HYDROLOGICAL VIABILITY ASSESSMENT STUDY OF IRRIGATION TANKS

APIIATP project
(World Bank Ph-II)

By

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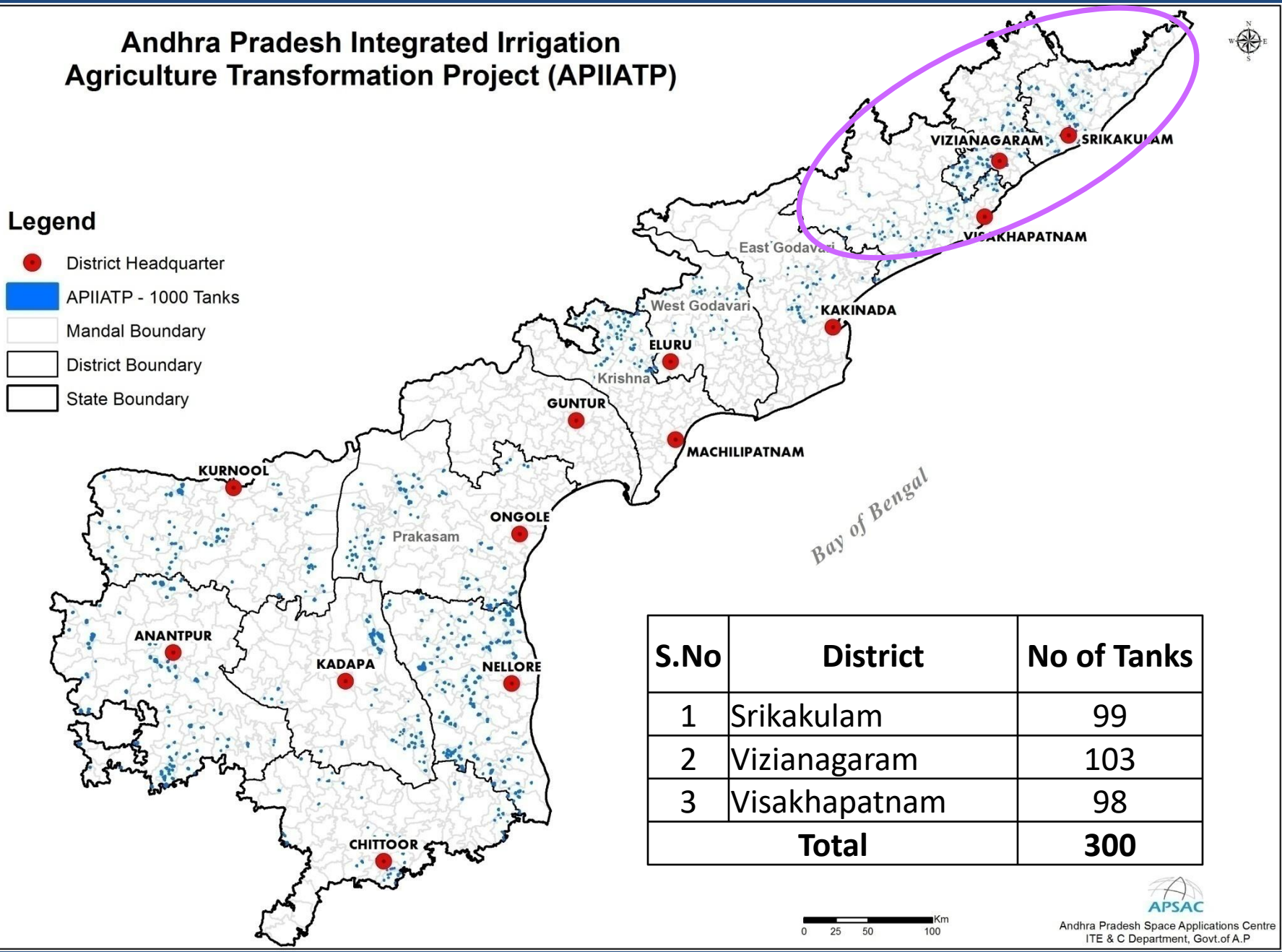
Source wise Irrigation

AP

- Net area Irrigated 29 lakh ha (45.7% od Net sown area)
- Canal 13.21 lakh ha
- Tanks 3.42 lakh ha
- Wells 11.36 lakh ha
- Other sources 1.20

Dist wise	NSA	Tanks	GW	Canal
Srk	1.86 L ha	28.39%	14.40%	54.63%
Vzm	1.57	41.04	33.00%	24.64%
Vsp	1.22	19.98	27.38%	34.25%

Andhra Pradesh Integrated Irrigation Agriculture Transformation Project (APIIATP)



S.No	District	No of Tanks
1	Srikakulam	99
2	Vizianagaram	103
3	Visakhapatnam	98
Total		**300**

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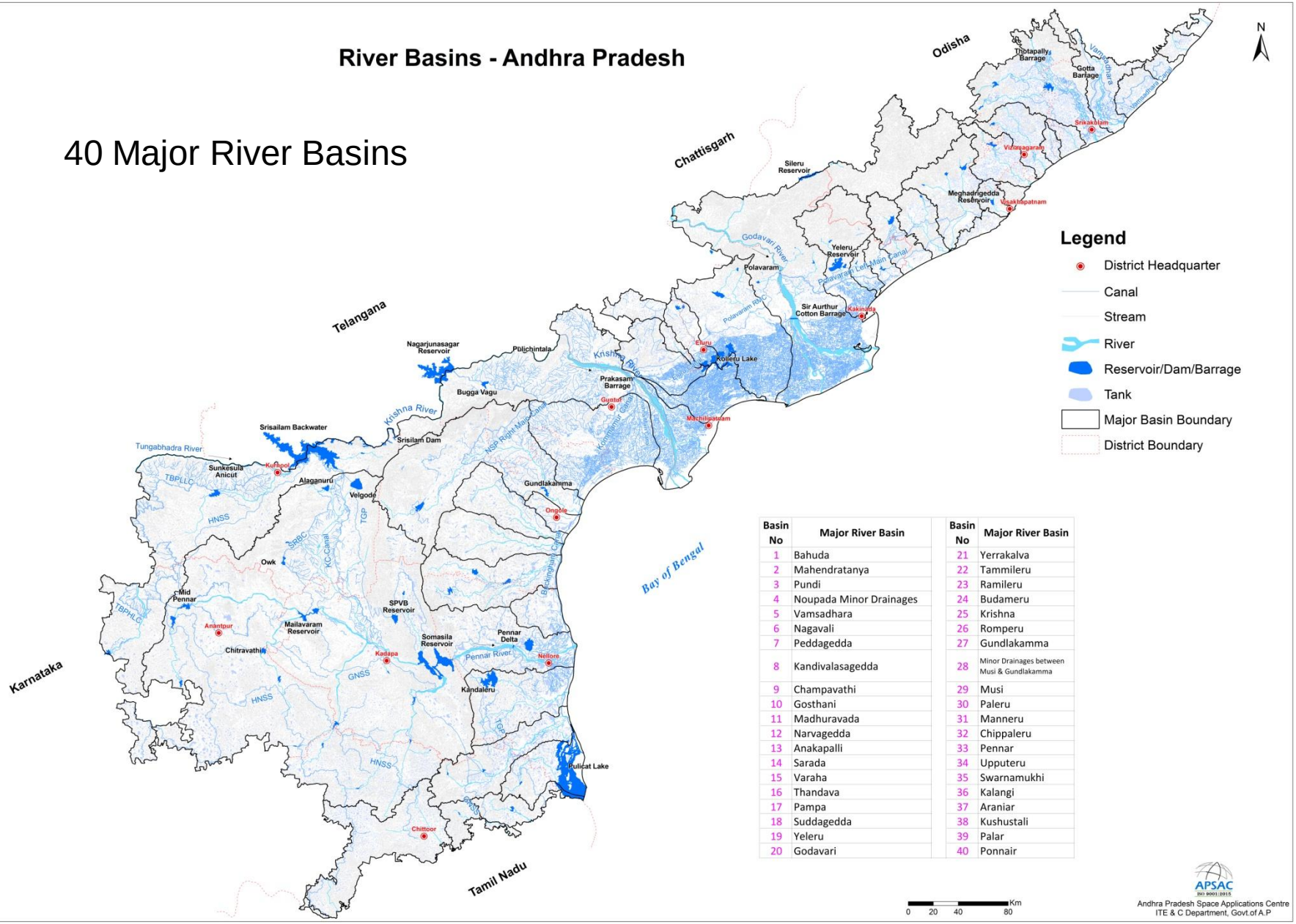
River Basins - Andhra Pradesh

40 Major River Basins



Basin No	Major River Basin	Basin No	Major River Basin
1	Bahuda	21	Yerrakalva
2	Mahendratanya	22	Tammileru
3	Pundi	23	Ramileru
4	Noupada Minor Drainages	24	Budameru
5	Vamsadhara	25	Krishna
6	Nagavali	26	Romperu
7	Peddagedda	27	Gundlakamma
8	Kandivalasagedda	28	Minor Drainages between Musi & Gundlakamma
9	Champavathi	29	Musi
10	Gosthani	30	Paleru
11	Madhuravada	31	Manneru
12	Narvagedda	32	Chippaleru
13	Anakapalli	33	Pennar
14	Sarada	34	Upputeru
15	Varaha	35	Swarnamukhi
16	Thandava	36	Kalangi
17	Pampa	37	Araniar
18	Suddagedda	38	Kushustali
19	Yeleru	39	Palar
20	Godavari	40	Ponnair

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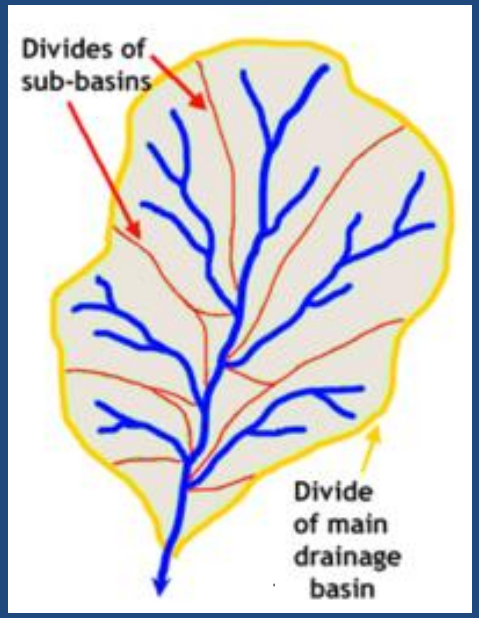
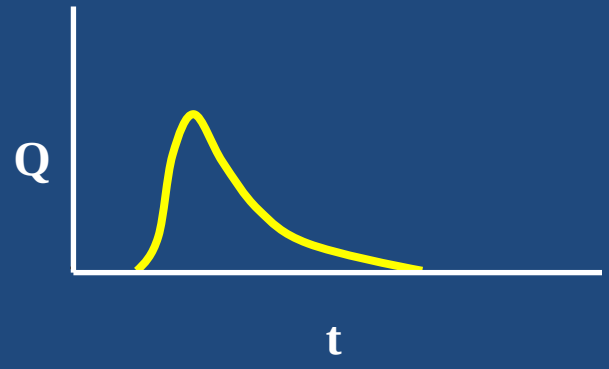
Presentation details

- About Runoff modelling
- Types of Runoff modelling
- Details of SCS curve method
- Case study

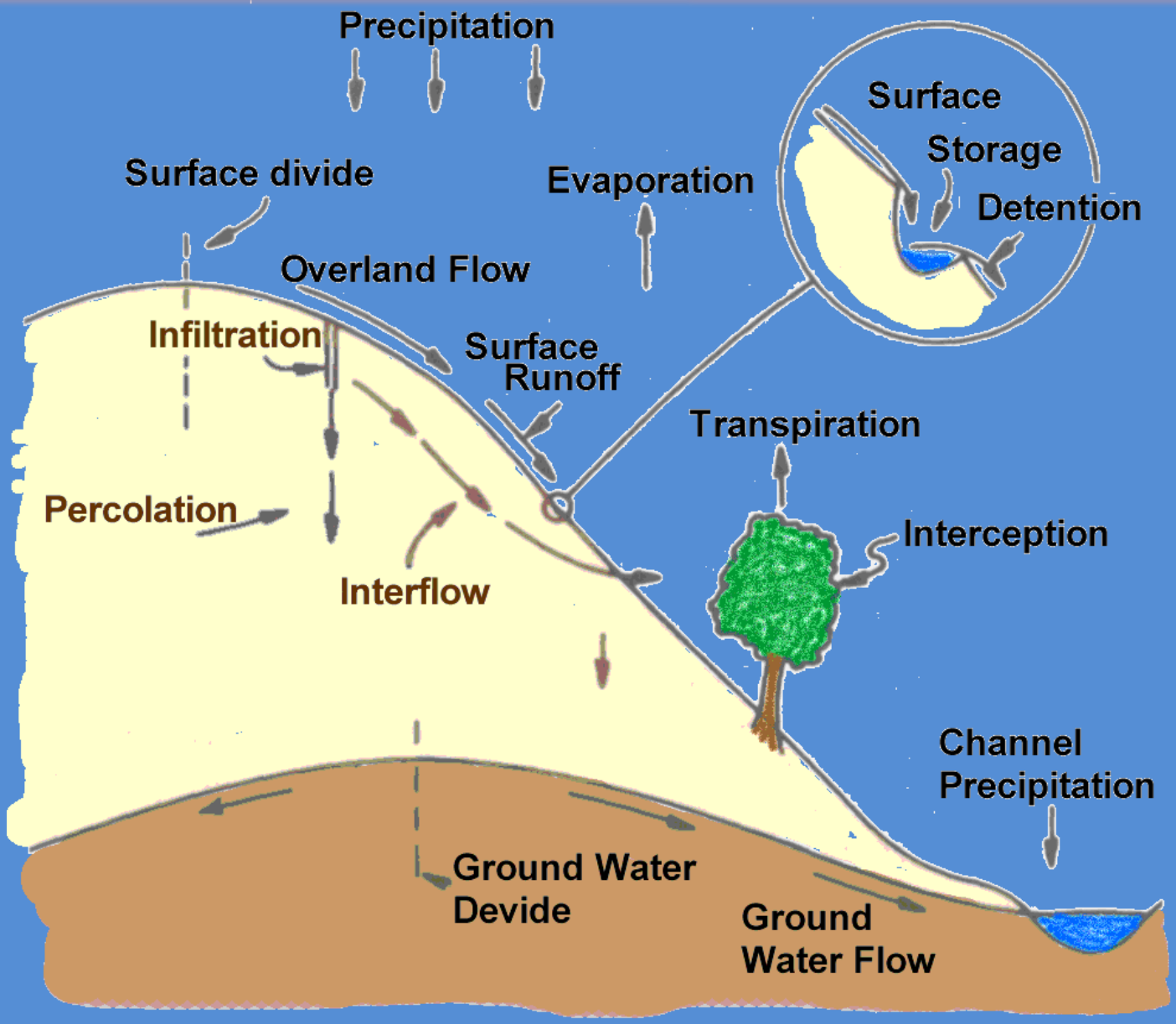
Runoff model

Runoff model is a mathematical **model** describing the **rainfall–runoff** relations of a **rainfall** catchment area, drainage basin or watershed. More precisely, it produces a surface **runoff** hydrograph in response to **rainfall** event, represented by and input as a hyetograph.





