Powering Second Green Revolution through Emerging Technologies

Alok K Sikka
IWMI Representative-India
and Principal Researcher
International Water Management Institute
New Delhi

Technology-led Agriculture Growth Trajectory

Traditional Farming (Early 1900s)

Mechanization (1960s)

Green Revolution (1970s)

Initiation of Missions, Biotech & notechnology Era (2000s)

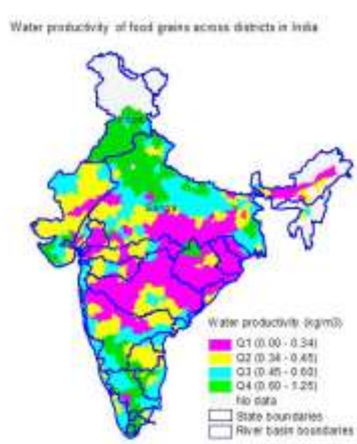
Convergence of Technologies, innovations, programs and Resources (Second GR in *21st century*)

- GR turned India from 'Begging bowl' to 'grain bowl'
- Pulled India out of hunger
- Concentrated in rice & wheat in irrigated areas
- HYV seeds, fertilizer, irrigation and enabling policies
- Un-sustainable use of NRs

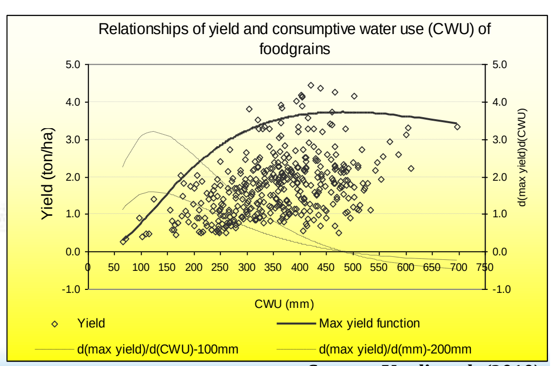
Powering Second Green Revolution: Challenges

- Challenged to sustain and usher into Second Green Revolution based on learnings and second generation concerns of GR
- Second GR to be
  - Inclusive in coverage of by-passed rainfed areas, eastern and north-eastern region, low productivity areas with easy access to small holders
  - Should cover range of food basket NOT just cereals
  - Natural resource based and farmer centric, area specific science led and knowledge based approach
  - Enhanced Profitability Not only productivity alone
  - Climate resilient and sustained agriculture

Is there a large scope for increasing WP?



- Large variation in WP
- A significant gap exists between the actual and maximum WP
- Reducing the gap alone will substantially reduce additional need for irrigation water



Great opportunity to increase yield & WP in rainfed districts and irrigated areas with CWU below 300 mm with RWH

Source: Upali et al. (2010)

Emerging Technologies and Innovations

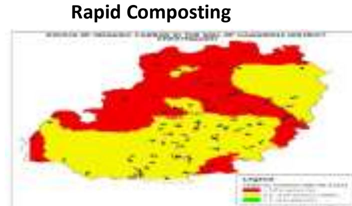
Required for SGR:

- **Soil Health Management**
- **Micro-level Land Use Planning and Management**
- **Closing gaps between IPC & IPU**
- **Resource Recovery and Reuse**
- **Sustainable agriculture water management**
- **Multiple stress tolerant/Improved crop varieties**
- **Multiple water use based Integrated farming systems**
- **Climate resilient/smart practices**

Soil Health Management: Critical for SGR

- **Conjunctive use of chemical fertilizers, organic manures and bio-fertilizers**
- **Promote INM packages developed by ICAR for dominant cropping systems**
- **Use GIS soil fertility maps of ICAR for precise and balanced fertilizer use.**
- **Technology for production of bio-fertilizers, vermi/ enriched compost.**
- **Promote Fortified/ neem coated and customized fertilizers with micro and secondary nutrients**
- **Capitalize best use of Soil Health Cards for judicious nutrient management**
- **Use of on-line soil test based fertilizer recommendation package.**

