Risk and Vulnerability Assessment of Flood Prone Urban Areas of Pakistan

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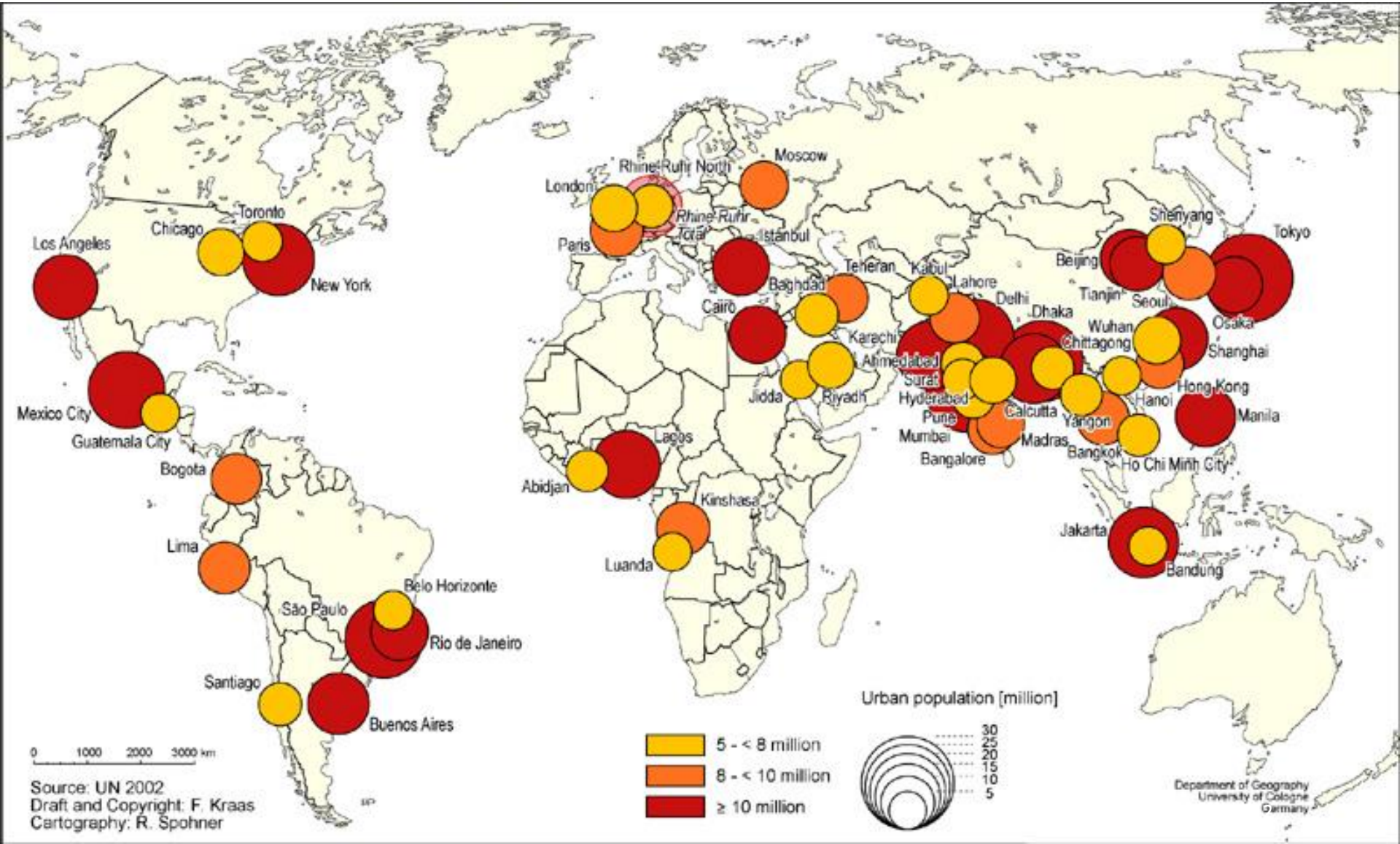
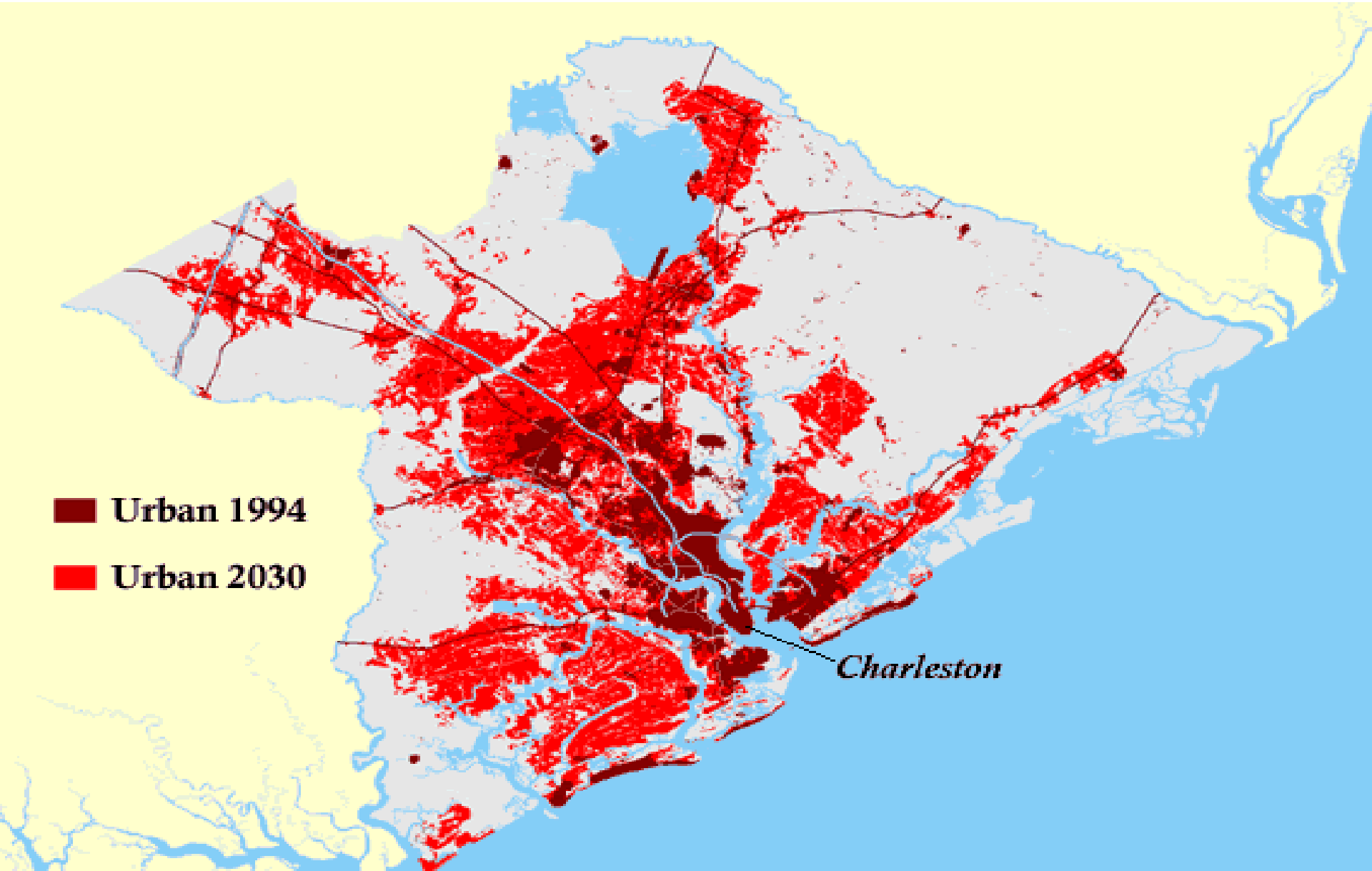
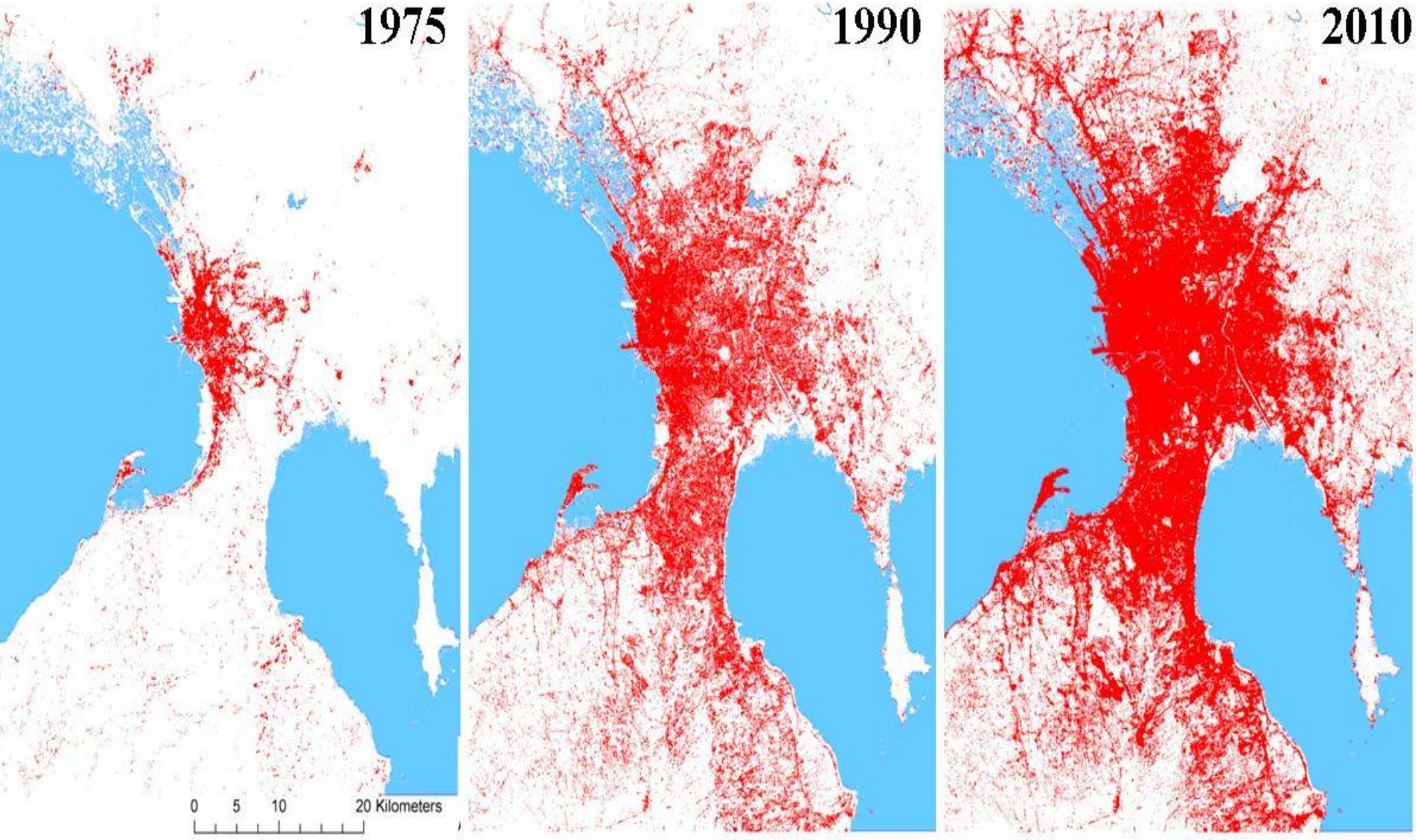
Ekistics – Science of Human Settlements



