RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR

Water Security in the Bhadrachalam Catchment: Emerging issues and potential solutions

Upali Amarasinghe, Krishna Reddy, Mallikarjuna Rao, Sumit Anand & Kanika Mehra

29/06/2016

Workshop on cumulative impact assessment
CSE, NEW DELHI

IWMI International Water Management Institute

ITC Limited

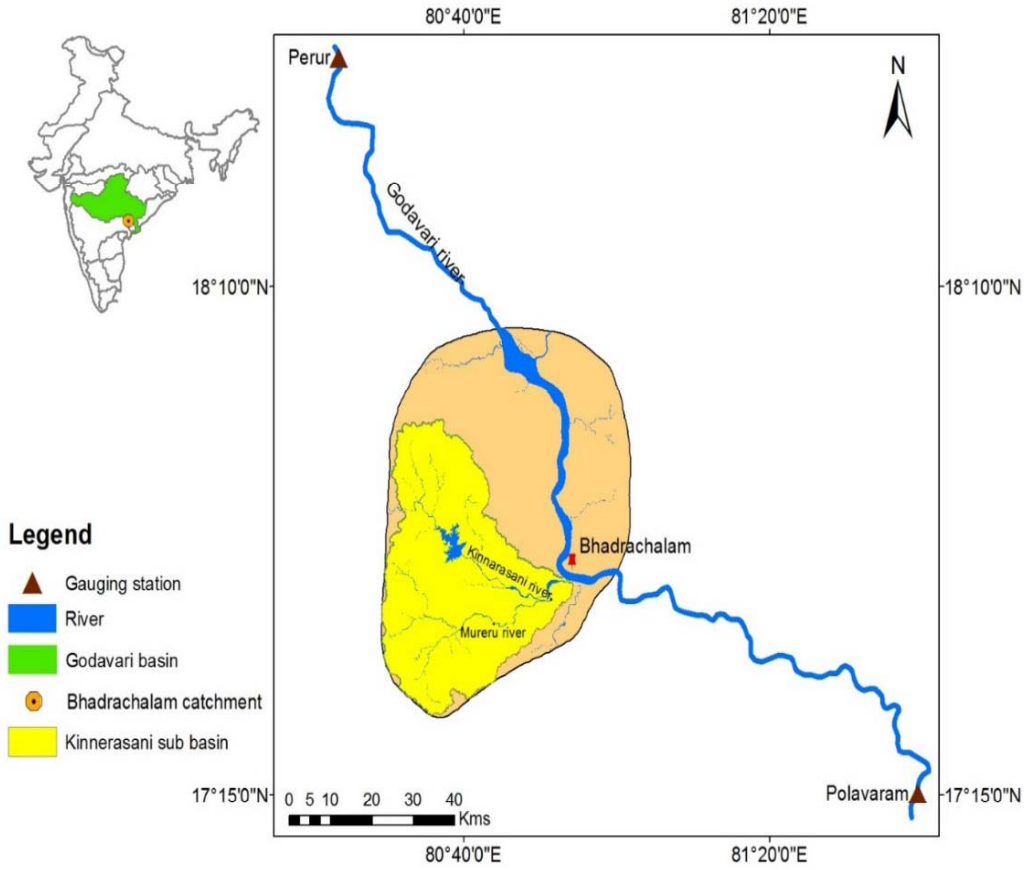
Background

- Increase in water demand and uncertain water supplies
- River basins are vulnerable (60% of the districts in Godavari)
- GW uncertainty and more runoff in the basins
- Increasing uncertainty in the rainfall
- Poor information – costs and returns of adaptation/interventions

Project objectives

Major objectives

– Enhance water security (WS) for all stakeholders in the Bhadrachalam catchment



Specific Objectives

– Identify major issues of WS: quantity, quality and variability

– Identify potential zones and interventions to enhance WS

– Provide insights on the costs and benefits of the interventions

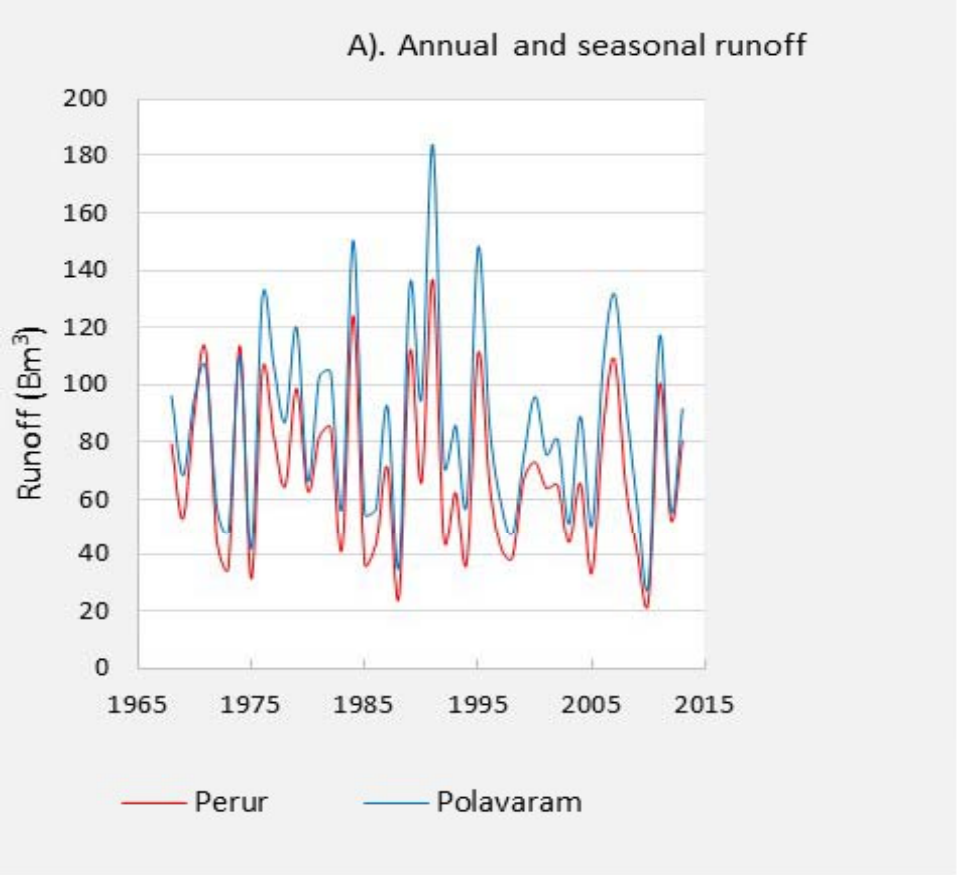
➢ Project Period: 1 year (2014-15)

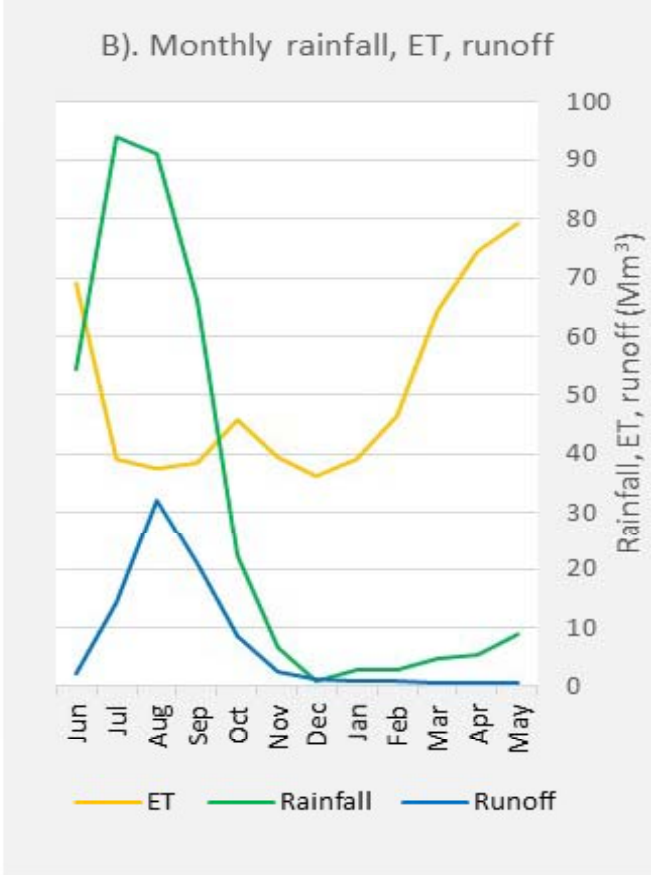
Research Activities

WS – Sustainable access to reliable and acceptable quantity and quality supply to meet demand

1. Water accounting to assess water supply/use
2. Assess minimum environmental flows
3. Peoples perception of WS issues (field survey) and cost and benefits of waste water use and sub-surface/surface interventions
4. GIS/Hydrological study for potential locations for MAR
5. GIS/RS study to assess potential surface storages

Emerging issues of water security





A). Surface runoff at Perur and Polavaram, and
B). Monthly rainfall, ET and runoff in the BC

RF, runoff and water withdrawals in BC

Sr no	Factor	Water availability, use and demand (Mm^3)					
		Annual			Non-monsoon		
1	Rainfall			3523			503
2	Runoff			1388			390
3	Sector	CWU	Withdrawals		CWU	Withdrawals	
			(1)	(2)		(1)	(2)
	Agriculture[1]	129	286	367	101	223	287
	Domestic[2]	8	40	40	5	23	23
	Industrial[3]	14	72	72	8	34	34
	E-flows[4]	-	49	49	-	4	4
4	Total	151	447	528	114	286	348

Note:[1]Irrigation withdrawals are estimated at efficiency of 45 and 35% respectively

[2]Domestic withdrawals are estimated at 20% efficiency of water use

[3]Industrial withdrawals are estimated at 25% efficiency of water use

[4]E-flows are the requirement for EMC C of moderately modified conditions

E-flows for different Environmental Management Classes (EMC) - Polavaram

Month	Average annual runoff	EMC A (Pristine)		EMC C (Moderately)		EMC F (Critical)	
		E-flows	Frequency of non exceedance[2]	E-flows	Frequency of non-exceedance	E-flows	Frequency of non exceedance
	Mm^3	Mm^3	%	Mm^3	%	Mm^3	%
June	2.32	1.18	46	0.81	20	0.63	11
July	14.32	12.63	51	8.63	37	5.77	11
August	32.24	21.86	23	16.60	14	9.40	3
September	21.06	20.02	49	13.92	37	8.61	26
October	8.50	7.94	60	5.16	43	3.41	23
November	2.40	2.52	60	1.71	31	0.92	3
December	1.32	1.15	40	0.80	14	0.42	0
January	1.01	0.68	14	0.48	6	0.24	0
February	0.82	0.47	6	0.29	3	0.14	0
March	0.78	0.45	3	0.29	0	0.15	0
April	0.65	0.30	11	0.19	0	0.10	0
May	0.66	0.32	14	0.23	6	0.12	0
Total (Nov-May)	78.45	63.63	-	45.11	-	27.82	-
Total (Jun-Oct.)	7.65	5.89	-	3.97	-	2.09	-
Total (All)	86.09	69.51	-	49.08	-	29.91	-

