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Study and Analysis of Hydrological Viability for Minor Irrigation Tanks Cascade System Using Remote Sensing and GIS

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Abstract: *Many of the irrigation tanks are interconnected forming cascades, allowing surplus flow of the upstream tanks(s) and return flow from the upstream command area(s) to reach the tank immediately downstream. This facilitates reuse of water in the command area of the downstream tank, and in effect, increases available water for irrigation. There are several problems of the irrigation tanks, such as reduction of design discharge as a result of silting of channel and tanks, deterioration of stone masonry channel, and encroachment of drainage courses and tank water spread leads to the decline of tank performance.*
Geographic information systems (GIS's) have become a useful and important tool in hydrology and to hydrologists in the scientific study and management of water resources. Climate change and greater demands on water resources require a more knowledgeable disposition of arguably one of our most vital resources. As every hydrologist knows, water is constantly in motion. Because water in its occurrence varies spatially and temporally throughout the hydrologic cycle, its study using GIS is especially practical. GIS systems previously were mostly static in their geospatial representation of hydrologic features.
Today, GIS platforms have become increasingly dynamic, narrowing the gap between historical data and current hydrologic reality. The elementary water cycle has inputs equal to outputs plus or minus change in storage. Hydrologists make use of a hydrologic budget when they study a watershed. A watershed is a spatial area, and the occurrence of water throughout its space varies by time. In the hydrologic budget are inputs such as precipitation, surface flows in, and groundwater flows in. Outputs are evapotranspiration, infiltration, surface runoff, and surface/groundwater flows out. All of these quantities, including storage, can be measured or estimated, and their characteristics can be graphically displayed in GIS and studied. As a subset of hydrology, hydrogeology is concerned with the occurrence, distribution, and movement of groundwater. Moreover, hydrogeology is concerned with the manner in which groundwater is stored and its availability for use. The characteristics of groundwater can readily be input into GIS for further study and management of water resources. Because 98% of the world's available freshwater is groundwater, the need to keep a closer eye on its disposition is readily apparent.
The prediction of water availability in tank is important for the purpose of improving productive use of the water resources in a tank cascade system. The land use/land cover map was prepared using Cartosat imagery. The land use/land covers are Agricultural, Non agricultural, barren land, forest and settlements. The drainage courses problems are identified in the tank cascade system by GPS tracking. The problems were found in the earthen channel, catchments and head works. For the identified problems, the remedial measures are suggested for improving the tank cascade system to restore it to its original condition.
Keywords: *Tank Cascade, Hydrological Viability, Remote Sensing & GIS,*

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I. Introduction

Tanks are traditional irrigation structures commonly situated in many parts of Indian sub-continent to capture monsoon runoff. A tank comprises the catchment area, feeder channels; water spread area, outlet structures (sluices), flood disposal structures (surplus weir) and command area. It is reported that more than 70 – 80 % of minor irrigation tanks need renovation to restore them for normal functioning. Tank Rehabilitation / Restoration / Renovation is termed as " the tanks which are dysfunctional are brought to normal functioning by way of undertaking works on breach closing, tank bund strengthening and repairs or reconstruction to sluices and weirs".

Many tanks are found in the form of cascades, which is defined as a series of small and medium tanks that are connected at successive locations down in one single common water course (MaddumaBandara, 1985; Panabokke, 1999). These tanks are hydro-geologically and socio-economically interlinked in terms of Storing, conveying and utilizing water. If the hydrology of one or few tanks is altered by increasing either storage capacity through rehabilitation programs or command area by developing new paddy lands, the entire cascade hydrology changes (Sakthivadivelet al., 1996). Such changes can also have a socio-economic impact on the surrounding communities dependent on the water availability of the system. Therefore, it is important to take the total tank cascade system rather than an individual tank into account when planning, development and operations of small tank systems are considered. Levine (1996) analyzes the fundamental reasons for the need to improve irrigation systems. He points out that the need for rehabilitation arises because of failures to adequately maintain irrigation systems. This problem is endemic throughout the world, but especially in the developing countries, due to severe constraints on the financial resources available for operation and maintenance. Many works have been done by various researchers for finding out the way and need to improve the performance of the tank system through rehabilitation process. Previously, walk through survey was conducted to identify the problems in drainage courses and command area and mapping was done by manually. Now a days the GPS and Remote Sensing technology can be used for identification and mapping the problems in the catchment and command area of irrigation tank system.

1.1 Remote Sensing:-

1.1.1. Definition

The process of acquiring data or information from the object without being physical contact with them is called Remote Sensing.

Ex: - Aerial Photography, Aircrafts etc.,

1.1.2. Stages of Remote Sensing:-

The stages of Remote Sensing include:

- A source of electromagnetic radiation or EMR (Sun)
- Transmission of energy from the source to the surface of the earth, through atmosphere
- Interaction of EMR with earth's surface.
- Transmission of energy from surface to Remote Sensor mounted on a platform, through atmosphere
- Detection of energy by the sensor
- Transmission platform sensor data to ground station
- Processing and analysis of the sensor data
- Final data output for various types of application

1.2. Geographic Information System (GIS):

A GIS (Geographic Information System) is a powerful tool used for computerized mapping and spatial analysis. A GIS provides functionality to capture, store, query, analyze, display and output geographic inform. Geographic information systems (GISs) have become a useful and important tool in hydrology and to hydrologists in the scientific study and management of water resources. Climate change and greater demands on water resources require a more knowledgeable disposition of arguably one of our most vital resources. As every hydrologist knows, water is constantly in motion. Because water in its occurrence varies spatially and temporally throughout the hydrologic cycle, its study using GIS is especially practical. GIS systems previously were mostly static in their geospatial representation of hydrologic features.A watershed is a spatial area, and the occurrence of water throughout its space varies by time. In the hydrologic budget are inputs such as precipitation, surface flows in, and groundwater flows in. Outputs are evapotranspiration, infiltration, surface runoff, and surface/groundwater flows out. All of these quantities, including storage, can be measured or estimated, and their characteristics can be graphically displayed in GIS and studied. As a subset of hydrology, hydrogeology is concerned with the occurrence, distribution, and movement of groundwater.

1.2.1. GIS in surface water:

It is possible to access historical and real time stream flow data via the Internet. Embedded within a GIS are layers with stream locations and gage or measuring/monitoring sites. It's also possible to link radio transmitted and remotely sensed (Remote Sensing) data in GIS. Historical and real time data are available from the United States Geological Survey (USGS) in the form of gage height and stream flow or discharge in cubic feet per second. Within a GIS, it's possible to direct link via the Internet to real time data. Other sources of data for flood information and water quality come from the National Weather Service (NWS) and United States Environmental Protection Agency (EPA). All these data are available for analysis within GIS, providing a spatial representation of what would otherwise be data in a table type format. GIS is much more capable of displaying data spatially than temporally. Within one GIS, ESRI's ArcGIS for example, is it possible to delineate a watershed. Digital elevation model (DEM) data are layered with hydro graphic data so that the boundaries of a watershed may be determined. Watershed delineation aids the hydrologist or water resource manager in understanding where runoff from precipitation or snowmelt will eventually drain. In the case of snowmelt, snowpack coverage may be determined from ground stations or remotely sensed observers and input into GIS to determine or predict how much water can be counted on to be available for use by cities, agriculture, and environmental habitat.