Hydrological process

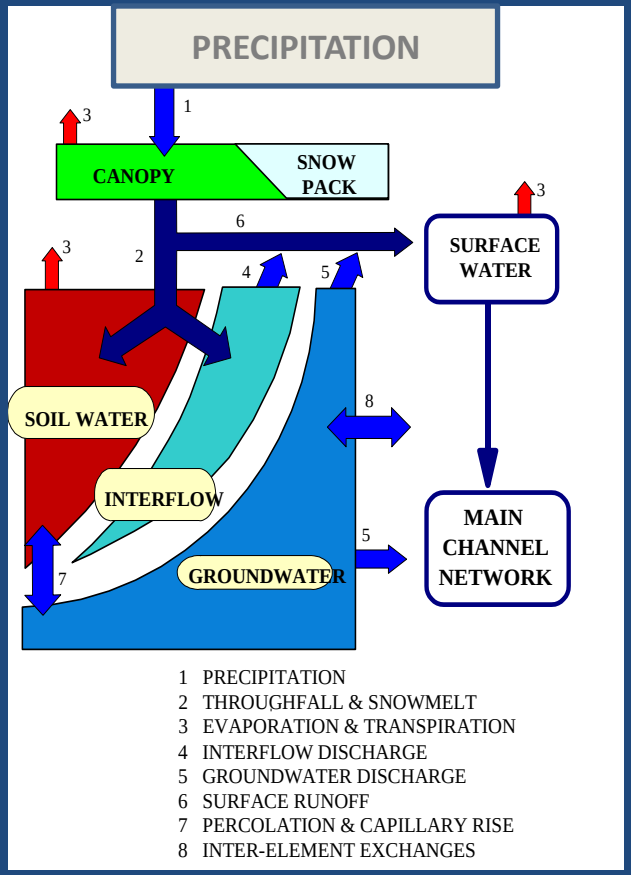


Runoff model

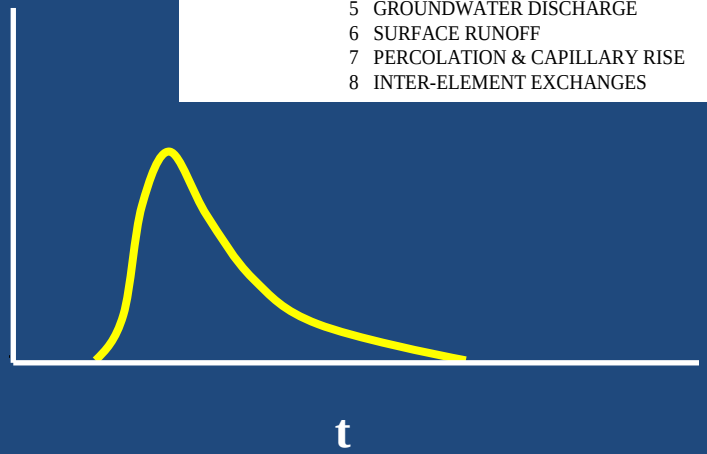
- Runoff depends on various parameters such as topographic conditions, vegetation cover, meteorological events, etc.
- **Modeling runoff** can help to understand, control, and monitor the quantity of water resources
- It helps to understand hydrological phenomena of a watershed and optimum utilisation of resources
- A runoff model can be selected based on the purpose, limitation of data availability, time and budget.

RUN-OFF

- **PHYSIOGRAPHIC FACTORS**
  - Basin characteristics
  - Infiltration characteristics
  - Channel characteristics
- **CLIMATIC FACTORS**
  - Storm characteristics
  - Evapotranspiration

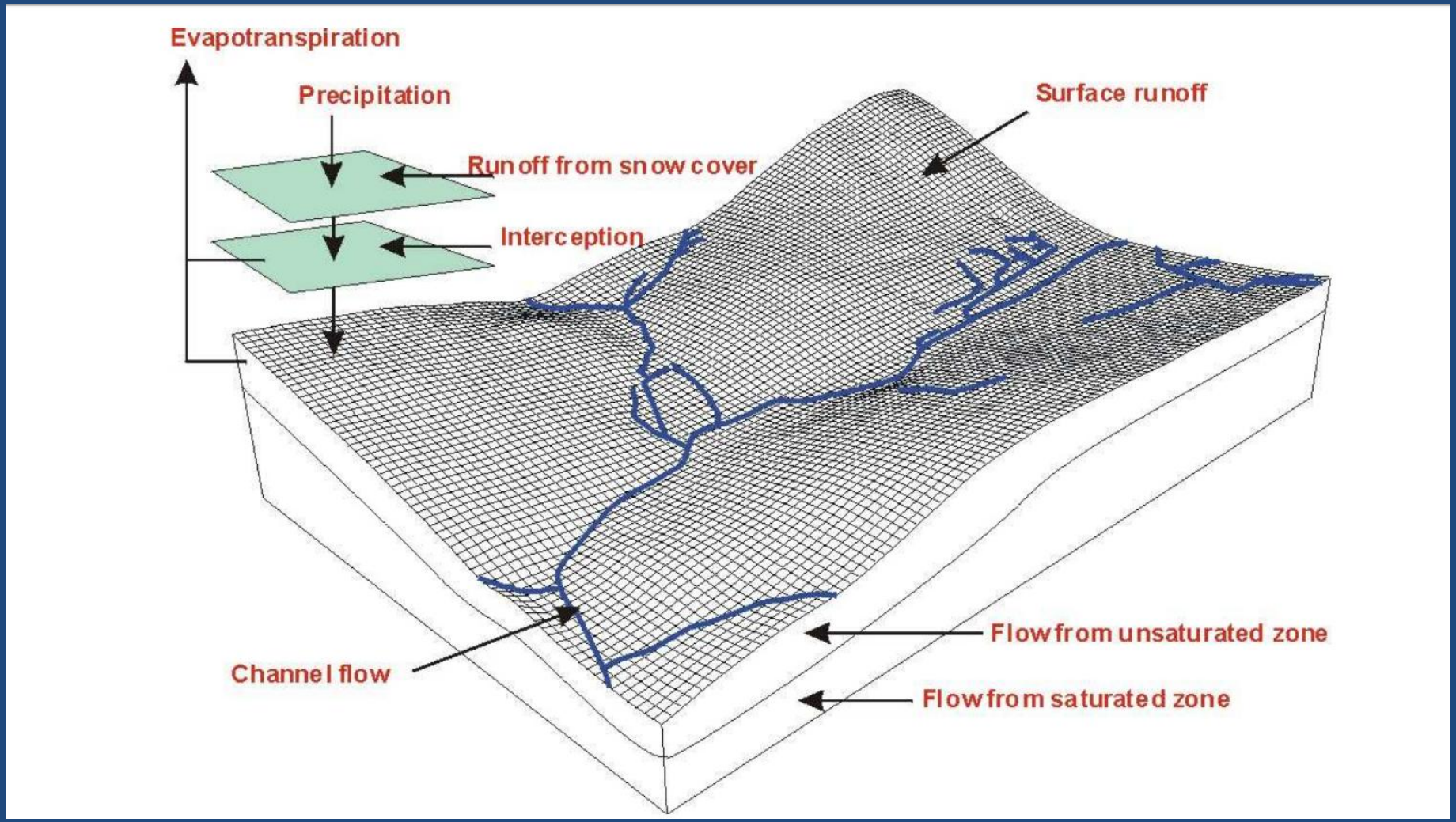


$$Qs = P - ET - \Delta SM - \Delta GW$$



Qs is surface runoff, P is precipitation, ET is evapotranspiration, ΔSM is change in soil moisture, and ΔGW is the change in groundwater storage.

General structure of a Hydrological model



Types of Rainfall models

Comparison of the basic structure for rainfall-runoff models

	Empirical	**Conceptual**	**Physical**
Method	Non-linear relationship between inputs and outputs, black box concept	Simplified equations that represent water storage in catchment	Physical laws and equations based on real hydrologic responses
Strengths	Small number of parameters needed, can be more accurate, fast run time	Easy to calibrate, simple model structure	Incorporates spatial and temporal variability, very fine scale
Weaknesses	No connection between physical catchment, input data distortion	Does not consider spatial variability within catchment	Large number of parameters and calibration needed, site specific
Best Use	In ungauged watersheds, runoff is the only output needed	When computational time or data are limited.	Have great data availability on a small scale
Examples	Curve Number, Artificial Neural Networks[a]	HSPF[b], TOPMODEL[a], HBV[a], Stanford[a]	MIKE-SHE[a], KINEROS[c], VIC[a], PRMS[d]

a] Devi et al. (2015)
[b] Johnson et al. (2003)
[c] Woolhiser et al. (1990)
[d] Singh (1995)

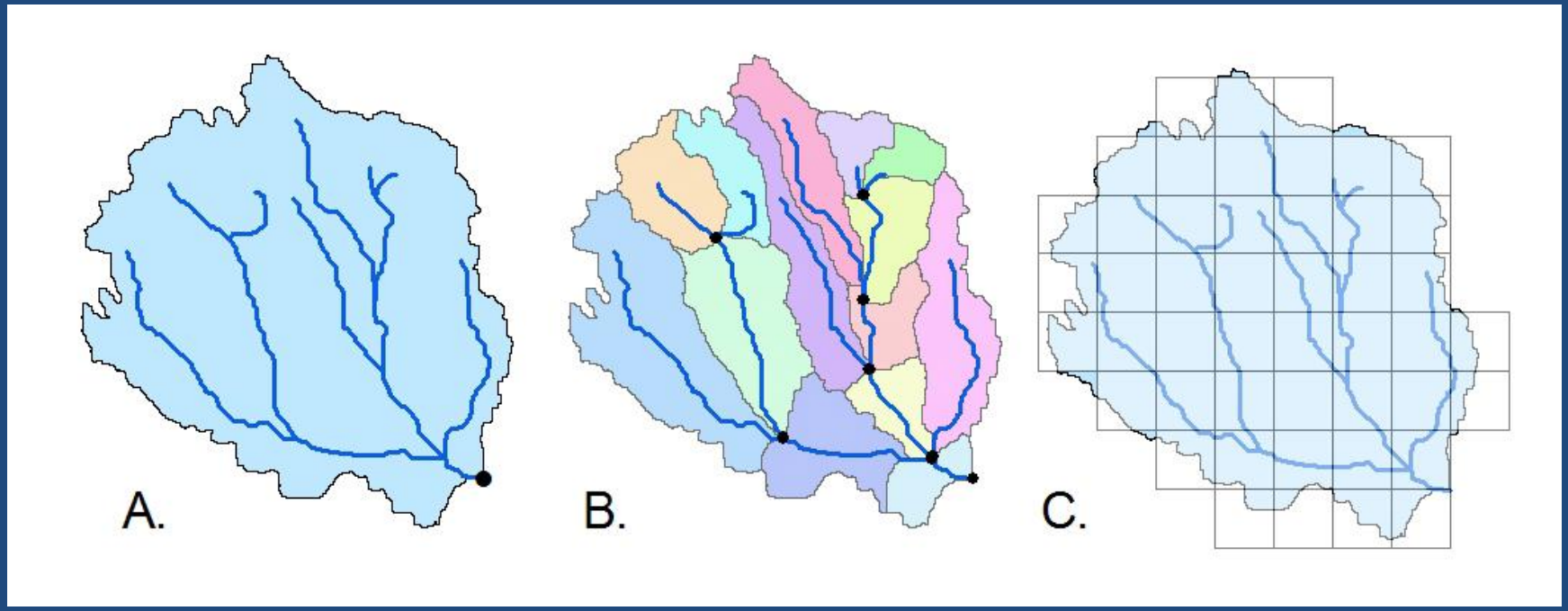
The spatial structure of catchment processes in rainfall-runoff models can be categorized as lumped, semi-distributed, and fully distributed

Comparison of the spatial structures in rainfall-runoff models

	Lumped	**Semi-Distributed**	**Distributed**
Method	Spatial variability is disregarded; entire catchment is modeled as one unit	Series of lumped and distributed parameters	Spatial variability is accounted for
Inputs	All averaged data by catchment	Both averaged and specific data by sub-catchment	All specific data by cell
Strengths	Fast computational time, good at simulating average conditions	Represents important features in catchment	Physically related to hydrological processes
Weaknesses	A lot of assumptions, loss of spatial resolution, not ideal for large areas	Averages data into sub-catchment areas, loss of spatial resolution	Data intense, long computational time
Examples	Empirical and conceptual models, machine learning	Conceptual and some physical models, TOPMODEL[a], SWAT[b]	Physically distributed models, MIKESHE[c], VELMA[d]

[a] Devi et al. (2015)
[b] Beven (2012)
[c] Singh (1995)
[d] McKane et al. (2014)

Visualization of the spatial structure in runoff models



A: Lumped model, B: Semi-Distributed model by sub-catchment, C: Distributed model by grid cell.

Runoff is calculated for each sub-catchment at the pour point represented by the black dots

SCS Curve Number method

The Soil Conservation Service (SCS) developed the SCS Curve Number method to compute abstractions from storm rainfall. This model is used to estimate the excess in the precipitation, as a function of cumulative precipitation, soil cover, land use and antecedent moisture. This is defined as:

$$Pe = \frac{(P - Ia)^2}{P - Ia + S}$$

where:

Pe = Cumulative excess rainfall depth
P = Cumulative depth of precipitation
Ia = Initial Loss / abstraction
S = Potential maximum retention

An empirical relation for calculation of initial abstraction is defined as:

$$Ia = 0.2 * S$$

DATABASE

1. Base maps (Source: SOI Toposheets)

2. Hydraulic particulars of a tank (Tank memoirs data from WRD)

3. Natural resources information like land use / land cover, Soils info generated from remote sensing data and from other collateral data.

4. Historical daily rainfall data (Source : IMD, DES, APSDPS)

RUNOFF ESTIMATION

SOIL CONSERVATION SERVICE (SCS) CURVE METHOD

$$R = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

$$S = \frac{25400}{CN} - 254$$

P = Rainfall in mm
R = Runoff in mm
CN = a coefficient called curve number

SCS CURVE METHOD FOR INDIAN CONDITIONS

$$R = \frac{(P - 0.3S)^2}{(P + 0.7S)} \quad \text{---(i)}$$

Black soil region AMC-I
All other regions

$$R = \frac{(P - 0.1S)^2}{(P + 0.9S)} \quad \text{---(2)}$$

Black soil region AMC-II & III

$$S = \frac{25400}{CN} - 254$$

S : Maximum Possible Retention
AMC : Antecedent Moisture Condition

Procedure

- Assigning of CN value derived based on Land use and Soil data of the catchment

- Calculation of monthly Rainy days, Rainfall, monthly & Yearly Runoff,

  75% dependable yield etc.

