International Commission on Irrigation and Drainage (ICID)

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Mr Sanjeeb Baral
Vice-President, ICID, Nepal

Transforming Traditional to Smart Irrigation System: Learning from Nepal

2nd Indo Global Irrigation Summit

24-25 June 2026, New Delhi India

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Joint Secretary, Government of Nepal

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Water Resources Availability and Management Challenges

Availability

Annual renewal surface water availability 225 BCM

Annual renewal Ground Water availability ~ 13 BCM

Per capita water availability ~ 7000 m^3/annum

Average annual rainfall ~ 1500 mm which is significantly higher than 800 mm world average

The dry season flow on an average year is only 12.5% of the annual flow (WECS, 2002)

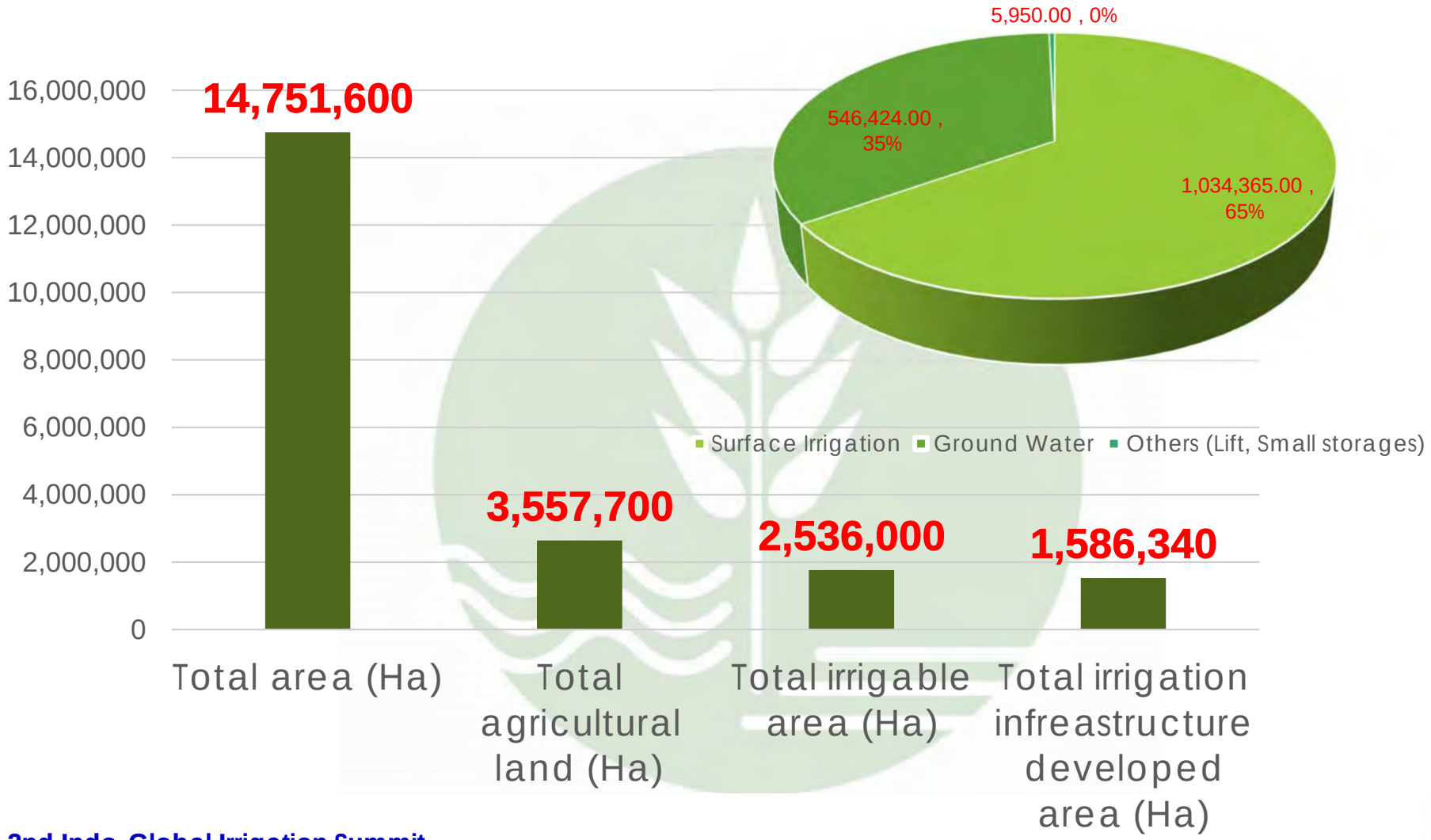
But the demand during dry season is high for consumptive and non consumptive uses.

About 80% of annual rainfall occurs in June-September.