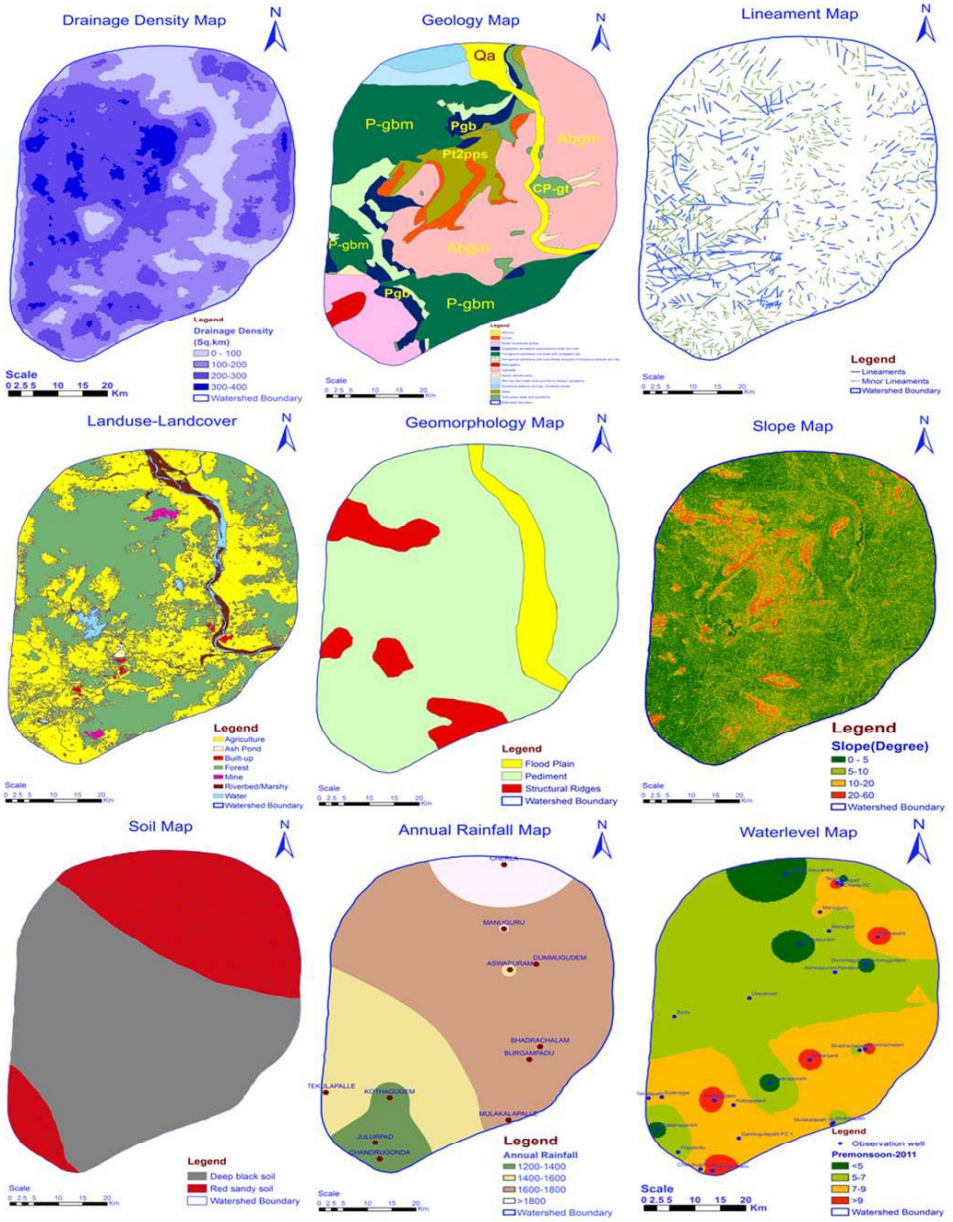
Notes: percentage of not reaching benchmark flows

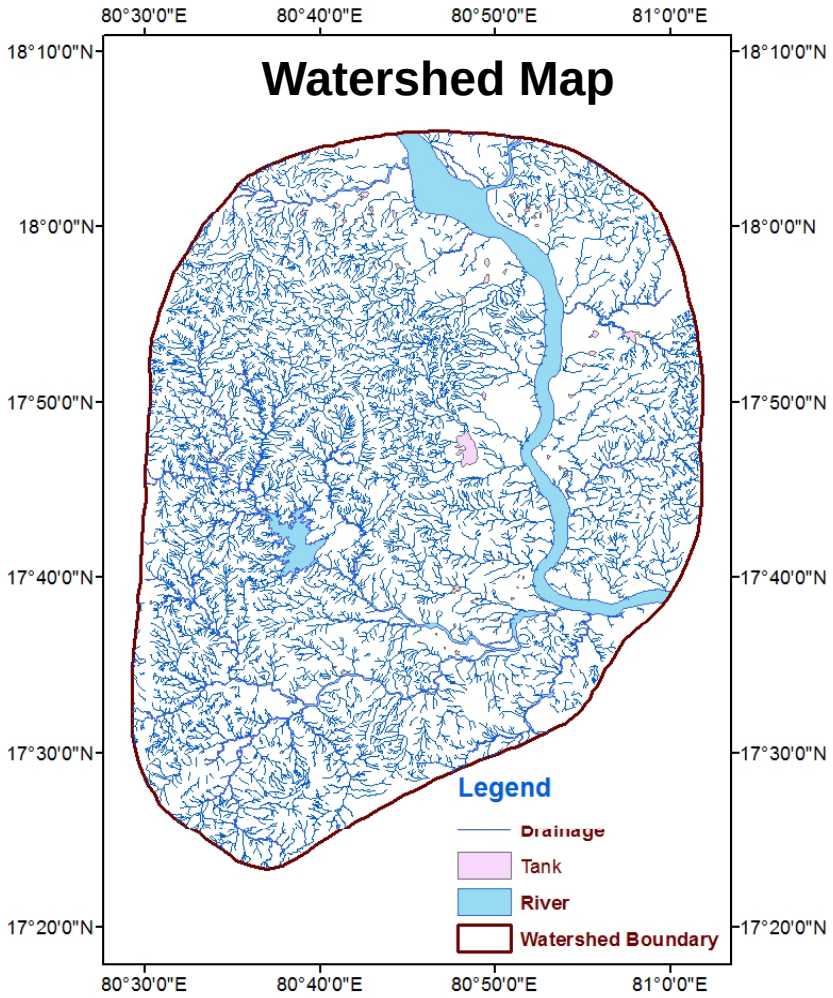
- Potential interventions for augmenting water supply for the non-monsoon periods are:

a) Managed Aquifer Recharge (MAR)

b) Tank rehabilitation

Thematic layers developed using GIS/RS analysis



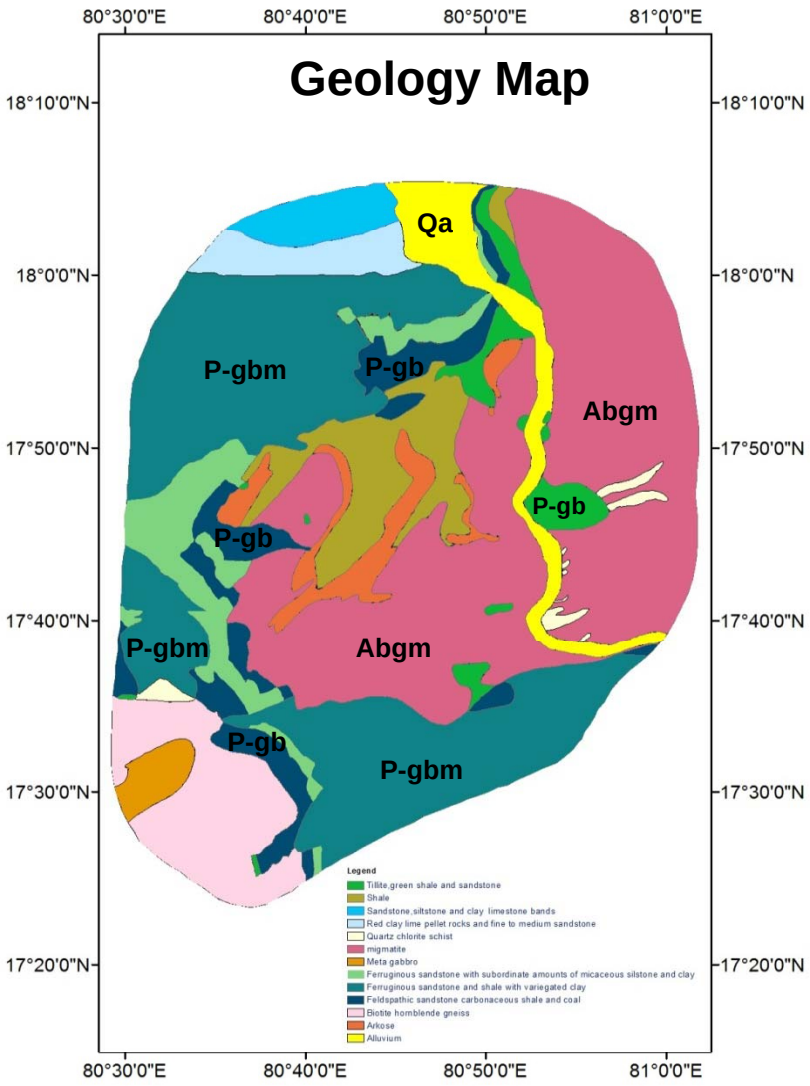


Location Map of Bhadrachalam catchment,Khammam

Drainage network in the study area:

- Watershed having good drainage density representing Dendritic drainage pattern.
- The study area are drained by numerous first, second, third and fourth order.
- Two rivers **Kinnarasani** and **Mureru** River are joining to Major River Godavari.
- **Ralla vagu, Mureru vagu, Karaka vagu and Nalla vagu** are small tributaries joining into rivers.

