Dryland Agriculture: Issues and Strategies

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Sectorial Scenario, Impact and Future Vision

Central Research Institute for Dryland Agriculture

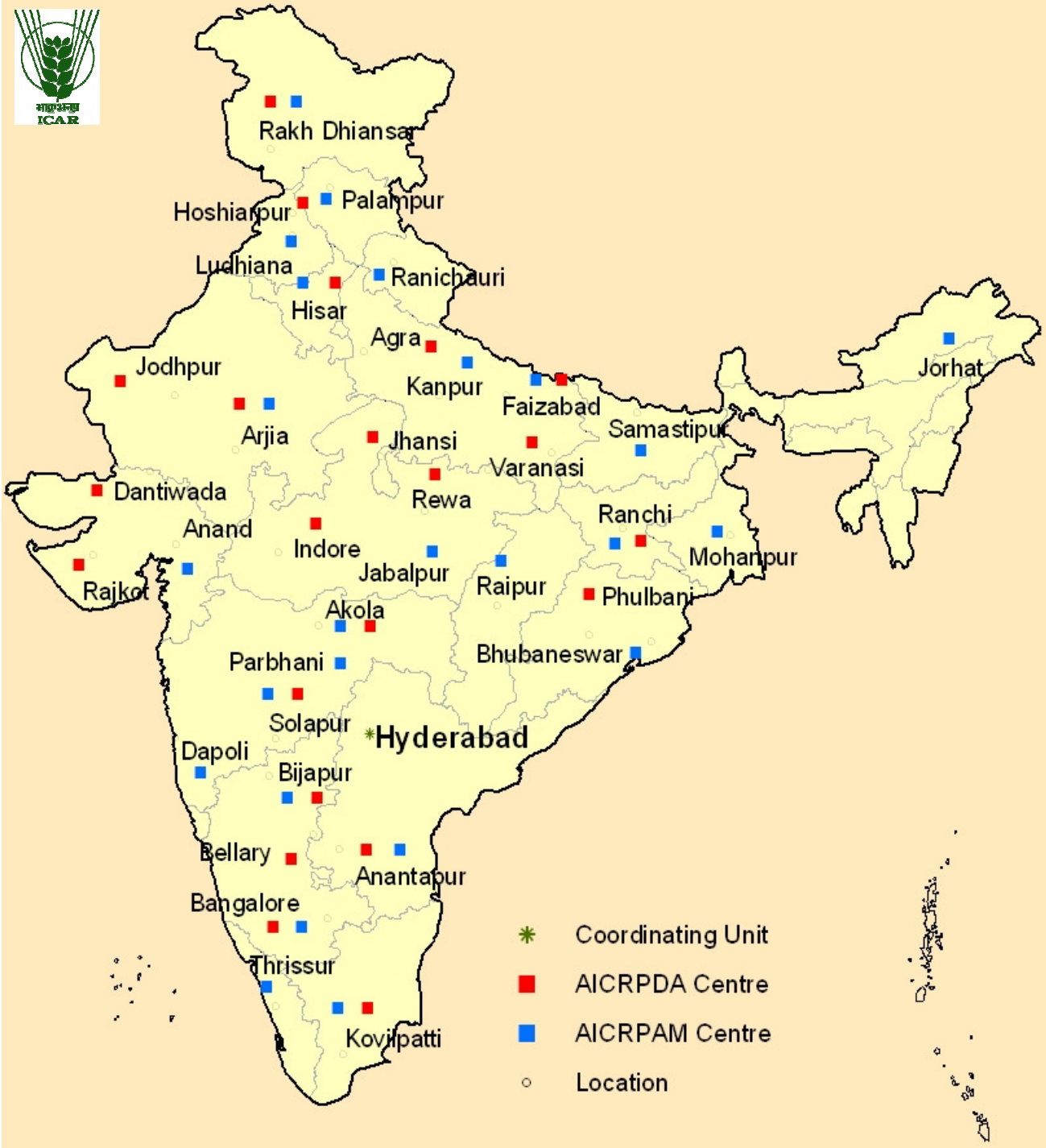
With

AICRPS

- **All India Coordinated Research Project for Dryland Agriculture**
- **All India Coordinated Research Project on Agrometeorology**

Network Project on Climate Change (23 centres)

National Initiative on Climate Resilient Agriculture (NICRA)



Dryland Agriculture Co-operating Centres 22

Agromet Co-operating Centres 25

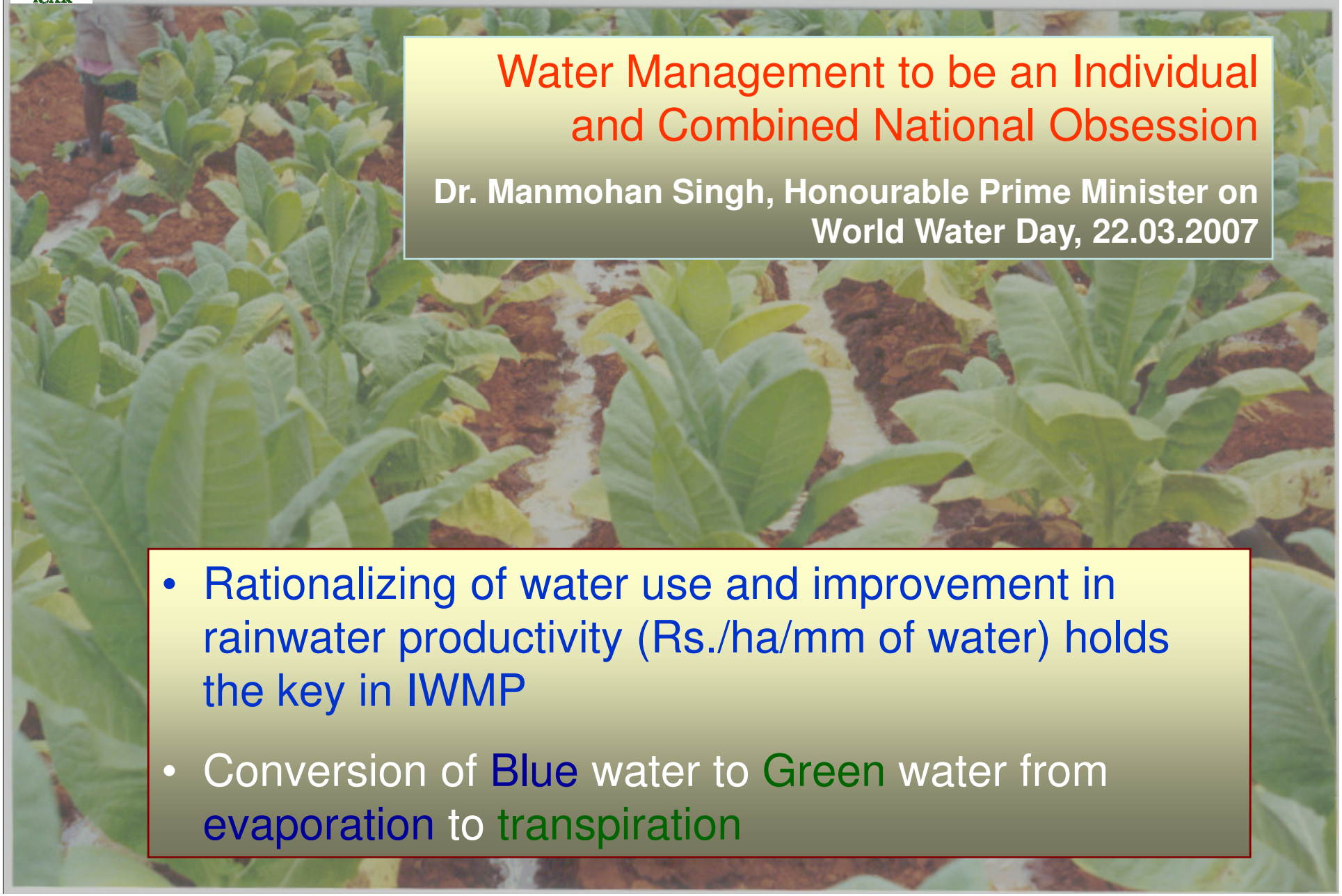
Rainfed Agriculture in India

- Supports 40% human population and 2/3rds of livestock
- 90% coarse cereals, 87% pulses, 74% oilseeds, 65% cotton and 48% rice are rainfed
- Diverse climate, soils and cropping systems
- Poor economic status of farmers

Current Scenario of Rainfed Agriculture

Parameter	Global	Indian
Area	1.13 billion ha (73%)	80 (58%)
Productivity	Developed – 2 - 3 tons Africa - 0.9 tons	0.8 – 1.2 t/ha
Contribution to total food	60%	41%
Commodity focus	Largely for animal feed or export, bio fuel	Largely for food and edible oils
Natural Resource status	Predictive and evenly distributed, low ET, moderate to high OC	Skewed, erosive and very high ET, low OC
Institutional support	Strong public policy, high subsidies, large holdings & commercial orientation	Small holders, subsistence orientation, weak institutional and credit support

WATER–SECURE INDIA



Water Management to be an Individual and Combined National Obsession

Dr. Manmohan Singh, Honourable Prime Minister on World Water Day, 22.03.2007

- Rationalizing of water use and improvement in rainwater productivity (Rs./ha/mm of water) holds the key in IWMP
- Conversion of Blue water to Green water from evaporation to transpiration

Future Scenario (next 10 years)

- Increased frequency of droughts and other extreme events with changing climate
- Major shifts in cropping pattern/crop mix driven by weather and economic drivers
- Increased soil erosion and floods due to high intensity rainfall
- Shortage of green fodder and more demand for feed and concentrates
- Acute labour shortage and sharp demand for mechanization of all operations
- Increased dependence on ground water in rainfed areas
- Operational holdings may not support household livelihood security of small and marginal farmers leading to more migration

Critical Areas to be Addressed in Watersheds

- Technologies to cope with high intensity droughts and other extreme weather events
- Rainwater management including groundwater recharge with focus on demand management to enhance productivity at farm level
- Small farm mechanization to overcome labour shortage
- Diversified cropping/farming systems for risk minimization and meeting household income needs

Technologies Transferred/ Popularized during the last 10 Years

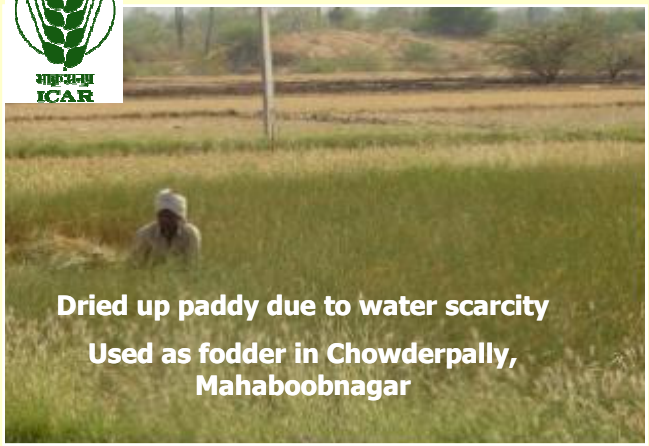
1. Land Treatment Across Rainfall Zones, Soil Types to Conserve Moisture *In situ*
2. Efficient Farm Implements for timely planting and interculture
3. Profitable cropping systems including agro-forestry model for pulp wood production

1. Land Treatment Across Rainfall Zones, Soil Types to Conserve Moisture *In situ*

Practice	Target Area	Adoption Rate (%)	Benefit (Rs/ha)
Broad bed furrow/ ridge furrow planting	Malwa region	75	3000-5000
Conservation furrow	Alfisol regions of southern plateau	20	800 -1000
Ridge and furrow planting of upland rice and redgram	Eastern U.P/ Vindyan plateau	25	2500-3000
Compartmental bunding	Vertisol regions of North Karnataka	10	1500-2000
Ridge and furrow across slopes	Sandy soils of Haryana, vertisols of Maharashtra, eastern Rajasthan etc.	15	1000-1500

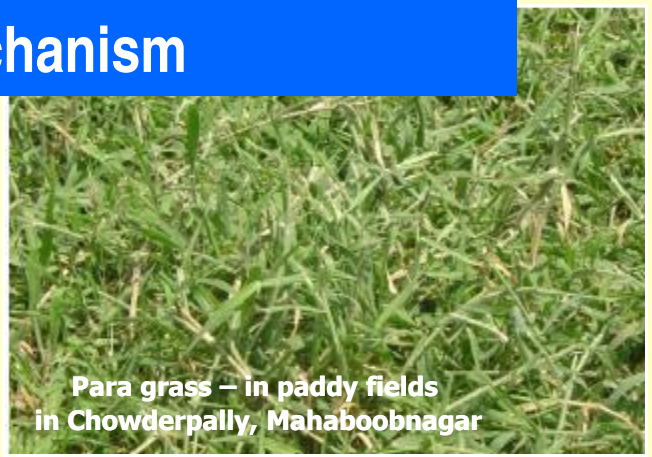
Land Treatments for In situ Moisture Conservation

Efficient Use of Water – ID crops promotion and a need for incentive mechanism



Dried up paddy due to water scarcity

Used as fodder in Chowderpally, Mahaboobnagar



Para grass – in paddy fields in Chowderpally, Mahaboobnagar

Chickpea crop – Alternative to paddy

Fingermillet in paddy fields in Chowderpally, Mahaboobnagar

Crop	Water Requirement	Area equivalent to of paddy(ha)
Paddy	1200	--
Groundnut	400	3.0
Maize	400	3.0
Chickpea	250	4.8
Fingermillet	400	3.0