High temporal and spatial variability

Management challenges

Irrigation Development Status



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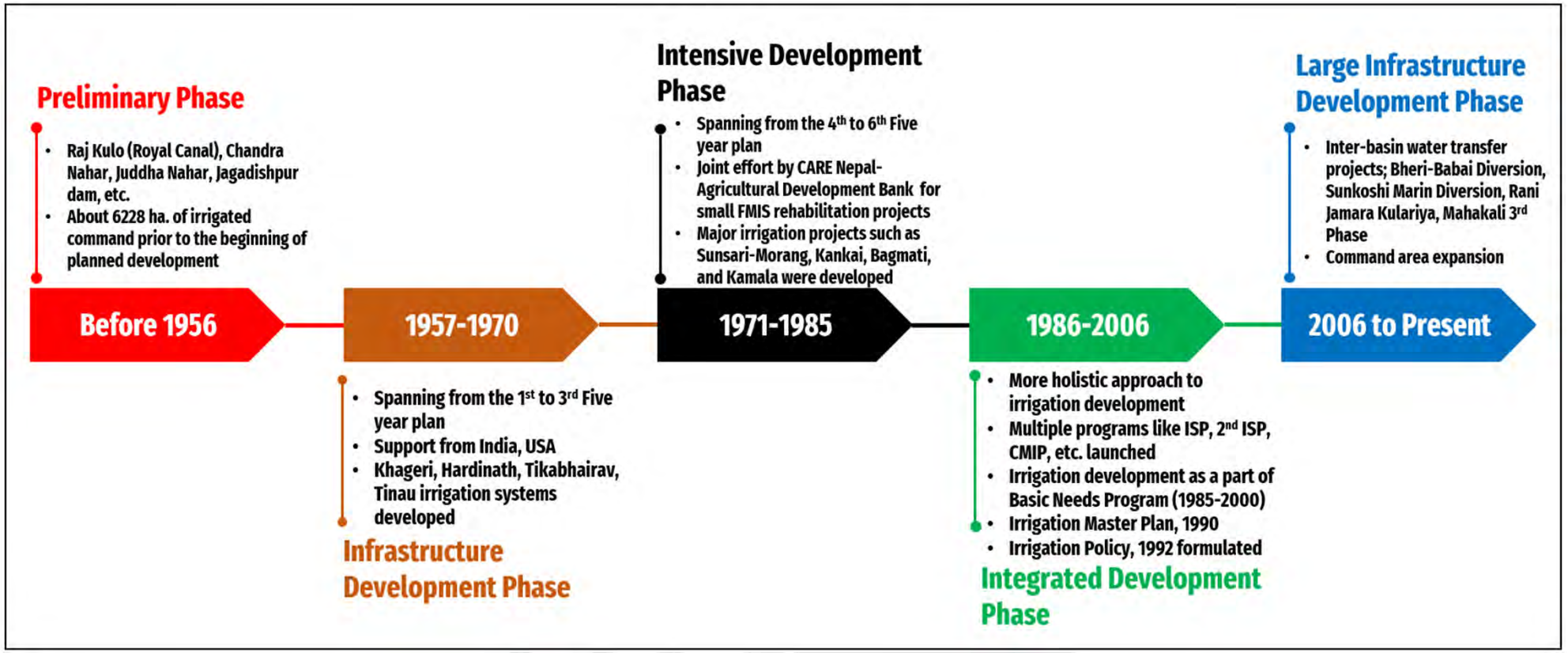
Irrigation Development History in Nepal



Modified Paudel (2003)

Current Focus

- Sustainable/ Climate Resilient
- Year Round
- High Water Productivity
- Digitation, precision agriculture and integration of AI
- Smart system – technology integration

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Traditional system: Modernization to Smart Irrigation system

Traditional System

- Good demonstration of indigenous knowledge and management technique
- Large number of FMIS
- Poor operation and maintenance
- Low efficiency
- Low system performance

Modernization

- Well functional infrastructure
- Good management and control
- Increased efficiency
- Better performance

Smart Irrigation

- Use of technology
- Training and capacity building
- Scada system and Data integration
- Modern system integration
- Higher performance

Modernization of FMIS

From Early Beginnings to a Sustainable, Inclusive, and Resilient Irrigation Future in Nepal

FMIS
(Farmer Managed Irrigation Systems)

- Indigenous irrigation heritage of Nepal
- Community-managed and self-governed
- Present in mountains, hills and Terai
- Supports local food security and livelihoods
- Climate-resilient and adaptive management

Farmer Managed Irrigation Systems (FMIS) are the backbone of irrigation in Nepal, deeply rooted in communities and sustaining agriculture for generations.

Based on data from
Nepal Irrigation Management Information System (NIMIS, Government of Nepal)
(Data up up to April 2024)

HILL IRRIGATION SYSTEM TRANSFORMATION JOURNEY

1. TRADITIONAL FMIS ORIGINS (Before 2000)

- Gravity-based canals
- Earthen & stone structures
- Manual operation
- Limited water control
- Low productivity

2. COMMUNITY ORGANIZATION (2000–2010)

- Rehabilitation of canals
- Improved structures (intake, weirs, outlets, cross-drain)
- Water user groups formed
- Capacity building & training
- Better water distribution

3. INFRASTRUCTURE IMPROVEMENT (2010–2015)

- Upgraded & modern infrastructure
- More efficient water management
- Enhanced monitoring & measurement
- Increased productivity & cropping intensity

4. MODERNIZED FMIS (2015–2020)

- Reliable year-round irrigation
- Sustainable O&M by WUAs
- Improved livelihoods & incomes
- Enhanced food security
- Resilient to climate variability

5. CLIMATE-RESILIENT FUTURE (2020 and Beyond)

- Smart irrigation & digital monitoring
- Integrated watershed management
- Inclusive & gender-responsive
- Climate resilient communities
- Sustainable irrigation for prosperity

FMIS IN NEPAL – KEY STATISTICS (Data up to April 2024)

6,040
FMIS Systems

668,677 ha
Gross Command Area (GCA)

540,765 ha
Net Command Area (NCA)

~70%
of Nepal's Irrigated Area Served by FMIS

FMIS continues to be the foundation of inclusive, community-driven and climate-resilient irrigation in Nepal.

Nepal's FMIS 1985-1990

Transforming to Smart Practice

Chandra Canal
Nepal First Agency managed Irrigation project (AMIS)

A Historical Landmark

Smart Sensors and Automating Gates of Isistsert, is seenting on exteminal historcal irrigation system

Rana Prime Minister Chandra Shamsher Nepal's First Historical Irrigation System, is camaton pammmited in anat and irrigation canal system.

Triyuga River, Saptari District, is seenting on exteminal historcal irrigation system

From Legacy to Smart Specifications

Main Canal Length **28 km**

Main Canal
28 km

Water Flow

26 km
Transtion Canal Loadon

190
Arounal Length
& 50
Water flow

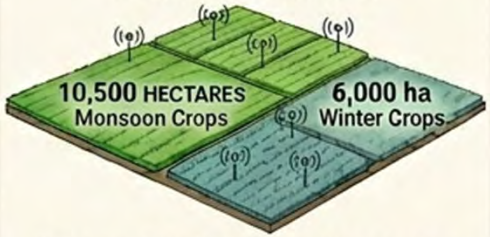
237
Total Structures

11 Branch Canals

38 Direct Outlets

Hundreds of Functional Structures

Agricultural Impact & Command Area



Crop and Soil Moisture Monitoring

Data-Driven Irrigation Decisions based on Soil and Weather Data

Benefiting **100,000 People,** via efficient, smart distribution.

Modern Rehabilitation (JICA Project)

Path to a Smart Canal (JICA & Future)
Supportes that an aniligation for major, suppors and restatries.