Rapid Composting



Response of Bio Fertilizer

IWMI A water-secure world www.iwmi.org

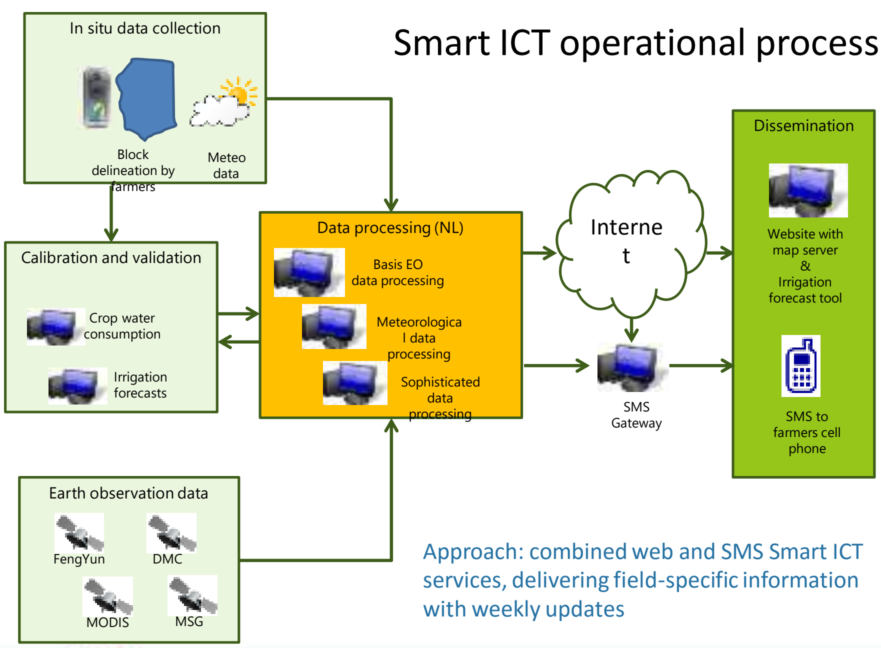
Closing Gap between Potential Created and Utilized

- ❖ Use of space technology and ICT in irrigation management
- ❖ Dialogic tools (based on DSS) for linkage of canal operation and on-farm water management
- ❖ Innovative ways of managing canal water through PPP, service providers, farmers' company, or federating WUAs into a Private Company
- ❖ Bringing pressurized irrigation/ micro-irrigation as adjunct with canals
- ❖ Follow concept of Total Water Solutions and Shift from PIM to PWM

Technology for system operation can:

- Provide real-time data
- Remote operations
- Improved access to information
- Offer new tools for manual system operations

Smart ICT operational process



Approach: combined web and SMS Smart ICT services, delivering field-specific information with weekly updates

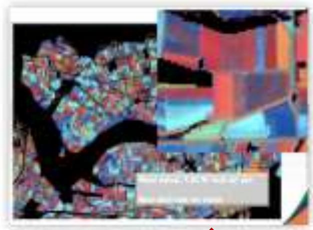
Use of Smart ICT for efficient Irrigation

ICT-based technologies integrating weather, water and crop related information and advice

The project uses satellite imagery, combined with other data, to produce practical agricultural information for farmers.

Complex water and crop growth models are run for each field using this combination of data and satellite imagery, producing specific, customized advisories for each farmer

Smart ICT project implemented in three countries in Africa – Ethiopia, Sudan and Egypt



UAV or Flying Sensors

Data Types: Fixed-Wing

Elevation models

- accuracy 1 cm
- dike control
- Erosion
- glacier movement
- change detection
- infrastructure