Sl.No	Drainage density (Sq.km)	Ranking in word	Rank value in number
1	< 0.5 (Low density)	Very good	1
2	0.5 to 1.0 (Low- Moderate)	Good	2
3	1.0 to 2.0 (High)	Poor	4
4	> 2.0 (Very high)	Poor	4

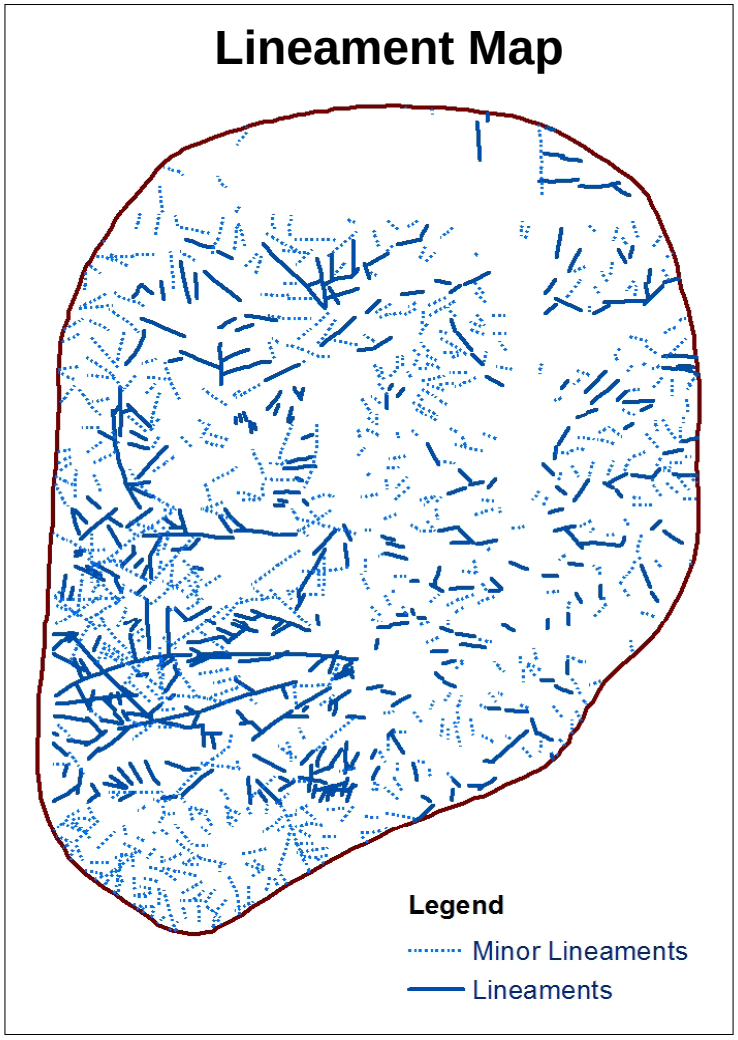


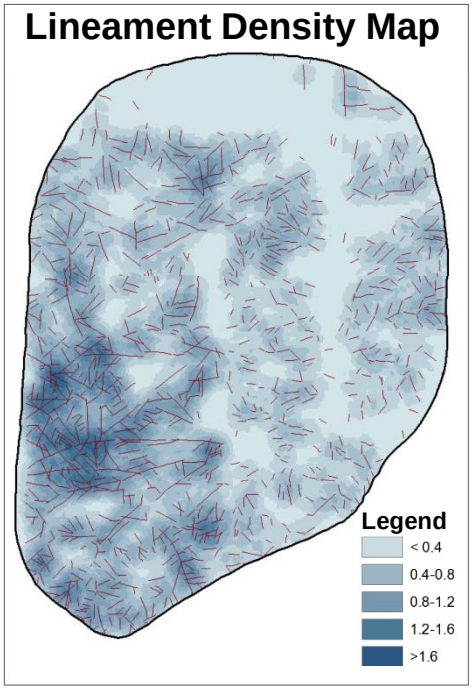
Geology Map of Bhadrachalam catchment, Khammam

Lithology present in the study area are:

- **Akhs, Akhg, Abmq and Abc** – are belong to Bengal group, Age: Archean
- **Abgm**-belong to Peninsular Gneissic Complex Age: Archean
- **Pt-pb**-belong to Bollapalli Formation, Age: Mesoproterozoic
- **Cp-gt**-belong toTalchair formation, Age: Lower Gondwana
- **P-gb**-belong to Barakar Formation, Age: Lower Gondwana
- **P-gbm**-belong to Barren Measuers, Age: Lower Gondwana
- **PT-gkm**-belong to Kamati Formation, Age: Lower Gondwana
- **Qa**-belong to Alluvium, Age: Quaternary

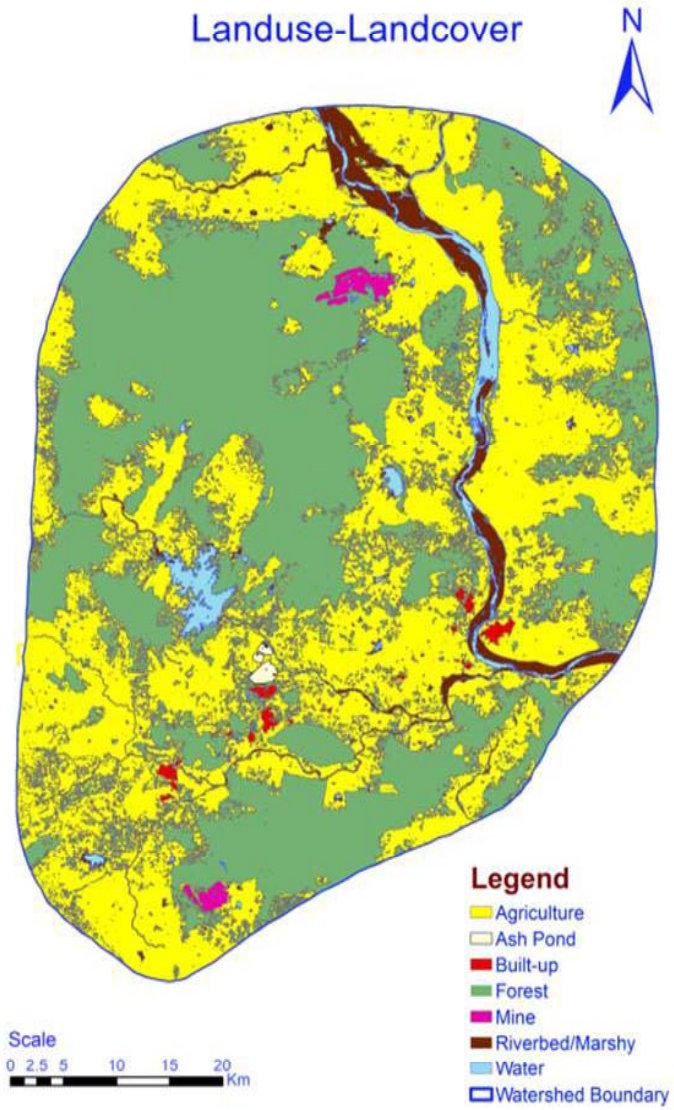
Sl.No	Geology	Ranking
1	Alluvium	1
2	Arkose	3
3	Biotite hornblende gneiss	4
4	Feld spathic sandstone carbonaceous shale and coal	2
5	Ferruginous sandstone and shale with variated clay	3
6	Ferruginous sandstone with subordinate amounts of micaceous siltstone and clay	3
7	Meta gabbro	4
8	Migamtite	4
9	Quartz chlorite schist	5
10	Red clay lime pellet rocks and fine to medium sandstone	3
11	Sandstone, siltstone and clay limestone bands	3
12	Shale	5
13	Tillite, green shale and sandstone	3





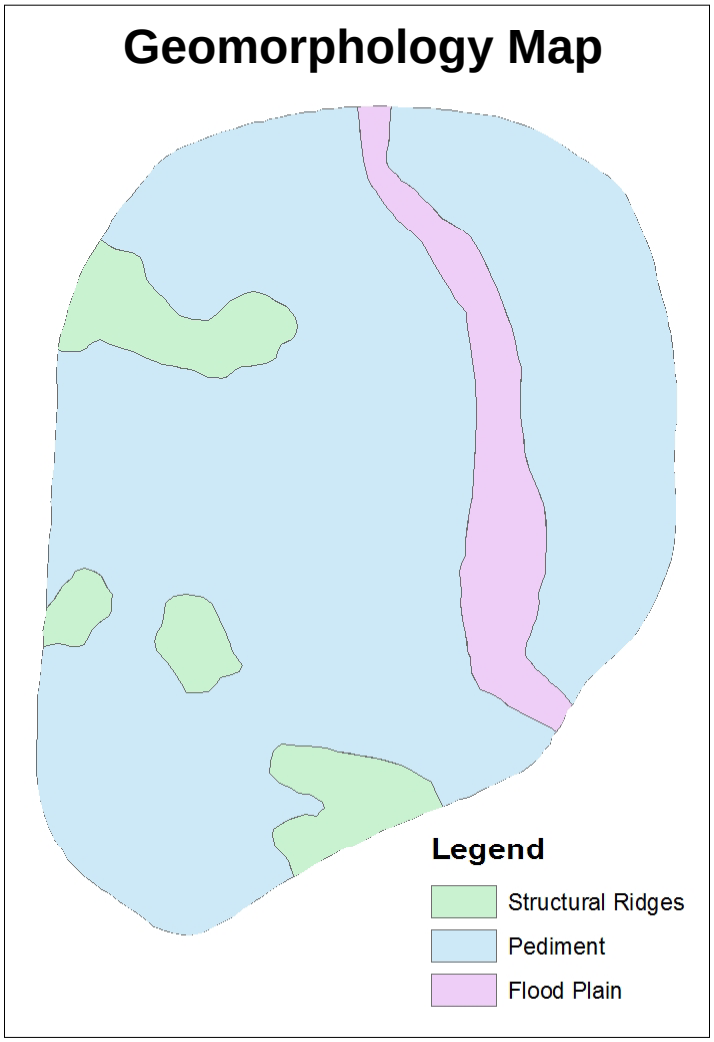
Sl.No	Lineament density (Sq.km)	Ranking in word	Rank value in number
1	<0.4(Very low density)	Very poor	5
2	0.4 to 0.8 (Low density)	Poor	4
3	0.8 to 1.2 (Moderate density)	Moderate	3
4	1.2 to 1.6(High Density)	Good	2
5	>1.6	Very good	1

Lineament Map of Bhadrachalam catchment, Khammam



LU-LC	Area(Sq.kms)
Forest/Trees	1553.019
Riverbed/Marshy	128.623
Agriculture	1702.860
Water	67.308
Mine	16.591
Built-up	13.762
Ash Pond	5.025
Total	**3487.188**

