TeMA

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This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

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SMART CITY

PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

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This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.

TeMA
Journal of
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TeMA Journal of Land Use, Mobility and Environment

EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time's shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

- Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;
- Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;
- Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

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Smart City - Planning for Energy, Transportation and Sustainability of the Urban System

Naples, 4-6 June 2014

OPEN SPACES AND URBAN ECOSYSTEM SERVICES

COOLING EFFECT TOWARDS URBAN PLANNING IN SOUTH AMERICAN CITIES

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ABSTRACT

Open space (OS) is a key element in the provision of ecosystem services (ES) in urban environments. Under a land cover-land use perspective, cities are incorporating into the expansion process to different types of surfaces: sealed, paved surfaces and OS. The first corresponds to a land cover change while the second, which includes bare soil, grass, forest or any other type of non-sealed surface, corresponds to a land use change, without physical transformations. As a land use change OS is able to keep fundamental pre-existing ecological properties. However, besides specific ecological characteristics, the overall capacity to provide ES depends also on the size, number and spatial distribution of OSs within the urban fabric. Those aspects which can determine the very ecological performance of urban ecosystem services (UES) are not yet included in the current urban planning in Latin America. OS is still understood mainly as green infrastructure and related mostly with aesthetic and cultural benefits. On the contrary, under an ecological point of view, OS is capable to provide fundamental UES, which can be spatially assessed and analyzed. In this paper the provision of cooling services (CS) is assessed in 2 South American cities: Lima and Santiago de Chile. The provision of CS is measured by means of a Remote Sensing-GIS-based method. Two aspects of CS are explored: (1) the current amount of existing OS; and (2) the trend of increasing/reducing CS within the urban tissue, in a dynamic assessment of spatial distribution and rates of OS incorporation to the continuous urban tissue. The aim is to analyze the CS generated by OS in those two cities. The analysis discusses the role of OS in the provision of CS, considering the current urban development trends and planning practice in these specific Latin American cities, highlighting the need to keep unsealed surfaces and increase in trees coverage, to retain the CS provision in certain levels.

KEYWORDS

Open space, Urban ecosystem services, Cooling effect, Santiago, Lima

1 INTRODUCTION

The global future will be dominated by urban development and driven by urban systems. On the regional scale, urban systems are a powerful force which transforms landscapes and affects the provision of ecosystem services (ES), both out and within urban areas. Cities evolve in a world pervasive urban expansion context, where the urban expansion is not likely to be put under control. Under the identified trends of expansion (Inostroza *et al.* 2010; Inostroza *et al.* 2013) Latin-America will be inevitably and deeply transformed at fast rate. The urban sprawl, fragmentation and discontinuity will impact on several scales. Under market conditions and without an adequate regional planning, these impacts can be even intensified (Inostroza *et al.* 2013), and several ES like water infiltration, carbon sequestration and cooling effect are might be lost. As a result of the process of rapid urbanization the urban heat island (UHI) arises as a relevant – hybrid – ecological urban phenomenon. Urban areas tend to have higher air temperatures than their rural surroundings as a result of gradual surface modifications that include replacing the natural vegetation with buildings and roads.

Open space (OS), understood as areas free of development left behind by the process of urbanization, with or without vegetation coverage and including or not green infrastructure, arises as an important ecological asset of cities, in terms of their capacity to provide ES and reducing the UHI effect. Connecting this positive ecological effect with the ES framework, in this paper the cooling service (CS) of OS is analyzed for two Latin American cities: Lima and Santiago de Chile. The aim is to understand the CS generated by OS within those urban areas. In the first part a dynamic assessment of urban expansion is provided to calculate the relevance of OS within the urban areas of 10 important South American cities in 20 years period of time. This analysis gives an overview of the dynamic spatial process affecting OS in the continent. In the second part land surface temperatures (LST) was calculated for both cities. Provision of CS provided by OS was explored in terms of their spatial distribution in both cities. Using LST as UHI proxy the thermal difference between open spaces and their surrounding urbanized areas was estimated. In the conclusion some recommendations for urban planning and policy making, looking specifically to green infrastructure in Latin American cities, are proposed.

1.1 THE UHI: AN HYDRID URBAN ECOSYSTEM FUNCTION

The UHI effect is a global regularity present in almost every cities. UHI it has been recognized as important negative effect of urbanization on local weather. Within the urban fabric temperature varies mainly due to two important reasons: (1) differences in the thermal properties of impervious surfaces and (2) a decreased rate of evapotranspiration (Streutker 2002).

