

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

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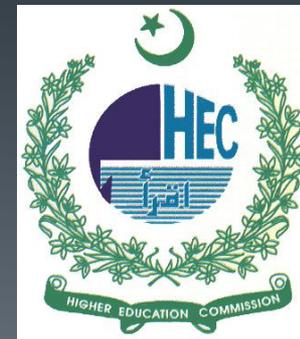
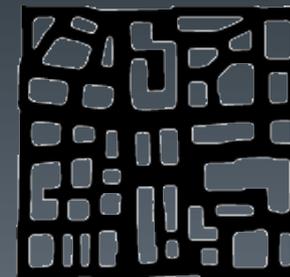
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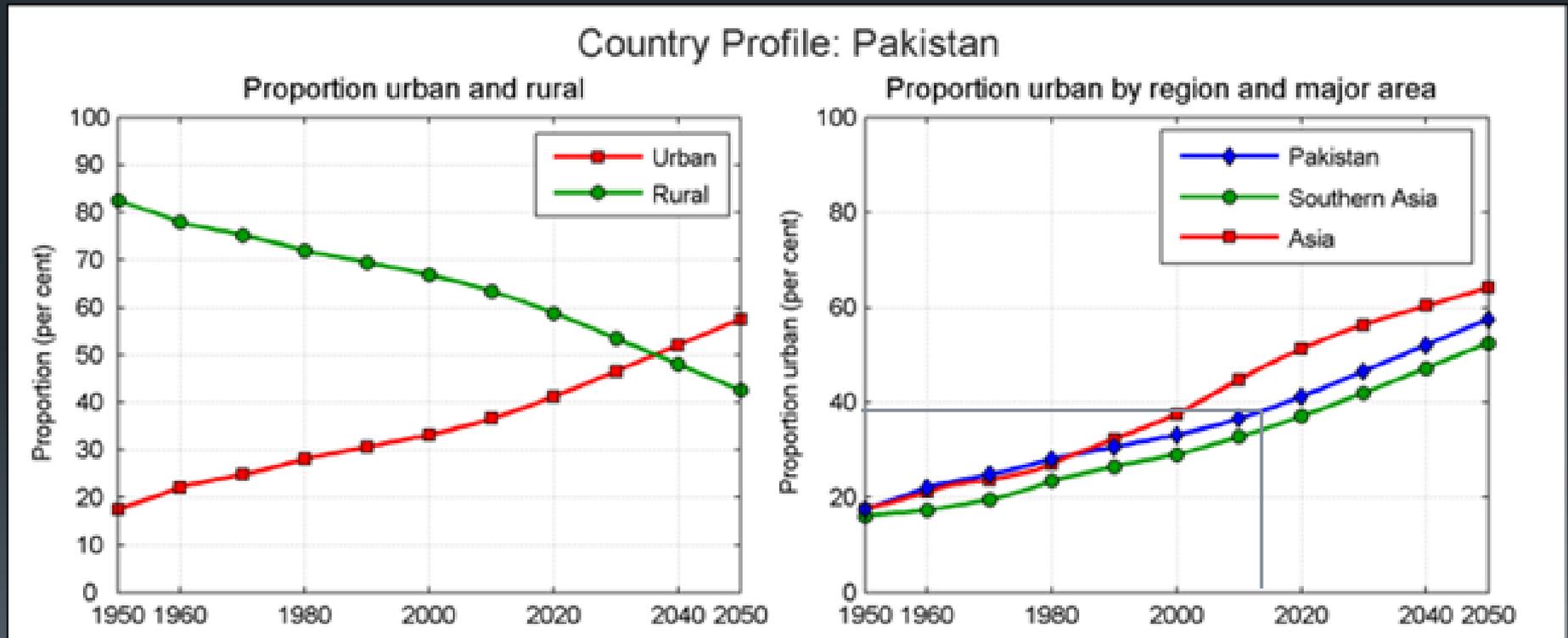
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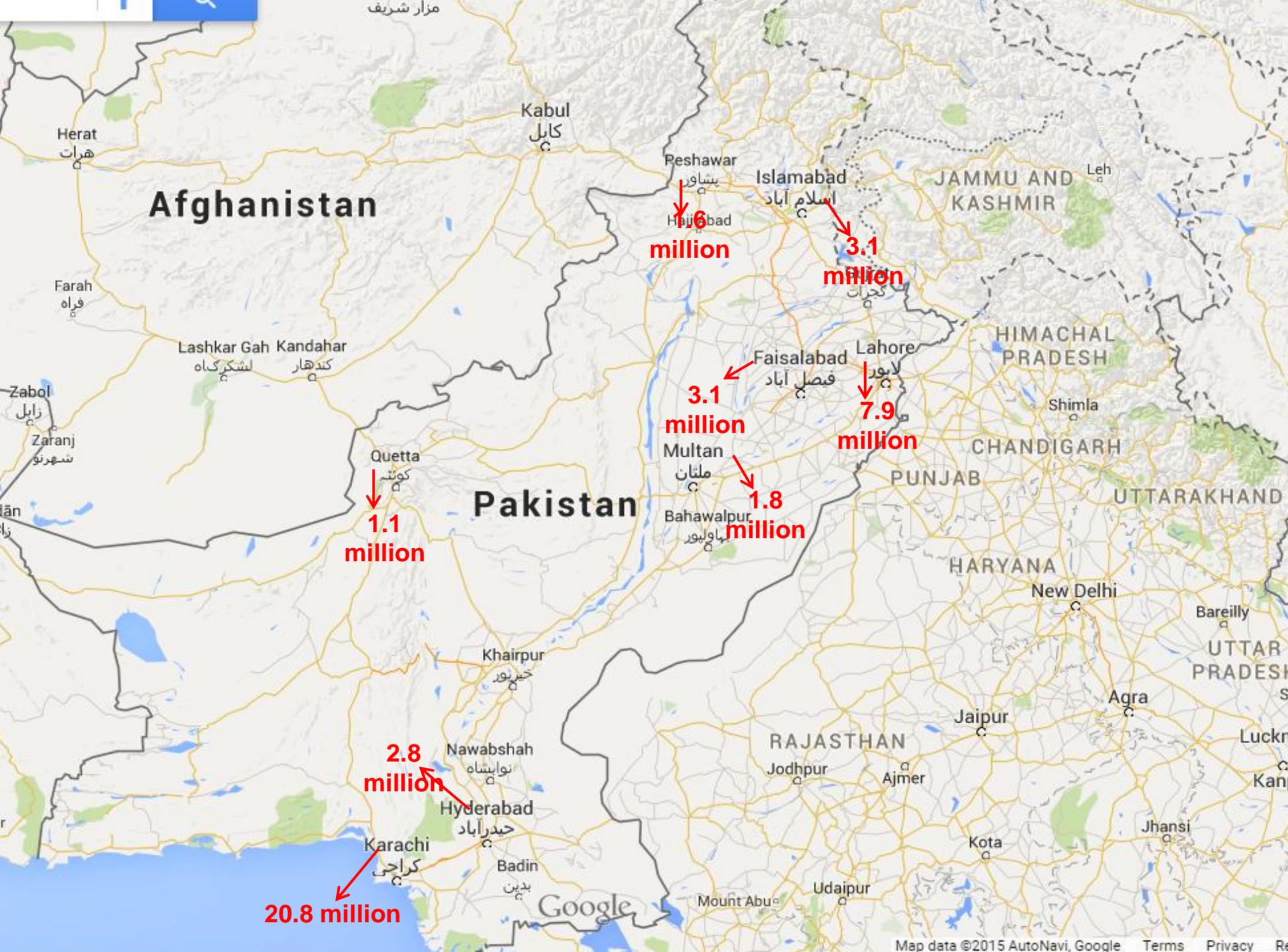


