XVII World Water Congress

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Water Security Challenges and Opportunities in Lahore – A City of Pakistan

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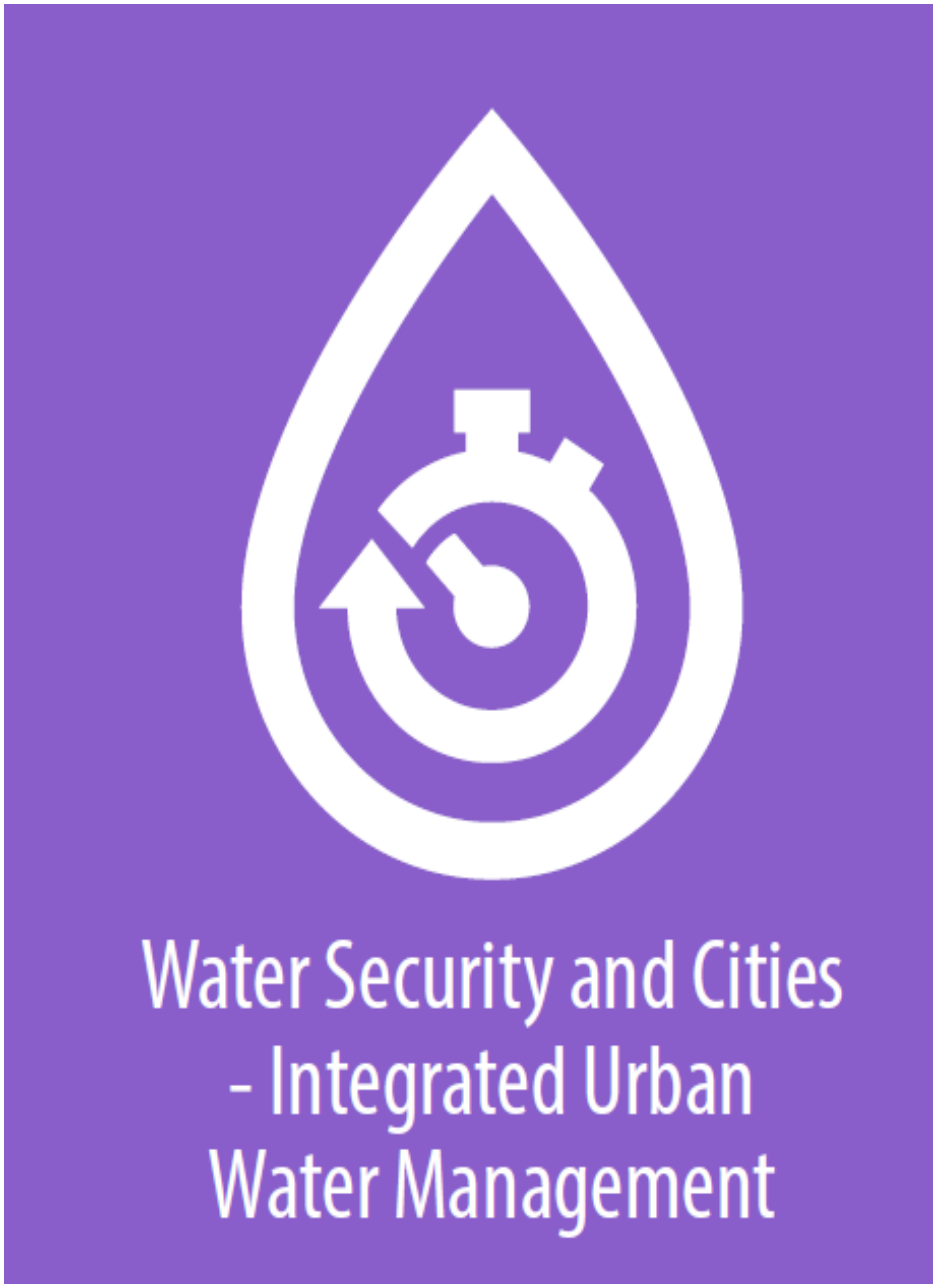
IRRIGATION RESEARCH INSTITUTE LAHORE

14-9-2023, Beijing

Charles Sturt University

Book Chapter



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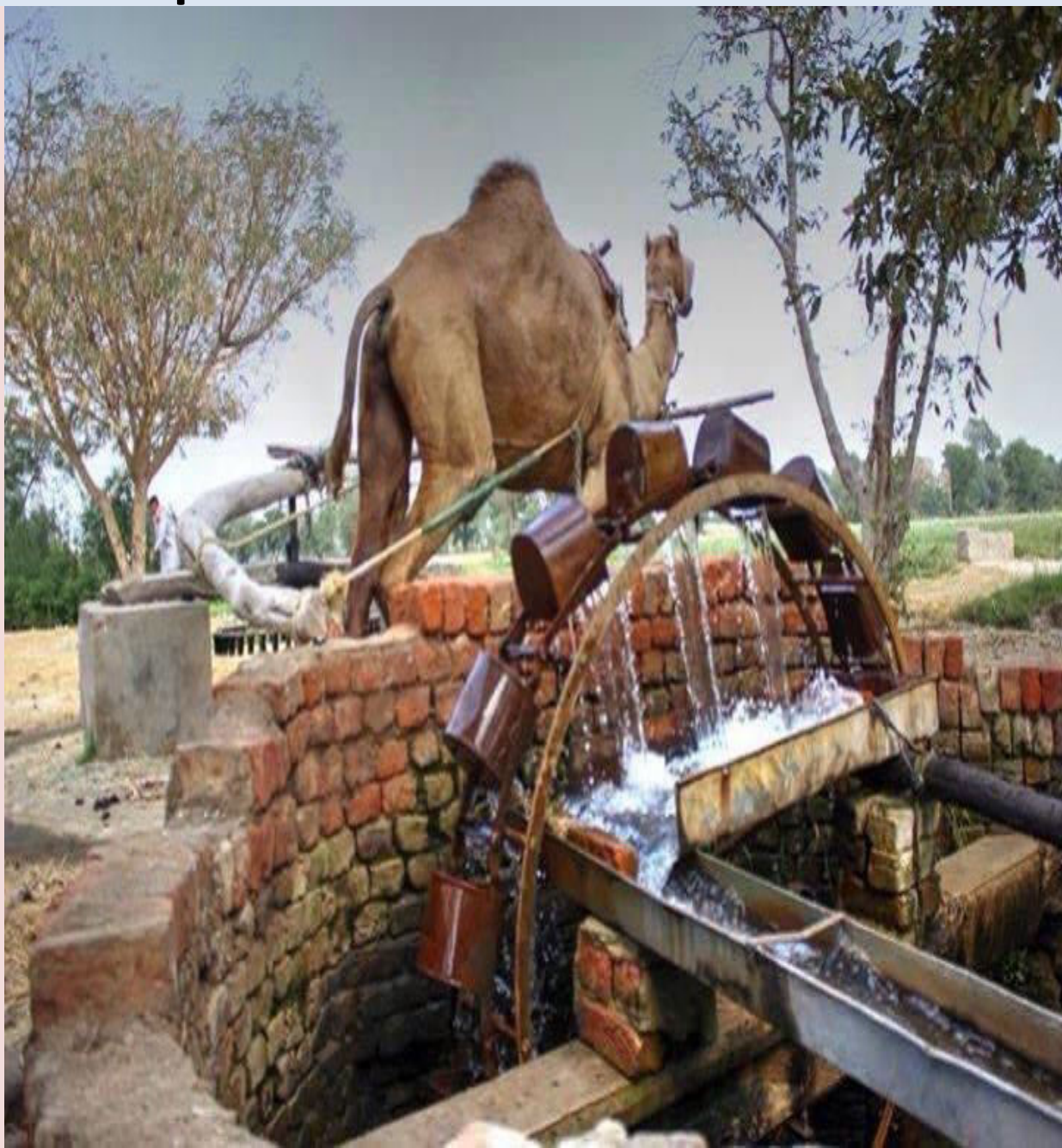
Irrigation Research Institute (IRI) – Major Research Disciplines

Irrigation Research Institute (IRI) was established in 1924 and is the oldest of its kind in the Sub-Continent.

1. Soil Mechanics /Geo-technical Issues
2. Hydrology and Environment/Climate changes
3. Groundwater Management and Recharge
4. Engineering Materials & Quality Control
5. Geo-Synthetics
6. Canal Lining and seepage investigations
7. Floods Monitoring and mitigation
8. Sediment Studies
9. Water Conservation & Soil Physics
10. Surface & Sub-Surface Drainage
11. Model Studies of Hydraulic Structures

Sequence

- Water Resources of Pakistan
- GW Overview
- GW Situation in Urban Centre (Lahore)
- Emerging threats
- Initiatives taken
- Outcomes
- Step forward



WATER RESOURCES OF PAKISTAN

Rainfall

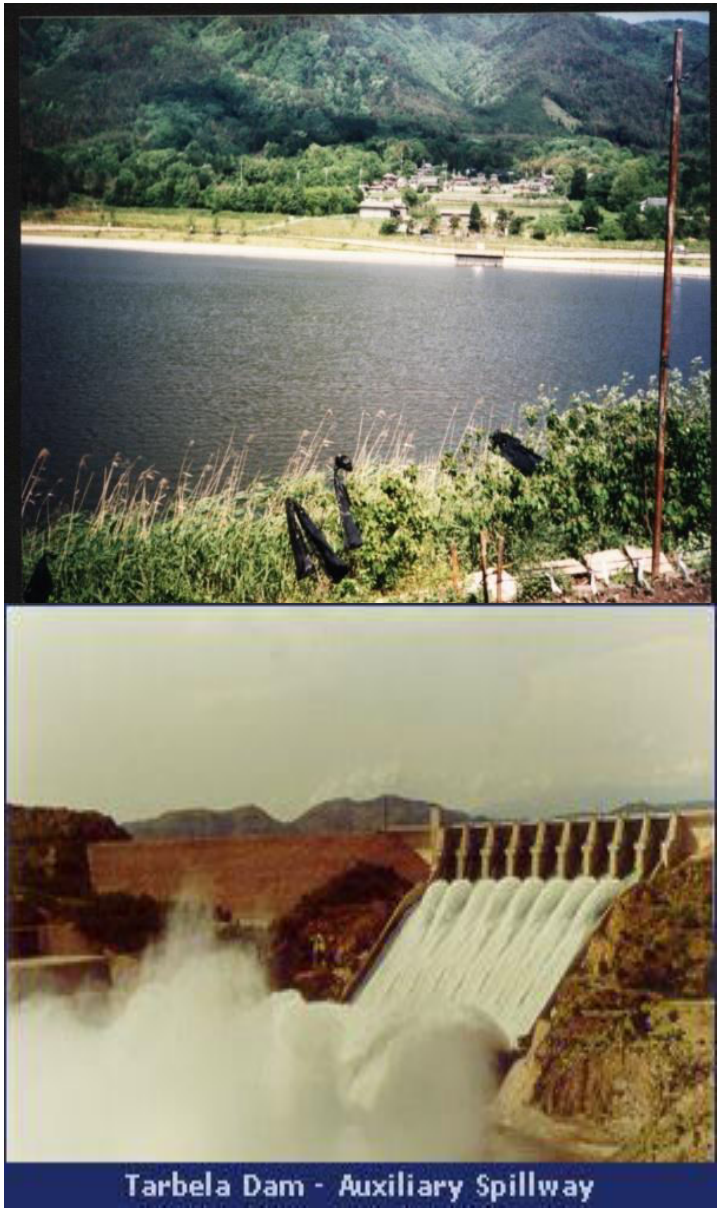
- Annual rainfall (125mm in South-East to 750mm North-West)
- Total water generated by rainfall is around 32 BCM
- Contribution to crops is 10-20%