Urban blue and green space regulates local temperatures (Hardin and Jensen 2007). Water areas absorb heat in summer time and release it in winter (Chaparro and Terradas 2009) and vegetation absorbs heat from the air through evapotranspiration, particularly when humidity is low (Hardin and Jensen 2007). Urban trees moderate local temperatures by providing humidity and shade (Bolund and Hunhammar 1999).

The share of impermeable surface is the most important factor determining urban sensitivity to heat. Large water bodies are important as well. Less important factors include the vegetation index (NDVI), the share of traffic infrastructure and shade. As such UHI emerges as the combination of preexisting geographical conditions, i.e. local climate conditions, altitude, etc. and artificial conditions resulting from the urbanization process, i.e. land cover, morphology of urban tissues, percent cover of buildings, etc. As it is depending on both types of factors, UHI can be characterized as hybrid ecosystem function. This is an ecological property and will constraint the possible control over the UHI effects. The concept it has been used to describe the phenomenon of altered temperatures in urban areas compared to their rural hinterlands. The UHI effect is characterized as the influence of urban surfaces on temperature patterns in urban areas as opposed to surrounding areas (Oke 1982). The increase in the urban temperature shows higher temperatures in urban than in rural areas (e.g., Jin i 2005) and depends on a variety of factors, such as latitude, height above sea level, topography, city size (Wienert and Kuttler 2005) and atmospheric stability (Tomlinson *et al.* 2010; Sun *et al.* 2011).

Remote sensing is one of the most common techniques to map magnitude and spatial extent of UHI, allowing assessments without expensive and time demanding in situ measurements. Remote sensing techniques are focused on the surface urban heat island (SUHI), i.e. the surface temperatures of the emitting materials and not the air temperature as in situ measurements often are. Remotely sensed data and above ground air temperatures are not identical, but related (Mostovoy *et al.* 2006; Prihodko and Goward 1997). Thus, a very high correlation between surface temperatures and temperature comfort exists (Inostroza and Csaplovics 2014). The term SUHI is often used to explicitly distinguish SUHIs measured using land surface temperatures (LST) from air temperature patterns (e.g., Voogt and Oke 2003). LST modulates the air temperature of the lower layer of the urban atmosphere and is a primary factor in exploring surface radiation and energy exchange, the internal climate of buildings, the spatial structure of urban thermal patterns and their relation to urban surface characteristics, surface-air temperature relationships, and human comfort in cities (Liang *et al.* 2012).

Remote sensing data use the thermal emissivity of land surfaces to derive land surface temperatures (LSTs). Remotely sensed LST records the radiative energy emitted from the ground surface, including building roofs, paved surfaces, vegetation, bare ground, and water (Arnfiel, 2003; Voogt and Oke 2003). Therefore, the pattern of land cover in urban landscapes may potentially influence LST (Arnfield 2003; Forman 1995). The percent cover of buildings arises as the most important land cover feature increasing the magnitude of LST. From the side of mitigation, percent of woody vegetation is the most important factor (Zhou *et al.* 2011).

1.2 STUDY AREAS

Lima is the capital and the largest city of Peru situated in the central coastal part of the country in front of the Pacific Ocean (Fig. 1). The city is located in the 12°2’36”S Latitude and 77° 1’42”W Longitude, in the valleys of the Chillón, Rímac and Lurín rivers. With a population of over 7 million, Lima is the most populated city of Peru, and the fifth largest city in the Americas.

Lima has two distinct seasons, summer and winter. The Peruvian Humboldt Current, cold water, giving rise to the phenomenon of inversion defined as the increase in temperature with increasing altitude. Hence the presence of cloud type layers (not give rise to precipitation) throughout the year. The inversion height varies between 1,000 m and 1,500 m in winter and summer, respectively, for which Lima is a city with the presence of clouds all year (SENAMHI 2009).

The climate is characterized as semi-warm and moderate humidity conditions (SENAMHI, 2009). The average annual temperature ranges between 18.6° C and 19.8° C, with temperatures ranging between 15° C and 20° C in the winter months and between 19° C and 27° C during the summer (SENAMHI 2009). The humidity varies between 81% and 85% for the year, which intensifies the thermal sensation of heat or cold, depending on the season. The temperature is sinusoidal, varying from low temperatures in the months of June to September with peaks from December to April, causing the city to register two well defined, one cold and one warm. Minimum temperatures vary between 15° C and 21° C, depending on the season and recorded in the areas closest to the coast. In the summer ranges from 17.1° C and 20.5° C in the winter between 10.7° C and 15.4° C. The maximum temperatures ranging between 17° C and 29° C, recorded lower values during winter (June to August) and higher during summer. In turn, the maximum temperatures are lower in areas close to the coast, while in the areas closest to the Andes with values of 25° C to 30° C.

