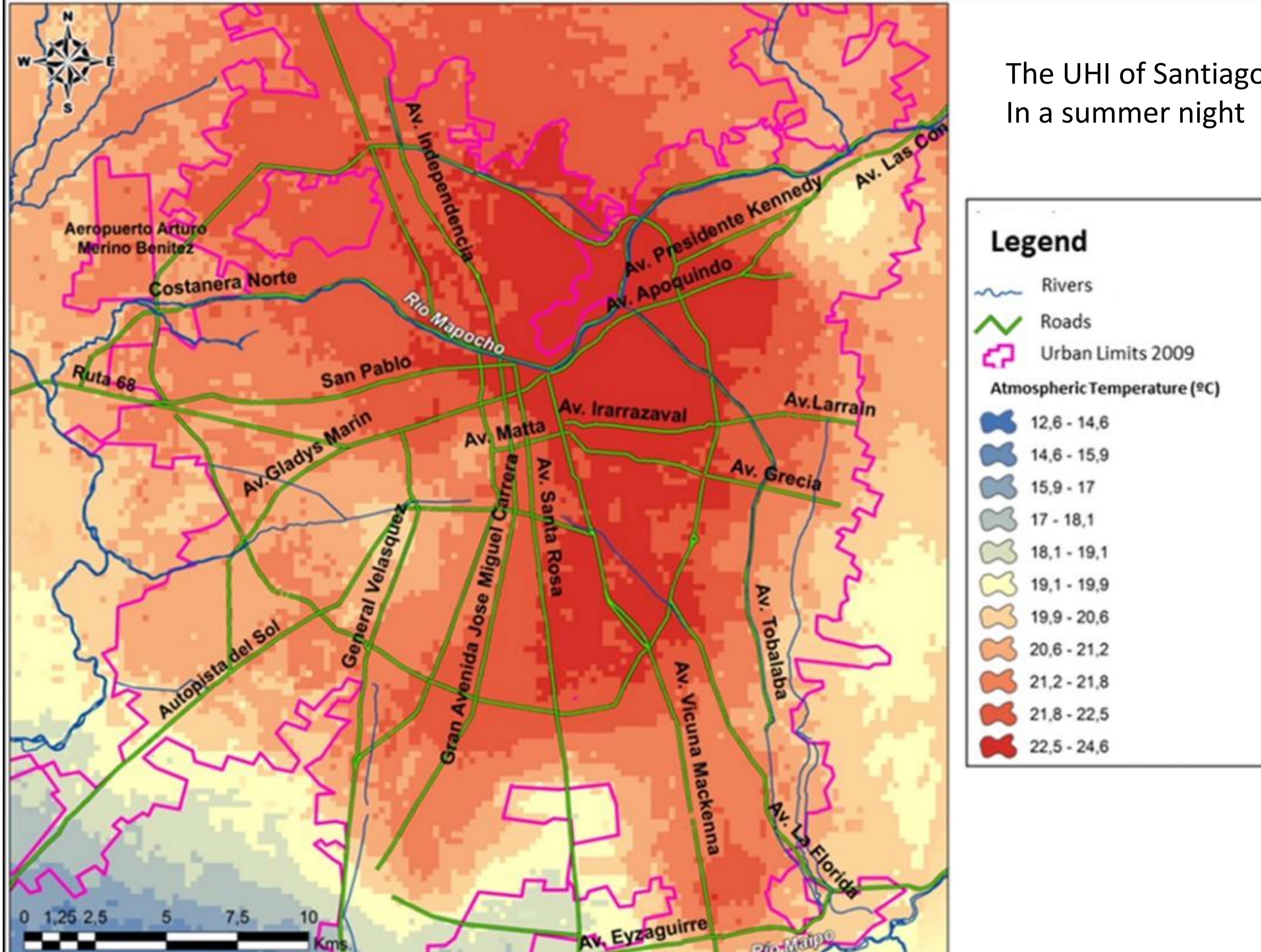


Región de Valparaíso
ARGENTINA
PACIFIC OCEAN
Región del Libertador Bernardo O´Higgins
Tiltil
Colina
Lampa
Lo Barnechea
Curacavi
Quilicura
Vitacura
Huechuraba
Pudahuel
Renca
Las Condes
Santiago
La Reina
Cerrillos
Peñalolen
Maipu
La Florida
Maria Pinto
Padre Hurtado
Puente Alto
Peñaflor
San Bernardo
La Pintana
El Monte
San Jose de Maipo
Buin
Pirque
Isla de Maipo
Melipilla
Paine
San Pedro
Alhue
Rio Olivares
Rio Colorado
Rio de Colina
Rio Negro
Rio Barroso
Rivers
Communes
Highways
Surface Temperatures 2014 (ºC)
0 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 51,9
20 10 0 20 Kms
280000
320000
360000
400000
440000
6360000
6330000
6300000
6270000
6240000
6210000