Phase 1 (Completed/Current)
- Restoration of key structures, flow sensors (ss seen in), data collection infrastructure (JICA supported)

Phase 2 (Near Future)
- SCADA (system system roliout for central control
- Automating remaining major control gates (solar-powered, connected)
- Farmer-facing mobile app integration for water demand requests and schedule updates

Phase 3 (Long-Term/Vision)
- Predictive AI for water demand and drought forecasting
- Dynamic, precision-irrigation control
- Complete real-time water accounting across the network

JICA

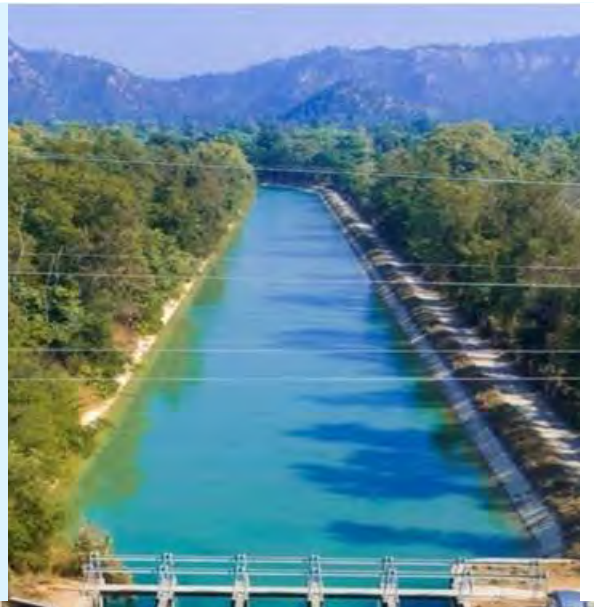
Modernization of- First Agency managed Irrigation project (AMIS) : Chandra Canal

Instrumentation in Babai Irrigation Project (BIP) for informed decision making

National Pride Project
Location: Bardiya,
Total command area: 36,000 ha
Eastern canal system: 21,000 ha
Western canal System: 15,000 ha
Main Canal Length: 91 km

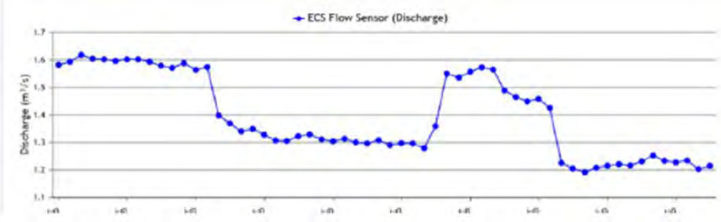
Beneficiary

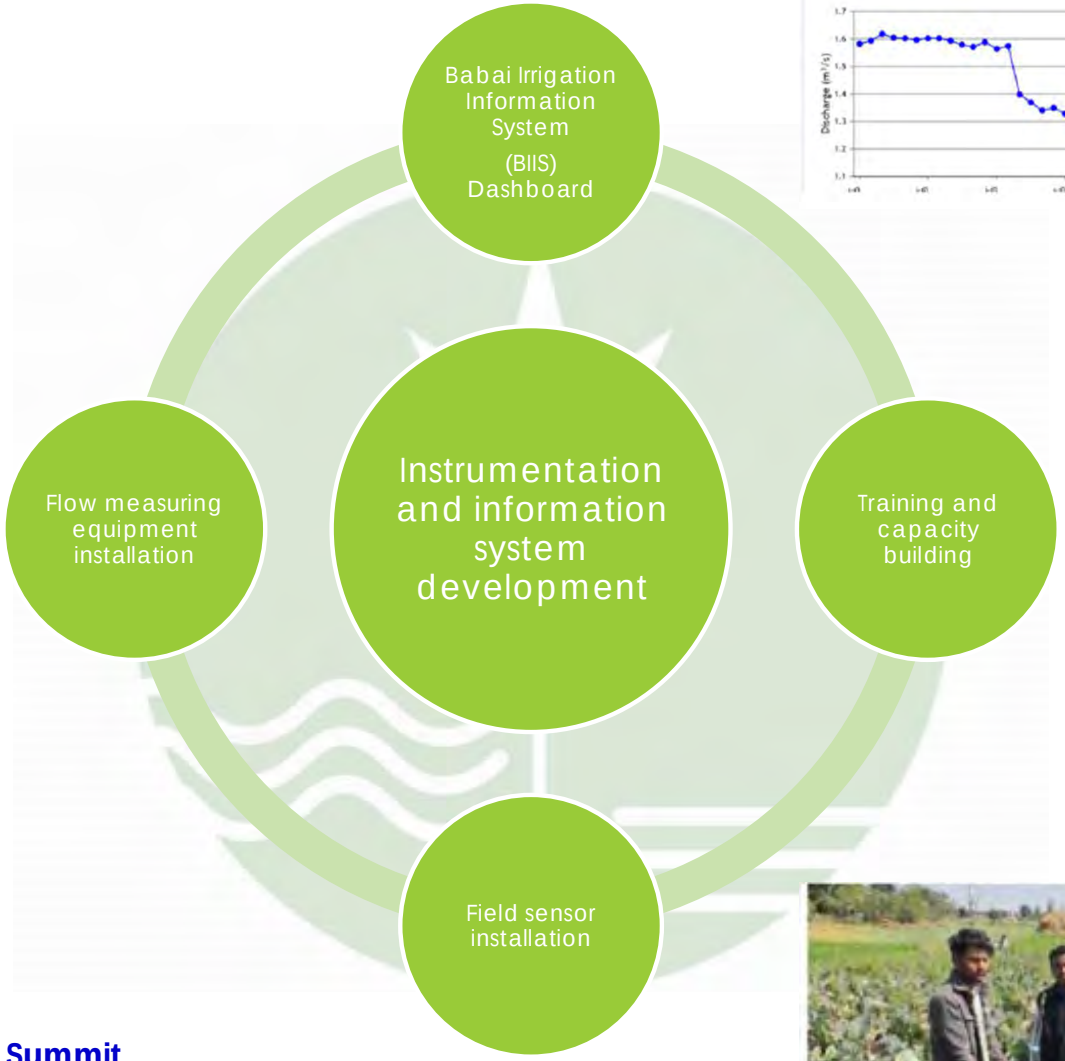
Household: 59,216
Population: 3,64,080



- **IWMI** and **DWRI** introduced **basic canal flow measurements and soli sensors** in BIP.
- This initiative provides **real-time data on water** availability and usage, aiding in efficient water scheduling and allocation, ultimately reducing water conflicts and benefiting farmers and irrigation managers.