1.2.2. GIS in groundwater:

As mentioned earlier, 98% of the available freshwater (negating polar and glacial ice) for human and environmental uses is in groundwater. In the United States, about ¼ of the water used for personal, commercial/industrial, and irrigation uses comes from groundwater. With increasing demands placed on surface water resources, it is likely the demand for groundwater will increase. In some places, this resource has already been severely tapped, and even mismanaged.

The two resources are by no means disjoint, as knowing where surface water recharges groundwater and where groundwater flows supply surface water is an important aspect of the hydrologic cycle. Hydrogeology is especially well suited to GIS. Head values, geology, groundwater flow direction, even water table height and location of aquifers are among the quantities which may be presented spatially in GIS and used for analysis, management of water availability and water quality, and land use practices.

1.2.3. Arc GIS:

In this project, I using Arc GIS Desktop 10, the newest version of popular GIS software produced by ESRI. This course is meant to teach some fundamental GIS operations using Arc GIS. It is not meant to be a comprehensive course in GIS or Arc GIS. However, I hope this Project will get started using GIS and excited about learning more.

Components of Arc GIS:

TheArc GIS Desktop is comprised of a set of integrated applications, which are accessible from the Start menu of your computer:

1. Arc Map
2. Arc Catalog.
3. Arc Toolbox

1. Arc Map is the main mapping application which allows you to create maps, query attributes, analyze spatial relationships, and layout final projects.Arc Catalog organizes spatial data contained on your computer and various other locations and allows for you to search, preview, and add data to Arc Map as well as manage metadata and set up address locator services (geocoding).
2. Arc Toolbox is the third application of Arc GIS Desktop. Although it is not accessible from the Start menu, it is easily accessed and used within Arc Map and Arc Catalog.

Arc Toolbox contains tools for Geoprocessing, data conversion, coordinate systems, projections, and more. This workbook will focus on Arc Map and Arc Catalog.

II. Background Information

- Water Resources Department (WRD) is implementing Andhra Pradesh Integrated Irrigation and Agriculture Transformation Project (APIIATP) for improvement and management of minor irrigation tanks through community based approach with the funding of World Bank. The project focuses on Planning, implementation and monitoring to promote self-sustaining water management by the Water Union Associations for maximizing the economic returns through increased water use efficiency.
- The objective of the project is to enhance agricultural productivity, profitability and resistance to climate variability in selected tank systems of Andhra Pradesh.
- A protocol was developed for screening of tanks based on the 75% dependable yield under Andhra Pradesh Community Based which was funded by World Bank.
- It is suggest to using the same protocol for screening of tanks based on hydrological viability for Andhra Pradesh Integrated Irrigation and Agricultural Transformation Project.
- Accordingly an agreement has signed between the State Project Director Andhra Pradesh Integrated Irrigation and Agricultural Transformation and Andhra Pradesh Space Application Centre, for screening of 1211 hydrological tanks.
- It providing benefits to 2 lakh farming families covering 1.47 lakh Ha of agriculture land in 1,211 tank command areas.
- The total estimated project cost is Rs. 1,600 cr.

III. Objectives

- The main objective of the study is to analyze and assess the hydrological viability of 01 cascade consisting of 03 tanks considering various factors like rainfall, tank storage, catchment, land use, soil, Ayacuts details, etc.
- The Project development objective is to enhance agricultural productivity, profitability and resilience to climate variability in selected tank systems of Andhra Pradesh.
- The project beneficiaries will include small and marginal farmers, water users associations, farmer producer organization and other agro-entrepreneurs.
- During project preparation, specific target areas will be identified and specific intervention will be designed to benefit women and other vulnerable groups.

IV. Data Used And Methodology

4.1. Datasets used:

- Location maps of the tanks are from WRD, APIIATP
- Survey of India topo sheets, latest satellite data (LISS IV)
- Thematic maps like soils, land use/land cover, drainage, catchment boundaries
- The non-spatial data like command area, beneficiaries, meteorological data
- (DES/IMD) information and other resource attributes

4.2. Surface Runoff estimation:

- Rainfall - Runoff modeling is an essential part in water resources planning and management.
- The soil conservation service curve number (SCS-CN) is a simulation model that analyzes runoff volumes from the rainfall.
- It is one of the efficient methods to estimate direct runoff volume in un gauged catchments (Hawkins, 1993; McCuen, 2002; Michel et al., 2005; Ponce and Hawkins, 1996).
- It uses the curve number (CN) to determine the runoff volumes. Curve number varies with the terrain conditions.
- The SCS-CN method uses Land use / Land cover, Soil information and antecedent soil moisture conditions of the catchment.
- The modifications suggested by the Ministry of Agriculture, Govt. of India, (Hand book of Hydrology, 1972), to suit Indian conditions are included in the study.
- A brief account of inputs and formulae of the SCS method adopted for the present study is given below.

a. Rain gauges in the neighbourhood of the tank catchment are taken and weighted average rainfall of catchment arrived usingThiessen polygons.
b. Hydrological soil group's map is prepared based on soil classification map.
c. Integrating Hydrological soil groups and Land use / Land cover information, a weighted Curve number-CN (II) for each tank catchment is arrived based on cure number table.

4.3. SCS – Curve Method:

- The fundamental hypotheses of SCS method are:

a. Runoff starts after the initial abstraction, Ia, has been satisfied.
b. The ratio of actual retention of rainfall to potential maximum retention(S) is equal to the ratio direct runoff to rainfall minus initial abstraction.
c. The initial abstraction Ia is related to S as Ia = aS with the value of a being a function of antecedent moisture condition (AMC) and type of soil. The relationship between runoff depth Q (in mm) and rainfall P (in mm) in a rainfall event in the catchment for Indian conditions is given as

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

(Black and all other soil regions for AMC I)

$$Q = \frac{(P-0.1S)^2}{(P+0.9S)} \text{... (ii)}$$

(Black soil region for AMC-II & III)

Where $S = \frac{25400}{CN} - 254$ ... (iii)

In which CN = a co-efficient called Curve Number

If P is less than 0.3 S in the runoff is taken as zero.

- The Curve number CN is a relative measure of retention of water by a given soil-vegetation-land use (SVL) complex and takes values from 0 to 100.
- The Curve number CN depends upon

- Hydrological soil groups
- Land use
- Antecedent Moisture Condition (AMC)

The definitions of AMC types (3 types), which depend upon the antecedent 5-day rainfall and upon whether the season is growing or a dormant one, are available and are shown in the following Table.

Table-A: Antecedent Moisture Conditions (AMC):

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

- The determination of CN for AMC Type II (CN (II)) can be determined for hydrologic soil cover complexes and land use based on the curve numbers. The curve numbers CN (III) for AMC Type III and CN (I) for AMC Type (I)) can be computed by using the following equations:

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

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

V. Study Area

The present study for my project **"Study and Analysis of Hydrological Viability for Minor Irrigation Tanks Using Remote Sensing and GIS''** has been carried out at **Vishakhapatnam** district and Study Tanks Covered in **Pendurthi**Mandal.