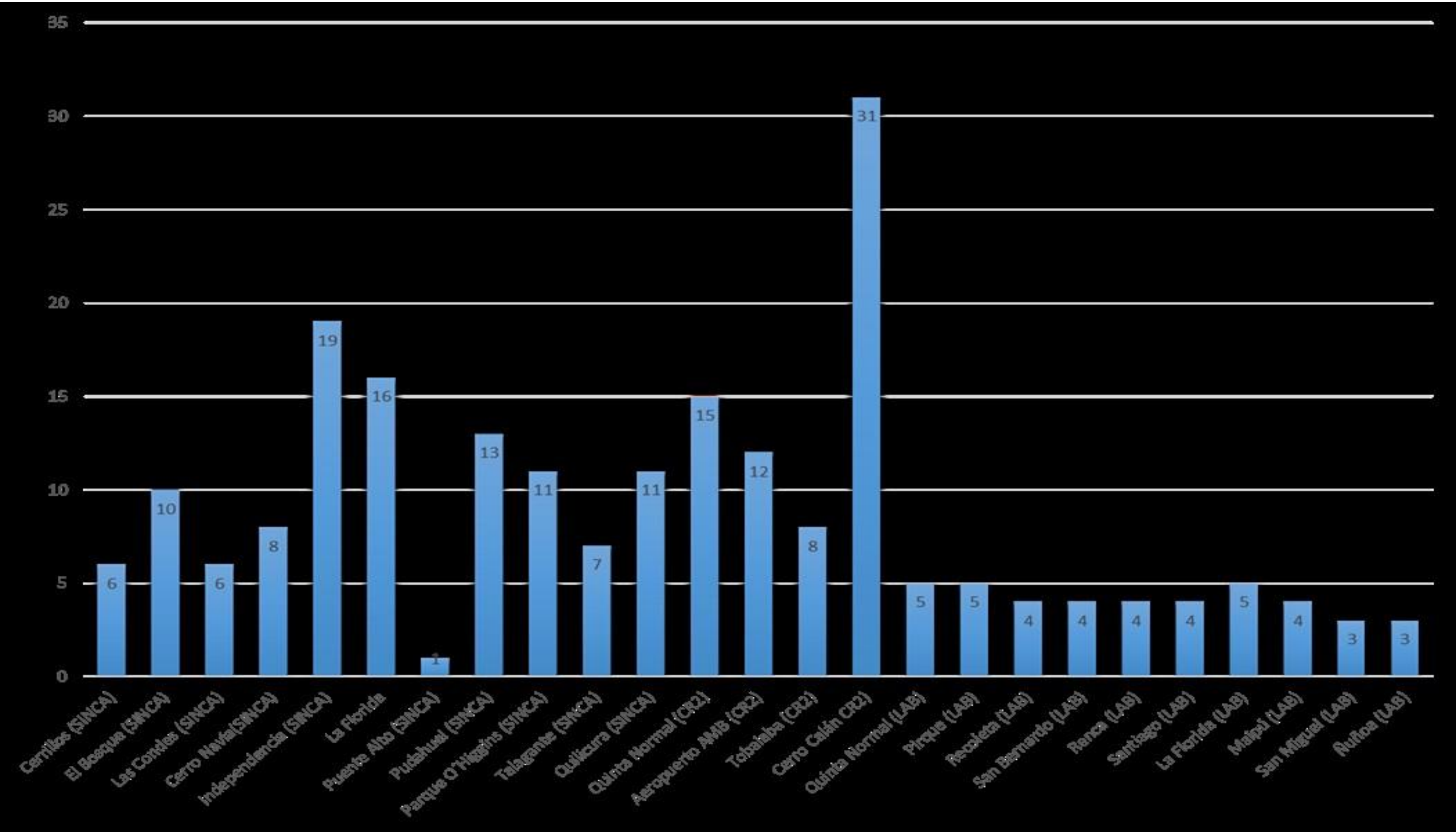
The UHI of Santiago in a summer mornimg

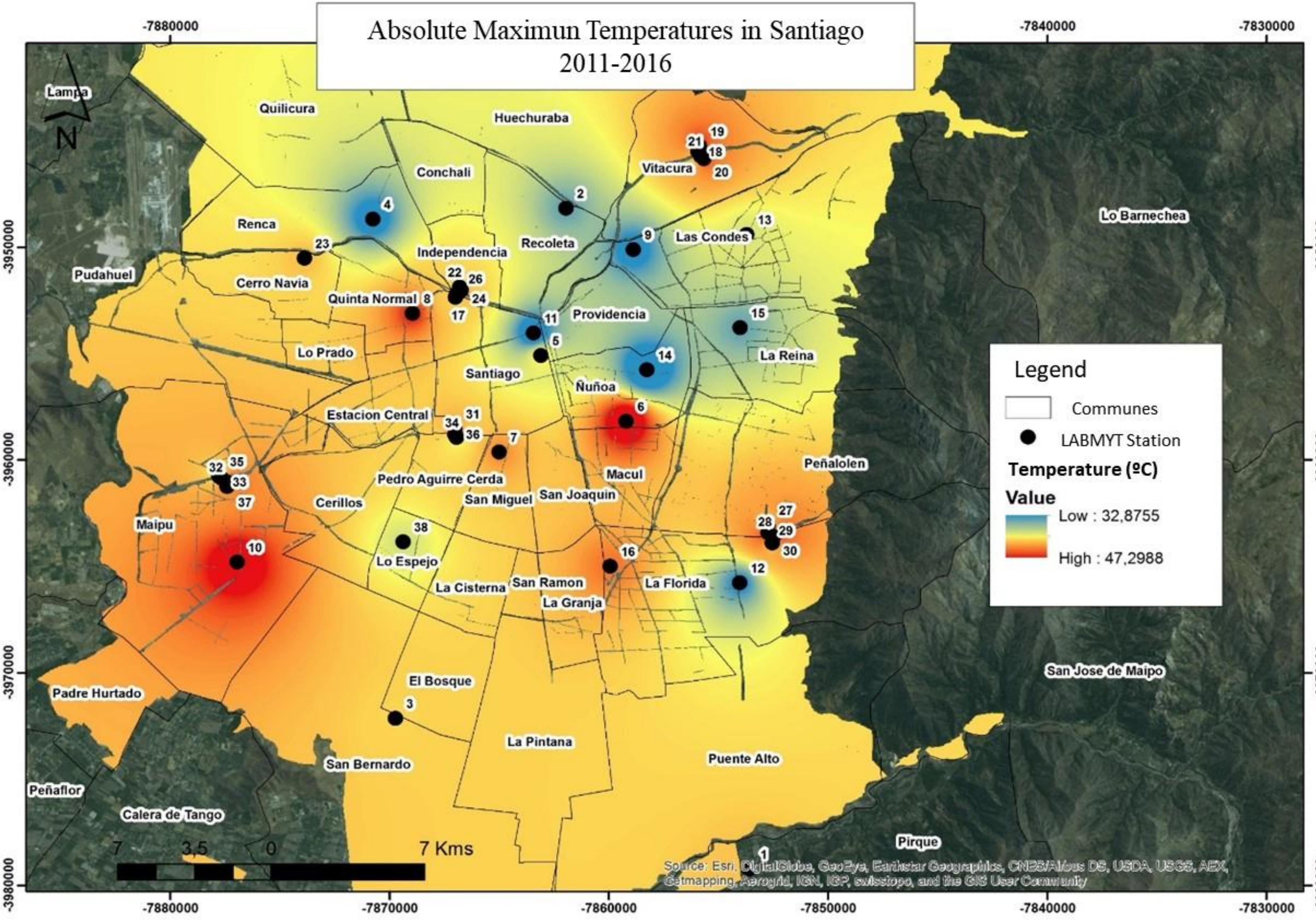


The UHI of Santiago
In a summer night

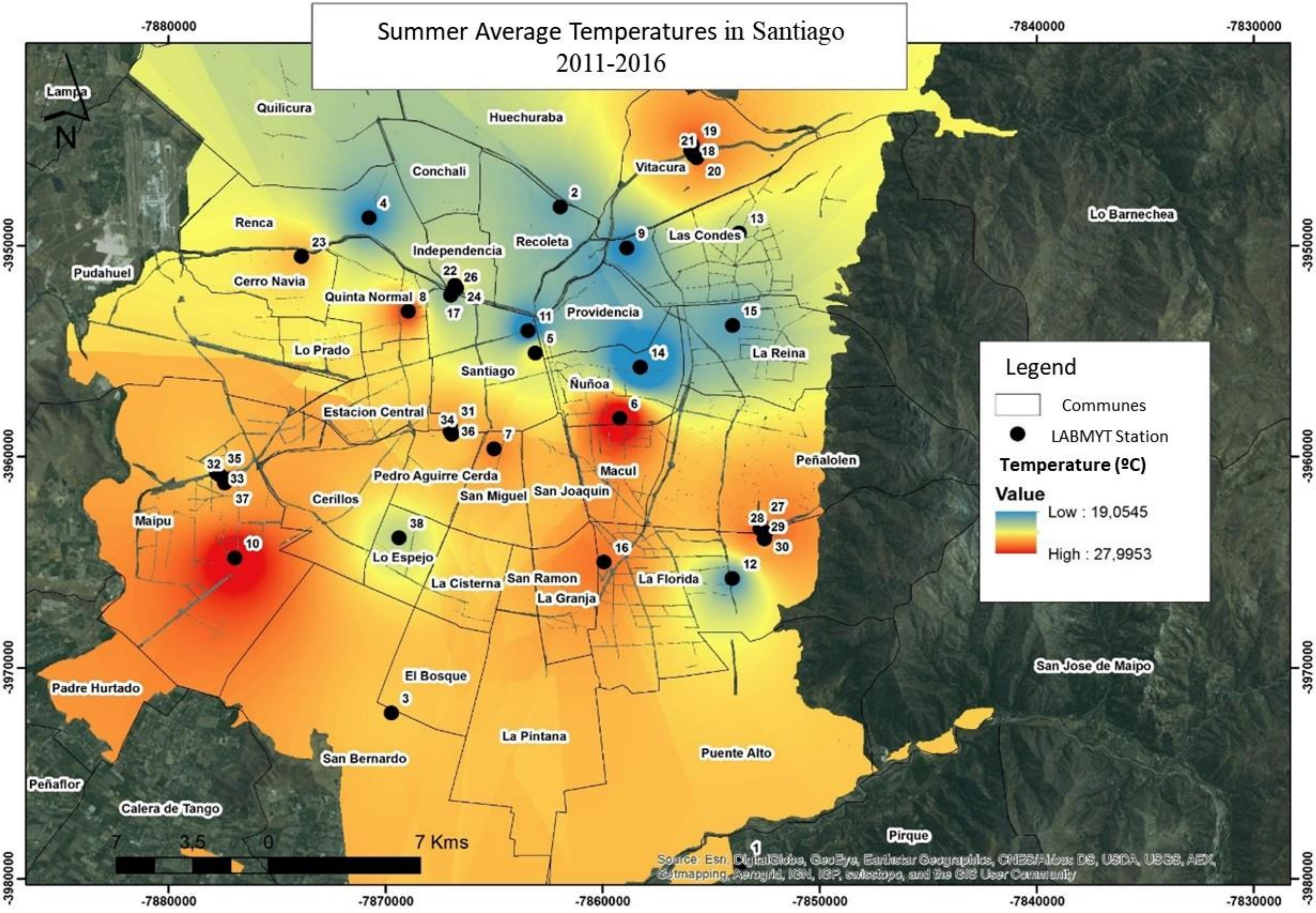


Number of heat waves in Santiago de Chile¨s neighborhoods 2010-2017

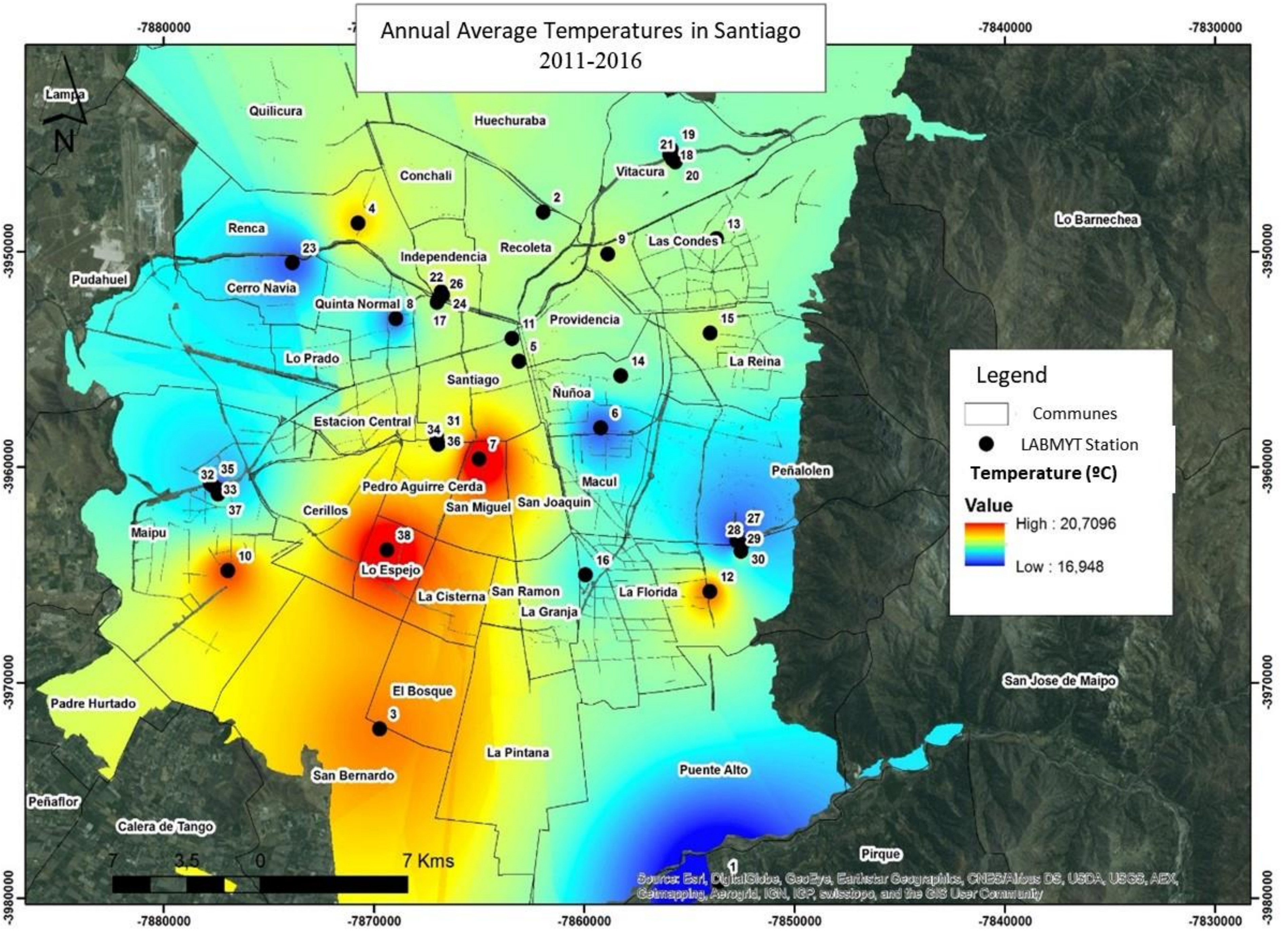




Absolute Maximun Temperatures in Santiago
2011-2016
Legend
Communes
LABMYT Station
Temperature (ºC)
Value
Low : 32,8755
High : 47,2988
7 3,5 0 7 Kms
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Lampa
Quilicura
Huechuraba
Conchali
Vitacura
Renca
Recoleta
Las Condes
Lo Barnechea
Pudahuel
Independencia
Cerro Navia
Quinta Normal
Providencia
Lo Prado
Santiago
La Reina
Ñuñoa
Estacion Central
Peñalolen
Pedro Aguirre Cerda
Macul
San Miguel
San Joaquin
Cerillos
Maipu
Lo Espejo
La Cisterna
San Ramon
La Florida
La Granja
San Jose de Maipo
El Bosque
Padre Hurtado
La Pintana
San Bernardo
Puente Alto
Peñaflor
Calera de Tango
Pirque
-7880000
-7870000
-7860000
-7850000
-7840000
-7830000
-3950000
-3960000
-3970000
-3980000



Summer Average Temperatures in Santiago
2011-2016
-7880000
-7840000
-7830000
-7870000
-7860000
-7850000
-3950000
-3960000
-3970000
-3980000
N
Lampa
Quilicura
Huechuraba
Conchali
Vitacura
Renca
Independencia
Recoleta
Las Condes
Lo Barnechea
Pudahuel
Cerro Navia
Quinta Normal
Providencia
La Reina
Lo Prado
Santiago
Ñuñoa
Estacion Central
Peñalolen
Pedro Aguirre Cerda
Macul
San Miguel
San Joaquin
Cerrillos
Maipu
Lo Espejo
La Cisterna
San Ramon
La Granja
La Florida
El Bosque
Padre Hurtado
San Jose de Maipo
La Pintana
San Bernardo
Puente Alto
Peñaflor
Calera de Tango
Pirque
Legend
Communes
LABMYT Station
Temperature (ºC)
Value
Low : 19,0545
High : 27,9953
7 3,5 0 7 Kms
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Annual Average Temperatures in Santiago
2011-2016
-7880000
-7870000
-7860000
-7850000
-7840000
-7830000
-3950000
-3960000
-3970000
-3980000
N
Lampa
Quilicura
Huechuraba
Conchali
Vitacura
Renca
Recoleta
Las Condes
Lo Barnechea
Independencia
Pudahuel
Cerro Navia
Quinta Normal
Providencia
Lo Prado
La Reina
Santiago
Ñuñoa
Estacion Central
Peñalolen
Pedro Aguirre Cerda
Macul
San Miguel
San Joaquin
Cerrillos
Maipu
Lo Espejo
La Cisterna
San Ramon
La Florida
La Granja
El Bosque
Padre Hurtado
San Jose de Maipo
La Pintana
San Bernardo
Puente Alto
Peñaflor
Calera de Tango
Pirque
7 3,5 0 7 Kms
Legend
Communes
LABMYT Station
Temperature (ºC)
Value
High : 20,7096
Low : 16,948
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