Introduction

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



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

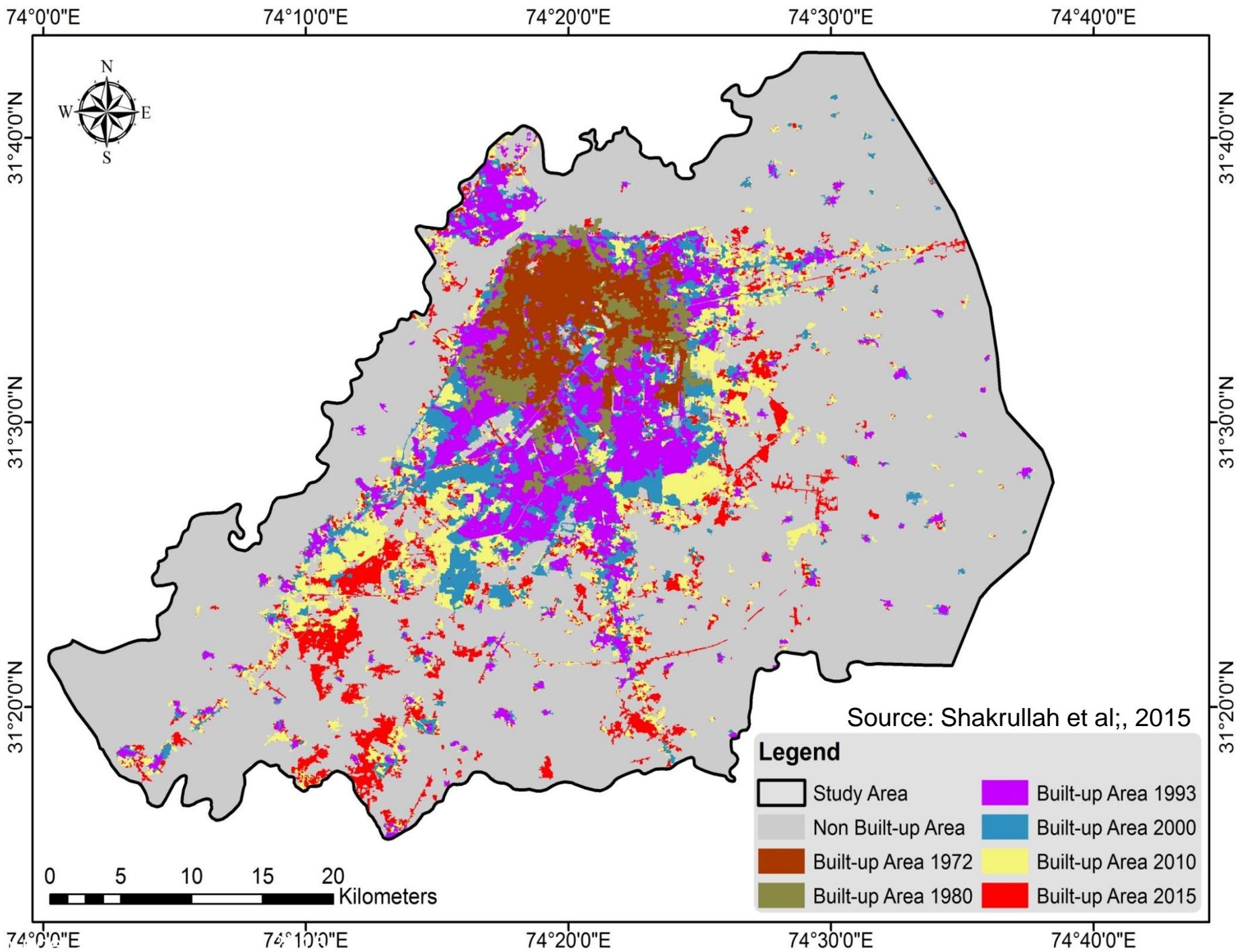


