ACKNOWLEDGEMENT

The visual guide is developed by LEAD Pakistan based on World Bank Group's report "Pakistan: Getting More from Water."


© 2019 International Bank for Reconstruction and Development / The World Bank. Some rights reserved. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent. The World Bank does not guarantee the accuracy of the data included in this work. This work is subject to a CC BY 3.0 IGO license (https://creativecommons.org/licenses/by/3.0/igo).
Livestock production uses very little water compared to irrigated cropping while it represents largest share of agricultural GDP.

- **58%**: share of agricultural GDP comes from livestock production
- **37%**: share of agricultural GDP comes from major crops

The four major crops responsible for around 80% of agriculture water consumption currently contribute less than 5% of total GDP and this share is in decline.

**LOW YIELDS PER HECTARE BY GLOBAL STANDARDS**

Average yields for the major food crops are:

- **1.5 to 4.2 times** below field potential in Punjab
- **2.1 to 5.6 times** below international best practice in Sindh

**PRODUCTION PER UNIT OF IRRIGATION WATER**

Water productivity is significantly higher in Punjab than in Sindh even though yield per hectare is lower.

This is due to several factors:
- Waterlogging and salinity impacts in Sindh
- Groundwater provides greater irrigation control in Punjab
- Water losses are a greater fraction of withdrawals in Sindh
- Higher evaporative losses due to greater proportion of rice crop in Sindh

**WATER PRODUCTIVITY (US$/m³)**

- **0.08**: Punjab
- **0.06**: Sindh

Water productivity must improve markedly as potential to increase yields through additional inputs is limited.

**THE ECONOMIC RETURN FROM IRRIGATION WATER**

The economic return from irrigation water has doubled over the last three decades.

**THE ECONOMIC COST RELATED TO WATER**

- **4% of GDP**: Average annual losses associated with inadequate water supply and sanitation services, flood damages to property, and water scarcity in agriculture.

Additionally, there are costs due to loss of ecosystem services and indirect costs of water-related disasters.
SOCIAL OUTCOMES

HUMAN HEALTH AND WELL-BEING

An estimated 20% to 40% of hospital admissions and a large proportion of infant deaths have been linked to water-related diseases.

On average, 110 children die each day in Pakistan because of water-related diseases, poor sanitation and hygiene.

This equates to 39,000 children every year.

SOCIAL COST OF POOR WATER SUPPLY, SANITATION AND HYGIENE

Average time spent by women on collecting water:
- 15% of their time

20 deaths / 100,000

Mortality rate

People at risk due to arsenic contamination of water supplies:
- Over 50% in Balochistan and FATA
- 50-60 M people in Punjab & Sindh

44% National

Childhood stunting

WATER-LED CONFLICT AND MIGRATION

Short-term, temporary migration is a common response to droughts and floods, especially in Balochistan and Sindh.

In Tharparkar, Sindh during the 2014–17 drought, 35% - 45% of families migrated to barrage areas in search of labor and grazing for livestock.

ENVIRONMENTAL OUTCOMES

Environment resources and ecosystems are under increasing stress from high levels of water withdrawal, widespread water pollution, rapid urbanization, and agricultural expansion.

Consequences of environmental stress include biodiversity loss, declining fish stocks, and degradation of ecosystems in the Indus Delta and other parts of the Indus Basin.

Degradation of the Indus delta has affected the lives of at least 1/2 M people.

Shrimp production and the catch of the prized Palla fish has fallen by 90%.

Indus delta is the world’s 5th largest delta home to more than 180 species.

4 out of 8 plant species in the delta have disappeared in recent years.

Adverse impacts on Ramsar sites that support 18 threatened mammal species.

The catfish, Glyptothorax kashmirensis, for example, has suffered an abundance decline of more than 80% over 5 to 10 years, given the preference of the species for fast-flowing habitat.

Tor putitora, or Himalayan Mahseer, abundance has declined by more than 50%. Trends suggest decline could reach 80%.

This series of infographics is developed by LEAD Pakistan based on World Bank Group’s report Pakistan: Getting More from Water (Young et al. 2019).
PAKISTAN’S WATER ENDOWMENT

AVERAGE WATER BALANCES

PAKISTAN’S AVERAGE ANNUAL AVAILABLE WATER RESOURCES (BCM*)

<table>
<thead>
<tr>
<th>Area</th>
<th>Surface Water</th>
<th>Groundwater</th>
<th>Total (BCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharan Desert</td>
<td>2.9</td>
<td>0.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Makran Coast</td>
<td>6.2</td>
<td>0.7</td>
<td>6.9</td>
</tr>
<tr>
<td>Indus Basin</td>
<td>205.7</td>
<td>12.7</td>
<td>218.4</td>
</tr>
</tbody>
</table>