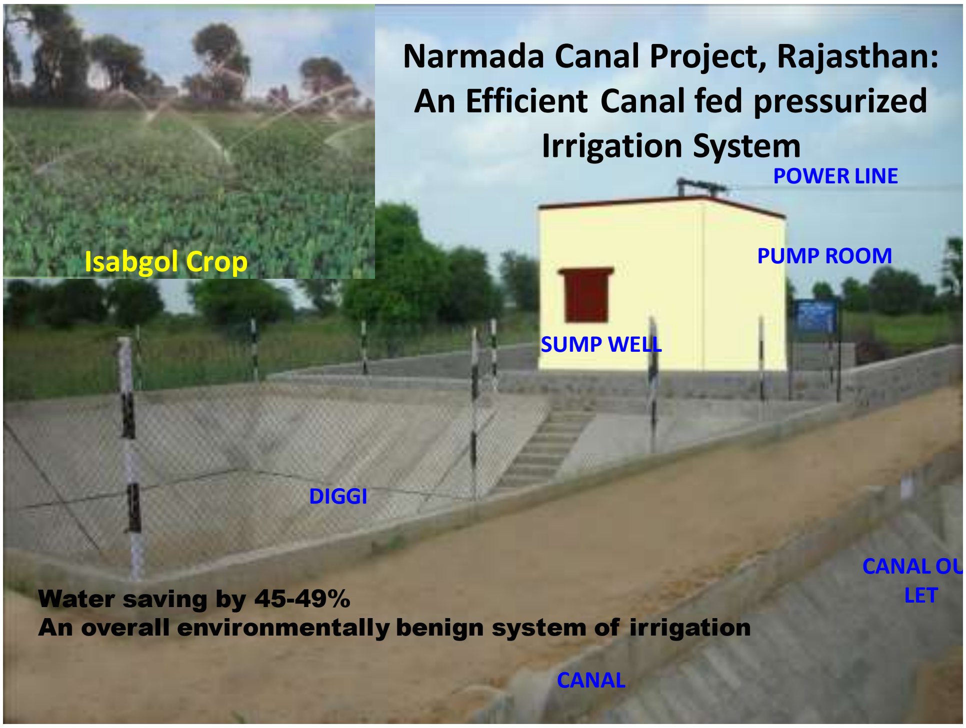
Monitoring vegetation

- visible and non-visible spectrum
- Agriculture
- water mgmt
- nature conservation

Advantage of UAV

- Powerful alternative to air/spaceborne multi/hyperspectral imaging systems for Earth observation
- Flexible/cheaper than airborne systems
- Major focus is local applications
- The current bottleneck for EO-applications is not the UAV but suitable payloads (multi-/hyperspectral camera)

IWMI A water-secure world www.iwmi.org

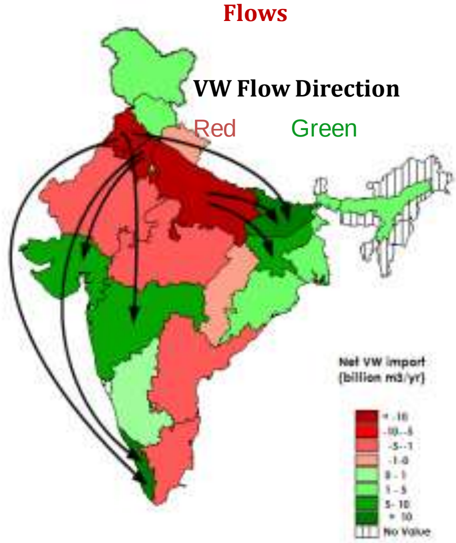


Issues & Opportunities in Eastern India

- ➢Limited access to small farmers
- ➢Low affordability
- ➢Higher cost of pumping

- ➢Technological push for GW use
- ➢ Promoting institutional arrangements including groundwater markets, water franchisees, community/group tube wells for increased access to water
- ➢ Underground taming of flood waters for irrigation
- ➢ Complement government's program of Bringing Green Revolution in Eastern India.

Interstate food grain or Virtual Water Flows



Virtual water, movement of food grains from water scarce region of western IGP to water surplus eastern region

Underground Taming of Floods for Irrigation (UTFI)

Piloting and upscaling an innovative underground approach for mitigating urban floods and improving rural water security in South Asia

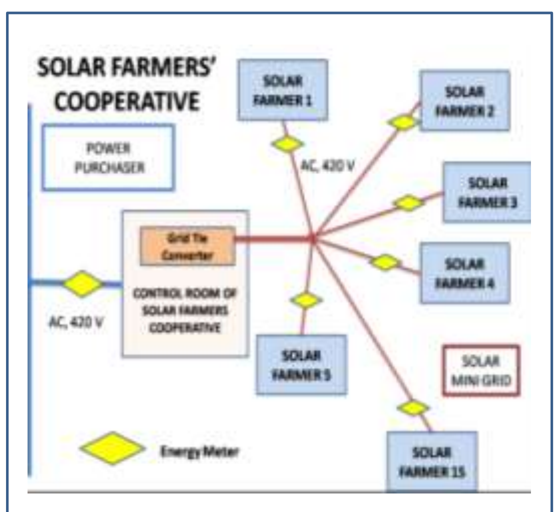
Site visits by IWMI, CSSRI and KVK researchers for upscaling