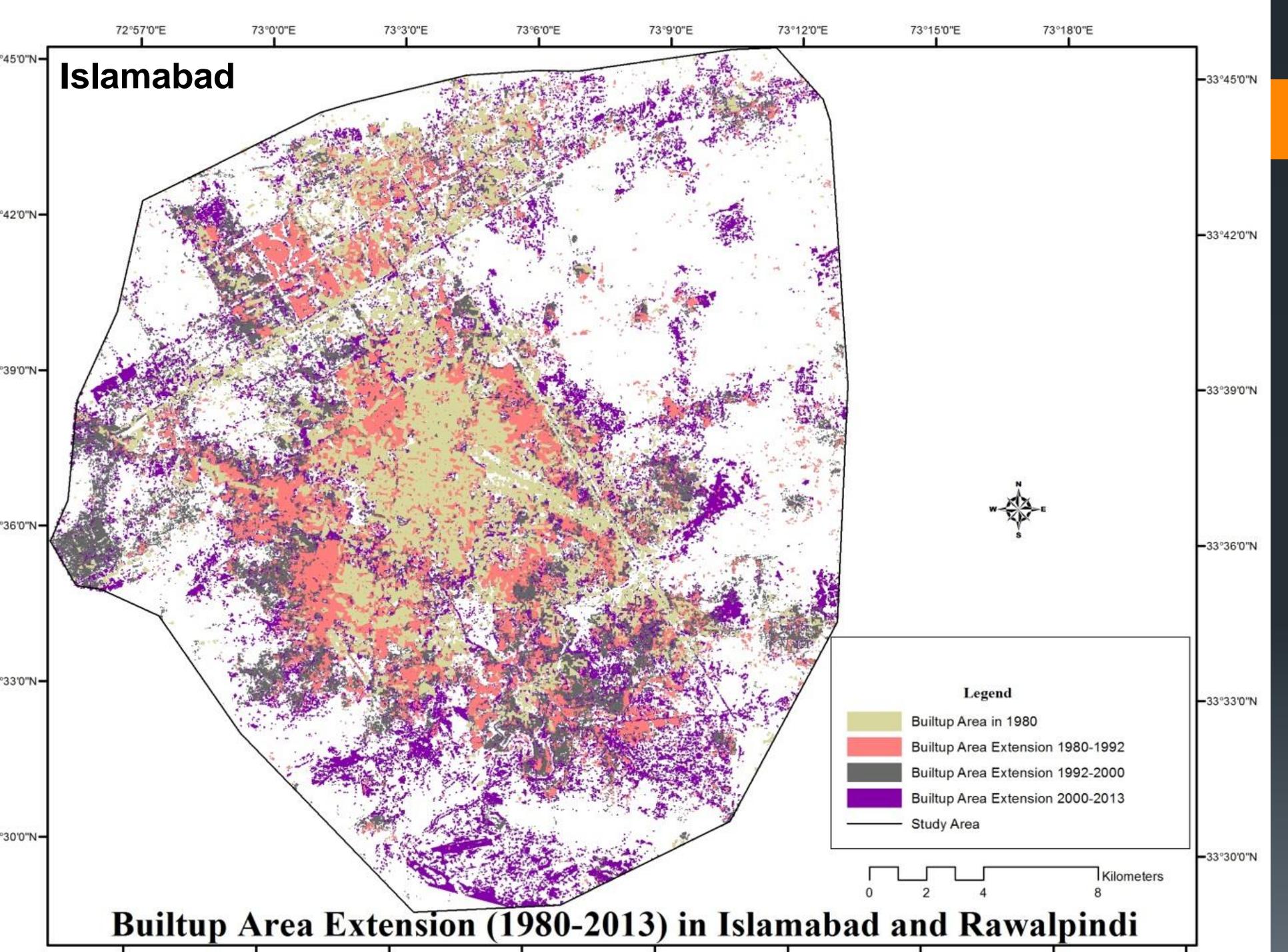
Problem

- 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

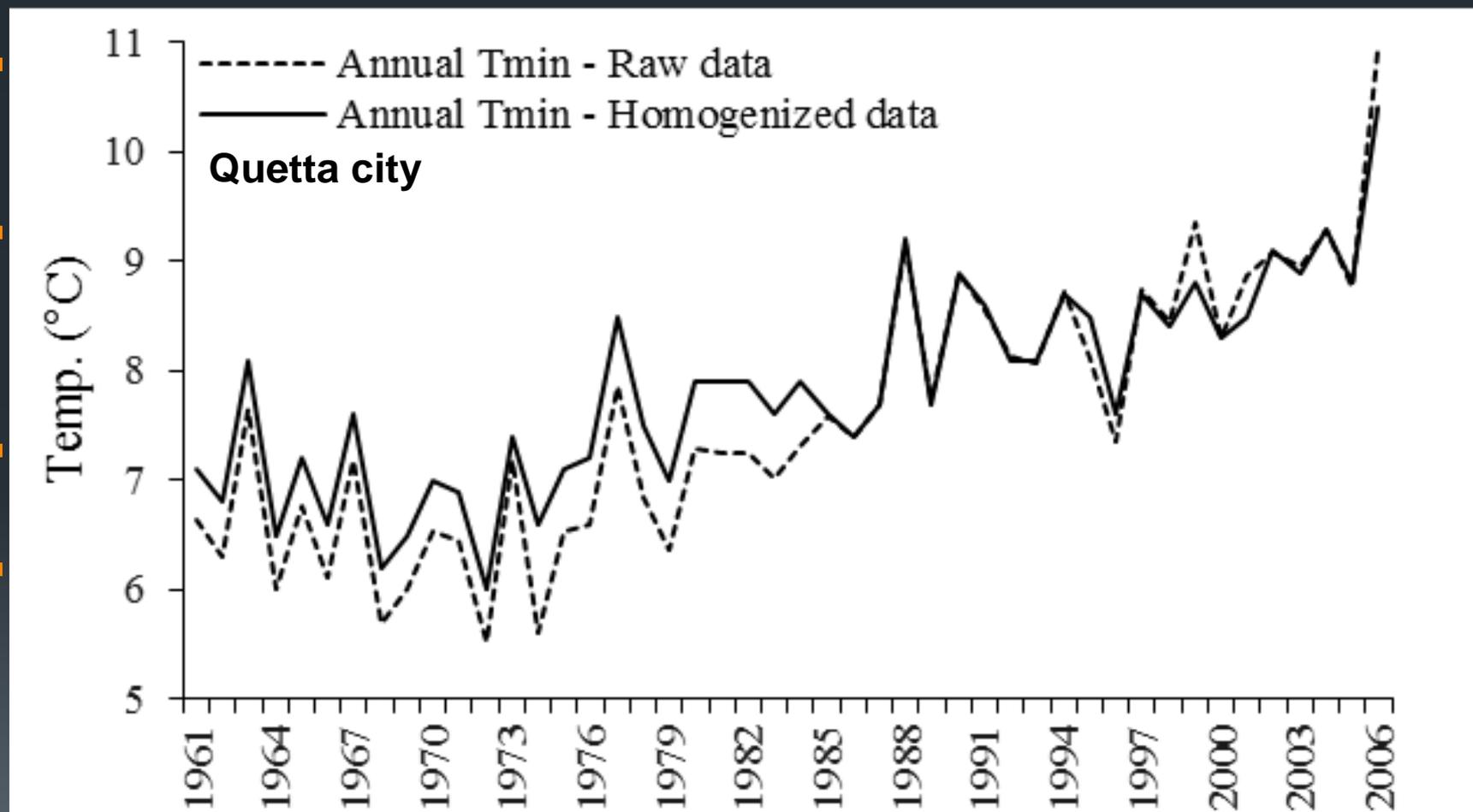
Data and methodology

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 | Panjkur | 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