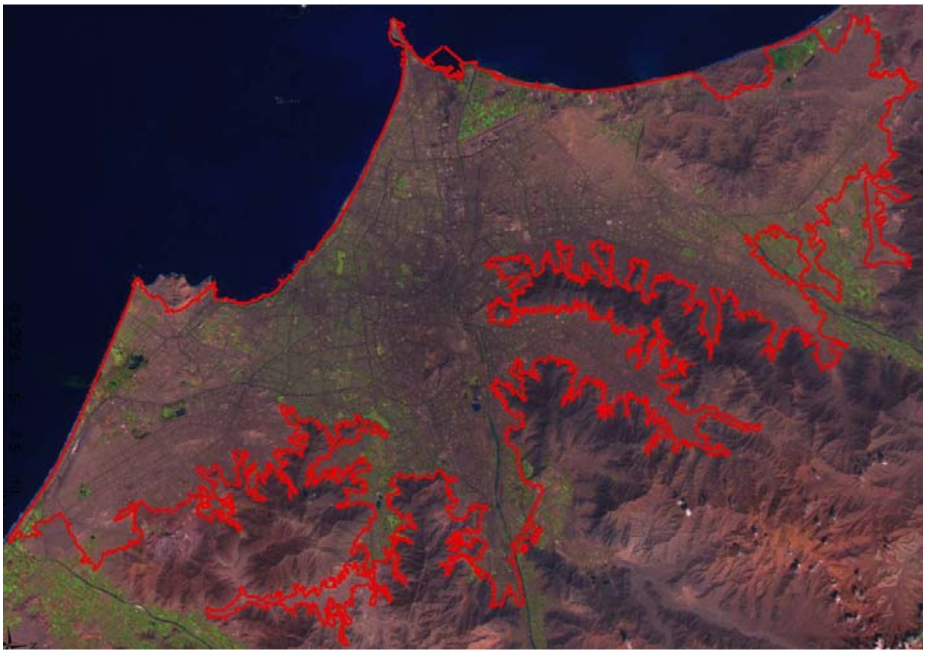

Fig. 1 Lima, continuous urban area (red line) over a 742 LANDSAT image FILE_NAME = "L5CPF20090401_20090630_09". 2009-04-02