Selection of potential sites and its upscaling through convergence with government schemes PMKSY/IWMP/Minor Irrigation/RKVY

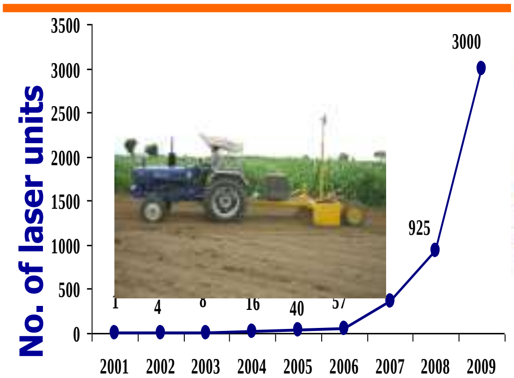
Solar Power – Harnessing the power of the Sun

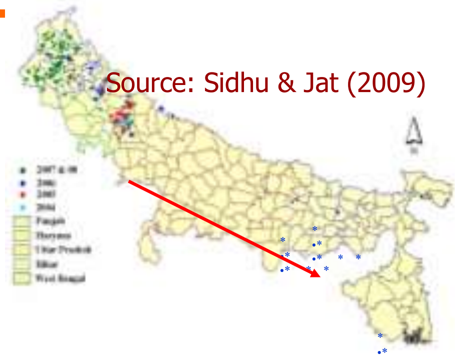
SPaRC – Solar Power as a Remunerative Crop
An innovative concept which links farmer's solar irrigation pump to the electricity grid presenting the farmer with the choice to sell the surplus power

SPICE – Solar Pump Irrigators' Cooperative Enterprise
Institutionalizing the idea of SPaRC through a cooperative model

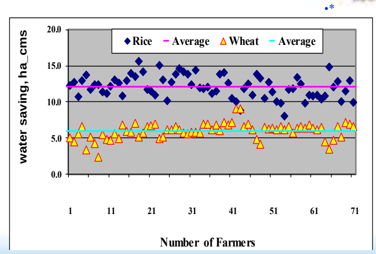


Improve water use efficiency: Laser land leveling





- Increases irrigated area ~ 2%
- Improves crop stand and yields
- Additional field area added ~ 3%
- Farmer Investments: USD 50Million
- Area under laser leveling in IGP= 1.0 m ha
- Energy saving
- Water Saving ~ 10 km³/ year



Technological Interventions for Increasing WUE

Improving Irrigation Water Management:

- Improving conveyance and distribution system of irrigation network
- Canal Supply & Demand Management through automation
- Improved on-Farm Water Management including Structures
- Laser Land leveling, Zero-Tillage & Resource Conservation Technologies
- Location specific groundwater recharge
- Modern Irrigation Methods (Drip & Sprinklers)
- Conjunctive use of good and poor quality GW / wastewater

Laser land levelling to reduce GW draft by 19 cm Rice-Wheat areas in Punjab (Applicable to Yamuna Alluvial Plains)

Raised Beds

Horticultural Crops

Zero Tillage

Mulching

Contd.

MICROIRRIGATION IN RAINFED AREAS/HILLS



SPV capacity (Watts) to irrigate 1 ha using MI systems

Water table depth, m	Drip system	Mini sprinkler system	Sprinkler system
35	4000	5500	7300
45	5000	6500	8200
55	5600	7200	9200

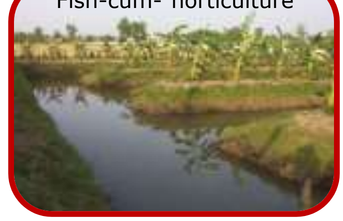
Red gram with pond water

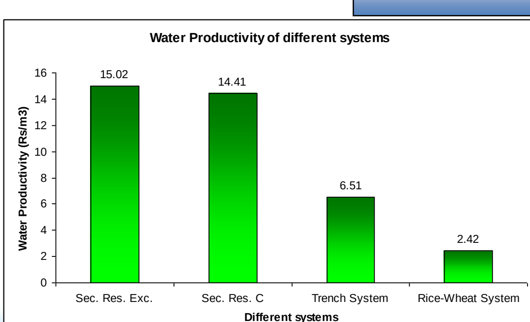
Multiple use based IFS for enhancing water productivity