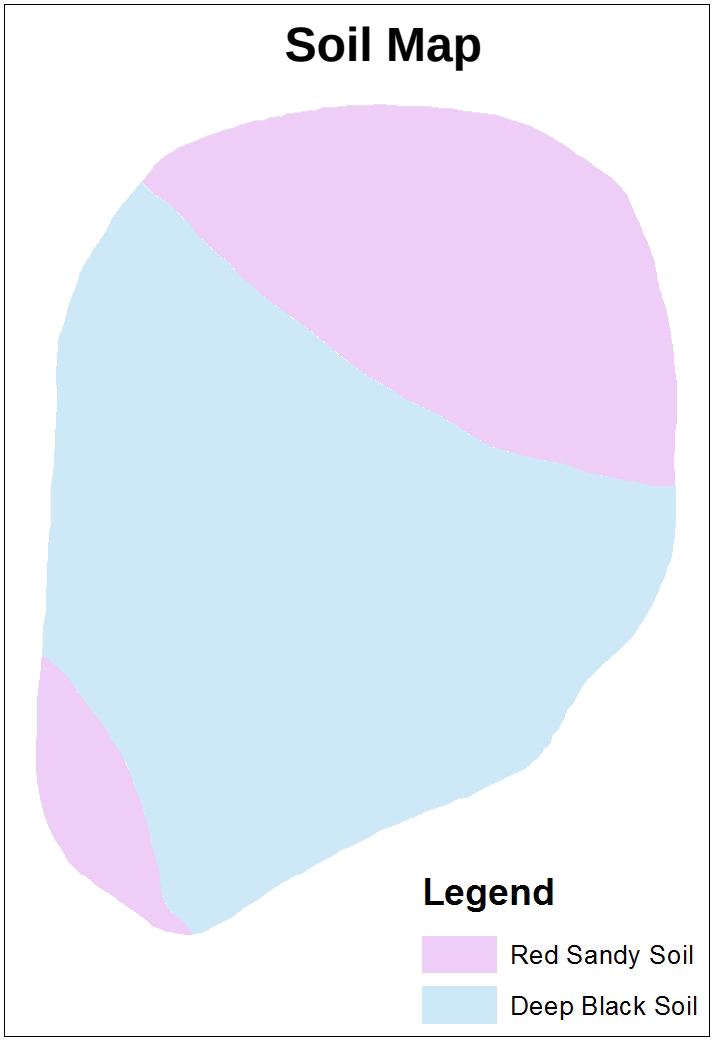
Landuse-Landcover in the Bhadrachalam catchment, Khammam



Geomorphic features in the catchment:

- Natural agencies acted upon the earth surface resultant topographic expressions are termed as geomorphic features
- Three features are present in the area, They are:
- **Floodplain**-occurs along the river flow direction.
- **Pediment:** is a very gently sloping (5°-7°) inclined bedrock surface and it occupies almost 65% area in the entire catchment.
- **Structural ridges:** are formed highly elevated areas in the catchment.

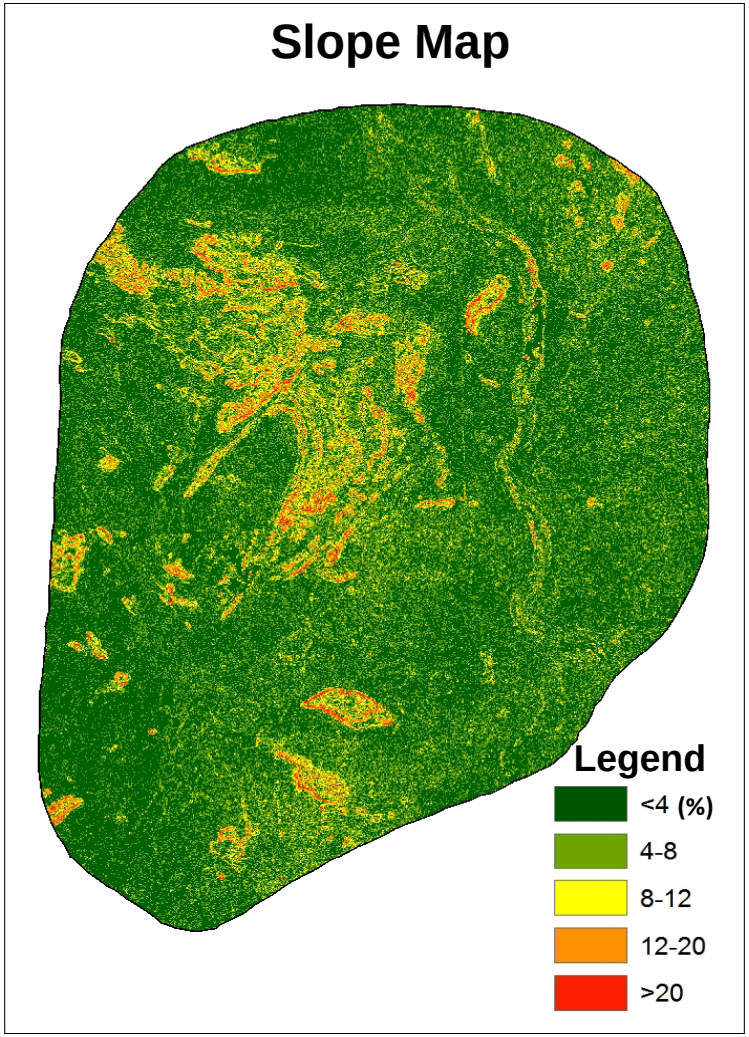
Geomorphic features in the Bhadrachalam catchment, Khammam



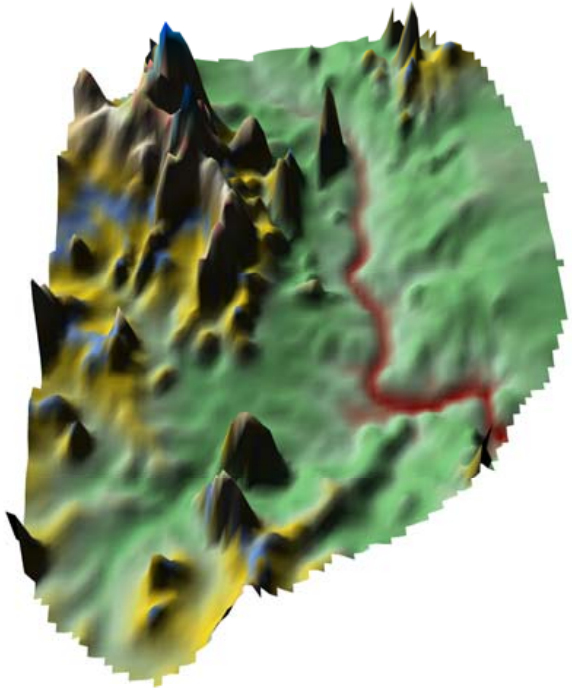
Type of the soils:

- Soil are derived from the breaking down of the pre -existing rocks in the area
- Mainly two types of soil are presented: morphology and characteristic of the soil depends on the host rock and agents.
- They are Red sandy soil & Deep black soil.
- Both of them are occupying almost same propitiation