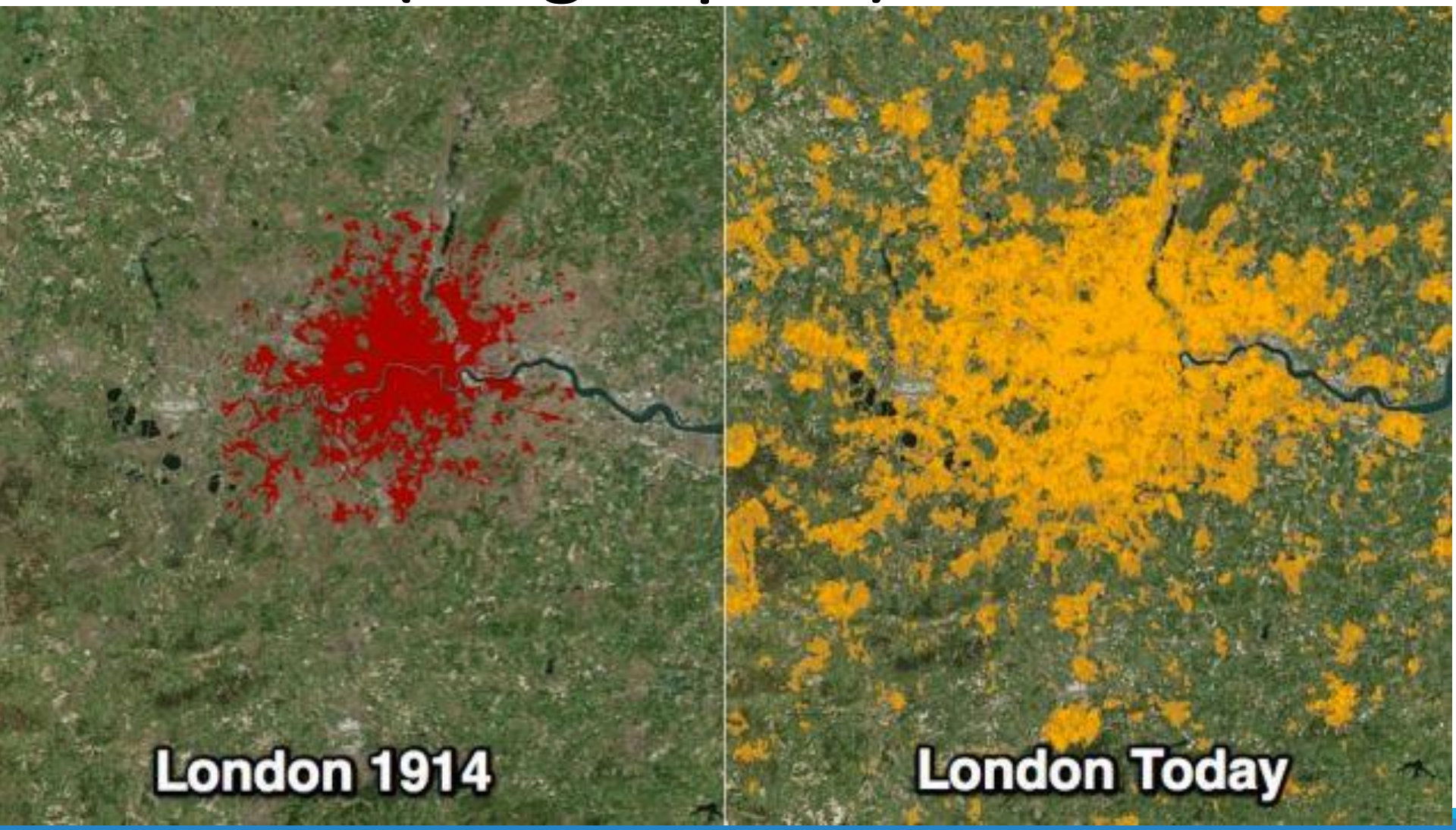
Charleston (City)