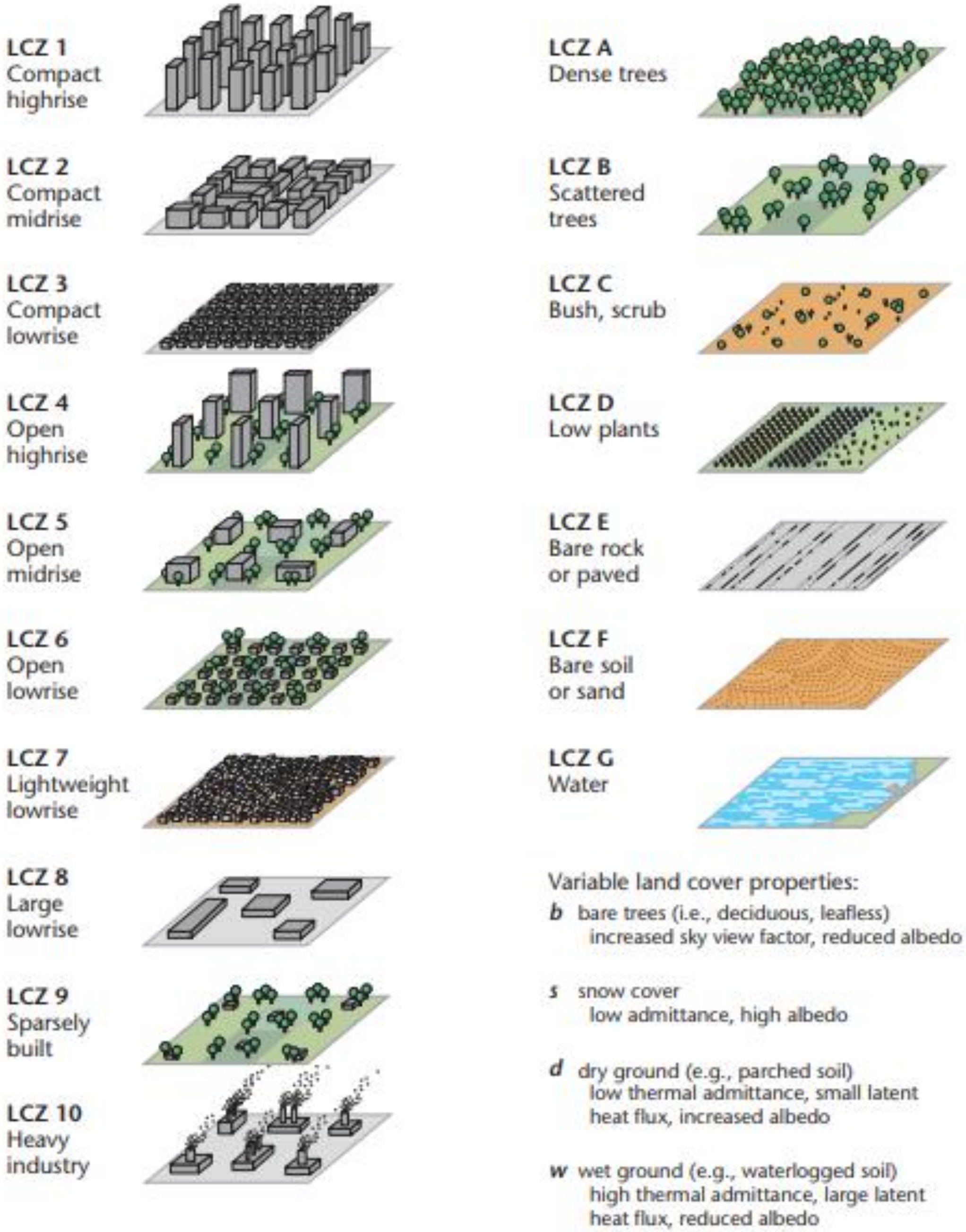
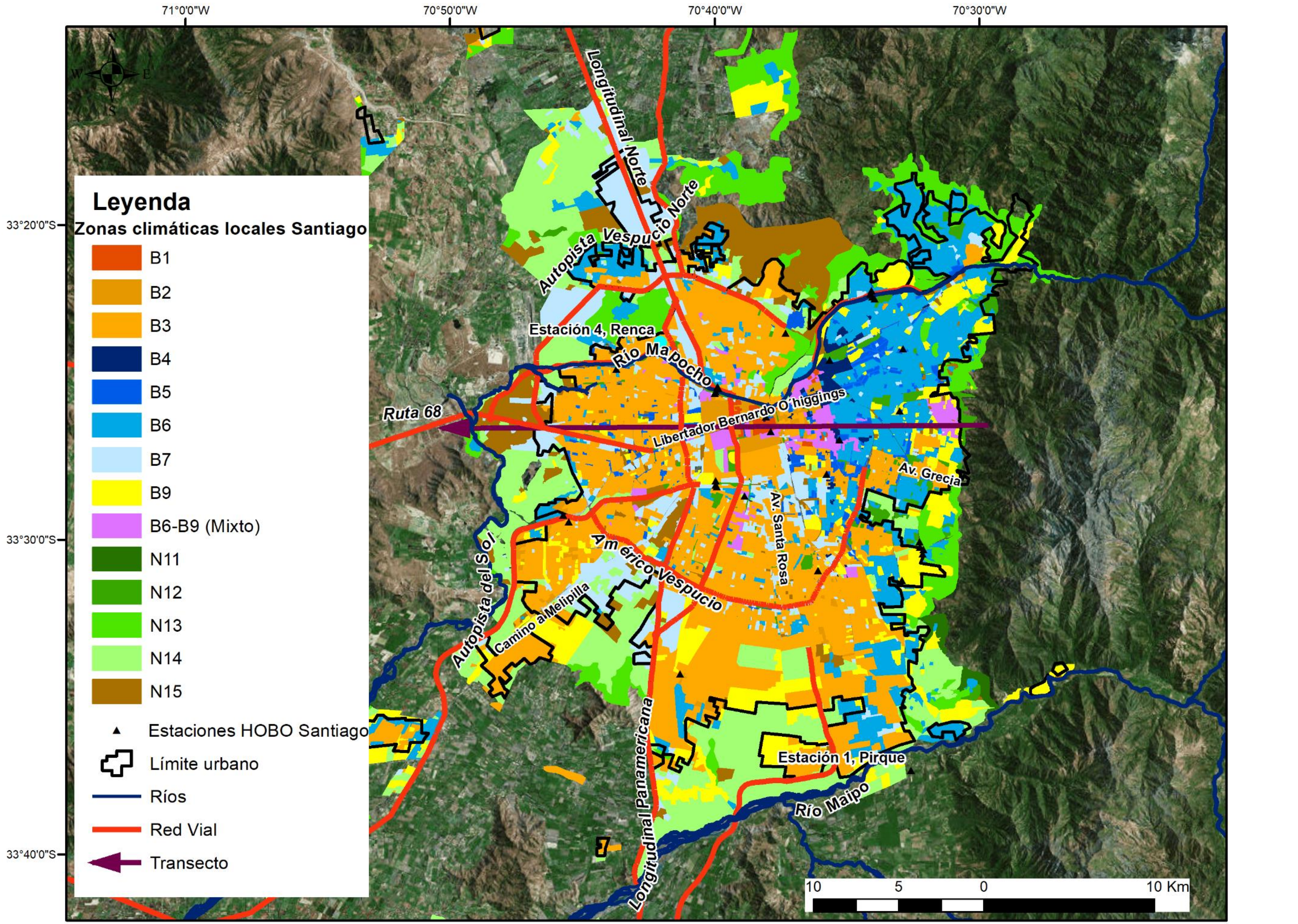


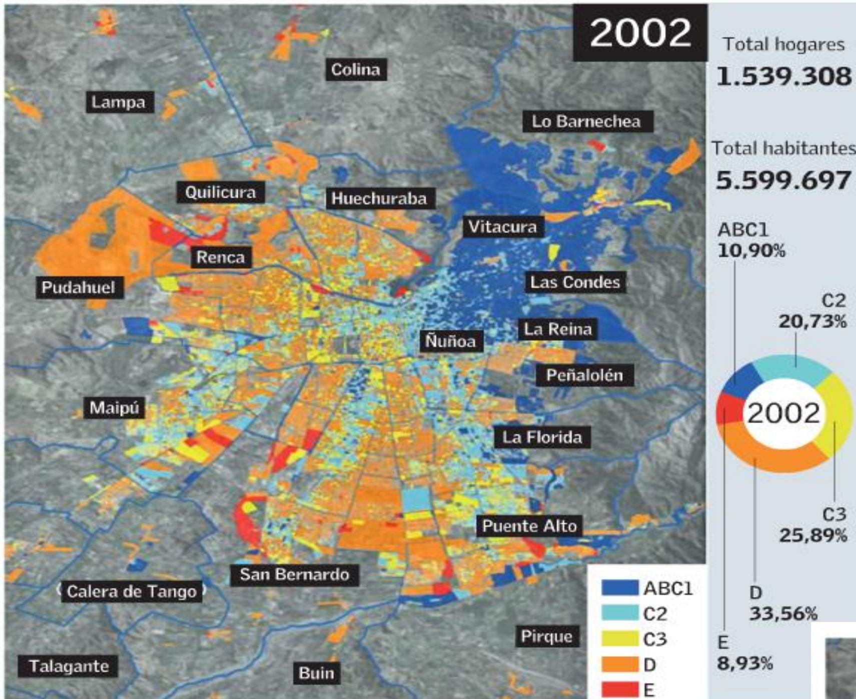
Figure 2.9 Classification of Local Climate Zones (LCZ) according to their perceived ability to modify local climate (Source: Stewart and Oke, 2012; © American Meteorological Society, used with permission). For quantitative measures of urban zone properties (first ten zones), see Table 2.2.