2. Efficient Farm Implements for timely planting and interculture

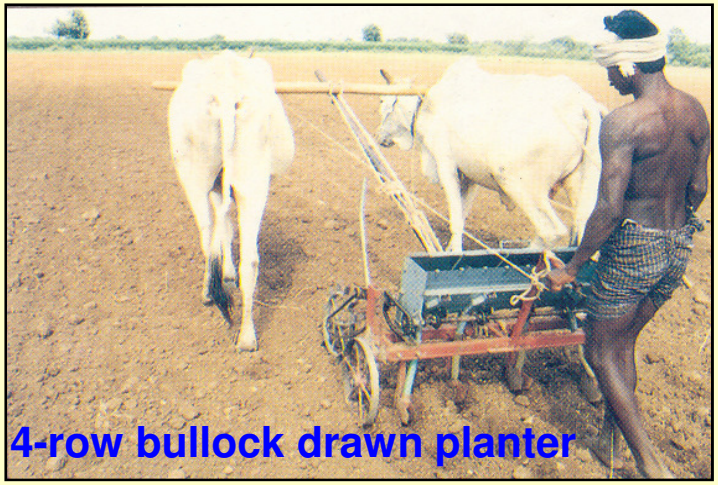
- CRIDA along with SAUs designed and commercialized 12 implements for rainfed crops
- Two patents granted and 3 filed
- Designs licensed to 12 industries in 7 states
- More than two lakh ha area covered so far
- Very large scope to promote through custom hiring under IWMP

Some of the implements widely adopted by farmers


9-row planter


Groundnut stripper


Rotary weeder


4-row bullock drawn planter

Impact of Mechanization

Crop	Yield increase (%)	Reduction in cost of production (%)
Castor	23	45
Cotton	22	34
Sorghum	36	38
Groundnut	18	20
Finger millet	35	32
Redgram	18	35
Soyabean	20	35
Maize	27	33

3. Intercropping systems that optimize rainfall and land productivity

Economic Impact of Efficient intercropping systems

System	Target domain	Adoption rate	Impact (Addl. Net Income Rs/ha)
Groundnut + Pigeonpea (7:1)	Rayalaseema	70% of the total groundnut area (8.5 lakh ha)	3,000
Cotton + Sorghum + Pigeonpea+ sorghum (6:1:2:1)	Vidarbha	40%	5,000 – 8000
Maize + pigeonpea (1:1)	Orissa	40%	2,600
Sorghum + pigeonpea (2:1)	Telangana	40%	1,500
Fingermillet + pigeonpea (10:1)	South Karnataka	20%	2,500
Pearlmillet + pigeonpea (2:1)	Sholapur region	35%	3,000
Maize –wheat + Raya (2:1)	Kandi region of Punjab	38%	2,500
Maize + blackgram (2:2)	Southern Rajasthan	63%	3,000-4,000
Pearlmillet + castor (2:1)	North Gujarat	15%	2,500-3,000

4. From Farm Forestry to Agroforestry

- The agroforestry model (paired row intercropping) developed by CRIDA changed the entire concept of pulp wood plantations from farm forestry to agroforestry models
- ITC has been popularizing this model across the country

Intercropping alongwith Subabul

Other important achievements

1. Formulated contingent plans/disseminated through Institute/ICAR Website

2. Established agro-advisory system through SAUs

3. Capacity building of IWMP personnel. Evaluation of NABARD and Indo-German watershed projects.

4. Developed GV technology for castor semi-looper and microbial inoculants for heat stress tolerance in plants. Zn solubilizing organisms identified (IPM & INM).

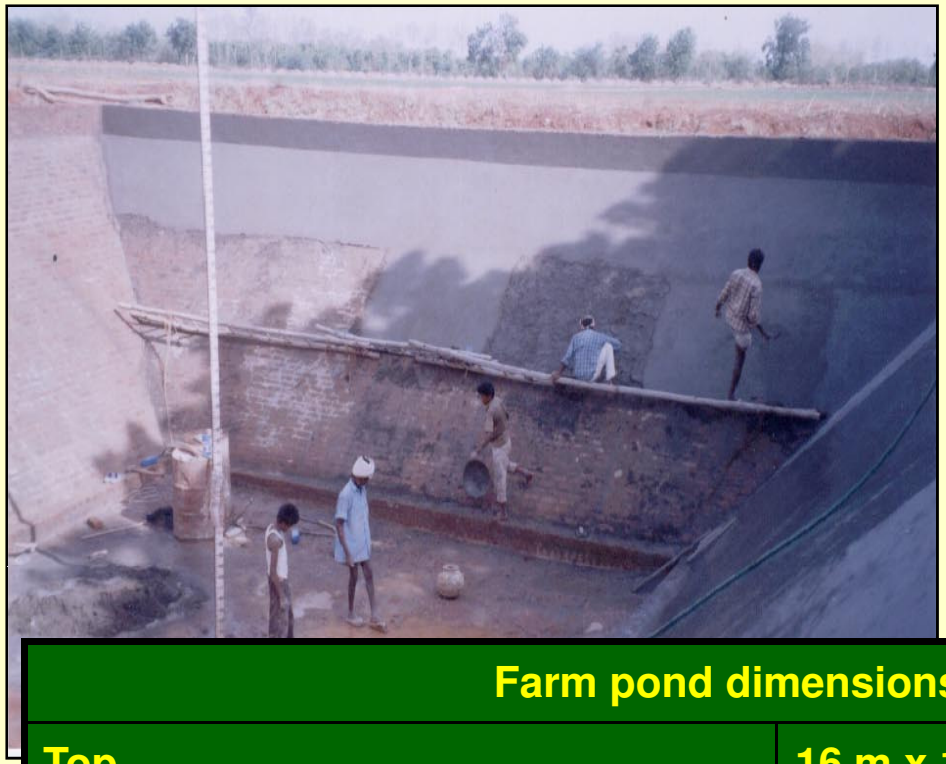
5. Developed DSS for drought monitoring for AP

6. Evolved innovative models of convergence at village level for water harvesting interventions through NREGA under NAIP

Pond water for Life Saving Irrigation using low-lift Portable Pump

Portable pump sets of 1.5 hp petrol-start diesel engines are suitable for 1 ha farm size for sprinkler irrigation.

Farm pond under construction



Brick and cement lined farm pond in Prakasam district, A.P., payback 7-10 years

Farm pond dimensions	
Top	16 m x 16 m
Bottom	8 m x 8 m
Depth	4.5 m
Volume	650 m^3
Cost of digging, lifting and lining	Rs. 1.0 lakh per pond (2003)
Catchment area	2.0 ha
% area of pond to total area	1.3

25% increase in yield of FCV tobacco

Issues to be addressed in watershed programme

WATERSHED PROCESS

Water is driver of nature while watershed as driver of rainfed agriculture

1. **Conceptualization – Futuristic**
2. **Characterization - Realistic**
3. **Planning – High tech & Participatory (HRD)**
4. **Design of component systems – Scientific & Local wisdom (HRD)**
5. **Implementation- Participatory &, Contributory (HRD)**
6. **Monitoring & Evaluation – Participatory and external**
7. **Withdrawal Mechanism – Policy frame work and Revisit**

Conceptualization – Futuristic

Watershed development and management **is not one time job** – continuous monitoring and support is needed in the context of livelihoods and improving the resource and production base in the changing climate scenario.

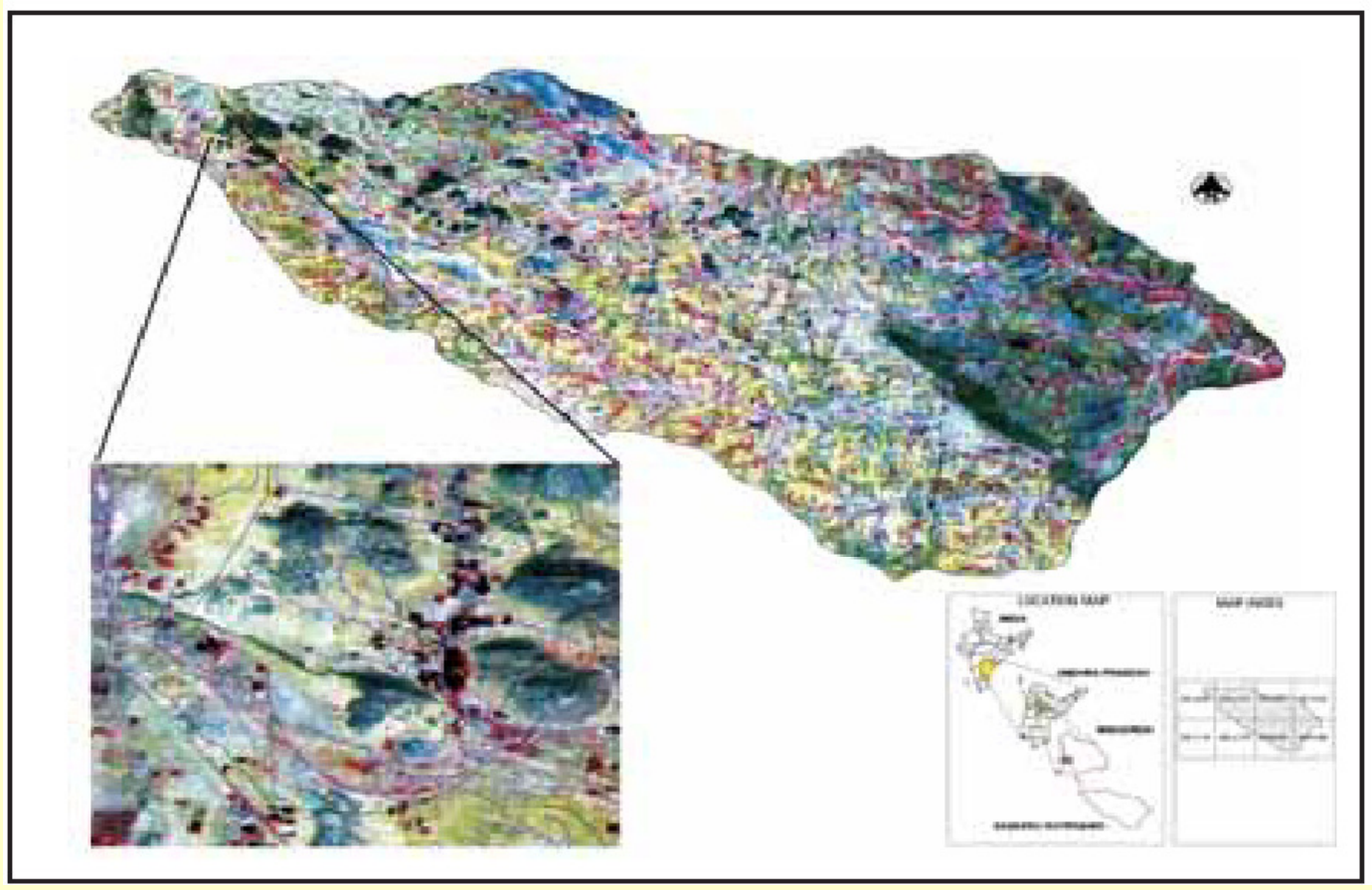
The developmental initiatives are dynamic in nature -
fixing a vision to-day and dumping all resources for an unforeseeable future events like Climate Change, E-governance, Global market, Organic farming, natural farming, ITKs, MGNREGs etc. ?

The natural processes should be dealt slowly but steadily.

Characterization - Realistic

- Essential for planning, monitoring and evaluation
- Higher emphasis on socio-economic but less on bio-physical resources, needs balanced approach.
- 1% of budget is earmarked for DPR preparation under new guidelines but this is low when new tools like RS, GIS & GPS are employed alongwith geo-hydrological studies.
- Presently more focus on conservation than on production: crop productivity, soil health improvement, livestock issues need specific attention.
- Exploration of livelihood opportunities – forward and backward linkages

Planning



Use of remote sensing in delineation and planning of micro watershed – Scale effect in participatory net planning? Technology limitations?

In reality no expertise is available with many PIAs to procure, analyse, ground truth and use the presently available RS data for planning purpose

4. Design of components

No

Professionalism ?

Lack of ownership of the programme as most officials are on deputation

Yes

HRD - Limitations

- HRD is essential for the staff executing the programme. At present, very few PIAs having professional competence
- Professionalism is lacking as there is no institutional mechanism that can sustain the interest of staff over a longer period for making their career
- Remuneration/honorarium/salary, etc. paid to the staff (in rural settings) are very less compared to their counterparts in organized sector in urban areas. This does not encourage a professional to join watershed team though this involves a challenging work
- Capacity building and awareness of not only farmers but also for staff (those implementing) at regular interval

TECHNICAL

- ITKs should find a place in the technical programme at planning stage
- Most sites in watersheds showing medium to high level of P, therefore soil-test based fertilizer management has to be introduced/encouraged
- Soil health card is a must (beyond NPK) matching to land use for achieving the goal of precision agriculture
- Incentive for biomass generation to reduce dependence on fertilizers as it is labour intensive (support from MGNREGs)

- Participatory water budgeting and ground water monitoring should form a part of planning process. In the budget, special provision for gauging of major and minor streams should be taken up. A rain guage has to be installed in each *Gram Panchayat*

- Social regulations are more theoretical than practical. More on paper than on ground

- Bench mark watersheds to be developed & maintained on long term basis in collaboration with NARS for budgeting natural resources and the impact on livelihoods in the changing climate scenario. They will serve as models for research, development, demonstration and capacity building purpose

Administrative Cost

- Though 10% is allocated in the plan but, when any R&D institution is planning to develop a Model Watershed, the amount is not available – this weakens the linkage for such Development Initiatives.

