

ANALYSIS OF OBSERVED TEMPERATURE TRENDS OVER URBAN, TOWN AND RURAL AREAS OF PAKISTAN

Sajjad Hussain SAJJAD

Department of Earth Sciences, University of Sargodha, 40100 Sargodha –
Pakistan

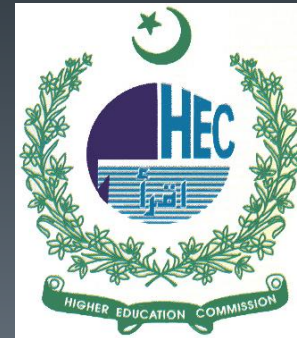
Email: shsajjad@hotmail.com

Nadège BLOND, Manon KOHLER, Alain CLAPPIER

Laboratoire Image Ville et Environnement, UMR 7362, CNRS, Strasbourg, 67000
Université de Strasbourg, 67000 Strasbourg – France

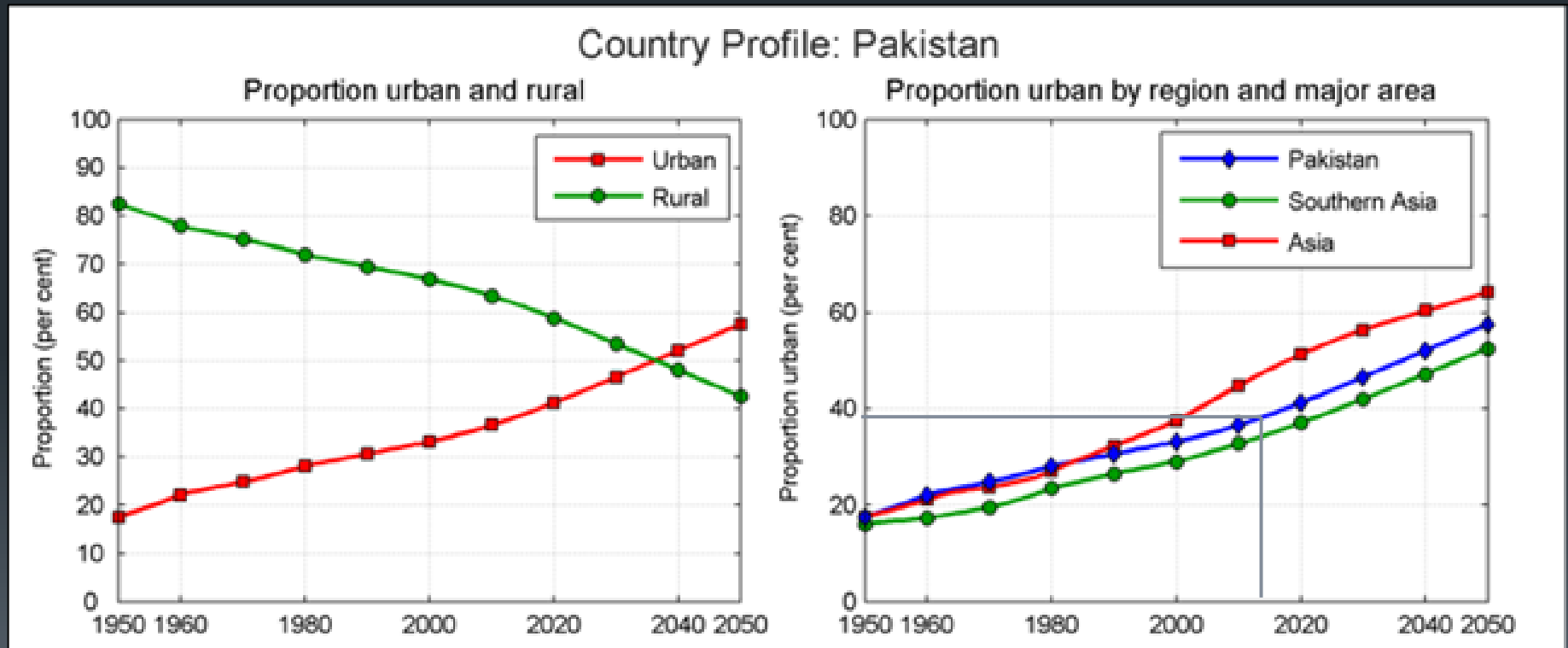
9th International Conference on Urban Climate

Toulouse, France – July 20-24, 2015.