Soil map in the Bhadrachalam catchment, Khammam

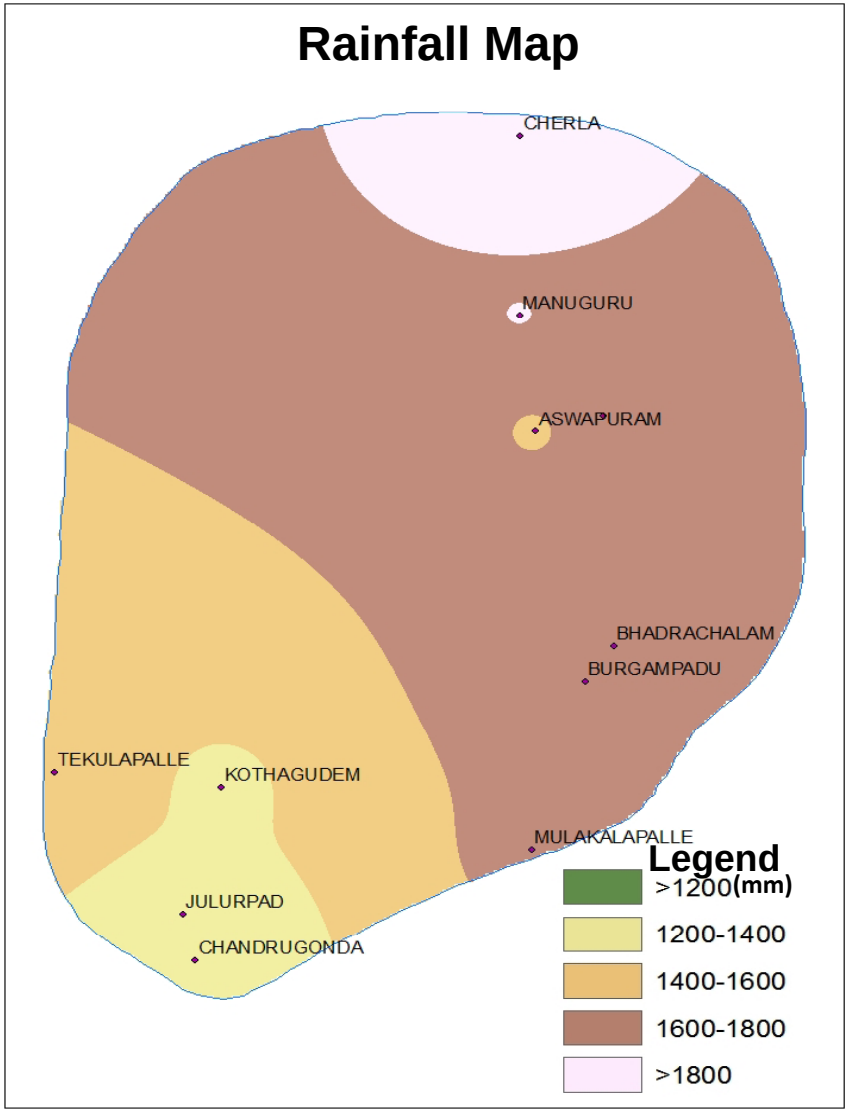


3-Dimensional view in the catchment

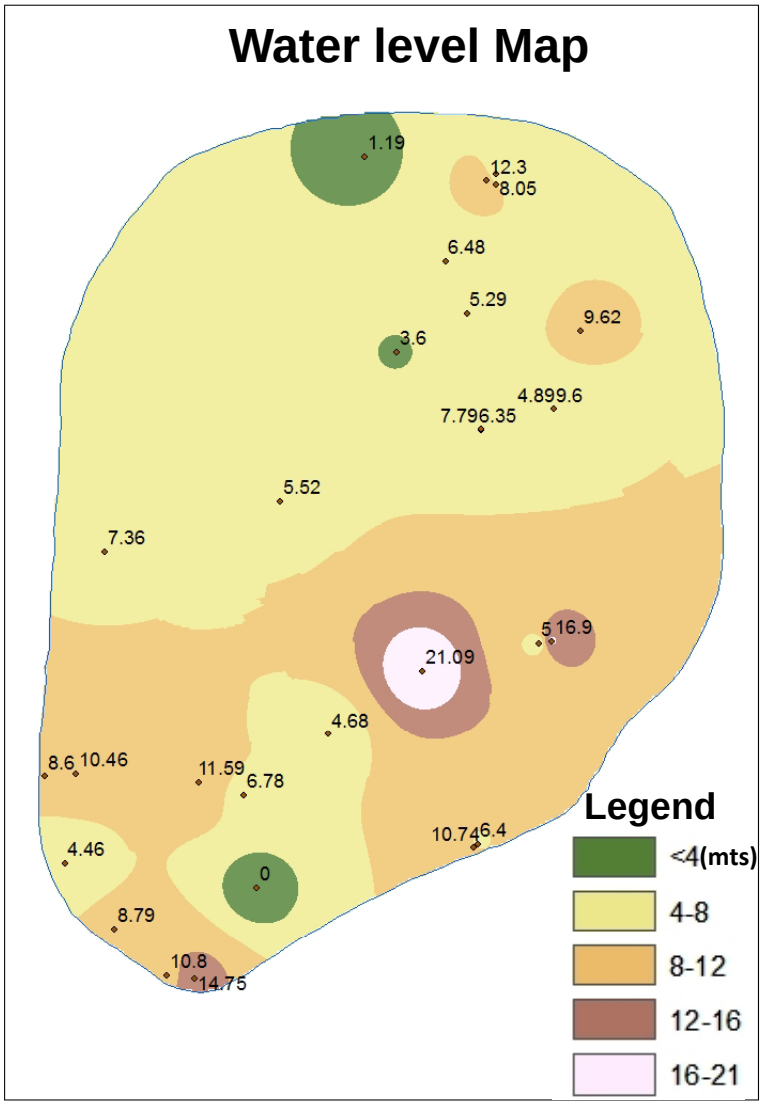


Sl.No	Slope (%)	Rank value in number
1	< 2.0(Nearly levelled)	1
2	2.0-4.0(Gentle sloping)	3
3	4.0-8.0 (Moderately sloping)	4
4	8.0-12(Nearly steep sloping)	4
5	>12 (Steep sloping)	5