- Formally no budget is available for R&D head

NB: Study shows that about 26% budget is needed for administrative expenses

LINKAGES

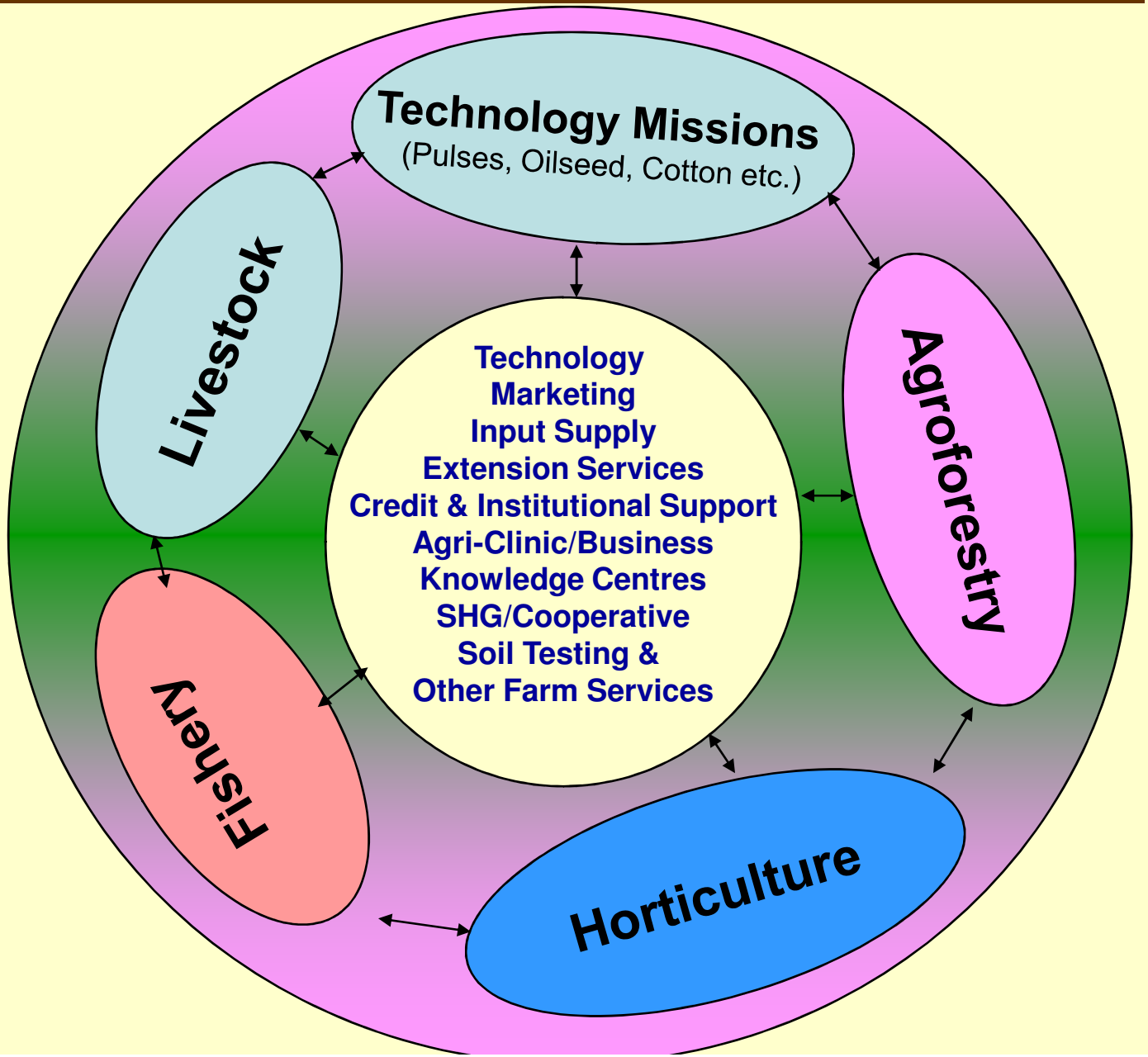
- **WS demands not only multi-disciplines but also multi-institutions – What is the reality ?**

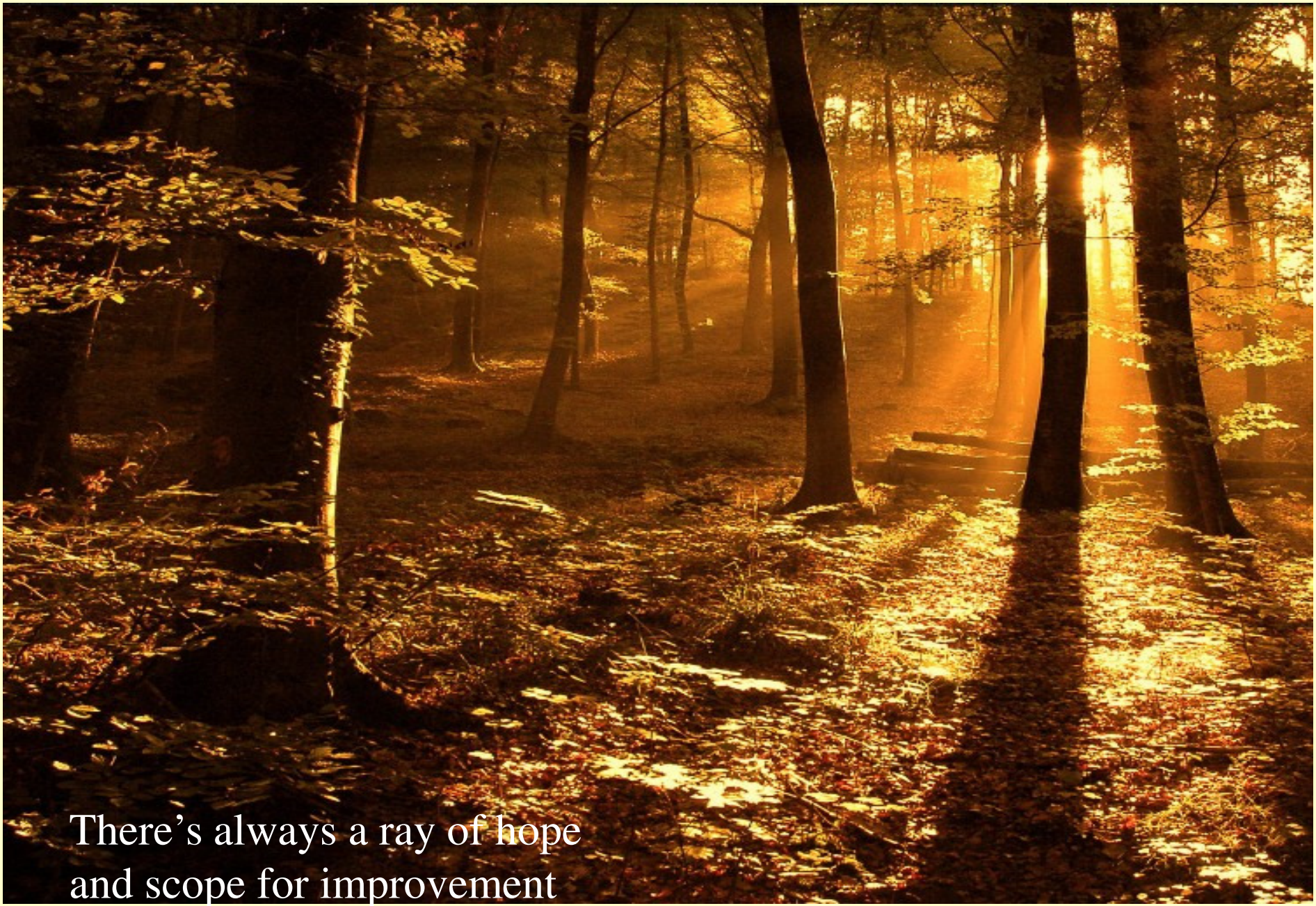
- **Consortium approach is the best way but mostly preached, therefore, delegate roles and responsibilities to the partners alongwith allocation of money – should be more formal**

- **Linkage with Revenue Department for updating of land record-cadastral map in GIS mode and Ground Water Department for planning of structures.**

- **Provision of separate fund for planning and monitoring to R&D Institutions (earlier it used to be 2.5% under NWDPRA)**

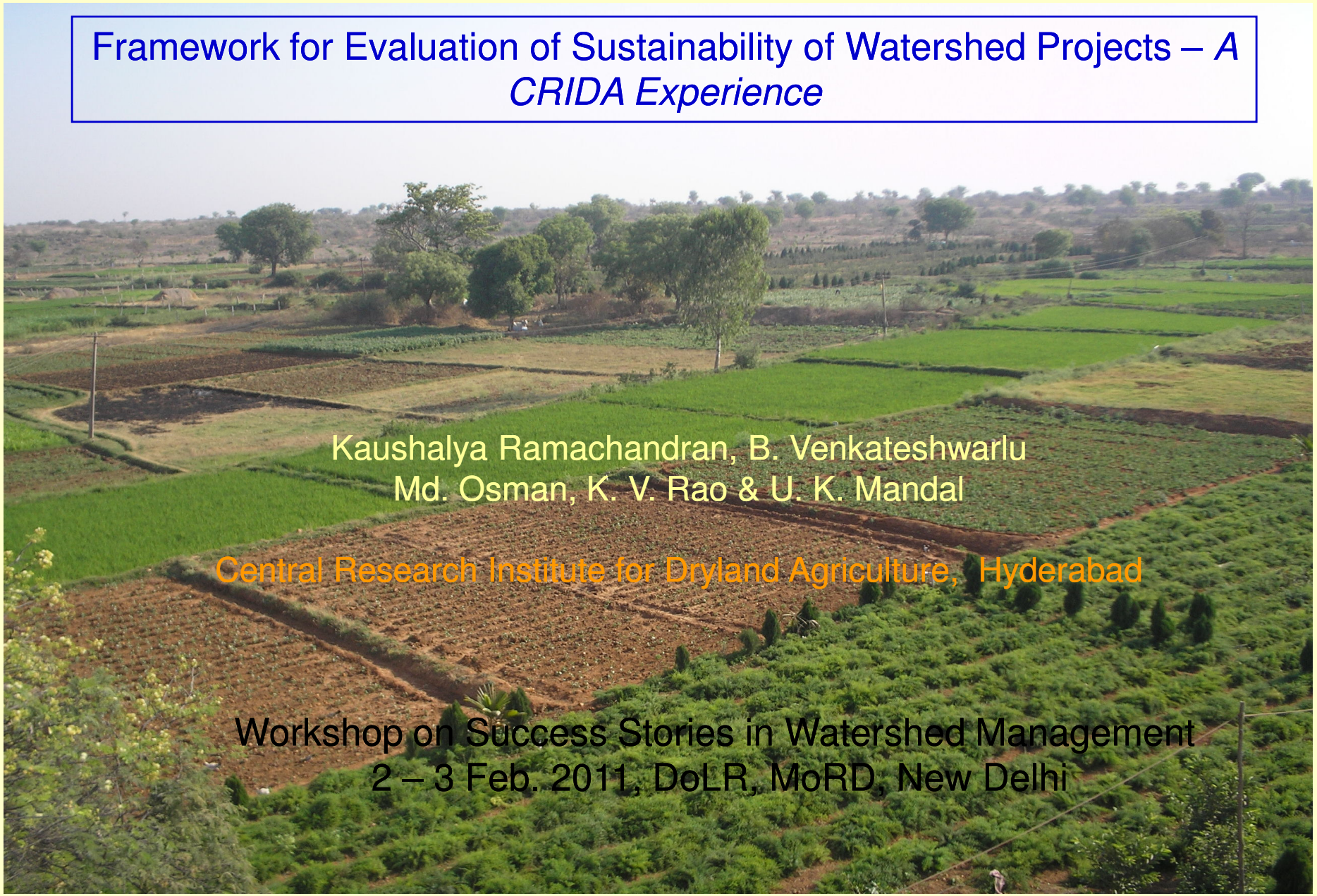
Convergence on watershed platform





THANK YOU

Framework for Evaluation of Sustainability of Watershed Projects – *A CRIDA Experience*



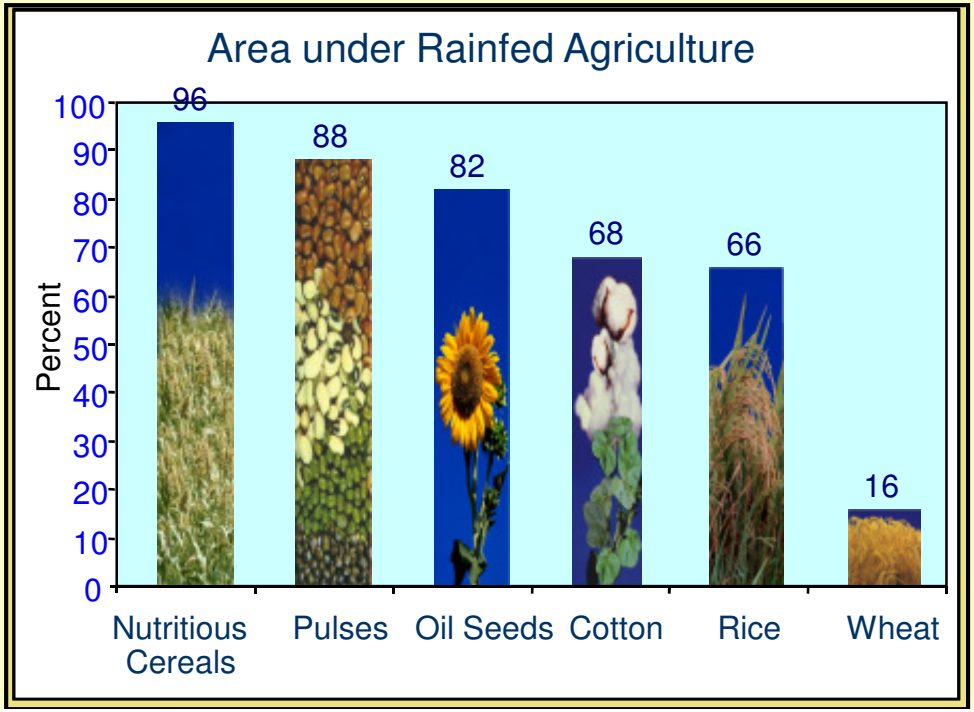
Kaushalya Ramachandran, B. Venkateshwarlu
Md. Osman, K. V. Rao & U. K. Mandal