S No	District	Mandal	Village	Type of the Tank	Tank Name
1	Visakhapatnam	Pendurthi	Gorapalli	Cascade 14	Sudi Banda
2	Visakhapatnam	Pendurthi	Gorapalli	Cascade 14	Vadla Tank
3	Visakhapatnam	Pendurthi	Gorapalli	Cascade 14	Appalanaidu Tank

CASCADE NO.14
(Sudi Banda to Appalanaidu Tank)

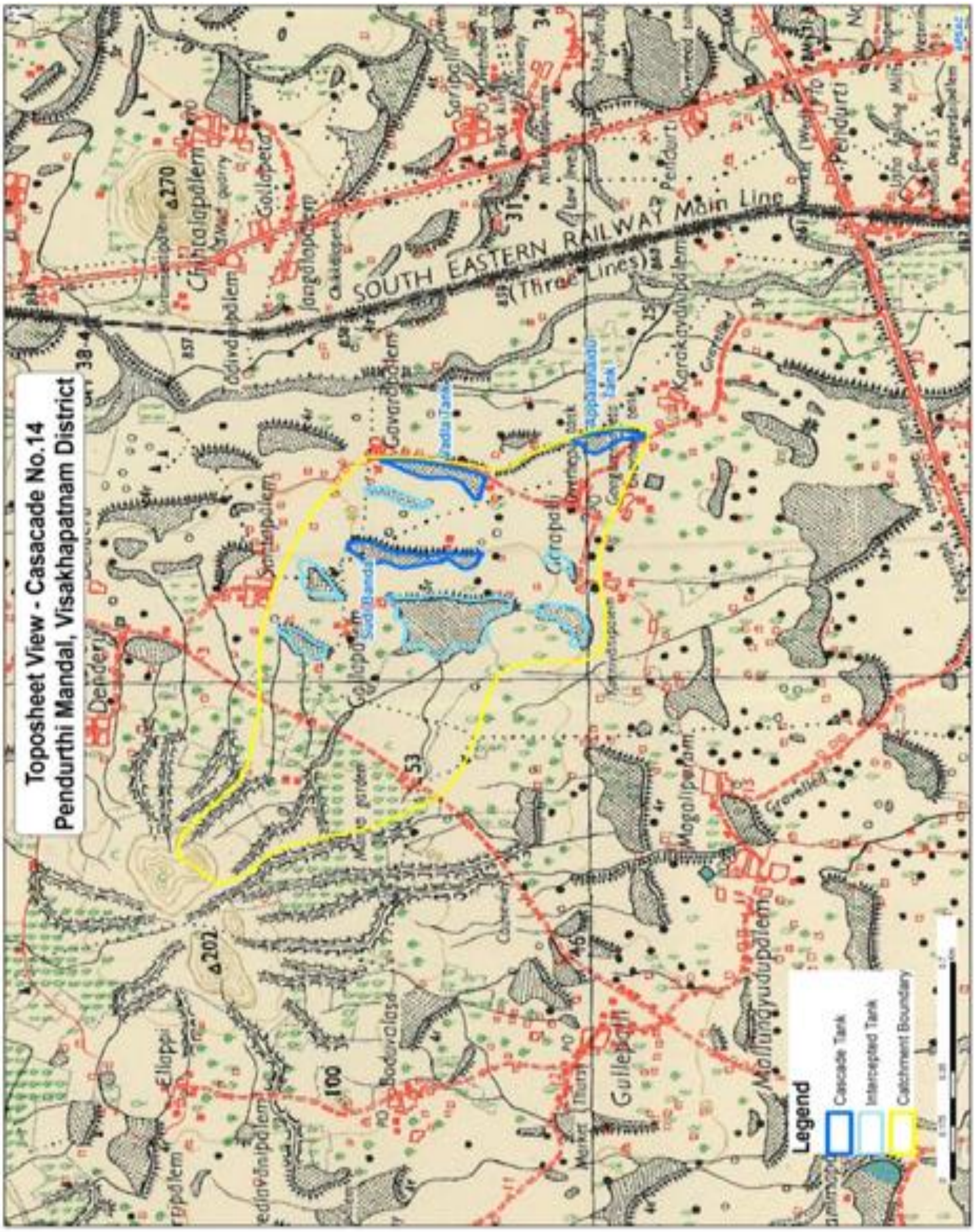
There are three study tanks covering in this cascade viz., Sudi Banda, Vadla Tank, Appalanaidu Tank and 05 intercepted tanks. The cascade is covered in Gorapalli Village, Pendurthi Mandal, and Visakhapatnam district. The catchment area of the cascade is 4.76 Km^2. The cascade map is shown below.

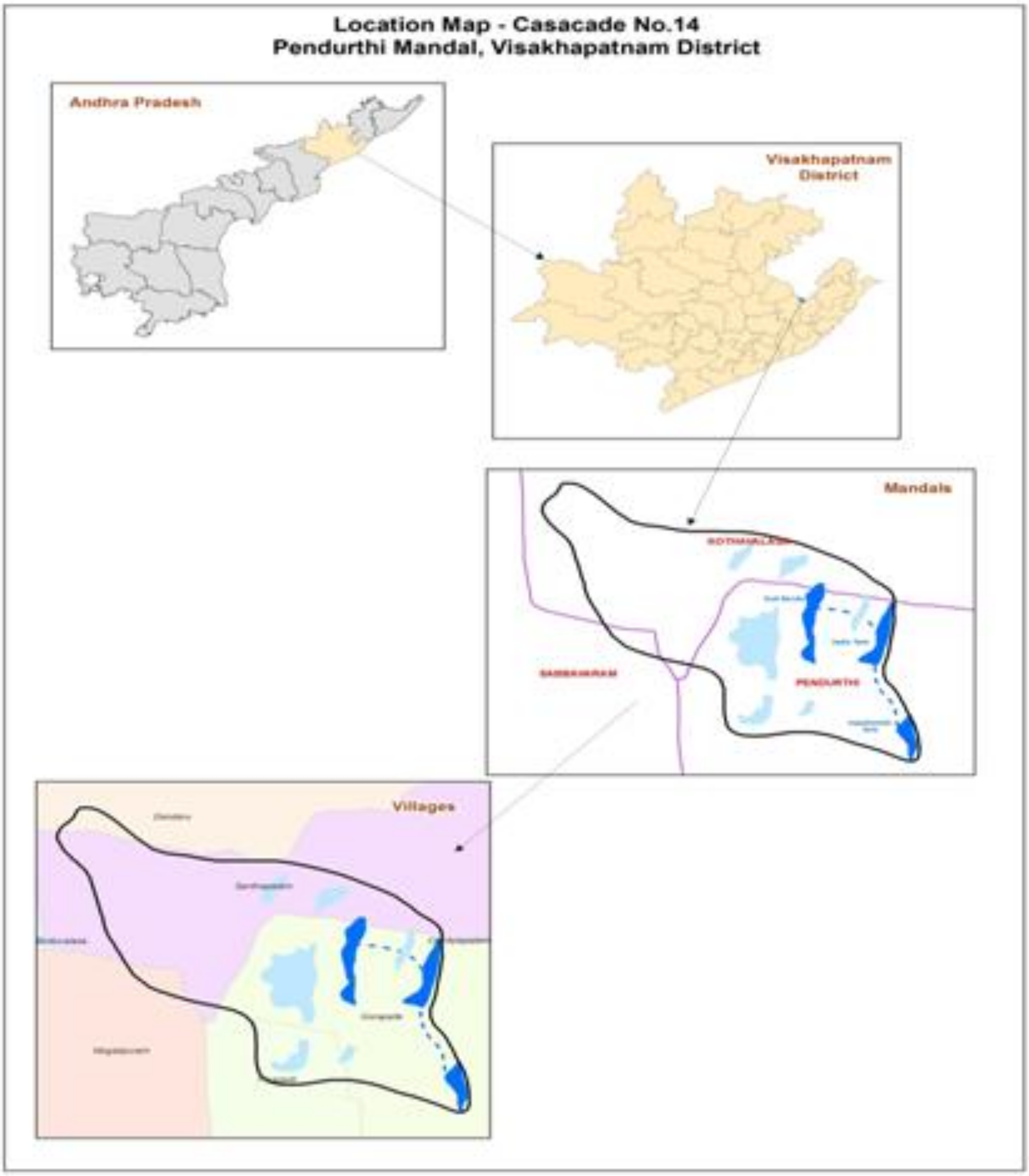
Drainage and Administration in Cascade:-
The length of the cascade from Sudi Banda to Vadla Tank is 0.62 Km, Vadla Tank to Appalanaidu Tank is 0.70 Km.