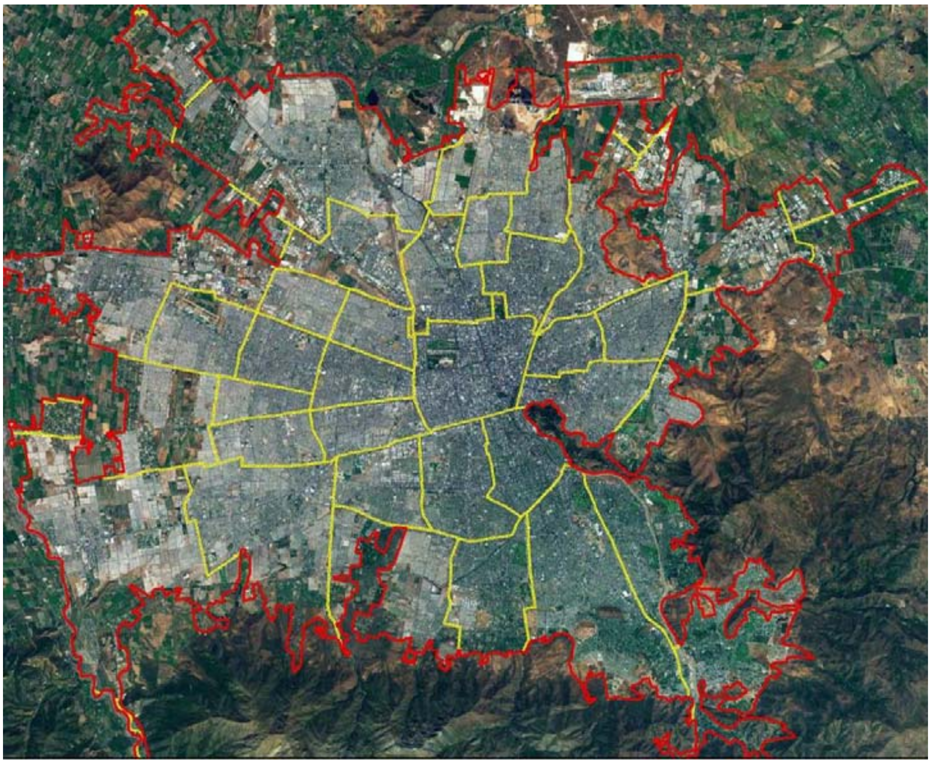

Fig. 2 Santiago de Chile. Continuous urban area (red line) and municipalities' divisions (yellow line) overlaying an IKONOS RGB image

Santiago is located in the central valley of Chile in the coordinates 33°26′16″S latitude and 70°39′01″O longitude, is the capital of the country concentrating the economic and political power (Fig. 2). It concentrates more than 43% of the countries´ population and more than 40% of the GDP is produced in the city. With an estimated population of 6,5 millions it has been suffering a strong process of urban expansion during the last decades, adding more than 1,300 ha per year to the continuous urban fabric (Inostroza et al. 2013). Politically administrative speaking the city contains 40 municipalities, which represent the local administrative level (commune).

2 MATERIAL AND METHODS

The methodology is spatially explicit and quantitative at city scale. An important aspect to consider is the spatial delineation of the urban area under study and its rural counterpart. For the purposes of this research the spatial scope of the analysis is the continuous urban fabric (red line in Fig. 1 and Fig. 2). For the definition of this area see (Inostroza *et al.* 2013). Calculation of sizes gains and loses and spatial distribution of the incorporated OS in a 20 years time period was performed. Over that basis, the provision of CS was explored under an Ecosystem Services perspective.

2.1 LAND SURFACE TEMPERATURE (LST) ESTIMATION[1]

In order to determine the SUHI within the continuous urban fabric, LST was calculated using the thermal band of the Landsat 5 TM. Even though the spatial resolution of the thermal band is 120m x 120m, resampled to 60 m x 60 m per pixel, a rescaling to 30 x 30 m. was performed. The extension of the image was fitted to the extension of the continuous urban fabric.

The Landsat -5 & Landsat-7 Thematic Mapper sensor systems contain a thermal band that collects data in the wavelength interval of 10.40 – 12.50 μm. This band can be converted to temperature by using the calibration information from the Landsat manual. LANDSAT 5TM band 6 is produced by a 120 m resolution thermal detector capable of sensing radiant temperature differences of approximately 0.6°C (Avery and Berlin, 1985; (Aniello et al. 1995).

At-satellite temperature can be determined for TM thermal data in a two step process (Markham and Barker, 1987; Sun et al. 2009). The first step is to convert the digital number (DN) into spectral radiance (Lλ). In the original LANDSAT image pixels are converted to units of absolute radiance using 32 bit floating point calculations. Pixel values are then scaled to byte values prior to media output. The spectral radiance Lλ of each DN value is calculated using the following equation:

$$L\lambda = Grescale * QCAL + Brescale$$

Lλ	Spectral Radiance at the sensor's aperture in watts/(meter squared * ster * μm).
Grescale	Rescaled gain (the data product "gain" contained in the Level 1 product header or ancillary data record) in watts/(meter squared * ster * μm)/DN.
Brescale	Rescaled bias (the data product "offset" contained in the Level 1 product header or ancillary data record) in watts/(meter squared * ster * μm).

Which is also expressed as:

$$L\lambda = ((LMAX\lambda - LMIN\lambda)/(QCALMAX-QCALMIN)) * (QCAL-QCALMIN) + LMIN\lambda$$

QCAL	the quantized calibrated pixel value in DN
LMINλ	the spectral radiance that is scaled to QCALMIN in watts/(meter squared * ster * μm)
LMAXλ	the spectral radiance that is scaled to QCALMAX in watts/(meter squared * ster * μm)

[1] http://landsathandbook.gsfc.nasa.gov/data_prod/prog_sect11_3.html.