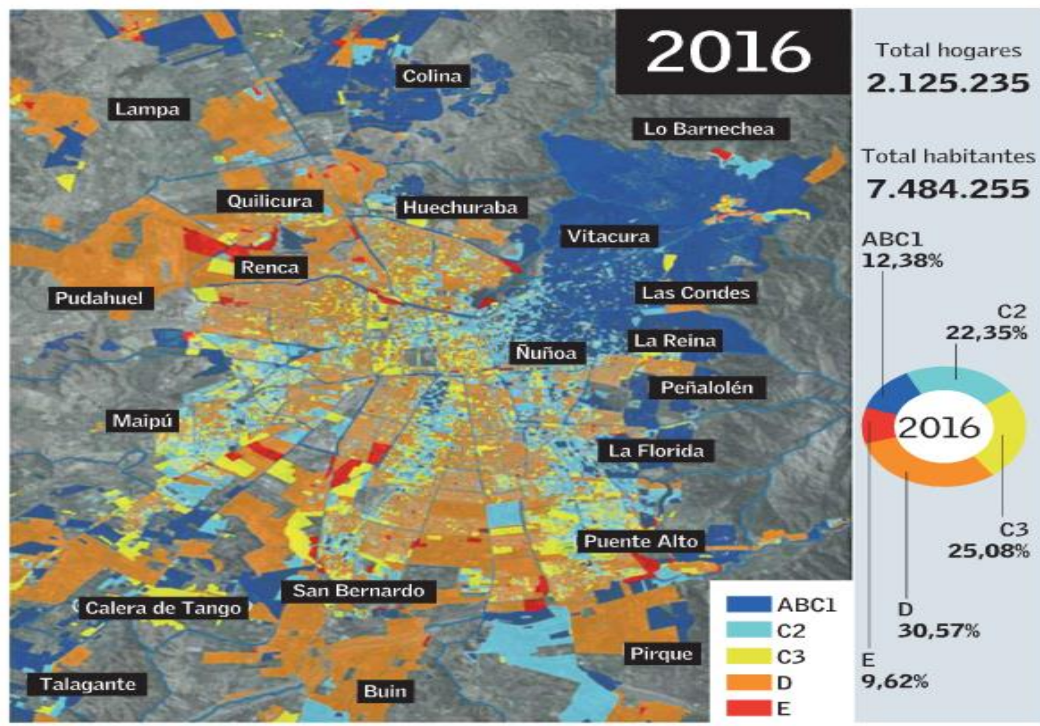


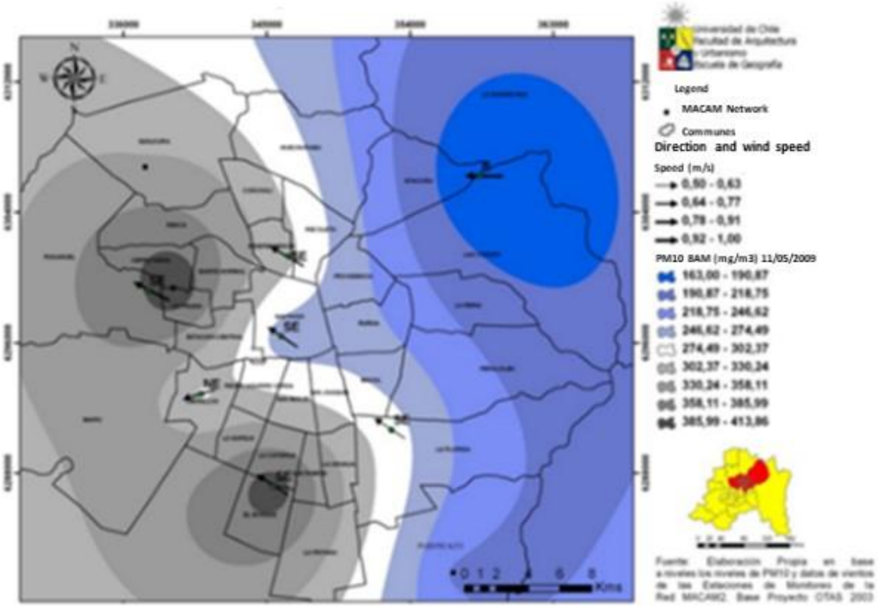
71°0'0"W
70°50'0"W
70°40'0"W
70°30'0"W
33°20'0"S
33°30'0"S
33°40'0"S
Leyenda
Zonas climáticas locales Santiago
B1
B2
B3
B4
B5
B6
B7
B9
B6-B9 (Mixto)
N11
N12
N13
N14
N15
Estaciones HOBO Santiago
Límite urbano
Ríos
Red Vial
Transecto
Longitudinal Norte
Autopista Vespucio Norte
Estación 4, Renca
Río Mapocho
Ruta 68
Libertador Bernardo O'higgins
Av. Grecia
Av. Santa Rosa
Américo Vespucio
Autopista del Sol
Camino a Melipilla
Longitudinal Panamericana
Estación 1, Pirque
Río Maipo
10
5
0
10 Km

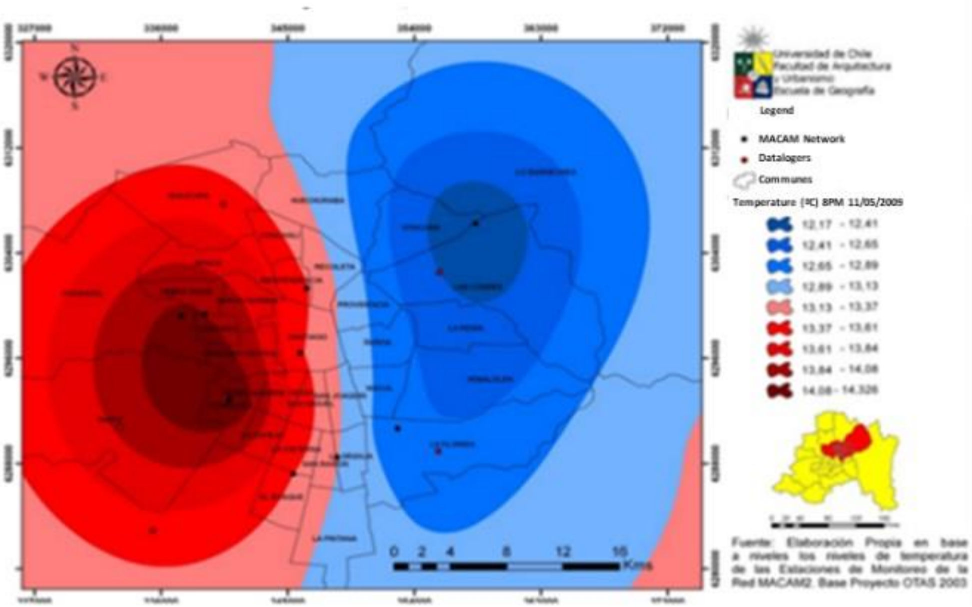

37

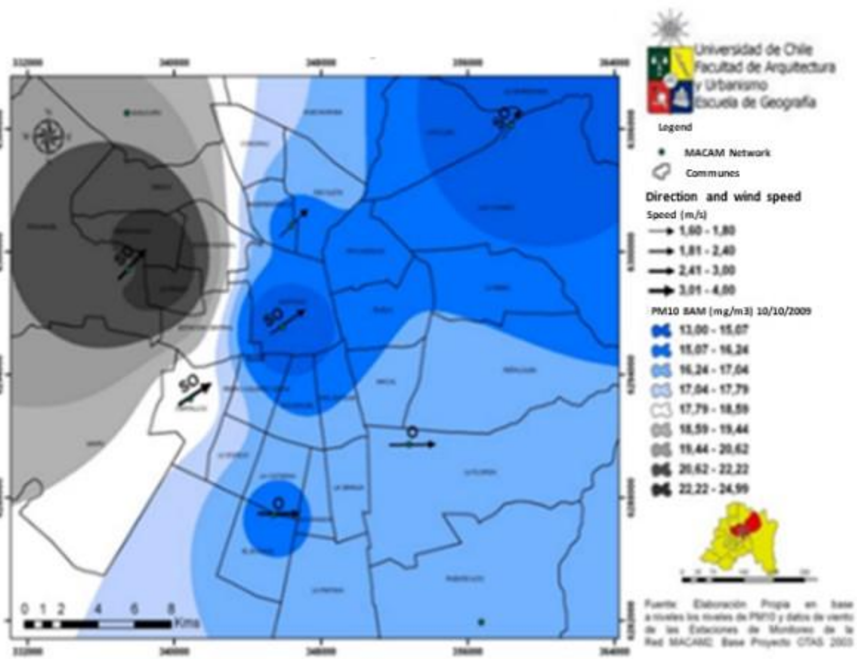
The distribution of homes in Santiago de Chile according to income in 2002 and 2016

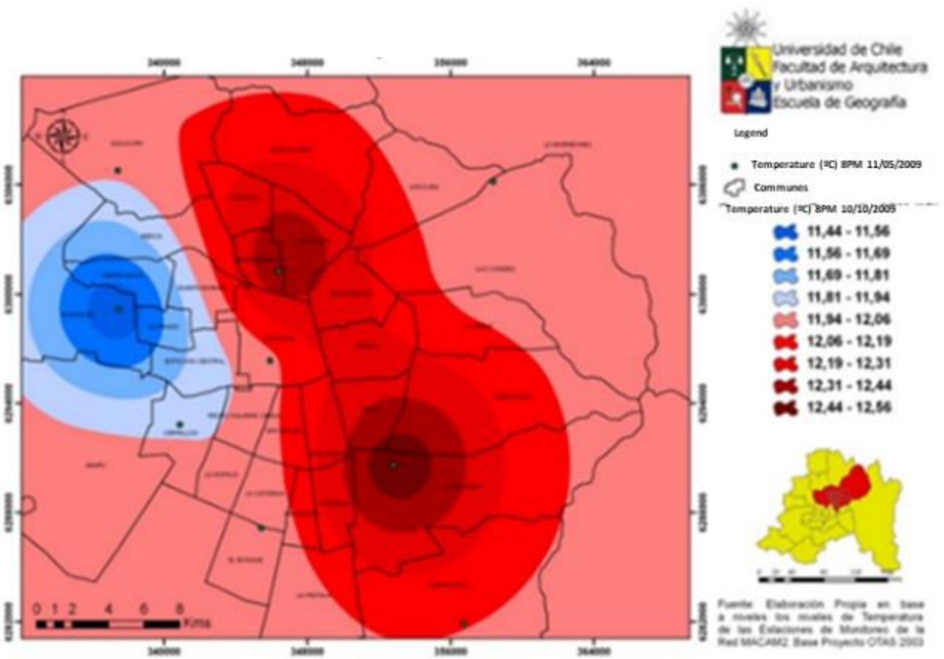


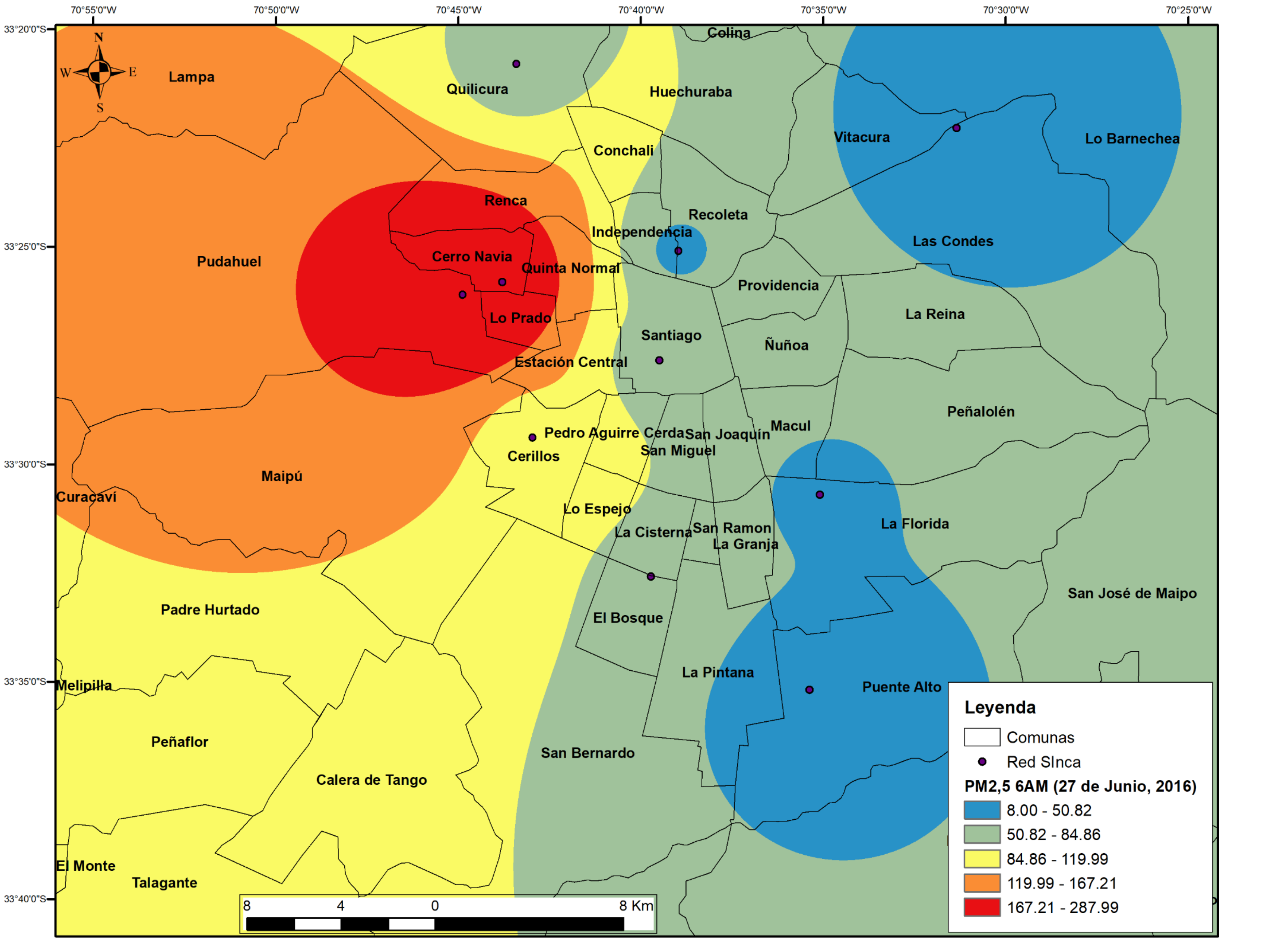



Legend
MACAM Network
Communes
Direction and wind speed
Speed (m/s)
0,50 - 0,63
0,64 - 0,77
0,78 - 0,91
0,92 - 1,00
PM10 8AM (mg/m3) 11/05/2009
163,00 - 190,87
190,87 - 218,75
218,75 - 246,62
246,62 - 274,49
274,49 - 302,37
302,37 - 330,24
330,24 - 358,11
358,11 - 385,99
385,99 - 413,86
Kms