Run-off curve numbers – CN (II) for hydrologic soil cover complexes for AMC(II)

Run-off curve numbers – CN (II)

Land use	Cover		Hydrologic soils group			
	Treatment or Practice	Hydrologic condition	A	B	C	D
Cultivated	Straight row		76	86	90	93
Cultivated	Contoured	Poor Good	70 65	79 75	84 82	88 86
Cultivated	Contoured and terraced	Poor Good	66 62	74 71	80 77	82 81
Cultivated	Bunded	Poor Good	67 59	75 69	81 76	83 79
Cultivated	Paddy		95	95	95	95
Orchards/ Plantations	With understory cover Without under story cover		39 41	53 55	67 69	71 73
Forest	Dense Open Scrub		26 28 33	40 44 47	58 60 64	61 64 67
Pasture	Poor Fair Good		68 49 39	79 69 61	86 79 74	89 84 80
Wasteland			71	80	85	88
Roads(dirt)			73	83	88	90
Hard surface areas			77	86	91	93

Antecedent Moisture conditions (AMC) for determining the values for CN

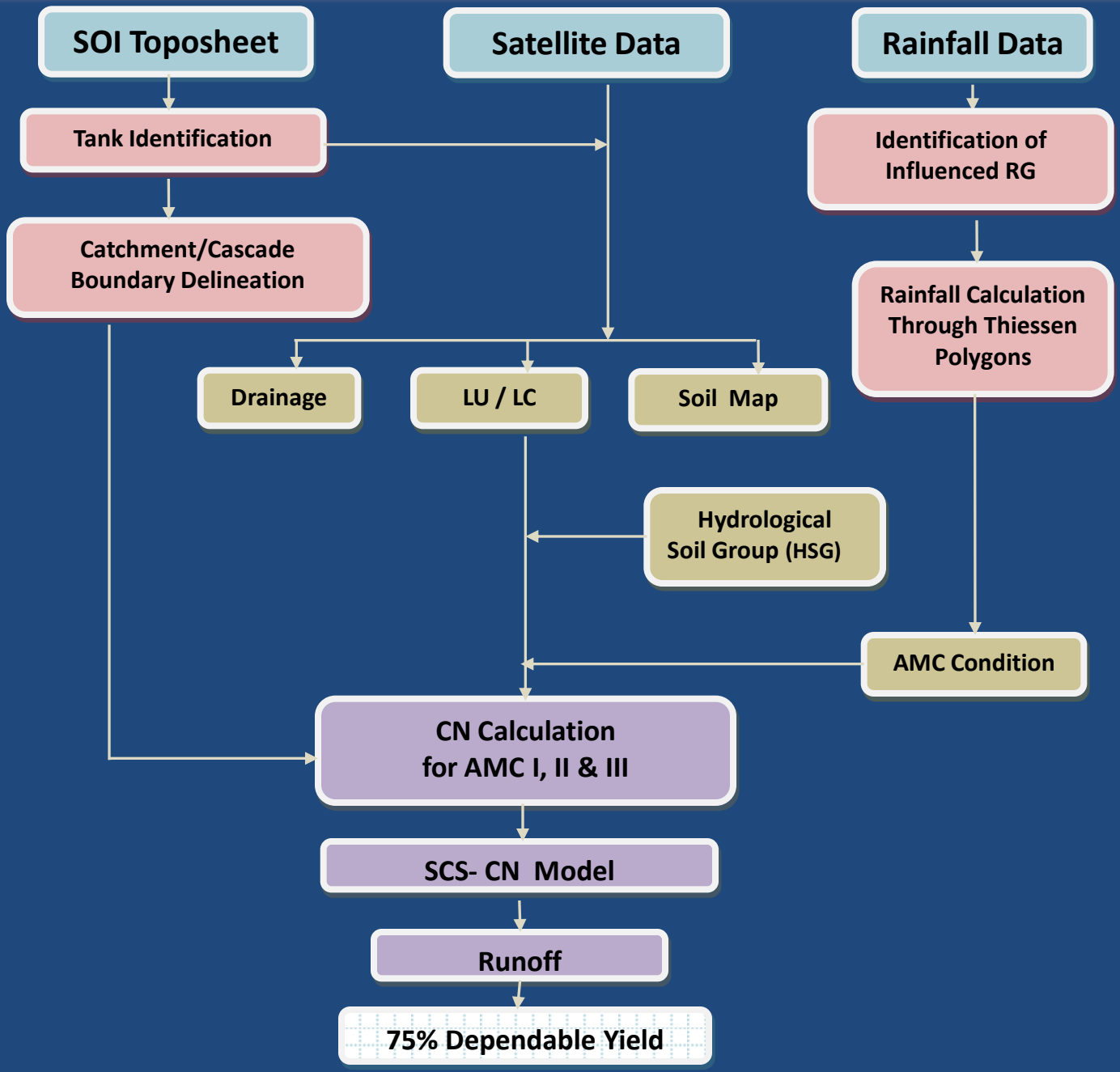
AMC type	Total rain in previous 5 days	
	Dormant season	**Growing season**
I	Less than 13 mm	Less than 36 mm
II	13 to 28 mm	36 to 53 mm
III	More than 28 mm	More than 53 mm

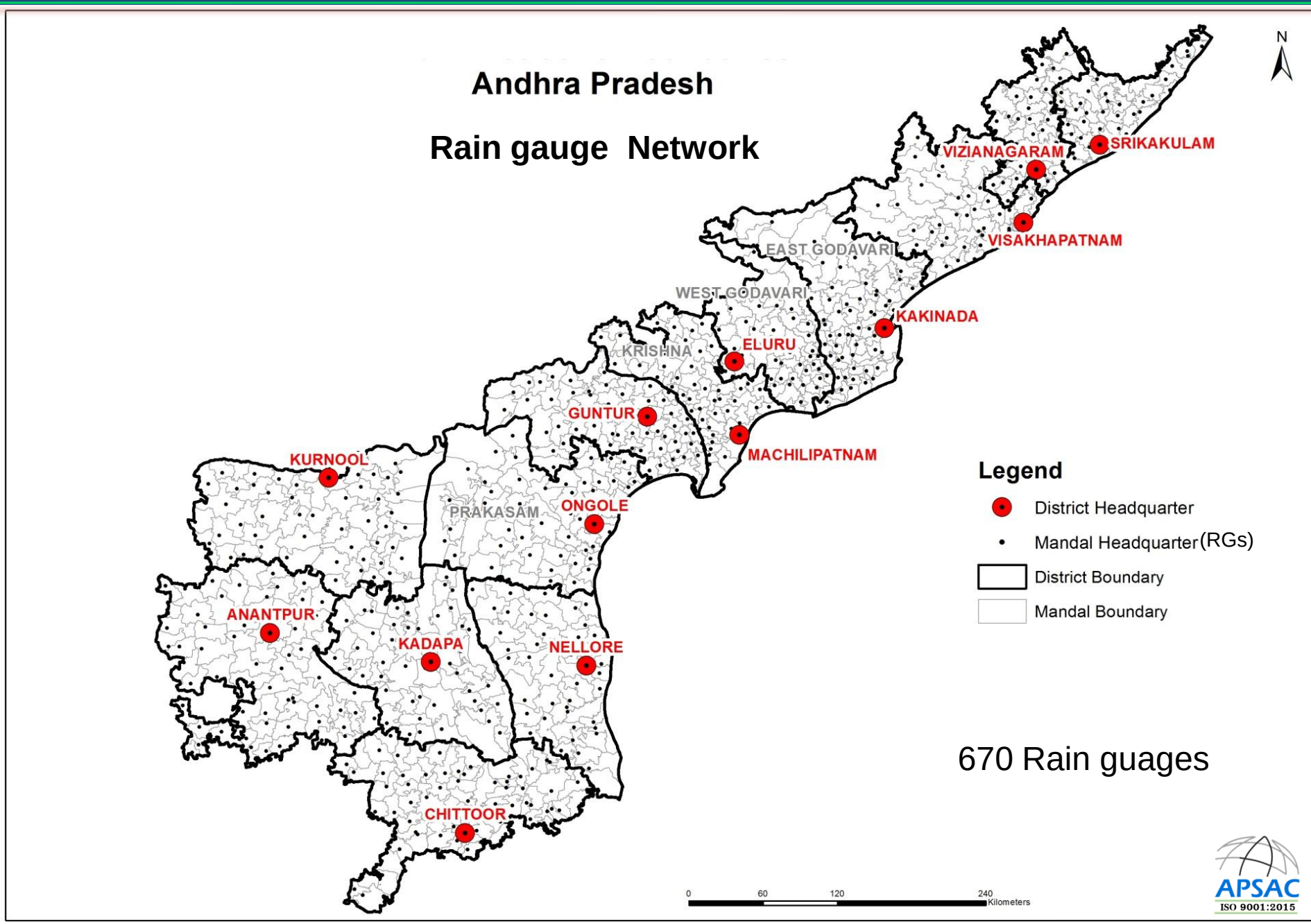
Calculation of CN values for AMC Type I & II

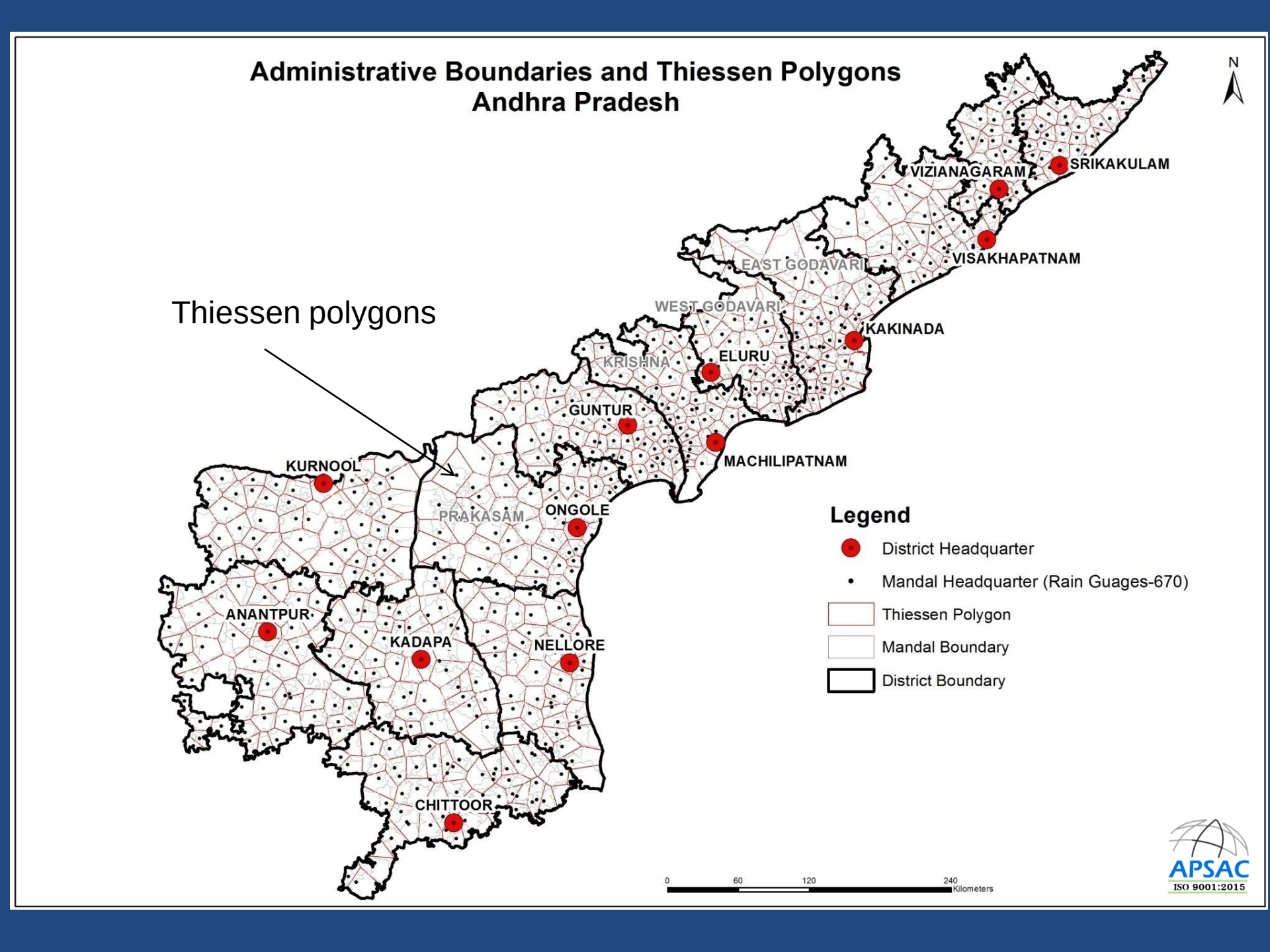
$$CN(I) = \frac{4.2\ CN(II)}{10 - 0.058\ CN(II)}$$

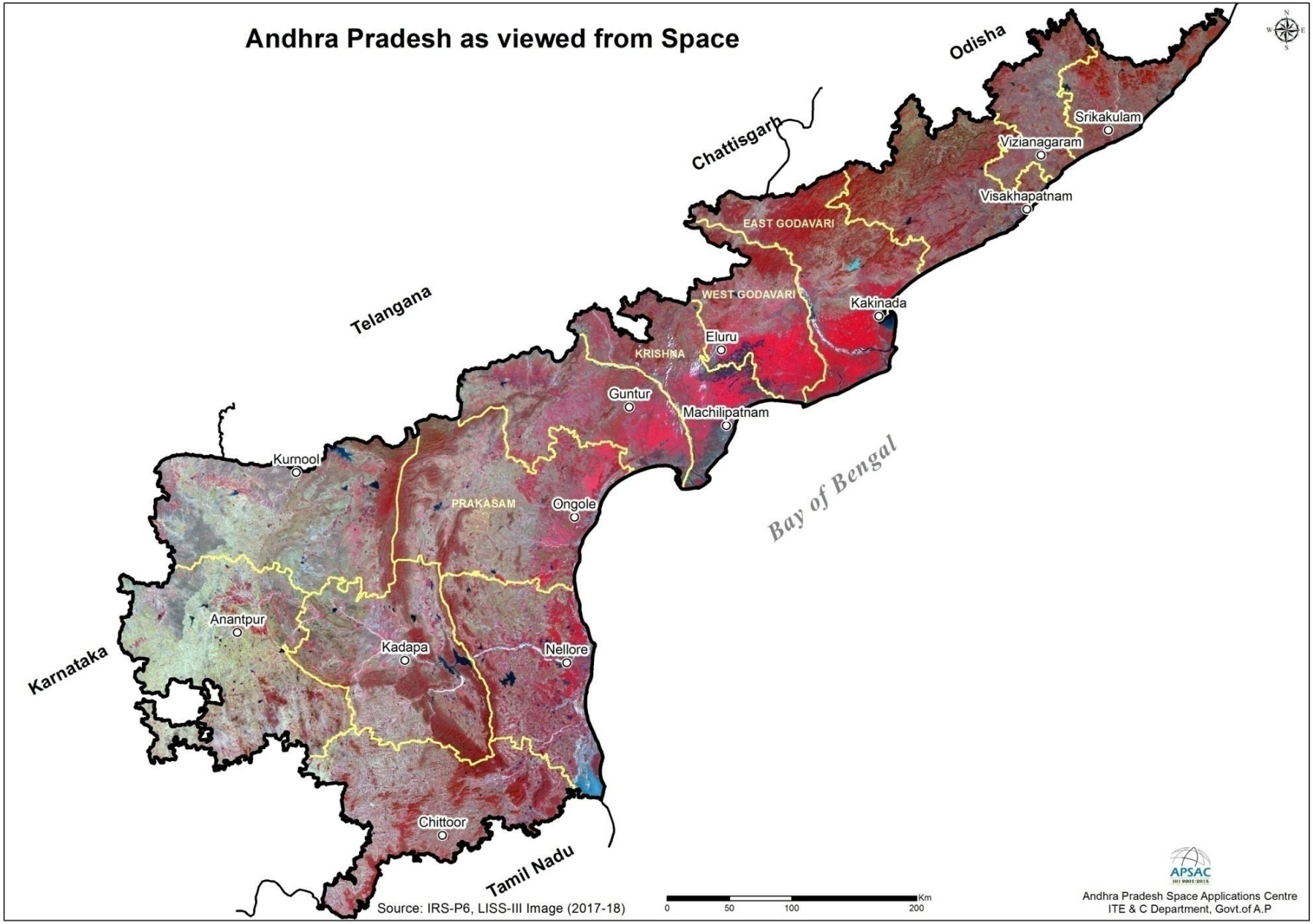
$$CN(III) = \frac{23\ CN(II)}{10 + 0.13\ CN(II)}$$

Hydrological Analysis – Estimation of 75% Dependable Yield Flow Chart




Andhra Pradesh
Rain gauge Network
N
SRIKAKULAM
VIZIANAGARAM
VISAKHAPATNAM
EAST GODAVARI
WEST GODAVARI
KAKINADA
KRISHNA
ELURU
GUNTUR
MACHILIPATNAM
KURNOOL
PRAKASAM
ONGOLE
ANANTPUR
KADAPA
NELLORE
CHITTOOR
Legend
District Headquarter
Mandal Headquarter (RGs)
District Boundary
Mandal Boundary
0
60
120
240
Kilometers
670 Rain guages
APSAC
ISO 9001:2015


Administrative Boundaries and Thiessen Polygons
Andhra Pradesh
Thiessen polygons
N
SRIKAKULAM
VIZIANAGARAM
VISAKHAPATNAM
EAST GODAVARI
WEST GODAVARI
KAKINADA
KRISHNA
ELURU
GUNTUR
MACHILIPATNAM
KURNOOL
PRAKASAM
ONGOLE
ANANTPUR
KADAPA
NELLORE
CHITTOOR
Legend
District Headquarter
Mandal Headquarter (Rain Guages-670)
Thiessen Polygon
Mandal Boundary
District Boundary
0
60
120
240
Kilometers
APSAC
ISO 9001:2015