Land Use and Land cover in Cascade:-

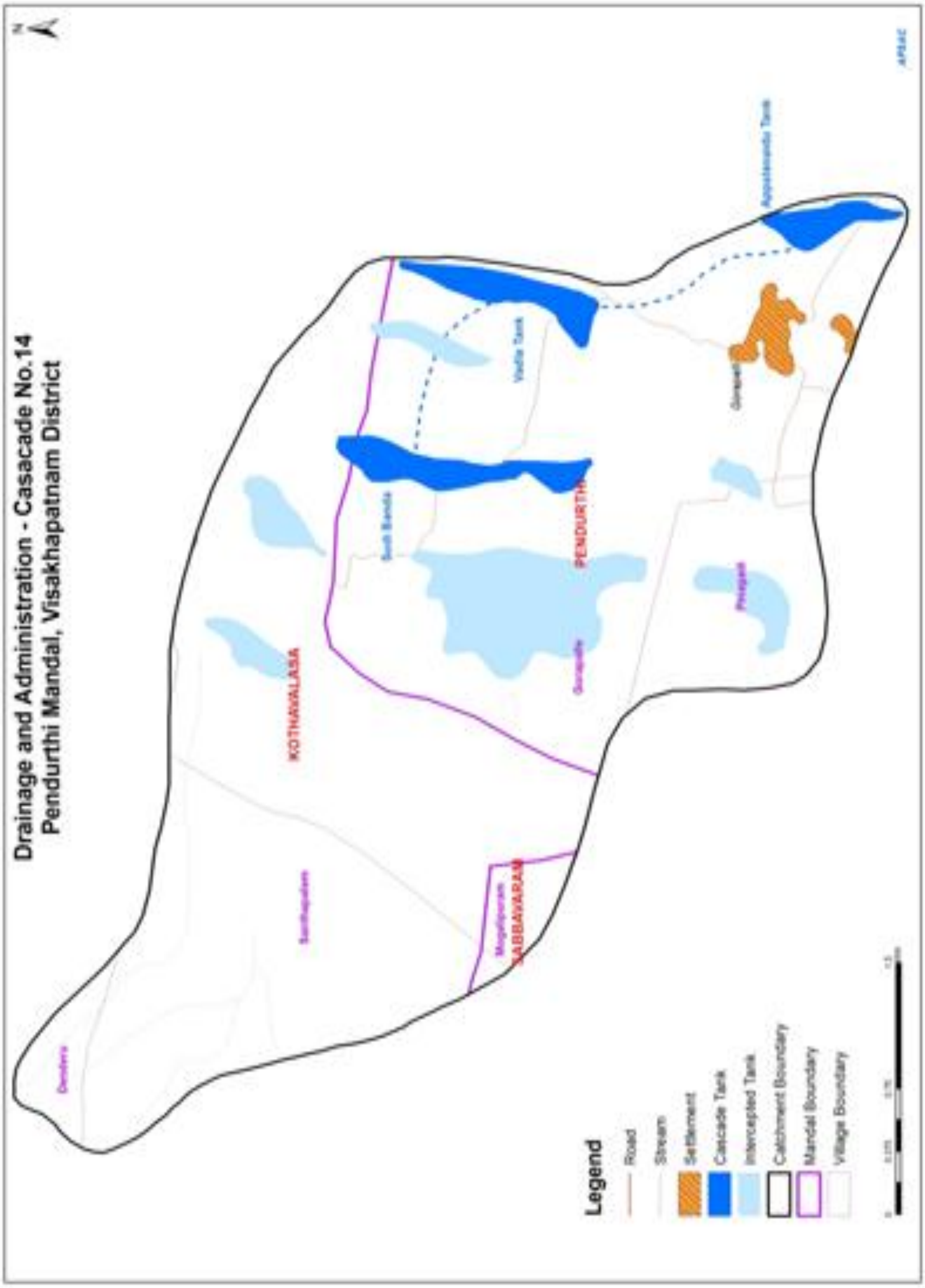
The major land use classes covered in the cascade areAgriculture land (205.33 ha),Agriculture Plantation (171.25 ha), Built up land (12.58 ha), Scrub land (37.51 ha),Gullied / ravenous (3.12 ha), -Barren rocky (3.47 ha) andWater bodies (52.37 ha)