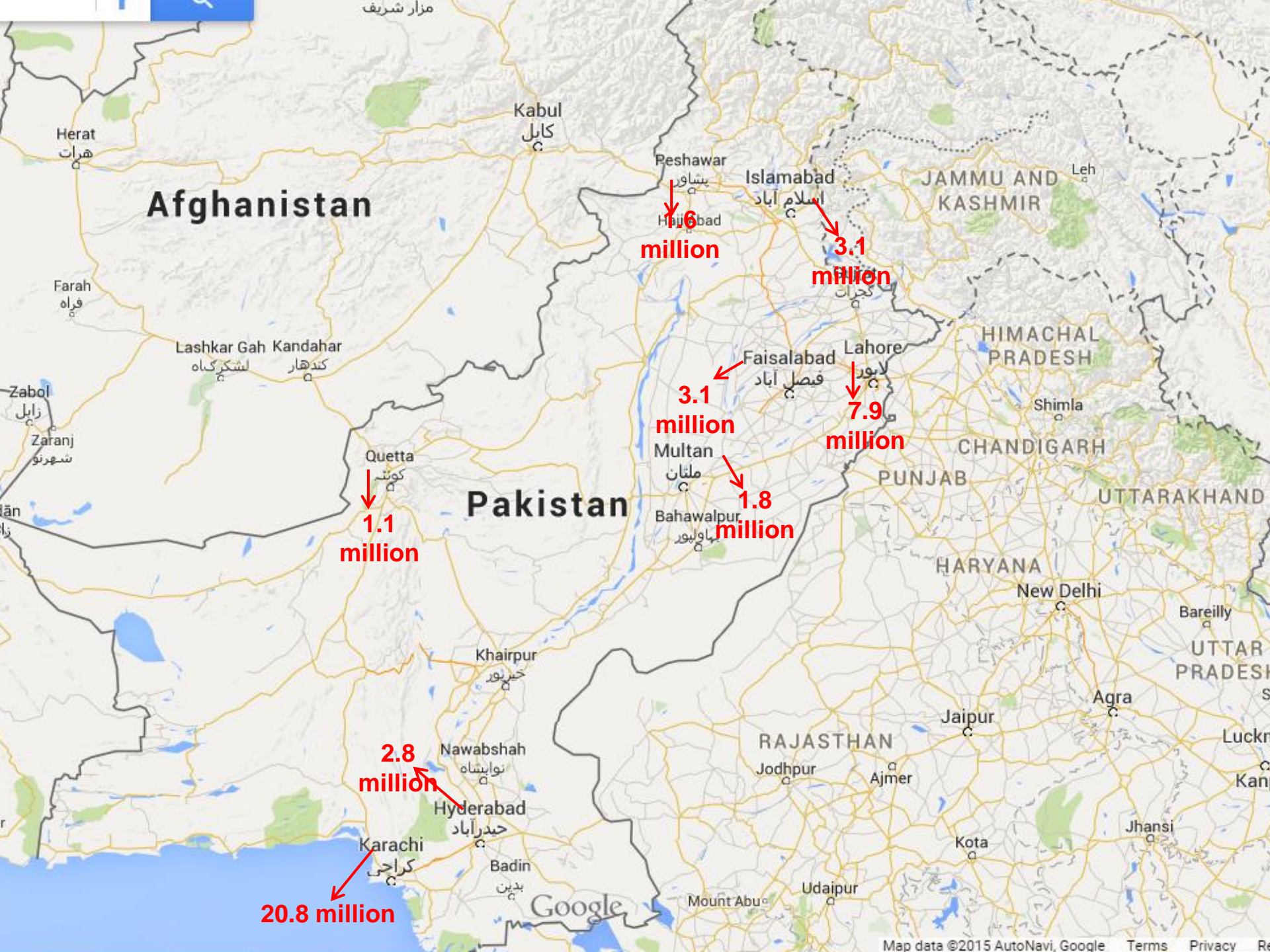


Introduction

- Rapidly growing population
- Highest urban population growth rate in South Asia*