Andhra Pradesh as viewed from Space
Odisha
Chattisgarh
Telangana
Karnataka
Tamil Nadu
Bay of Bengal
Srikakulam
Vizianagaram
Visakhapatnam
EAST GODAVARI
WEST GODAVARI
Kakinada
Eluru
KRISHNA
Guntur
Machilipatnam
Kurnool
PRAKASAM
Ongole
Anantpur
Kadapa
Nellore
Chittoor
Source: IRS-P6, LISS-III Image (2017-18)
0 50 100 200 Km
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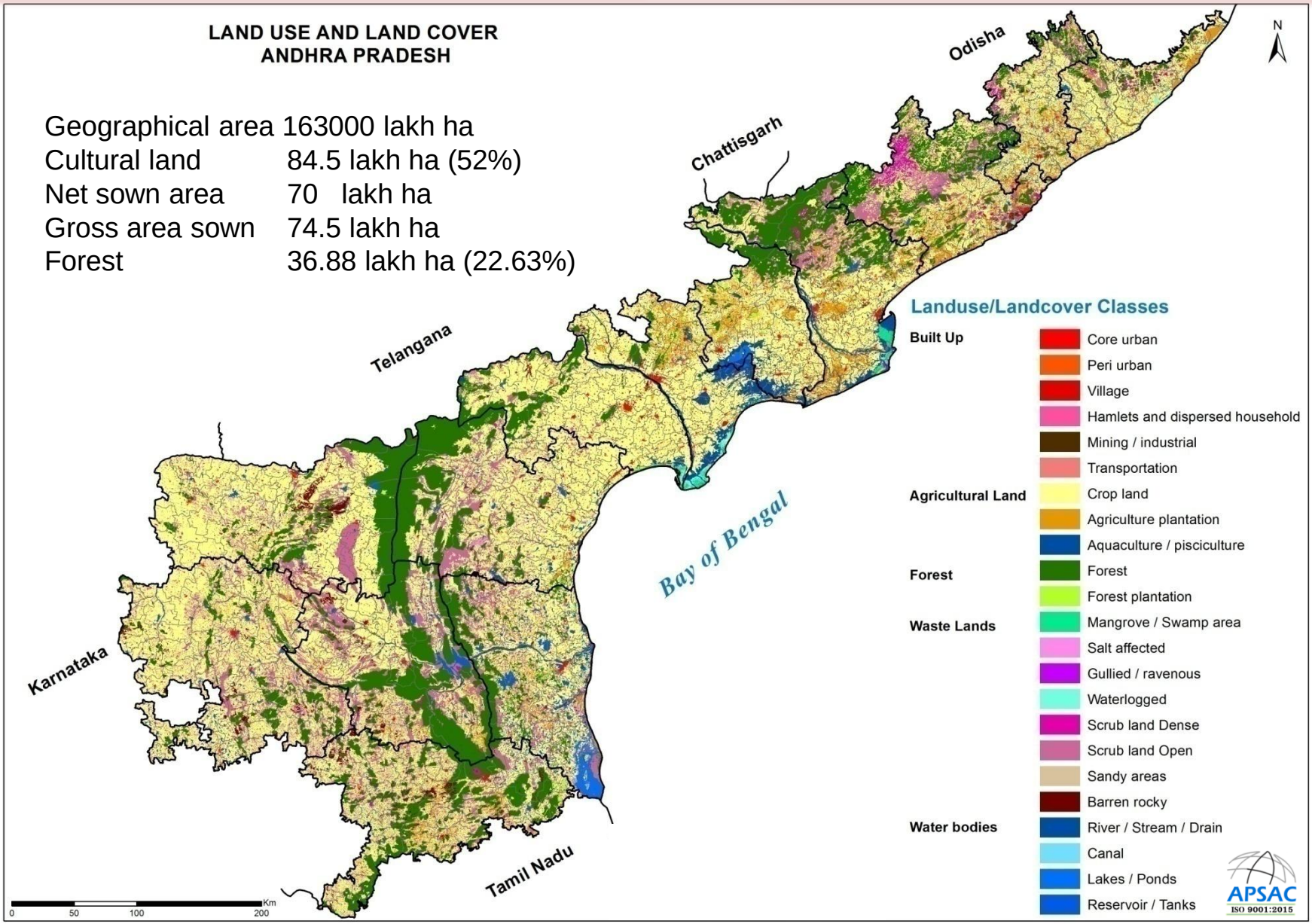
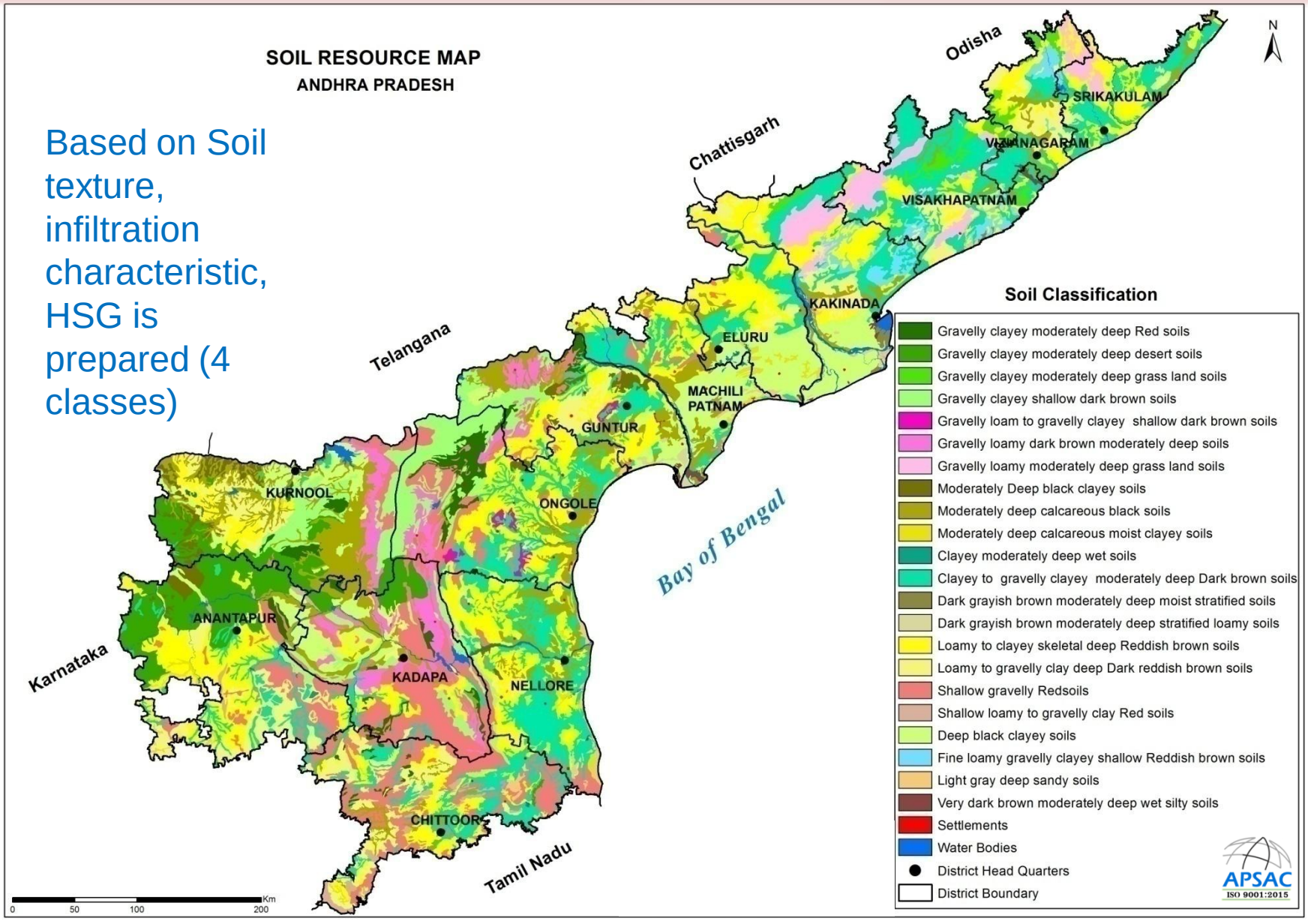
LAND USE AND LAND COVER
ANDHRA PRADESH

Geographical area 163000 lakh ha
Cultural land 84.5 lakh ha (52%)
Net sown area 70 lakh ha
Gross area sown 74.5 lakh ha
Forest 36.88 lakh ha (22.63%)

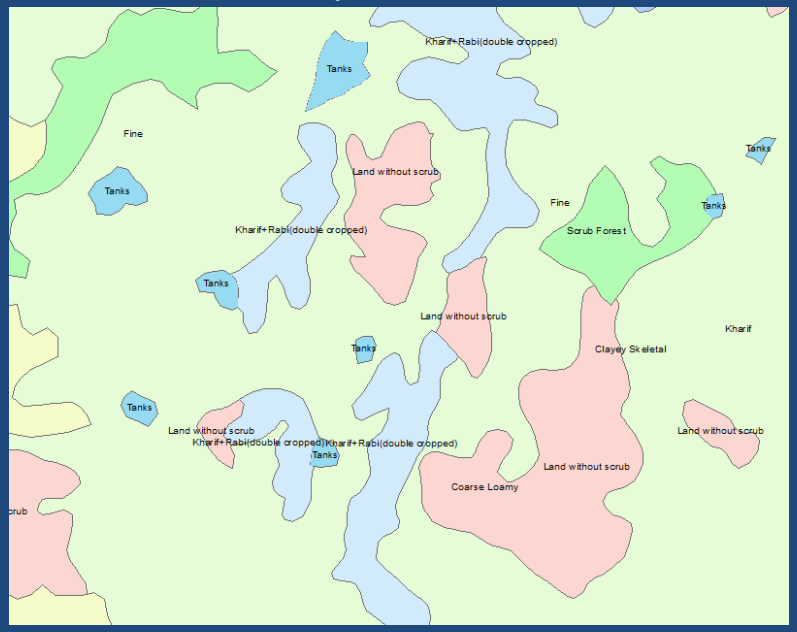


Based on Soil texture, infiltration characteristic, HSG is prepared (4 classes)

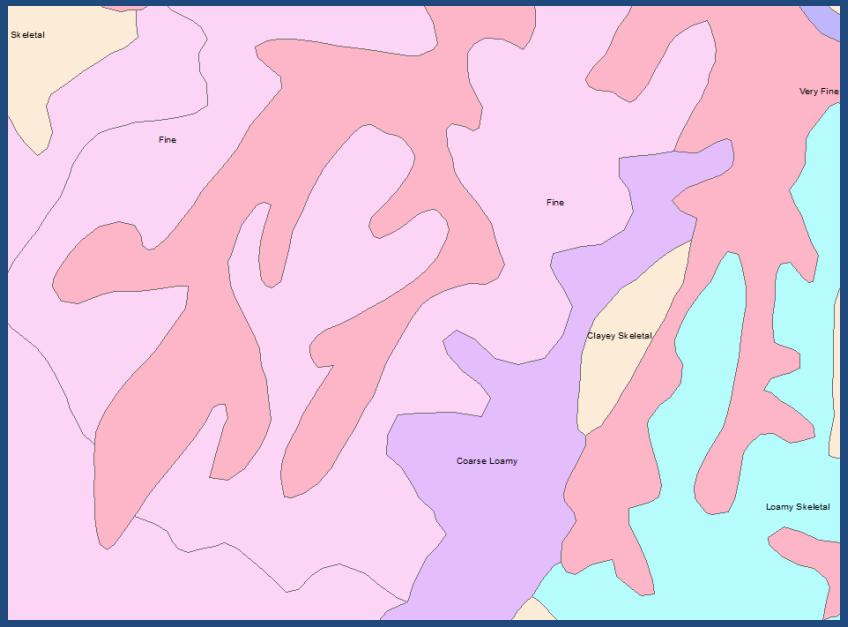


Integration

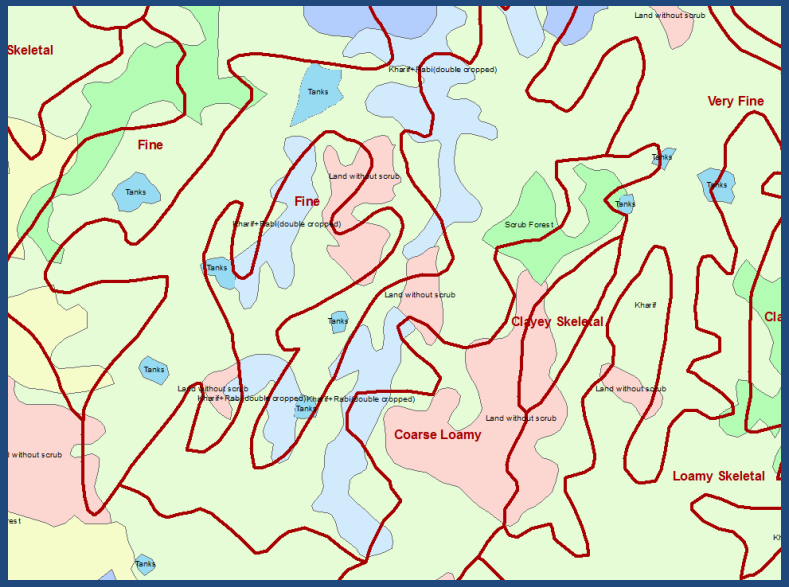
Land use / Land cover



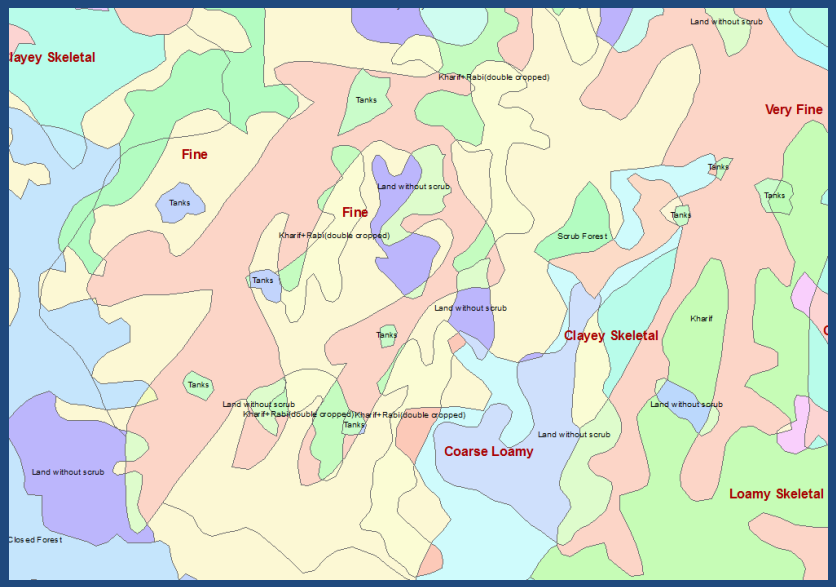
HYDROLOGICAL SOIL GROUP (HSG)