QCALMIN the minimum quantized calibrated pixel value (corresponding to LMINλ) in DN
1 for LPGS products
1 for NLAPS products processed after 4/4/2004
0 for NLAPS products processed before 4/5/2004
QCALMAX the maximum quantized calibrated pixel value (corresponding to LMAXλ) in DN
255

QCAL, LMIN, LMAX, and QCAL, are obtained directly from EOSAT for each LANDSAT sensor system.
LMIN and LMAX values for conversion to radiance units are in the metadata file (header file) of each image.
The second step is to convert the spectral radiance as described above to at-sensor brightness temperature. This is the effective at-satellite temperatures of the viewed Earth-atmosphere system under an assumption of unity emissivity and using pre-launch calibration constants listed in Tab. 1. It is carried out by using the following conversion formula:

$$T = \frac{K2}{\ln\left(\frac{K1}{L_\lambda} + 1\right)}$$

T = Effective at-satellite temperature in Kelvin
K2 = Calibration constant 2 from Tab. 1
K1 = Calibration constant 1 from Tab. 1
L = Spectral radiance in watts/(meter squared * ster * µm)

	Constant 1- **K1** watts/(meter squared * ster * µm)	Constant 2 - **K2** Kelvin
Landsat 5	607.76	1260.56

Tab. 1 ETM+ and TM Thermal Band Calibration Constants

Now the ETM + Band 6 imagery was converted to a more physically useful variable. Last step is to transform temperature from Kelvin to Celsius degrees. Once calibrated, surface temperatures can be determined at any LANDSAT pixel location. Temperatures were grouped into appropriate ranges and color-coded to generate a thermal pattern distribution map of both studied areas (Fig. 3 and Fig. 6).

3 RESULTS

3.1 URBAN EXPANSION AND THE INCORPORATION OF OPEN SPACE

Cities are expanding as a matter of fact. The pace of urban expansion in South American cities is fast. An average of 360 ml/year growth rate has been observed in main cities during the last 20 years, this means around 40 m^2/minute as average for the continent (Inostroza *et al.* 2013).
Under a land cover-land use perspective, cities are incorporating into the expansion process to different types of surfaces: sealed, paved surfaces and OS. The first corresponds to a land cover change, suitable to be detected by remote sensing techniques. The second one, OS, corresponds to a land use change, without physical transformations. It could be bare soil, grass, forest or any other type of not-sealed surface. However, OS not necessarily correspond to green infrastructure; part of it is the result of the

suburbanization process, not sealed surfaces within new urban plots or the passive inclusion of fragmented large areas without development. In some cases those areas are targets for infilling urban development. If land surface is not sealed, OS is able to keep most of their pre-existing ecological properties.

The ecological value of OS it has to be assessed regarding specific urban ecosystem services (UES) it provides. There are at least three UES provided by OSs: rainfall infiltration, carbon sequestration and cooling effect (UHI mitigation). The provision of each ES is determined by the type of land coverage of the area.

OS as remaining land within the urban expansion process can be, in some cases transformed into formal green areas. However in the context of Latin America this is not the common situation; many OSs remain in initial conditions for decades and or they are urbanized (sealed). If not sealed, OS keeps its potential provision of UES, which can hardly be substituted by other urban elements without increasing vulnerability to other hazards, such as floods or heat.

In quantitative terms, the incorporation of OS into the urban areas is a key factor considering the fast expansion process of South American cities. In table 2 an overview of the overall incorporation of OS in 10 South American cities is presented. The incorporation of OS is relevant in all cities.

In average core areas (continuous urban fabric) increased in 200 km^2 between T1 and T2; 50 km^2 where of OS, this is 24%. There is a net increase in the overall average surface of OS in the 10 cities, from 140 in T1 up to 190 in T2, which represents a net increase of 35%. However, in relative terms, this is considering the growth of core urban areas, the overall percentage has decreased from 34% to 31%. This because despite the increase in OS's surface, the increase in core areas and built up areas has been faster, 47% and 52% respectively. This means that in 2010 most of those cities they have less open space in proportion to the urban area, than they had in 1990.

CITY	YEARS	CORE T1	CORE T2	BUILT T1	BUILT T2	OS T1	OS T2	OS T1 %	OS T2 %
Asunción	23	336	534	190	327	146	207	43%	39%
Bogota	22	297	362	224	281	74	81	25%	22%
Brasilia	21	406	718	140	370	265	348	65%	48%
Buenos Aires	21	1577	2,103	1,127	1517	450	587	29%	28%
Cordoba	24	252	337	164	230	88	107	35%	32%
La Paz	23	113	236	83	169	31	67	27%	28%
Lima	**22**	**446**	**695**	**374**	**547**	**71**	**149**	**16%**	**21%**
Montevideo	24	291	310	167	201	124	109	43%	35%
Santa Cruz	25	88	287	61	186	27	101	31%	35%
Santiago	**24**	**479**	**710**	**353**	**568**	**126**	**142**	**26%**	**20%**