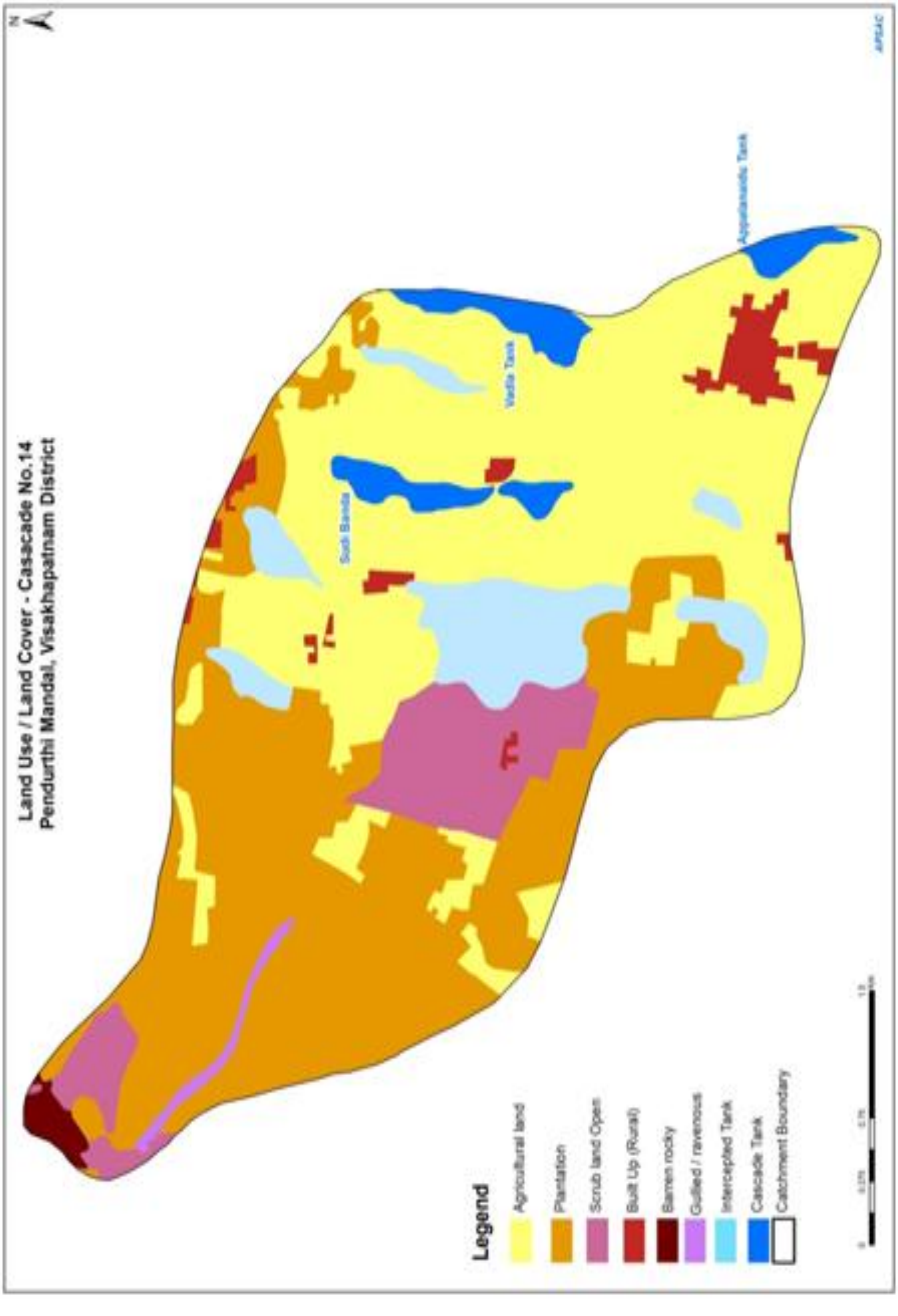
Soil Type in Cascade:-
The type of soil in the cascade area is Fine loamy gravelly clayey shallow Reddish brown soils (485.64 ha).

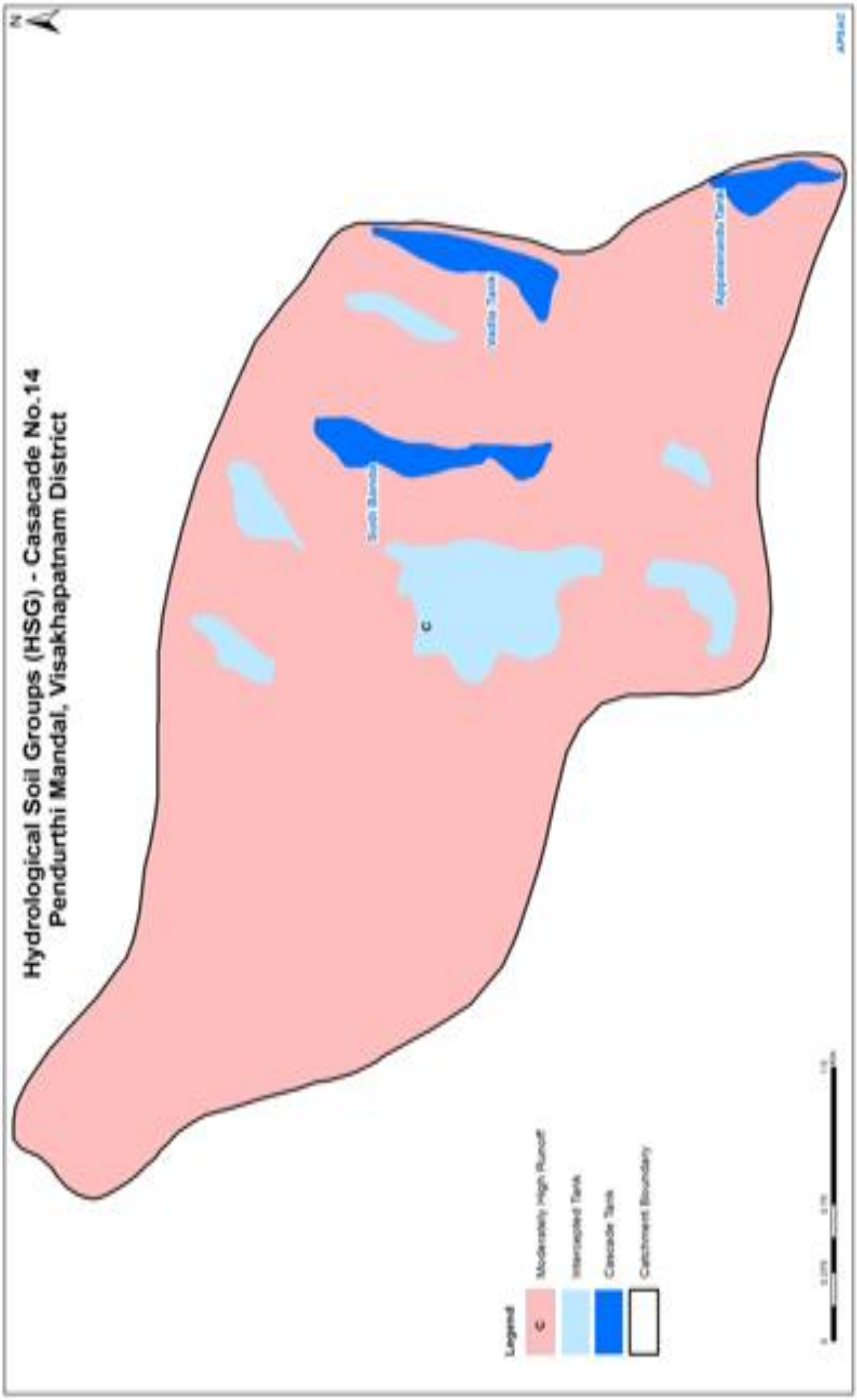

Toposheet View - Casacade No.14
Pendurthi Mandal, Visakhapatnam District
SOUTH EASTERN RAILWAY Main Line
(Three Lines)
Legend
Cascade Tank
Intercepted Tank
Catchment Boundary


Location Map - Casacade No.14
Pendurthi Mandal, Visakhapatnam District
Andhra Pradesh
Visakhapatnam District
Mandals
PENDURTHI
Villages