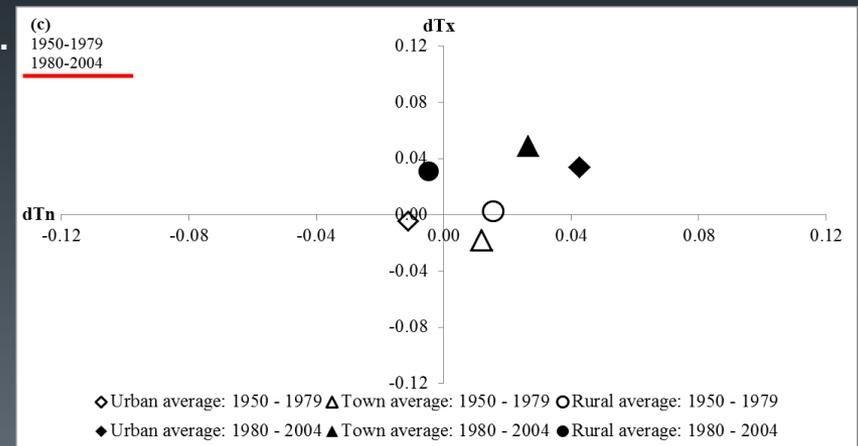
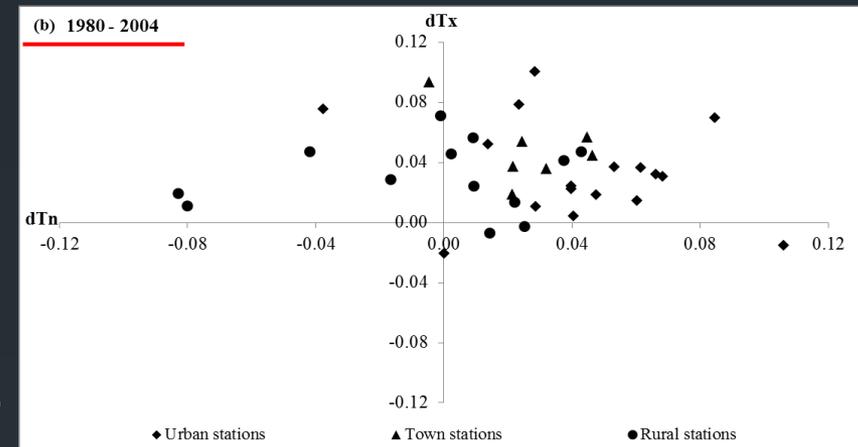
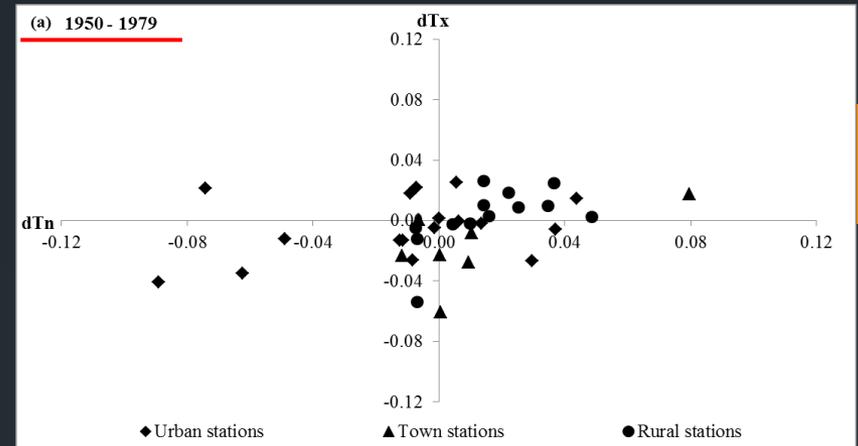


Results

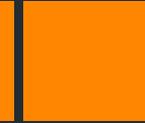
Minimum temperature as a function of maximum temperature for urban, town and rural stations.

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?