*South Asia: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka

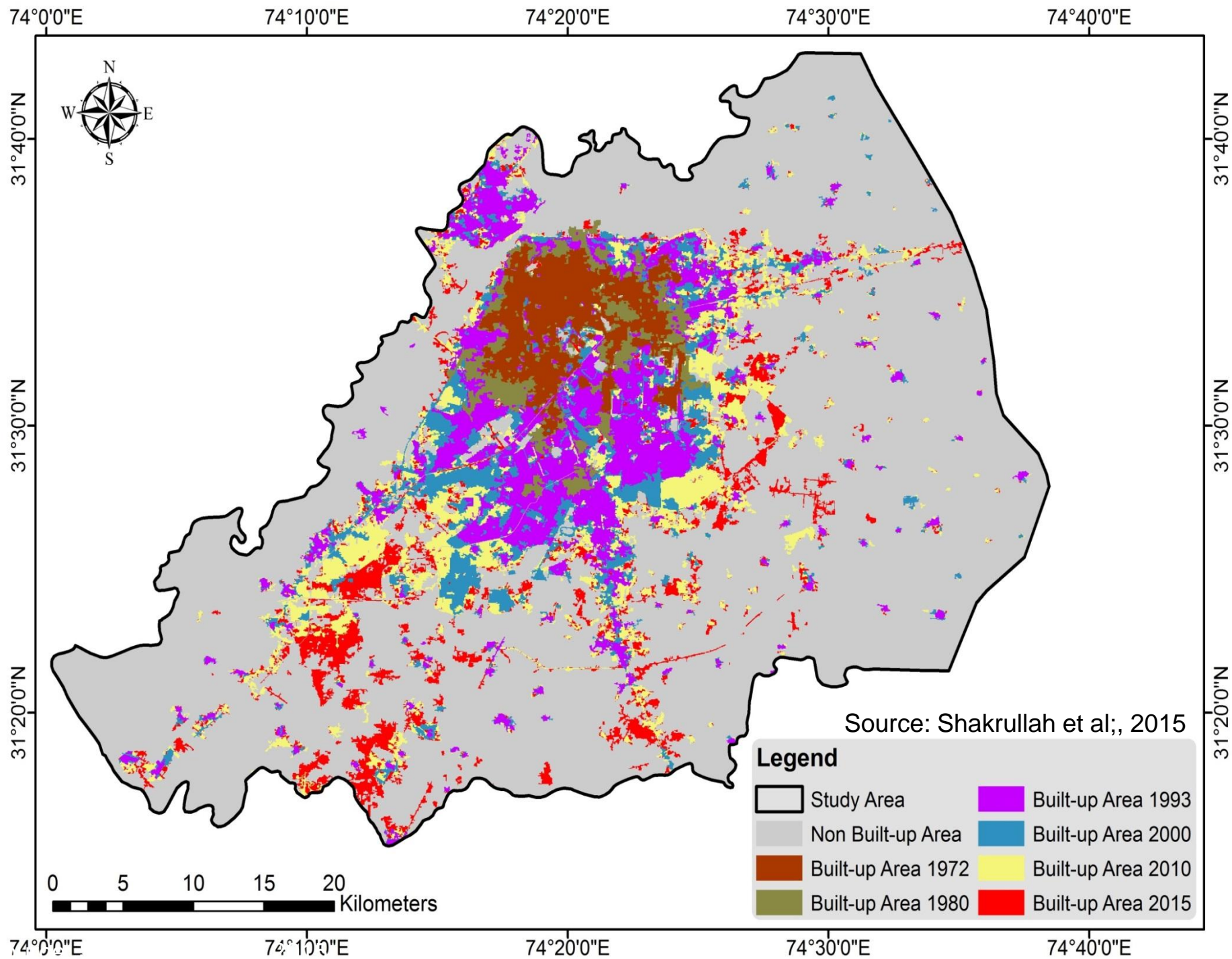


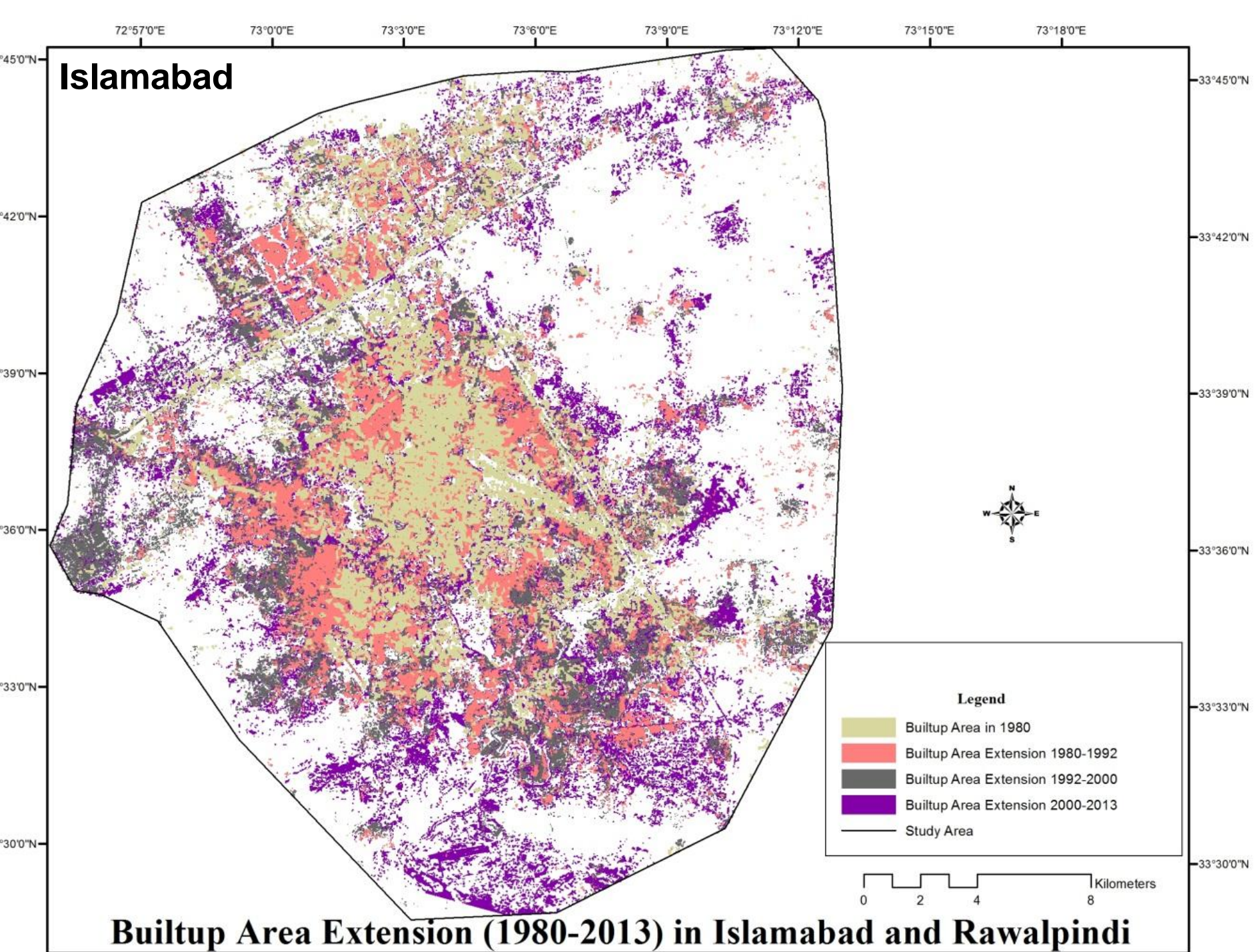
Problem

- Expansion of the cities
- Shift of smaller towns into major cities
- Worse environmental problems
 - sealing over more urban area (i.e., becomes impermeable through paving or building construction),
 - lessening the green area,
 - increasing energy consumption,
 - modifying urban areas energy balance.
 - change in temperature at local scales (UHI) and at global scale (CC)

Less developed countries:

- the most vulnerable
- the least means to adapt against changing climate at local, regional or global scales





Objectives

- To quantify the local increase of temperature by studying the evolution of temperatures at several locations in Pakistan based on the type of the settlement such as:
 - mega cities (named as urban),
 - smaller cities (named as town),
 - rural areas.

Data and methodology



Meteorological data

- Daily minimum (T_n) and maximum (T_x) temperature data, averaged on an annual, monthly and seasonal basis
- Data period: 1950 to 2004
- Data source: Pakistan Meteorological Department (PMD).
- Number of stations: 42