Land use + HSG



Union of Land use and HSG



Calculation of CN Value

SNo	Tank Name	LU / LC	HSG	Area (Sq.km)	CN	Total CN
1	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.028	53	1.484
2	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.005	53	0.265
3	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.004	53	0.212
4	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.003	53	0.159
5	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.002	53	0.106
6	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.057	53	3.021
7	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.003	53	0.159
8	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.013	53	0.689
9	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.016	53	0.848
10	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	B	0.006	53	0.318
11	Yeerakanna Dora Tank	Agricultural Land-Agricultural Plantation-Agricultural Plantation	C	0.012	67	0.804
12	Yeerakanna Dora Tank	Agricultural Land-Cropland-Kharif	B	0.015	75	1.125
13	Yeerakanna Dora Tank	Agricultural Land-Cropland-Kharif	B	0.007	75	0.525
14	Yeerakanna Dora Tank	Agricultural Land-Cropland-Kharif	B	0.053	75	3.975
15	Yeerakanna Dora Tank	Agricultural Land-Cropland-Kharif	B	0.028	75	2.1
16	Yeerakanna Dora Tank	Agricultural Land-Cropland-Kharif	B	0.022	75	1.65
17	Yeerakanna Dora Tank	Agricultural Land-Cropland-Kharif	B	0.004	75	0.3
18	Yeerakanna Dora Tank	Agricultural Land-Cropland-Kharif	B	0.109	75	8.175
19	Yeerakanna Dora Tank	Agricultural Land-Cropland-Kharif	B	0.076	75	5.7
20	Yeerakanna Dora Tank	Agricultural Land-Cropped in two Seasons	B	0.001	95	0.095
21	Yeerakanna Dora Tank	Agricultural Land-Cropped in two Seasons	B	0.011	95	1.045
22	Yeerakanna Dora Tank	Agricultural Land-Cropped in two Seasons	B	0.007	95	0.665
23	Yeerakanna Dora Tank	Agricultural Land-Cropped in two Seasons	B	0.053	95	5.035
24	Yeerakanna Dora Tank	Agricultural Land-Cropped in two Seasons	B	0.105	95	9.975
25	Yeerakanna Dora Tank	Agricultural Land-Cropped in two Seasons	C	0.033	95	3.135
26	Yeerakanna Dora Tank	Agricultural Land-Fallow land-Fallow land	B	0.03	69	2.07
27	Yeerakanna Dora Tank	Agricultural Land-Fallow land-Fallow land	B	0.003	69	0.207
28	Yeerakanna Dora Tank	Agricultural Land-Fallow land-Fallow land	B	0.043	69	2.967
29	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.026	86	2.236
30	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.044	86	3.784
31	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.001	86	0.086
32	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.029	86	2.494
33	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.016	86	1.376
34	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.003	86	0.258
35	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.032	86	2.752
36	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.013	86	1.118
37	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.001	86	0.086
38	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.013	86	1.118
39	Yeerakanna Dora Tank	Built Up-Rural-Rural	B	0.122	86	10.492
40	Yeerakanna Dora Tank	Built Up-Rural-Rural	C	0.004	91	0.364
41	Yeerakanna Dora Tank	Built Up-Rural-Rural	C	0.005	91	0.455
42	Yeerakanna Dora Tank	Built Up-Urban-Industrial-Industrial Area	B	0.024	86	2.064
43	Yeerakanna Dora Tank	Built Up-Urban-Industrial-Industrial Area	B	0.001	86	0.086
44	Yeerakanna Dora Tank	Wastelands-Scrub land-Dense/Closed	B	0.102	69	7.038
45	Yeerakanna Dora Tank	Wastelands-Scrub land-Dense/Closed	B	0.549	69	37.881
46	Yeerakanna Dora Tank	Wastelands-Scrub land-Open	B	0.02	69	1.38
47	Yeerakanna Dora Tank	Wastelands-Scrub land-Open	B	0.052	69	3.588
48	Yeerakanna Dora Tank	Wastelands-Scrub land-Open	B	0.104	69	7.176

Weighted Average Curve Number of each tank catchment =

Total CN / Total Area

Runoff Calculation

Home RainyDays Monthly Yearly RunOff-Monthly RunOff-Yearly MonSoon All Soils RO MonSoon BC Soils RO Missing Dates

RID	RDATE	RAINFALL_VALUE	CUMULATIVE_RAINFALL	AMCTYPE	CN_VALUE	ALL_SOILS_RF	BLACK_SOILS_RF
1	1988-01-01	0.00	null	null	null	null	null
2	1988-01-02	0.00	null	null	null	null	null
3	1988-01-03	0.00	null	null	null	null	null
4	1988-01-04	0.00	null	null	null	null	null
5	1988-01-05	0.00	0.00	I	47.54	0.00	0.00
6	1988-01-06	0.00	0.00	I	47.54	0.00	0.00
7	1988-01-07	0.00	0.00	I	47.54	0.00	0.00
8	1988-01-08	0.00	0.00	I	47.54	0.00	0.00
9	1988-01-09	0.00	0.00	I	47.54	0.00	0.00
10	1988-01-10	0.00	0.00	I	47.54	0.00	0.00
11	1988-01-11	0.00	0.00	I	47.54	0.00	0.00
12	1988-01-12	0.00	0.00	I	47.54	0.00	0.00
13	1988-01-13	0.00	0.00	I	47.54	0.00	0.00
14	1988-01-14	0.00	0.00	I	47.54	0.00	0.00
15	1988-01-15	0.00	0.00	I	47.54	0.00	0.00
16	1988-01-16	0.00	0.00	I	47.54	0.00	0.00
17	1988-01-17	0.00	0.00	I	47.54	0.00	0.00
18	1988-01-18	0.00	0.00	I	47.54	0.00	0.00
19	1988-01-19	0.00	0.00	I	47.54	0.00	0.00
20	1988-01-20	0.00	0.00	I	47.54	0.00	0.00
21	1988-01-21	0.00	0.00	I	47.54	0.00	0.00
22	1988-01-22	0.00	0.00	I	47.54	0.00	0.00
23	1988-01-23	0.00	0.00	I	47.54	0.00	0.00
24	1988-01-24	0.00	0.00	I	47.54	0.00	0.00
25	1988-01-25	0.00	0.00	I	47.54	0.00	0.00
26	1988-01-26	0.00	0.00	I	47.54	0.00	0.00
27	1988-01-27	0.00	0.00	I	47.54	0.00	0.00
28	1988-01-28	0.00	0.00	I	47.54	0.00	0.00
29	1988-01-29	0.00	0.00	I	47.54	0.00	0.00
30	1988-01-30	0.00	0.00	I	47.54	0.00	0.00
31	1988-01-31	0.00	0.00	I	47.54	0.00	0.00
32	1988-02-01	0.00	0.00	I	47.54	0.00	0.00
33	1988-02-02	0.00	0.00	I	47.54	0.00	0.00
34	1988-02-03	0.00	0.00	I	47.54	0.00	0.00
35	1988-02-04	0.00	0.00	I	47.54	0.00	0.00
36	1988-02-05	0.00	0.00	I	47.54	0.00	0.00
37	1988-02-06	0.00	0.00	I	47.54	0.00	0.00

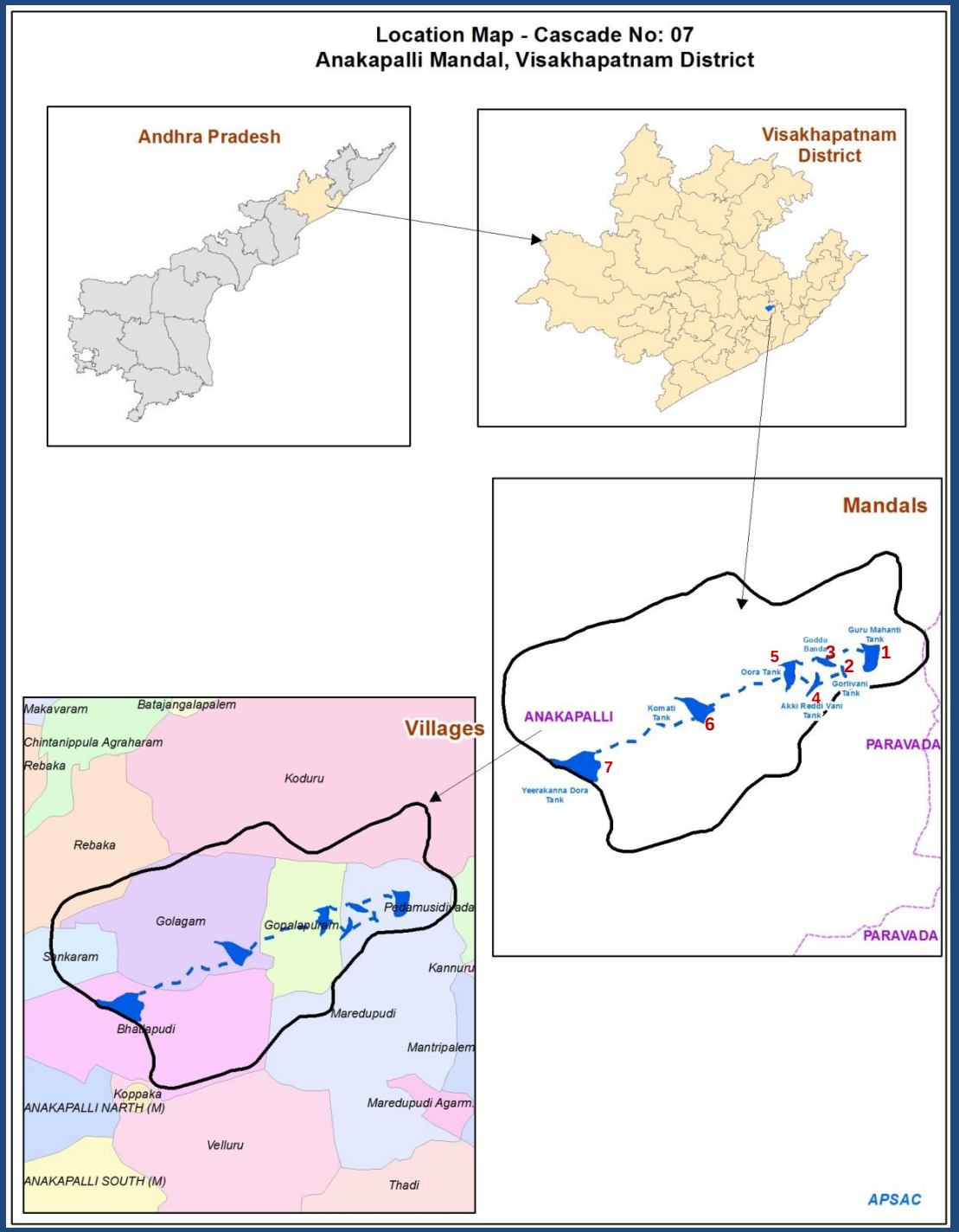
A tool is developed to calculate AMC, weighted CN value, monthly / yearly Rainfall / runoff, rainy days of each tank catchment