Central Research Institute for Dryland Agriculture, Hyderabad

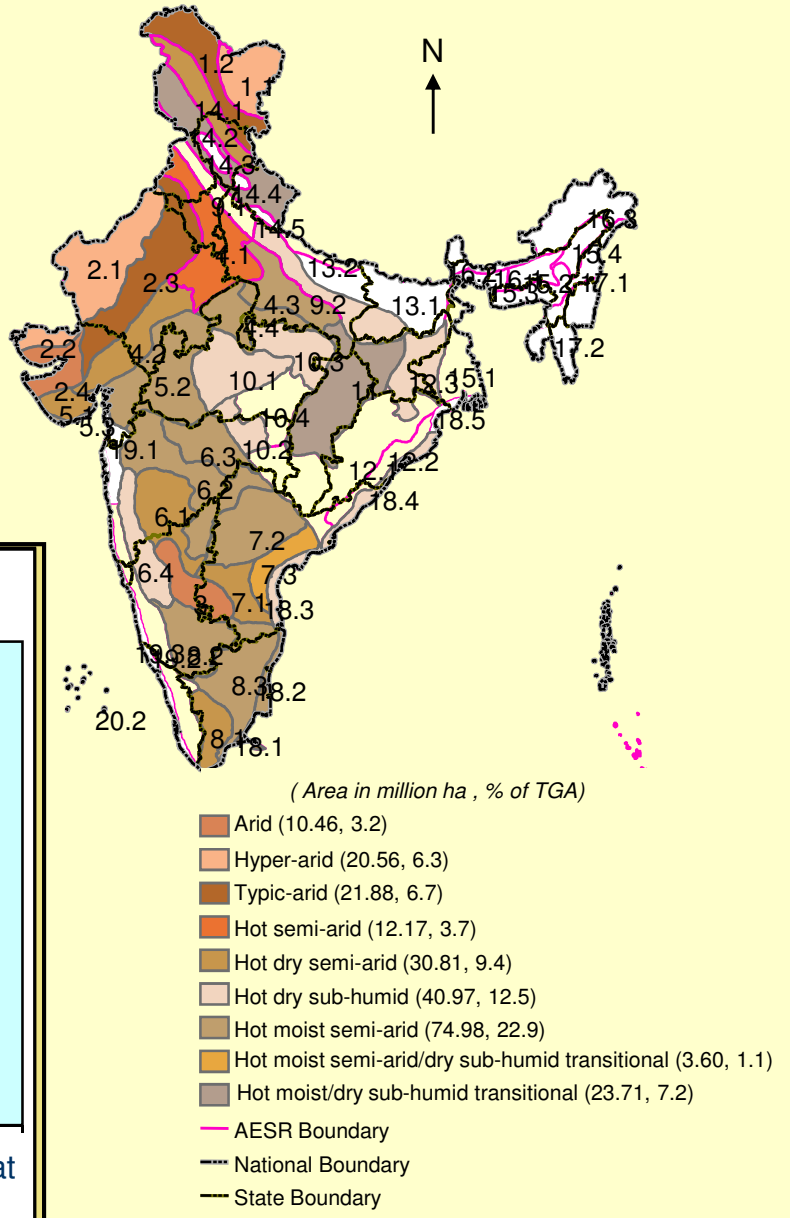
Workshop on Success Stories in Watershed Management
2 – 3 Feb. 2011, DoLR, MoRD, New Delhi

Importance of Rainfed Agriculture to India

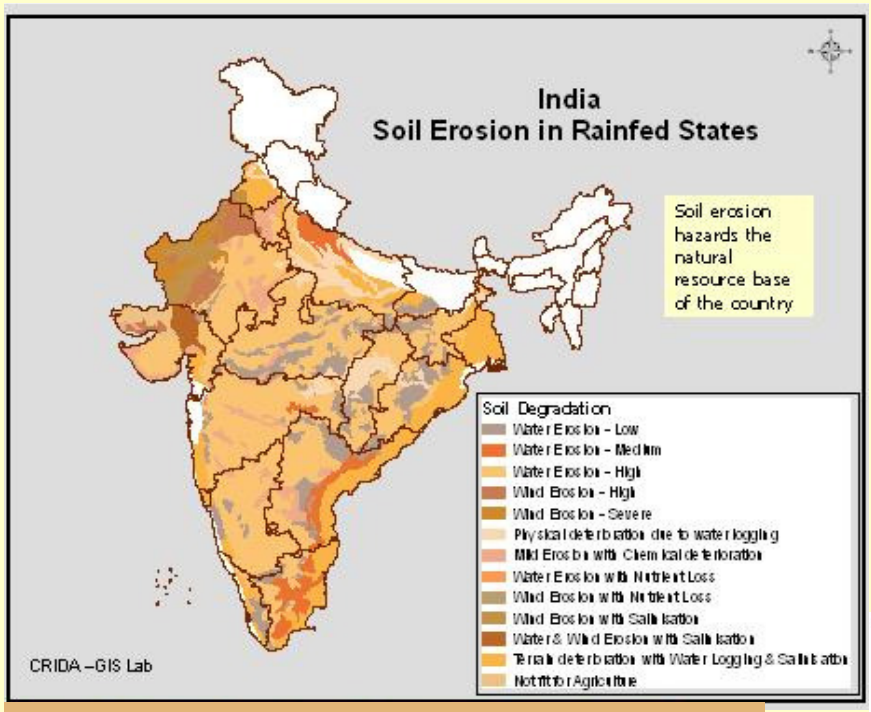
- 65% / 92 m ha of net sown area in India is rainfed
- It contributes 42% of food crops
- Supports 40% of population
- Feeds two out of every three cattle in the country



India - Extent of Rainfed Agriculture

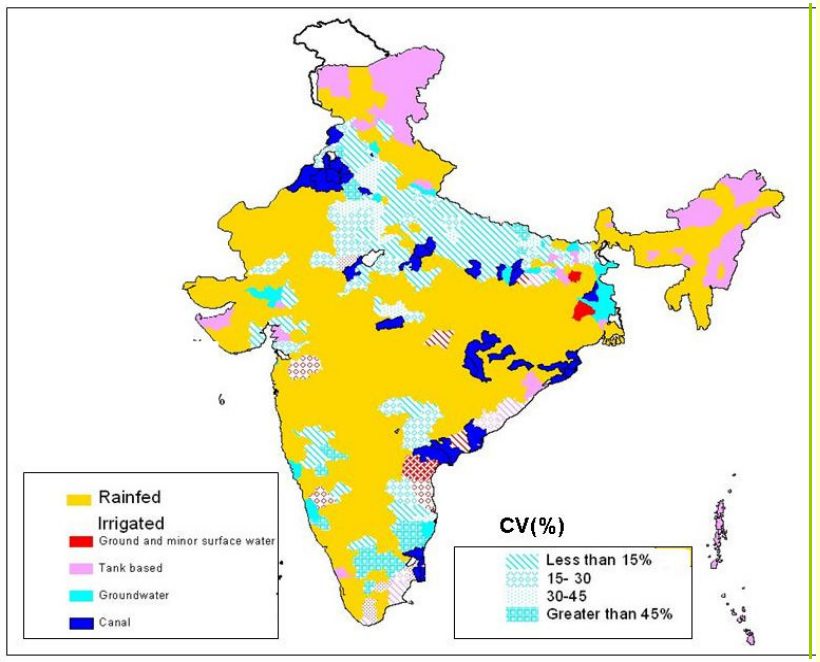


Challenges in Rainfed Region



Source: India map(SOI 2003) Soil Degradation Data(NBSS & LUP 1999)