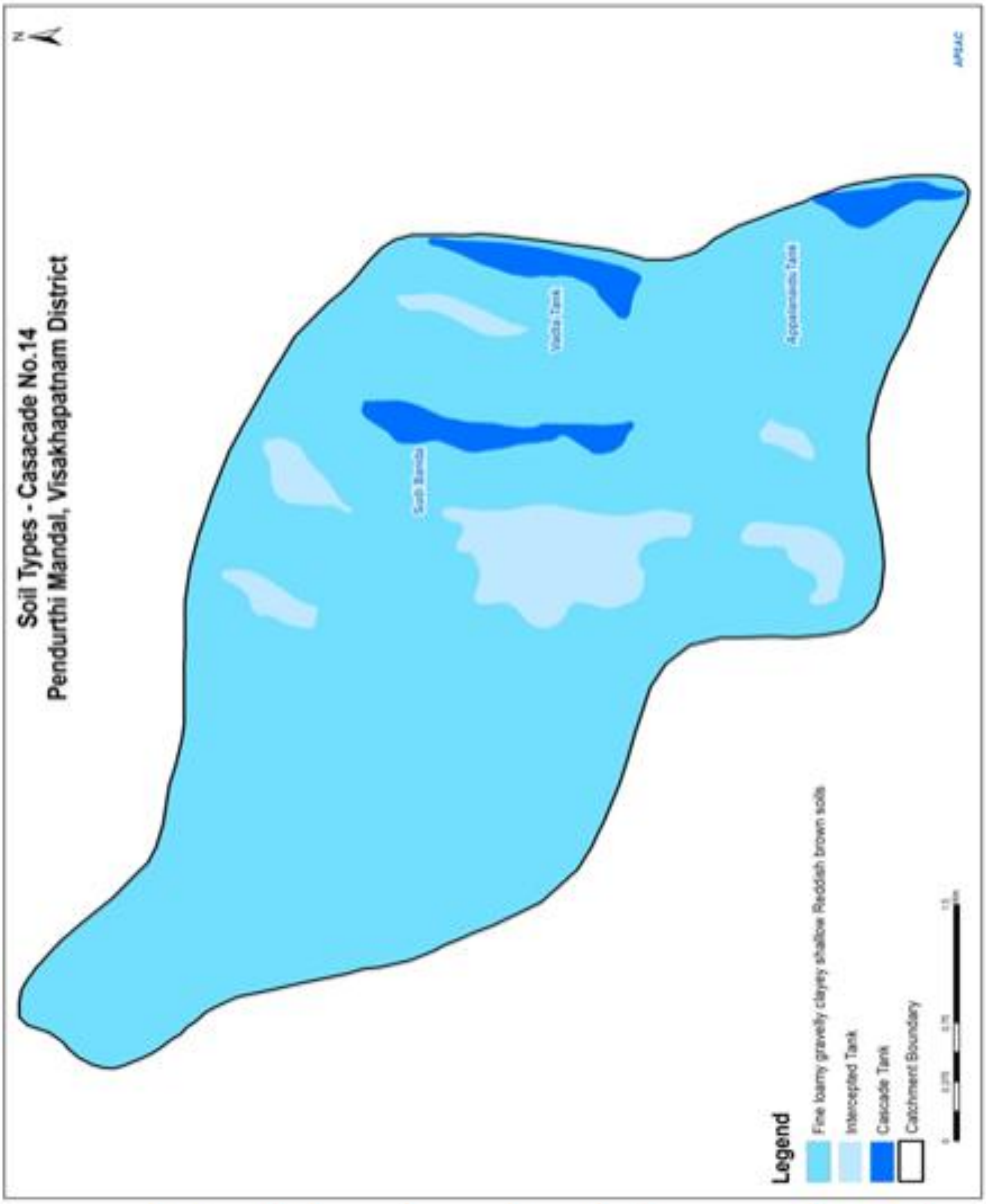

Satellite View - Casacade No.14
Pendurthi Mandal, Visakhapatnam District
Legend


Drainage and Administration - Casacade No.14
Pendurthi Mandal, Visakhapatnam District
KOTHAVALASA
PENDURTHI
SABBAVARAM
Legend
Road
Stream
Settlement
Cascade Tank
Intercepted Tank
Catchment Boundary
Mandal Boundary
Village Boundary


Land Use / Land Cover - Casacade No.14
Pendurthi Mandal, Visakhapatnam District
Legend
Agricultural land
Plantation
Scrub land Open
Built Up (Rural)
Barren rocky
Gullied / ravenous
Intercepted Tank
Cascade Tank
Catchment Boundary


Hydrological Soil Groups (HSG) - Casacade No.14
Pendurthi Mandal, Visakhapatnam District
Legend
C
Moderately High Runoff
Intercepted Tank
Cascade Tank
Catchment Boundary
APSAC

Cascade No.14 (Sudi Banda to Appalanaidu Tank) Analysis:



Land use / land cover classes and type of soils were extracted using the latest satellite data. The cascade wise land use and soils were merged using Arc map (GIS) software. Total curve number was assigned using the unique land use and hydrological soil group. The ratio of total curve no and its corresponding area gives the weighted curve number (WCN). This generated weighted curve number is a factor for runoff estimation. The free yield and balance intercepted yield of Sudi Banda is (2.03 and 12.25 Mcft), Vadla tank is (0.40 and 0.85 Mcft) and Appalanaidu Tank is (1.02 and 2.53 Mcft). 75% dependable yield was estimated for each tank in the cascade using SCS Curve method. The tank wise details are as follows.

Cascade wise Tanks - Analysis results

S. No	Cascade No	Mandal	Village	Name of Tank	Registered Ayacut (Ac)	Basin	Catchment Area (Sqkm)	75% Dependable Yield (Mcft)	Storage Capacity (Mcft)	Demand (0.15 Mcft per Acre)	Balance Yield (Mcft)	Status
1	Cascade No.014	Pendurthi	Gorapalli	**Sudi Banda**	41	Naravagedda	0.45	14.28	4.06	6.15	**8.13**	Viable
2				**Vadla Tank**	32		0.19	1.26	0.27	4.8	**4.59**	
3				**Appalanaidu Tank**	34		0.29	3.54	0.66	5.1	**3.03**	

Sudi Banda

Sudi Banda lies in 83°10'22" East Longitude and 17°50'39" North Latitude and is falling in Gorapalli village, Pendurthi Mandal, Visakhapatnam district.

The capacity of the tank is about 4.06 Mcft and provides irrigation facilities to an Ayacut of 41 Ac. It comes under Naravagedda basin. The Influencing rain gauge station is Kothavalasa. It is at 5.50 Km from Kothavalasa station. The Total catchment area, Free Catchment and Intercepted Catchment areas are 3.16 Km^2, 0.45 Km^2 and 2.71 Km^2 respectively.

The daily rainfall data for a period of more than 25 years is collected and used for the analysis. The average annual rainfall of the catchment is 1189 mm. The 75% dependable yield of the tank is estimated to be 14.28 Mcft.