Data and methodology

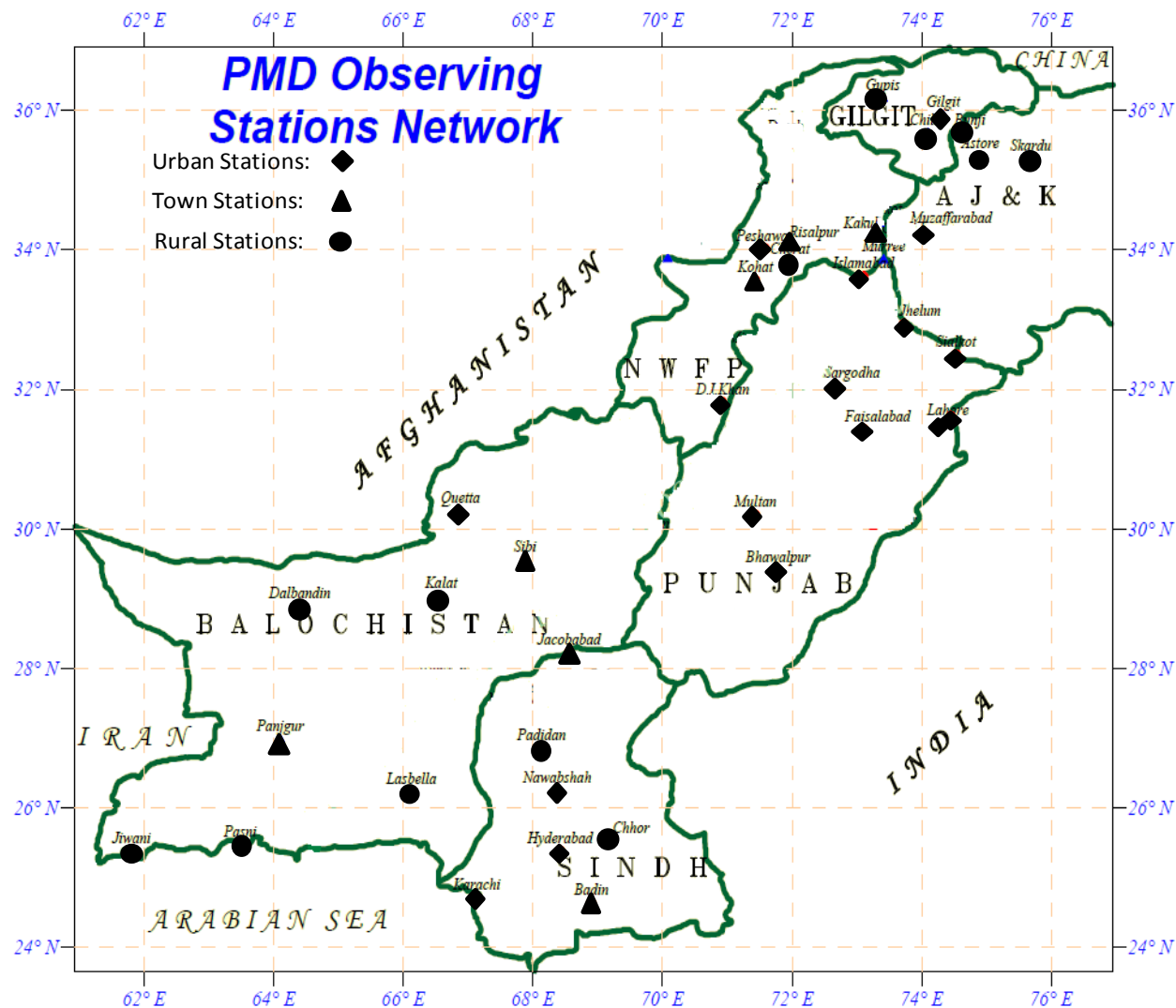


Classification of meteorological stations

The classification of monitoring stations into urban, town and rural stations is done by using the traditional method based on population:

- urban areas: more than > 100,000 persons
- town area: 1000 to 100,000 persons
- rural area: >1000 persons