AVERAGE ANNUAL WATER BALANCE FOR PAKISTAN’S THREE HYDROLOGIC UNITS (BCM)

<table>
<thead>
<tr>
<th>Area</th>
<th>Inflows from outside Pakistan</th>
<th>Beneficial consumption</th>
<th>Induced losses</th>
<th>Natural losses</th>
<th>Outflows</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharan Desert</td>
<td>0.0</td>
<td>0.0</td>
<td>2.5</td>
<td>1.2</td>
<td>1.2</td>
<td>6.7</td>
</tr>
<tr>
<td>Makran Coast</td>
<td>174</td>
<td>1.2</td>
<td>2.0</td>
<td>1.2</td>
<td>0.7</td>
<td>23.3</td>
</tr>
<tr>
<td>Indus Basin</td>
<td>45</td>
<td>80</td>
<td>41</td>
<td>68</td>
<td>30</td>
<td>266</td>
</tr>
</tbody>
</table>

>> Groundwater withdrawals are largely supported by leakage from irrigation canals, distributaries and drainage.

>> High level of withdrawal means that the average basin outflow is low, currently averaging 16% of the total system resource.

>> Natural losses include evaporation and nonagricultural plant transpiration.

AREA COVERED BY WATER RESOURCES

- The Indus Basin: 65%
- Makran Coast: 18%
- Kharan Desert: 17%
TEMPORAL PATTERNS

AVERAGE ANNUAL PATTERN OF AVERAGE 10-DAY INFLOWS AND CANAL WITHDRAWALS, PAKISTAN

Flow volume (BCM)

Source: WAPDA unpublished data.

LOSES AND GAINS VARY CONSIDERABLY THROUGH TIME

Rabi Season
October to March, as river flows start to recede, the river gains water from landscape and aquifer storage.

Kharif Season
During July-October high flows typically recharge groundwater and the river is losing water overall.

PROVINCIAL ENDOWMENT

The 1991 Water Apportionment Accord defines water allocation between provinces. The groundwater resource is solely direct rainfall recharge; river outflows are not allocated to any province but are reflected in the total resource estimate.

AVERAGE ANNUAL PROVINCIAL WATER AVAILABILITY IN PAKISTAN (BCM)

GROUNDWATER

● Indus Basin aquifer waters cover 16 M hectares.
● There are significant provincial differences in groundwater availability and in discharge and recharge.

ESTIMATED AVERAGE ANNUAL GROUNDWATER BALANCES (BCM)

Within provinces, there are areas where groundwater depletion is concentrated especially in parts of Punjab and Balochistan.

This series of infographics is developed by LEAD Pakistan based on World Bank Group's report Pakistan: Getting More from Water (Young et al. 2019).
PAKISTAN’S WATER SECTOR ARCHITECTURE

INFRASTRUCTURE

INDUS BASIN IRRIGATION SYSTEM (IBIS)

IBIS serves 17.2 M Hectares Regulated through 3 Major reservoirs, 16 Barrages, 2 Siphons, 12 Head works, and 44 Link Canals and Canal Commands.

STORAGE AND HYDROPOWER

HYDROPOWER GENERATION (GW)

Reservoirs are vital for hydropower generation. Hydropower accounts for 35% of national electricity generation.

<table>
<thead>
<tr>
<th>Dam</th>
<th>Live Storage Capacity (BCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarbela</td>
<td>12</td>
</tr>
<tr>
<td>Mangla</td>
<td>7.3</td>
</tr>
<tr>
<td>Chashma</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Original combined live storage capacity was: 19.4 BCM

Sedimentation has decreased capacity by 1% per year to:

<table>
<thead>
<tr>
<th>Dam</th>
<th>Hydropower Generation (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarbela</td>
<td>3.5 GW</td>
</tr>
<tr>
<td>Mangla</td>
<td>1.5 GW</td>
</tr>
<tr>
<td>Chashma</td>
<td>1.0 GW</td>
</tr>
</tbody>
</table>

(*Gigawatt)

The level of storage required in a water supply system depends on the variability of inflows, the temporal pattern of demand, and the economically acceptable level of variation in meeting these demands. Reservoir storage capacity alone does not address Pakistan’s lack of water security.

FLOOD PROTECTION

LENGTH OF LEVEES AND NUMBER OF SPURS BY PROVINCE IN PAKISTAN

- Length of levees: Punjab (2,200 km), Sindh (1,500 km), Khyber Pakhtunkhwa (500 km), Balochistan (200 km)
- Number of spurs: Punjab (50), Sindh (70), Khyber Pakhtunkhwa (30), Balochistan (10)

- Source: Ali, 2013

FEDERALLY OPERATED REGULAR FLOW GAUGING STATIONS IN THE UPPER INDUS BASIN AND AVERAGE PERIOD OF RECORD

- Cumulative number of stations: 60 stations
- Cumulative period of record: 60 years

- Source: WAPDA Unpublished Data.