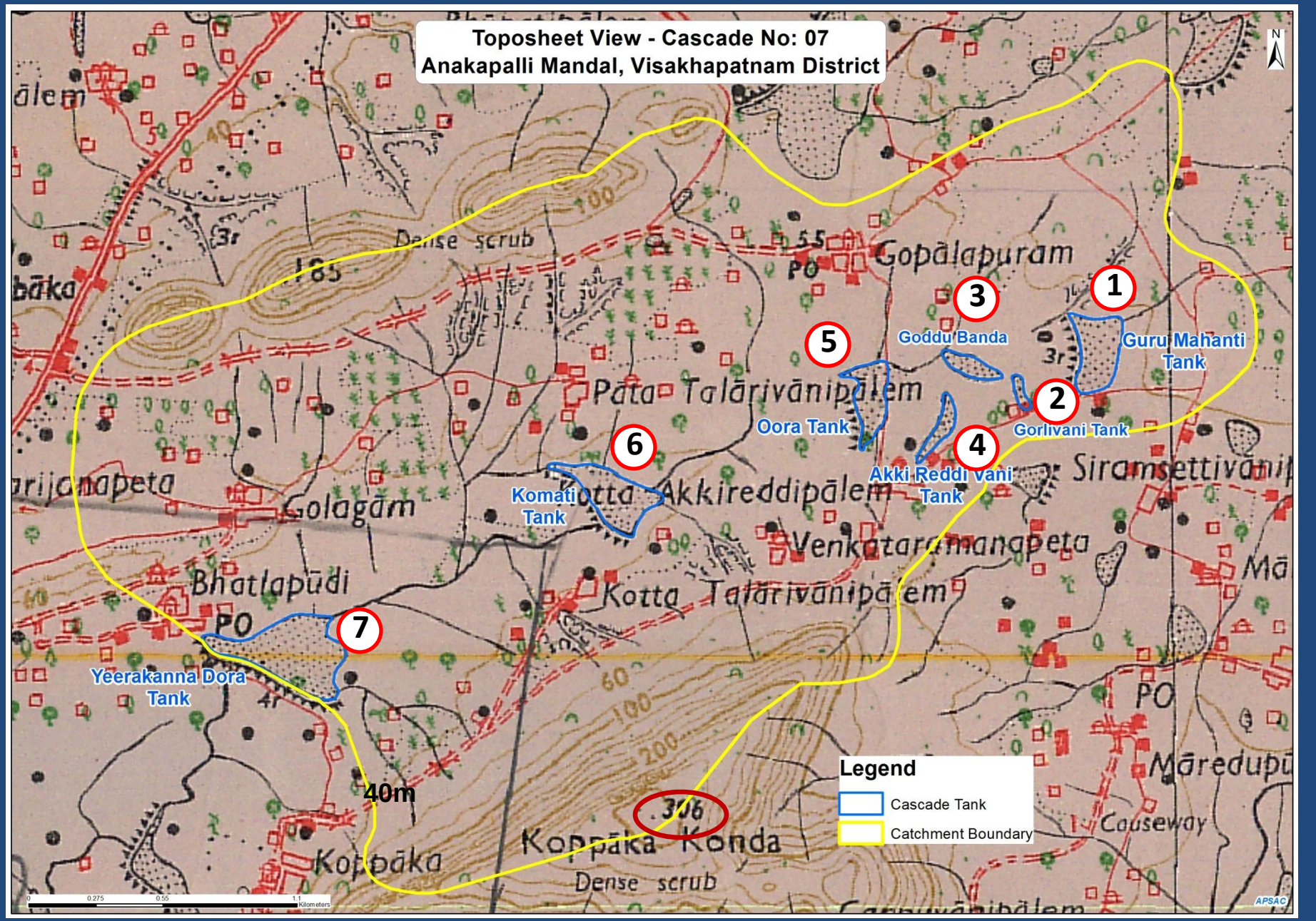
CASE STUDY

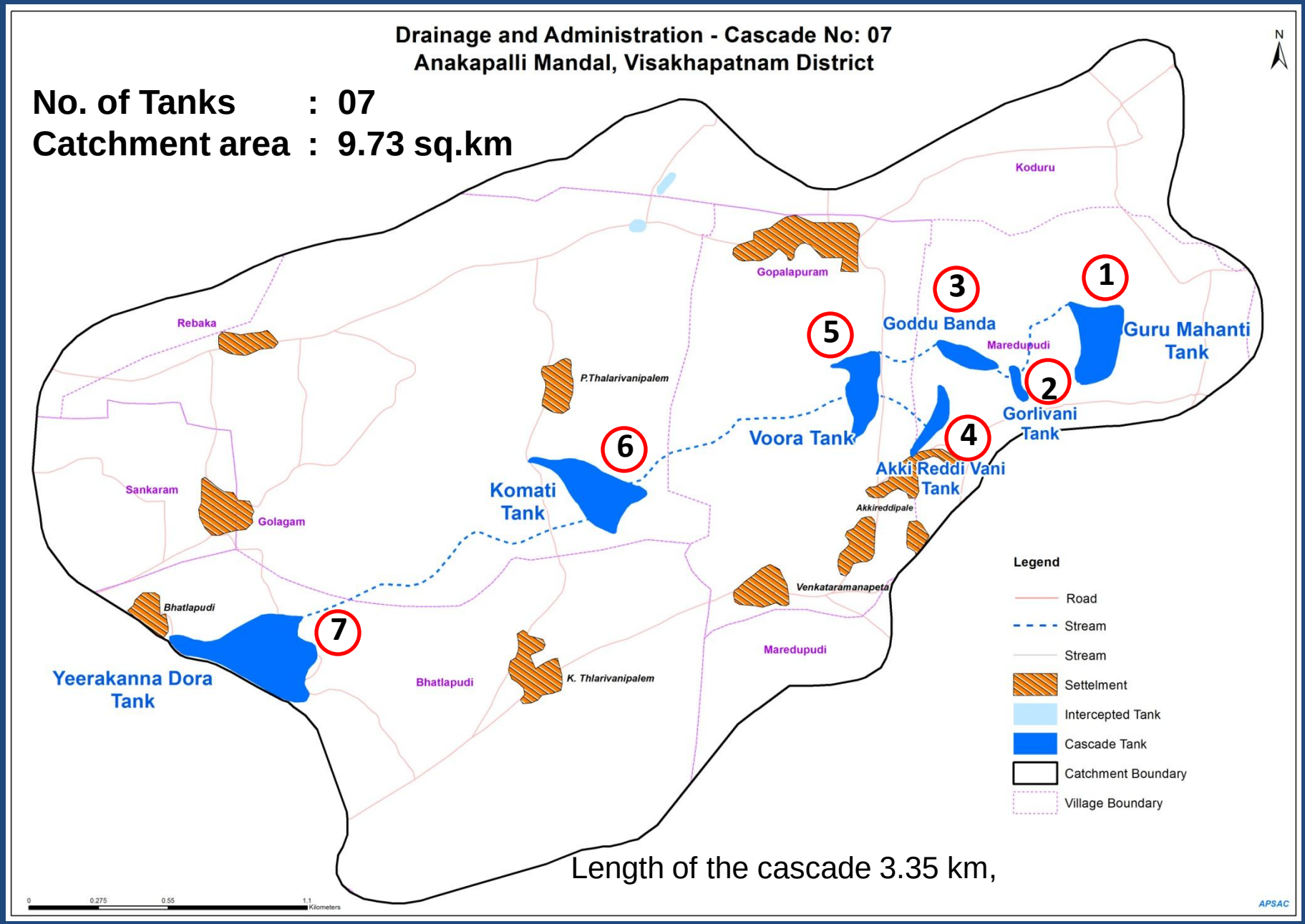
Cascade No-7
Anakapalli Mandal

CASE STUDY
Cascade No-7
Anakapalli Mandal

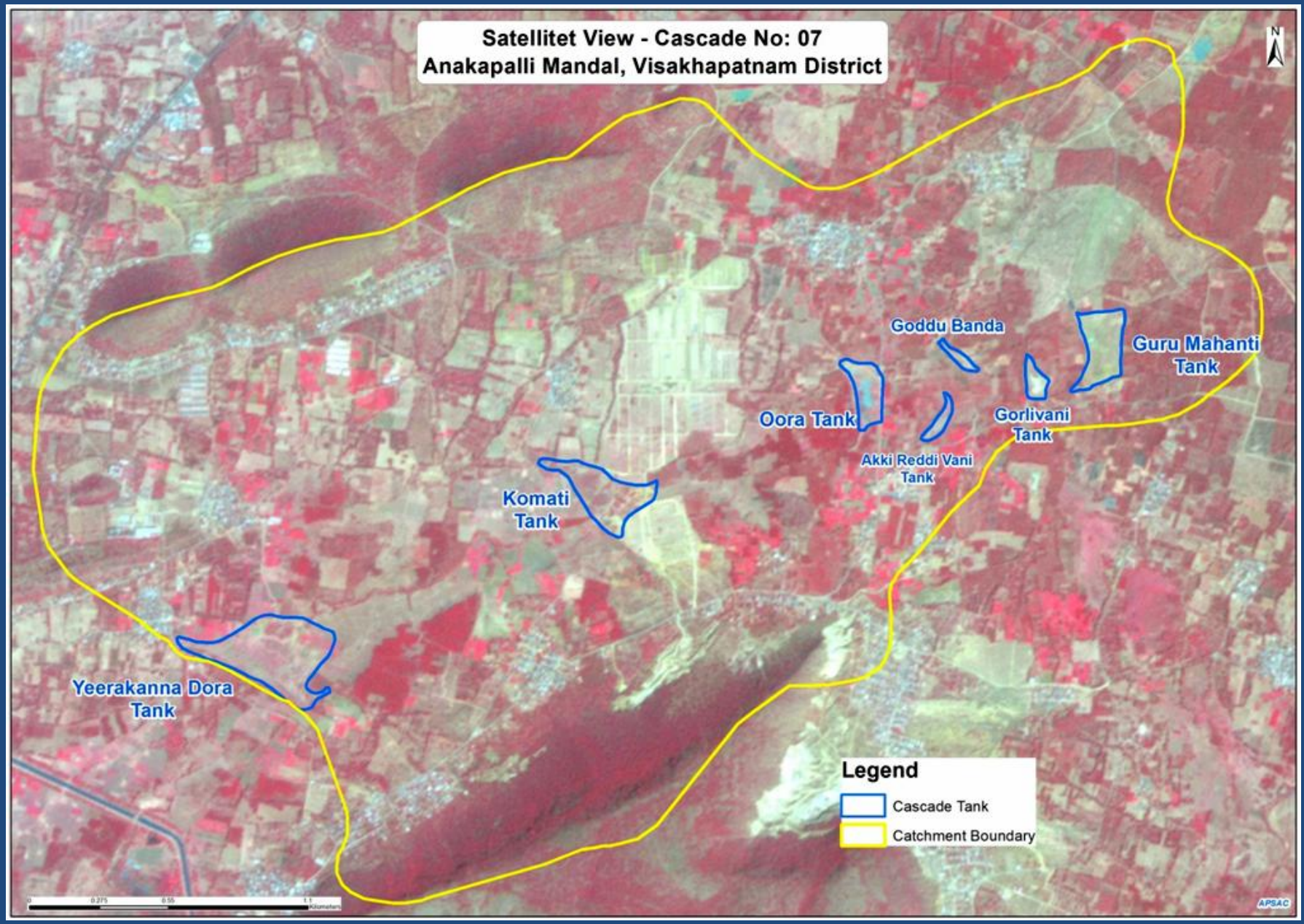
S. No	Name of Tank	Registered Ayacut (Ac)	Tank Capacity (Mcft)	Catchment Area (Sq.km)
1	Guru Mahanti	26	2.56	0.73
2	Gorlivani	13	1.31	0.87
3	Goddu Banda	11	1.12	0.46
4	Akki Raddi Vani	12	1.19	0.20
5	Voora	20	2.03	0.71
6	Komati	93	9.30	2.00
7	Yeerakanna Dora	157	15.72	4.76
	Total	**332**	**33.23**	**9.73**

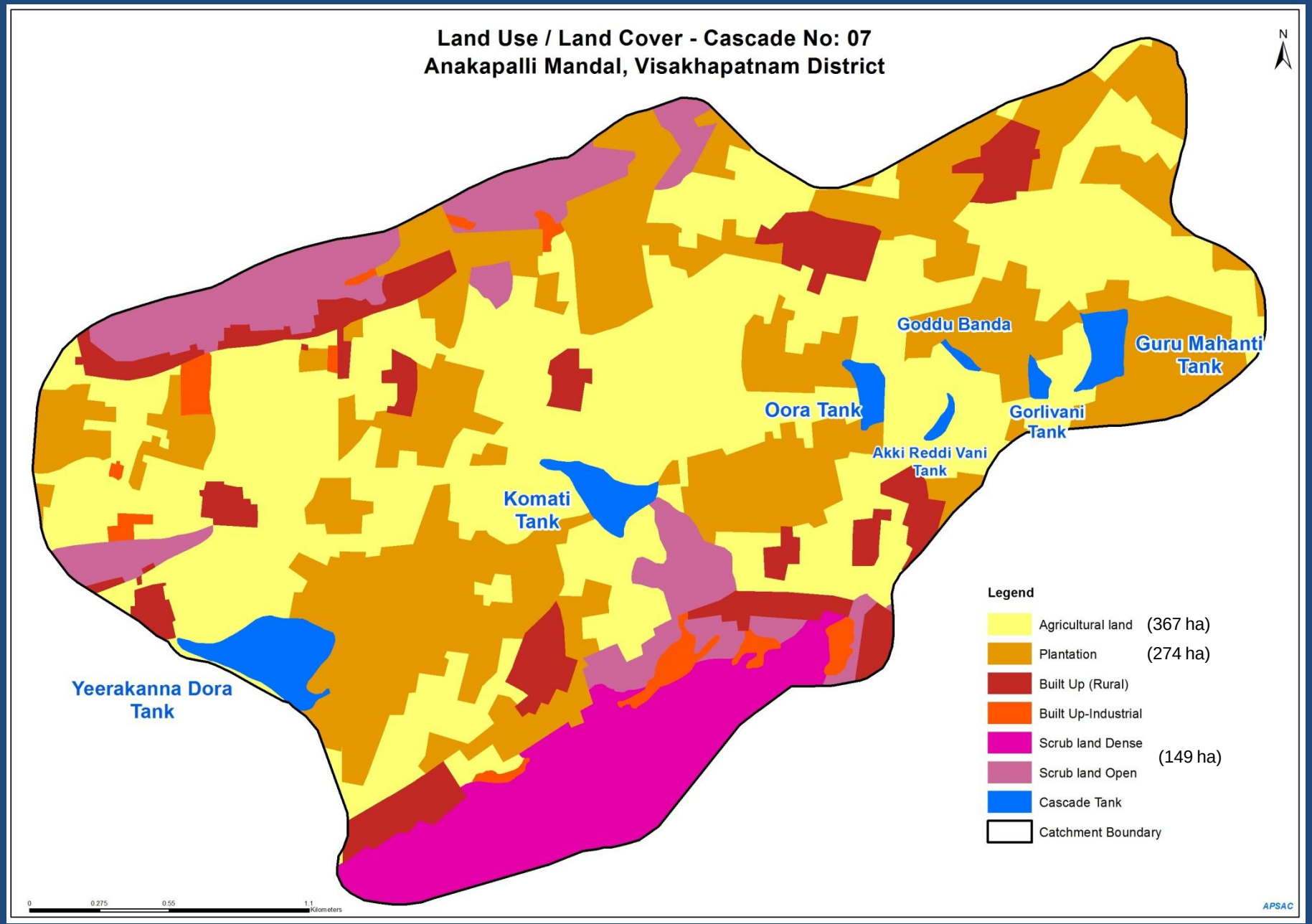


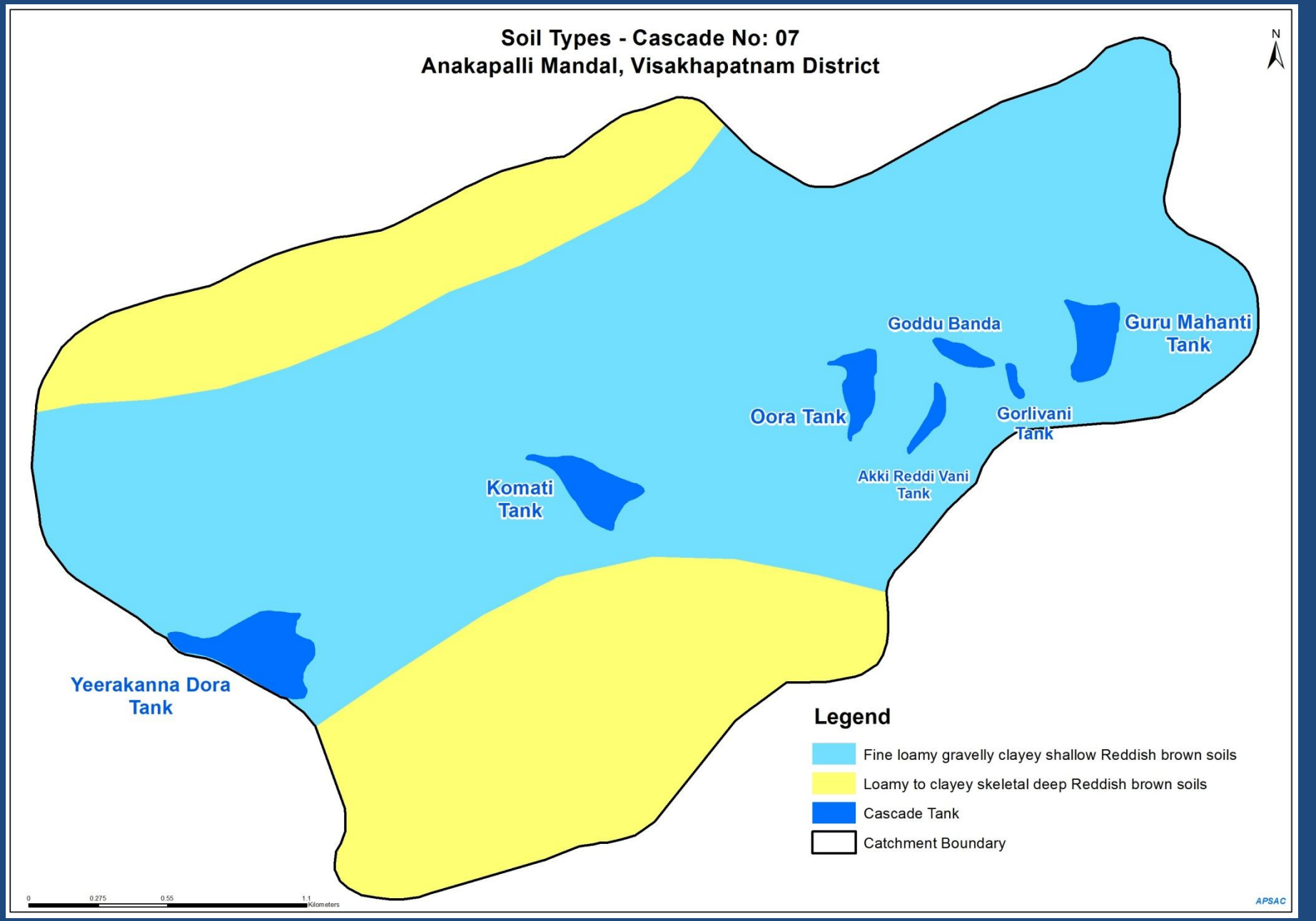

Toposheet View - Cascade No: 07
Anakapalli Mandal, Visakhapatnam District
Gopālapuram
Pāta Talārivānipālem
Akkireddipālem
Golagām
Bhatlapūdi
Kotta Talārivānipālem
Venkataramanapeta
Siramsettivanipalem
Māredupūdi
Koppāka
Koppāka Konda
Dense scrub
Causeway
PO
1
2
3
4
5
6
7
Guru Mahanti Tank
Gorlivani Tank
Goddu Banda
Oora Tank
Akki Reddi vani Tank
Komati Kotta Tank
Yeerakanna Dora Tank
40m
306
Legend
Cascade Tank
Catchment Boundary
N
APSAC