MI TANK DETAILS		
1	Name of the tank	Sudi Banda
2	Village	Gorapalli
3	Mandal	Pendurthi
4	District	Visakhapatnam
5	Ayacut (Ac)	41
6	Longitude	83° 10' 22"
7	Latitude	17° 50' 39"
8	Capacity (Mcft)	4.06
9	Free Catchment (Km^2)	0.45
10	Intercepted Catchment (Km^2)	2.71
11	Total Catchment Area (Km^2)	3.16
12	Basin Name	Naravagedda
13	Cascade No	Cascade No.14
14	75% dependable Yield (Mcft)	14.28
15	demand (Mcft)	6.15
16	Balance Yield (Mcft)	8.13

Graph: Sudi Banda- Monsoon rainfall and runoff (mm)

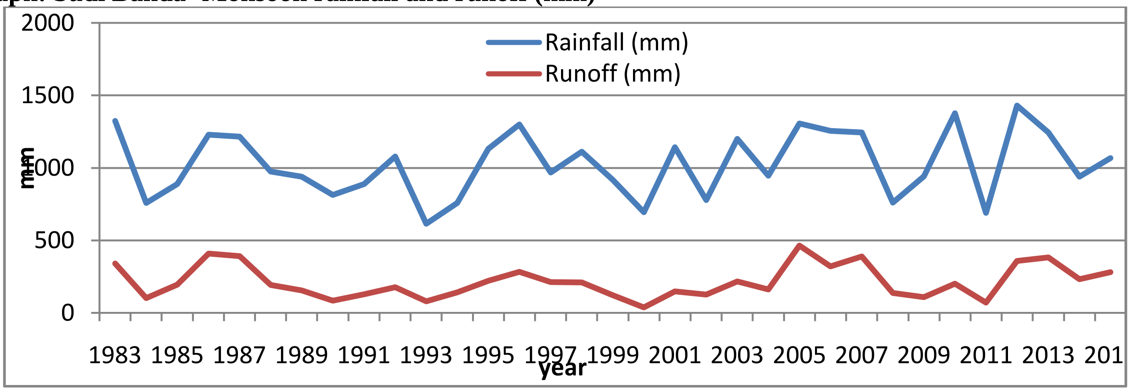


Table: Sudi Banda- - 75% Dependable yield estimation (Monsoon)

S.No	Year	Rainfall (mm)	Runoff (mm)
1	2005	1306	462.36
2	1986	1229	407.07
3	1987	1215	389.14
4	2007	1245	388.42
5	2013	1245	380.7
6	2012	1430	356.07
7	1983	1323	339.1
8	2006	1256	318.33
9	1996	1300	282.8
10	2015	1067	279.02
11	2014	938	232.16
12	1995	1131	221.4
13	2003	1200	215.97
14	1997	968	212.03
15	1998	1111	208.84
16	2010	1376	199.99
17	1985	888	194.54
18	1988	974	192.32
19	1992	1078	175.83
20	2004	946	161.8
21	1989	939	153.59
22	2001	1142	148.29
23	1994	758	140.17
24	2008	760	135.96
25	1991	888	128.01
26	2002	777	126.08
27	1999	917	122.42
28	2009	942	107.44
29	1984	758	100.77
30	1990	814	83.45
31	1993	614	80.26
32	2011	690	70.19
33	2000	694	37.72

75% yield in mm - 128.01
75% yield in mcft - 14.28

Vadla Tank

Vadla Tank lies in 83°10'42" East Longitude and 17°50'31" North Latitude and is falling in Gorapalli village, Pendurthi Mandal, Visakhapatnam district.

The capacity of the tank is about 0.27 Mcft and provides irrigation facilities to an Ayacut of 32 Ac. It comes under Naravagedda basin. The Influencing rain gauge station is Kothavalasa. It is at 5.48 Km from Kothavalasa station. The Total catchment area, Free Catchment and Intercepted Catchment areas are 3.75 Km^2, 0.19 Km^2 and 3.56 Km^2 respectively.

The daily rainfall data for a period of more than 25 years is collected and used for the analysis. The average annual rainfall of the catchment is 1189 mm. The 75% dependable yield of the tank is estimated to be 1.26 Mcft.

MI TANK DETAILS		
1	Name of the tank	Vadla Tank
2	Village	Gorapalli
3	Mandal	Pendurthi
4	District	Visakhapatnam
5	Ayacut (Ac)	32
6	Longitude	83° 10' 42"
7	Latitude	17° 50' 31"
8	Capacity (Mcft)	0.27
9	Free Catchment (Km^2)	0.19
10	Intercepted Catchment (Km^2)	3.56
11	Total Catchment Area (Km^2)	3.75
12	Basin Name	Naravagedda
13	Cascade No	Cascade No.14
14	75% dependable Yield (Mcft)	1.26
15	demand (Mcft)	4.8
16	Balance Yield (Mcft)	4.59

Graph:Vadla Tank - Monsoon rainfall and runoff (mm)

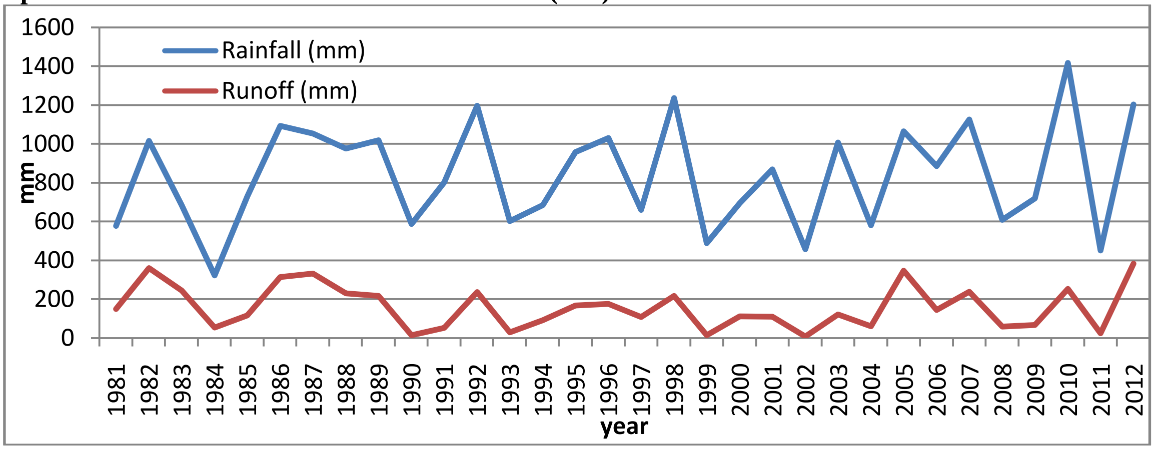


Table: Vadla Tank - 75% Dependable yield estimation (Monsoon)

S.No	Year	Rainfall (mm)	Runoff (mm)
1	2012	1203	382.98
2	1982	1016	359.64
3	2005	1065	346.87
4	1987	1053	332.37
5	1986	1093	314
6	2010	1418	253.48
7	1983	684	245.36
8	2007	1126	238.47
9	1992	1197	235.9
10	1988	976	230.33
11	1989	1019	217.31
12	1998	1236	217.06
13	1996	1031	175.96
14	1995	958	167.98
15	1981	578	148.92
16	2006	885	144.4
17	2003	1007	121.8
18	1985	729	116.34
19	2000	695	110.51
20	2001	869	109.65
21	1997	660	107.37
22	1994	684	91.48
23	2009	719	66.09
24	2004	581	60.33
25	2008	609	58.13
26	1984	322	53.38
27	1991	802	51.83
28	1993	603	28.73
29	2011	451	24.18
30	1999	489	13.62
31	1990	588	13.21
32	2002	457	7.4

75% yield in mm - 60.33
75% yield in mcft - 1.26

Appalanaidu Tank

Appalanaidu Tank lies in 83°10'50" East Longitude and 17°49'58" North Latitude and is falling in Gorapalli village, Pendurthi Mandal, Visakhapatnam district.