Improved data collection, visualization, and informed decision-making





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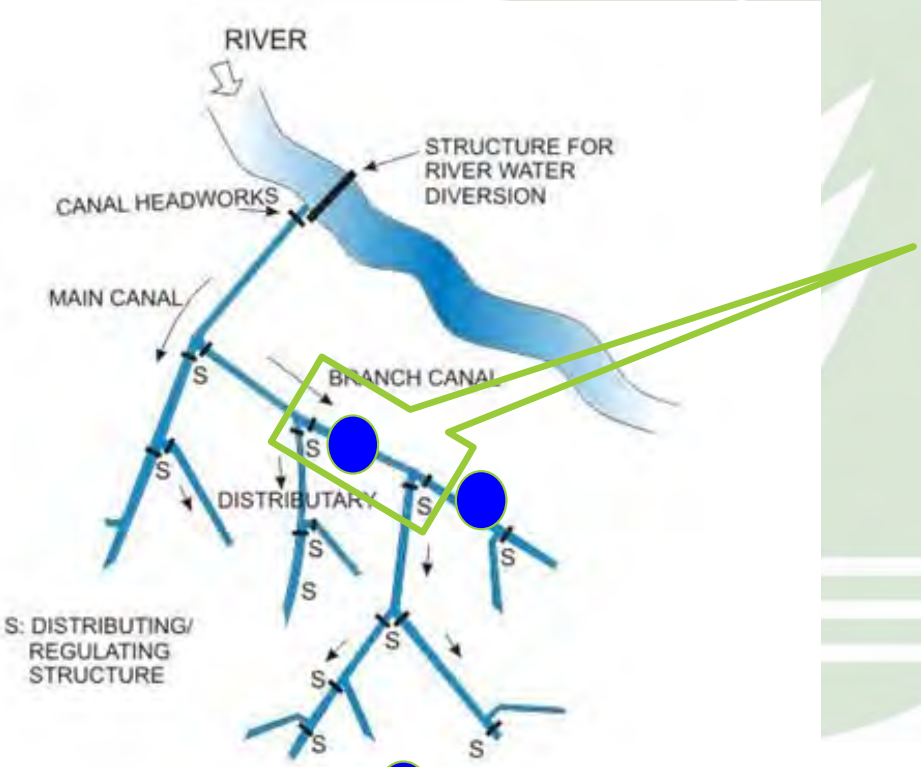
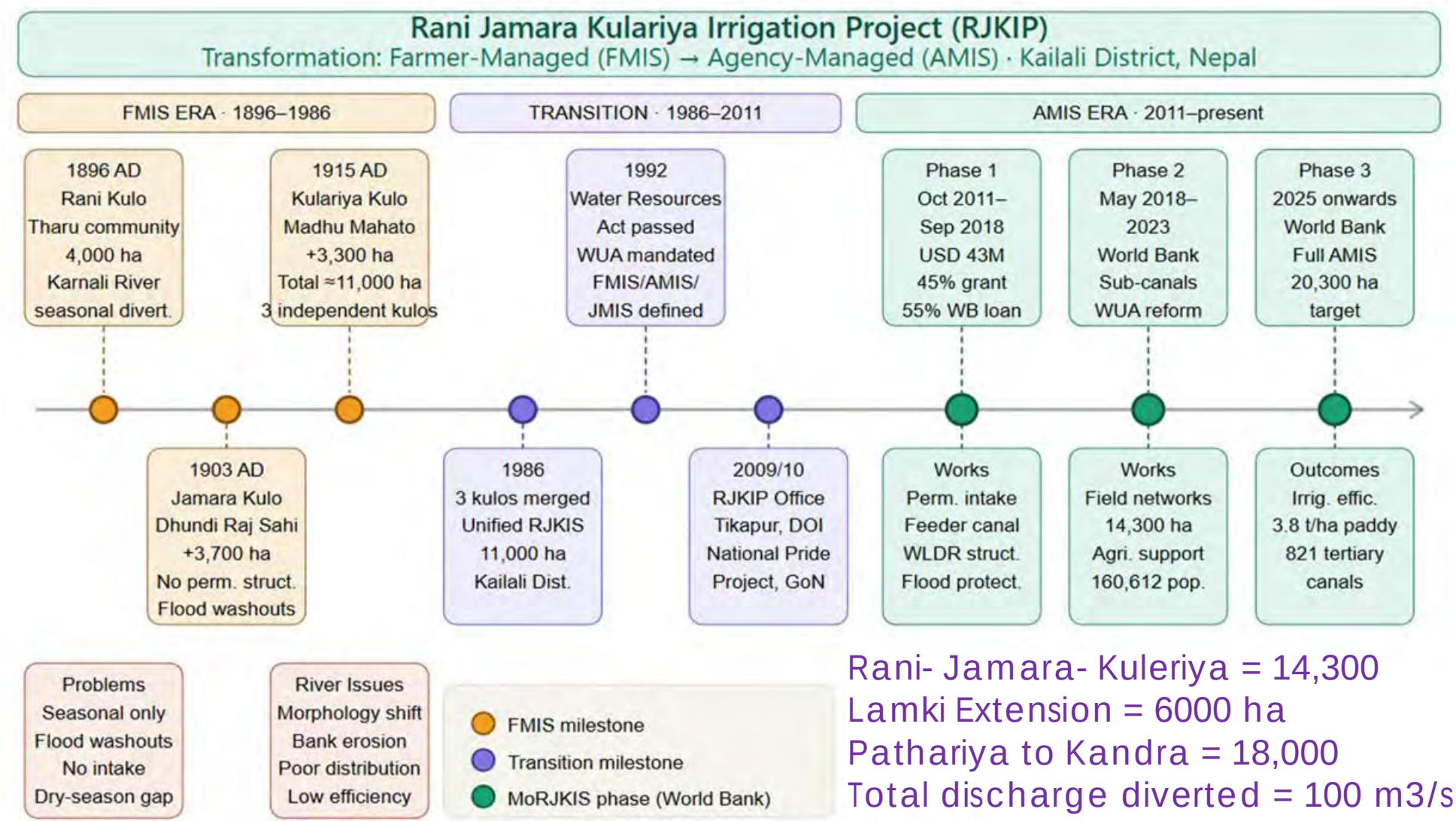
Modernization Interventions: Water control management