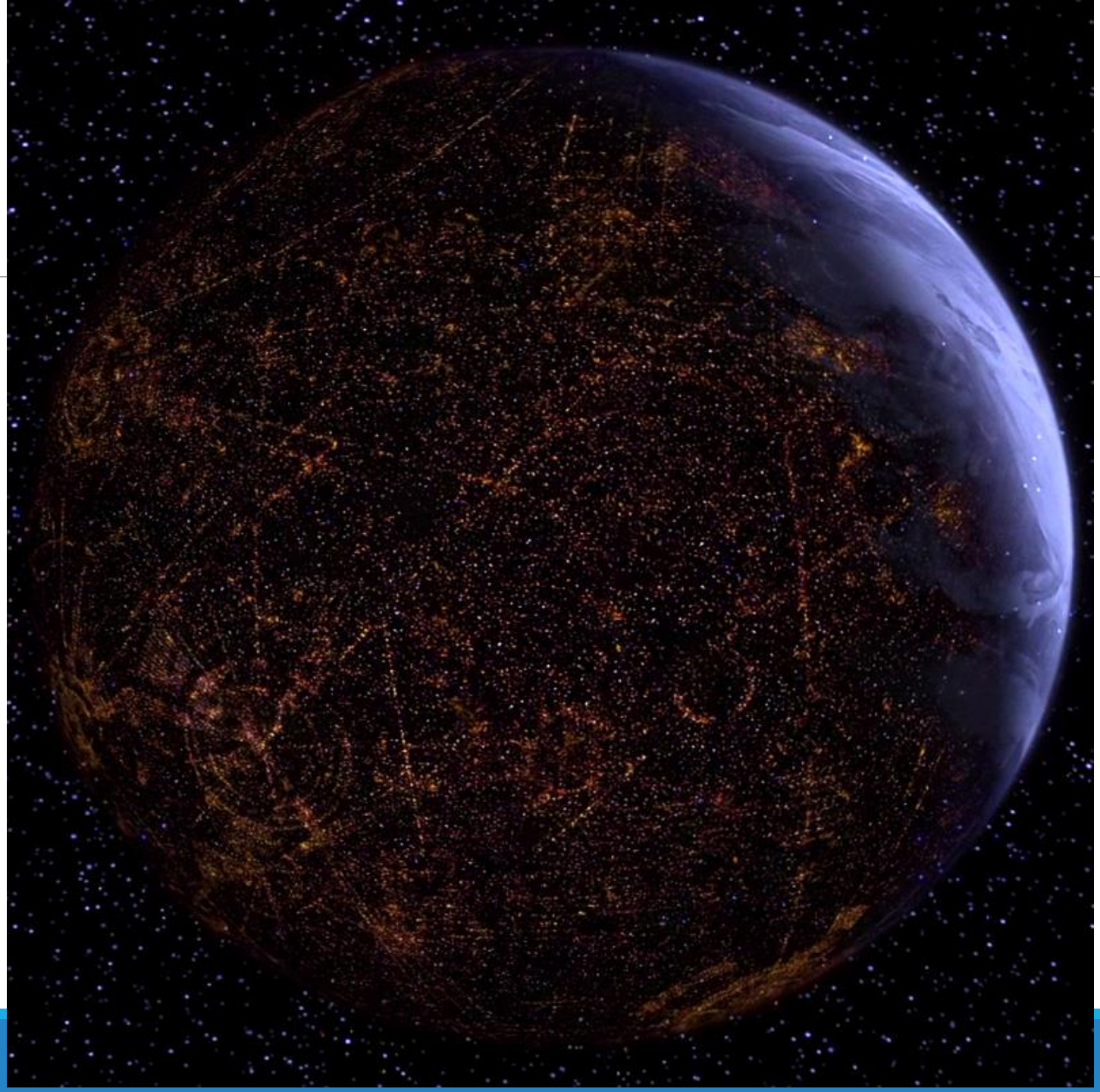


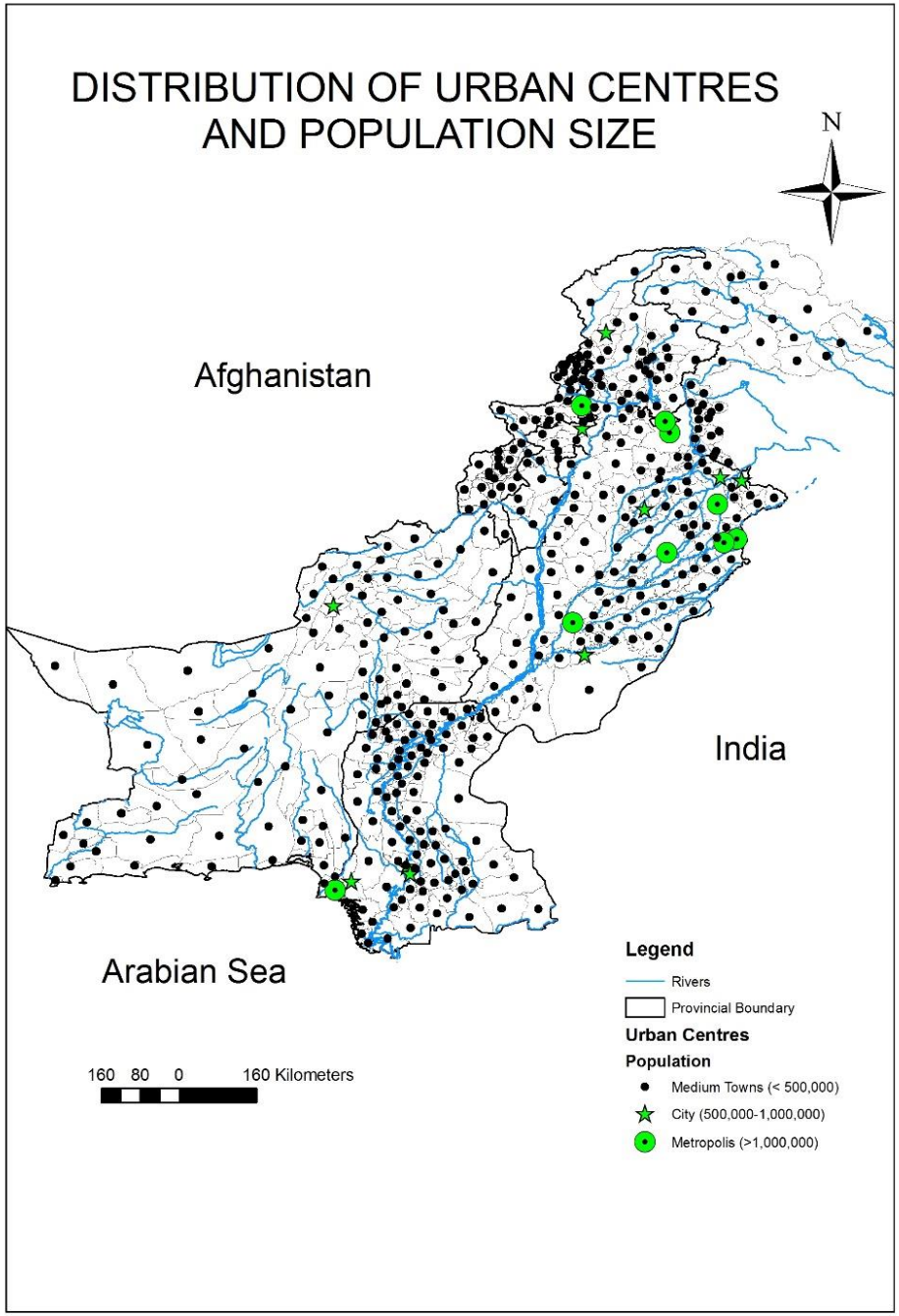
Manila (Metropolis)



London (Megalopolis)

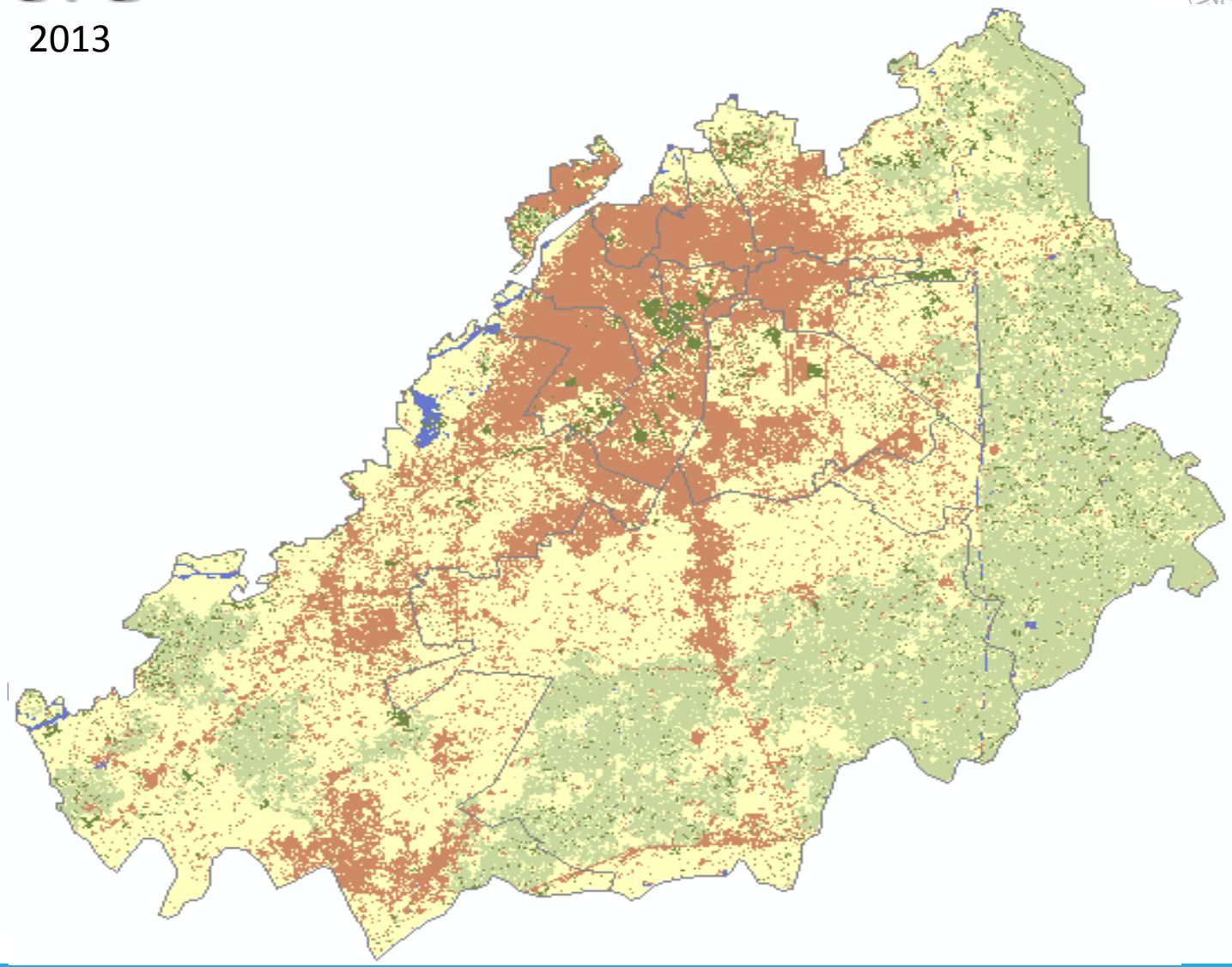





DISTRIBUTION OF URBAN CENTRES
AND POPULATION SIZE
N
Afghanistan
India
Arabian Sea
160 80 0 160 Kilometers
Legend
Rivers
Provincial Boundary
Urban Centres
Population
Medium Towns (< 500,000)
City (500,000-1,000,000)
Metropolis (>1,000,000)