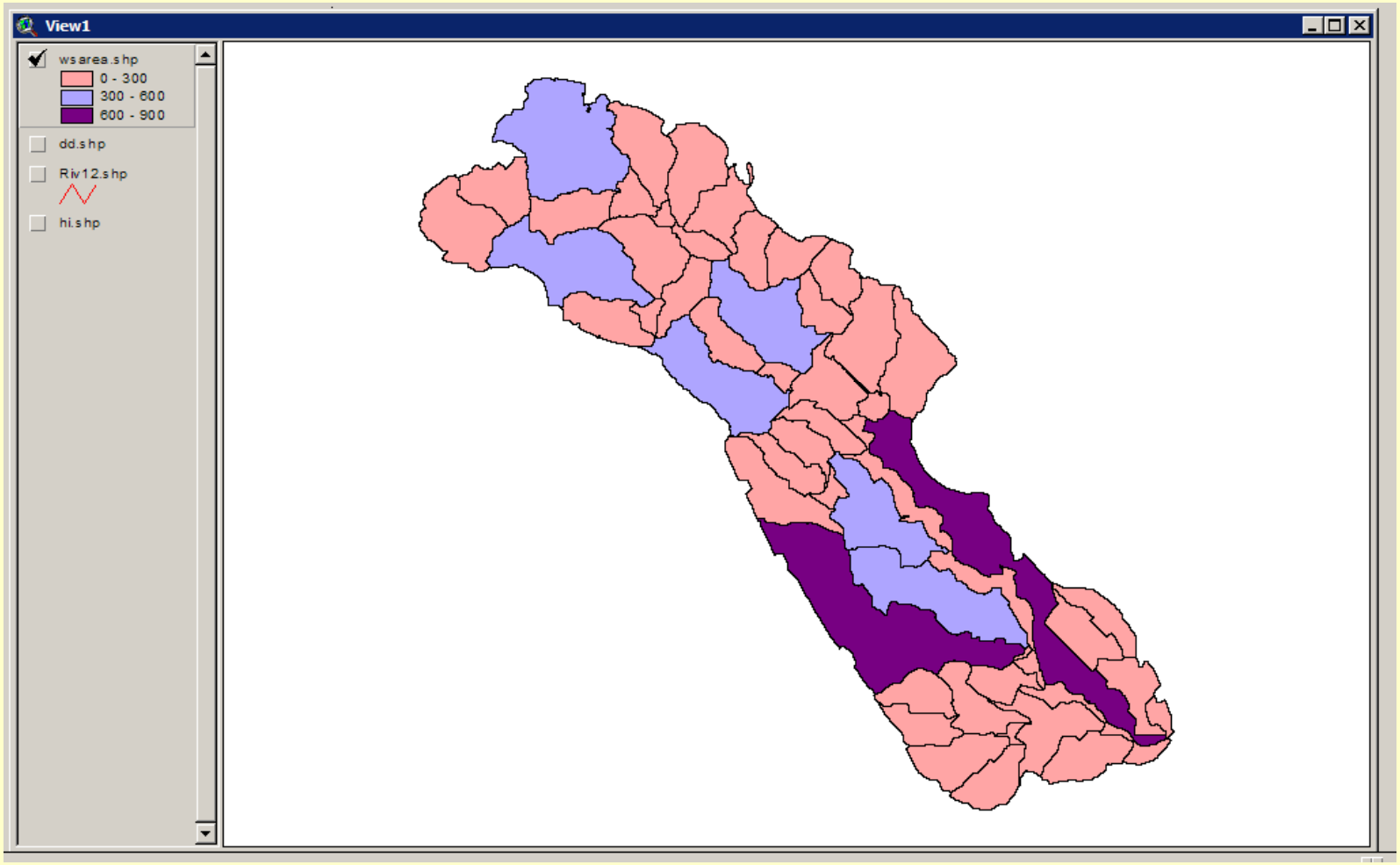
Extent of irrigation in India



Scope of application of GIS & RS for Watershed Management

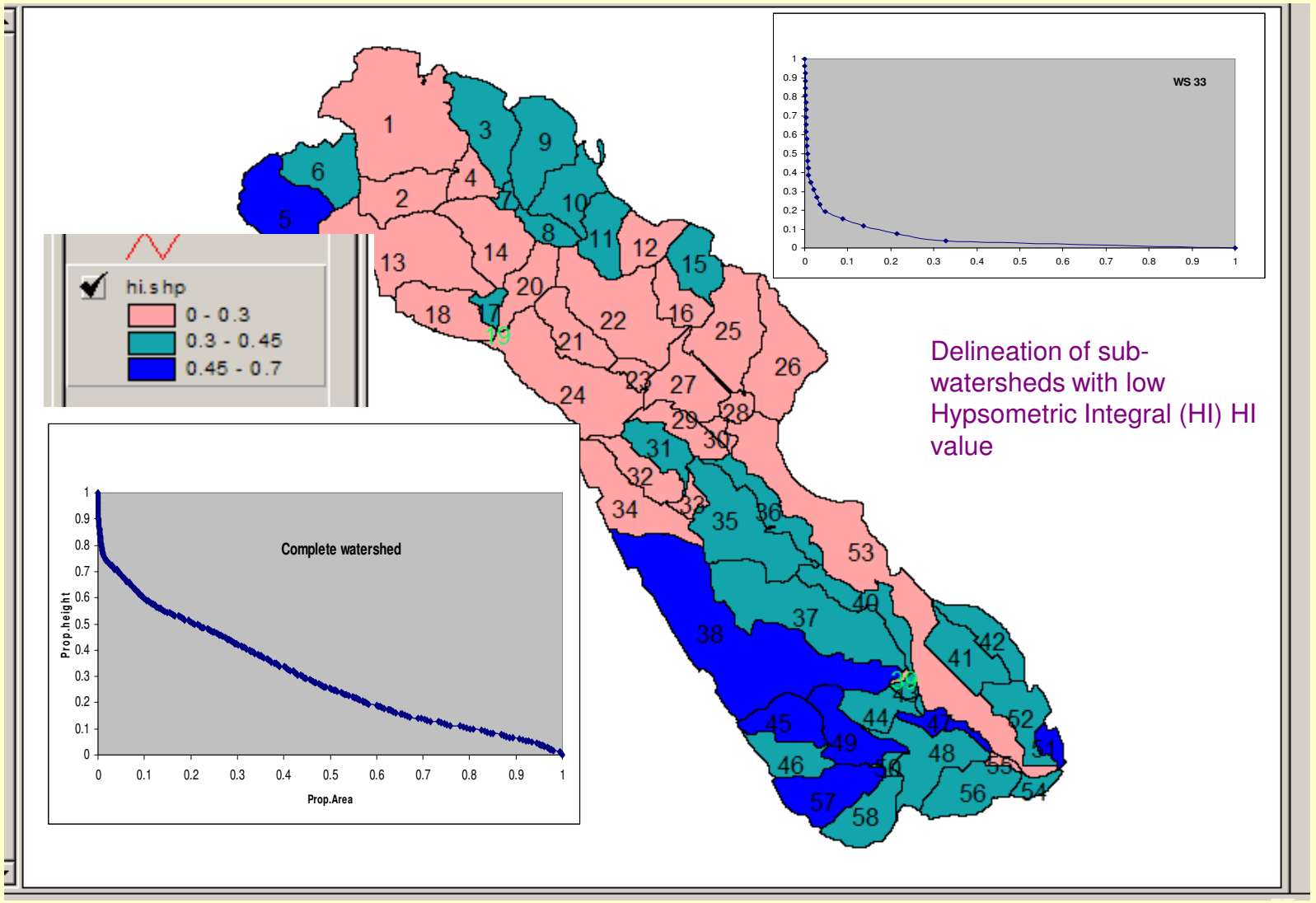
- To delineate the watersheds
  - *Automated Watershed delineation*
- Prioritize watersheds based on runoff and erosion potential
  - *Drainage basin morphological analysis, stream order, drainage density, basin slope & shape, circularity, cumulative area distribution, hypsometric curves*
  - *Identification of vulnerable areas*
  - *Rainfall-runoff modeling*
- Management strategies for interventions to reduce resource losses - *Stability analysis*
- Implementation of development program in rainfed areas for resource conservation
  - *Land use planning*

Automatic delineation of watersheds from DEM of 100 km^2 area using ArcGIS



K.V. Rao et. al. 2009

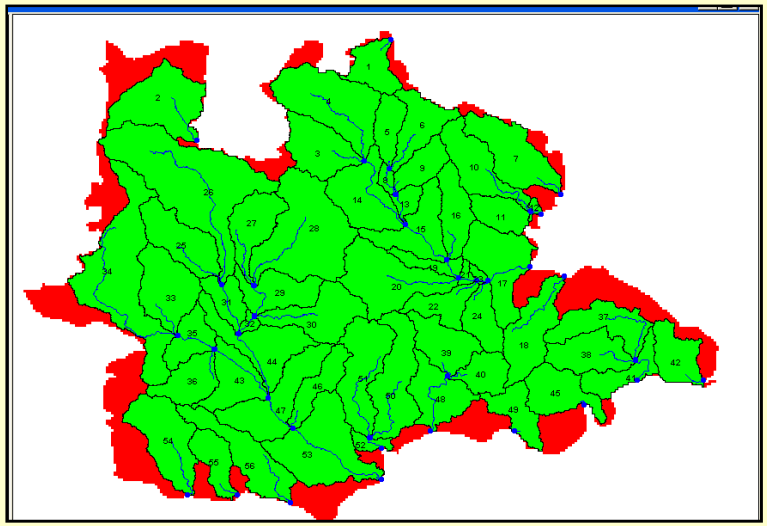
Sub-watershed prioritization based on erosion status

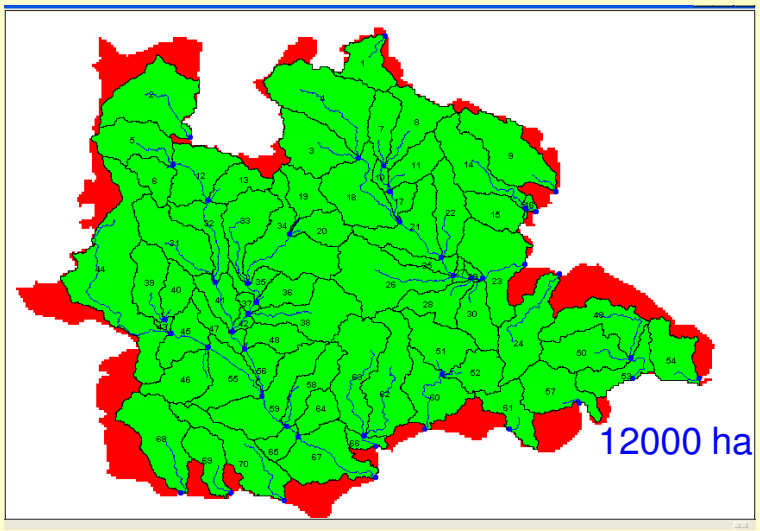


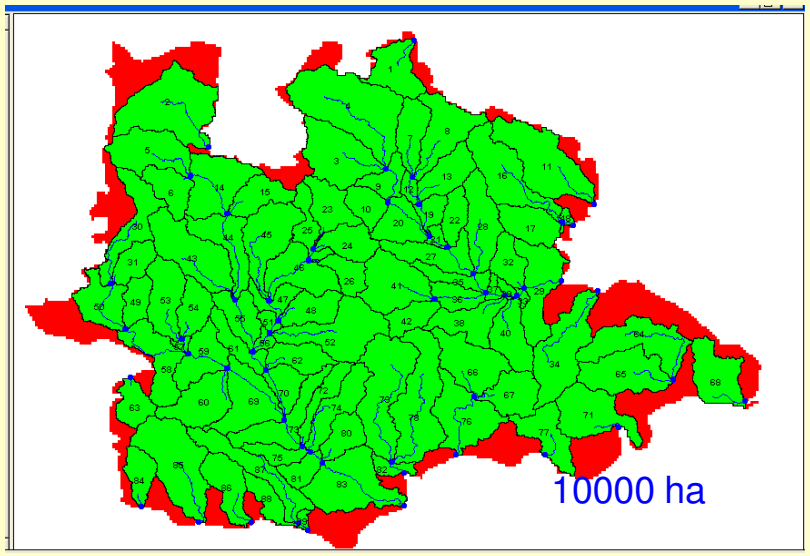
Qualitative prioritization of sub-watersheds based upon drainage density & HI values using SRTM data

K.V. Rao et. al. 2009

Automated delineation of watersheds – case study of Mahabubnagar district

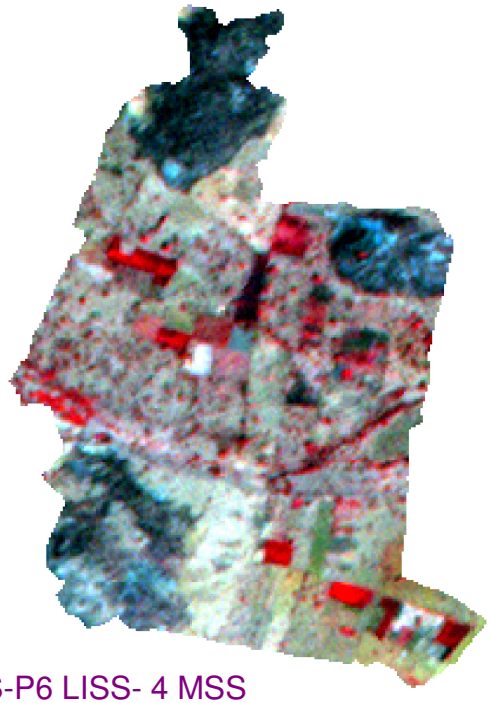






K.V. Rao et. al. 2009

Use of satellite image with varying ground resolution - Sakaliseripalli watershed