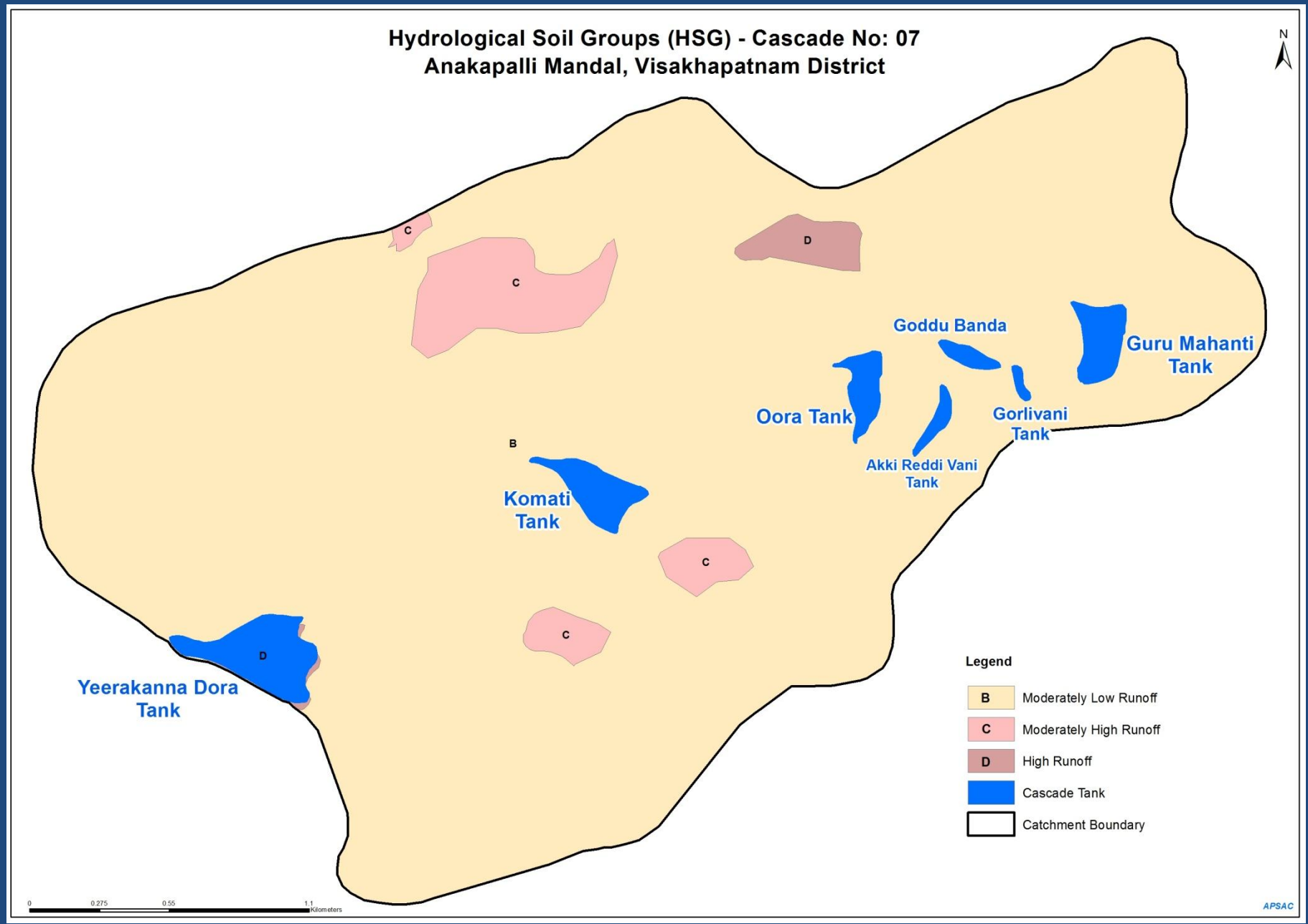


Length of the cascade 3.35 km,


Satellitet View - Cascade No: 07
Anakapalli Mandal, Visakhapatnam District
N
Goddu Banda
Guru Mahanti Tank
Oora Tank
Gorlivani Tank
Akki Reddi Vani Tank
Komati Tank
Yeerakanna Dora Tank
Legend
Cascade Tank
Catchment Boundary
APSAC


Land Use / Land Cover - Cascade No: 07
Anakapalli Mandal, Visakhapatnam District
N
Goddu Banda
Guru Mahanti Tank
Oora Tank
Gorlivani Tank
Akki Reddi Vani Tank
Komati Tank
Yeerakanna Dora Tank
Legend
Agricultural land (367 ha)
Plantation (274 ha)
Built Up (Rural)
Built Up-Industrial
Scrub land Dense
Scrub land Open
(149 ha)
Cascade Tank
Catchment Boundary
0 0.275 0.55 1.1 Kilometers
APSAC


Soil Types - Cascade No: 07
Anakapalli Mandal, Visakhapatnam District
N
Goddu Banda
Guru Mahanti Tank
Oora Tank
Gorlivani Tank
Akki Reddi Vani Tank
Komati Tank
Yeerakanna Dora Tank
Legend
Fine loamy gravelly clayey shallow Reddish brown soils
Loamy to clayey skeletal deep Reddish brown soils
Cascade Tank
Catchment Boundary
0
0.275
0.55
1.1
Kilometers
APSAC

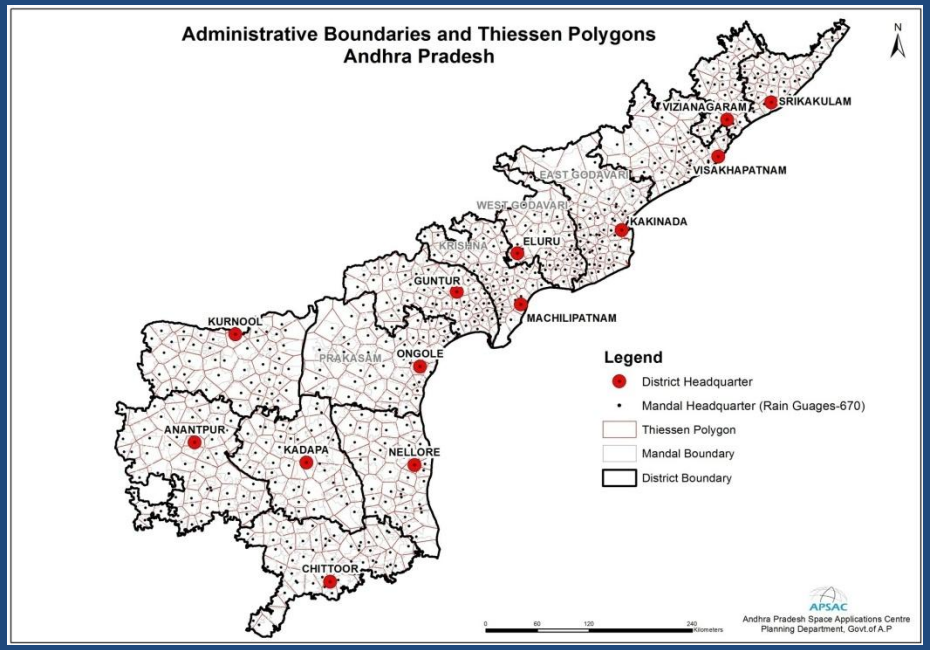

Hydrological Soil Groups (HSG) - Cascade No: 07
Anakapalli Mandal, Visakhapatnam District
N
C
C
D
Goddu Banda
Guru Mahanti Tank
Oora Tank
Gorlivani Tank
Akki Reddi Vani Tank
B
Komati Tank
C
C
D
Yeerakanna Dora Tank
Legend
B Moderately Low Runoff
C Moderately High Runoff
D High Runoff
Cascade Tank
Catchment Boundary
0 0.275 0.55 1.1 Kilometers
APSAC

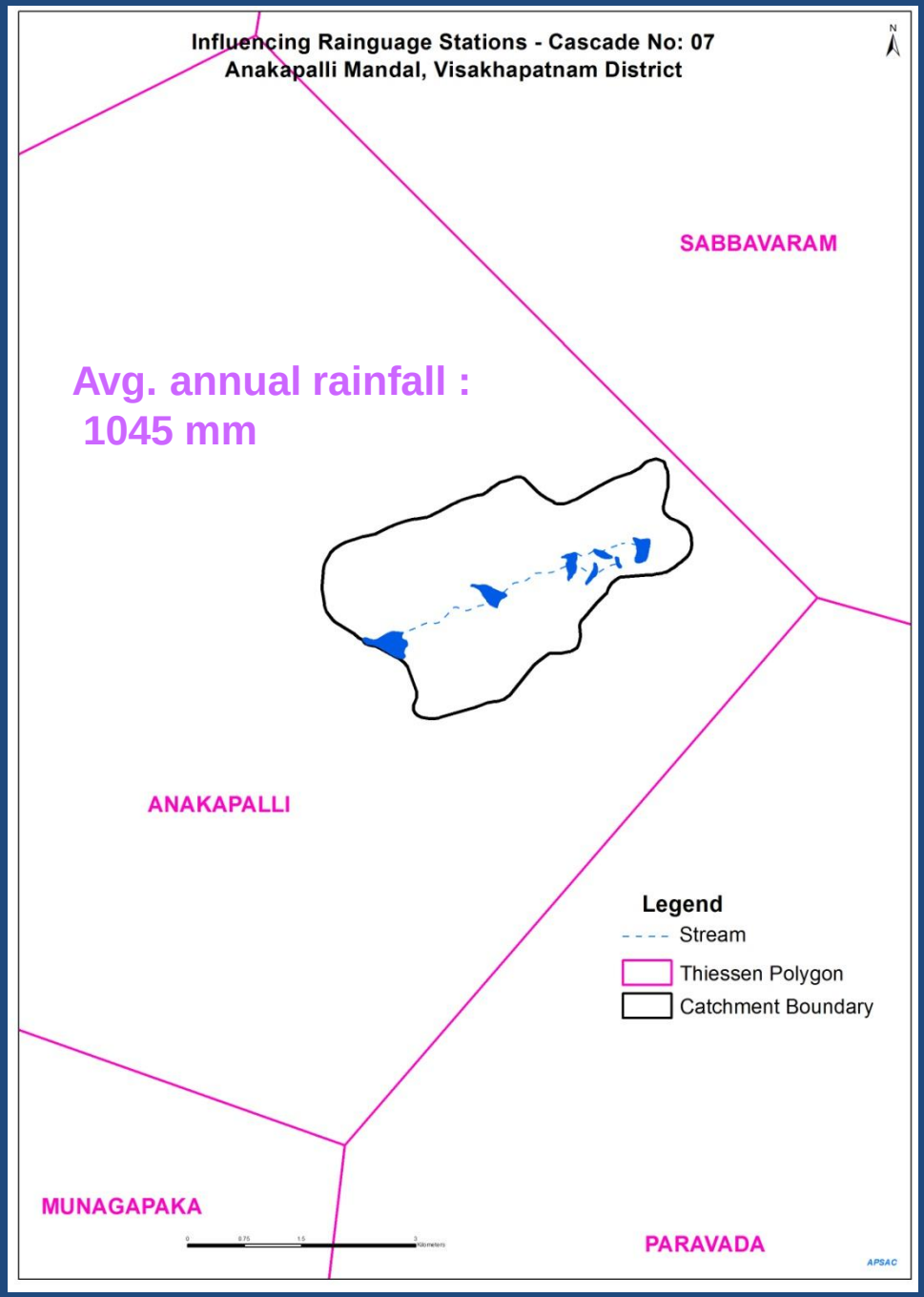
HSG and soil characteristics

Group	Characteristics
A	Having a higher infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sand or gravely sand. These soils have a high rate of water transmission.
B	Having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
C	Having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
D	Soils have a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay that has high shrink-swell potential, soils that have a permanent high water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material.

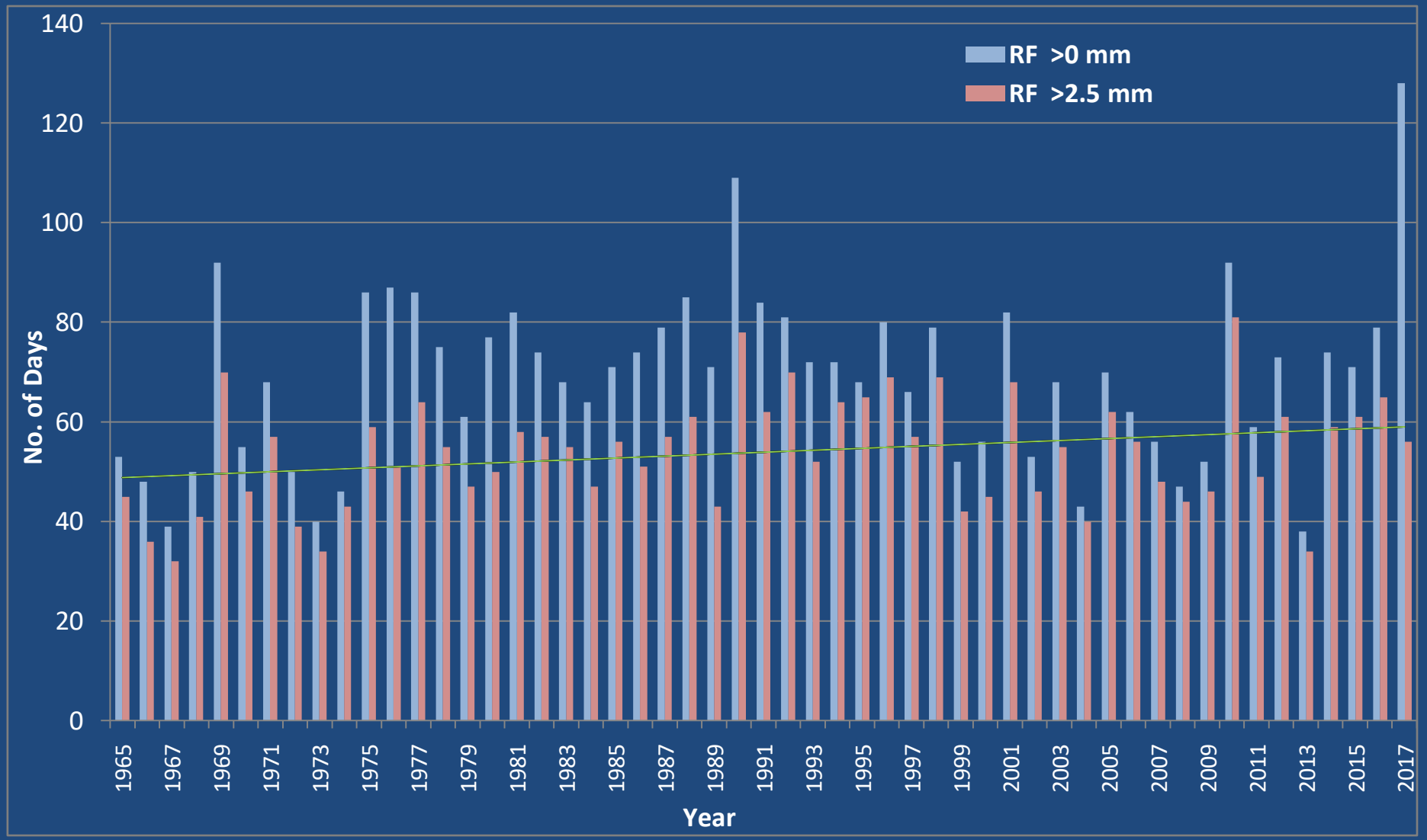
Influenced Rain gauge : Anakapalli

Thiessen polygons

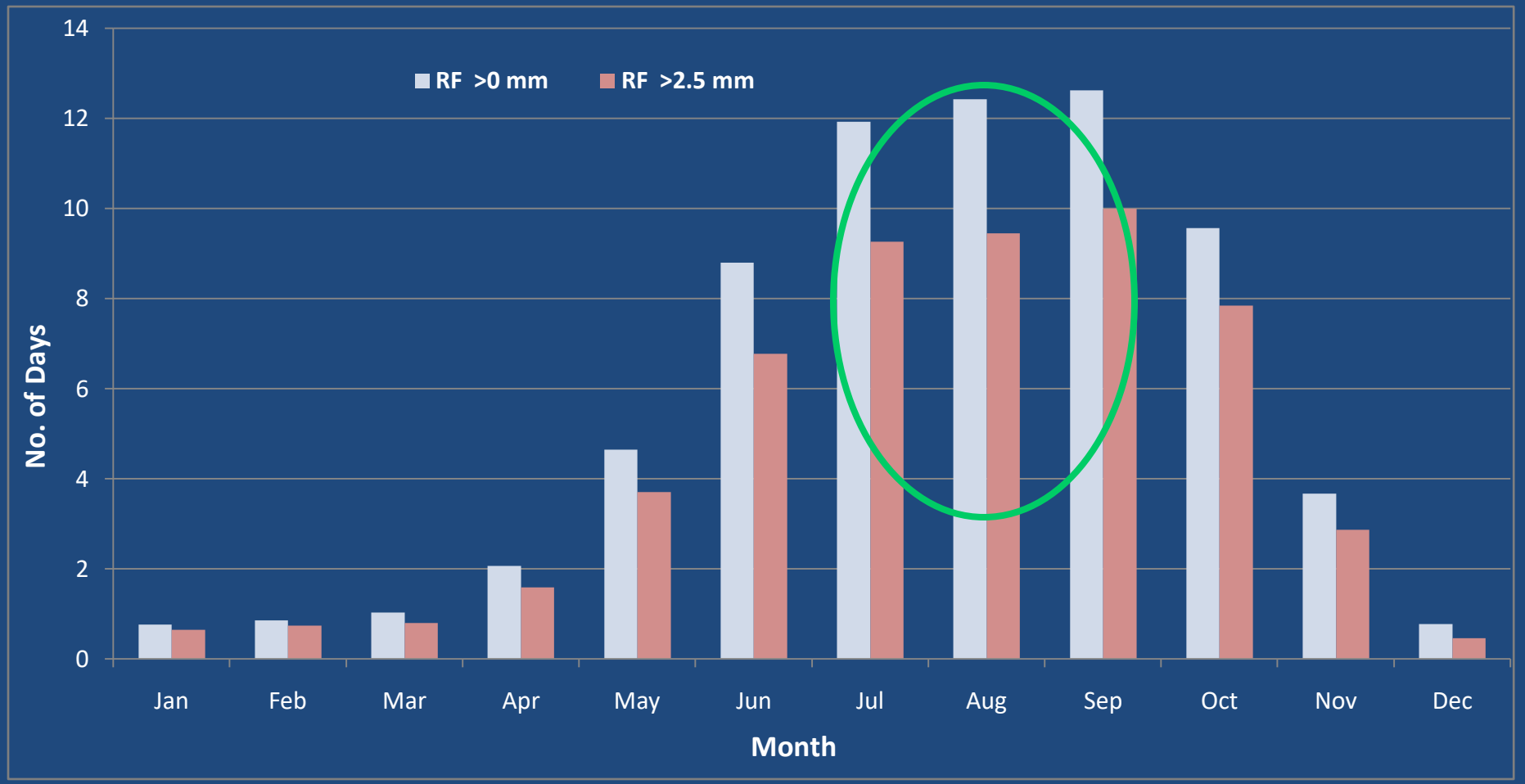




Yearly no. of rainy days



Monthly no. of rainy days



Monsoon Rainfall and Runoff (mm)