HYDROMETEOROLOGICAL DATA

CHALLENGES

- Sedimentation
- Breaches upstream of barrages
- Increased frequency of floods
- Outdated flood infrastructure
- Lack of integration with non-structural flood management measures

- Rudimentary and non-standardized infrastructure for managing data
- Lack of accurate data monitoring
- Limited active hydrological monitoring outside the Indus Basin
- Limited operational monitoring of groundwater
- Uncertainty in hydrological monitoring and lack of trust among the provincial governments in flow measurements
Water supply and sanitation infrastructure is weak across provinces.

Inadequate public supply infrastructure
Aging pipe networks
Dysfunctional pumping stations
Low piped network coverage for sewerage and supply
Inadequate wastewater treatment infrastructure

Inadequate sewerage or wastewater treatment capacity of Pakistan’s major cities:

**Quetta**
- 100 km of sewers cover a small fraction of the city
- 1 dysfunctional wastewater treatment plant

**Karachi**
- 1.8 M m³ wastewater generated daily
- 2 out of 3 wastewater treatment plants are functional
- 1.6 M m³ untreated discharge goes into Arabian Sea daily

**Peshawar**
- None of the 3 wastewater treatment plants are functional

**Lahore**
- 14 major sewerage drains
- 0 wastewater treatment plants
- 2.4 M m³ untreated sewerage goes into the Ravi River daily

Water governance:

1. Institutional responsibilities for water resource management are poorly delineated between national and provincial levels.
2. Inadequate availability of water related data.
3. Extend trans-boundary water management arrangements beyond the Indus Basin.
4. National and provincial legal frameworks need strengthening.
5. Provincial policy frameworks are partial, fragmented or non-existent.
6. Policy frameworks for urban water services are unclear and not aligned with relevant legislation.

Financing:

Federal and provincial government water sector funding allocations and percentage of total federal budget (2010-17) (PKR billions)

Recommended investments in priority action areas, commitments, and expenditures by Pakistan’s water sector task force, 2013–17 (US$ millions)

Source: Report by Friends of Democratic Pakistan (FoDP), 2012

This series of infographics is developed by LEAD Pakistan based on World Bank Group’s report Pakistan: Getting More from Water (Young et al. 2019).
WATER RESOURCES MANAGEMENT

DATA, INFORMATION AND ANALYSIS

MONITORING AND WATER INFORMATION SYSTEM
- Develop a national level integrated water information system and improve access to and sharing of data
- Strengthen hydrological monitoring systems and develop robust water accounting to guide improved water resource planning and allocation.

In the Upper Indus, to measure precipitation, there is only:

1 Gauge/5,000 km²

Below the WMO* (1994) standard of

1 Gauge/250 km²

*World Meteorological Organization

Improve systematic groundwater monitoring (urban and rural) including adequate monitoring of surface and ground water quality.

FORECASTING

Currently generated forecasts and hydrometeorological monitoring is insufficient for provincial irrigation and agricultural planning and drought forecasting.

Weather forecast
1-2 day

Weather outlooks
3-5 day

Hydrological forecasts
24 hours

Various hydrologic and water resource simulation models exist for the Indus. However, they are not used by government departments for planning purposes.

- Indus Basin Model Revised (IBMR)
- Indus River System Model (IRSM)

RESOURCES PLANNING AND ALLOCATION

Water resource planning has focused on supply-side infrastructure with no established mechanism for strategic basin-scale planning that comprehensively considers sustainable management of existing infrastructure assets. Better planning regimes are needed for:

Conjunctive use of surface and groundwater

Intersectoral water management

Interprovincial water sharing

Basin-scale management of sediment and salinity

10-year National Flood Protection Plan describes an investment of around

US$1.7 B

90% of which is related to infrastructure development.

DROUGHT PLANNING

Drought can affect 1/3rd of Pakistan with Balochistan being most drought prone. During 1998-2002 drought, agricultural productivity halved in Balochistan and affected 3.5 M people nationally.

Institutional arrangement for drought planning is well defined but drought forecasting, planning and response suffers from capacity deficiencies, lack of standardized risk assessments and inadequate hydrometeorological monitoring and data sharing protocols.

INTERPROVINCIAL WATER ALLOCATION

The Water Apportionment Accord of 1991 shares a baseline river inflow volume of

144.7 BCM per year between the provinces.

Urgent need for economically efficient approaches to water sharing as flow variability increases with climate change.