Total income generated from secondary reservoir (Crop+ Vegetables + Fruits + Fish) - Rs 1,32,000/ha/year

Net Income from Trenches and beds-Rs 80000 /ha (fish-banana vegetables)

Fish-cum- horticulture





Additional benefit from fish: 11 t/ha

Crops being engineered with abiotic stress resistant traits by ICAR

Crop	Abiotic Stress type
Rice	Drought, Salinity
Wheat	High temp., Drought, Salinity
Sorghum	Drought
Maize	Water logging, drought
Chickpea	Drought, Cold tolerance
Pigeonpea	Salinity, Drought
Groundnut	Drought
Sugarcane	Drought, Water logging
Potato	Drought, High temperature, Salinit
Mustard	Drought, Salinity
Tomato	Drought, Salinity
Cotton	Drought, Salinity

IWMI A water-secure world www.iwmi

Cultivation of high value crops: Strawberries, Floriculture

IWMI A water-secure world www.iwmi.org

Hydrogel-Technology for areas with limited water availability

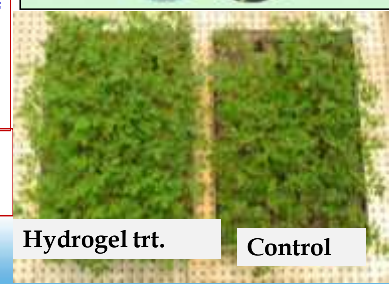
Superabsorbent Pusa hydrogel developed by Indian Agricultural Research Institute

- Natural polymer backbone based anionic polyacrylate hydrophilic polymer
- Exhibits maximum absorbency at high temperatures
- Absorbs water 300-400 times its dry weight (pure water basis)
- Low rates of soil application : 2.5-5 kg/ ha
- Cost of Hydrogel: Rs. 1000/Kg

- Improves physical properties of plant growth media and seed germination
- Helps plants withstand prolonged moisture stress
- Reduces irrigation and fertigation requirements of crops
- Yield increase
- Increased net return in groundnut, soyabean & potato from 10-25%.

Status of Commercialization

Eight Firms given licence to manufacture and sell

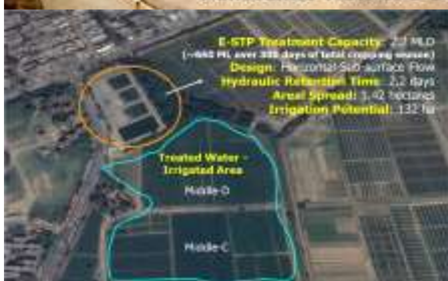


Waste Water Management

- ✓ India produces > 38,000 MLD wastewater from all the Class I cities and Class II towns
- ✓ About 74% of this is discharged untreated causing serious environmental implications.
- ✓ Wastewater irrigation is a common practice in peri-urban areas
- ✓ India - 3rd largest user of untreated wastewater (73,000 ha) after China and Mexico
- ✓ Potential irrigable land estimated at **1.1 Million Hectares**
- ✓ Emerging technologies to make best use of this resource

- ❖ Decentralised faecal sludge management business models demonstrated by IWMI
- ❖ Guidelines for reuse options and awareness.
- ❖ IARI Model for eco-friendly management and reuse of waste water

ENVIRONMENT FRIENDLY SEWAGE WATER TREATMENT FACILITY
for augmenting IARI farm irrigation water supply



- Just 1% energy requirement
- Zero-chemical application
- 50-65% reduced treatment cost

Exceptional treatment efficiency w.r.t. Turbidity (99%), BOD (87%), Nitrate (95%), Phosphate (90%), Lead (81%), Iron (99%).

Business models to turn waste into an asset

- Solid waste and fecal sludge composting in Asia and Africa could save billions of US$ per year, assuming a market for only 25% of the urban organic waste.
- Not a new concept, but many pilots not viable or sustainable
- Business models for **resource recovery & reuse** (RRR) target private and public investors and business schools.