Slope in the Bhadrachalam catchment, Khammam

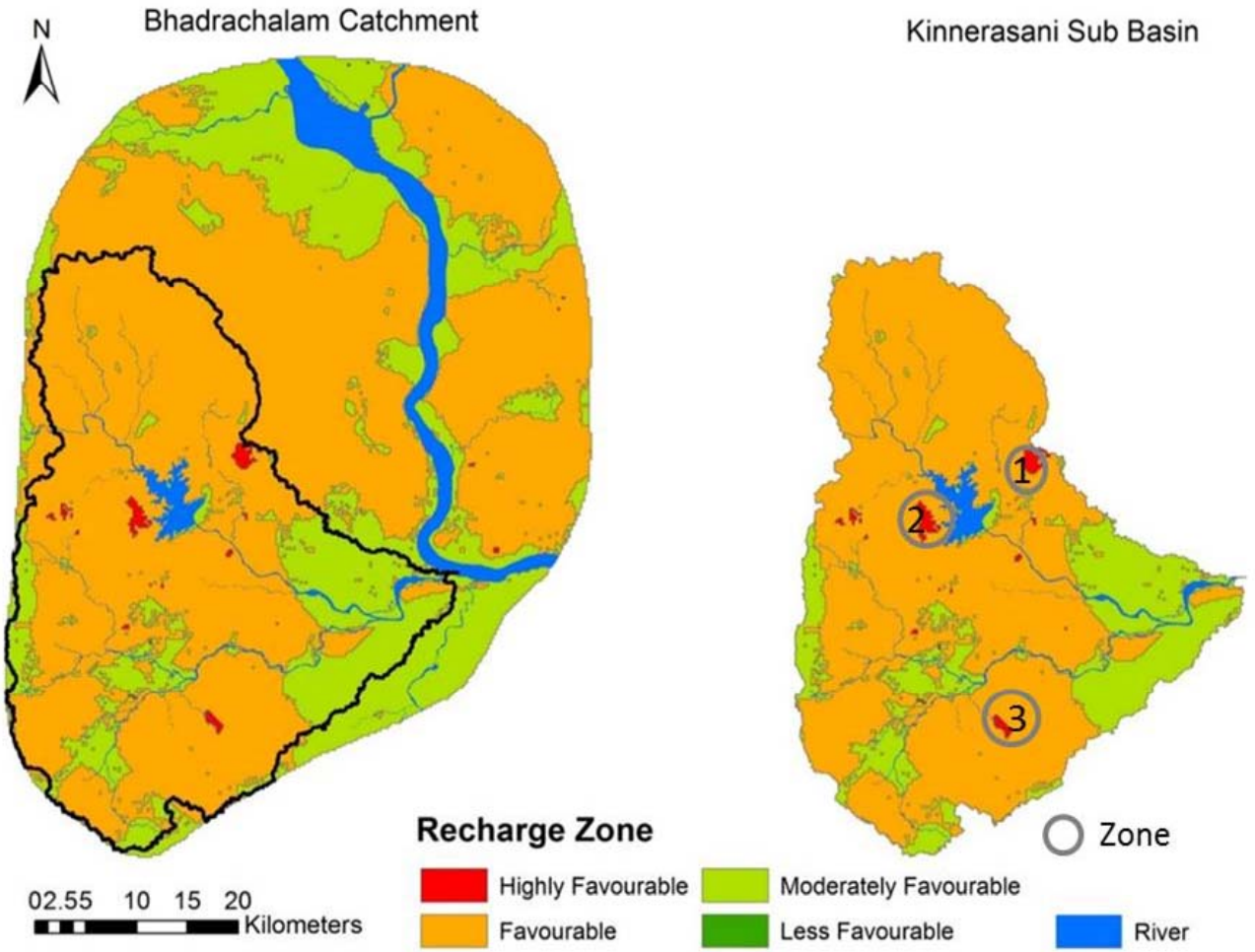


Annual Rainfall contour Map in the Bhadrachalam catchment, Khammam

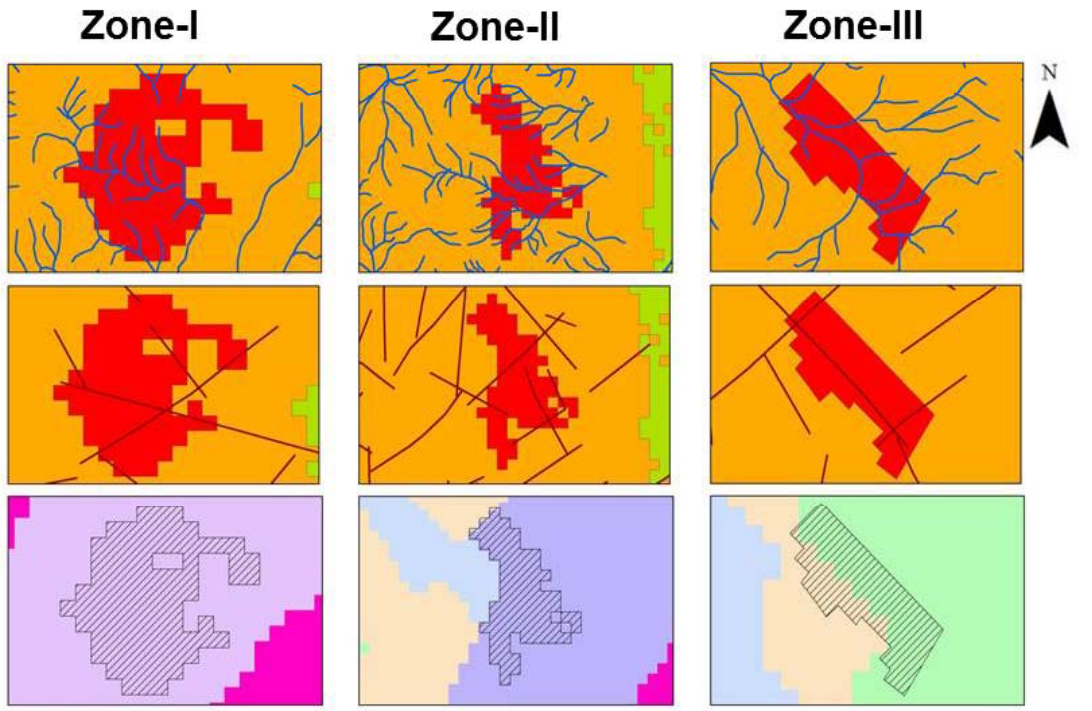


Water level contours (2012) in the Bhadrachalam catchment, Khammam

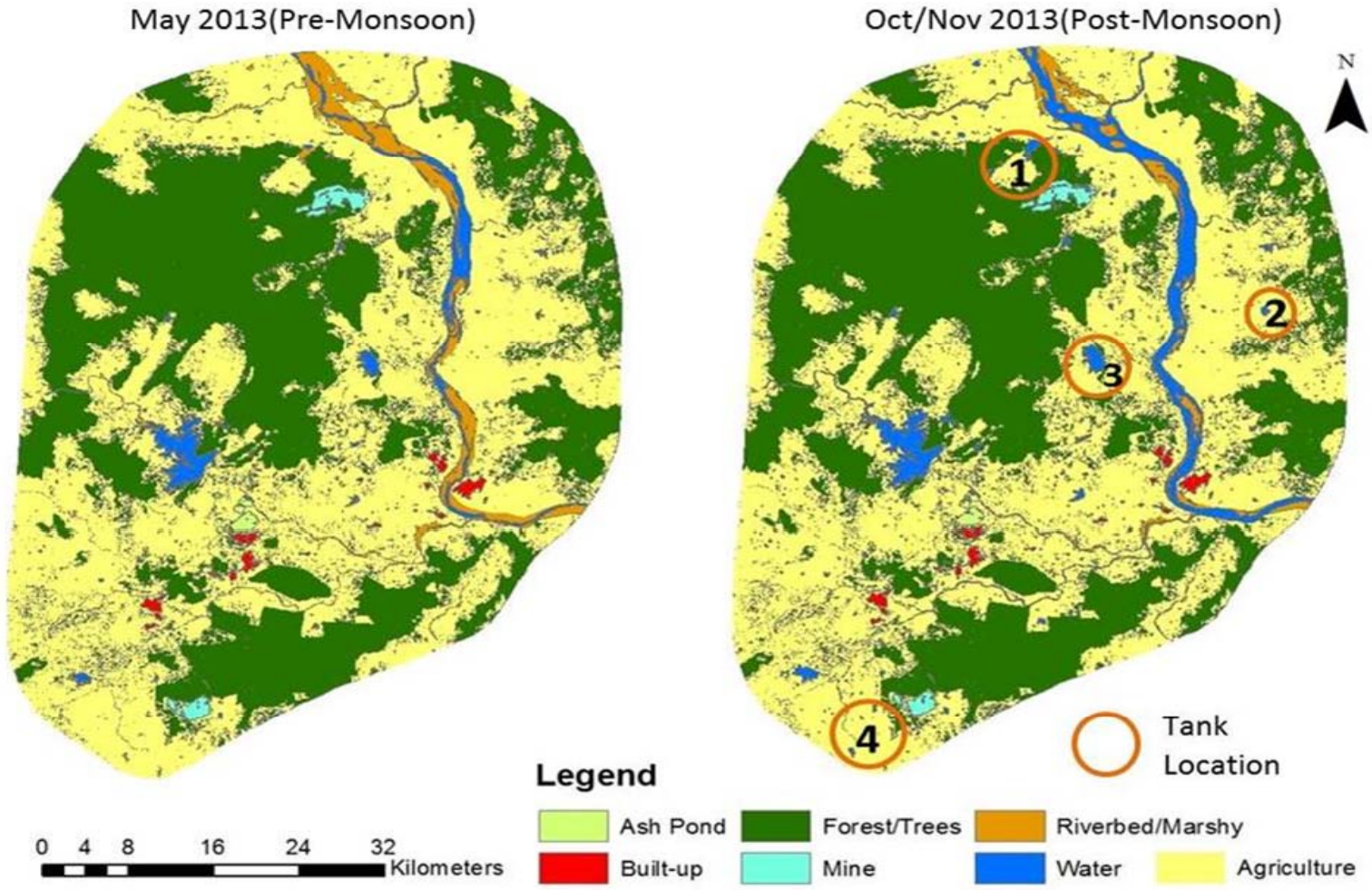
Potential groundwater recharge zones of the BC



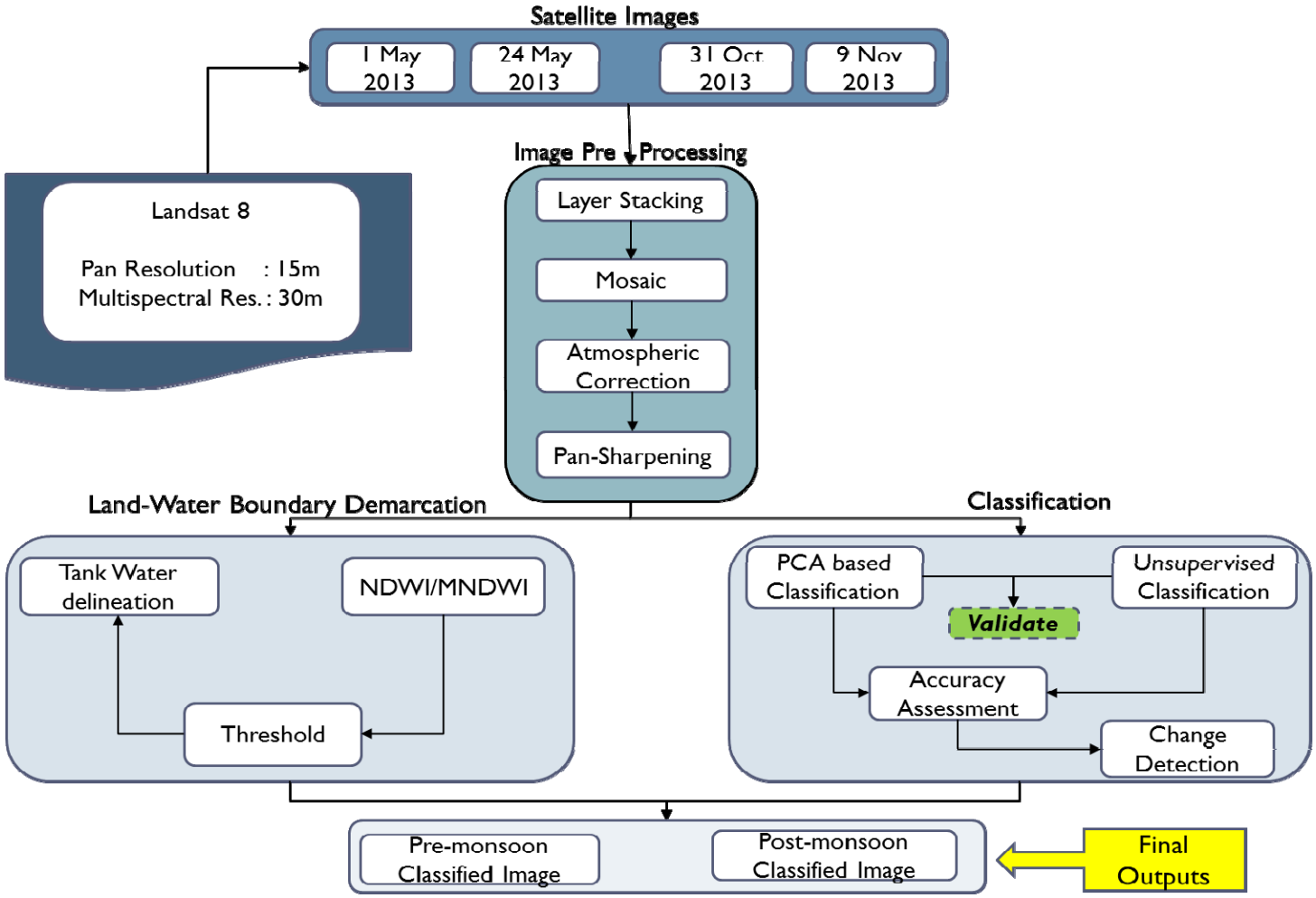
Drainage patterns, lineaments and geology of the highly favorable groundwater recharge zones



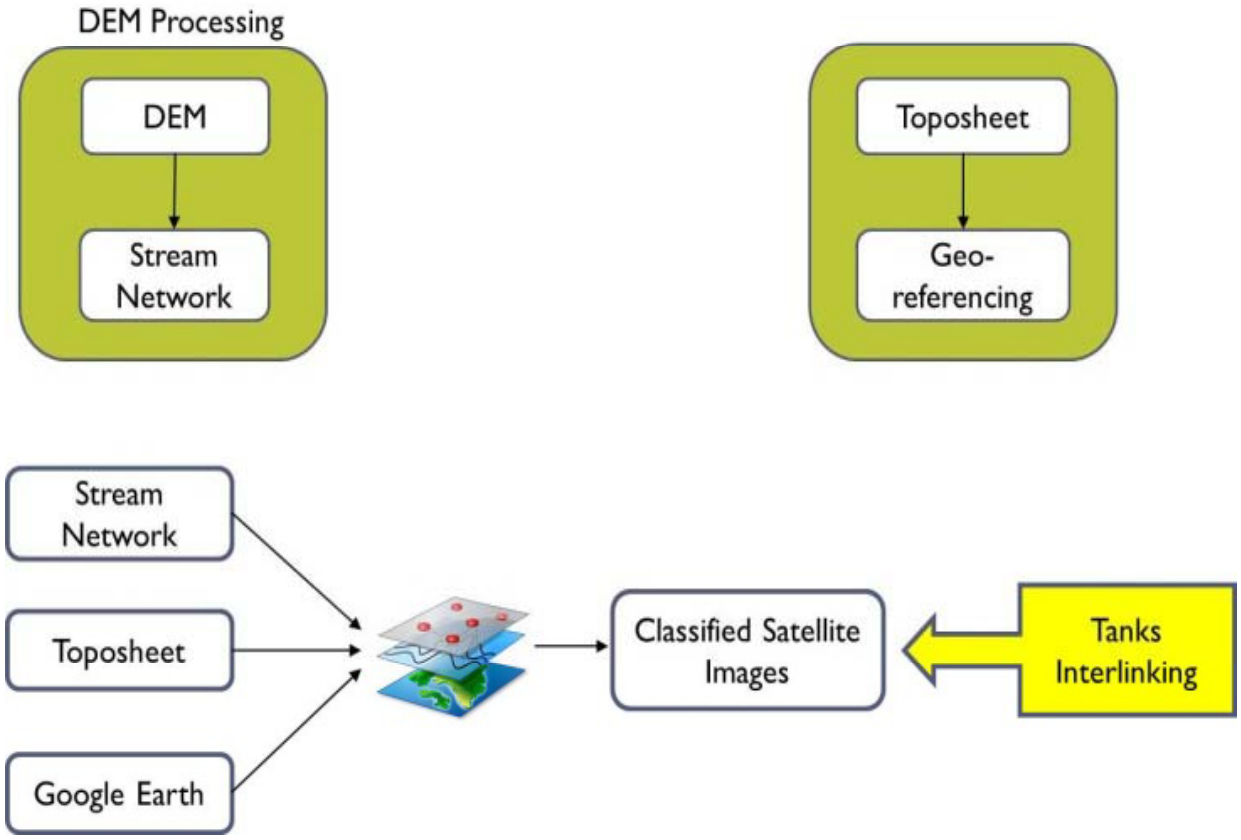
Pre-and post-monsoon processed images of the BC



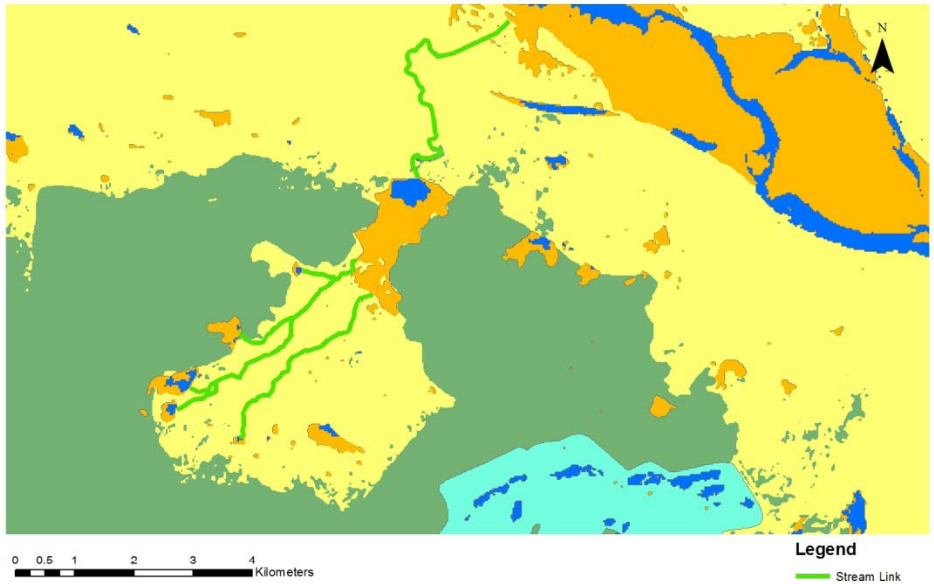
Methodology for Tanks identification and quantification