In case of shortfalls, Accord’s guidance on water sharing is vague and causes interprovincial disputes.

Environmental flows acknowledged but no agreement on quantity or rules for guaranteeing e-flows.
Lacking an established mechanism for water allocation to key sectors.

Restructuring provincial irrigation departments to manage water for multiple outcomes.

The warabandi system acts as a constraint to allocative efficiency.

Inadequate maintenance, significant sedimentation and lack of consideration to environmental issues has compromised the performance of key reservoirs and barrages.

A multipurpose approach to reservoir operations could increase economic benefits up to 20% for Indus, affecting water distribution, hydropower generation, and flood mitigation.

Revised reservoir operating protocols for Tarbela and Mangla should include environmental flow management and sediment management.

Since 2000, annual system outflows are just 10% of system inflows and outflows during rabi season are 3% of the rabi system inflows. This adversely affects water-dependent ecosystems.

Seawater has penetrated 30–50 km inland in some coastal areas of Sindh impacting ecosystems, productivity and livelihoods.

1 in 6 industries in Pakistan is heavily polluting water resources.

Pakistan ranks 8th lowest in the world, generating only US$1.38 per cubic meter of water withdrawn.

Globally, Pakistan is in the lowest decile for agricultural water productivity generating only US$0.37* per cubic meter of water withdrawn.

*Agricultural water productivity including for crops, livestock, fisheries, and forestry.

Water productivity (US$ per m³)
Access to sanitation services improved steadily over the last 15 years but 13% or over 26 M people still defecate in the open.

But given rapid population growth, number of people lacking access to improved water supply increased by nearly 6 M between 2000-2015.

Pakistan’s urban population is expected to double over the next three decades to 155 M.

Only 4 out of 10 cities with more than 1 M inhabitants have some wastewater treatment facilities.

91% of population has access to improved water supply.

13% or over 26 M people still defecate in the open.

URBAN WATER SUPPLY AND SANITATION SERVICES

48% Urban households rely on piped water

29% Urban households rely on motorized groundwater pumps

27% Households receive water for more than 6 hours per day

80% Urban water supplies are unsafe for consumption in Sindh and Balochistan

57% Average non-revenue water leading to low cost recovery

RURAL WATER SUPPLY AND SANITATION SERVICES

90% households rely on groundwater in Punjab and Sindh

One-half and two-thirds of the households in Sindh and Balochistan respectively, rely on unimproved toilets and pit latrines.

Artesian wells in groundwater exposes 50-60 M people to serious health risks.

IRRIGATION SERVICES

Much of the inefficiency in water delivery comes from high levels of canal leakages.

Delivery Performance Ratio is on average around 70% indicating water delivery is consistently below capacity.

Warabandi system exists but there is no agreed measure of equity, which is typically assumed to be described by duration, prorated by area.

OPERATIONAL PERFORMANCE

4.5 M hectares of irrigated land and reduce agricultural production by 25%

Water logging & salinity affect an estimated 4.5 M hectares

Around half the farmland in Sindh and Balochistan is affected due to salinity exacerbated by seawater intrusion.

FINANCIAL SUSTAINABILITY

Abiana (water tariff) is not based on water consumption and is levied on cropped area which minimizes incentive for water conservation or shift to high water productive crops. Abiana is not linked to service quality and non-payment does not affect service.

On average, only 20% of the total operating cost of the distribution system is covered from abiana.

The operational cost of service providers is far too high.

There is limited enforcement capacity and no legal basis to penalize defaulters.

EQUITY AND AFFORDABILITY

Abiana (water tariff) is not based on water consumption and is levied on cropped area which minimizes incentive for water conservation or shift to high water productive crops. Abiana is not linked to service quality and non-payment does not affect service.

On average, only 20% of the total operating cost of the distribution system is covered from abiana.

The operational cost of service providers is far too high.

There is limited enforcement capacity and no legal basis to penalize defaulters.
Climate change will not have much impact on water supplies in the short run, but will increase variability. More extreme floods and droughts are expected.

Accelerated glacial melting in the Upper Indus Basin could increase the risks of glacial lake outburst floods (GLOFs), often devastating at the local level.

Improved data, modeling, and forecasting to guide preparedness and response to extreme events will be increasingly important.

Sea level rise and increases in the frequency and severity of coastal storms in the Lower Indus Basin could exacerbate seawater intrusion into the delta and coastal groundwater.

Climate change could induce increase in water demand by 5 to 15% over the next three decades, especially in irrigated agriculture.

Climate change could induce increase in water demand by 5 to 15% over the next three decades, especially in irrigated agriculture.

