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Central Ground Water Board

AQUIFER MANAGEMENT PLAN OF PAVAGADA TALUK, TUMKUR DISTRICT, KARNATAKA STATE

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1. Salient features:

Pavagada Taluk, is somewhat irregular shape located in north eastern portion of Tumkur district, Karnataka state totally detached from the district covering an area of 1358 Sq. Kms and is a part of North Pennar river basin located at longitudes $13^0$53'13.7": 14^0 20' 38" and east latitude of $77^0$00'8.0": $77^0$31'1.9". It is almost surrounded on all sides by Andra Pradesh with western border for a very short stretch it touches Chitradurga district. The Location map of the Taluk is in **Figure-1.**

The Pavagada Taluk is a part of Madhugiri revenue sub-division with Pavagada as Taluk head quarter. There are four revenue hoblies - Pavagada, Nidugal, Hosakote and Nagalamadike which covers 149 inhabitated and 4 uninhabitated villages. The Taluk is well connected with good network of roads with State highways and the Rayadurga-Tumkur railway line connecting Pavagada-Bangalore forming good network of transport facility.

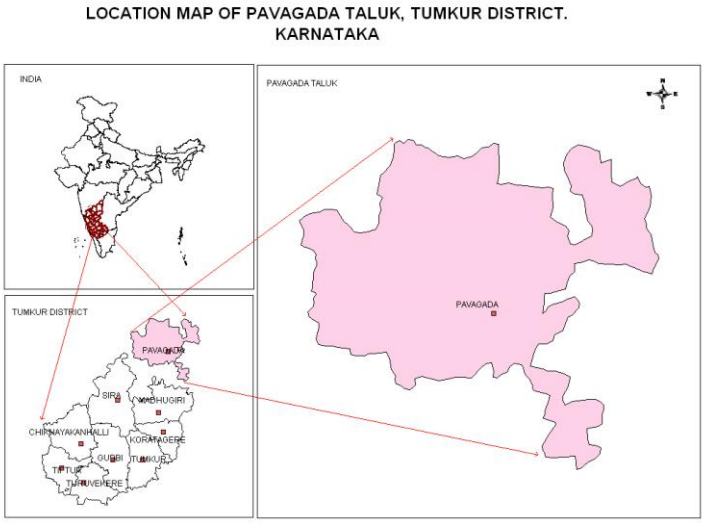


Figure-1: Location Map of Pavagada Taluk, Tumkur district

1.2 Population:

As per 2011 census, the total population in Pavagada Taluk is 245194 (123680 males and 121514 Females) of which about 216708 (88.382 %) constitutes the rural population. The Taluk has an overall population density of 159.57 persons per sq.km. The decadal change is -0.43%.

1.3 Rainfall:

Pavagada Taluk enjoys arid climate. Dryness and hot weather prevails in major part of the year. The area falls under Central Dry agro-climatic zone of Karnataka state and is categorized as drought prone. The climate of the Taluk is quite agreeable and free from extremes. The temperature in summer is in between 29^{0C} to 37^{0C} and in winter it is 16^0 to 27^0 C. The rainy season or South-West monsoon is from June to September followed by North-East monsoon and post-monsoon from October to December.

The Annual Normal rainfall (1981 to 2010) in the Taluk is 589 mm and the statistical analysis of rain fall data is presented in the **Table-1**.

Table 1: Statistical Analysis of Rainfall Data of Pavagada Taluk, Tumkur District, Karnataka for the Period 1981 to 2010

STATION	Item	JAN	FEB	MAR	APR	MAY	PRE	JUN	JUL	AUG	SEP	SW	OCT	NOV	DEC	NE	Annual
PAVAGADA	NRM	1	4	10	22	62	99	53	60	94	124	330	106	43	10	160	589
	STDEV	3	16	25	24	46	66	48	47	84	85	152	78	52	19	87	172
	CV%	288	349	247	107	74	67	91	79	90	69	46	73	122	182	55	29

Assessment of Drought

Rainfall data has been analysed to assess the drought condition using for 104 years Rain fall data and the results / classification thus obtained are listed in the **Table-2.** It is observed that the Pavagada Taluk has experienced alternating no drought to moderate drought conditions over the years.