Madhya Pradesh, India
Feasibility study completed
Waste: 40m^3 FS/day from scheduled desludging every 3 years and 12.8 tons MSW/day
Capital: INR 4.4 crores
O&M: INR 4 lakhs/month
Technology: Drying beds, DEWATS, Windrow composting and Landfill for MSW

Integrated Watershed Management


Parasai-Sindh Watershed, District Jhansi

Drought Mitigation and Integrated Development of Bundelkhand Region


Rubber Dam

Hydrponics for production of fodder

- Involves growing of plants without soil.
- Hydroponic green fodder production unit is inbuilt with a green house and a control unit for regulation of light , temperature , humidity and water
- For the production of hydroponics maize spouts, seeds should be soaked in normal water for four hours followed by draining and placing it in individual greenhouse trays for sprouting for seven days.
- Seed rate of 7.6 kg/m2 is recommended.
- Plants are harvested on 8th day and fed to the animals.
- About 5-6 kg hydroponics green fodder is produced from each kg of maize seed.



2015 DROUGHT IN MAHARASHTRA STATE, INDIA



9

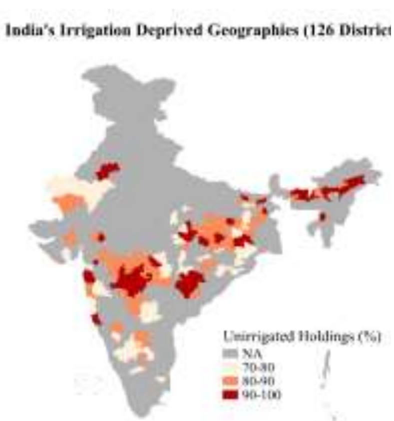

10


13

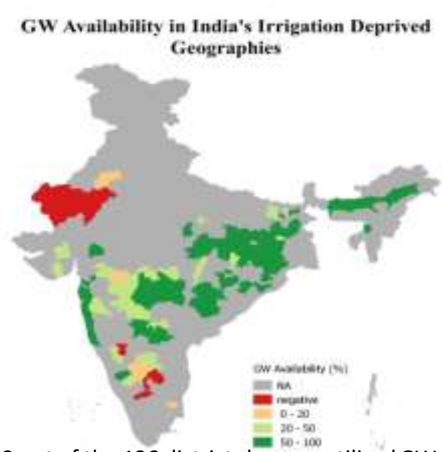

14

IWMI-TATA POLICY PAPER

India's Most Irrigation Deprived Districts



India's most irrigation deprived districts are primarily located in Central Indian Tribal Highlands, Rajasthan and the Deccan region



112 out of the 126 districts have unutilized GW potential for future irrigation development
Source: Tushaar et. Al. 2016

IWMI-TATA POLICY PAPER

Key Points & Recommendations from ITP Study

- The 30-odd DIPs on the Web shows that Chattisgarh alone requires over Rs 45,000 Cr over 2015-20, suggesting prioritization.
- PMKSY should target the 126 most irrigation deprived districts on priority basis to reach *Har khet ko paani*
- Expand irrigation access in 112 districts (out of 126) which have unutilized groundwater resource available
- Within these, target 'Irrigation-deprived' holdings
- PMKSY should focus on the Adivasi areas of Central Indian Tribal Highlands
- *Per drop more crop* will have significance only when they have access to TypwII irrigation (groundwater/surface/surface flow)
- MGNREGA for wells; solar pumps for energy
- Wastewater irrigation by design than default
- Maximise conjunctive water management

Key message

- Second Green Revolution needs to be inclusive in its coverage of small farmers, rainfed areas and eastern region, more crops and commodities, sustained use of natural resources.
- Mainstreaming of emerging innovations and technologies through on-going National/Regional/State programs/schemes for ushering in Second Green Revolution.
- Science and Technology led implementation of Flagship programs/schemes of the Government of India like PMKSY, Soil Health Card, National Mission for Sustainable Agriculture, MGNREGA, Bringing Green Revolution in Eastern India is very important for SGR
- Capacity development and knowledge management.