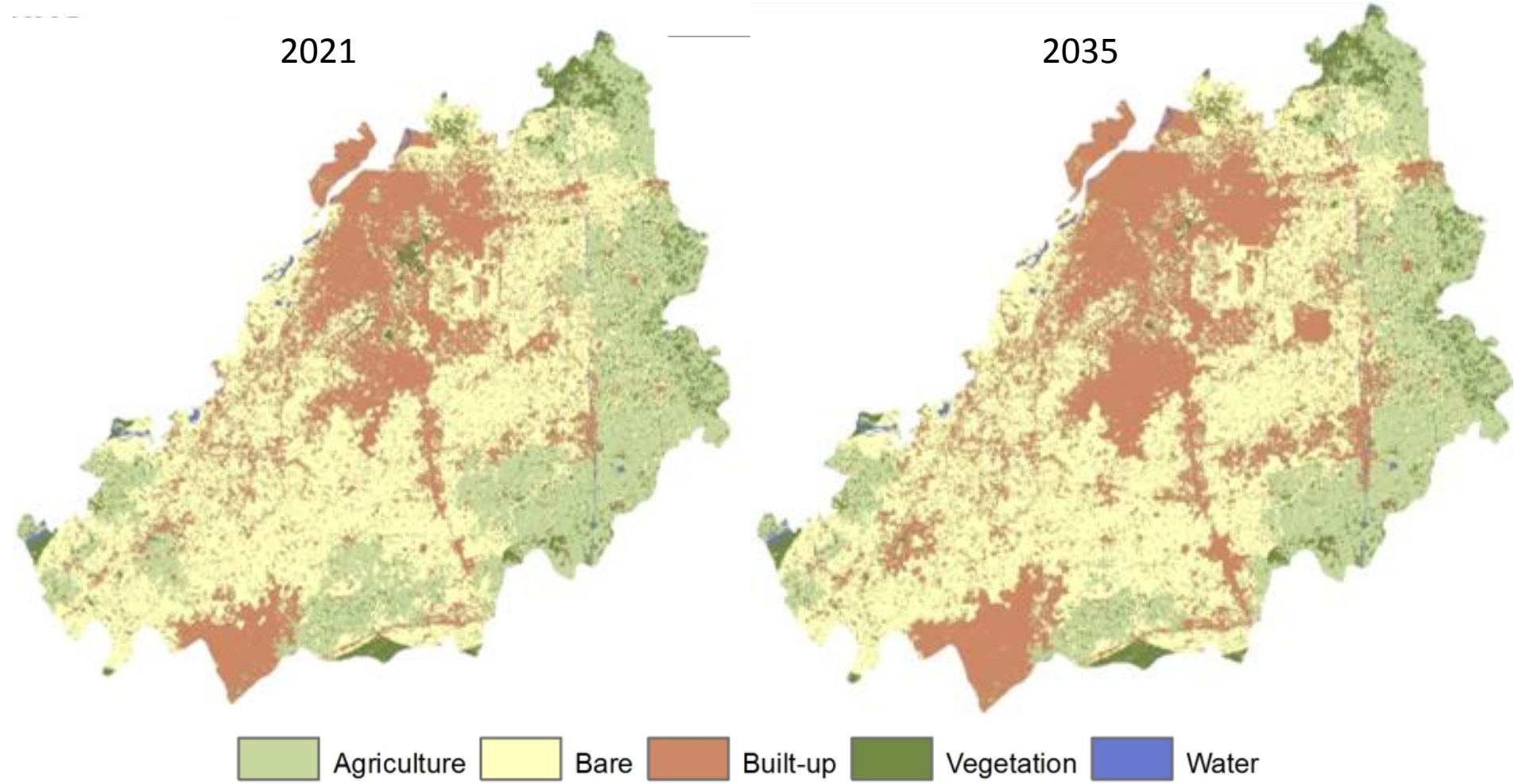
Lahore

2013



Agriculture Bare Built-up Vegetation Water

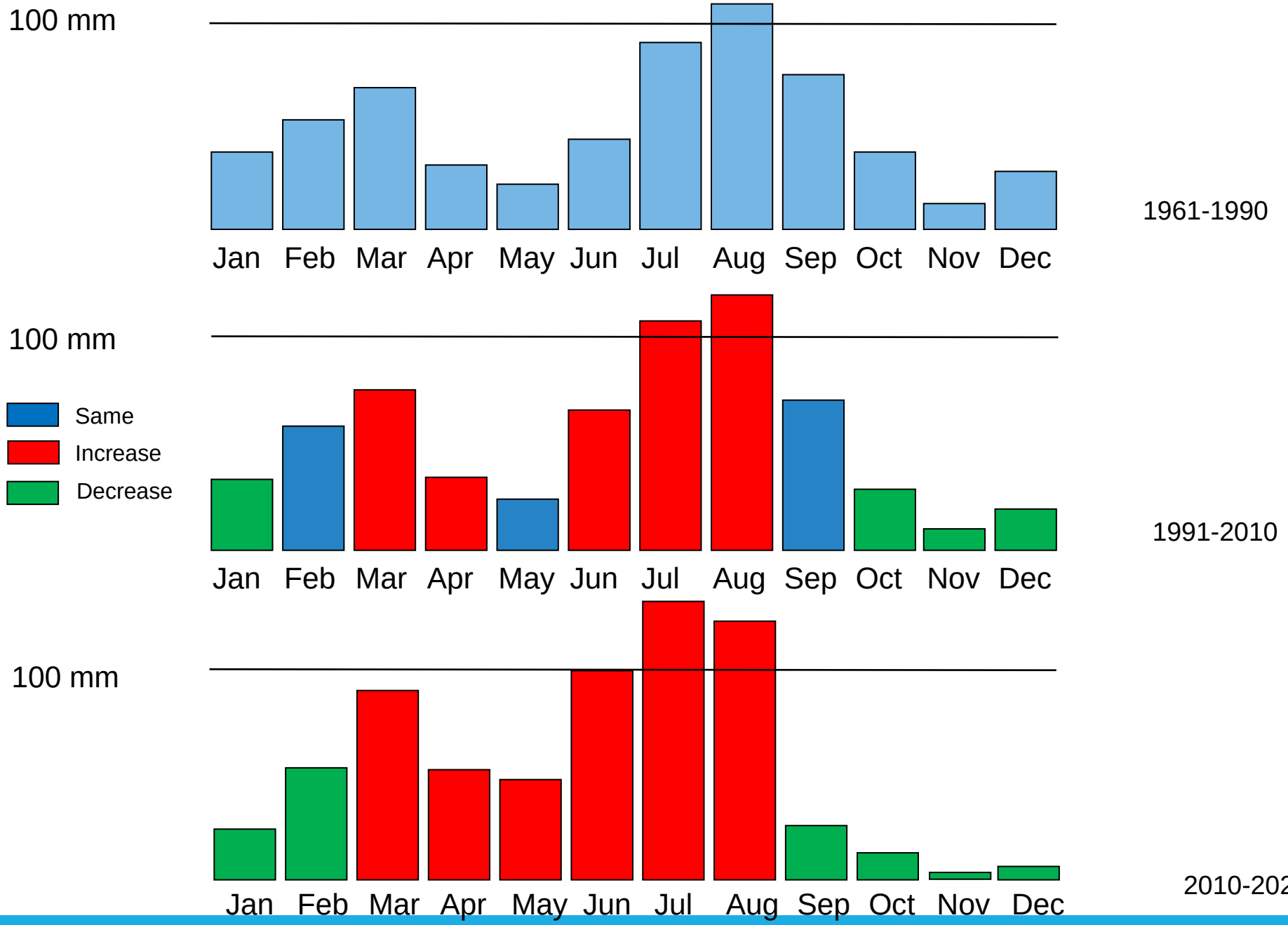
Prediction



Source: Bhatti, Tripathi and Rana, Habitat International 2015

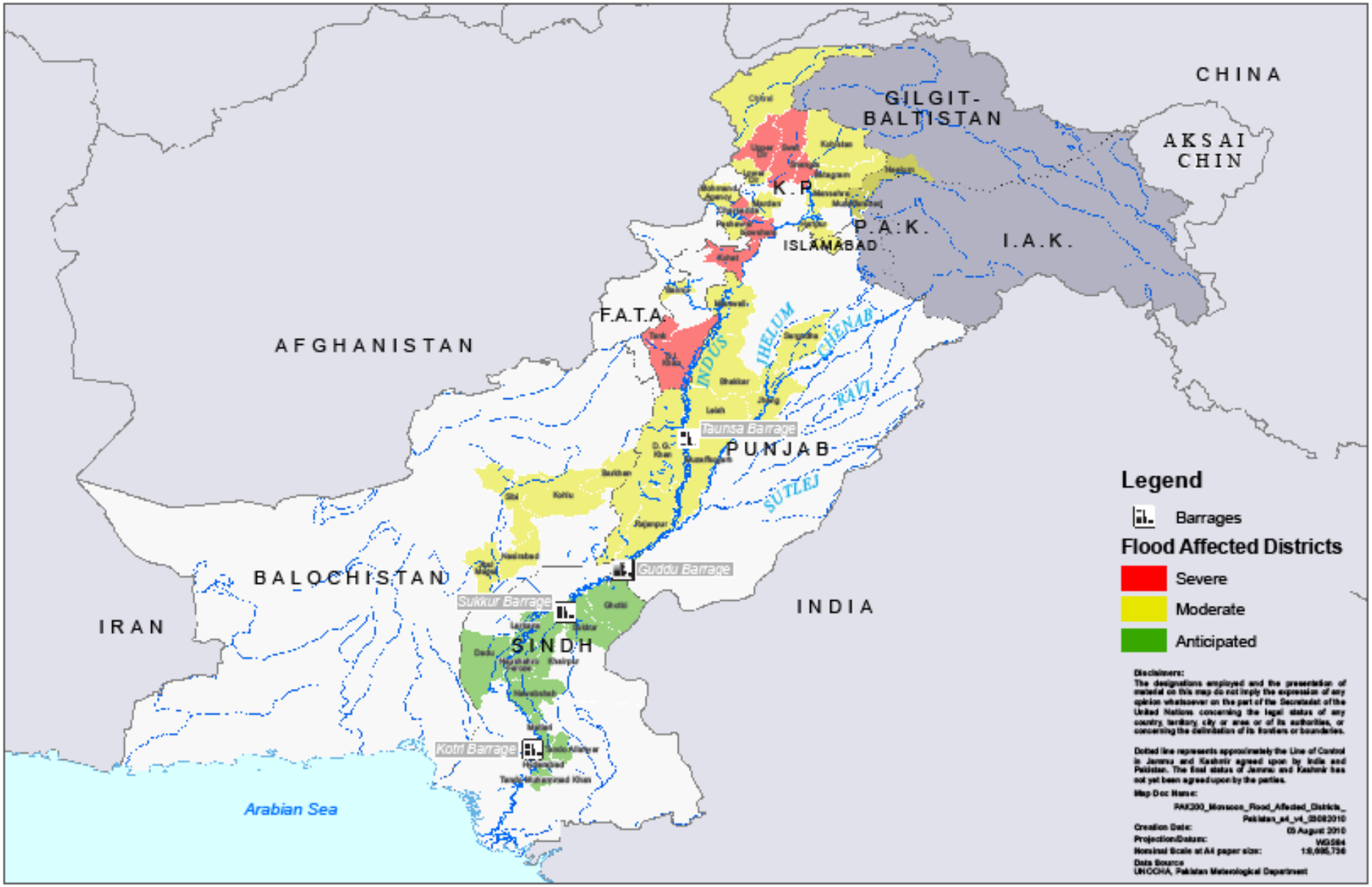
Flood Hazards in Pakistan

- Climate Change
- Monsoon (70-80% of rains in three months, July – Sept)
- River flooding is most common along the Indus in the Sindh and Punjab provinces
- Potential risk from Glacier Lake Outburst Floods (GLOFs) extend to the Northern Provinces, Khyber Pakhtunkhwa and Balochistan.
- El Niño/La Niña-Southern Oscillation

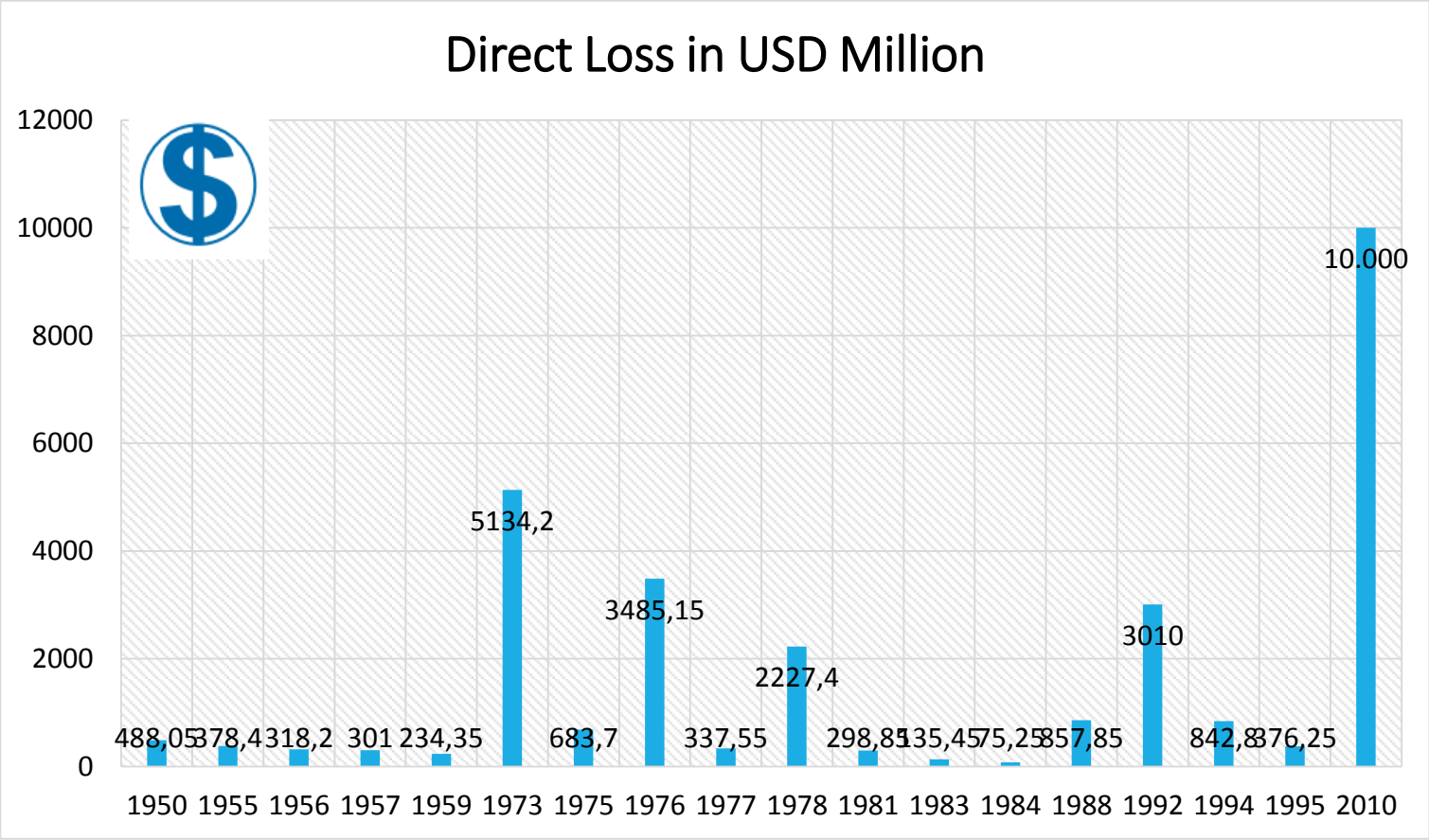

100 mm
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1961-1990
100 mm
Same
Increase
Decrease
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1991-2010
100 mm
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2010-2020

Pakistan - Floods Impact Profile
03 August 2010

OCHA



Flood Damages in Pakistan



Annual Flood Report 2010, Federal Flood Commission (2011)


NOT FOR SALE

Uncertain Future in Pakistan?

- Mean rainfall in the arid plains of Pakistan and the coastal belt has decreased by **-10 to -15%** since 1960 while the mean rainfall over the same time period in Northern Pakistan has increased.
- Expected temperature increase in Pakistan as whole is higher than the expected global average increase.
- Non existent sea-level rise and storm-surge scenarios for Pakistan coastlines.
- Country's varied topography means that many critical regions are left uncovered.
- No meteorological stations exist on the some river basins, which severely limits the utility of modelled river flows under a changing climate.

Source: Climate Change Portal, World Bank

Dilemma of Climate Change Adaptation and Disaster Risk Reduction

▪ CCA	or	DRR
▪ IPCC	or	UNISDR
▪ Paris Agreement	or	Sendai Framework
▪ Global Models	or	Community Based Disaster Risk Models

An integrated approach????

Revisiting Concepts of Risk