Groundwater

- Exploitation of Groundwater is 59 BCM
- Over 1.2 M private tubewells
- 40% of total supply at farm-gate

Surface Water Resources

- Total Inflow is 171 BCM
- Tarbela (10.38 BCM - 485 ft),
- Mangla (5.90 BCM - 380 ft)
- 48 Canals (61000 km), 19 Barrages
- 1,70,000 Watercourses (1.6 Million km)



Tarbela Dam - Auxiliary Spillway

GROUNDWATER-overview-Pakistan

Groundwater budget negative

Pakistan is 4th largest user of groundwater after India, USA & China

Pakistan - Over 90% drinking water and 100% industrial water comes from groundwater

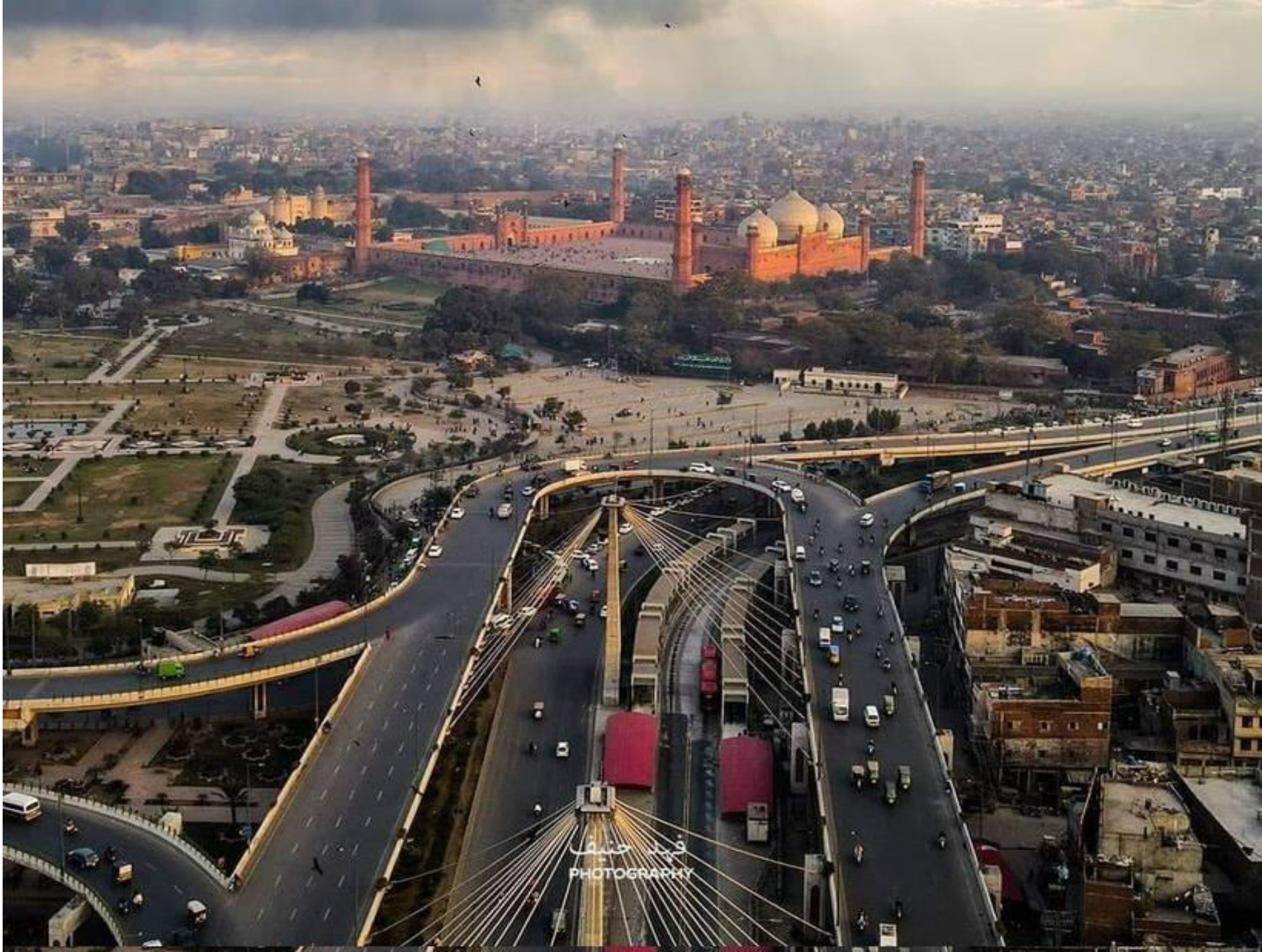
In Irrigation more than 40% contribution

cropping intensity increased from 63% (1947) to 160% (2015)

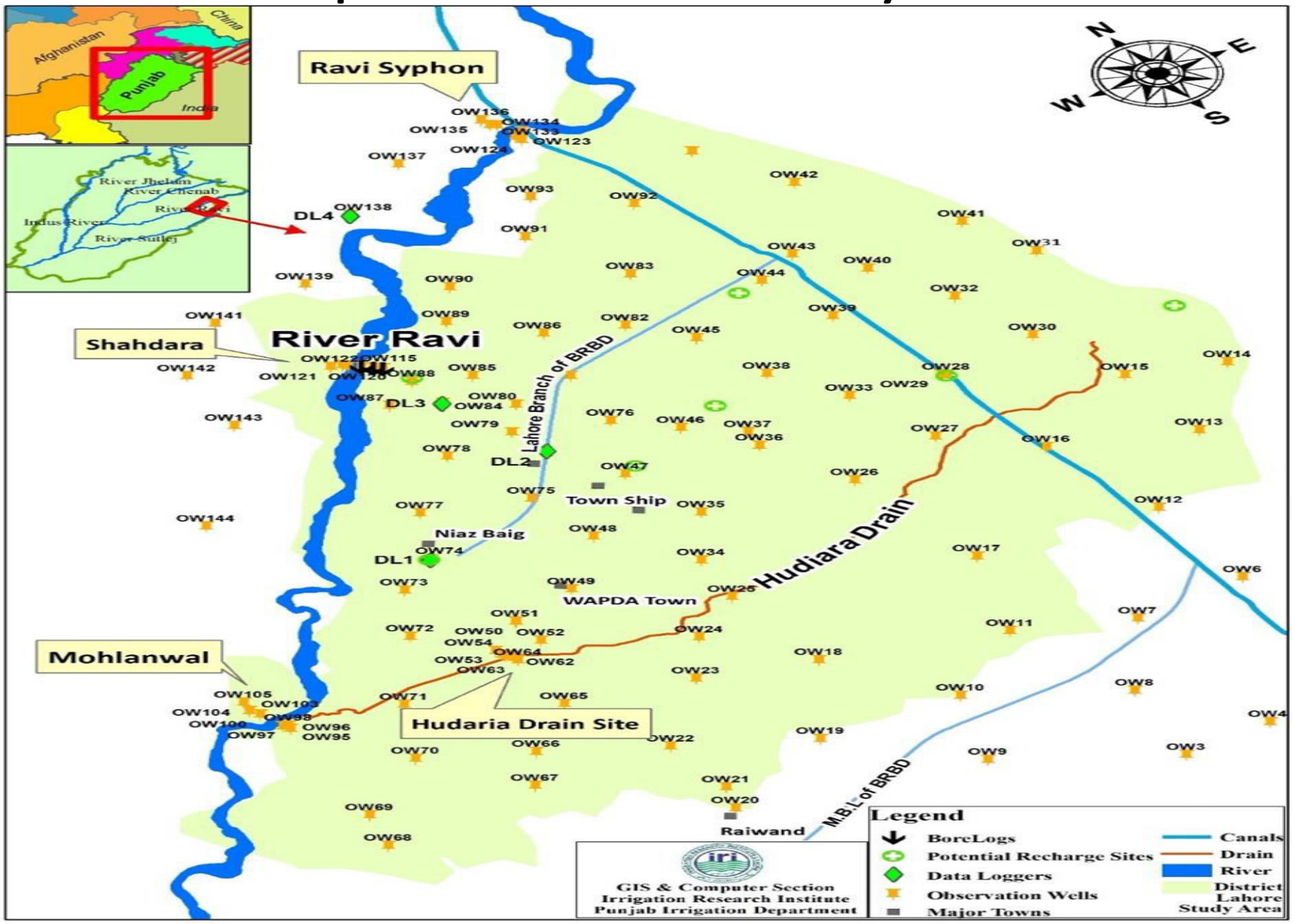
1.3 m tubewells pumping 40-50 MAF

Lahore Case Study-The provincial Capital

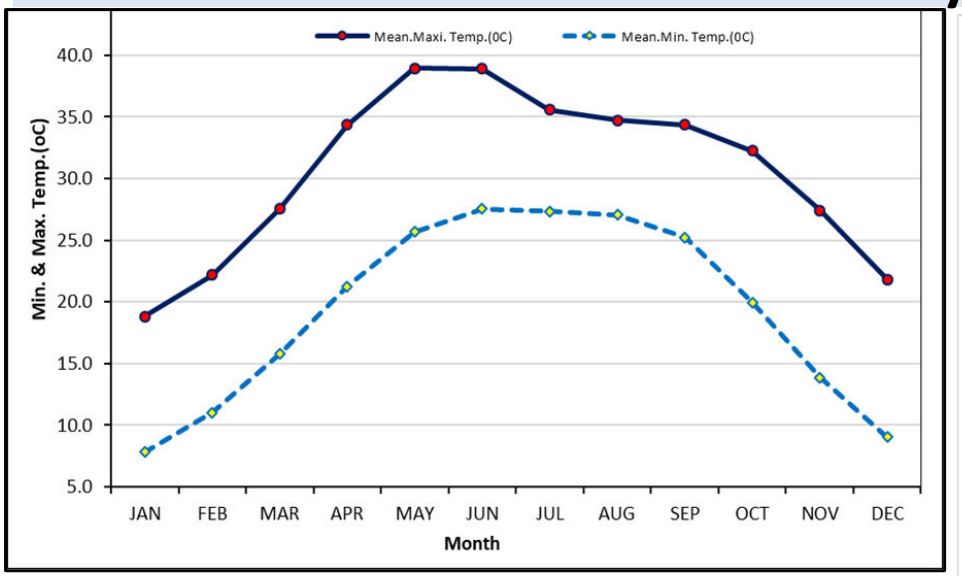
- Lahore is the 2nd largest city of the Pakistan, and 24th largest in the world
- An old historical city, hub of industrial, cultural, and social activities
- Current population: 13 M
- Water resources: Canal, rainfall and groundwater
- Historical places: Lahore Fort, Badshahi Masjid, Lahore Museum, Quaid-e-Azam Library etc.
- Situated of left bank of Ravi river-Indus Valley Civilization