Water-Related Risk Mitigation

Estimated increase in water demand attributable to projected warming in Pakistan, 2025 and 2050

<table>
<thead>
<tr>
<th>1°C warming</th>
<th>3°C warming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture (crops and livestock)</td>
<td>Domestic/urban (drinking, sanitation and urban services)</td>
</tr>
<tr>
<td>2025</td>
<td>2050</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

This series of infographics is developed by LEAD Pakistan based on World Bank Group’s report *Pakistan: Getting More from Water* (Young et al. 2019).
PAKISTAN’S WATER SECURITY TRAJECTORIES

PROJECTION FOR PAKISTAN’S WATER IN 2047

Scenario modeling* reveals:
Water scarcity will not prevent Pakistan from achieving upper-middle-income status, provided changes in the structure of the economy and increased productivity across all sectors.

Without significant reform and better demand management, water demand can increase by 50% exceeding water supply.

THE MACRO DRIVERS OF CHANGE IN THIS MODEL ARE:

- Economic growth
- Population growth
- Urbanization
- Climate change

PAKISTAN’S TOTAL WATER DEMAND IN 2015 AND PROJECTED FOR 2025 AND 2050

Source: Amir and Habib, 2015

NON-AGRICULTURAL WATER DEMAND

Domestic and industrial demand will grow several fold by 2050 because of greater household incomes and industrial activities.

In absence of demand management, faster warming would cause significant additional increases, with the maximum projected water demand 58% higher than current level.

*This scenario modeling uses a computable general equilibrium (CGE) model of the Pakistan economy coupled to a water system model of the Indus Basin that includes water demand, water routing, and water stress modules.

MODELED ANNUAL NON-AGRICULTURAL WATER DEMAND, 2014-2047

RUMI: Reaching Upper Middle Income
BAU: Business As Usual (No reform and slower economic growth across all sectors)
WATER CONSUMPTION IN IRRIGATION & GROWTH IMPACTS ON AGRICULTURE

Water consumption in agriculture continues to grow because of:

- Growing demand
- Climate change

Groundwater use in irrigation declines as nonagricultural demand for groundwater increases.

Around 4/5th of the water used in agriculture irrigates four major crops (Wheat, Rice, Sugarcane, Cotton).

Nearly 1/2 of the current rice production is exported.

Cotton (and high value crops in general) can be a better option than rice as the higher value leads to a transfer of water away from rice.

WATER PRODUCTIVITY IN PAKISTAN BY CROP FOR BASELINE YEAR (2013/14) AND PRODUCTIVITY GROWTH RATES UNDER *BAU AND *RUMI

Baseline Water Productivity (US$/m³)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Baseline Water Productivity (US$/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>0.42</td>
</tr>
<tr>
<td>Rice</td>
<td>0.13</td>
</tr>
<tr>
<td>Cotton</td>
<td>0.24</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Water Productivity Growth Rate

<table>
<thead>
<tr>
<th>Crop</th>
<th>*BAU, %</th>
<th>*RUMI, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>1.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>1.2</td>
<td>2.6</td>
</tr>
</tbody>
</table>

CONSUMER PREFERENCES

17.8% of food expenditure is on cereals.

Keeping total irrigation use constant, a reduction in demand for cereals allows more production of cotton (and high value crops in general).

A shift towards cotton can increase export share of textiles from 31% to 41%.

POLICY REFORMS AND TRADE SHIFTS

- Mitigate risks to economic growth arising from water scarcity, by improving overall efficiency of irrigation water consumption.
- Re-distribute water supply in agriculture from low value, high water-use crops, to high value, low water-use crops.
- Reform agricultural investment priorities and remove subsidies on wheat and sugarcane to encourage move towards high value, low water-consumptive crops.
- New dams are not critical to this agricultural transformation but do provide important improvements in system performance & resilience.

IMPROVE ENVIRONMENTAL MANAGEMENT

Explore and implement end-of-system flow increases (downstream of Kotri Barrage) to better manage environmental flows to the Indus Delta and to meet future water demand for Karachi.

This series of infographics is developed by LEAD Pakistan based on World Bank Group's report Pakistan: Getting More from Water (Young et al. 2019).
IS PAKISTAN WATER SECURE?

1. ASSESSING THE

Pakistan is not water secure

2. Pakistan is well endowed with water but water availability per person is comparatively low

3. Across 32 countries with less water per person than Pakistan

4. 1/5th of national GDP but less than half of this is from irrigated crops

5. Economic contribution from water use in hydropower generation is significant

6. Economic costs from poor water and sanitation, floods and droughts are about 4% of GDP.

7. Economic cost of degradation of the Indus Delta are estimated to be US$2 B per year.

8. Waterborne diseases and high levels of stunting undermine human capital, with woman and children affected the most.

9. Water-dependent ecosystems are in rapid decline but environmental outcomes are given scant attention.

Social

Economic

Environmental

outcomes from how water is managed and used indicates that
WHAT UNDERMINES WATER SECURITY IN PAKISTAN?