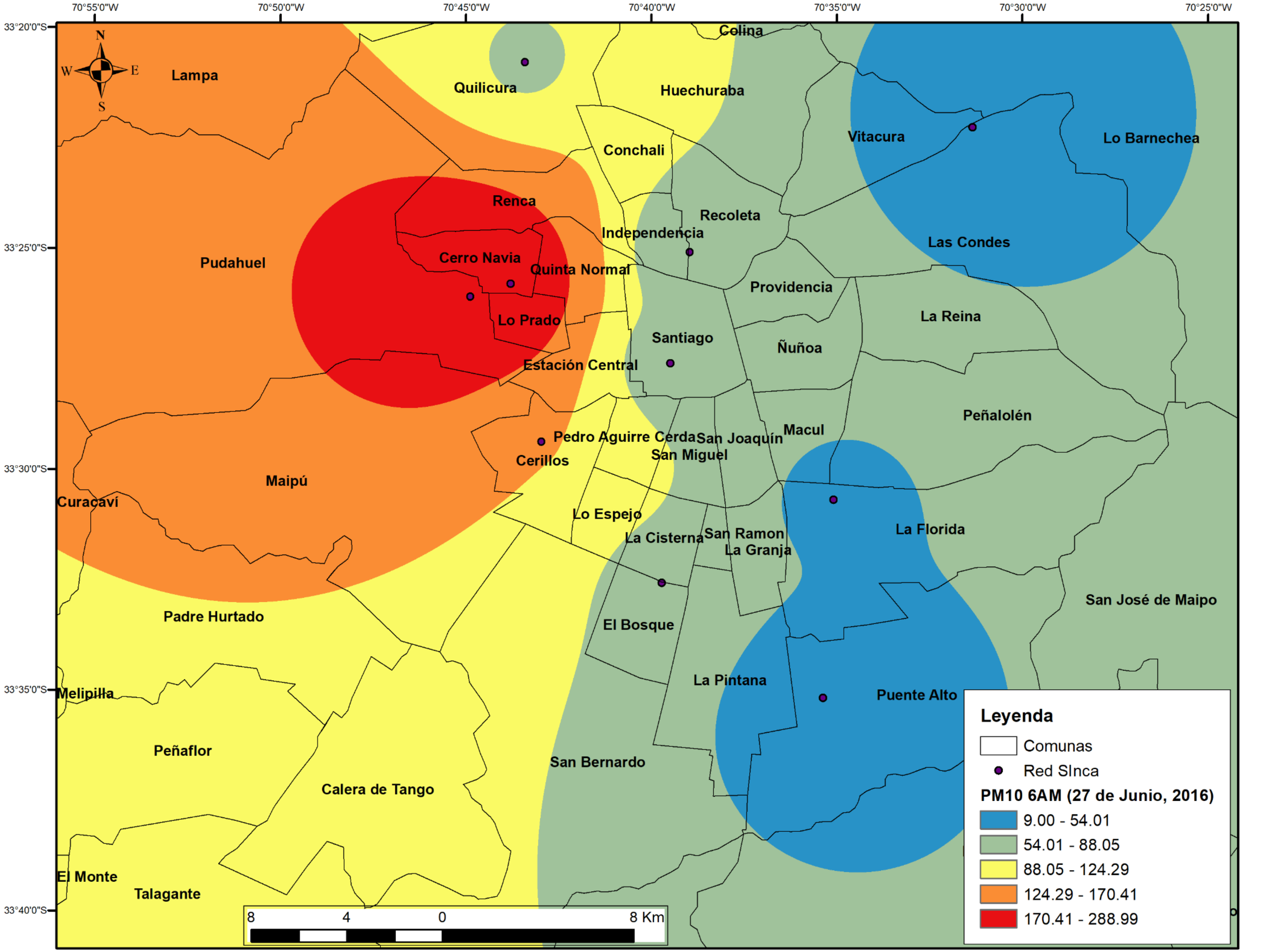

Legend
MACAM Network
Datalogers
Communes
Temperature (ºC) 8PM 11/05/2009
12,17 - 12,41
12,41 - 12,65
12,65 - 12,89
12,89 - 13,13
13,13 - 13,37
13,37 - 13,61
13,61 - 13,84
13,84 - 14,08
14,08 - 14,326
Fuente: Elaboración Propia en base a niveles los niveles de temperatura de las Estaciones de Monitoreo de la Red MACAM2. Base Proyecto OTAS 2003


Universidad de Chile
Facultad de Arquitectura
y Urbanismo
Escuela de Geografía
Legend
MACAM Network
Communes
Direction and wind speed
Speed (m/s)
1,60 - 1,80
1,81 - 2,40
2,41 - 3,00
3,01 - 4,00
PM10 8AM (mg/m3) 10/10/2009
13,00 - 15,07
15,07 - 16,24
16,24 - 17,04
17,04 - 17,79
17,79 - 18,59
18,59 - 19,44
19,44 - 20,62
20,62 - 22,22
22,22 - 24,99
Kms

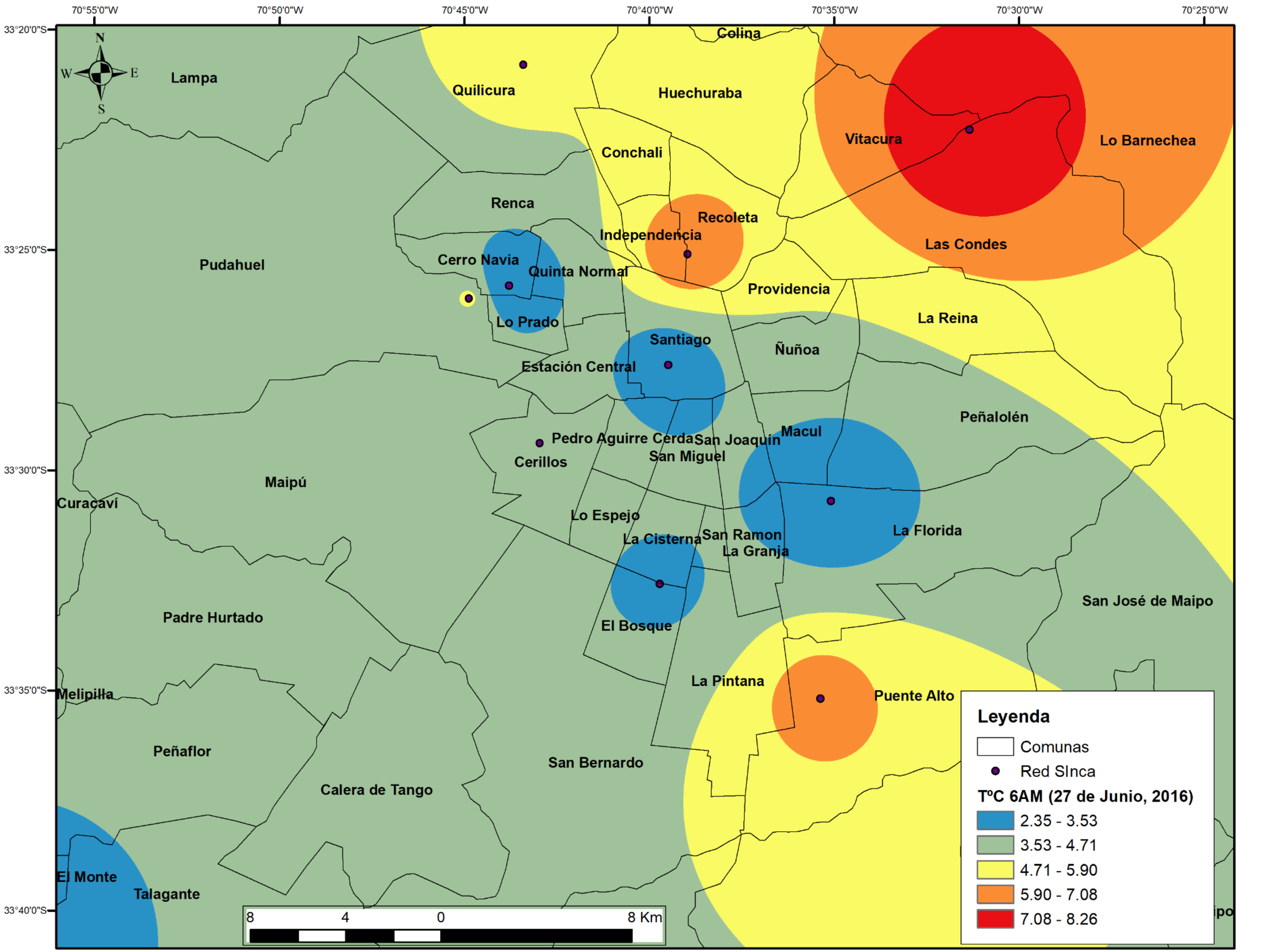

Universidad de Chile
Facultad de Arquitectura
y Urbanismo
Escuela de Geografía
Legend
Temperature (ºC) 8PM 11/05/2009
Communes
Temperature (ºC) 8PM 10/10/2009
11,44 - 11,56
11,56 - 11,69
11,69 - 11,81
11,81 - 11,94
11,94 - 12,06
12,06 - 12,19
12,19 - 12,31
12,31 - 12,44
12,44 - 12,56
Kms



70°55'0"W
70°50'0"W
70°45'0"W
70°40'0"W
70°35'0"W
70°30'0"W
70°25'0"W
33°20'0"S
33°25'0"S
33°30'0"S
33°35'0"S
33°40'0"S
N
S
E
W
Lampa
Quilicura
Colina
Huechuraba
Vitacura
Lo Barnechea
Conchali
Renca
Recoleta
Independencia
Las Condes
Pudahuel
Cerro Navia
Quinta Normal
Providencia
La Reina
Lo Prado
Santiago
Ñuñoa
Estación Central
Peñalolén
Pedro Aguirre Cerda
San Joaquín
Macul
San Miguel
Cerillos
Maipú
Curacaví
Lo Espejo
La Cisterna
San Ramon
La Granja
La Florida
San José de Maipo
Padre Hurtado
El Bosque
La Pintana
Puente Alto
Melipilla
Peñaflor
San Bernardo
Calera de Tango
El Monte
Talagante
8
4
0
8 Km
Leyenda
Comunas
Red SInca
PM2,5 6AM (27 de Junio, 2016)
8.00 - 50.82
50.82 - 84.86
84.86 - 119.99
119.99 - 167.21
167.21 - 287.99