Meteorological Stations/observatories



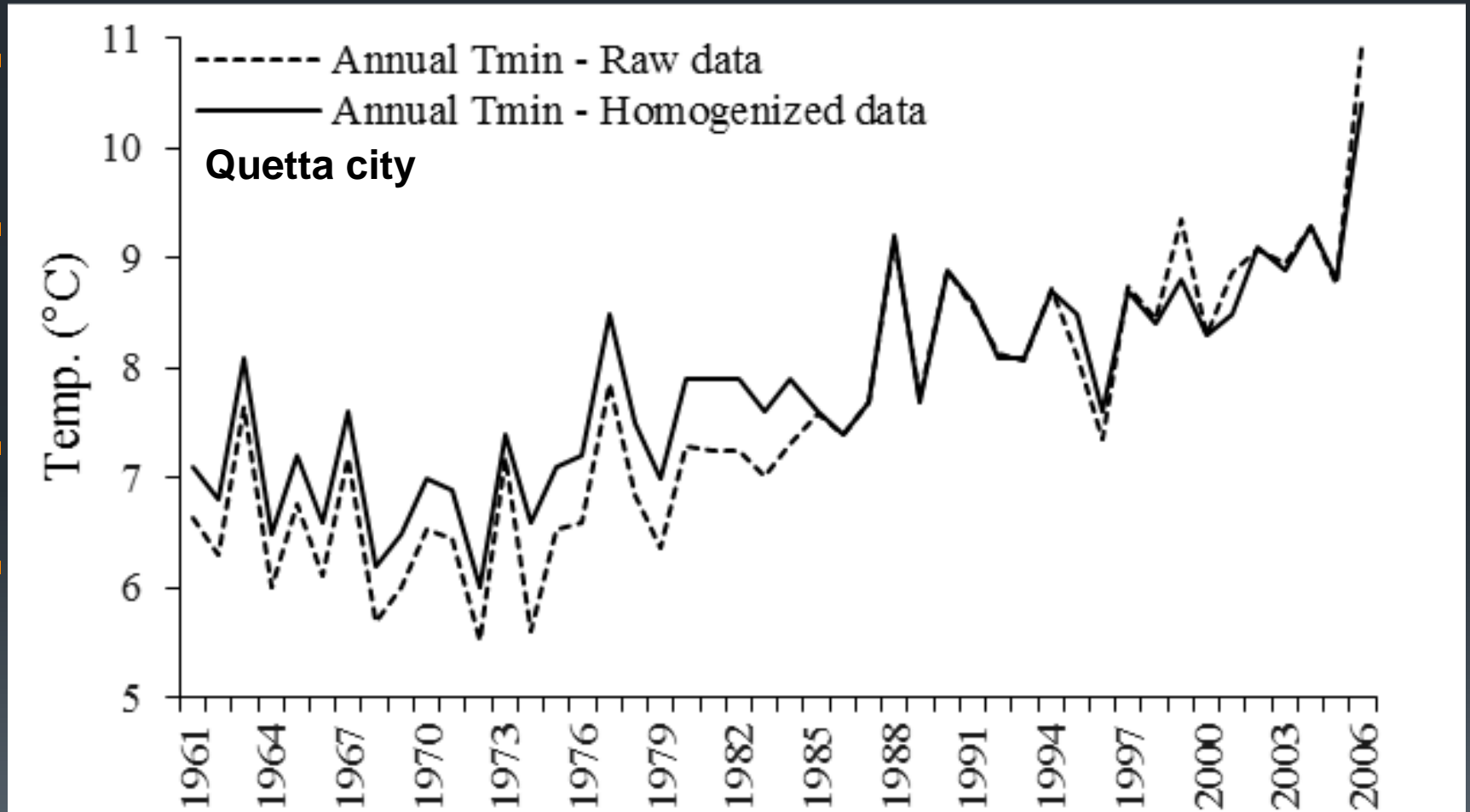
Data and methodology

Geographical information about meteorological Stations/observatories

No.	Code	Name	Station location		Elevation (m)	Station type	Data record
			Latitude	Longitude			
1	41516	Gilgit	35.55	74.2	1460	Urban	1950-2004
2	41530	Peshawar	34.1	71.35	360	Urban	1950-2004
3	41532	Muzaffarabad	34.22	73.29	2300.9	Urban	1950-2004
4	41571	Islamabad	33.37	73.6	508.1	Urban	1950-2004
5	41594	Sargodha	32.3	72.4	188.1	Urban	1950-2004
6	41598	Jhelum	32.56	73.44	287.1	Urban	1950-2004
7	41600	Sialkot	32.31	74.32	255.1	Urban	1950-2004
8	41624	D.I.Khan	31.49	70.56	171.2	Urban	1950-2004
9	41630	Faisalabad	31.26	73.8	185.6	Urban	1950-2004
10	41640	Lahore-urb	31.33	74.2	214	Urban	1950-2004
11	41641	Lahore-ap	31.35	74.24	216.1	Urban	1950-2004
12	41660	Quetta	30.15	66.53	1588.9	Urban	1950-2004
13	41675	Multan	30.12	71.26	122	Urban	1950-2004
14	41700	Bahawalpur	29.2	71.47	110	Urban	1950-2004
15	41749	Nawabshah	26.15	68.22	37	Urban	1950-2004
16	41764	Hyderabad	25.23	68.25	28	Urban	1950-2004
17	41780	Karachi-ap	24.54	67.8	21.9	Urban	1950-2004
18	41697	Sibbi	29.33	67.53	132.9	Town	1950-2004
19	41739	Panjgur	26.58	64.6	968	Town	1950-2004
20	41785	Badin	24.38	68.54	9	Town	1950-2004
21	41533	Risalpur	34.4	71.59	317	Town	1950-2004
22	41564	Kohat	33.34	71.26	513	Town	1950-2004
23	41715	Jacobabad	28.18	68.28	54.9	Town	1950-2004
24	41535	Kakul	34.11	73.15	1307.9	Town	1950-2004
25	41504	Gupis	36.1	73.24	2155.9	Rural	1950-2004
26	41517	Skardu	35.18	75.41	2317	Rural	1950-2004
27	41518	Bunji	35.4	74.38	1372	Rural	1950-2004
28	41519	Chilas	35.25	74.6	1249.1	Rural	1950-2004
29	41520	Astore	35.2	74.54	2168	Rural	1950-2004
30	41565	Cherat	33.49	71.33	1372	Rural	1950-2004
31	41685	Chhor	29.53	69.43	4.9	Rural	1950-2004
32	41696	Kalat	29.2	66.35	2015	Rural	1950-2004
33	41712	Dalbandin	28.53	64.24	848	Rural	1950-2004
34	41742	Lasbella	26.14	66.1	87	Rural	1950-2004
35	41746	Padidan	26.51	68.8	46	Rural	1950-2004
36	41756	Jiwani	25.4	61.48	56	Rural	1950-2004
37	41759	Pasni	25.16	63.29	9	Rural	1950-2004

Data and methodology

Homogenization of data



Results

- In the space (dim 1, dim 2), we can distinguish two specific directions ($\pm 45^\circ$ in a trigonometric circle with reference dim 1 axe) that distinguish the sets of monitoring stations with decreasing or increasing T_n and T_x during 1950–2004.
- The first two dimensions summarize 74.85% of the total variances of the cloud of dataset.