- The potential disaster losses in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period" *(UNISDR, 2009).*
- The probability of a hazard occurring and creating loss (*Smith & Petley, 2008).*
- A natural hazard converts into a disaster only when it affects a "vulnerable" population *(Uitto, 1998),* and where proper mitigation systems are absent *(Chadha et al., 2007).*
- It often varies among:
  - individuals
  - communities
  - and regions

Types of Risks in contexts of Natural Disasters

Actual Risk

- Identifies vulnerabilities and capacities of disaster prone communities.
- Based on hazard, exposure, sensitivities and capacities of households

Perceived Risk

- Based on exposure, past experiences and individuals/community understanding and cognitive thinking.
- Way the potential victims understand, which may not be necessarily true.

Both are simultaneously used for RISK ASSESSMENT for effective disaster risk reduction strategies

Revisiting Concepts of Vulnerability

- A multidimensional concept
- The inability (of a system or a unit) to withstand the effects of a hostile environment
- Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change

Types of Vulnerability

- **Physical Vulnerability:** The vulnerability of an area depending on geographic proximity to the source.
- **Social Vulnerability:** The inability of people, organizations and societies to withstand adverse impacts to hazards due to characteristics inherent in social interactions, institutions and systems of cultural values.
- **Economic Vulnerability:** The potential impacts of hazards on economic assets and processes.
- **Attitudinal Vulnerability:** A community which has negative attitude towards change and lacks initiative in life resultantly become more and more dependent on external support.
- **Environmental Vulnerability:** The potential impacts of events on the environment.

General Terminologies

- Hazard or Exposure
- Vulnerability or Risk
- Sensitivity or Fragility/Susceptibility
- Coping Capacity or Adaptive Capacity

Confused???