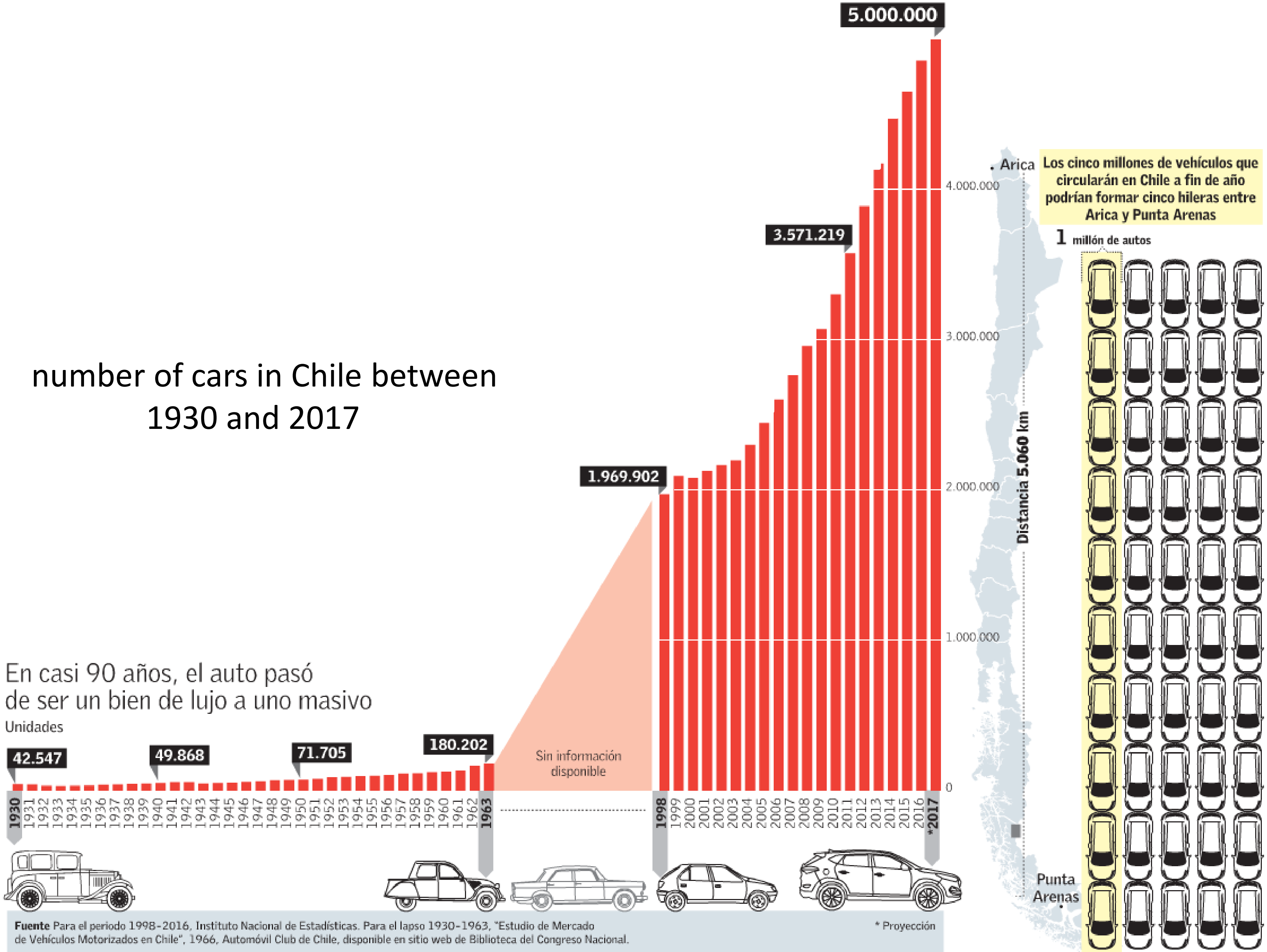


70°55'0"W
70°50'0"W
70°45'0"W
70°40'0"W
70°35'0"W
70°30'0"W
70°25'0"W
33°20'0"S
33°25'0"S
33°30'0"S
33°35'0"S
33°40'0"S
N
S
E
W
Lampa
Quilicura
Colina
Huechuraba
Conchali
Vitacura
Lo Barnechea
Renca
Recoleta
Independencia
Pudahuel
Cerro Navia
Quinta Normal
Las Condes
Providencia
Lo Prado
La Reina
Santiago
Ñuñoa
Estación Central
Peñalolén
Macul
Pedro Aguirre Cerda
San Joaquín
San Miguel
Cerillos
Maipú
Curacaví
Lo Espejo
La Cisterna
San Ramon
La Granja
La Florida
San José de Maipo
Padre Hurtado
El Bosque
La Pintana
Puente Alto
Melipilla
Peñaflor
San Bernardo
Calera de Tango
El Monte
Talagante
8
4
0
8 Km
Leyenda
Comunas
Red SInca
PM10 6AM (27 de Junio, 2016)
9.00 - 54.01
54.01 - 88.05
88.05 - 124.29
124.29 - 170.41
170.41 - 288.99



70°55'0"W
70°50'0"W
70°45'0"W
70°40'0"W
70°35'0"W
70°30'0"W
70°25'0"W
33°20'0"S
33°25'0"S
33°30'0"S
33°35'0"S
33°40'0"S
N
S
E
W
Colina
Lampa
Quilicura
Huechuraba
Vitacura
Lo Barnechea
Conchali
Renca
Recoleta
Independencia
Las Condes
Pudahuel
Cerro Navia
Quinta Normal
Providencia
La Reina
Lo Prado
Santiago
Ñuñoa
Estación Central
Peñalolén
Macul
Pedro Aguirre Cerda
San Joaquín
San Miguel
Cerillos
Maipú
Curacaví
Lo Espejo
La Cisterna
San Ramon
La Granja
La Florida
San José de Maipo
Padre Hurtado
El Bosque
La Pintana
Puente Alto
Melipilla
Peñaflor
San Bernardo
Calera de Tango
El Monte
Talagante
8
4
0
8 Km
Leyenda
Comunas
Red SInca
TºC 6AM (27 de Junio, 2016)
2.35 - 3.53
3.53 - 4.71
4.71 - 5.90
5.90 - 7.08
7.08 - 8.26

number of cars in Chile between 1930 and 2017



Fuente: El Mercurio. Economía y Negocios B12. 03/09/2017

Cambios en la contribución relativa de las fuentes de PM2,5 en el tiempo, indicando proimedio para el período

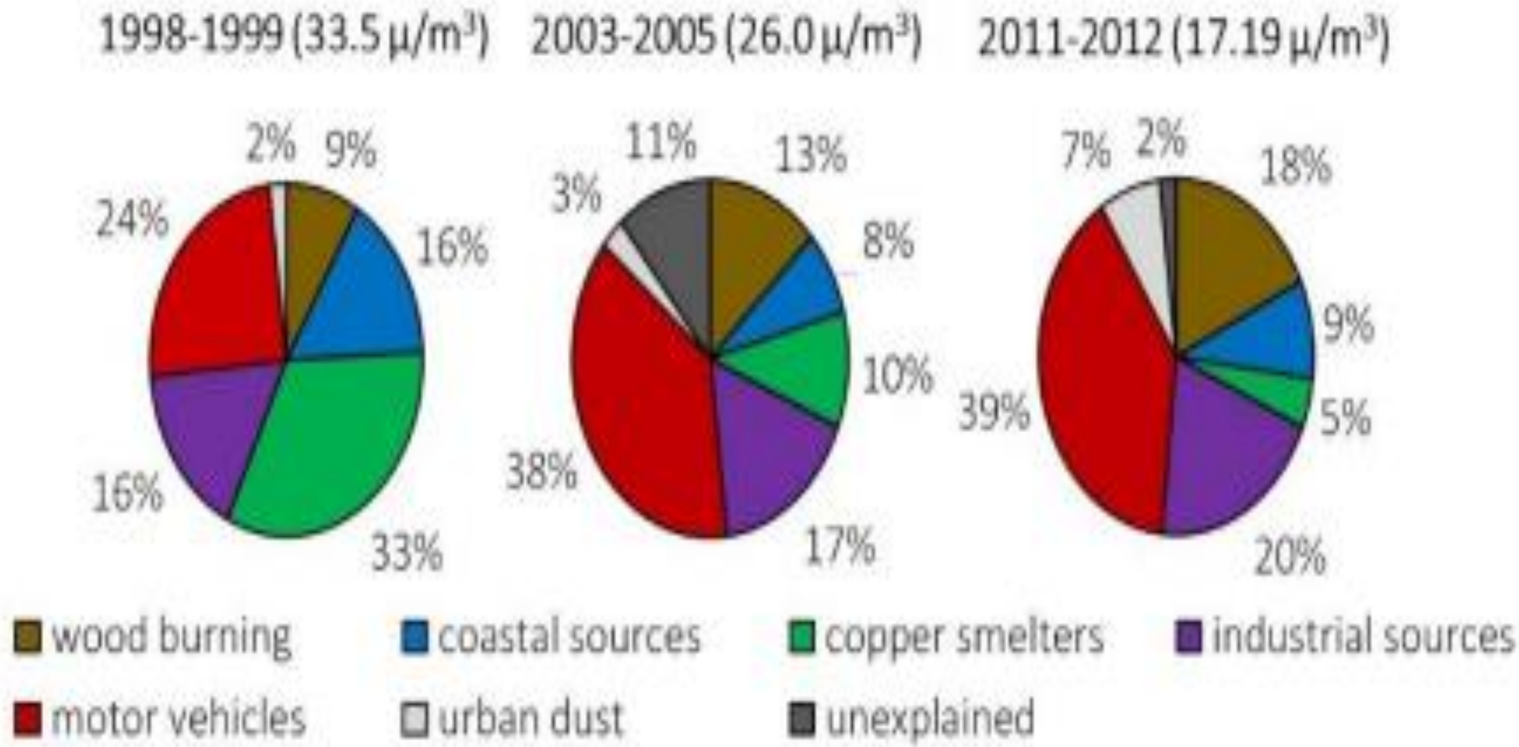


Figure 10 Relative contribution change of each source in the beginning, middle, and end of the period Median levels of total PM2.5 are given in brackets next to the corresponding time period.