Tab 2 Overall urban core values and open space in 10 South American cities for circa 1990 and circa 2010. Values are in km^2

As a result of the persistent expansion process fundamental ecological functions are changed or eventually lost. Thus an important question for urban planning and policy making is to determine how much of this surface has to be maintain free of development to ensure the provision of certain Ecosystem Services eventually lost due to the urbanization process. To ensure the maintenance – ideally the increase – in the environmental quality of new urbanized areas, a portion of this open space has to be kept free of development in the long term, under an ecosystem services perspective. Open space is a passive incorporation of areas with higher ecological value than standard urbanized areas.

3.2 SANTIAGO

There is a pattern in the spatial distribution of LST in Santiago. Lower temperatures follow the Cordillera in the east part of the city. Higher temperatures are concentrated in the centre and in the western part as well. Big OS are playing an important cooling role (Fig. 3). Municipalities in the west part of the city they have higher values of LST, while municipalities located at piedmont they have lower LST values. Considering that western municipalities are poor while eastern municipalities are richer, it is clear that the LST has an uneven socioeconomic spatial pattern as well. In some cases the cooling islands are associated with higher shares of vegetation, i.e. the presence of consolidated green areas, parks or other historical green areas. In some others cases the dismissing in the amount of sealed surfaces accounts for the lower LST (Fig. 3). At smaller scale the spatial correlation between big OSs, and lower LST (Fig. 4) is more evident. On the contrary, lack of green areas is correlated with higher LST, like in the central and western areas of the city.