Risk and Vulnerability

- Disaster Risk (R) is conceptualized often as function of hazard and vulnerability *(Wisner, 2004; **UNISDR 2004**)*, and expressed as:

$$R = f(h, v)$$

where, H = Hazard, V = Vulnerability

- **Intergovernmental Panel for Climate Change (IPCC)** defines vulnerability as a function of exposure, sensitivity and capacity *(IPCC, 2012),* and expressed as:

$$V = f(E, S, C)$$

where, V = Vulnerability, E = Exposure, S = Sensitivity, C = Capacity

Components of Vulnerability and Risk

- **Hazard:** A potential of natural geophysical or hydro-meteorological events that may cause damages to an area over a specific period of time *(Birkmann, 2006).*
- **Exposure:** The presence of susceptible elements. (IPCC, 2012)
- **Sensitivity:** A tendency/degree of elements at risk that can come to any harm as a result of the hazard. *(Birkmann et al., 2013)*
- **Capacity:** Ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters. *(UNISDR, 2009)*

Coping and Adaptive

Models for assessing Vulnerability and Risk

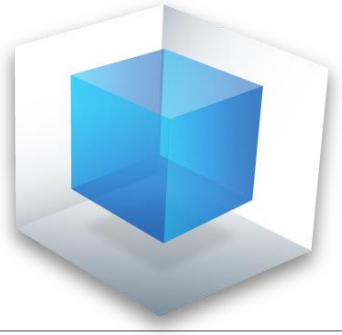
Vulnerability Assessment

- Hazards of place vulnerability model *(Cutter, 2000)*
- Turner's vulnerability framework *(Turner et al. 2003)*
- Bogardi, Birkmann and Cardona Framework *(Bogardi et al. 2004)*
- Spheres of Vulnerability *(Birkmann, 2006)*

Risk Assessment

- Risk Triangle Model *(Crichton, 1999)*
- Davidson's/Bollin's Disaster Risk Model *(Davidson 1997; Bollin et al. 2003)*
- Pressure and Release Model *(Wisner et al., 2004)*
- Methods for the Improvement of Vulnerability Assessment in Europe (MOVE) framework *(Birkmann et al. 2013)*

Defining Disaster Risk Model



In, Disaster Risk Science: (UNISDR)

$$\text{Disaster Risk} = \text{Hazard} \times \textit{Vulnerability}$$

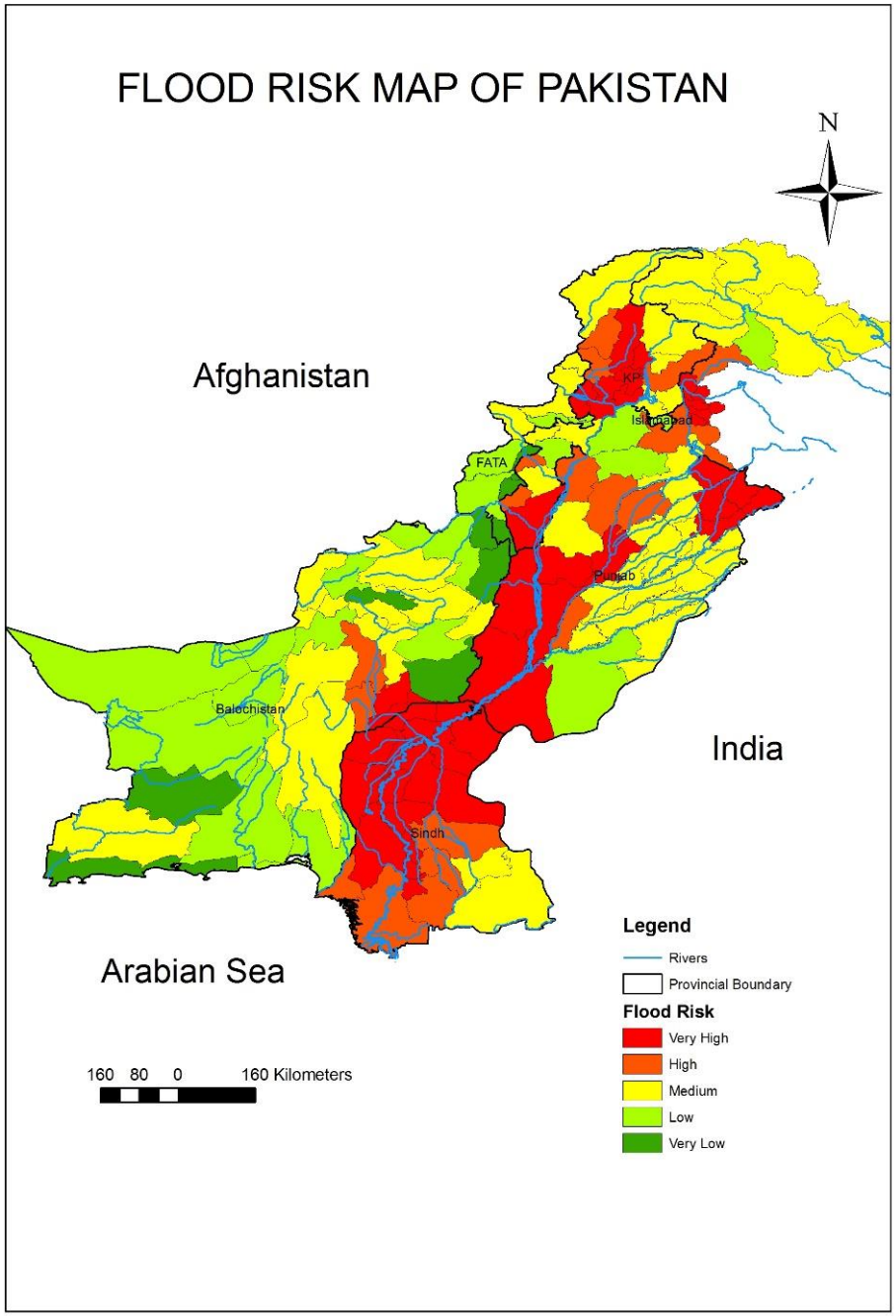
In, Climate Change Adaptation: (IPCC)

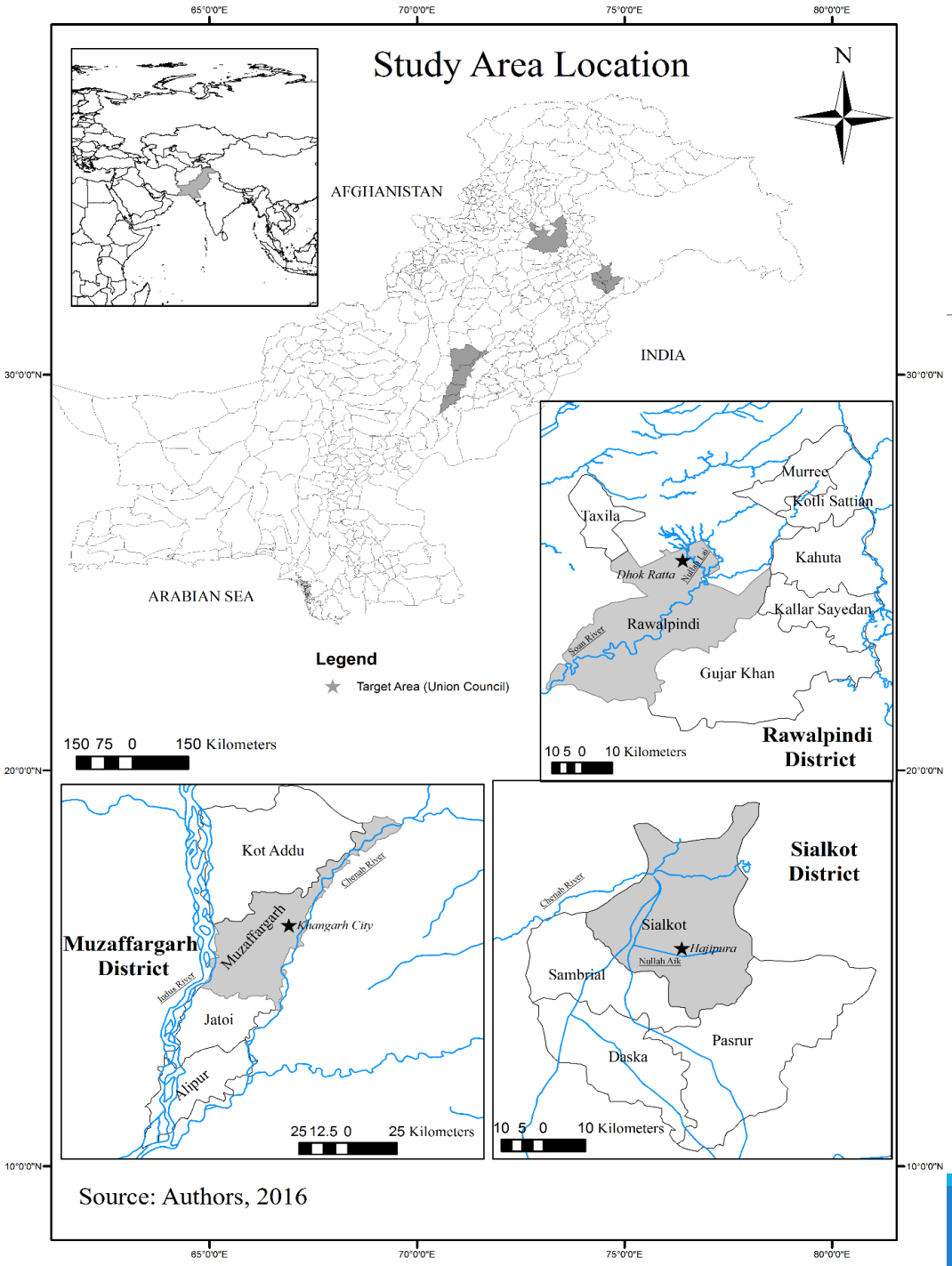
$$\textit{Vulnerability} = (\text{Exposure} \times \text{Sensitivity})/\text{Capacity}$$