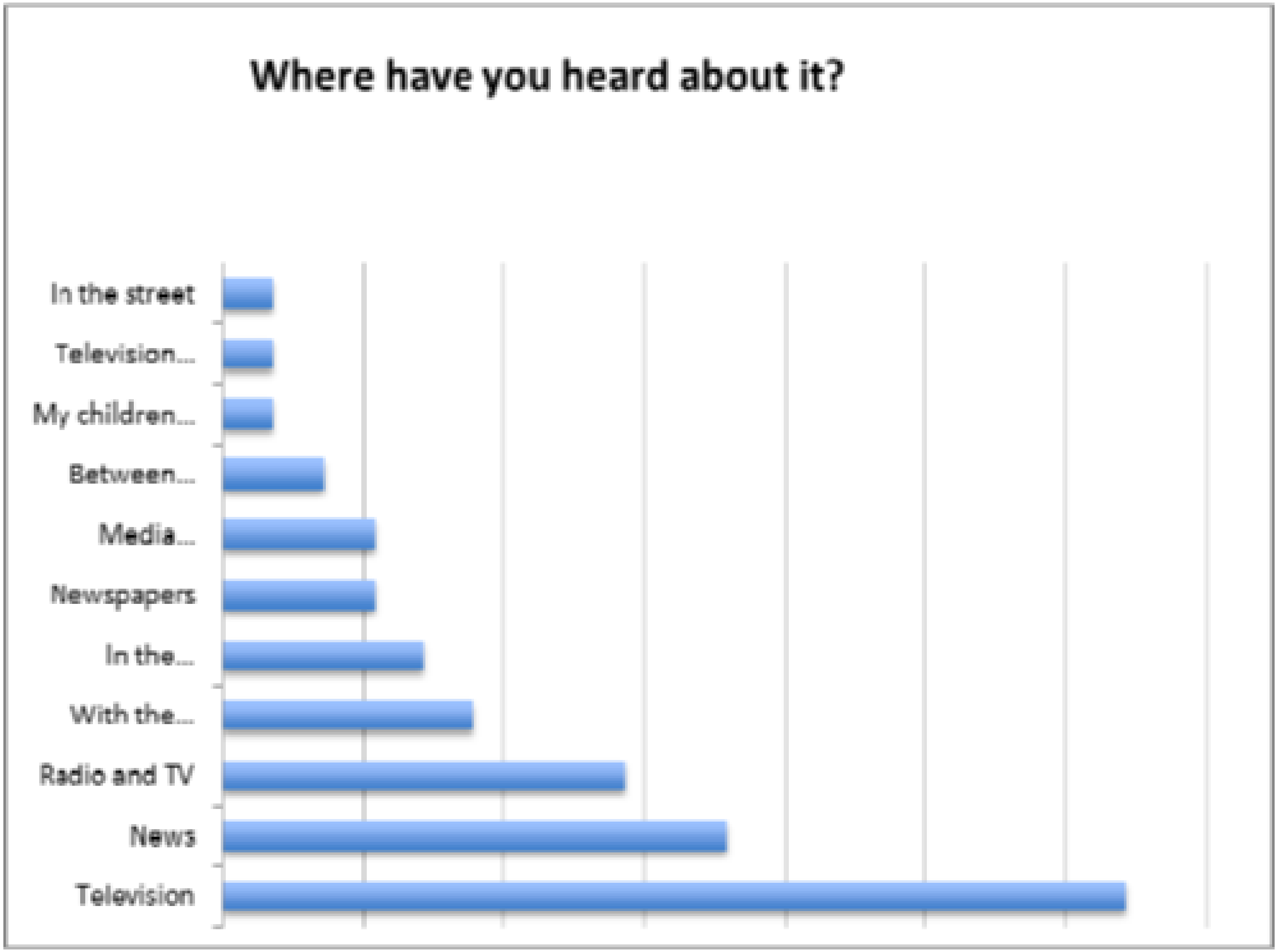


Figure 3. Mediation on climate change.

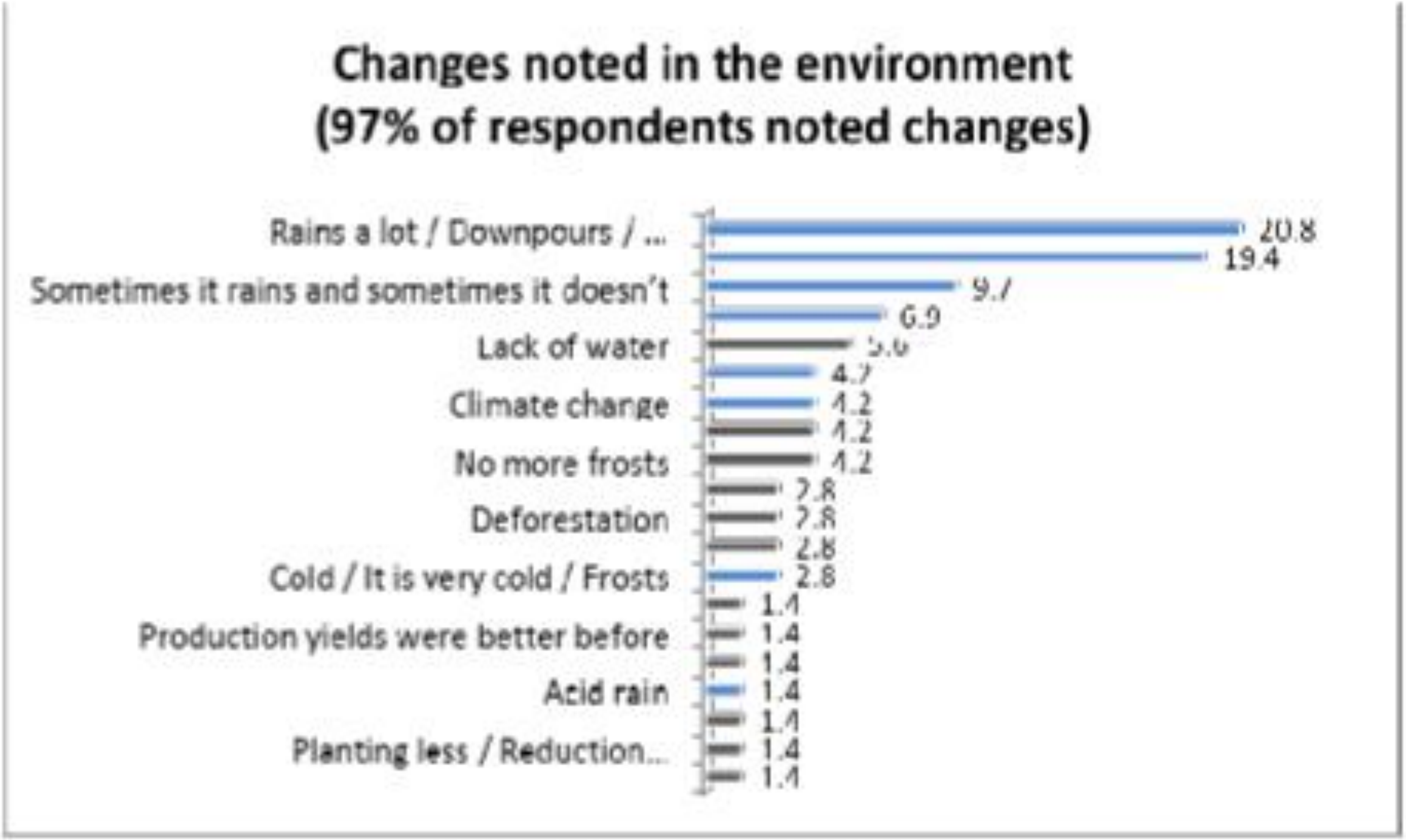


Figure 1. Changes in the environment.

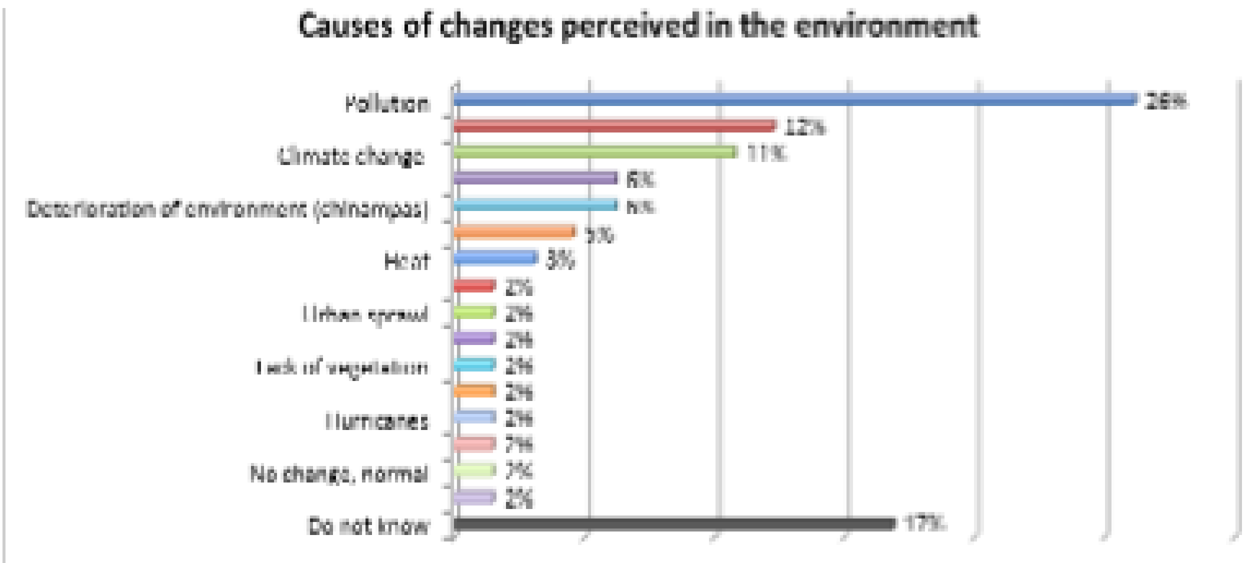


Figure 2. Perceived changes in the environment.

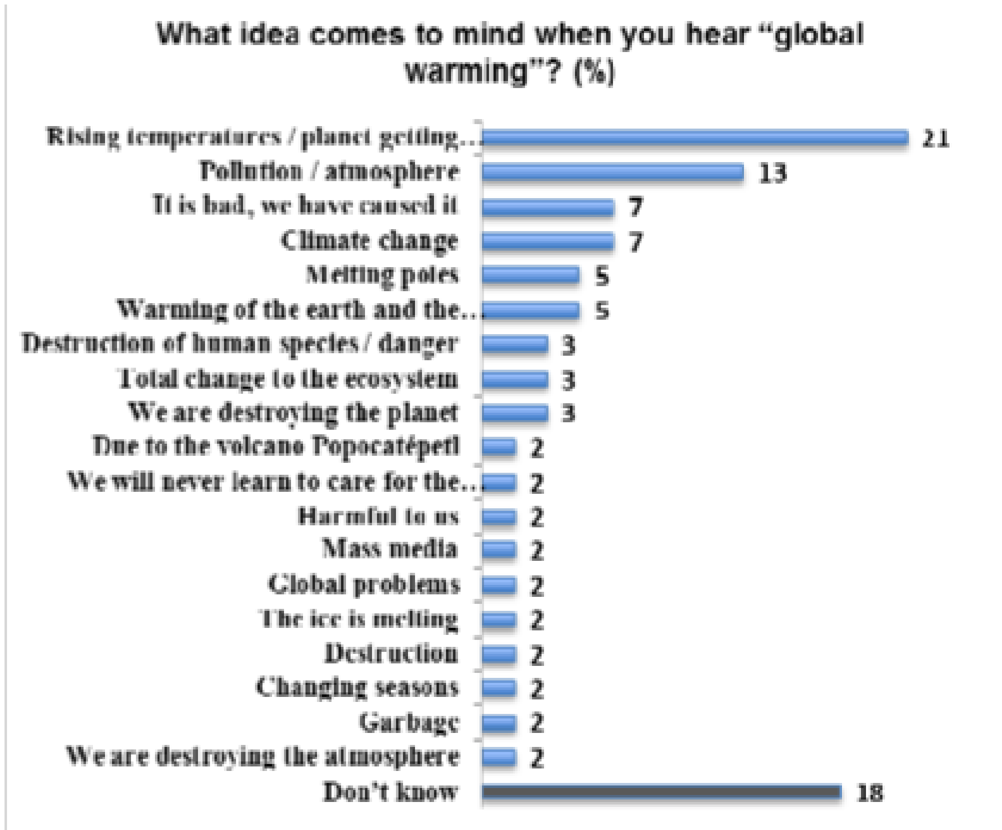


Figure 6. Relationship with everyday life concept.

Variables to estimate WTP of meteorological information from Korean households

Table 4. Definitions and sample statistics of the variables.

Variables	Definitions	Mean	Standard Deviation
Education	The respondent's education level in years	13.72	2.35
Gender	The respondent's gender (1 = male; 0 = female)	0.50	0.50
Age	The respondent's age in years	46.07	9.47
Income	The respondent's household's monthly income before tax deduction (unit: million Korean won = USD 865.8)	4.09	1.93

Table 5. Estimation results of the spike model with covariates.