Table 2: Classification of drought and its periodicity (IMD, 1971)

% Deviation (Di)		>0	0 to -25	-25 to -50	Probability of drought occurrences
Category		No drought	Mild (Normal)	Moderate	
		Years			
Taluk	Pavagada	48	28	22	Once in 4 years

Out of 104 years of analysis in Pavagada Taluk, “No Drought” condition is experienced in 48 years, “Mild Drought” condition is 28 years and “Moderate Drought” condition experienced in 22 years.

Further it is observed that "Severe Drought" condition is experienced in 6 years i.e, during 1908, 1920, 1923, 1931, 1934 and 1976.

Based on occurrence and frequency of past drought events, the probability of occurrence of various intensities of drought at each station has been studied. It has been observed that the frequency of occurrence of drought is **once in 4 years.**

1.4 Agriculture & Irrigation:

Pavagada Taluk is having 216708 (88.382 %) of rural population wholly dependent on the rain fall for their agricultural activities. The land use pattern of the Taluk is presented in the **Table-3**.

Table-3 Land use pattern in Pavagada Taluk (Ha)

Geographical area	Area under forest	Area not available for cultivation	Uncultivable land	Fallow land	Area sown		
					Net sown area	Area sown more than once	Total sown/cropped area
135849	5875	13421	13592	47971	54990	6168	61158

Source: District at a Glance 2014-2015, Govt. of Karnataka

1.4.1 Principle crops:

The only principle crop of the Taluk is Ground nuts - 46793 ha (76.51% to the total cropped area), followed by Tur dall (2915 ha) and caster-oil seed (1016 ha) which are normally rain fed crops. Overall food oil seeds are the major crops comprising of Ground nuts, caster, and sunflower grown in an area of 47960 ha (78.41% to the total cropped area) and pulses and food grains with an area of 7365 ha (12.04%) grown during Rabi season. Vegetables and paddy crops are the Kharif crops. The principle crops and area grown are in the below table-4.

Table-4 Principle crops in Pavagada Taluk

Crops	Cereals (Area in Ha)			Pulses (Area in Ha)				Fruits (Area in Ha)	Vegetables (Area in Ha)	Oil seeds (Area in Ha)		
	Paddy	Ragi & Maize	Others	Tur dall	Horse gram	Bengal gram	Others			Ground nuts	Castor	others
	1845	409+390	280	2915	887	283	356	1418	519	46793	1016	151
Total	2924			4441				1418	519	47960		
	Total Food Grains -7365 ha							**Fruits**	**Vegetables**	**Total Oilseeds-47960ha**		

Source: District at a Glance 2014-2015, Govt. of Karnataka

1.4.2 Irrigation Practices:

In Pavagada Taluk, the ground water is being developed from ground water structures like 34 dug wells and 5984 number of shallow tube wells (Report on 4th census of Minor Irrigation Schemes 2006-2007) for irrigation purposes. The ground water thus developed from these structures were managed through water distribution irrigation practices by adopting- Open channel (4017 bore wells & 27 dug wells), Underground pipe (1656 bore wells & 5 dug wells), surface pipe (237 bore wells & 1dug well), drip irrigation (47 bore wells & 1 dug well) sprinklers (15 bore wells & 0 dug wells) and others (2 bore wells).

1.4.3 Ground water and surface water Irrigation:

In Pavagada Taluk, ground water is the main source of irrigation. The details of surface water and ground water irrigation are in the Table-5.

Table-5: Details of irrigation in Pavagada Taluk.

Sl. No.	Source		No. / Length	Net area irrigated	Gross area irrigated
1	Surface water	Canals	0	0	0
		Tanks	125	201	201
2	Ground water	Dug Wells	4806	11	11
		Bore wells	13812	7769	9502
		Total	18743	7981	9714

Source: District at a Glance 2014-2015, Govt. of Karnataka

1.5 Geomorphology, Physiography & Drainage:

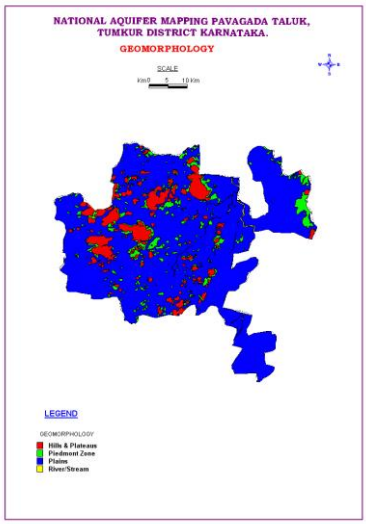
Geomorphologically Pavagada Taluk falls in southern maidan region. It is having rolling topography characterized by huge undulating plains and is part of Eastern Ghats with a parallel range of hills extends from north to south made up of granites. Prominent hill ranges are Kamanadurga (1060 m), Pavagada (904 m) and Nidugal (1131m) **Figure-2**. The average elevation of Taluk is 646 m a msl.