The capacity of the tank is about 0.66 Mcft and provides irrigation facilities to an Ayacut of 34 Ac. It comes under Naravagedda basin. The Influencing rain gauge stations are Kothavalasa and Pendurthi. It is at 6.49 Km from Kothavalasa station. The Total catchment area, Free Catchment and Intercepted Catchment areas 4.76 Km^2, 0.29 Km^2 and 4.47 Km^2 respectively.

The daily rainfall data for a period of more than 25 years is collected and used for the analysis. The average annual rainfall of the catchment is 1189 mm. The 75% dependable yield of the tank is estimated to be 3.54 Mcft.

MI TANK DETAILS		
1	Name of the tank	Appalanaidu Tank
2	Village	Gorapalli
3	Mandal	Pendurthi
4	District	Visakhapatnam
5	Ayacut (Ac)	34
6	Longitude	83° 10' 50"
7	Latitude	17° 49' 58"
8	Capacity (Mcft)	0.66
9	Free Catchment (Km^2)	4.47
10	Intercepted Catchment (Km^2)	0.29
11	Total Catchment Area (Km^2)	4.76
12	Basin Name	Naravagedda
13	Cascade No	Cascade No.14
14	75% dependable Yield (Mcft)	3.54
15	demand (Mcft)	5.1
16	Balance Yield (Mcft)	3.03

Graph: Appalanaidu Tank - Monsoon rainfall and runoff (mm)

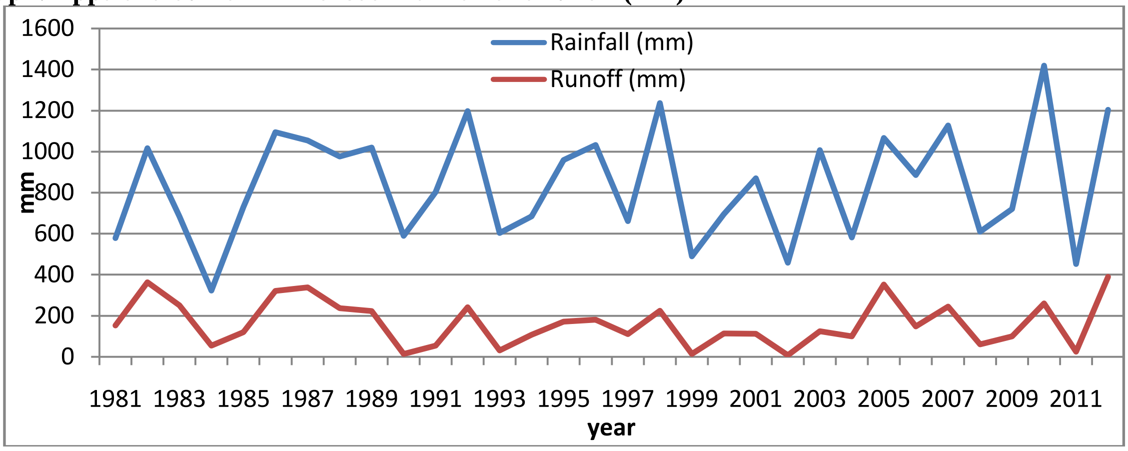


Table: Appalanaidu Tank - 75% Dependable yield estimation (Monsoon)

S.No	Year	Rainfall (mm)	Runoff (mm)
1	2012	1203	389.23
2	1982	1016	363.15
3	2005	1065	352.31
4	1987	1053	337.95
5	1986	1093	321.01
6	2010	1418	260.17
7	1983	684	249.93
8	2007	1126	244.51
9	1992	1197	242.08
10	1988	976	235.89
11	1998	1236	224.35
12	1989	1019	223.37
13	1996	1031	180.25
14	1995	958	171.94
15	1981	578	152.04
16	2006	885	147.65
17	2003	1007	125.1
18	1985	729	120.21
19	2000	695	113.32
20	2001	869	112.81
21	1997	660	110.28
22	1994	684	108
23	2009	719	100.35
24	2004	581	99.39

25	2008	609	60.12
26	1984	322	54.68
27	1991	802	54.57
28	1993	603	30.32
29	2011	451	24.8
30	1999	489	14.56
31	1990	588	14.1
32	2002	457	7.74

75% yield in mm - 99.39
75% yield in mcft - 3.54

Results And Discussions
PROBLEMS:-
Earthen channels

- Excessive weed growth-choking of sections of canal, thereby reducing the velocity of flow and causing the deposition ofsediment

Earthen channel (Drainage course)

- Excessive weed growth-choking of sections of canal, thereby reducing the velocity of flow and causing the deposition of sediment

SOLUTIONS:-
Earthen channels:-

- Aquatic weeds control at the source by their uprooting and destructedmanually

Catchment:-

- Various soil conservation measures within the catchment are the only and best solutions to check or minimize the silt accumulate in a reservoir.

VI. Conclusions

- The Environmental assessment at baseline shall enable identifying significant issues and the related impacts associated with the interventions such as strengthening and up gradation of tanks, dam safety, improving irrigation efficiency, crop diversification, productivity enhancement through climate resilient/adaptive sustainable agriculture production, technology promotion in fisheries etc.
- The Mid-term Environmental Management Audit shall assess to what extent the expected results have been achieved and if any mitigation measures are needed.
- Through analysis and assessment of 03 tanks. All are viable tanks and capable for minor irrigation which can be used to enhance agricultural productivity and profitability.
- The Final Environmental Management Audit shall assess whether the expected outcomes at baseline and mid-term have been achieved and mitigation measures proposed have been implemented.

Glossary

- **APCBTMP :** Andhra Pradesh Community Based Tank Management Project
- **ESRI :** Environmental Systems Research Institute
- **APIIATP :** Andhra Pradesh Integrated Irrigation and AgricultureTransformation Project
- **PSC** :Project Steering Committee
- **PMU** :Project Management Unit
- **DES** :Department of Environmental Sciences
- **WRD :** Water Resource Department
- **IMD** :India Meteorological Department
- **APSAC :** Andhra Pradesh Space Application Centre
- **EMR :** Electromagnetic Radiation
- **ICT :** Information And Communication Technology
- **WUA :** Water Users Association
- **CIG**'S **:** Common Interest Groups
- **CADA :** Command Area Development Authority
- **SEMF :** Semi Empirical Mass Formula
- **SES-CN :** Soil Conservation Service- Curve Number
- **WCN :** Weighted Curve Number
- **SVL :** Soil Vegetation Land use

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