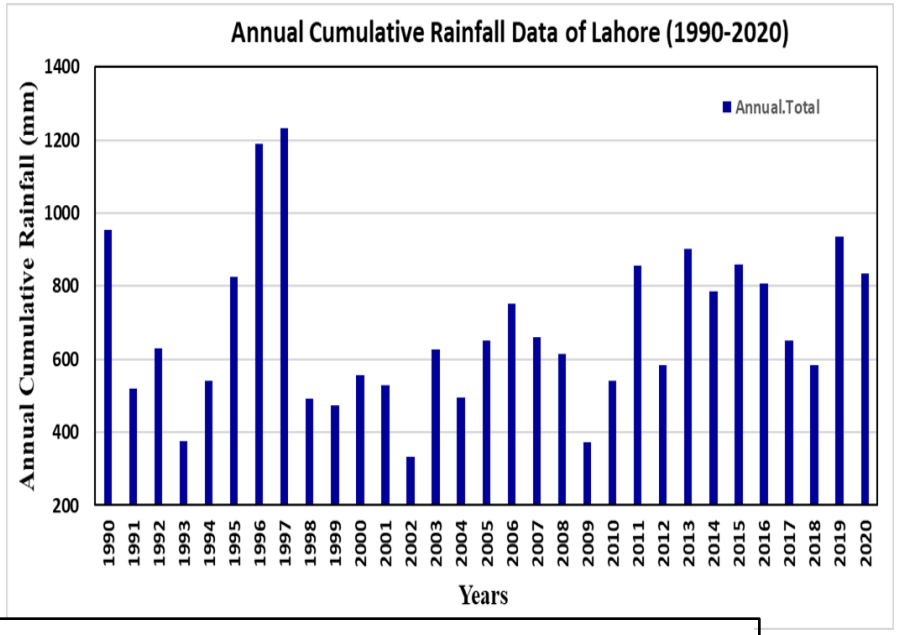

فہد حنیف
PHOTOGRAPHY

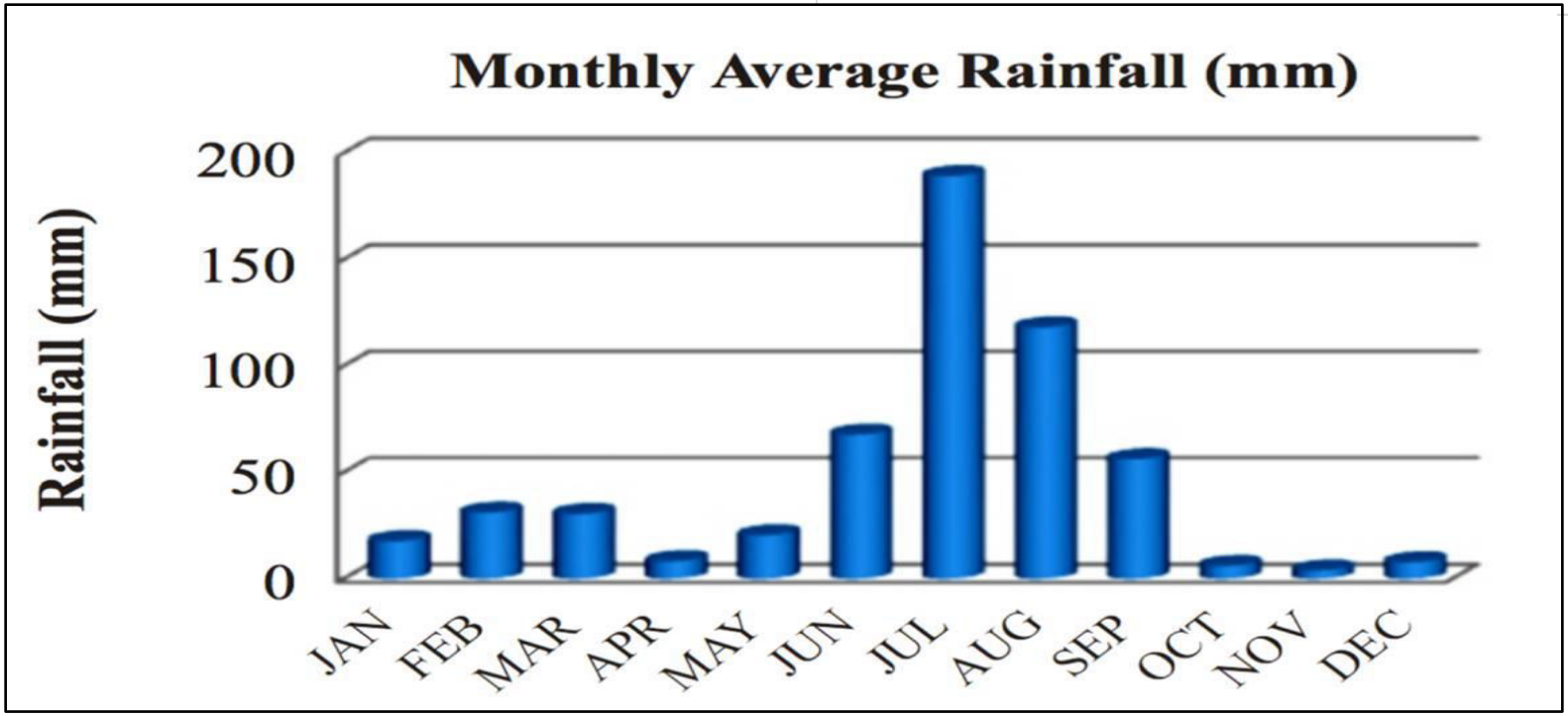
Map of Lahore - study area



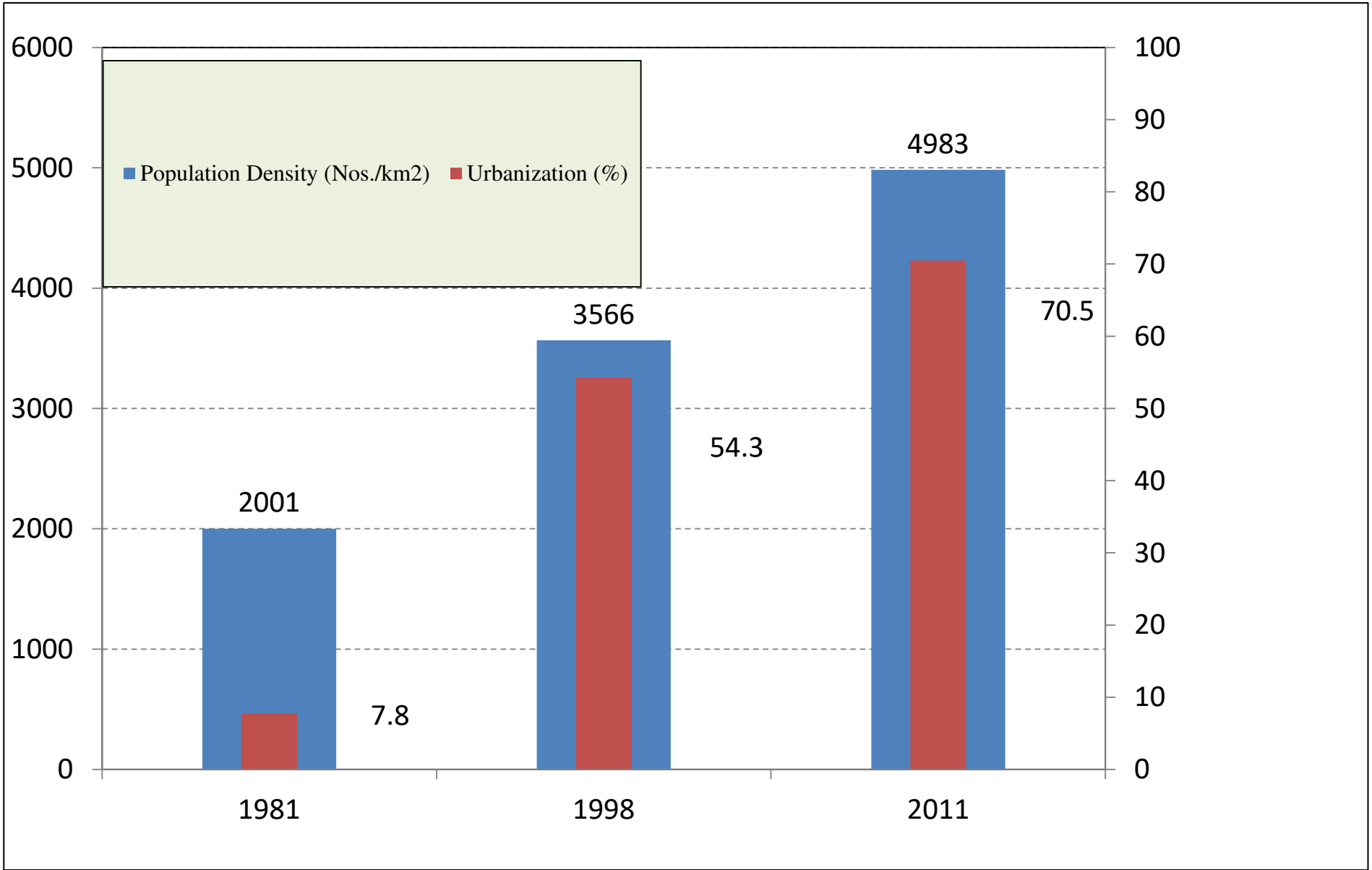
Study area


Mean.Maxi. Temp.(0C)
Mean.Min. Temp.(0C)
Min. & Max. Temp.(oC)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month