SNo	Year	June	July	August	September	October	November	December	Monsoon Rainfall	Monsoon Runoff (mm)
1	1988	24.29	37.61	2.8	34.79	71.23	0	0	954	170.72
2	1989	0	151.74	45.05	0.19	0	0	0	885	196.98
3	1990	0	0	16.82	26.18	51.28	0	0	734	94.28
4	1991	108.84	0.47	0	2.45	4.44	6.13	0	986	122.33
5	1992	19.8	43.11	10.56	32.4	19.66	116.81	0	1342	242.34
6	1993	0.48	0	0	41.86	9.93	0	0	687	52.27
7	1994	5.74	1.51	10.51	59.47	68.27	0	0	1028	145.5
8	1995	0	9.8	10.53	29.46	86.08	0	0	966	135.87
9	1996	69.24	2.77	54.83	0	156.78	0	0	1342	283.62
10	1997	0	0.76	13.72	145.77	1.81	0	0	995	162.06
11	1998	67.42	50.28	49.18	36.58	44.16	54.81	0	1312	302.43
12	1999	15.8	0	1.96	2.83	28.85	0	0	711	49.44
13	2000	50.9	0	44.15	13.37	20.23	0	0	810	128.65
14	2001	12.46	5.11	0	29.45	7.33	16.67	0	827	71.02
15	2002	0	62.13	0.85	0.02	0	0	0	631	63.00
16	2003	0	0.24	1.4	21.75	60.13	0	3.9	995	87.42
17	2005	22.82	0	0	136.04	98.21	0	0	1049	257.07
18	2006	26.35	1.59	128.69	25.56	50.9	27	0	1125	260.09
19	2007	56.55	0	0	38.51	74.99	0	0	1007	170.05
20	2008	0	38.67	18.45	55.04	0.01	0	0	616	112.17
21	2009	0	0	0	61.86	41.26	0	0	834	103.12
22	2010	0.87	18.77	0	21.65	22.45	170.66	38.97	1537	273.37
23	2011	0	13.09	0	30.13	0	0	0	594	43.22 Min
24	2012	0	13.03	40.73	36.2	25.35	159.22	0	1288	274.53
25	2013	0	0	106.48	147.73	346.31	5.72	0	1432	606.24 Max
26	2014	0	0	41.8	10.75	112	0	0	954	164.55
27	2015	28.46	13.37	77.59	50.12	0	50.87	0	1270	220.41
28	2016	21.86	16.29	0	45.39	45.25	0	0	934	128.79

Analysis table- Cascade No.07

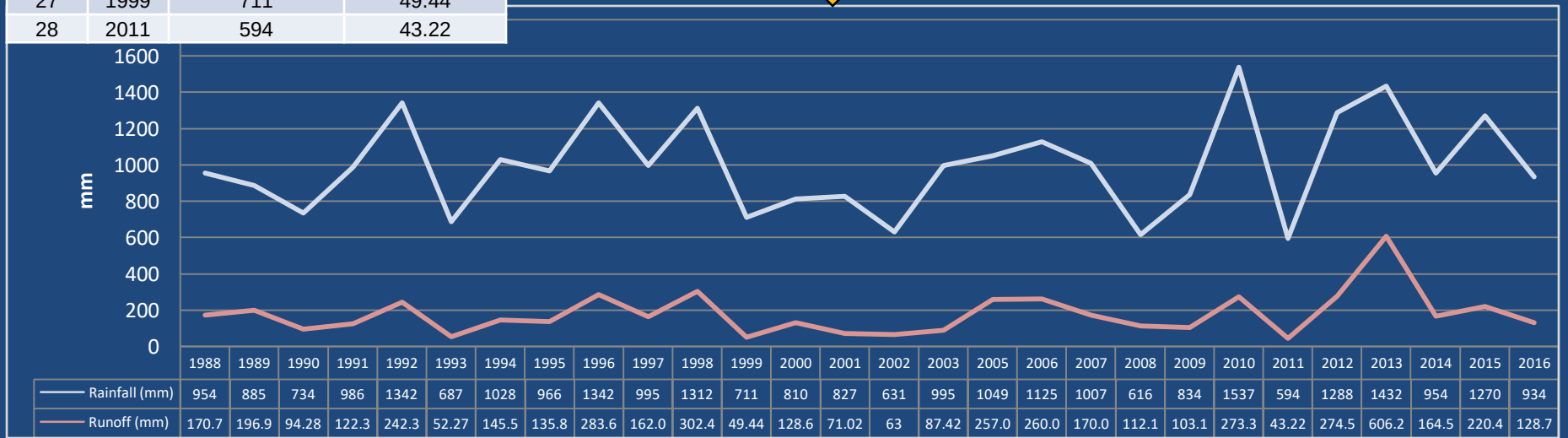
SNo	Year	Runoff (mm)								
		June	July	August	September	October	November	December	Monsoon Rainfall	Monsoon Runoff (mm)
1	2013	0	0	106.48	147.73	346.31	5.72	0	1432	606.24
2	1998	67.42	50.28	49.18	36.58	44.16	54.81	0	1312	302.43
3	1996	69.24	2.77	54.83	0	156.78	0	0	1342	283.62
4	2012	0	13.03	40.73	36.2	25.35	159.22	0	1288	274.53
5	2010	0.87	18.77	0	21.65	22.45	170.66	38.97	1537	273.37
6	2006	26.35	1.59	128.69	25.56	50.9	27	0	1125	260.09
7	2005	22.82	0	0	136.04	98.21	0	0	1049	257.07
8	1992	19.8	43.11	10.56	32.4	19.66	116.81	0	1342	242.34
9	2015	28.46	13.37	77.59	50.12	0	50.87	0	1270	220.41
10	1989	0	151.74	45.05	0.19	0	0	0	885	196.98
11	1988	24.29	37.61	2.8	34.79	71.23	0	0	954	170.72
12	2007	56.55	0	0	38.51	74.99	0	0	1007	170.05
13	2014	0	0	41.8	10.75	112	0	0	954	164.55
14	1997	0	0.76	13.72	145.77	1.81	0	0	995	162.06
15	1994	5.74	1.51	10.51	59.47	68.27	0	0	1028	145.5
16	1995	0	9.8	10.53	29.46	86.08	0	0	966	135.87
17	2016	21.86	16.29	0	45.39	45.25	0	0	934	128.79
18	2000	50.9	0	44.15	13.37	20.23	0	0	810	128.65
19	1991	108.84	0.47	0	2.45	4.44	6.13	0	986	122.33
20	2008	0	38.67	18.45	55.04	0.01	0	0	616	112.17
21	2009	0	0	0	61.86	41.26	0	0	834	103.12
22	1990	0	0	16.82	26.18	51.28	0	0	734	94.28
23	2003	0	0.24	1.4	21.75	60.13	0	3.9	995	87.42
24	2001	12.46	5.11	0	29.45	7.33	16.67	0	827	71.02
25	2002	0	62.13	0.85	0.02	0	0	0	631	63
26	1993	0.48	0	0	41.86	9.93	0	0	687	52.27
27	1999	15.8	0	1.96	2.83	28.85	0	0	711	49.44
28	2011	0	13.09	0	30.13	0	0	0	594	43.22

75% yield Dependable in mm

Year wise Rainfall and Runoff (Monsoon)

S.No	Year	Rainfall (mm)	Runoff (mm)
1	2013	1432	606.24
2	1998	1312	302.43
3	1996	1342	283.62
4	2012	1288	274.53
5	2010	1537	273.37
6	2006	1125	260.09
7	2005	1049	257.07
8	1992	1342	242.34
9	2015	1270	220.41
10	1989	885	196.98
11	1988	954	170.72
12	2007	1007	170.05
13	2014	954	164.55
14	1997	995	162.06
15	1994	1028	145.5
16	1995	966	135.87
17	2016	934	128.79
18	2000	810	128.65
19	1991	986	122.33
20	2008	616	112.17
21	**2009**	**834**	**103.12**
22	1990	734	94.28
23	2003	995	87.42
24	2001	827	71.02
25	2002	631	63.00
26	1993	687	52.27
27	1999	711	49.44
28	2011	594	43.22

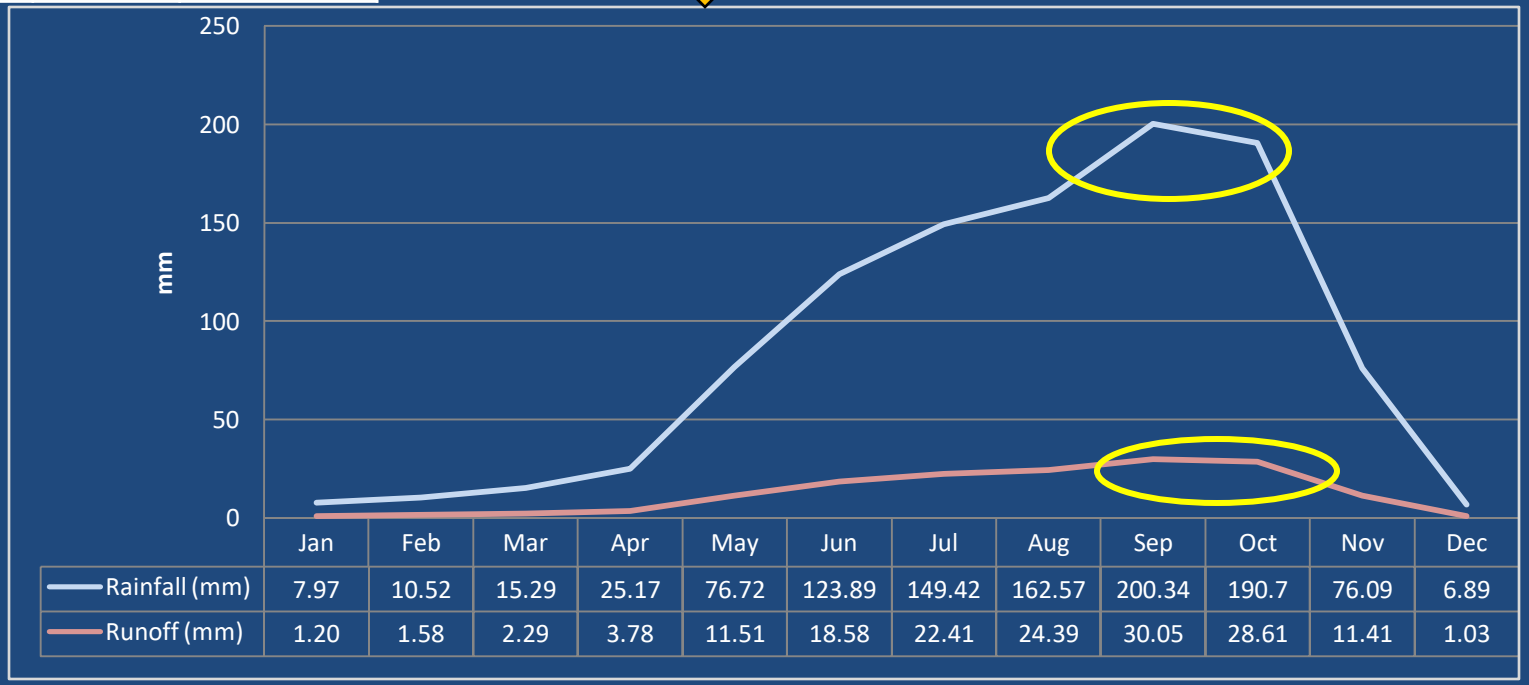
Monsoon Rainfall and Runoff



Monthly Rainfall and Runoff (Monsoon)

S.No	Month	Rainfall (mm)	Runoff (mm)
1	Jan	7.97	1.20
2	Feb	10.52	1.58
3	Mar	15.29	2.29
4	Apr	25.17	3.78
5	May	76.72	11.51
6	Jun	123.89	18.58
7	Jul	149.42	22.41
8	Aug	162.57	24.39
9	Sep	200.34	30.05
10	Oct	190.70	28.61
11	Nov	76.09	11.41
12	Dec	6.89	1.03

Monthly Rainfall and Runoff



Analysis results Cascade No.07
(Guru Mahanti Tank to Yeerakanna Dora Tank cascade)

S. No	Village	Name of Tank	Registered Ayacut (Ac)	Tank Capacity (Mcft)	Catchment Area (Sq.km)	75% Dependable Yield (Mcft)	Demand (0.1 Mcft per Acre)	Balance Yield (Mcft)	Remarks
1	Seethanagaram	Guru Mahanti Tank	26	2.56	0.73	3.33	2.6	**0.73**	Viable
2	Thumpala	Gorlivani Tank	13	1.31	0.87	4.24	1.3	**3.67**	Viable
3	Makavaram	Goddu Banda	11	1.12	0.46	2.32	1.1	**4.89**	Viable
4	Koduru	Akki Raddi Vani Tank	12	1.19	0.2	1.28	1.2	**0.08**	Viable
5	Cherlopalem	Voora Tank	20	2.03	0.71	4.85	2	**7.82**	Viable
6	P.Santhapalem	Komati Tank	93	9.3	2	9.45	9.3	**7.97**	Viable
7	Anakapalli	Yeerakanna Dora Tank	157	15.72	4.76	17.33	15.7	**9.6**	Viable

Results - Cascade No.07

- The average annual rainfall of the catchment is 1045 mm. The 75% dependable yield of the cascade is estimated to be 42.82 Mcft. The Balance yield of the cascade is 9.6 Mcft.

- The capacity of the tanks in cascade is about 33.23 Mcft and provides irrigation facilities to an ayacut of 332 Ac.

- The Total catchment area of the cascade is 9.73 sq.km.

- The total length of the cascade is 3.35 km, Gurumahanti Tank to Gorlivani Tank is 0.3 km, Akki Reddivani Tank to Oora Tank 0.23 km, Goddu Banda to Oora Tank is 0.9 km and Komati Tank to Yeerakanna Dora Tank is 1.35 km.

- The major land use classes covered in the cascade are Agriculture land (367 ha), Agriculture Plantations (274 ha) and Scrub Land (149 ha).

- The type of soils in the cascade areas are Loamy to clayey skeletal deep soils (101 ha), Loamy to clayey skeletal deep Reddish brown soils (180 ha) and Fine loamy gravelly clayey shallow reddish brown soils (622 ha).

THANK YOU
FOR
KIND ATTENTION