Thus,

$$\text{Risk Assessment} = \frac{\text{Hazard} \times \text{Exposure} \times \text{Sensitivity}}{\text{Capacity}}$$

(Rana & Routray, 2016)


FLOOD RISK MAP OF PAKISTAN
N
Afghanistan
KP
Islamabad
FATA
Punjab
Balochistan
India
Sindh
Arabian Sea
160 80 0 160 Kilometers
Legend
Rivers
Provincial Boundary
Flood Risk
Very High
High
Medium
Low
Very Low


Study Area Location
N
AFGHANISTAN
INDIA
ARABIAN SEA
65°0'0"E
70°0'0"E
75°0'0"E
80°0'0"E
30°0'0"N
20°0'0"N
10°0'0"N
Legend
Target Area (Union Council)
150 75 0 150 Kilometers
Murree
Kotli Sattian
Taxila
Kahuta
Dhok Ratta
Nullah Lai
Kallar Sayedan
Rawalpindi
Soan River
Gujar Khan
Rawalpindi District
10 5 0 10 Kilometers
Kot Addu
Chenab River
Muzaffargarh
Khangarh City
Muzaffargarh District
Indus River
Jatoi
Alipur
25 12.5 0 25 Kilometers
Sialkot District
Chenab River
Sialkot
Hajipura
Nullah Aik
Sambrial
Pasrur
Daska
10 5 0 10 Kilometers
Source: Authors, 2016

Sampling

1. Metropolitan

Population: >1 million

City: Rawalpindi

Town: Rawal Town

UC : Dhok Ratta

2. City

Population: 500,000 to 1 million

City: Sialkot

Town: Sialkot

UC : Hajipura

3. Medium Town

Population: < 500,000

City: Muzaffargarh

Town: Muzaffargarh

UC : Khangarh City

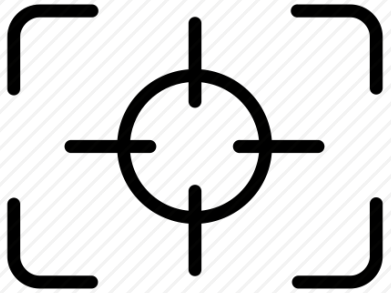
- Multi-stage sampling
- 210 samples
- 70 from each urban community

Hazard Indicators

Indicators
Frequency of flood (in number)
Height of flood (in meters)
Duration of flood (in days)
Likelihood of Inundation (very high, high, moderate, low, very low)
Damages of Previous flood (very high, high, moderate, low, very low)

Exposure Indicators

Indicators	
Household Size (in number)	Building Height (Number of stories)
Family Type	Building Age
Households with injury/death in previous floods	Building Construction Materials
Location of the House	Household's level of understanding National Warning System
Housing Type	



Sensitivity Indicators

Indicators	
Dependency Ratio (Dependents to Total household size)	Households living in rented houses
Female Male Ratio	Distance to nearest medical facility (in kilometers)
Households having family members with chronic illness/ pregnancy or disability	Households of access to drinking water (%)
Household living in community (in years)	Households not having access to improved sanitation
Average Monthly Household's Income (in Amount)	Households not getting Electricity
Occupation of Household head	Households having no means of communication (TV, Radio, Telephone, Mobile)
Households who have borrowed for loan anyone in last ten years	Households having no means of Transportation

Capacity Indicators

Indicators	
Household head's education level	Households having land/house outside the flood prone community
Households who have experience with floods	Households with family member employed outside flood prone area
Households having family member who can swim	Strength of community cooperation in disaster response
Households having family member who has First Aid Knowledge	Households aware emergency shelter and routes
Households having multiple sources of livelihood options	Households that have not gone to their local government for assistance in the past 12 months
Number of Earning Members in Household	Frequency of public awareness programs/ Drills attended by HH member (in number)
Average Monthly Households Savings (in. Amount)	Availability and circulation of emergency plans to households
Households having insurance (Life, Health, Building)	

Developing Indices

- Using Social Scaling Technique
- Assigning weights to classes (varies from 0.2 to 1)
- Computing Weighted Average Index (WAI)
- WAI = $(W_1 + W_2 + \ldots\ldots W_3)/n = = \sum_i^n W_i /n$

Disaster Risk Component	Levels of Measurement using Weights				
	1	0.8	0.6	0.4	0.2
Hazard	Very High	High	Moderate	Low	Very Low
Exposure	Very High	High	Moderate	Low	Very Low
Sensitivity	Very High	High	Moderate	Low	Very Low
Capacity	Very High	High	Moderate	Low	Very Low

Risk and Vulnerability Assessment

Risk Index (RI) and Vulnerability Index (VI) is calculated using Hazard Index (HI), Exposure Index (EI), Sensitivity (SI) and Capacity Index (CI):

$$RI = \frac{HI \times EI \times SI}{CI} \quad and \quad VI = \frac{EI \times SI}{CI}$$