Annual Cumulative Rainfall Data of Lahore (1990-2020)
Annual Cumulative Rainfall (mm)
1400
1200
1000
800
600
400
200
Annual.Total
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Years


Monthly Average Rainfall (mm)
Rainfall (mm)
200
150
100
50
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

URBANIZATION



Groundwater use in Lahore

Sector		Water Use	
		MCM/Day	MCM/Year
1. Domestic Use			
	Water and Sanitation Agency (WASA)	2.20	803
	Non-WASA	0.88	321
	Private Housing Schemes	0.71	260
	Sub-total 1	3.79	1384
2. Non-Domestic Use			
	Industrial	0.92	335
	Commercial and Institutional	0.76	227
	Sub-total 2	1.68	612
3. Agricultural Use			
	Agricultural Use (Groundwater)	1.71	623
	Agricultural Use (Surface Water)	3.00	1095
	Sub-total 3	4.71	1719
4. Total Groundwater Extraction in Lahore		7.18	2619

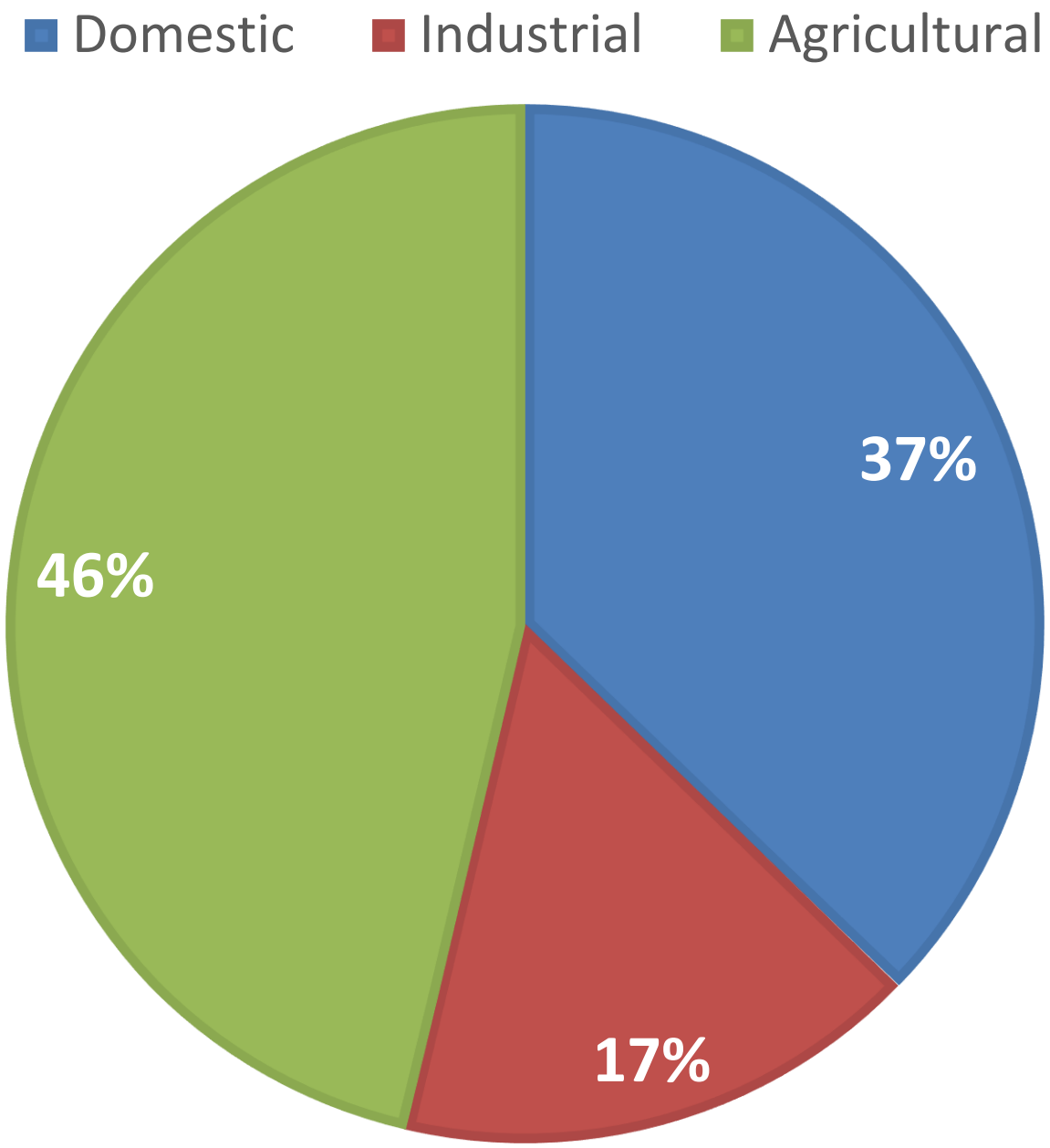
Groundwater deterioration-consequences

- **Depletion**
- Urbanization
- Rapid increase in population
- Industrialization
- Increasing of paved area
- Reduction in recharge
- Rural-urban migration
- Unplanned pumping
- Lack of holistic regulation
- Lack of capacity and awareness
- Low flow in River
- **Contamination**
- Sewage and Street runoff
- Agricultural Runoff
- Injection of untreated industrial water into Aquifer
- Ravi River-source of pollution
- Saline water intrusion and secondary salinization
- Street runoff
- Solid waste damping
- Leakage from sewer lines
- Vehicular and industrial emissions-acidic rains

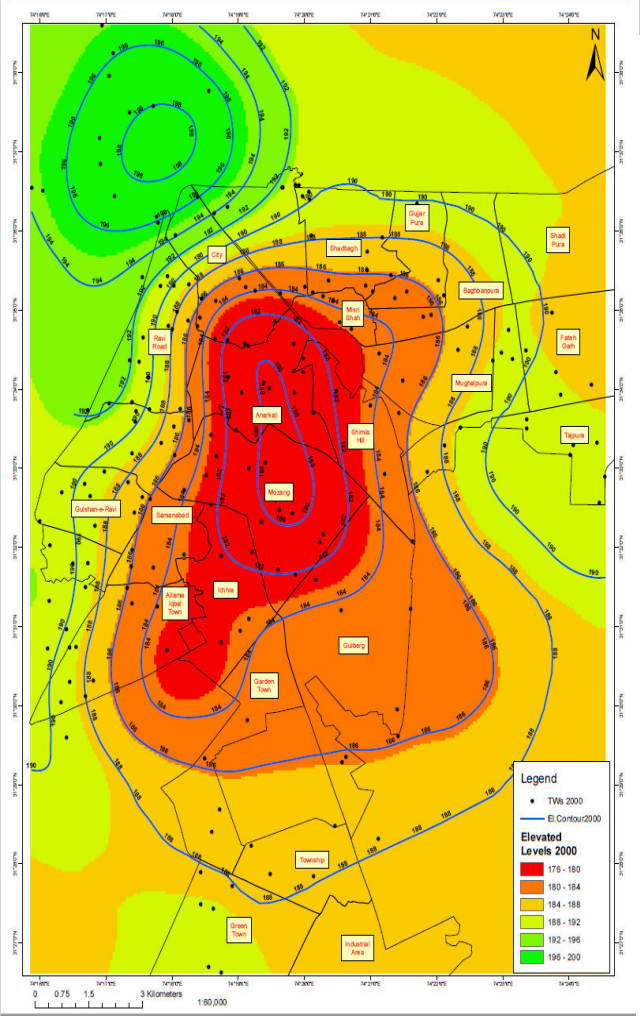
Consequences

- Increase in number of tubewells
- Increase in operating hours of tubewells
- Uncontrolled abstraction of groundwater by housing societies
- Increased demand-supply gap
- Increased Industrial/commercial extraction
- Groundwater decline 1m/year
- Land subsidence-feared
- Increased cost of GW extraction
- Health issues
- Loss of biodiversity
- Freshwater deeper 400-600 ft
- Increased treatment costs for drinking purpose
- Urban Flooding