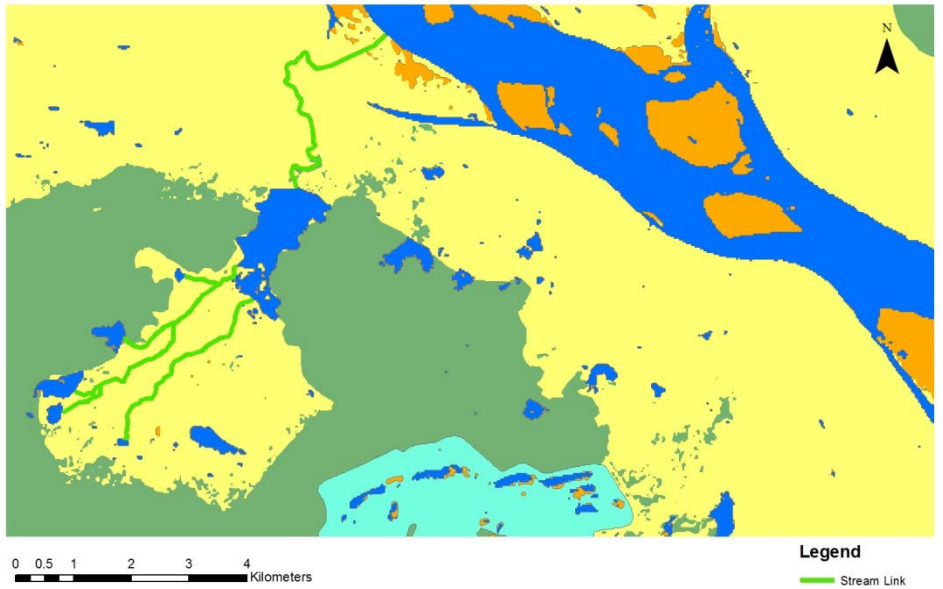
Methodology for identification of linkages



Pagidaru Cascade



Pre-Monsoon

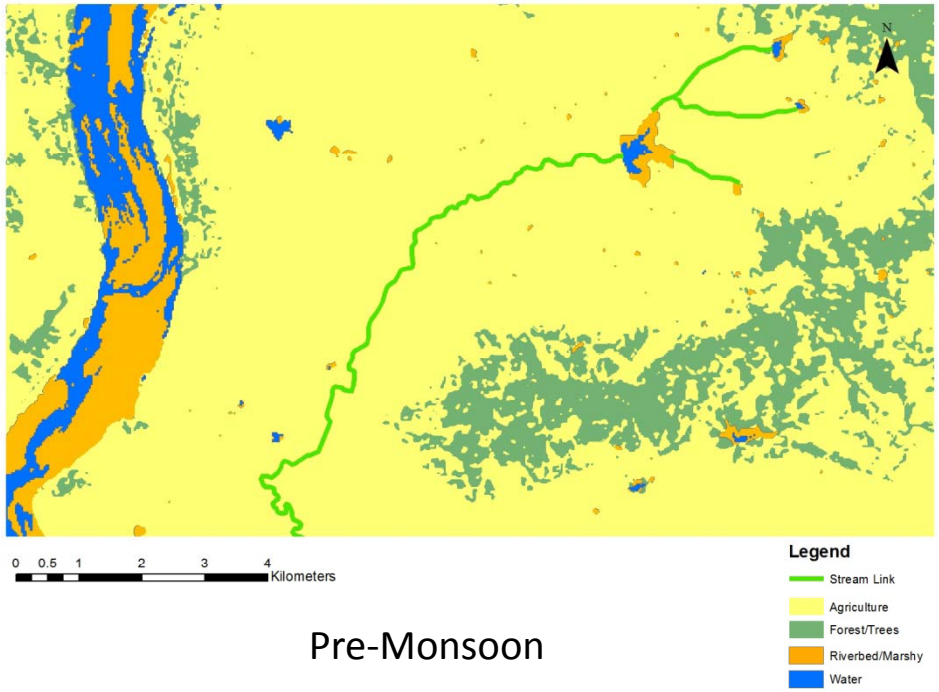


Post-Monsoon

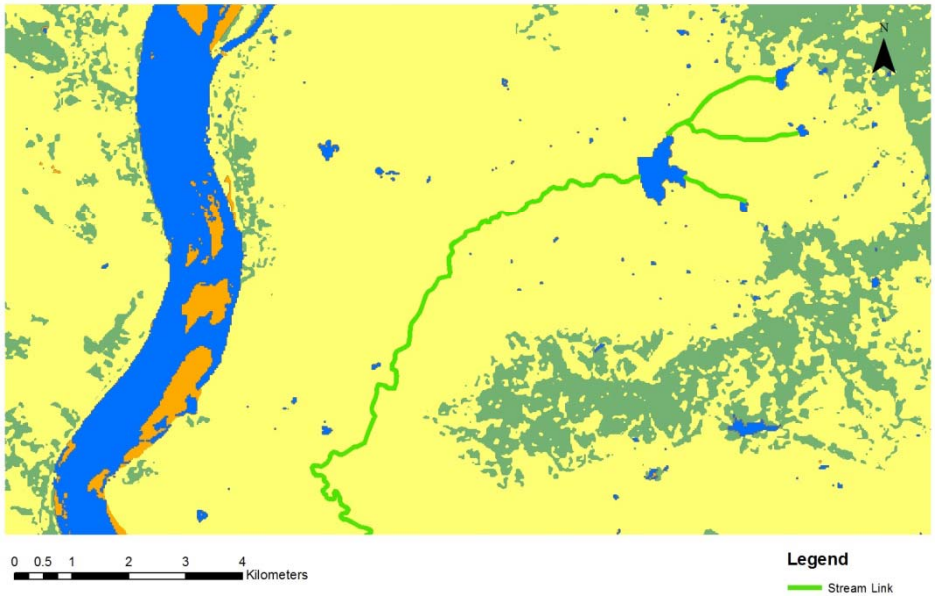
Pre & Post monsoon volumes of Pagidaru

Village	Tanks	Pre-monsoon volume (m3)	Post-monsoon volume (m3)	Area under irrigation (ha)	Proposed increase in bund height (ft)	Proposed desiltation depth (ft)	Sluice condition	Channel condition
Pagidaru	Sambai Gudem	327881	5559145	4000	2	6	fine	fine
Pagidaru	Ayyarkunta	4443	37635	20	2	4	Poor(no gates)	fine
Pagidaru	Ippgadda	9000	442508	80	3	3	Not well	Not well
Pagidaru	Ponchampalli 1	175218	778130	240	Not required	5	Not well	fine
Pagidaru	Ponchampalli 2	22387	172986	20	2	3	Not well	fine
Pagidaru	Kodichala	2643	39379	60	2	5	Poor(not working)	fine
Pagidaru	Chinna (individual)	41681	827635	200	9	3	Not well	No channel

Laxminagar Cascade



Pre-Monsoon

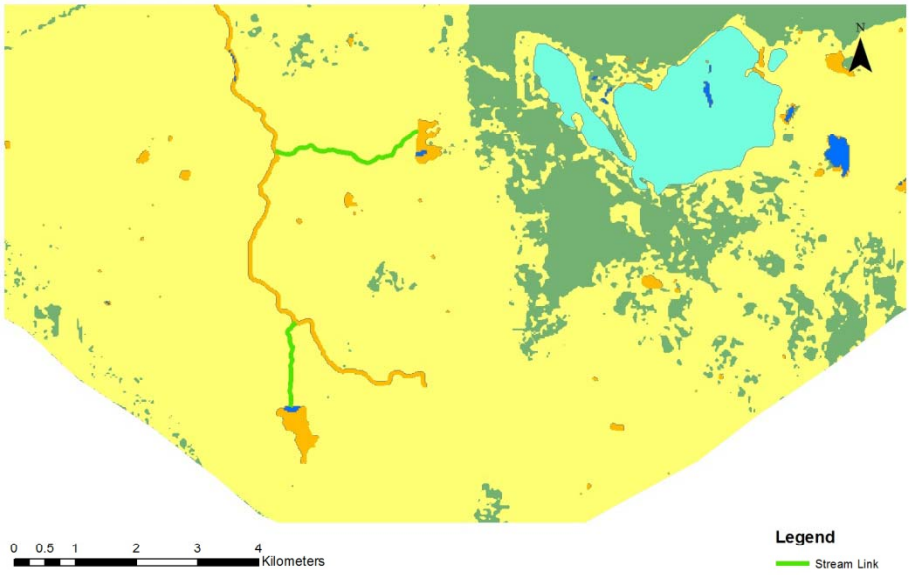


Post-Monsoon

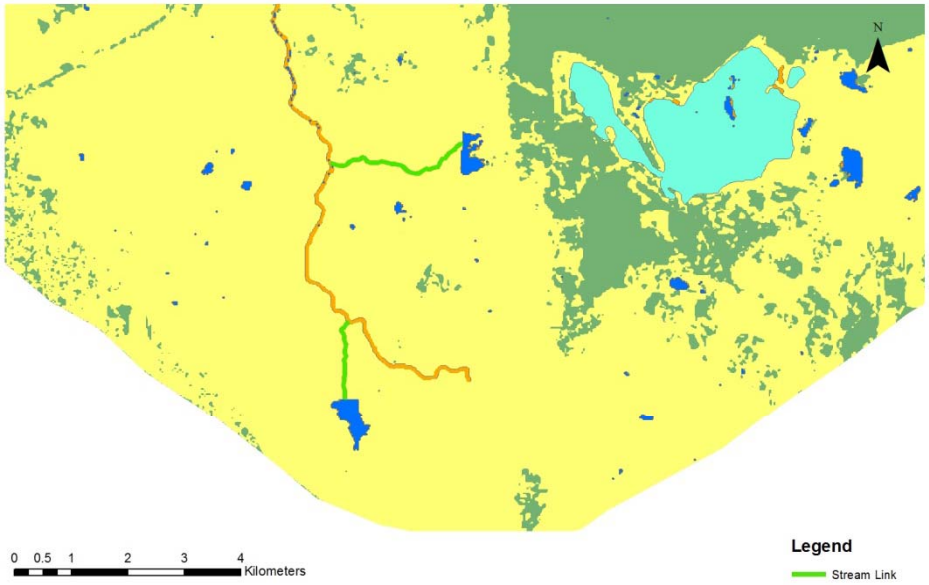
Pre & post monsoon volumes of Laxminagar