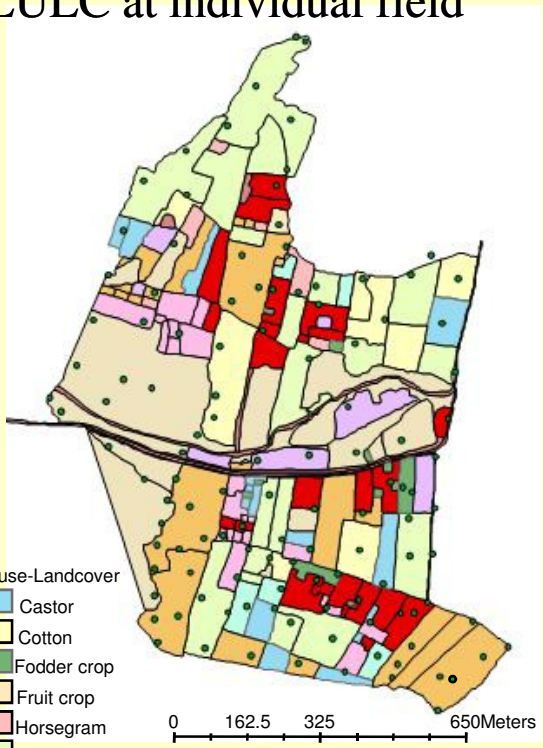


IRS-P6 LISS- 4 MSS
image 16 Feb 2009

Quickbird MSS image
16 March 2009

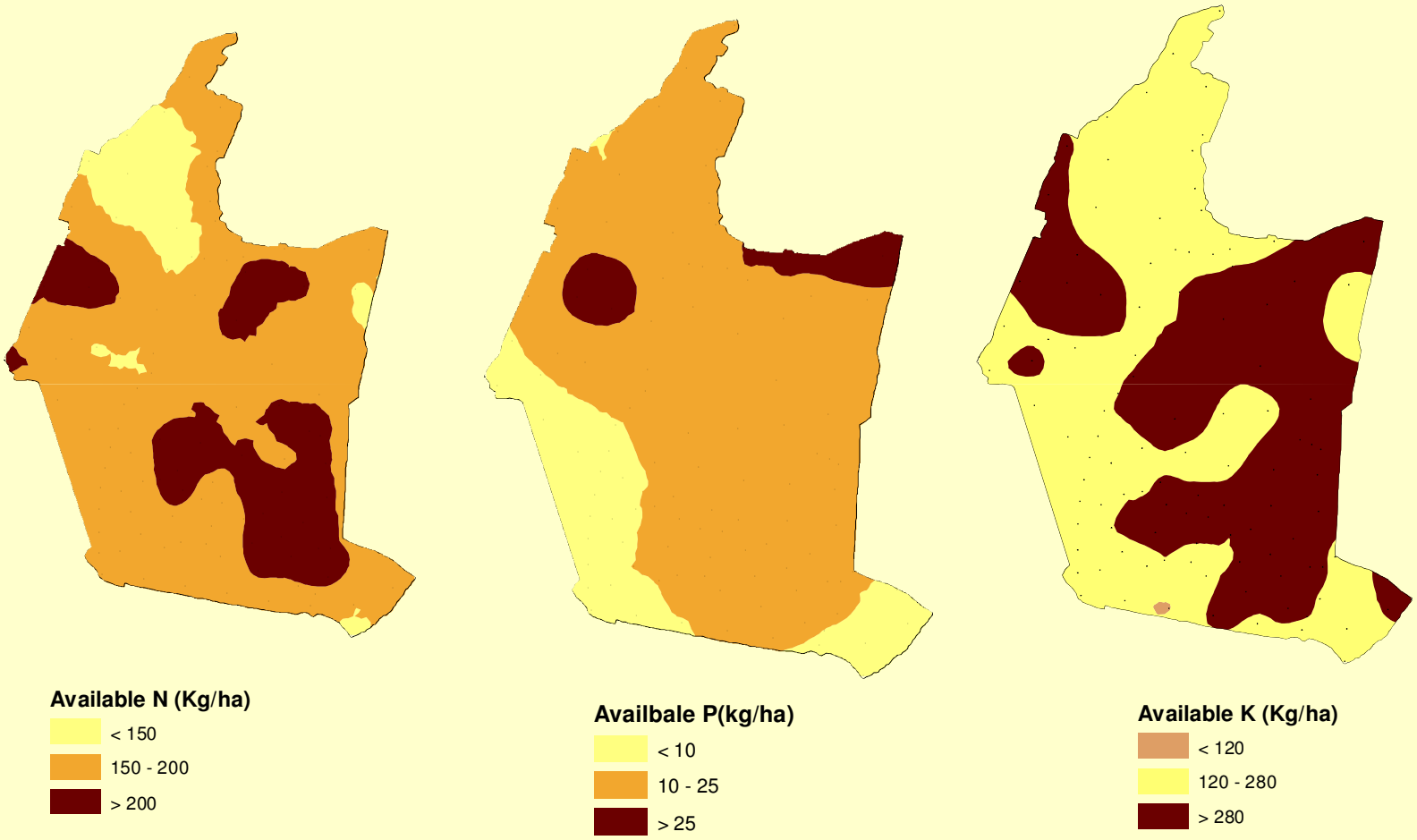
0 0.1 0.2 0.4 Kilometers

LULC at individual field



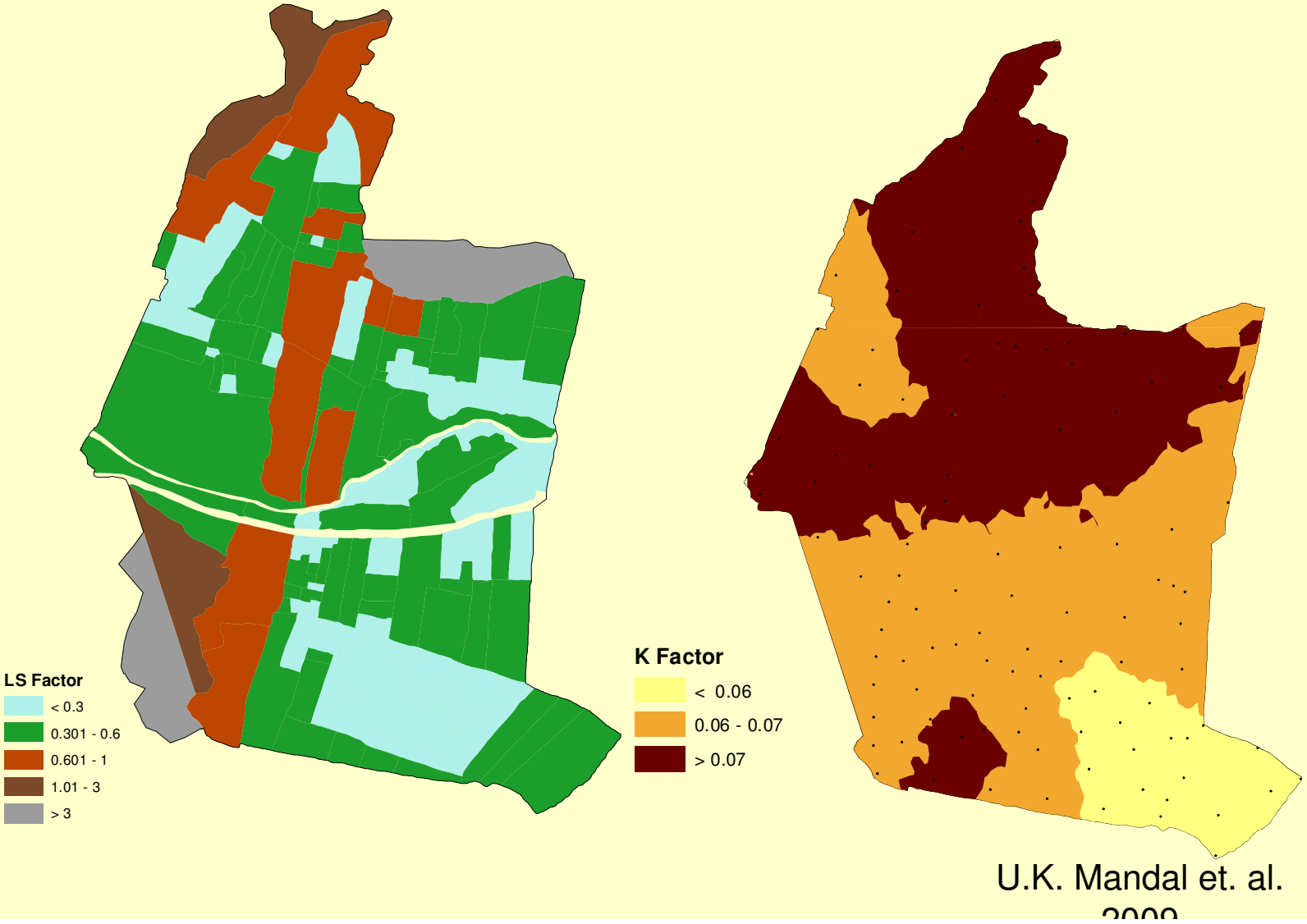
U.K. Mandal et. al.
2009

Kriging of Major Nutrients using ArcGIS



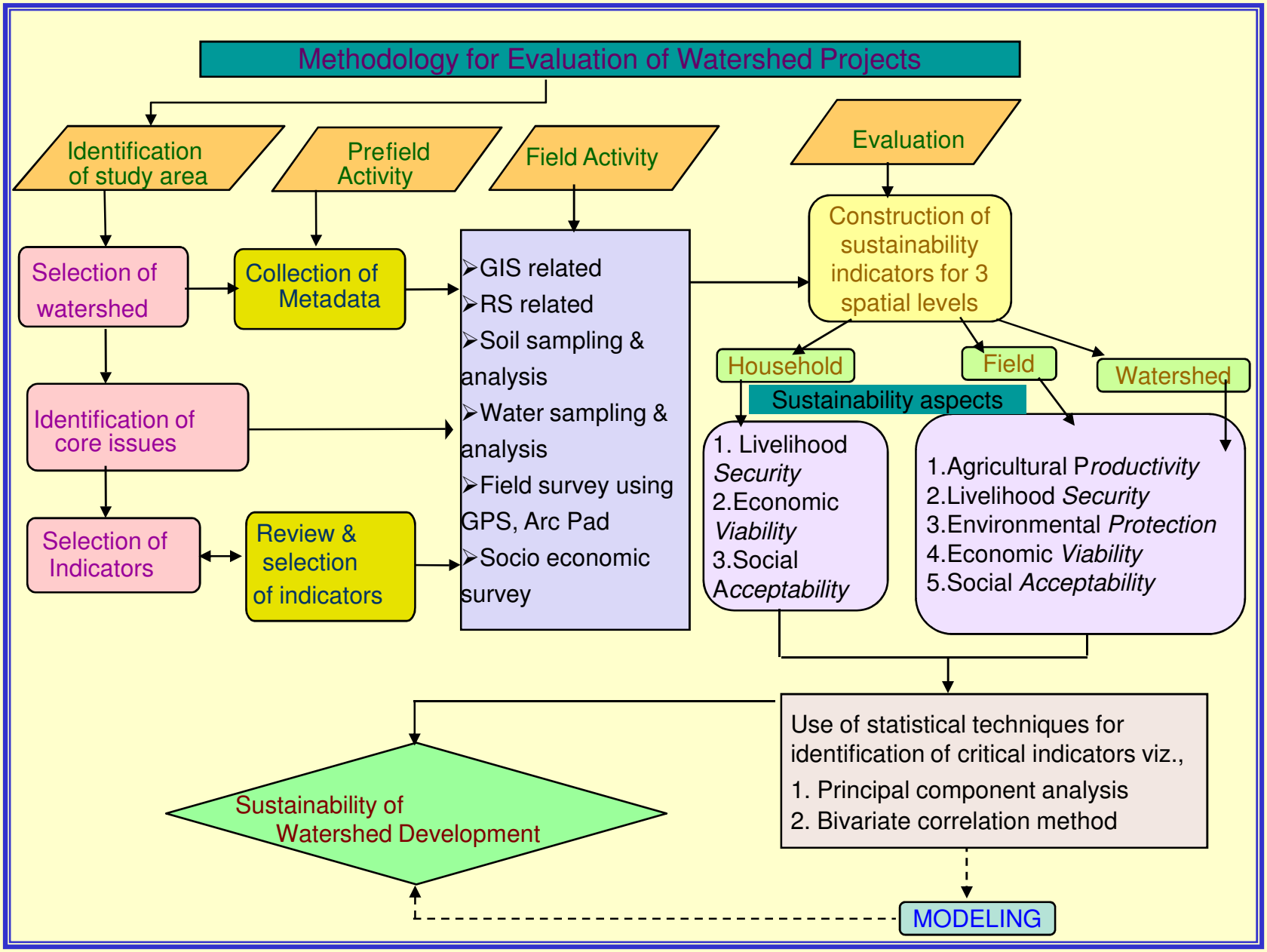
U.K. Mandal et. al.
2009

Estimating LS Factor (derived within GIS using elevation information) & Soil Erodibility

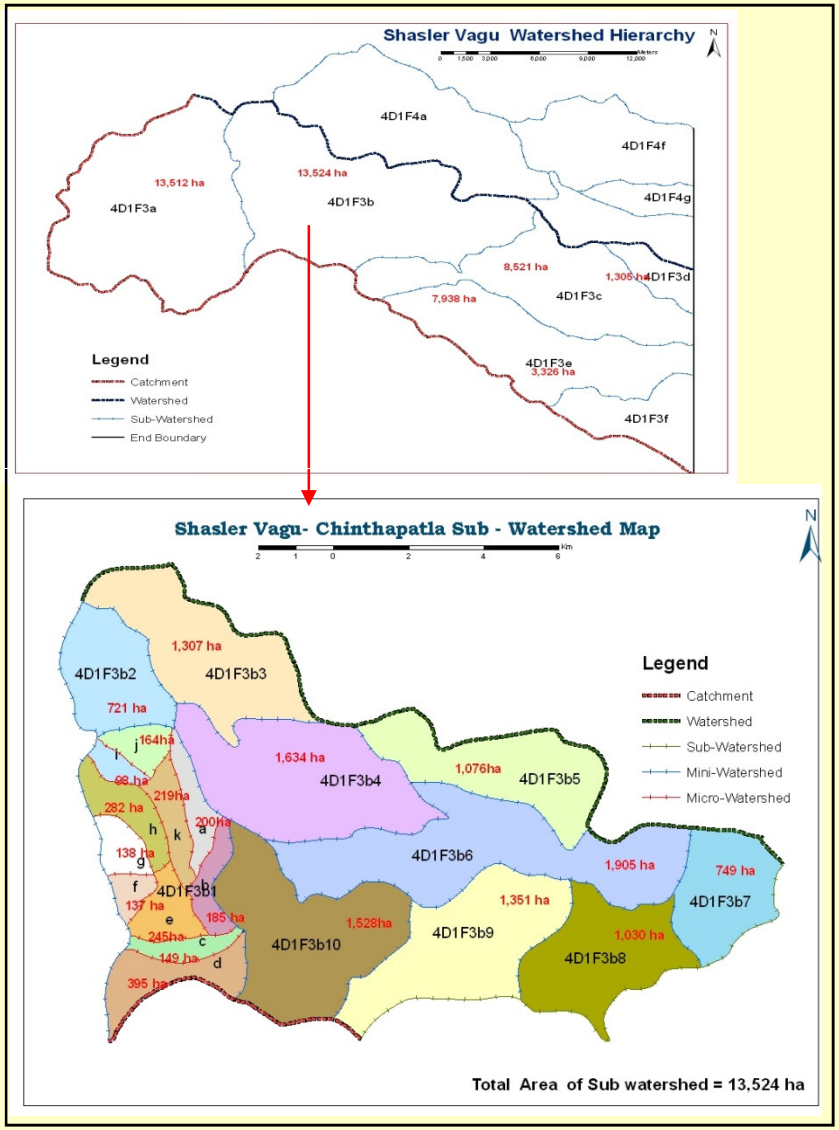


U.K. Mandal et. al.
2009

Monitoring & Evaluation of Watershed Projects


Methodology for Evaluation of Watershed Projects
Identification of study area
Prefield Activity
Field Activity
Evaluation
Selection of watershed
Collection of Metadata
GIS related
RS related
Soil sampling & analysis
Water sampling & analysis
Field survey using GPS, Arc Pad
Socio economic survey
Construction of sustainability indicators for 3 spatial levels
Household
Field
Watershed
Sustainability aspects
Identification of core issues
Selection of Indicators
Review & selection of indicators
1. Livelihood Security
2.Economic Viability
3.Social Acceptability
1.Agricultural Productivity
2.Livelihood Security
3.Environmental Protection
4.Economic Viability
5.Social Acceptability
Use of statistical techniques for identification of critical indicators viz.,
1. Principal component analysis
2. Bivariate correlation method
Sustainability of Watershed Development
MODELING

Delineation of micro-watersheds & up-linking with regional watershed hierarchy



Watershed hierarchy – coding system

Description of Sample No. **(4D1E8a4c)**

4 D1 E 8 a 4 c

- c → Micro-watershed.
- 4 → Mini-watershed
- a → Sub-watershed
- 8 → Watershed
- E → Sub-catchment
- D1 → Catchment
- 4 → Basin
- 4 → Region

List of sustainability indicators constructed for the study

S. No.	Level / Spatial extent of analysis	No. of suitable indicators used	Pillars of Sustainability				
			Agricultural Productivity	Livelihood Security	Environmental Protection	Economic Viability	Social Acceptability
1	Household level	20	0	11	0	7	5
2	Field level	29	11	22	15	20	11
3	Watershed level	35	14	27	17	22	15
*4	Village level	43	-	-	-	-	-
*5	AESR level	8	-	-	-	-	-
	Total no. of unique indicators	51	14	29	17	25	17