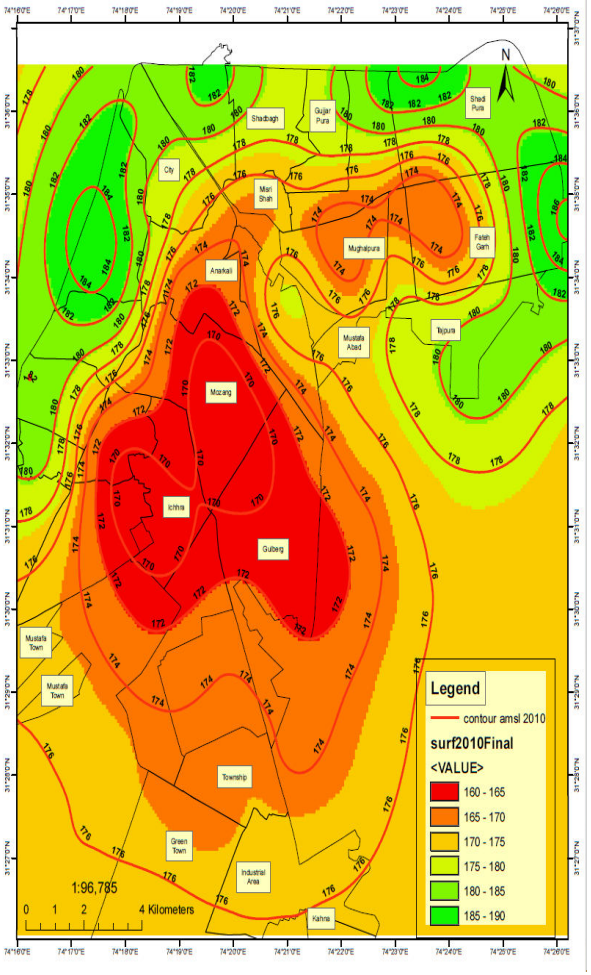
GW USE PATTERN IN LAHORE



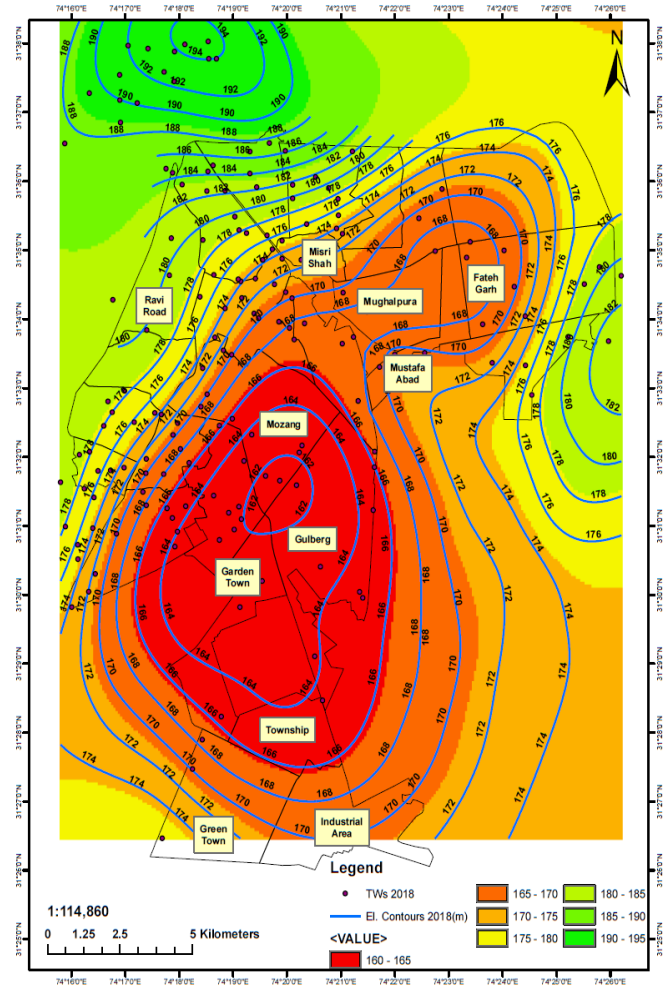
ZONATION MAP SHOWING ELEVATED WATER LEVELS (AMSL) IN LAHORE AREA IN 2000

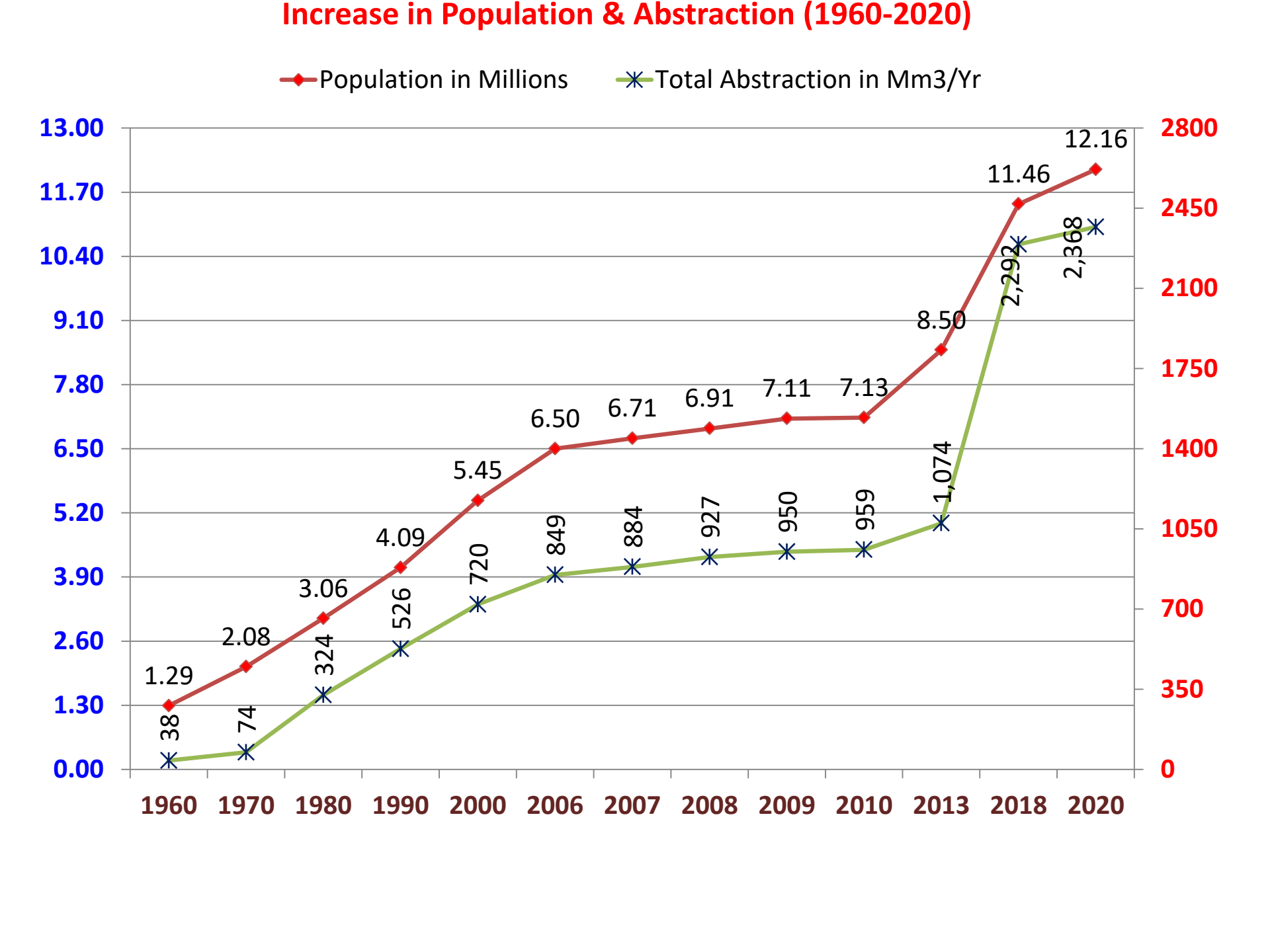


ELEVATED WATER LEVEL (AMSL) CONTOUR MAP OF WASA LAHORE AREA (2010)

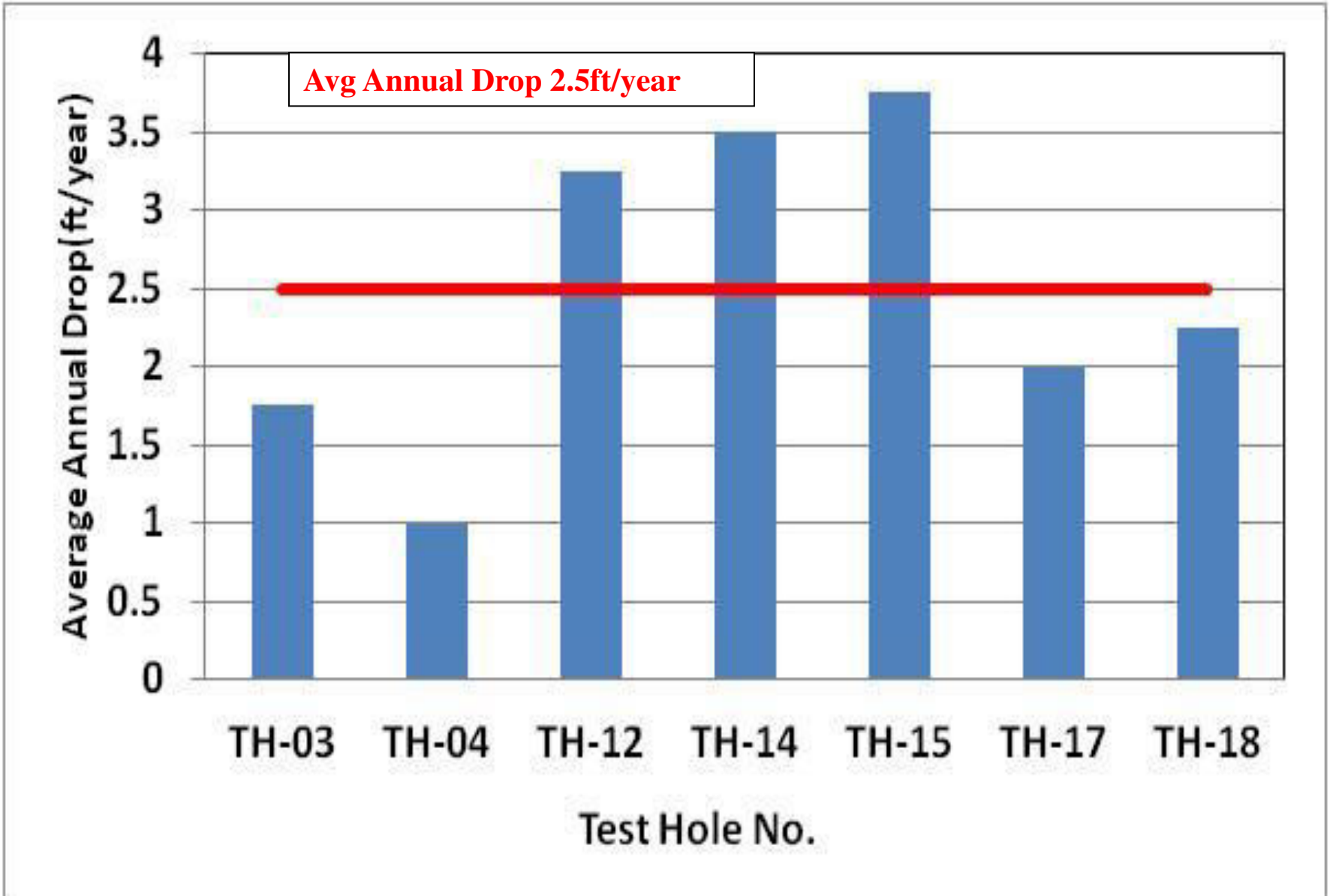


ELEVATED WATER LEVEL CONTOUR MAP OF WASA LAHORE AREA (2018)