Water security in Pakistan is undermined by:

2. Gaps in water resource management
   - Poor water data, information, and analytics
   - Weak processes for water resources planning and allocation
   - Environmentally unsustainable levels of water withdrawals
   - Low water productivity in agriculture

3. Poor irrigation service delivery
   - Poor financial and operational performance contributes to low productivity.

4. Inadequate domestic water coverage
   - Quality of services is poor especially for urban households.

5. Climate change is an unmitigated risk
   - Likely to increase variability of inflows, increasing the severity of floods and droughts.

6. Climate change induced warming
   - Warming is expected to drive water demands up by 5% to 15% by 2047.

7. Basin-scale river sediment dynamics
   - River sediment dynamics can increasingly threaten the safety and operational performance of water infrastructure.

HOW WELL ARE WATER RESOURCES UNDERSTOOD?*

1. Some of Pakistan’s water resources are well qualified, while others are poorly assessed or simply overlooked in most resource assessments.

2. The surface water inflows to Pakistan from the Indus and its tributaries are measured sufficiently well.

3. Runoff generated within Pakistan and smaller hydrological units outside the Indus Basin, especially in parts of Balochistan, are not well measured and often ignored in water resource assessments.

4. Groundwater has usually been quantified in terms of withdrawals, but this leads to a significant double counting in resource estimates.

5. Average annual renewable resource is 229 BCM* and average water availability is estimated at 1,100 cubic meters per capita.

6. Severe groundwater depletion is evident in some areas but water logging, salinity and contamination are far serious problems to groundwater sustainability.

*The complementary infographic series based on the same report provides further facts and figures and analysis of water resources in
WHAT INTERVENTIONS CAN IMPROVE WATER SECURITY IN PAKISTAN?

**Improving water security** requires addressing large infrastructure gaps involving significant financial resources. The biggest challenges, however, are of poor governance and weak institutions.

**Addressing infrastructure gaps:**

1. **Most important infrastructure gaps** are associated with water supply and sanitation, irrigation and drainage services.

2. **Modernization of irrigation and drainage infrastructure** is required on a massive scale.

3. **Continued investment in flood protection infrastructure** requires complementary “soft” measures such as floodplain zoning, improved flood forecasting, and early warnings.

4. **Large storage reservoirs** can help improve some aspects of water security but do not address the most pressing water security issues.

**Addressing challenges of governance:**

1. The legal frameworks for water management need to be far more comprehensive. Alignment of policy frameworks with relevant legislation is important.

2. Significant policy work is required at the provincial level, because policy frameworks are partial, fragmented, or nonexistent, and implementation has been inadequate.

3. Institutional responsibilities for several aspects of water resource management need to be better delineated both at national and provincial levels and between entities at these levels.
**PATHWAYS TO WATER SECURITY**

**WATER RESOURCES MANAGEMENT**

### RECOMMENDATIONS

1. **Strengthen water data, information, mapping, modeling, and forecasting**
   - Improve water resources planning and system operations
   - Improve flood/drought risk assessment, planning, and mitigation
   - Increase transparency of, and access to, water information

2. **Establish a multistakeholder process of basin-scale water resources planning for strategic basin planning**
   - Guide long-term sustainable economic development
   - Define agreed upon basin-level environmental flows
   - Build climate resilience across all sectors, including the environment

3. **Establish provincial water planning and intersectoral water allocation mechanisms**
   - Support a smooth economic structural transformation
   - Better manage temporary water shortages, including risk sharing
   - Improve efficiency and equity of irrigation water distribution

4. **Accelerate increases in agricultural water productivity**
   - Ensure future food security, given water availability constraints
   - Increase farmer incomes
   - Facilitate labor movement to other sectors
   - Contribute to overall increase in economic benefits from water

5. **Adopt conjunctive planning and management of surface water and groundwater**
   - Maximize the use of aquifer storage for drought resilience
   - Ensure sustainable groundwater use
   - Improve equity in water access across command areas
   - Reduce water logging and salinization
   - Better support multiple water management objectives
   - Manage changing flood risks and changing demand patterns
   - Improve reliability of rabi irrigation supply
   - Manage increasing variability of inflows, including flood mitigation
   - Mitigate sedimentation to improve storage longevity
   - Contribute to improved energy security