- Translating existing area-based water distribution to Volumetric water delivery
- Use of modern technology for water measurement and distribution



Rani Jamara Kulariya Irrigation Project
Modernization of large FMIS



Rani- Jamara- Kuleriya = 14,300
Lamki Extension = 6000 ha
Pathariya to Kandra = 18,000
Total discharge diverted = 100 m3/sec

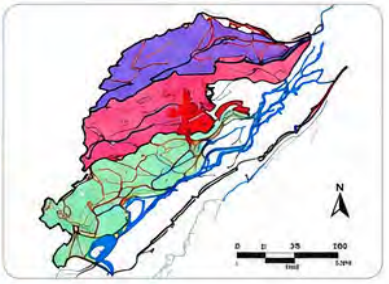
Source: DOI / RJKIP · Department of Irrigation, Nepal

Rani Jamara Kulariya Irrigation Project
Modernization of large FMIS

Lessons form RJKIP Interventions

- Farmer Ownership
- Institution Strengthening
- Water Management
- Climate Resilience
- Agricultural Productivity
- Inclusive Participation
- Good Governance
- Transparency & Equity
- Partnerships
- Sustainability

A smart, autonomous, climate-resilient irrigation system for sustainable prosperity in the Rani Jamara Kulariya Command Area.



1. Empowered Institutions → 2. Smart Water Management → 3. Autonomous Operation → 4. Climate Resilient Systems → 5. Productive & Inclusive Future

PILLARS	KEY ACTIONS	EXPECTED OUTCOMES
Institutional Strengthening	• Strengthen WUAs & federations • Capacity building & leadership • Legal empowerment & inclusion	• Strong, accountable & inclusive institutions • Active farmer participation
Smart Technology	• Install sensors & telemetry • Real-time monitoring platform • Data-driven decision support	• Timely decisions • Efficient water use • Reduced losses
Autonomous Governance	• WUA-led O&M • Transparent financial management • Performance-based incentives	• Sustainable O&M • Financial self-reliance • Reduced dependency
Climate Resilience	• Modernize infrastructure • Flood & drought management • Watershed & ecosystem protection	• Resilient infrastructure • Reduced climate risks • Environmental sustainability
Sustainable Livelihoods	• Promote water-efficient agriculture • Link to markets & value chains • Inclusive & gender-responsive programs	• Increased productivity & income • Food security • Inclusive growth

PHASE 1 (2025–2026) — Foundation
→ **PHASE 2** (2026–2027) — System Upgrade
→ **PHASE 3** (2027–2028) — Autonomous Operation
→ **PHASE 4** (2028–2030) — Smart & Resilient Future

KEY SUCCESS INDICATORS (KPIs)

Water Use Efficiency	Irrigation Reliability	WUA Participation	Crop Productivity	O&M Cost Recovery	Women Participation
+20–30%	>95%	>80%	+25%	>100%	>50%