Village	Tanks	Pre-monsoon volume (m3)	Post-monsoon volume (m3)	Area under irrigation (ha)	Proposed increase in bund height (ft)	Proposed desiltation depth (ft)	Sluice condition	channel condition
Laxminagar	Chinnarulagubal	222750	1744887	800	2	Full needed	Not well	Fine
Laxminagar	Kothuru	43031	221085	40	2	4	Fine	Fine
Laxminagar	Kamalapuram	13331	77970	20	2	Partial needed	Fine	Fine
Laxminagar	Rajupeta	Marshy	30884	10	Not required	Full needed	Not well	Fine

Ganugapadu and Thungaram Tank

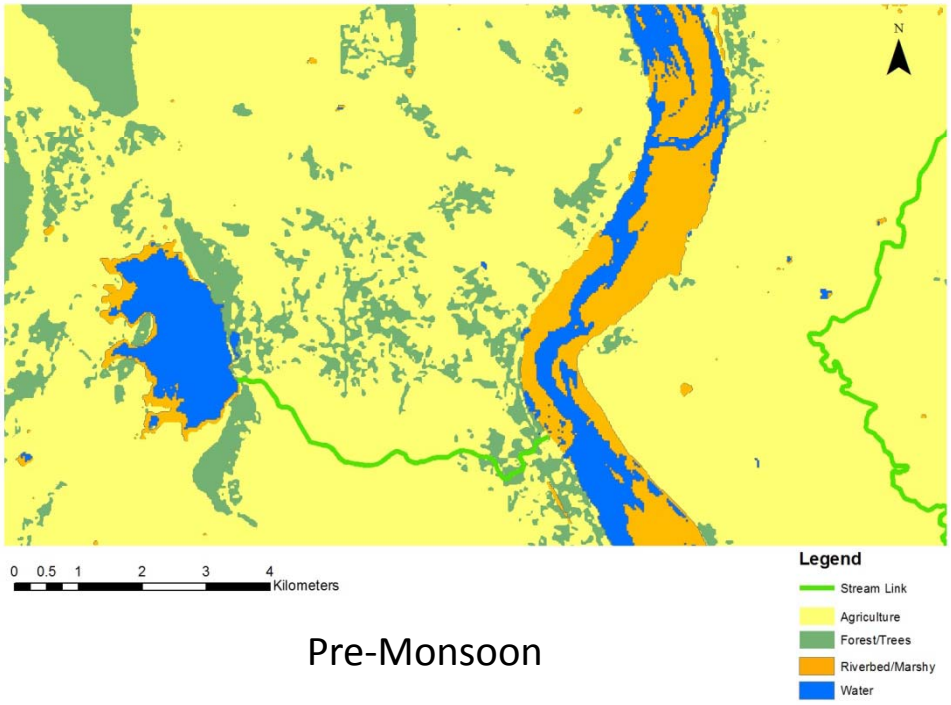


Pre-Monsoon

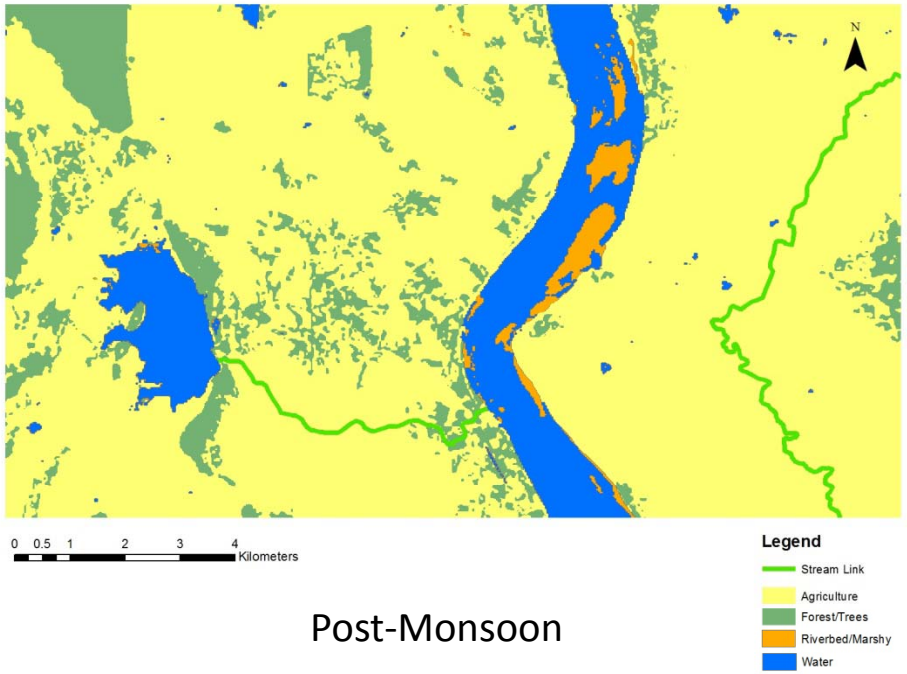


Post-Monsoon

Tummala Tank



Pre-Monsoon



Post-Monsoon

Individual tank statistics

Tanks	Pre-monsoon volume (million m3)	Post-monsoon volume (million m3)	Area under irrigation (ha)	Proposed increase in bund height (ft)	Proposed desiltation depth (ft)	Sluice condition
Ganugapadu	Less water(marshy)	0.92	120-160	Not required	Partial needed	Fine
Thungaram	Less water(marshy)	0.54	120	3	10	Fine
Tummala	7.5	20.7	2000	Not required	Required	Fine

Pagidaru cascade area & crop details

Village	Tanks	Tank area(m^2)	Depth (m)	Actual command area (ha)	Area under cultivation (ha)	Paddy (ha)	Cotton (ha)
Pagidaru	Sambai Gudem	1,588,327	3.5	4,000	3,200	2,560	640
	Ayyarkunta	25,090	1.5	20	16	12.8	3.2
	Ippgadda	147,502	3.0	80	64	51.2	12.8
	Ponchampalli 1	222,323	3.5	240	192	153.6	38.4
	Ponchampalli 2	69,194	2.5	20	16	12.8	3.2
	Kodichala	19,689	2.0	60	48	38.4	9.6

Scenarios for Tank- BCR analysis

Sl.No	Scenario	Particulars
1	S1	Actual irrigated area+ desilt cost 50 INR/m^3+actual yield+ paddy area (80%)+cotton (20%)+revenue from desilted soil
2	S2	Increased area by 20% + desilt cost 50 INR/m^3+actual yield + paddy area (80%)+cotton area (20%) + revenue from desilted soil
3	S3	Actual irrigated area+ desilt cost 50 INR/m^3+increase in yield (30%) + paddy area (80%) + cotton area (20%) + revenue from desilted soil
4	S4	Increase area by 20% + desilt cost 50 INR/m^3+Increase in yield (10%) + Paddy area (80%)+ cotton area (20%)+revenue from desilted soil
5	S5	Actual irrigated area + desilt cost 76 INR/m^3+actual yield + paddy area (80%)+cotton (20%)+revenue from desilted soil
6	S6	Additional benefits only due to increased area (20%) +desilt cost 50 INR/m^3+paddy area (80%) + cotton area (20%)
7	S7	Only additional benefit due to increased area (20%) + desilt cost 50 INR/m^3 + paddy area (50%) + cotton area (50%)

BCR of tank rehabilitation

	S1	S2	S3	S4	S5	S6	S7
BCR	1.84	2.21	5.91	3.83	1.45	0.38	0.43
IRR (%)	23	35	740	115	12	-19	-17

Managed Aquifer Recharge (MAR)

- Total MAR Structures identified: 10
- Cost of MAR = Rs.400,000
- Area under MAR = 40 acres
- Initiated (year) = 2012
- Life span = 10 years
- Cost/acre = Rs.1000 /year/acre
- Crops: Cotton, paddy

Source: district water management agency

Cost benefits of MAR

Manag.	Particulars
M1	Current cropping pattern of 32 acres (80% of the area) of cotton and 8 acres (20%) of paddy, with an O & M cost of InRs 5000
M2	Current cropping with of 32 acres (80% of the area) of cotton and 8 acres (20%) of paddy with an O & M cos of InRs.10000
M3	New cropping pattern with 20% area under cotton and 80% area under paddy with an O and M cost of InRs.10,000
M4	New cropping pattern with 50% area under cotton and 50% area under paddy with an O and M cost of InRs.10,000
M5	New cropping pattern with 50% under paddy, 25% cotton, and 25% eucalyptus with an O and M cost of InRs.10,000
M6	Only the additional benefits with MAR under current cropping pattern and O and M cost of InRs.10,000

BCR of MAR under different scenarios

	M1 (C-32, P-8) O &M 5K	M2(C-32, P-8)- O &M 10K	M3 (C-8, P-32)	M4 (C-20, P-20)	M5 (50% P, 25% E, 25% C)	M6 (A.Benefit only)
BCR	2.15	2.02	1.34	1.68	6.50	1.46
IRR	35	33	11	21		14

Conclusions

- The high-intra- and inter-annual variability of the Godavari Basin is affecting water availability of the BC.
- More than 80% of the runoff is generated in the monsoon months.
- Low river flows with high consumptive water use (CWU) during the non-monsoon months (November to May) are critical issues related to WS of the Godavari Basin and of the BC.
- The current river flows, especially in low-rainfall years, even fall below the minimum flows required to maintain the river at an acceptable environmental condition
- A substantial potential exists to manage aquifer recharge and tank rehabilitation that can enhance WS of the BC
- Suitable changes in agricultural practices has the potential to reduce water demand and increase financial viability.

Recommendations

- Management of aquifer recharge (MAR) should be implemented in the high and moderately high potential zones, either through private or public partnership or both.
- De-silting of tank beds and repairing damaged infrastructure of small tanks should also be considered a priority investment.
- While direct water withdrawals from the river are essential for sustainable operation of industries, the access to acceptable quality return-flows can be a financially viable source for irrigation users, especially during the non-monsoon months.

RESEARCH PROGRAM ON
Water, Land and Ecosystems

CGIAR

Thank you

IWMI International Water Management Institute · CGIAR Challenge Program on WATER & FOOD · CIAT Centro Internacional de Agricultura Tropical International Center for Tropical Agriculture · ICARDA · ICRISAT Science with a human face · World Agroforestry Centre Transforming Lives and Landscapes · Bioversity International · Centro Internacional de la Papa CIP · IFPRI International Food Policy Research Institute A member of the CGIAR Consortium · ILRI International Livestock Research Institute · IITA Research to Nourish Africa · WorldFish Center · FAO