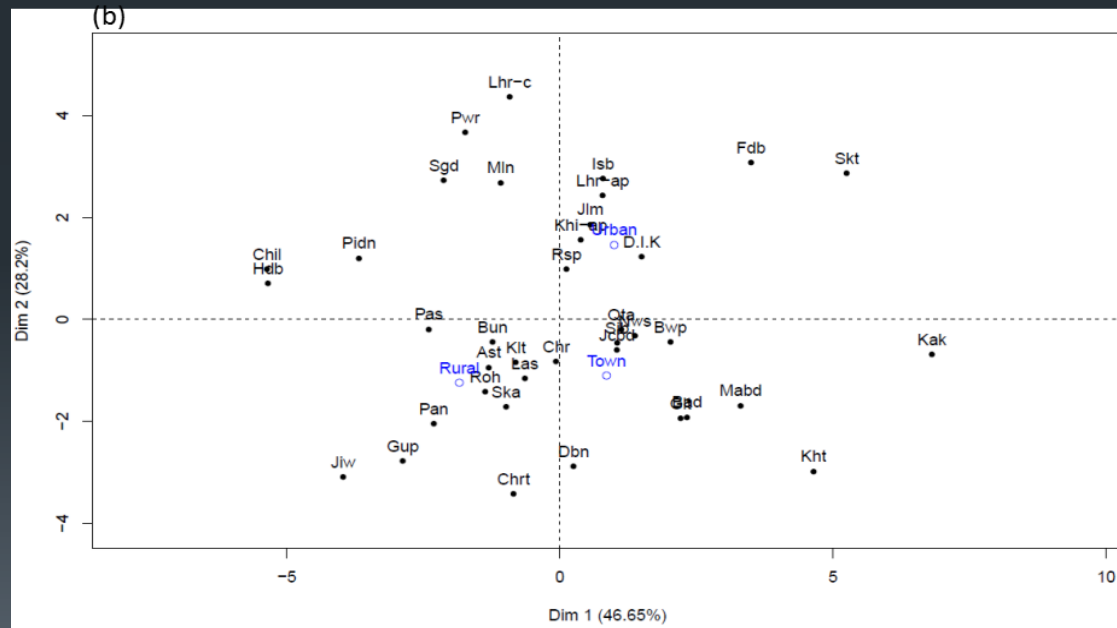
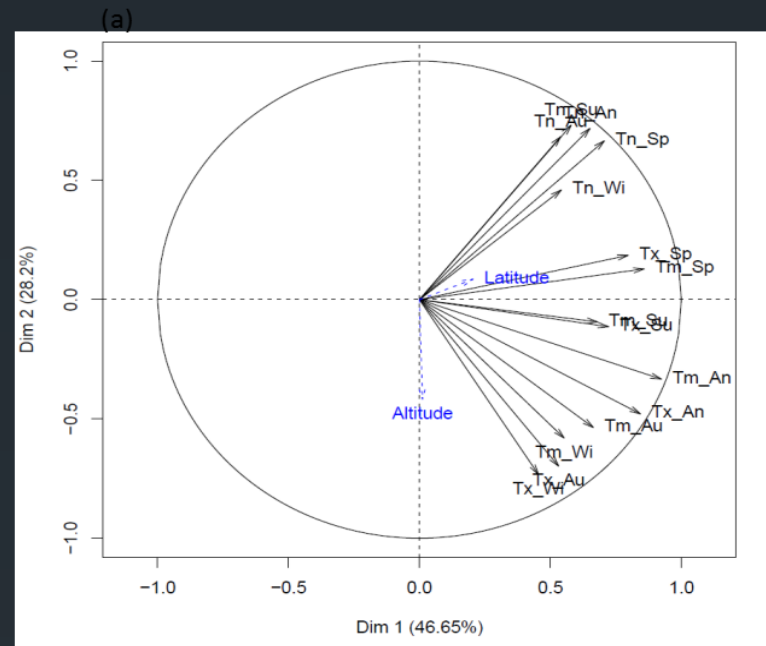