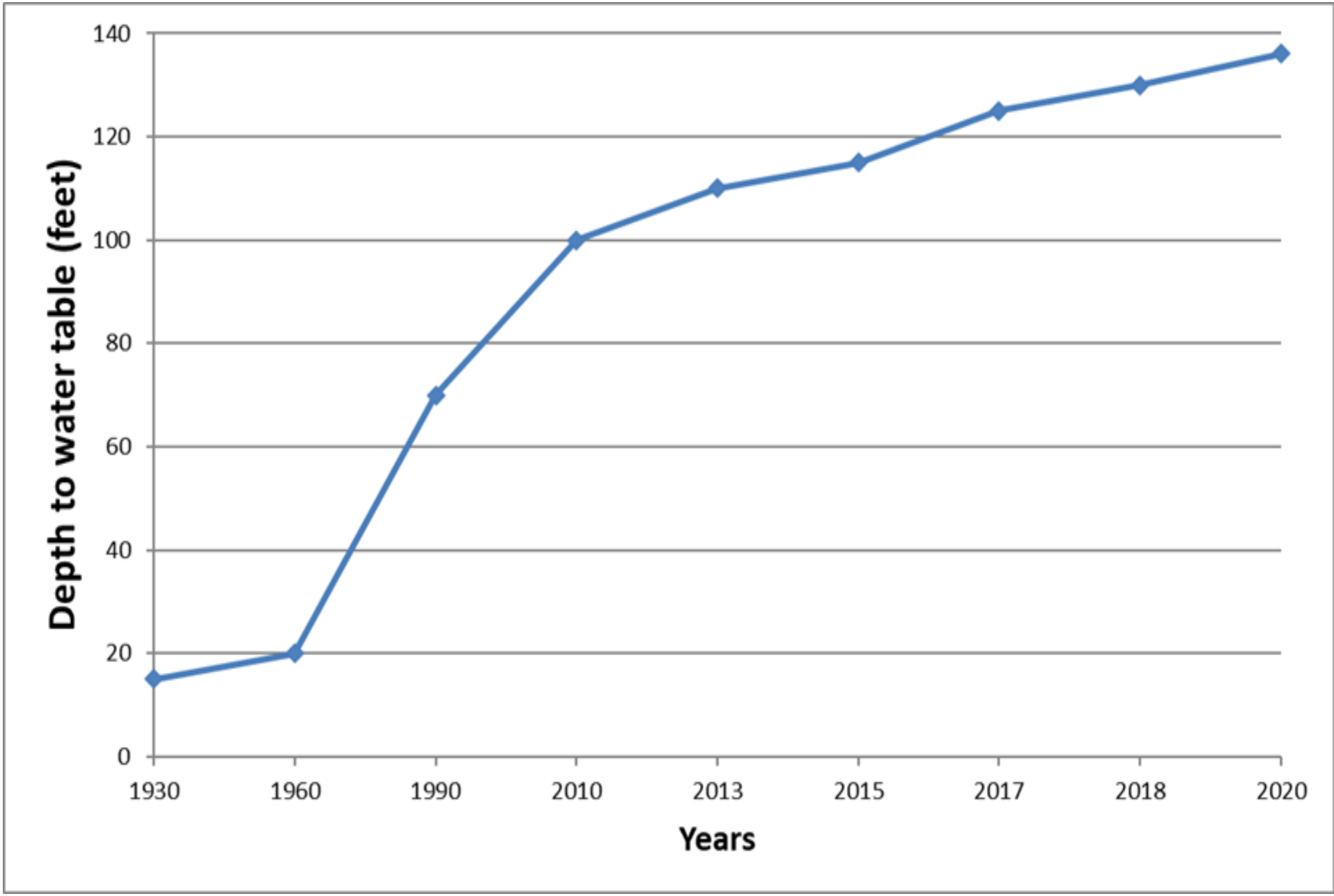



Increase in Population & Abstraction (1960-2020)
Population in Millions
Total Abstraction in Mm3/Yr
13.00
11.70
10.40
9.10
7.80
6.50
5.20
3.90
2.60
1.30
0.00
2800
2450
2100
1750
1400
1050
700
350
0
1.29
2.08
3.06
4.09
5.45
6.50
6.71
6.91
7.11
7.13
8.50
11.46
12.16
38
74
324
526
720
849
884
927
950
959
1,074
2,292
2,368
1960
1970
1980
1990
2000
2006
2007
2008
2009
2010
2013
2018
2020

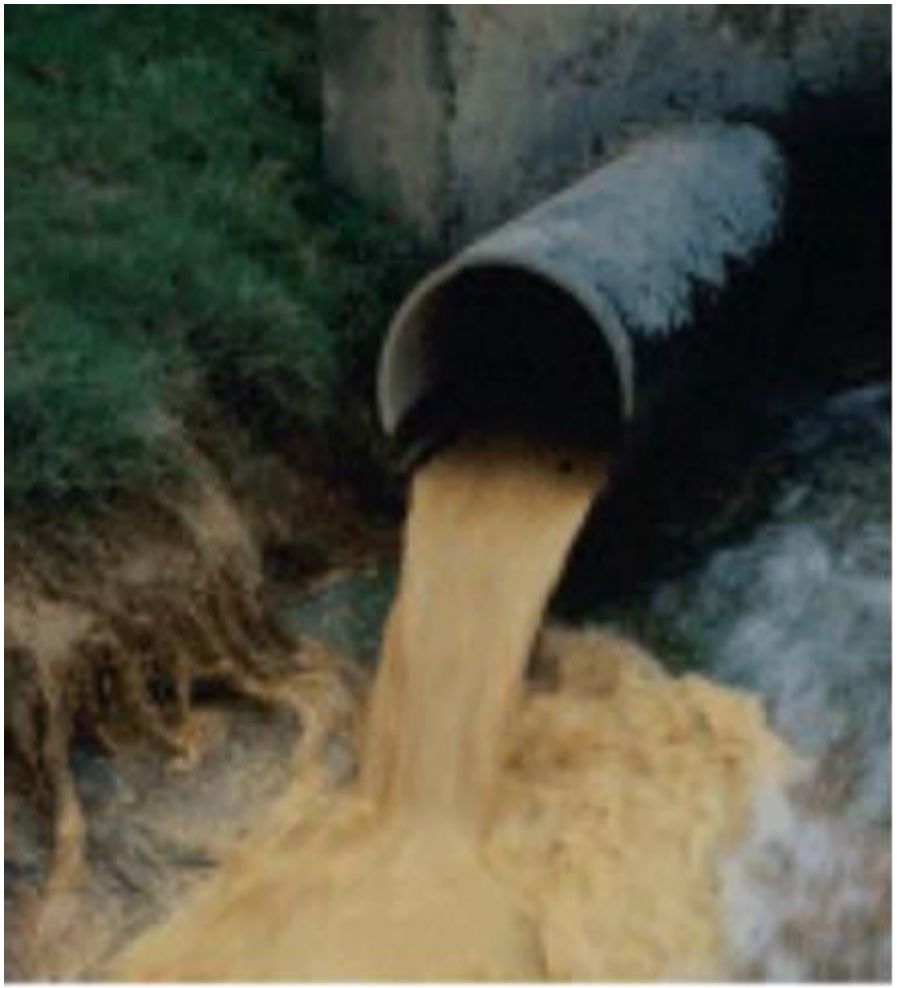
AVERAGE DEPLETION RATES OF GROUNDWATER IN LAHORE (2009-2018)



Historic depth to water table trend in Lahore city



Untreated Effluents- big threat



Urban Flooding- a challenge every year

- **Loss of human lives**
- **Loss of infrastructure**
- **Interruption in water supply**

- Climatic changes-trends changing
- Jun-July August heavy rainfalls
- Inadequate drainage setup
- Chocked disposal channels
- Plastic pollution

Initiatives

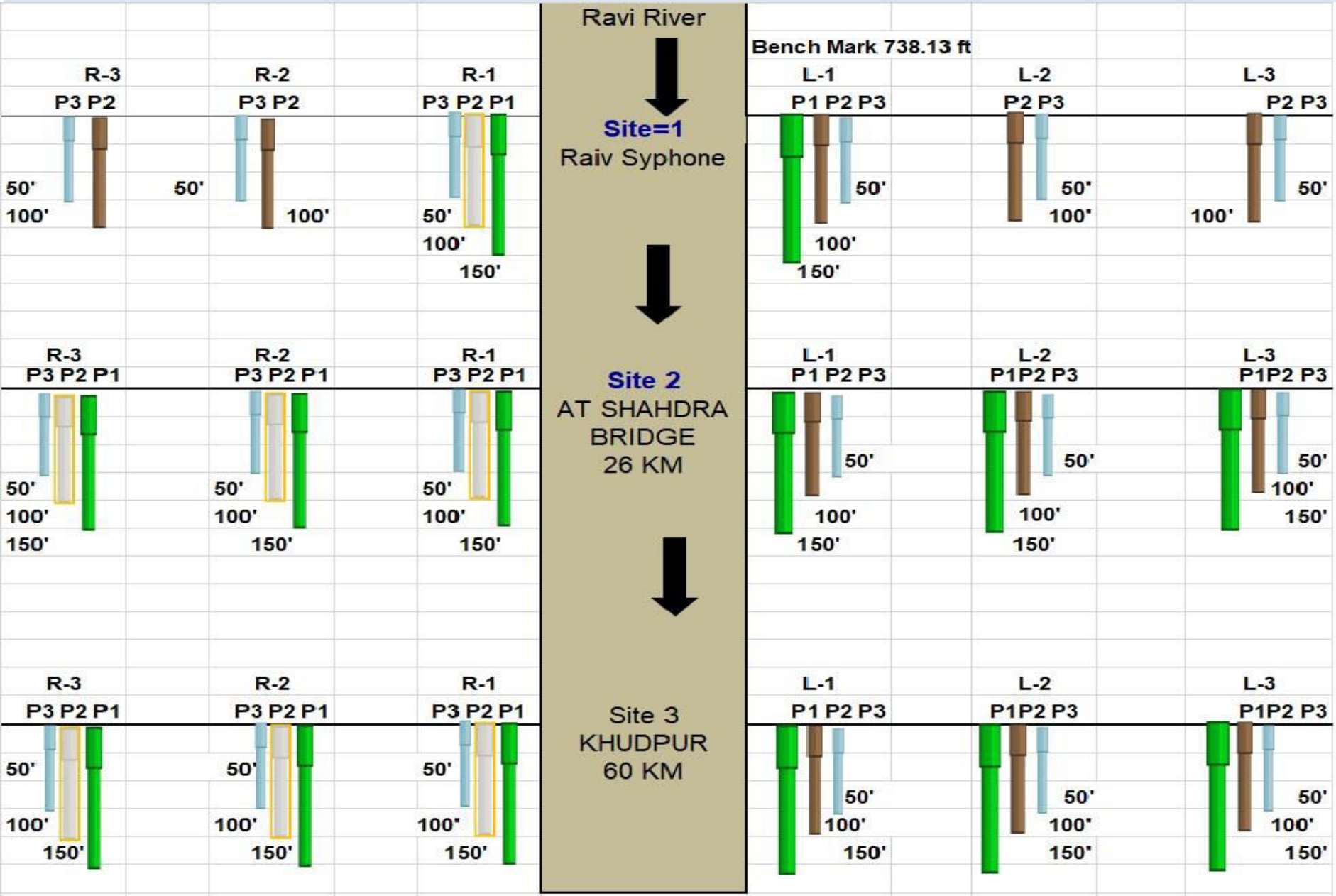
EXPERIMENTAL WORKS/INVESTIGATIONS

- Installation of piezometers in Lahore city area
- Installation of data loggers
- Experimental layout along the Ravi River
- Lithological Investigations- Exploratory Drilling
- Impact of Drainage System on Groundwater
- Identification of potential sites for artificial recharge of the aquifer
- Managed Aquifer Recharge projects
- Rainwater Harvesting
- Recharge galleries-green belts