6. **Construct limited new storage and review reservoir operations**
   - Better support multiple water management objectives
   - Manage changing flood risks and changing demand patterns
   - Improve reliability of rabi irrigation supply
   - Manage increasing variability of inflows, including flood mitigation
   - Mitigate sedimentation to improve storage longevity
   - Contribute to improved energy security

### STRATEGIC OBJECTIVES

- **US$1–10M**
- **< US$1M**
- **US$1-10M**
- **<US$1M**
- **> US$1B**

### ANNUAL COST

**INFRASTRUCTURE INVESTMENT**

- Short-term (Less than 5 years)
- Medium-term (5 to 15 years)
- Long-term (More than 15 years)

**LEGAL REFORMS**

- 5
- 1
- 3 4

**POLICY REFORMS**

- 1
- 3
- 4
- 5
- 6
- 2

**INSTITUTIONAL REFORMS**

- 1
- 4
- 5
- 6
- 2
- 3

**ANNUAL COST**

- US$1–10M
- < US$1M
- US$1-10M
- <US$1M
- > US$1B
**LEGAL REFORMS**

- Clarify the legal mandates at federal level for water information collection and sharing.
- Strengthen provincial legal frameworks for land-use planning that considers flood risks.
- Establish a sound legal mandate for federally led cooperative basin planning. Strengthen provincial legal frameworks for water resource planning.
- Establish clear legal property rights for water, separate from land, and legal requirements to maintain public register of water licenses.
- Scope legal provisions to support pricing and trading of water rights.
- Establish provincial-level regulatory frameworks for groundwater access, management and regulation.

**POLICY REFORMS**

- Establish an implementation framework for the National Water Policy (NWP), with clear roles and responsibilities for water data and information.
- Establish an implementation framework for the NWP that articulates roles, responsibilities, time frame, and process for basin planning.
- Develop and implement provincial water policies to establish sectoral priorities to define allocation processes.
- Phase out subsidies for wheat and sugarcane. Support adoption of water efficient technologies and diversification to higher-value crops.
- Develop conjunctive water management plans at the district level that focus on building drought resilience.
- Review and revise reservoir standard operating procedures, based on detailed modeling and analysis.

**INSTITUTIONAL REFORMS**

- Strengthen technical capacity in the Water and Power Development Authority (WAPDA) and Indus River System Authority (IRSA) for water data management, modeling, and forecasting, including the use of Earth observations.
- Strengthen capacity of WAPDA and IRSA to enable periodic reviews of operating procedures and to support a multi-objective approach to operations.
- Establish a national water council to provide strategic framing for cross-jurisdictional basin planning. Strengthen federal government capacity for river basin management.
- Strengthen capacity for economic modeling within federal and provincial governments. Improve on-farm water management through farmer training and awareness raising.
- Strengthen the capacity of provincial water resource management departments for groundwater management and conjunctive planning.
- Build capacity of the Pakistan Council of Research in Water Resources (PCRWR) for basin-scale modeling and analysis of surface water–groundwater interactions.

**INFRASTRUCTURE INVESTMENTS**

- Expand national and provincial hydromet networks, including for cryosphere and groundwater monitoring. Establish interoperable national and provincial water information systems.
- Secure financing for construction of Diamer Bhasha Dam and associated power generation and distribution infrastructure.

---

### Complexity, Urgency, and Scale of Impact of Key Recommendations for Pakistan

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Urgency</th>
<th>Scale of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less complex</td>
<td>Less urgent</td>
<td>1</td>
</tr>
<tr>
<td>More complex</td>
<td>More urgent</td>
<td>6</td>
</tr>
<tr>
<td>Less complex</td>
<td>More urgent</td>
<td>3</td>
</tr>
<tr>
<td>More complex</td>
<td>Less urgent</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Relative scale of impact is indicated by bubble sizes.
**SERVICE DELIVERY**

**RECOMMENDATIONS**

1. Modernize irrigation and drainage and improve operations
   - Improve irrigation service delivery in terms of efficiency and equity
   - Increase agricultural productivity, including more high-value crops
   - Ensure food security for a growing population
   - Enable reallocation of some water to cities and environment

2. Reform urban water governance and close infrastructure gap
   - Improve quality, equity and sustainability of urban water supply services
   - Reduce environmental and public health impacts of poor sanitation
   - Keep pace with population growth and urbanization

3. Improve rural sanitation
   - Improve quality and coverage of rural sanitation services
   - Reduce environmental and public health impacts of poor sanitation

**LEGAL REFORMS**

- Revise Provincial Irrigation and Drainage Authority (PIDA) legislation to clarify roles and responsibilities in irrigation management between PIDAs and provincial government departments.
- Establish legal mandate for regulatory oversight of urban water supply service provider performance. Strengthen the regulatory framework for pollution discharges.
- Establish clear legal mandate for the provision of rural sanitation services.