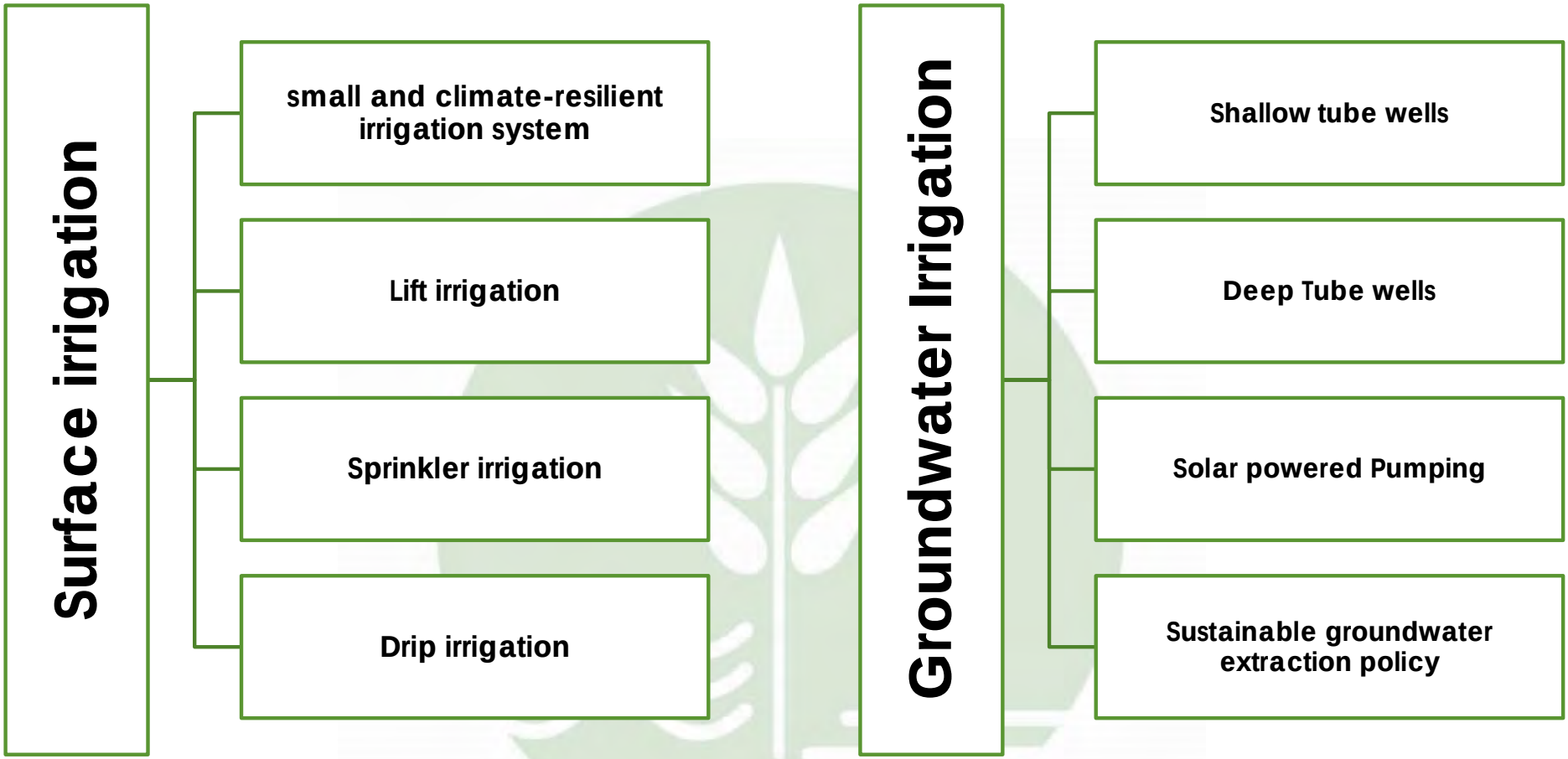
ENABLERS

- Policy & Legal Support
- Capacity Development
- Financing Mechanisms
- Partnerships & Collaboration
- Knowledge & Innovation

LONG-TERM IMPACT

- Water Security
- Climate Resilience
- Food Security
- Rural Prosperity
- Sustainable Future

Irrigation Master plan, 2019: Focus



New Irrigation Master Plan has balances approach of development and management of irrigation system for the focus of use of technology, innovative approach : Smart Irrigation

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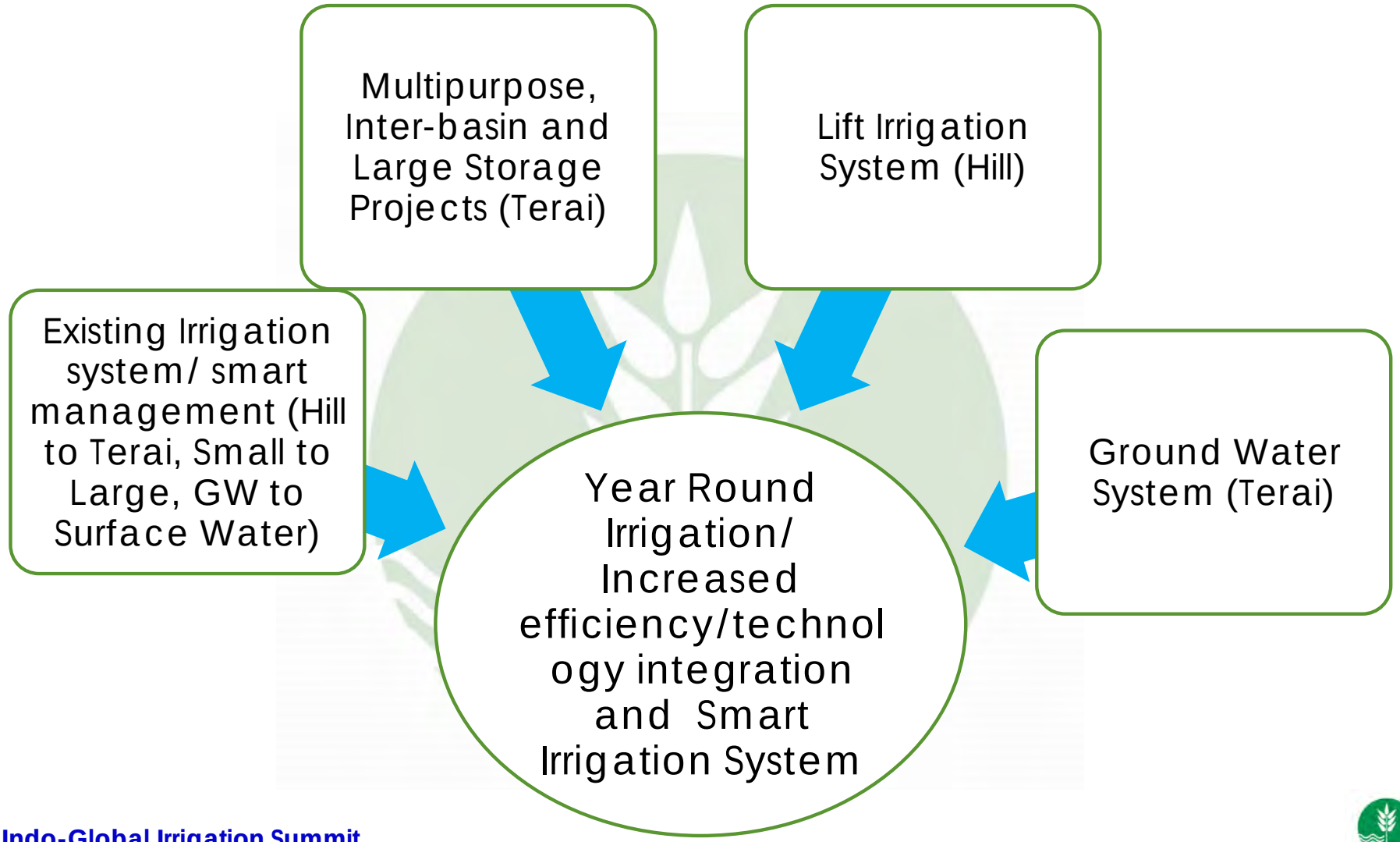
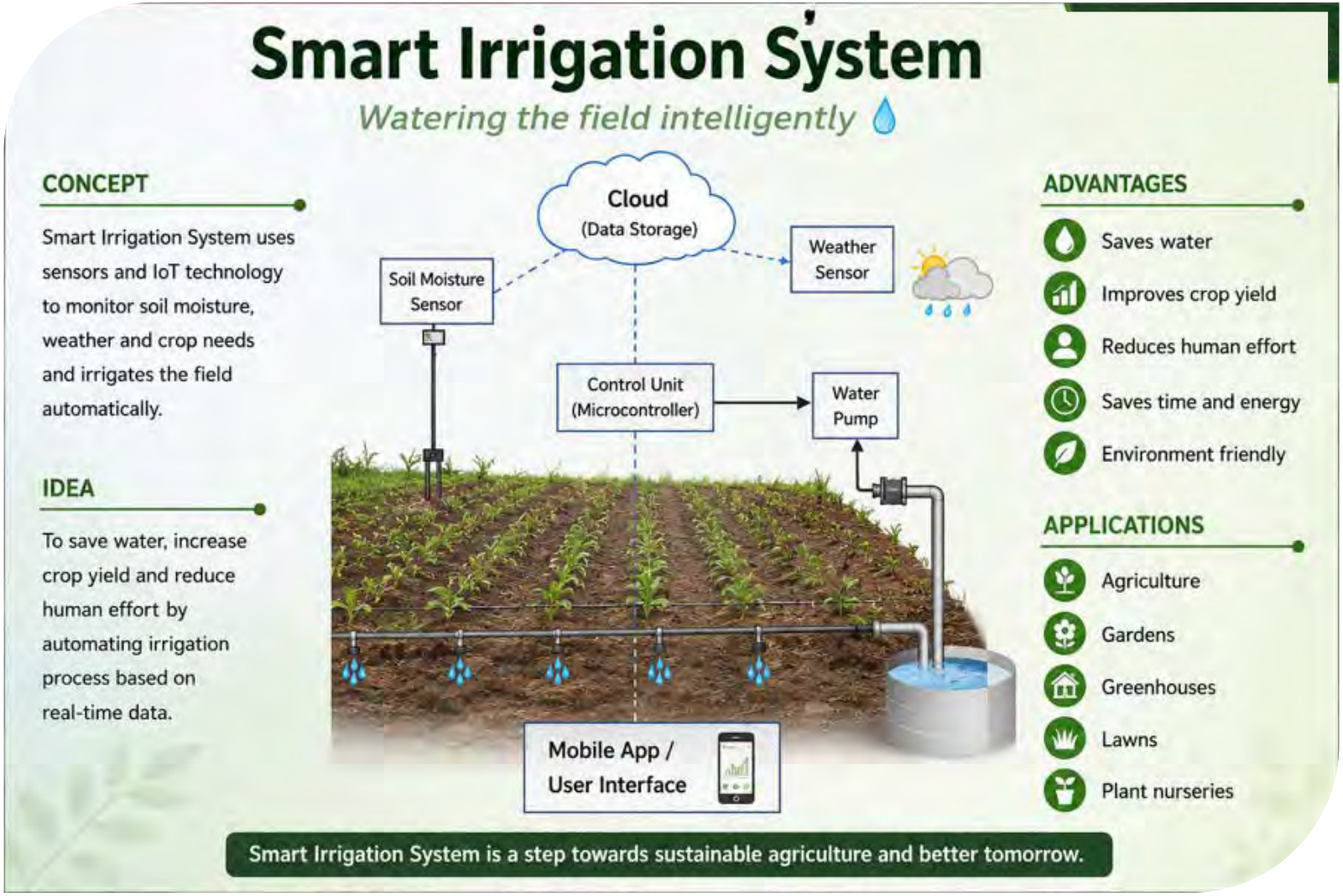
Pathways for Smart Irrigation System