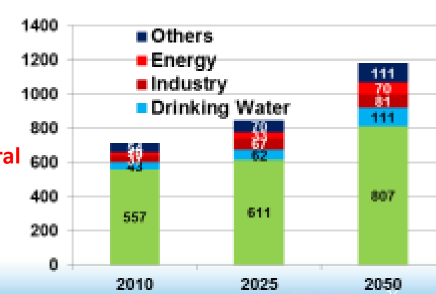
Thank you

National Agriculture & Water Resources

- ❖ Net sown area increased from 119 (1950-51) to 140 (1970-71) M ha, and still about 141 M ha.
- ❖ Net Irrigated Area 64 Mha (44%)
- ❖ Groundwater Contribution 61%
- ❖ Rainfed Area 78 Mha (56%)
- ❖ Untapped potential in rainfed areas
- ❖ Challenged to produce 345 Mt by 2030 from 141 M ha or less with less water
- ❖ Degraded land 120 M ha
- ❖ 80% small & marginal holders posses 36% land –Core of Indian Agriculture

Challenged with water shortage, degrading natural resources and access of water to small holders

- ➢ Irrigation uses 83% of water, diversion of water to agriculture expected to reduce (72% by 2025)
- ➢ Likely further reduction due to climate change
- ➢ **LOW Irrigation Efficiency (≈38% in MMI Projects)** and 65-70% in ground water
- ➢ Attributed to *inefficient management of irrigation* systems



INDEX-BASED FLOOD INSURANCE IN INDIA TO ENHANCE AGRICULTURE RESILIENCE AND FLOOD PROOFING LIVELIHOODS

CGIAR · Research Program on Climate Change, Agriculture and Food Security · CCAFS · MAFF

http://ibfi.iwmi.org/

- Setting up pilot-scale trials to demonstrate that positive verifiable impacts emerge from IBFI in terms of agriculture resilience and improving productivity, and household incomes, locally and at the broader scale
- Developing tools and strategies that support IBFI development and upscaling, integrated with existing and future flood control measures.

Project Period: 2015 - 2018
Pilot Districts : Muzaffarpur, Darbhanga, Samastipur

Partners: International Food Policy Research Institute (IFPRI), Indian Institute of Technology (IIT)-Gandhinagar, Indian Institute of Water Management (IIWM-ICAR)*; Agriculture Insurance Corporation of India, MoA; Bajaj Allianz, Insurer, Swiss Reinsurance

Key Agricultural Activities for Managing Risks

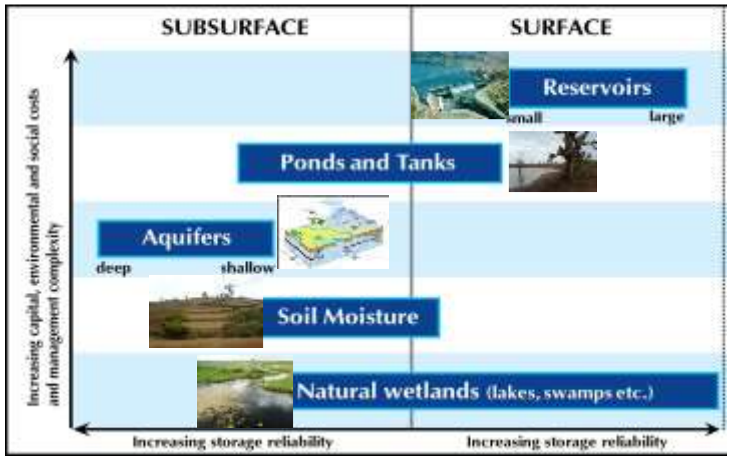
CLIMATE SMART VILLAGE / FARM

Weather	- Seasonal weather forecast - ICT based agro-advisories - Index based insurance - Climate analogues
Water	- Aquifer recharge - Rainwater harvesting - Community management of water - Laser leveling - On-farm water management
Carbon	- Agroforestry - Conservation tillage - Land use systems - Livestock management
Nitrogen	- Site specific nutrient management - Precision fertilizers - Catch cropping/legumes
Energy	- Biofuels - Fuel efficient - Residue management - Minimum tillage
Knowledge	- Farmer-farmer learning - Farmer networks on adaptation technologies - Seed and fodder banks - Off-mark risk management kitchen garden

Apply Smart Water Solutions under Varying Agro-hydrological Situations

Water Storage Continuum

Source: McCartney & Smakhtin 2010



Smart farming

'smart' is not only about technology,

also about smarter ways of doings things and help in precision farming,

Geospatial technological developments facilitated by Global Navigation Satellite Systems (GNSS), unmanned aerial vehicles (UAVs), robotics, communications, sensory and other data acquisition technologies are representative of these technologies.

Management of Waterlogged Saline soils