* FUTURE ANALYSIS

Geo-referencing check-dam

Setting GPS base-station

Initialization of spectro-radiometer

Measuring spectral reflectance

Sustainability Indicators measurable from satellite data

S. no.	Land quality / Sustainability Indicator	Field level	Micro watershed level	Village level	AESR level
1	**Felling of trees / Deforestation rate**		C, F	C, F	B ,C ,F
2	**Change in Land Cover**	C, F	C, F	C, F	B, C, F
3	**Change in Land use**	C ,F	C, F	C ,F	B, C, F
4	**Land degradation**		C ,F	C, F	B ,C ,F
5	**Decrease in waste land**				B ,C ,F
6	**Slope**	C, F	C, F	C ,F	B ,C ,F
7	**Soil erosion**		C, F	C, F	B ,C ,F
8	**Soil quality mapping**		C, F	C, F	B ,C, F
9	**Efficacy of S & WC measures**		C ,F	C, F	B ,C, F
10	**Type of Vegetation cover**		C, F	C, F	B ,C ,F
11	**Change in density of vegetation**		C ,F	C, F	B ,C, F
12	**Estimation of bio-mass**		C, F	C, F	B ,C, F
13	**Impact of drought**		C, F	C, F	B, C ,F
14	**Impact of flood**		C ,F	C, F	B ,C ,F
15	**Crop diversity index**		C, F	C ,F	B, C, F
16	**Production / Yield**	C, F	C ,F	C ,F	B ,C ,F
17	**Water quality**		C, F	C, F	B ,C, F
18	**Change in surface water spread**				B, C, F

B - Baseline
C - Current
F - Future

Collecting geo-referenced soil sample

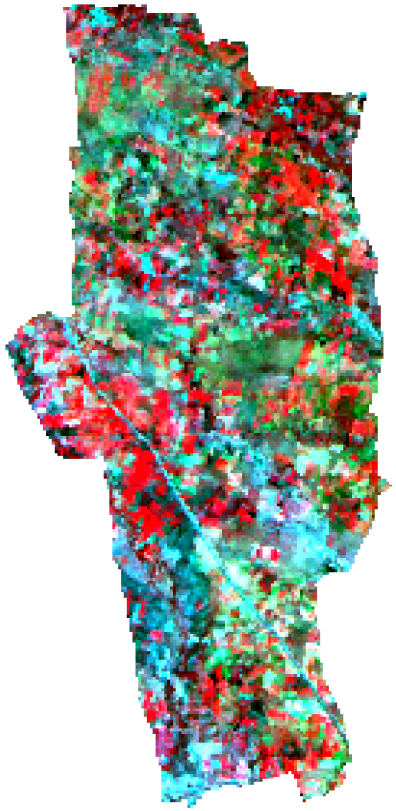
Updating field boundary using GPS

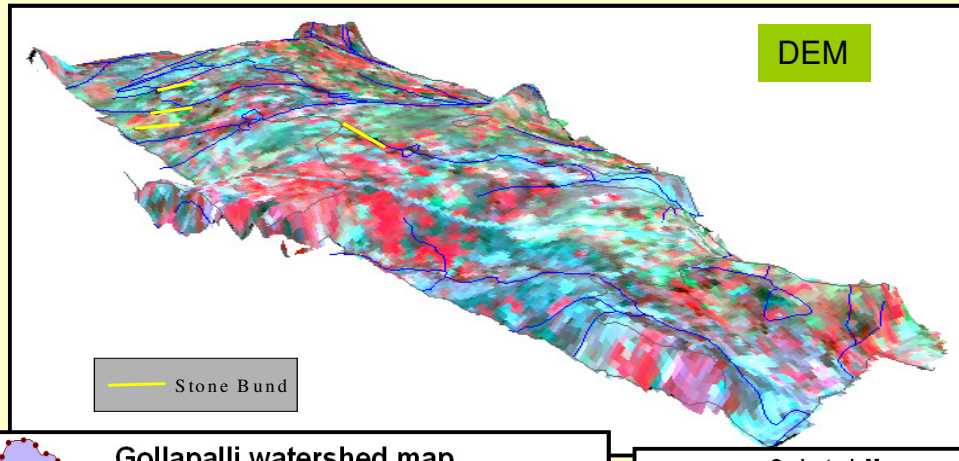
Survey at farmers field

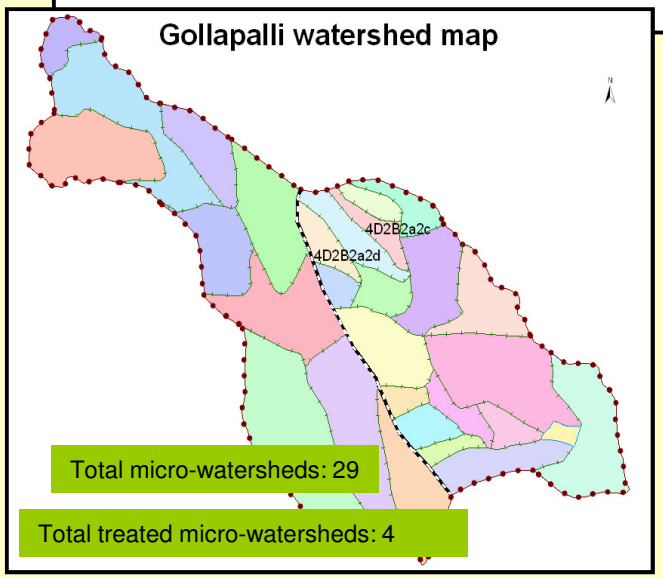
Discussion with watershed committee

Measuring Sustainability Indicators

Gollapalli Village
LISS III IRS 1D November 2004 Image

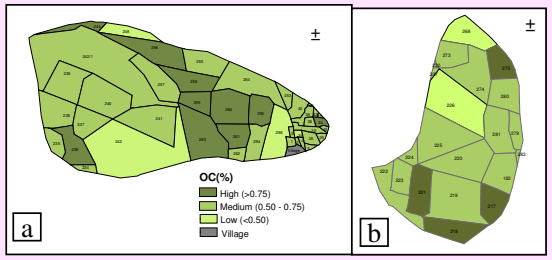




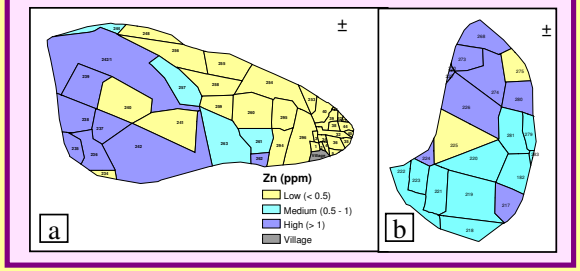


Mapping soil fertility status – *quantification of indicator*

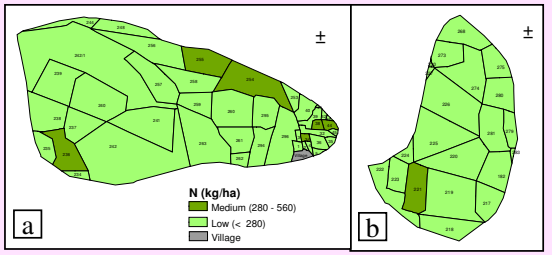
Soil Organic Carbon

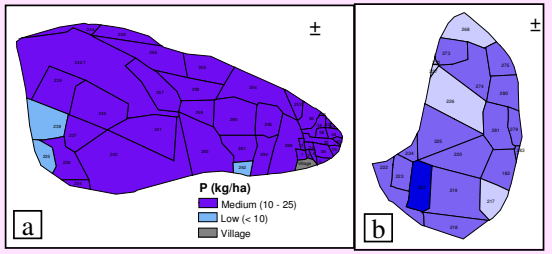


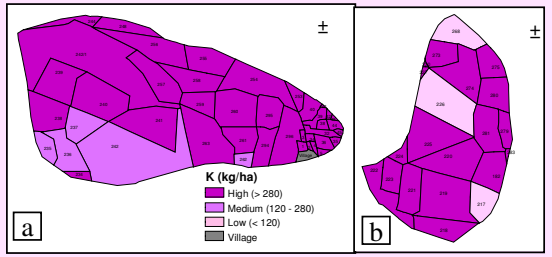
Micro-nutrient: available - Zinc



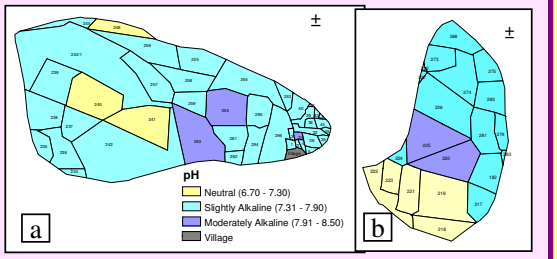
Major nutrients: available – NPK

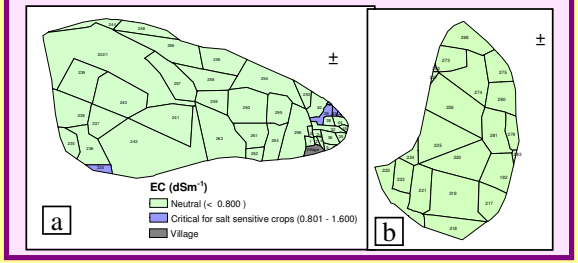




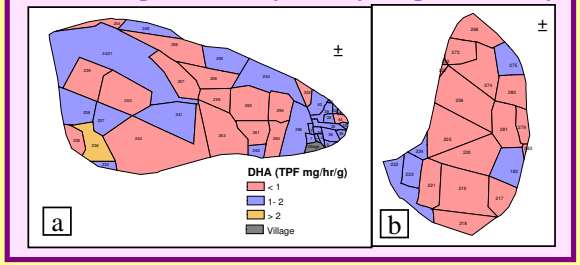


Soil physico-chemical properties





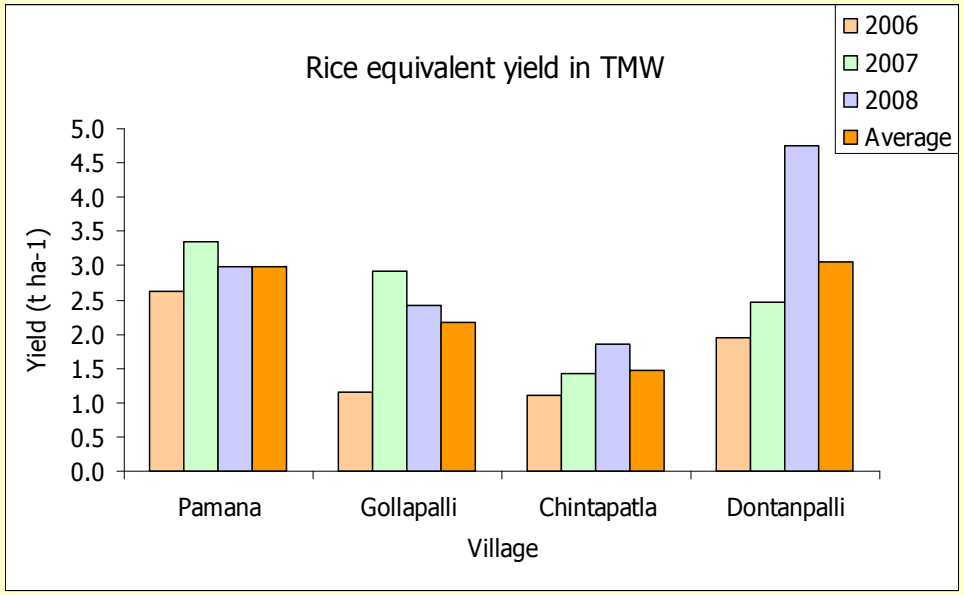
Soil biological activity – dehydrogenase assay



TMW – Treated micro-watershed

UTMW – Untreated micro-watershed

Rice equivalent yield (t ha^{-1}) in TMW and UTMW (2006-2008)

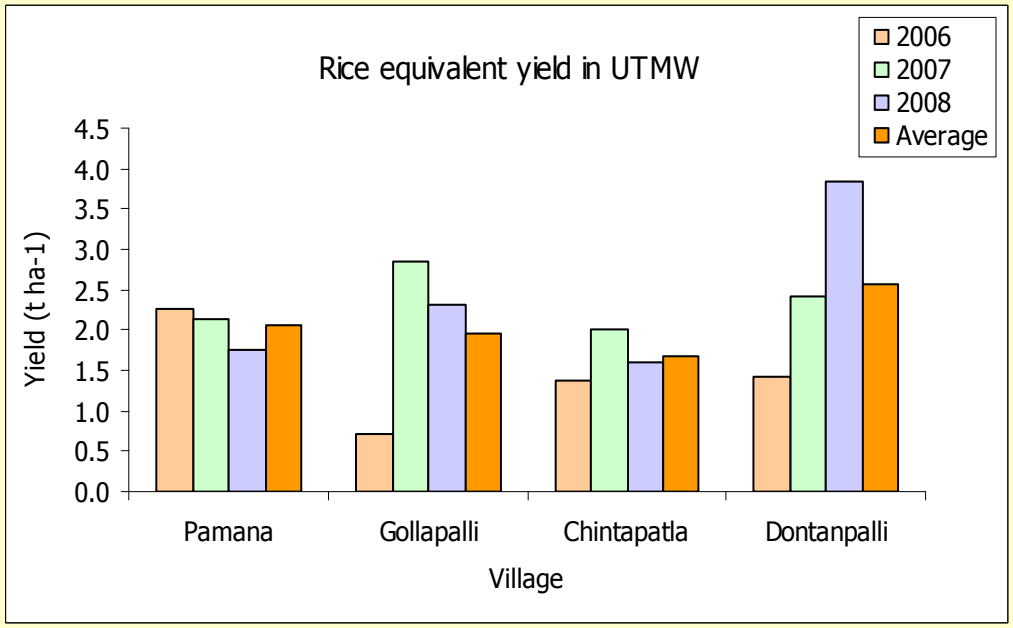


Result

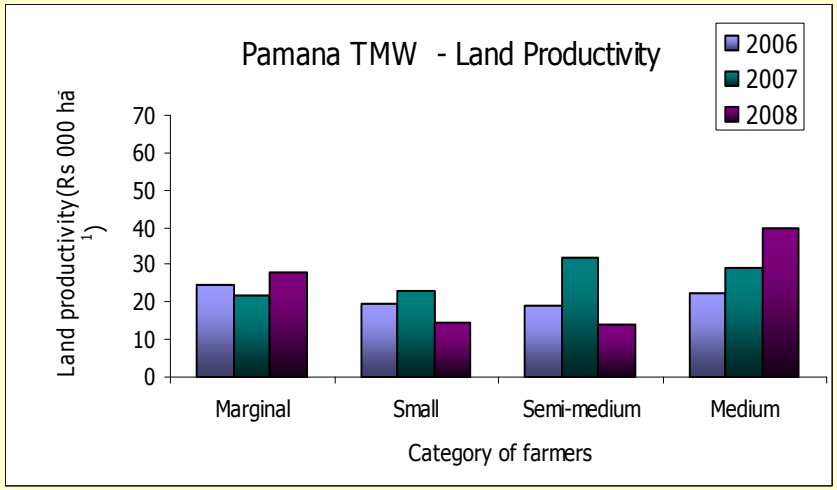
Yield level was marginally better in case of TMW when compared to those in UTMW