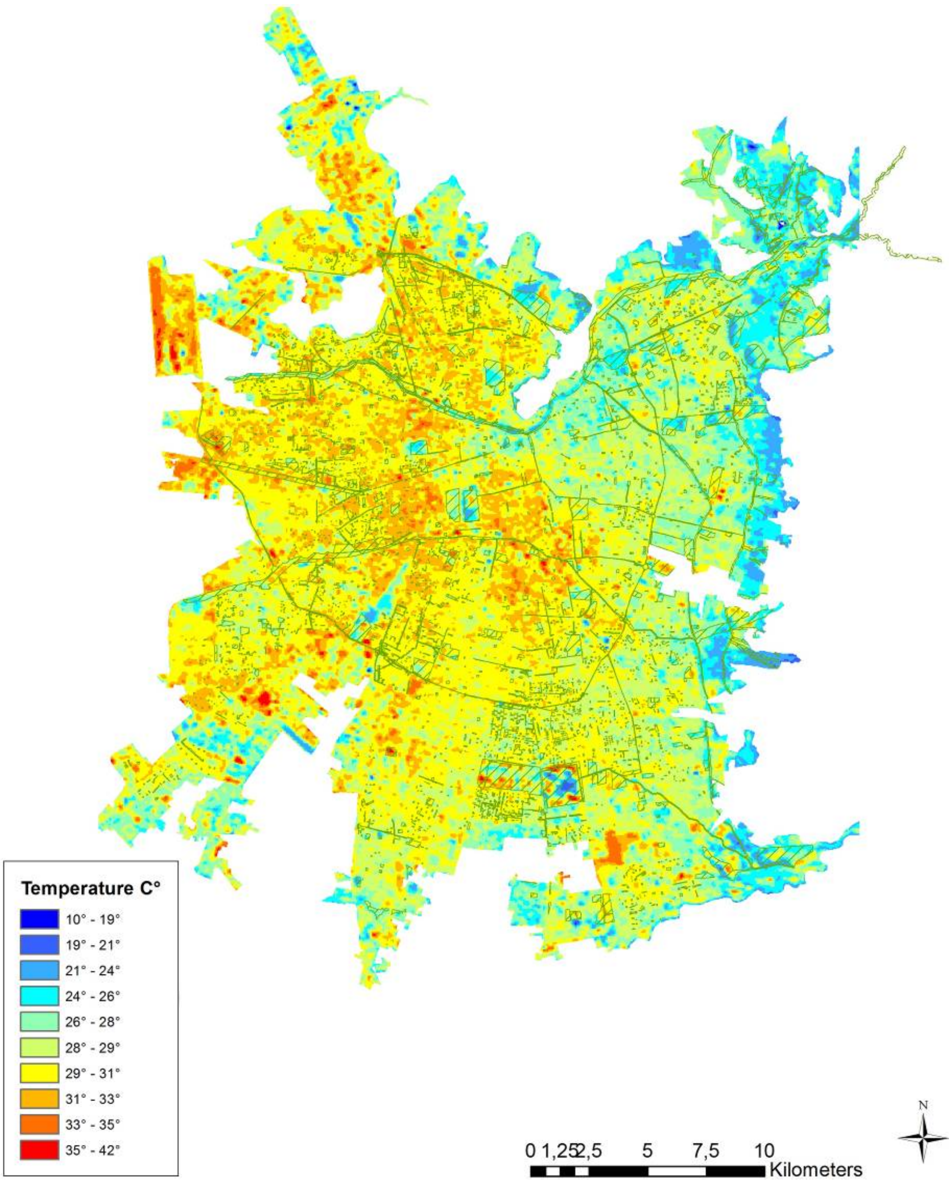

Fig. 3 Land Surface Temperature (LST) patterns and green areas in Santiago de Chile. Cooling islands within the continuous urban fabric are clear

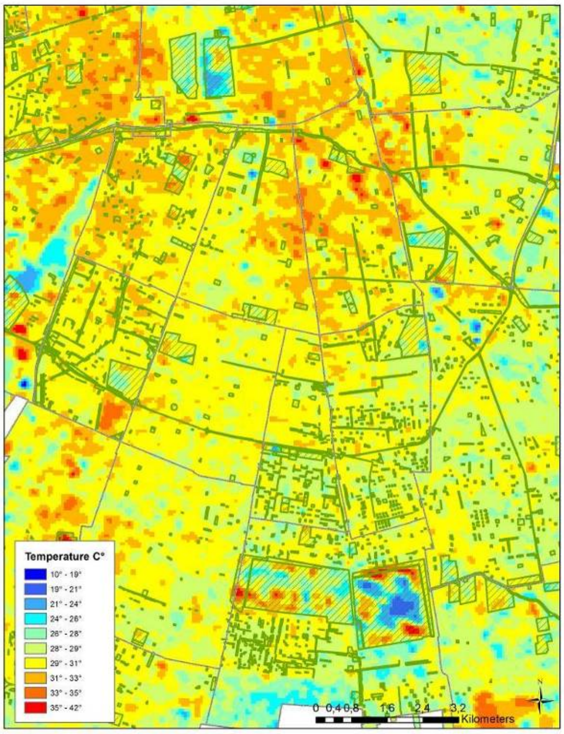

Fig. 4. A zoom into Land Surface Temperature patterns and green areas in Santiago de Chile

3.3 LIMA

Higher LST values are located in the north and south part of the city (Fig. 6), related to the presence of hills and barren soils. This is a typical pattern of a desert city. Presence of green areas, but mostly the presence of river basins (Rimac, Chillón, and Lurín) are helping to decrease the LST in the central parts of Lima (Fig. 5). Higher temperatures within the urban fabric in the central part of the city respond to barren soils and hills, as is shown in Fig. 5, where San Cristobal hill shows the highest temperatures.