Variables [a]	Estimates	*t*-Values
Constant	−1.870	−2.89 **
Education	0.069	2.11 *
Gender	0.072	0.50
Age	−0.011	−1.41
Income	0.132	3.95 **
Bid amount [b]	−0.425	−17.81 **
Number of observations	1000	
Log-likelihood	−842.08	
Wald statistic [c]	170.59	
(*p*-value)	(0.000)	

[a] The variables are defined in Table 4; [b] the unit is 1000 Korean won, and USD 1.0 was approximately equal to KRW 1155 at the time of the survey; [c] the null hypothesis is that all the parameters are jointly zero, and the corresponding *p*-value is reported in the parentheses beside the statistic; the symbols ** and * indicate statistical significance at the 1% and the 5% level, respectively.

Table 6. Annual economic value of the national meteorological service (MS) in Korea.

Monthly Expenditure on the National MS	Monthly Additional Mean Willingness to Pay	Monthly Economic Value of the National MS	Annual Economic Value of the National MS
KRW 1459 (USD 1.26) per household	KRW 860 (USD 0.75) per household	KRW 2319 (USD 2.01) per household	KRW 513.6 billion (USD 444.9 million)

So-Yeon Park, Seul-Ye Lim and Seung-Hoon Yoo 2016

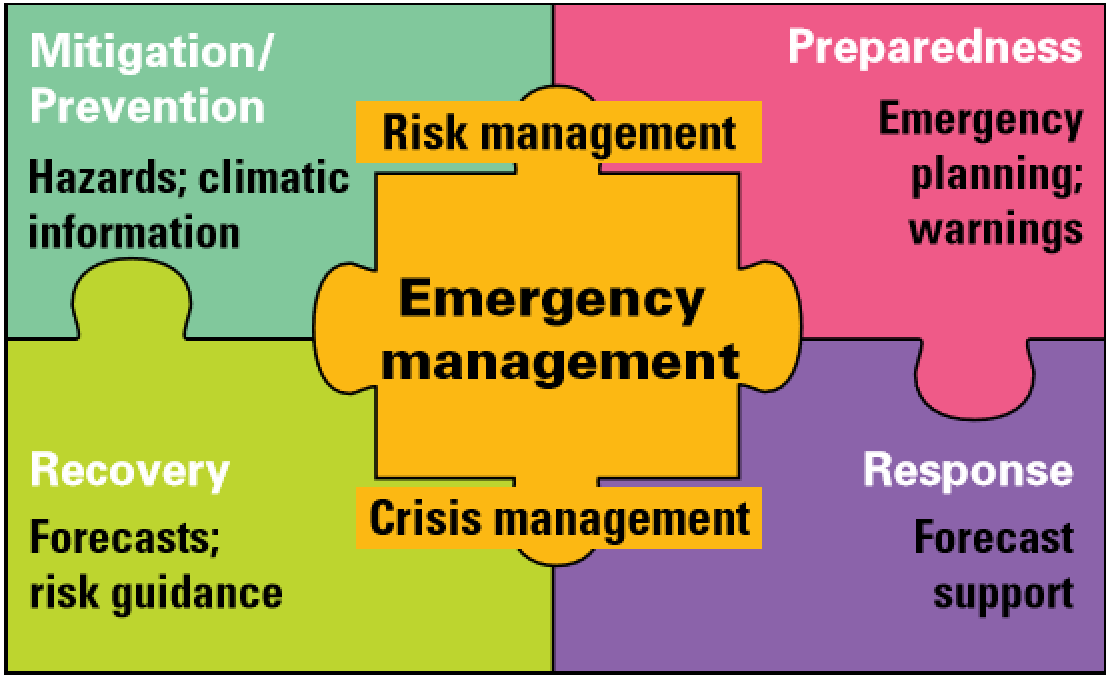


Figure 2 — Potential roles of the NMHS in disaster/emergency management systems through four pillars of action: risk management actions through the pillarsprevention/ mitigation and preparedness; and crisis management actions through the pillars emergency response and recovery and re-building

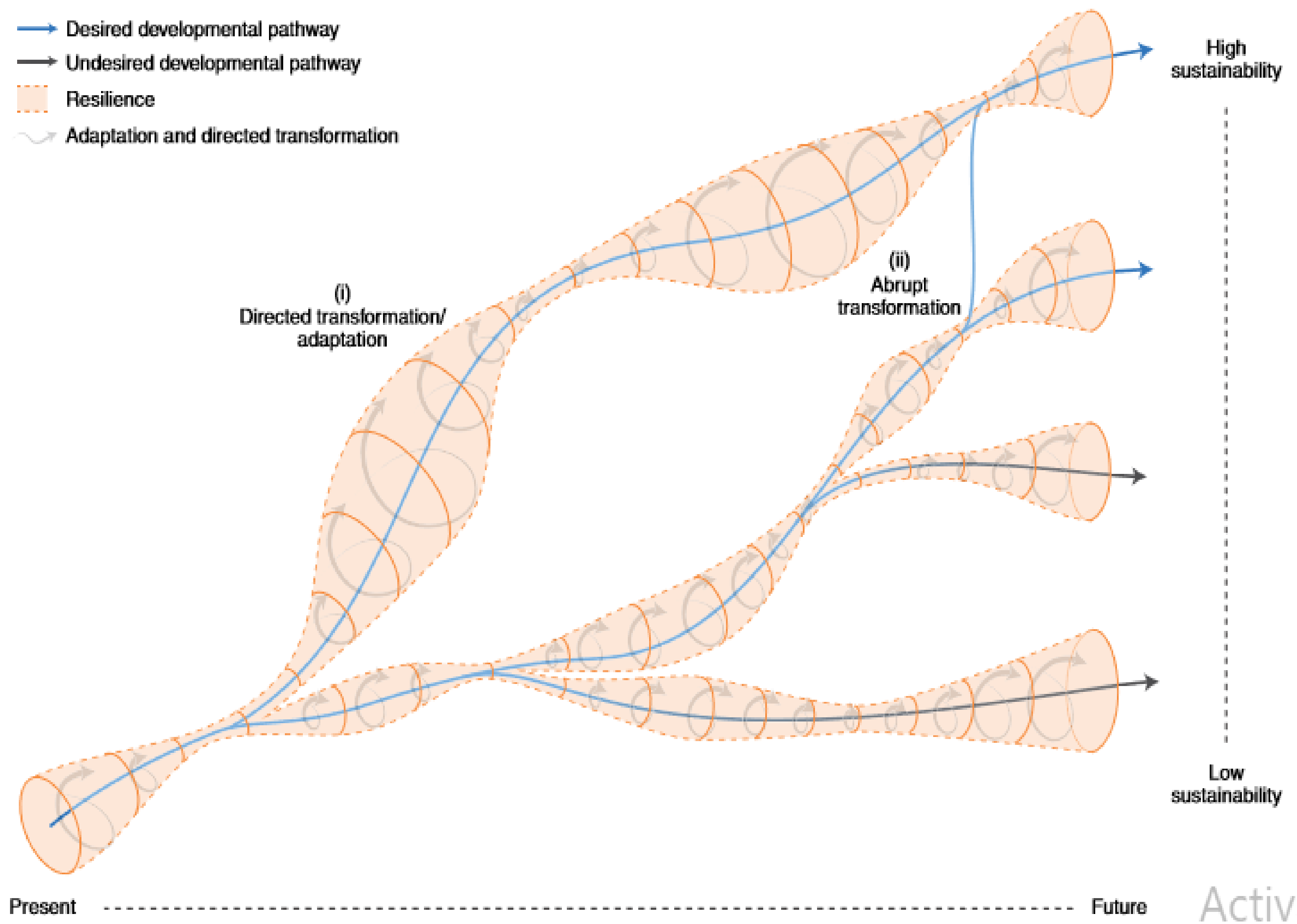


Fig. 2 | Interlinkages between sustainability, resilience and transformations. See text and Box 1 for further explanation.

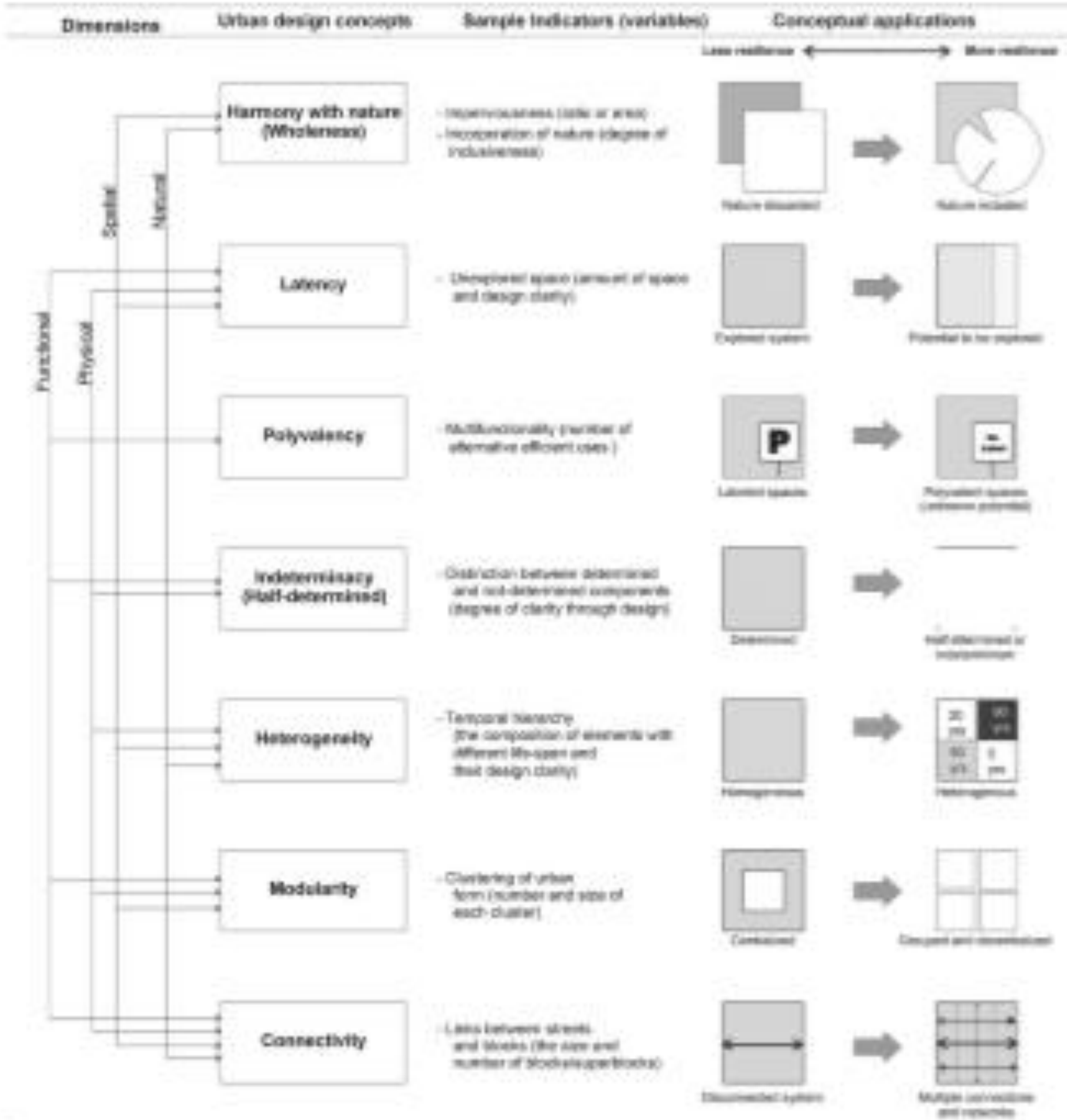


Fig. 6. UDRI's design concepts and sample variables.