Management Initiatives

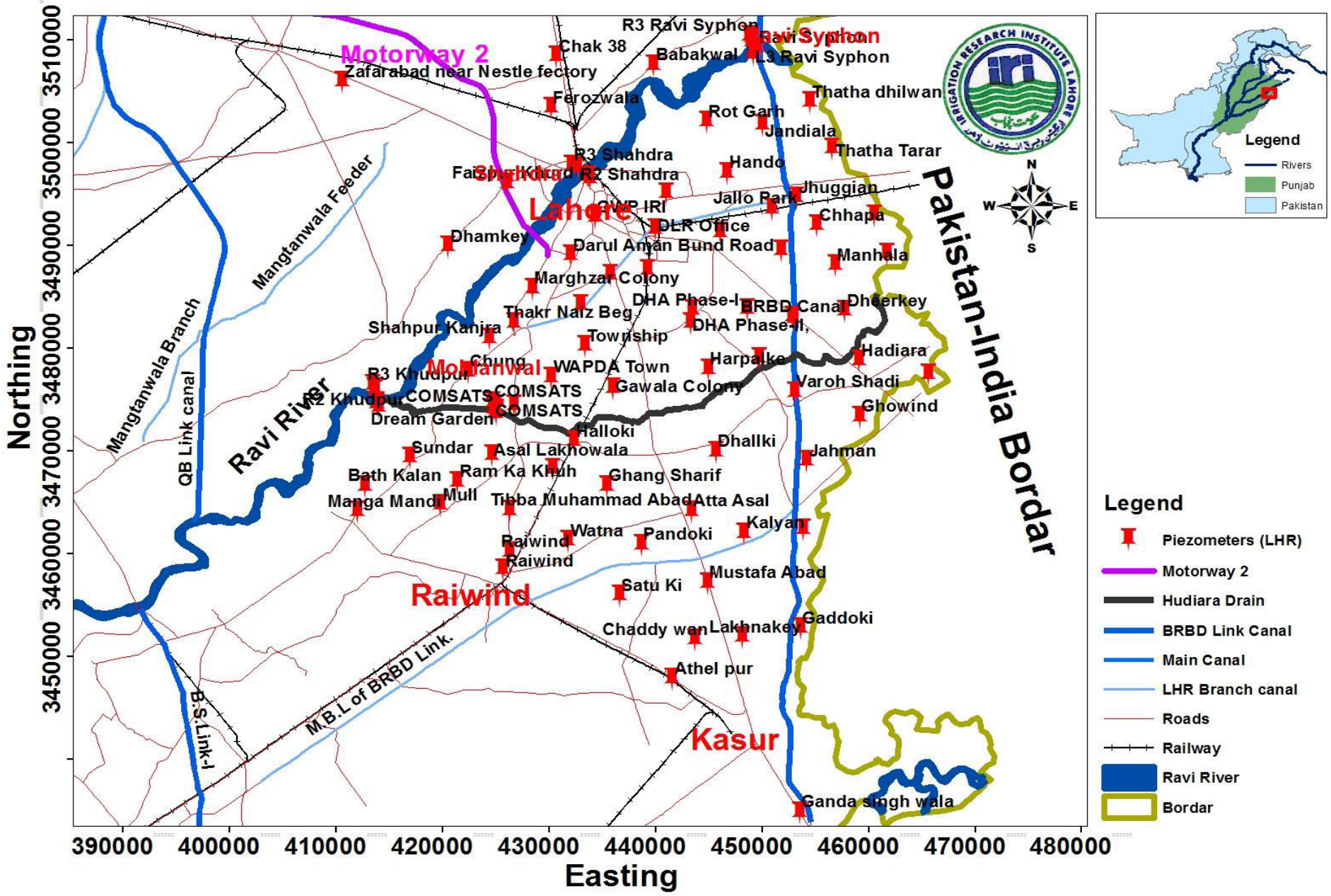
- Imposition of Aquifer Charges
- License/ permission for users other than WASA
- Reuse of Ablution Water- Parks , grounds
- Revival of Irrigation Water Courses/Outlets
- Rainwater Harvesting and using –less pumping
- Car Wash Recycling Systems- no groundwater
- Rationalization of Tubewells Pumping Hours
- Punjab Water Policy 2018
- Punjab Water Act 2019
- Punjab Water Resources Commission 2020
- Punjab Water Services Regulatory Authority 2020
- Awareness raising-media etc
- Diversion of more 100 cusecs of canal water for city
- Reuse of ablution water
- Revival of irrigation water courses
- Measures under process
  - Water Metering through public-private partnership (PPP)
  - Induction of surface more water

Monitoring - Extensive

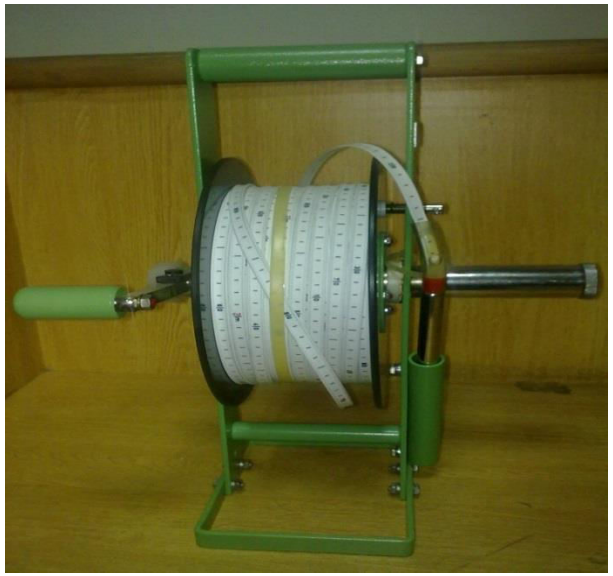


Experimental Layout

PIEZOMETERS INSTALLED



GW Monitoring



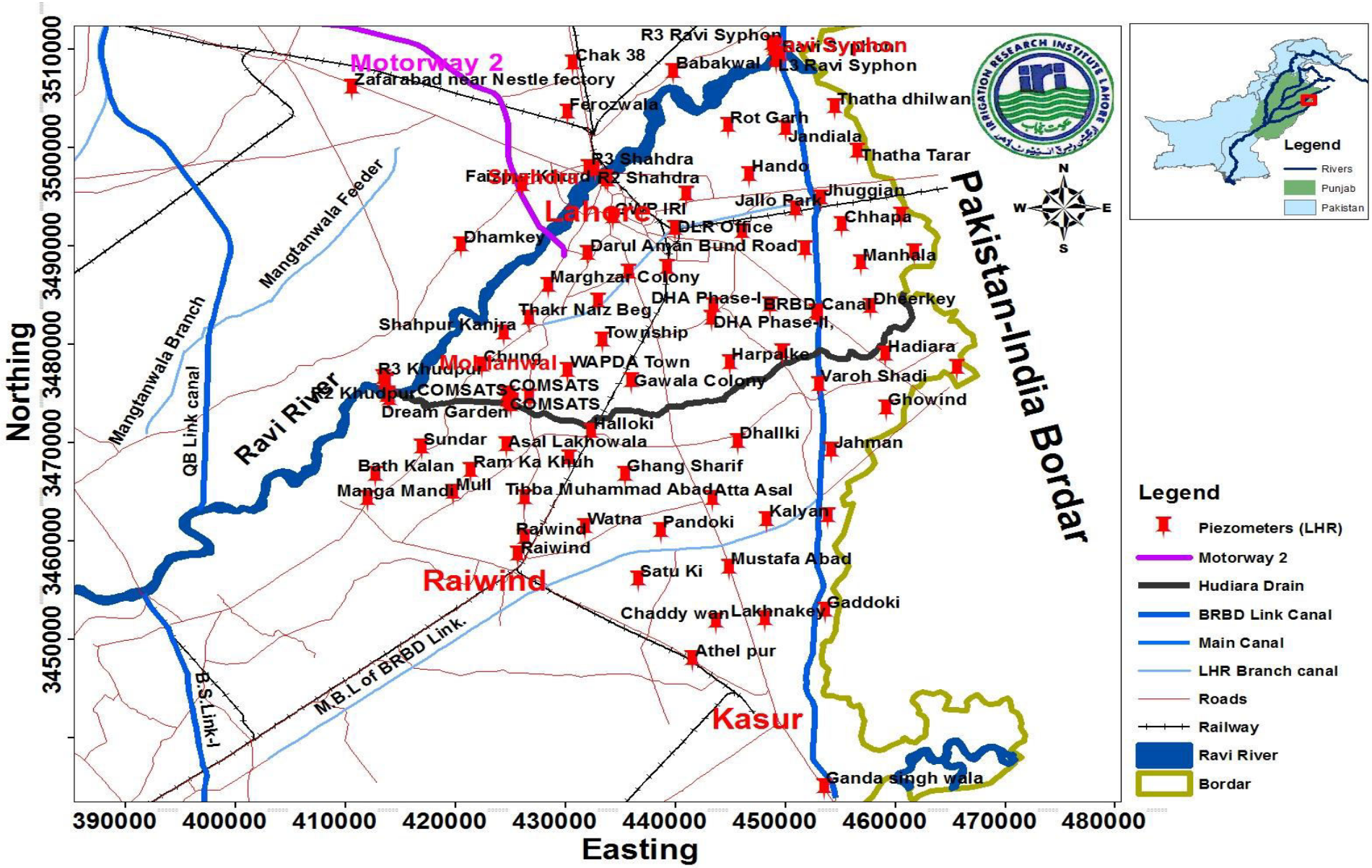
Water Level Sounder

pH Meter (330 I)

Conductivity & EC Meter (CON 11)

GPS MAGELLAN TRITON 400

Monitoring network-strengthened



Policy and Acts

National Water Policy - 2018

2.15 **Promoting appropriate technology for rainwater harvesting in rural as well as urban areas.**

2.16 **Regulating groundwater withdrawals for curbing over-abstraction and promoting aquifer recharge.**

Punjab Water Policy - 2018

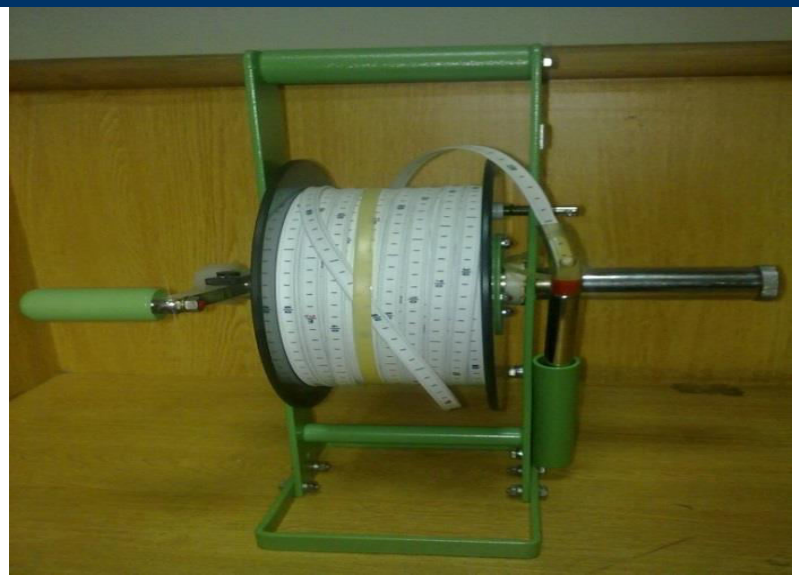
2.2 Groundwater.