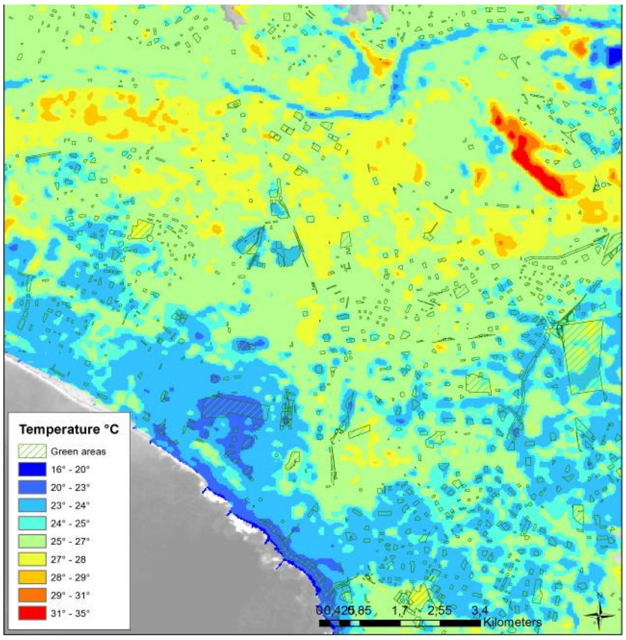

Fig. 5 A zoom into Land Surface Temperature patterns and green areas in Lima

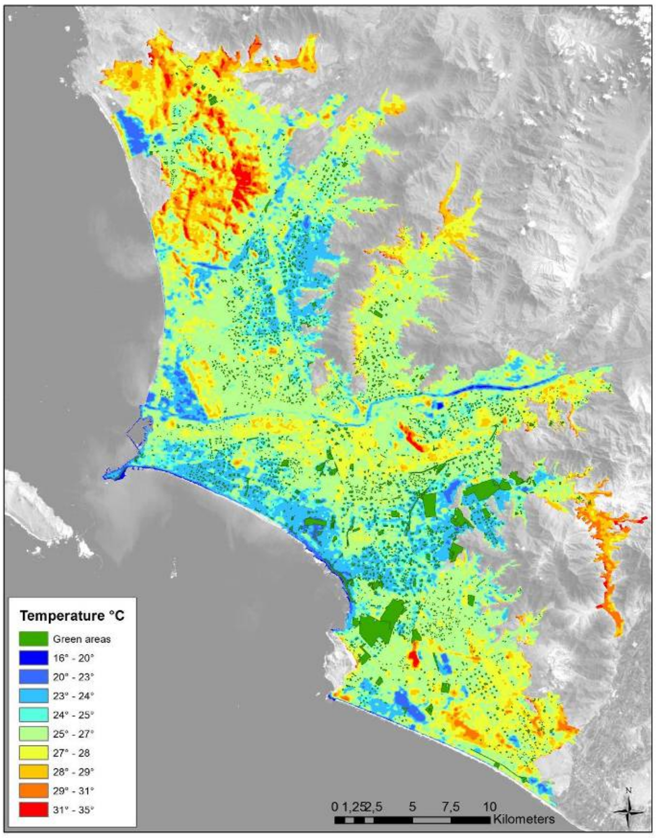

Fig. 6 Land Surface Temperature (LST) patterns and green areas in Lima

4 DISCUSSION AND CONCLUSIONS

UHI is a typical effect of urbanization present in most cities. There is a growing awareness to develop strategies to cool urban areas (Mackey *et al.* 2012), specially when it is expected that the urban temperature will increase due to climate change. Vulnerability to heat waves is high in Latin American cities. However UHI remain out of the scope of urban adaptation strategies. New spatially explicit approaches are needed to cope with the expected impacts of heat waves (Inostroza and Csaplovics 2014).

To understand the relevance of the OS regarding the CS, it is necessary to understand not only the specific mitigation it can be provided. The locally generated UES have a substantial impact on the quality-of-life in urban areas and should be addressed in land-use planning (Bolund and Hunhammar 1999). It is also important to account for specific ecological features of such spaces. To produce large cooling effects, grass – or lawn - is not effective, as other studies have also shown (Mackey *et al.* 2012). Vegetation must be dense and include shrubs/trees in order to have an affect on an urban scale (Mackey *et al.* 2012; Bowler *et. al.* 2010; Chang *et. al.* 2007; Potchter *et. al.* 2006). This is a fundamental consideration for urban planning not yet well accounted for the design of green areas in Latin America. But at the same time open space is under strong pressure. Due to increasing urbanization, combined with a spatial planning policy of densification, more people face the prospect of living in less green residential environments, especially people from low economic strata. This may lead to environmental injustice with regard to the distribution of (access to) public green space (Groenewegen *et. al.* 2006).

The exploration of the potential roles in the provision of UES it is also being done considering urban form properties, specifically those regarding compactness. In terms of Latin American cities the aim of a compact urban development is highly necessary (Inostroza *et al.* 2010). How this aim will not negatively affect the current provision of CS in targeted OS's is an important question for planners. When developing such OS's UES assessment has to be done to ensure that current provision will be maintained.

However planning practice in Latin America has been largely overcome by the contingency of urban development: fast growing rates, poverty, informality and land markets. It is necessary to ensure that the passive provision of UES of OS's is not threatened by lack of awareness and appropriated assessments. If the provision of CS will be included in cost-benefit analysis, the positive impact would be of great interest. For instance 17 municipalities in Santiago with the highest temperatures they reach over 2 million persons. The direct CS benefits of those populations it can be determined in economic terms by using available spatial methods. Normally it has been accepted that parks and lawns they have positive impact in terms of reducing the effects of the UHIs. However looking at NDVI the stronger and valuable CS resides on trees, but not in green areas in general and not at all in lawns in particular. This is an important fact to keep in mind for the design of green infrastructure and the identification of the very CS of existing OS.

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