Gomati Bahuntar Smart Irrigation

- Location: Benighat Rorang RM–05, Dhading (SMART SYSTEM)
- Net Command Area: 21 ha
- Current Status : In Operation and maintenance phase
- All of the 44 OutlConnected to Server at WRERC

Gomati Bahuntar Smart Irrigation System



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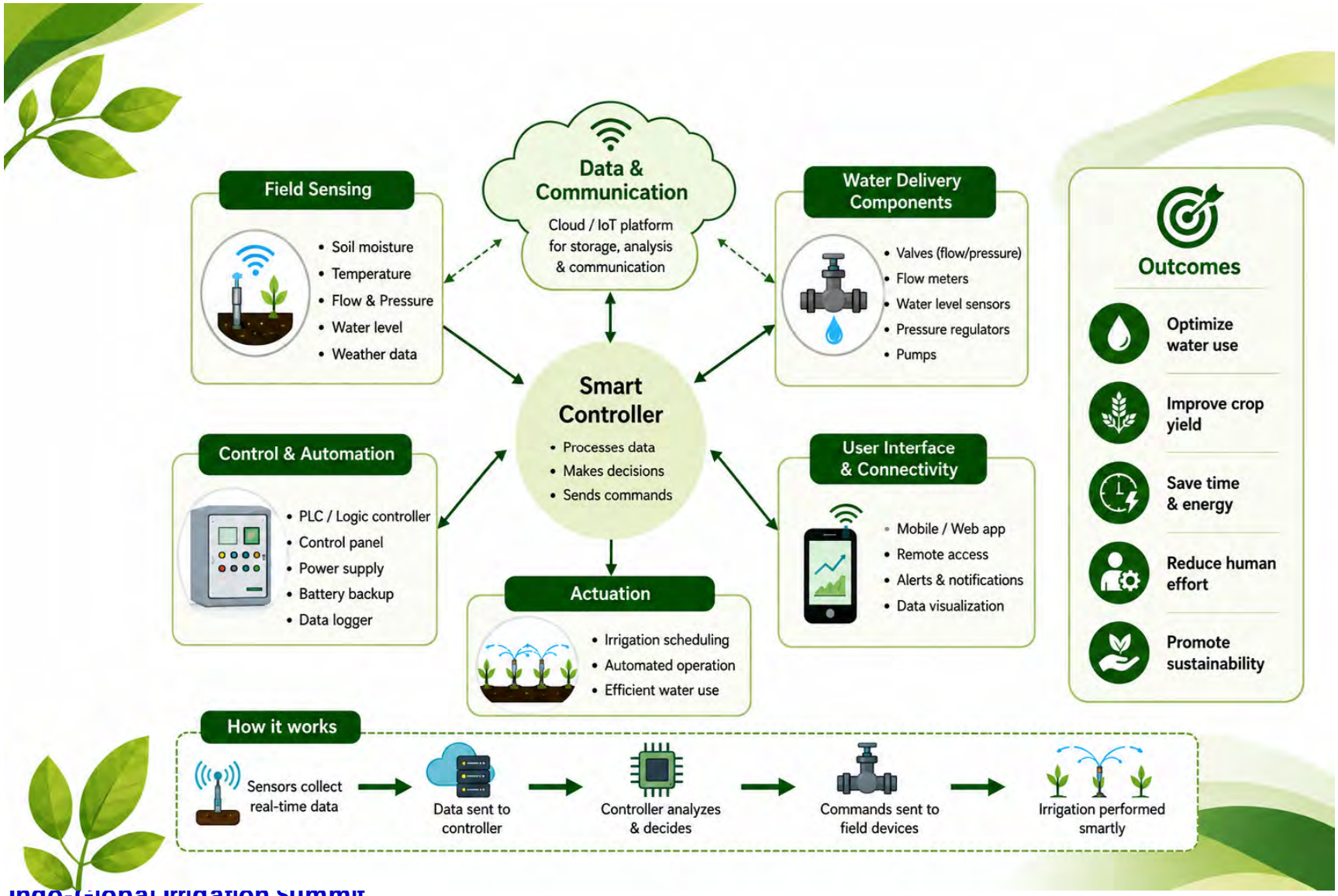
Smart Irrigation Components Architecture