- **Groundwater abstraction should be optimized at balance recharge ,**
- **Water Resources Commission should be created to manage groundwater abstraction,**
- **Artificial recharge of groundwater through flood channels, rubber dams, detention ponds, rainwater harvesting etc.**

Punjab Water Act 2019

Monitor, regulate, and monitor

GW Monitoring



Water Level Sounder

pH Meter (330 I)

Conductivity & EC Meter (CON 11)

GPS MAGELLAN TRITON 400

Groundwater Monitoring Instruments

Water level, Conductivity Meter

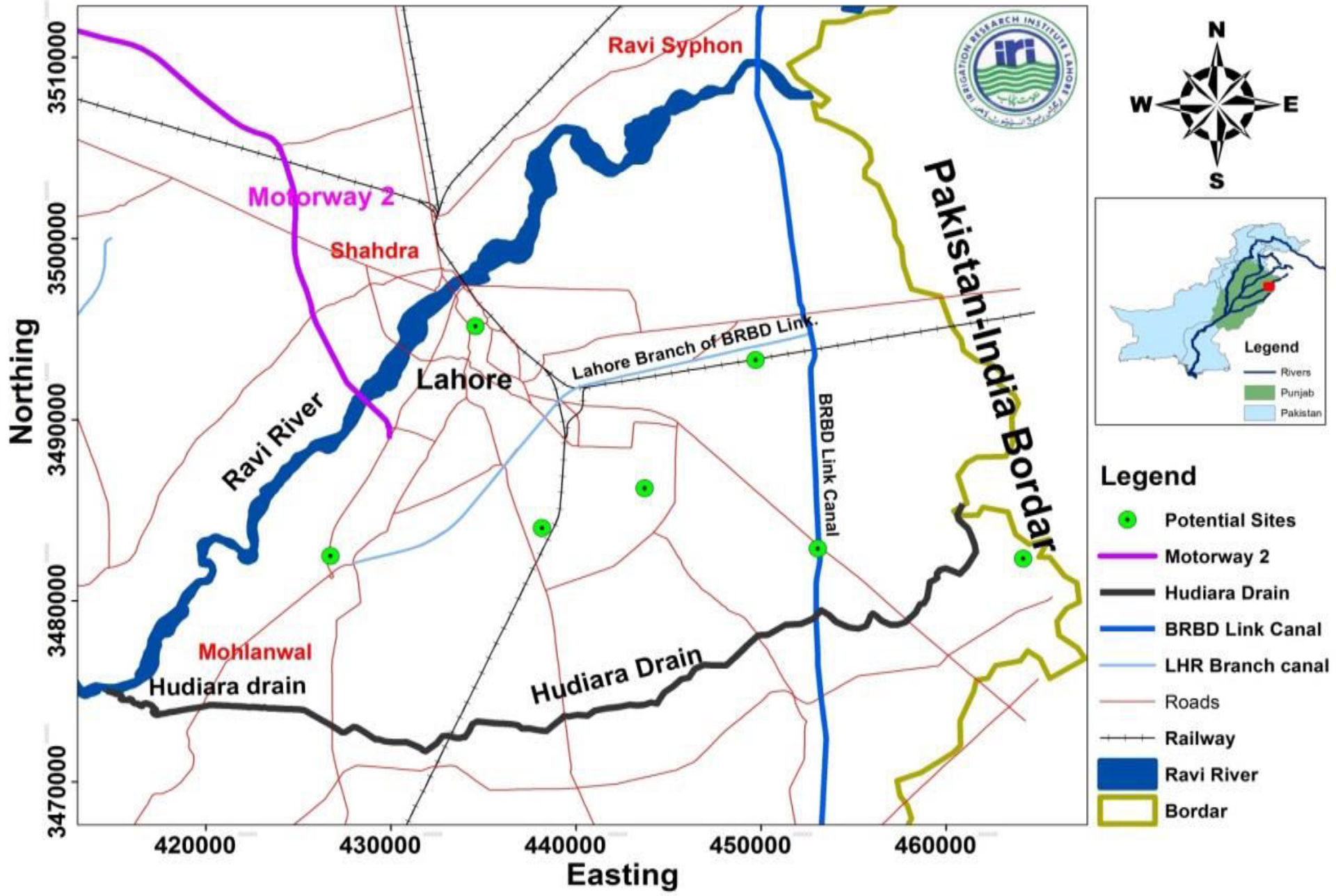
Data Loggers

DTS meters

Installation of data loggers

Monitoring of Groundwater Levels and Quality

POTENTIAL SITES FOR ARTIFICIAL RECHARGING



Outlet of Badshahi Mosque Lahore

Water Storage in Padhana Lake

Over view of Padhana Lake

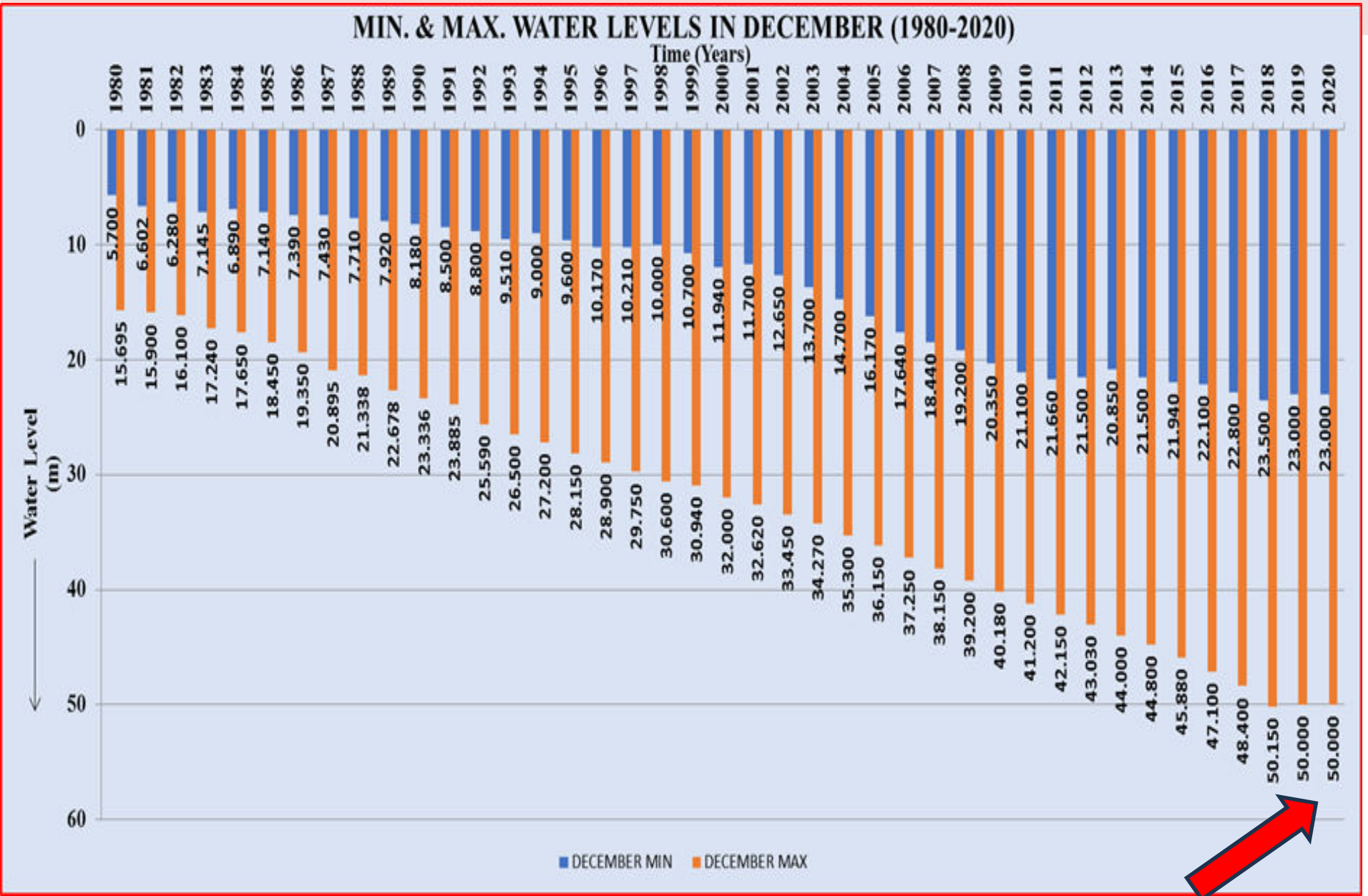
Installation of Exploratory Boreholes in the Field

Rain-water flooding at Walton Air Port Lahore

Rainwater harvesting (Rooftop)

Rainfall harvesting and MAR (Green Park)

Out come of Management Interventions



Wayforward

- **Groundwater Recharge- Natural and Artificial**
- **Rainfall harvesting** through rainfall-runoff modeling
- **Strengthening the monitoring network of groundwater Levels and Quality.**
- Institutional setup for GW Management
- Implementation of Regulations/legal framework for sustainable use of groundwater in rural and urban areas.
- Formulation of long-term policy framework
- Public awareness through mass media campaign, seminars, workshops , walks etc.,
- Capacity building of all stakeholders (Planners, Managers, Users etc)
- Controlling cropping pattern and intensities would be the best option for GW governance in depleting areas
- Environmental flows in the Ravi River

Thanks

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Acknowledgements

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