HI = $\sum_i^n HW_i$ /n

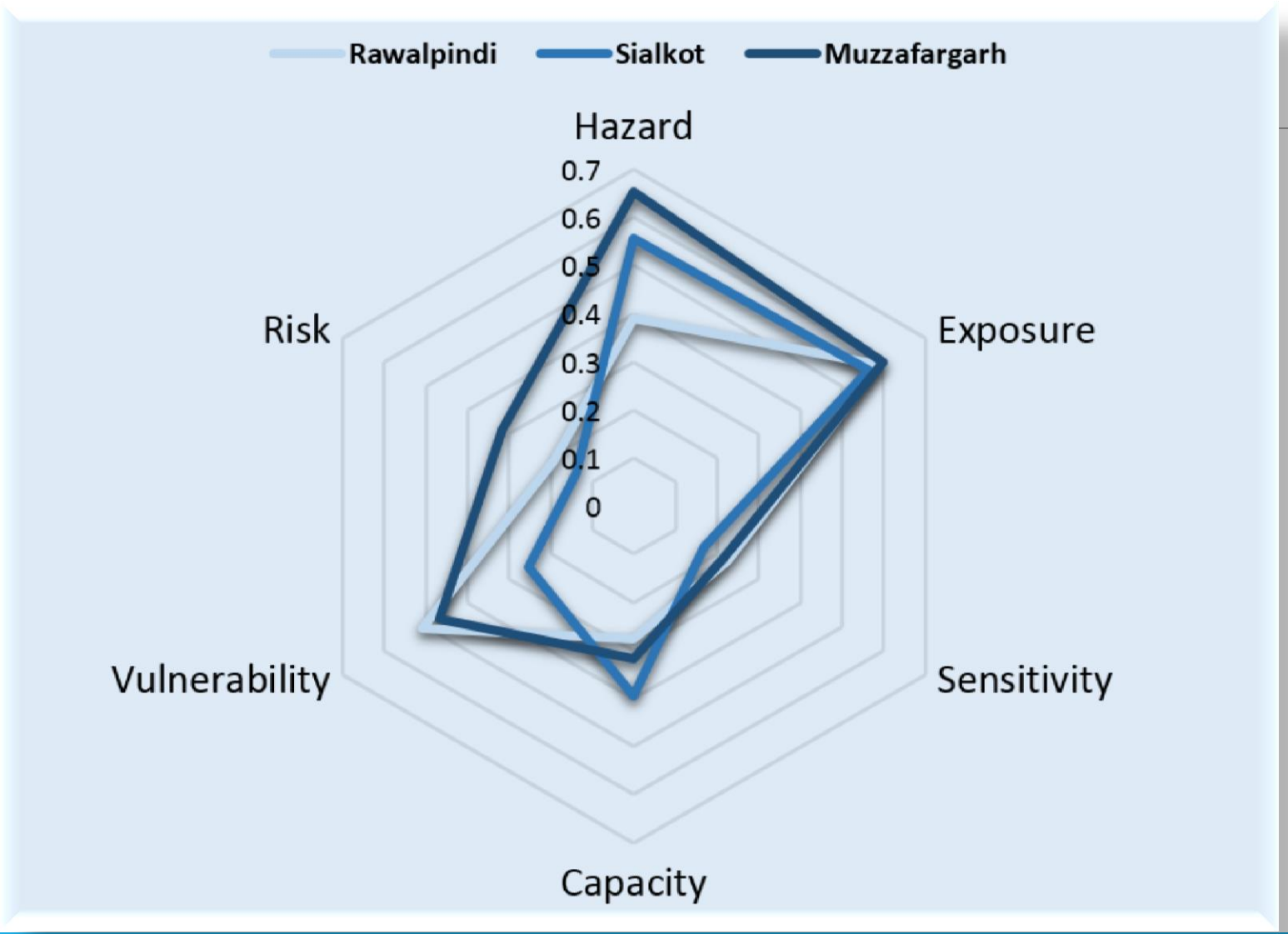
EI = $\sum_i^n EW_i$ /n

SI = $\sum_i^n SW_i$ /n

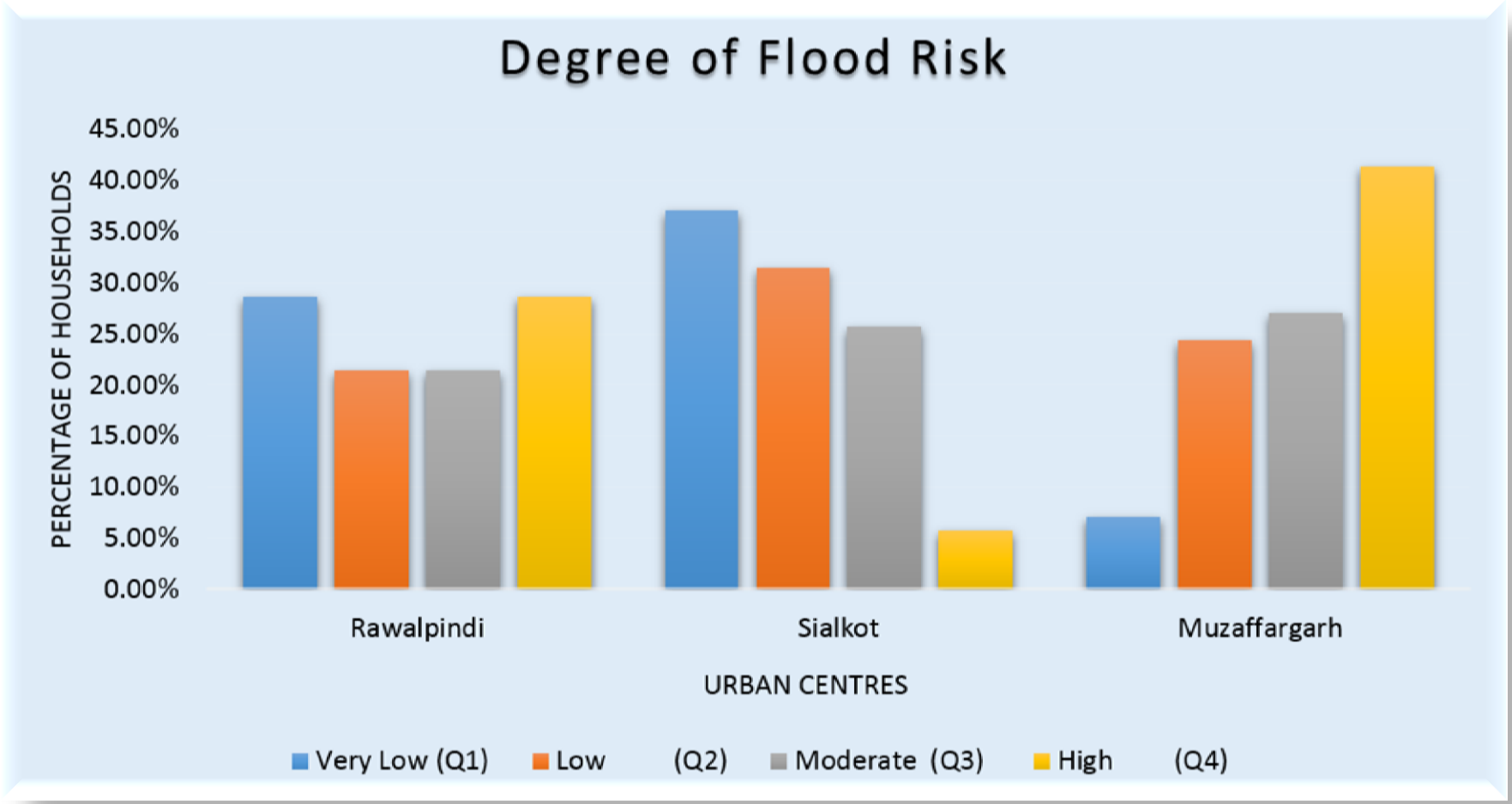
CI = $\sum_i^n CW_i$ /n

W_i is the weight value of ith variable, *n* is number of variables

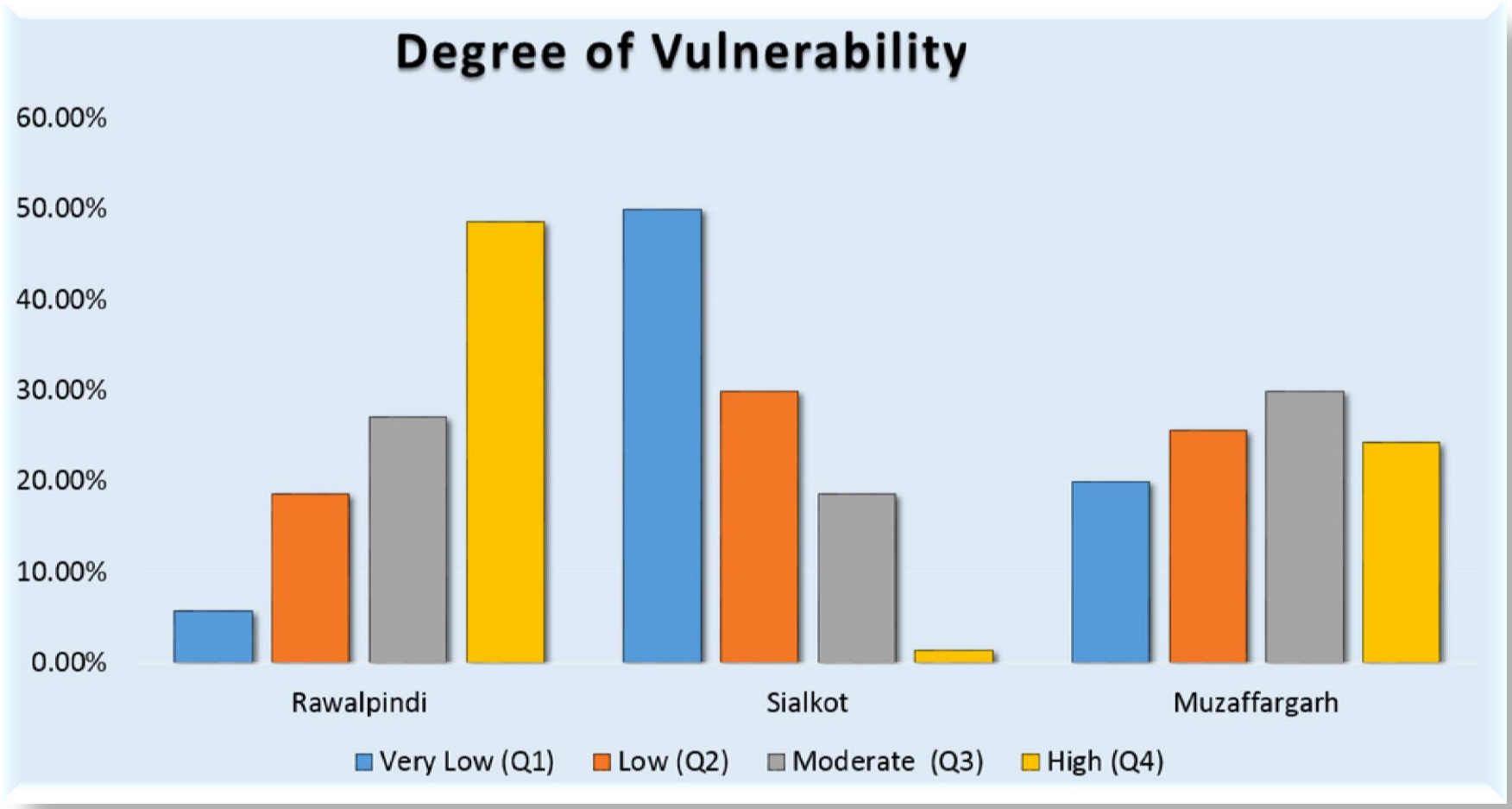
Findings


Rawalpindi
Sialkot
Muzzafargarh
Hazard
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Exposure
Sensitivity
Capacity
Vulnerability
Risk

Findings for DRR



Findings for CC



Findings

- Households in study areas are coping with flood risk and still living there despite high exposure and sensitivity.
- Significant difference in levels of vulnerabilities and capacities in metropolitan, city and medium town.
- Metropolitan is less exposed to floods but communities' vulnerabilities are higher.
- Smaller cities are more exposed but less vulnerable due to better coping mechanisms and capacities**.**
- Proper maintenance, de-sedimentation and regular cleaning of Nullahs
- Strict urban planning regulations to restrict future urban growth in floodplains.
- Most of respondents were unware of climate change and disaster risk reduction concepts.

Policy Recommendations

- Dedicated District Disaster Management Authority is needed.
- No comprehensive urban development plan at national, provincial and regional level.
- Some urban development plans for major cities but they all lack disaster risk and climate change adaptation component.
- Unclear Risk/Vulnerability Assessment methodology in disaster management/Climate Change framework of Pakistan
- An inspiration is needed to a light sense of self preservation and preparedness to participate in government initiatives.

Global Challenge

- Same terminologies and interpretations in CC and DRR
- Generally, RS only used for hazard assessment and damage loss estimation.
- Integrated Spatial data infrastructure. (including socioeconomic data) of disaster prone communities.

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THANK YOU