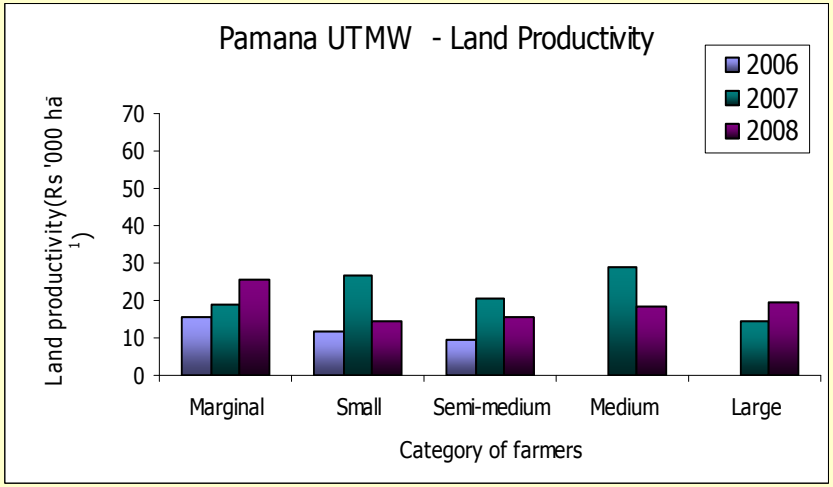
Definition

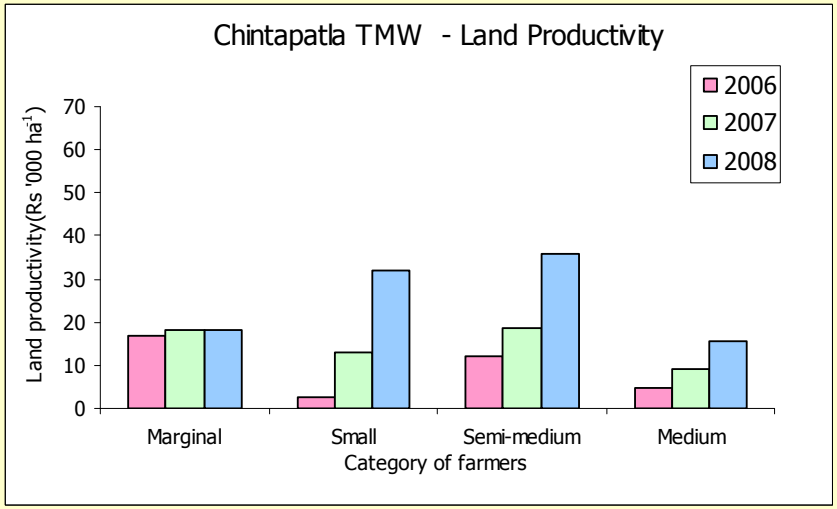
As a measure to compare yield of various crops during various years (2006-2008) at several locations within the study area, *Rice Equivalent Yield* was calculated.

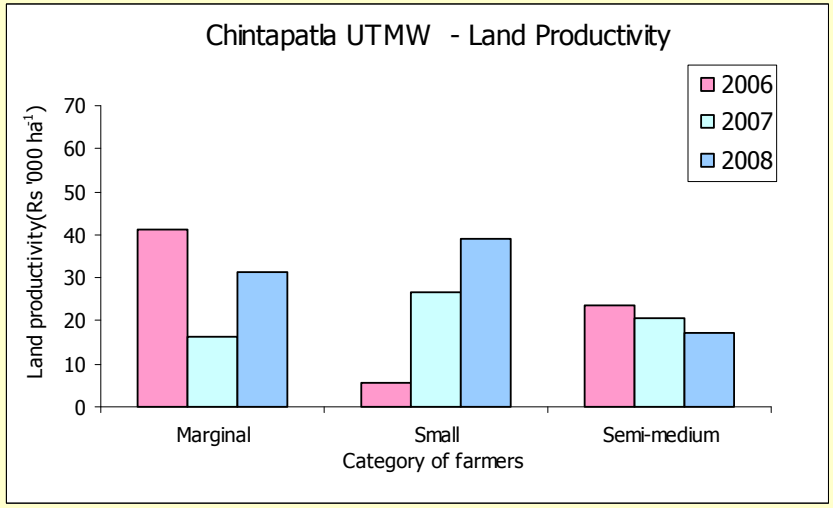


Land productivity – *Farmer category-wise (2006 – 2008)*



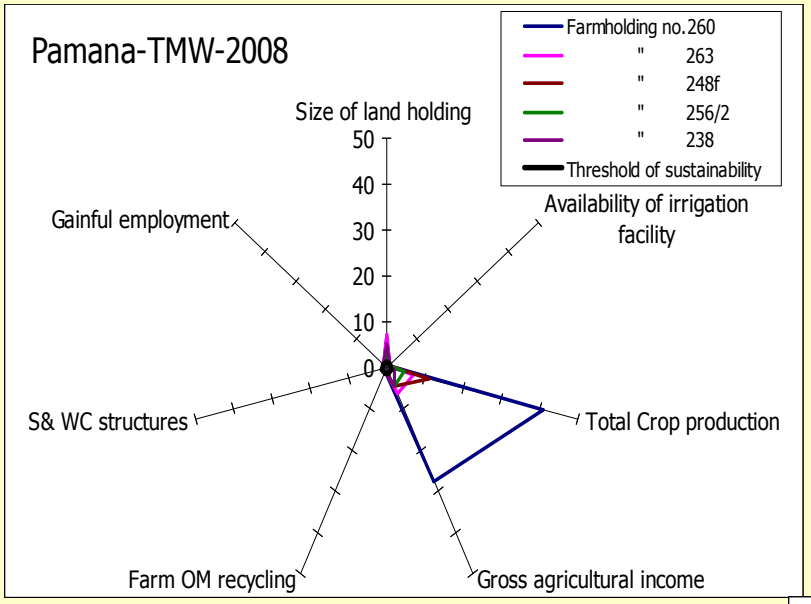


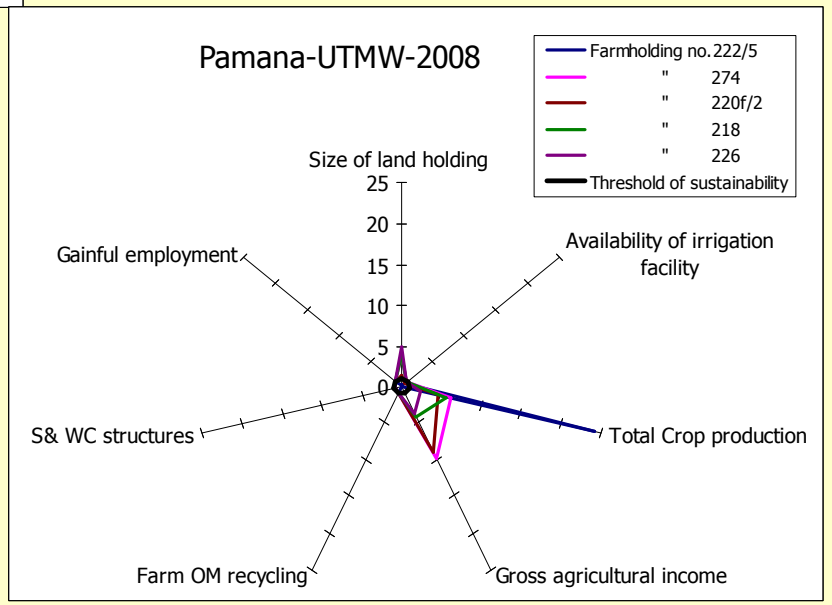




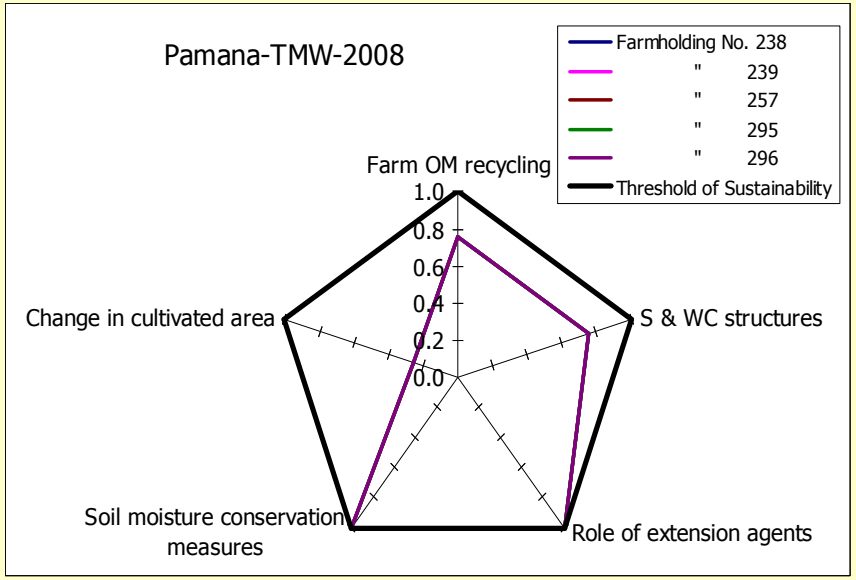
Scenario in post WDP implementation phase – different years in Pamana

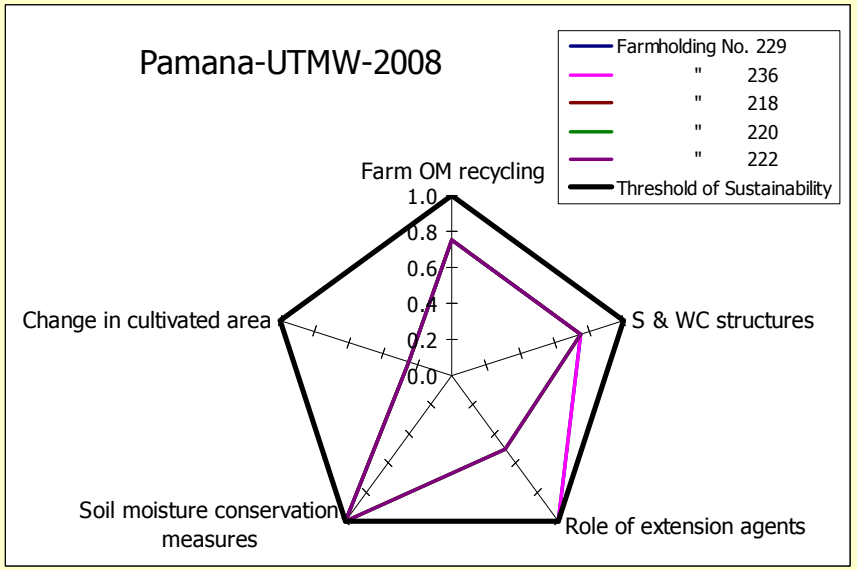
Evaluation of sustainability of *Agriculture Productivity* at field-level





Evaluation of sustainability of *Environmental Protection* at watershed-level





Critical Sustainability Indicators for WDP in AESR 7.2

Household-level	Field-level	Watershed-level	Weightage for indicator (%)		
			Household - level	Field-level	Watershed - level
Improving availability and encouraging cultivation of fodder			50	1.6	3.5
Improving nutritional security among women & children	Increasing total Crop production		25	14.1	7.8
Reducing input cost	Increasing gross agricultural income		25	9.9	7.8
	Maintaining S & WC structures			19.7	17.9
	Large scale adoption of soil moisture conservation measures			15.5	17.9
	Encouraging farm OM recycling			5.5	13.4
	Improving gainful employment options			9.9	3.5
	Practicing Crop Contingency Planning			4.5	8.6
	Improving security of tenure			1.6	7.8
	Increasing Crop Diversity (No.of crops/Cultivated area)			5.3	3.5
	Improving availability of water for irrigation			3.2	3.5
	Increased role of extension agents	Increase in cultivated area		9.4	4.9

Conclusions

- Application of GIS & RS are critical for planning, implementation & objective evaluation of NRM projects like Watershed Projects as indicated by CRIDA. However, evaluation of Sustainability requires analysis of Environment-Population Interactions at larger spatio-temporal scales.
- Higher resolution satellite data would enhance utility of Geomatics
- Use of DGPS enhances utility of GIS & satellite data
- Urgent need to address data requirements of Environment-Population research community

Thank you for your kind attention