Lift Irrigation Suitability for Hill & Mountains

Getting river water uphill to the hill and mountain farms that rain alone can't reach.
To develop reliable irrigation in sloping terrace and rivers banks

468,000 ha

Hill farmland that could be irrigated by lifting river water to the fields above
IMP 2019 identified potential for lift irrigation scheme considering economic Pumping head: 140 m and minimum flow 60 l/s,

68%

Of Nepal's land lies in the mid-hills, where farms sit far above the rivers

Making Smart Lift Irrigation system

A river-current pump lifting water with no fuel or grid power

Solar-powered lift station feeding an elevated storage tower

Lifted water discharging into a field irrigation canal

From river current to sunlight, hill farmers now have options beyond diesel.

River-Current Pumps

Spiral 'Barsha' pumps use only the river's current — no fuel, no grid — to lift water up to 25m. 131 now run across 30 hill districts.

Solar Lift Irrigation

With 300+ sunny days a year, solar pumps are reaching remote villages — though subsidized units still see about 10x more demand than supply.

Engineered Lift Schemes/ Storages

Projects in districts like Bajhang and Bajura lift river water to shared reservoirs, turning rain-fed hillsides into year-round orchards.

Smart Sensors for Demand

Actual demand estimation based on soil moisture sensors and mobile apps. Automate flow discharge based on actual crop evapotranspiration.

Effective Distribution

Replacing canal networks into piped system, automated valves and enhanced efficiency measures.

Delivery to the Field

Use of drip and sprinklers for effective application of water to the field, achieve higher application efficiency.

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SMART Groundwater

Scaling safe, sustainable irrigation across Nepal's Terai groundwater belt.

8.8 BCM

Annual renewable groundwater recharge in the Terai

22%

Share of that recharge currently used for irrigation

41.7%

Of irrigated land now depends on groundwater — up from 29.8% in 2011

318,000 Ha – GW Potential

Sources: Shrestha et al. 2018 (GWRDB recharge data) · Nepal Agriculture Census 2021/22

The Pathway for SMART GW System

Shallow-tubewell irrigation in a Terai

Canal-fed tubewell discharge recharging a field pond

Optimize groundwater use in the Terai without depleting it.

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Solarize Deep Tubewells

1,500 DTWs irrigate the Terai — nearly 1 in 3 sit idle from unreliable grid power. Solar conversion keeps them running. (net metering)

Track the Water Table (Monitoring)

Localized drops are already reported near Birgunj and the far-west. Real-time sensors can flag depletion early.

Balance Surface & Groundwater

Only 22% of the Terai's 8.8B m^3 recharge is used today. Scheduling pumps around canal flow keeps aquifers in balance.

Smart Sensors for Demand

Actual demand estimation based on soil moisture sensors and farmer facing mobile apps. Automate flow discharge based on actual crop evapotranspiration, eliminate waste.

Pump to Actual Need

Develop system with valves to supply the actual need, develop system for higher efficiency (piped distribution and leakage control)

Effective Regulation

Maintain effective regulation to control over exploitation.

Drip & Sprinkler Irrigation

Extending irrigation across hills and terai farms for better water saving and higher efficiency.

Sprinkler Irrigation

- Pressurized nozzles spray water in fine droplets across open fields and terraced plots
- Gives even coverage on sloped hill farms where flood irrigation isn't practical
- Promoted nationally under Nepal's Irrigation Policy alongside ponds and lift systems

Drip Irrigation

- Tubes and emitters carry water straight to plant roots inside poly-tunnels and greenhouses
- Cuts water use while extending the growing season for tomato, cucumber and cauliflower
- Low-cost kits, often subsidized by government and NGO programs, put it within reach of smallholders

Grassroots innovation: bottle-drip kits

In hill villages, farmers repurpose plastic bottles as low-cost drip emitters for community demonstration plots — an entry point before investing in manufactured kits.

Smart Drip and Sprinklers

Priorities for expanding drip and sprinkler access across Nepal's farms

~43% of Nepal's net cultivated area is currently irrigated. Scaling low-cost drip and sprinkler systems is central to closing that gap this year.

Q1

Expand Subsidized Access

Continue PMAMP and local-government subsidies for drip kits and sprinkler sets, prioritizing women-led and smallholder farms.

Q2

Scale Solar-Powered Drip

Pair solar irrigation pumps with drip lines — a Climate-Smart Agriculture priority under Nepal's NDC 3.0 — to cut the per-unit cost of water.

Q3

Train & Demonstrate

Expand farmer training and low-cost demo plots; build local technician skills for system operation and maintenance.

Q4

Extend Community Coverage

Scale community-driven minor irrigation, building on projects like the Community Irrigation Project, to reach marginal and smallholder farms.

Sources: Nepal Irrigation Policy 2060; Prime Minister Agriculture Modernization Project (PMAMP); Nepal's NDC 3.0; ADB Community Irrigation Project;

Way Forward

- Integration with technology, GIS mapping, remote sensing, and mobile applications can strengthen irrigation governance.
- Digital irrigation systems support climate adaptation, and sustainable agricultural transformation.
- Capacity building, farmer participation.
- Policy support are essential for large-scale implementation.
- Gradual shifting, demonstrate better performance.
- Continuous effort needed to transfer traditional irrigation system to modernize and translating it into smart irrigation system.

Smart irrigation

Transitioning legacy roots to tech-driven resilience.

THANK YOU !