**POLICY REFORMS**

- Replace warabandi with new water sharing rules based on economic efficiency and farmer equity. Reform abiana to reflect realistic operation and maintenance (O&M) costs.
- Rationalize overlaps in the provincial policy frameworks and align with the Local Government Act (2015). Develop and disseminate standards for urban water supply service delivery and link service tariff increases to service quality.
- Establish provincial standards and targets for rural sanitation services.

**INSTITUTIONAL REFORMS**

- Strengthen the capacity of new provincial government water resources management departments to oversee PIDAs and performance of water user associations (WUA) and farmer organizations.
- Strengthen and empower urban water supply service providers. Establish independent regulators to oversee service provider performance.
- Strengthen the capacity and increase the financing of provincial government departments responsible for rural sanitation.

**INFRASTRUCTURE INVESTMENTS**

- Modernize irrigation system, including new hydraulic control structures and lining of canals in waterlogged and saline areas. Automate control of hydraulic structures using real-time data acquisition systems.
- Greatly increase the capacity and performance of wastewater treatment. Improve O&M of existing major distribution infrastructure.
- Invest in public infrastructure for rural sanitation services, including wastewater collection, basic treatment and disposal at the village level.

**LEGAL REFORMS POLICY REFORMS INSTITUTIONAL REFORMS INFRASTRUCTURE INVESTMENTS**

<table>
<thead>
<tr>
<th>Complexity, Urgency, and Scale of Impact of Key Recommendations for Pakistan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short-term (Less than 5 years)</strong></td>
</tr>
<tr>
<td>Legal Reforms</td>
</tr>
<tr>
<td>Policy Reforms</td>
</tr>
<tr>
<td>Institutional Reforms</td>
</tr>
<tr>
<td>Infrastructure Investment</td>
</tr>
</tbody>
</table>

Note: Relative scale of impact is indicated by bubble sizes.
WATER-RELATED RISK MITIGATION

**RECOMMENDATIONS**

1. Improve understanding and management of climate risks to the lower Indus and delta
2. Strengthen planning and management of water-energy interactions
3. Improve understanding and management of basin-scale sediment dynamics

**STRATEGIC OBJECTIVES**

- Maintain natural green infrastructure for coastal protection
- Protect coastal groundwater resources
- Protect and restore delta ecosystems
- Build climate resilience of lower basin agriculture
- Manage the trade-offs and synergies between energy and water development and planning
- Inform investment choices
- Protect and improve water infrastructure operations
- Mitigate environmental impacts of changed sediment dynamics in the delta and lower river

**ANNUAL COST**

- < US$1 M
- US$1-10 M

**LEGAL REFORMS**

- Establish provincial-level regulatory frameworks for groundwater access and management.

**INSTITUTIONAL REFORMS**

- Strengthen the technical capacity of water and environmental management agencies for climate change impact assessments and mitigation planning.
- Increase coordination between government departments at federal and provincial levels and strengthen capacity for joint energy-water analysis.
- Strengthen capacity in relevant technical institutions for multiple aspects of sediment monitoring, modeling, and analysis.

**POLICY REFORMS**

- Develop long-term plans for sustainable management of the Indus Delta.
- Analyze the synergies and antagonisms between current national energy and water policy frameworks to inform policy implementation.
- Develop a management plan to guide long-term, basin-scale sediment management.

**INFRASTRUCTURE INVESTMENTS**

- Assess the feasibility of barrier groundwater wells to slow seawater intrusion.
- Expand solar and wind power investment where sensible.
- Explore feasibility for small-scale hydro on irrigation canals.
- Continue major hydroelectric power investment with run-of-river focus.
- Ensure that new reservoir designs and barrage rehabilitation projects consider sediment related risks to structural safety and operational performance.

**Complexity, Urgency, and Scale of Impact of Key Recommendations for Pakistan**

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Complexity</th>
<th>Urgency</th>
<th>Scale of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal Reforms</td>
<td>Less complex</td>
<td>Medium-term</td>
<td>Medium-term (5 to 15 years)</td>
</tr>
<tr>
<td>Policy Reforms</td>
<td>Less urgent</td>
<td>Medium-term</td>
<td>Medium-term (5 to 15 years)</td>
</tr>
<tr>
<td>Institutional Reforms</td>
<td>More urgent</td>
<td>Short-term (Less than 5 years)</td>
<td>Short-term (Less than 5 years)</td>
</tr>
<tr>
<td>Infrastructure Investment</td>
<td>Less urgent</td>
<td>Medium-term</td>
<td>Medium-term (5 to 15 years)</td>
</tr>
</tbody>
</table>

Note: Relative scale of impact is indicated by bubble sizes.