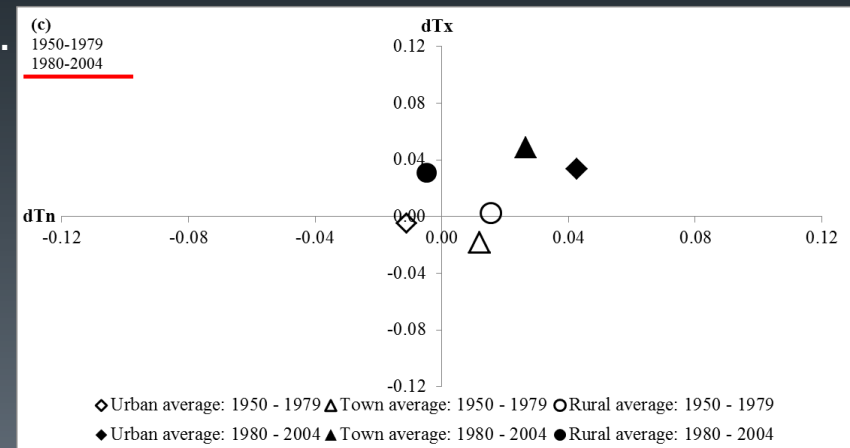
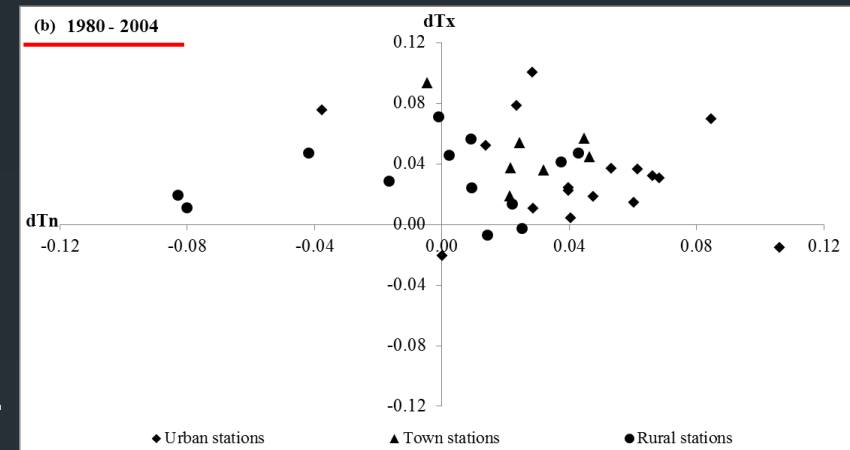
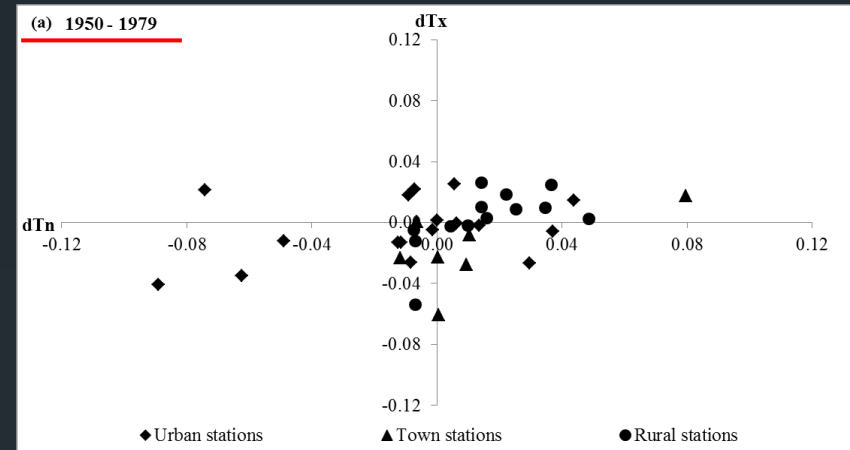
Figure: Principal Component Analysis results based on data from 1950–2004 showing variables graph (a) and individuals graph (b).

Results

Minimum temperature as a function of maximum temperature for urban, town and rural stations.

The trends are computed for:

- 1950–1979 (a)
- 1980–2004 (b)
- mean trends of all urban, town and rural stations for 1950–1979 and 1980–2004 (c).
- The values of dT_n and dT_x are in $^{\circ}\text{C year}^{-1}$.



Results



Trends (in $^{\circ}\text{C dec}^{-1}$) of mean annual minimum and maximum temperatures averaged on all urban, town and rural monitoring stations of Pakistan

Station type	1950-1979		1980–2004	
	dTn	dTx	dTn	dTx
Urban	-0.11	-0.05	0.43	0.34
Town	0.12	-0.18	0.27	0.49
Rural	0.16	0.02	-0.05	0.30

Results

Table: Percentage of total number of stations showing increasing trends of daily minimum and maximum temperature averaged on a annual (dT_{an}) and seasonal basis (dT_{Wi} for Winter, dT_{Sp} for Spring, dT_{Su} for Summer, and dT_{Au} for Autumn) for each type of stations (urban, town and rural) for the period 1950–1979 and 1980–2004.

	Period	URBAN		TOWN		RURAL	
		1950 - 1979	1980-2004	1950 - 1979	1980-2004	1950 - 1979	1980-2004
Minimum Temperature	dTn_An	35%	94%	57%	86%	77%	62%
	dTn_Wi	29%	94%	43%	86%	46%	62%
	dTn_Sp	59%	88%	57%	71%	100%	54%
	dTn_Su	24%	82%	43%	57%	69%	23%
	dTn_Au	41%	88%	71%	71%	62%	62%
Maximum Temperature	dTx_An	35%	88%	29%	71%	62%	85%
	dTx_Wi	12%	71%	14%	57%	31%	100%
	dTx_Sp	53%	100%	43%	86%	77%	100%
	dTx_Su	12%	53%	29%	57%	54%	38%
	dTx_Au	53%	47%	57%	57%	69%	77%

- the maximum number of stations showing increasing trends of minimal temperatures is noted in winter, while the minimum is noted in summer
- the maximum number of stations showing increasing trends of maximal temperatures is noted in spring, while the minimum is noted in summer too.

Conclusion

- The temperatures generally increase during 1950–2004.
- The increase in temperatures were more important during 1980-2004 than from 1950-1979.
- The increase in temperature on urbanized areas is significantly higher than the rural areas.
- After 1980s, minimum temperature is frequently increasing over urban areas more than town and rural stations. While maximum temperature is increasing more at town stations.

Future concerns:

- Why maximum temperature over smaller cities (towns) is increasing more than urban and rural stations?
- Why there is rapid acceleration in minimum temperature over urban areas?
- How to mitigate the effects of increasing urban areas temperature in future?