1.6 Drainage:

Pavagada Taluk is the part of North Pennar river basin. There are no perennial rivers in the Taluk. About three fourths of the Taluk that is 82% (1102 sq kms) of the Taluk is drained by North Pennar rivefr which rises near Chennakeshava hill (north of Nandidurga in Kolar district).

The springs called “Tala Pariges” or flowing wells are found in rest of the Taluk which are seasonal.

The general drainage pattern is of sub-rectangular due to marked influence of geologic structures in the basin **Figure-3**.



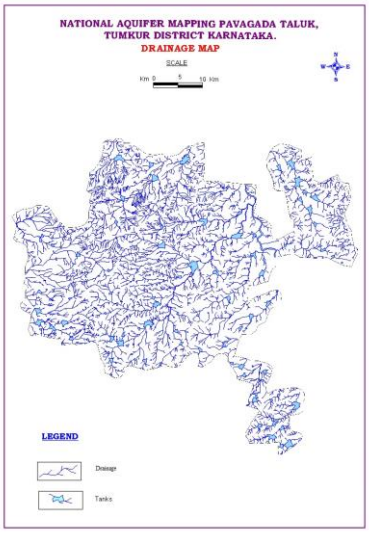


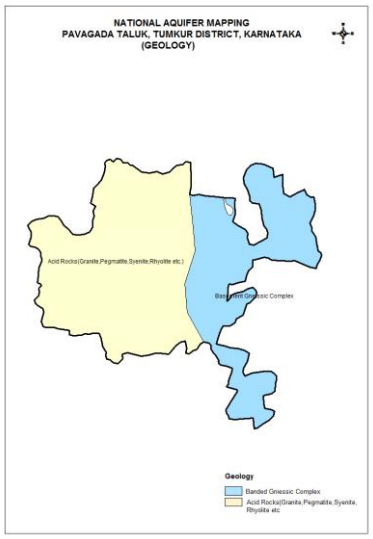
Figure-2 Geomorphology map **Figure-3 Drainage map**

1.6 Geology:

Pavagada Taluk is occupied by Banded Gneisses called as penninsular Gneiss and granites constituting acid rocks, pegmatites, syenite ans Rhyolite etc as major rock formation **Figure-4**.

1.7 Soil :

The soils of the area are derived from Gneiss / Granites. The soils are hard and poor in general. Sandy, clay, loam, black soils are the soil types **Figure-5**.



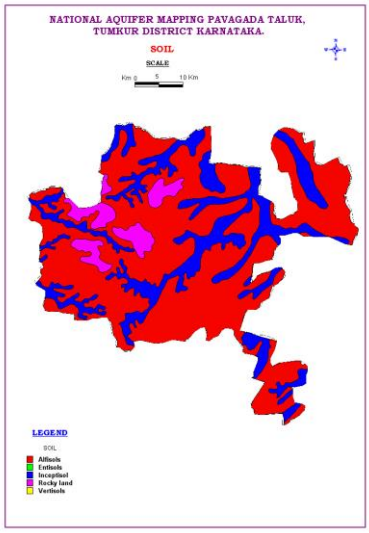


Figure-4: Geology map **Figure-5: Soil map**

1.8 Ground water resource availability and extraction:

The Ground water availability as per Resource Estimation 2009 & 2013 is as in the **Table-6**.

Table 6: Ground water Resource in 2009 and 2013

Year	Annual replenishable GW resources	Fresh In-storage GW resources		Total availability of fresh GW resources
		Phreatic	Fractured (Down to 200m)	Dynamic +phreatic in-storage + fractured
2009	9022	14501	3963	27486
2013	8172	0	3963	12135

As per the estimation **(GEC 2013)** the ground water draft (extraction) for irrigation worked out to be **5845 Ham** with stage of ground water development of 80%.

1.9 Existing and future water demands

As per GEC (2013) existing ground water draft for irrigation, industrial & domestic (all use) is **6530 Ham** and availability for future demands with judicious utilization since the stage of ground water development is already reached up to 80 % having less scope it is 2586 Ham of which 1167 Ham is for domestic and industrial use and 1419 Ham is for future irrigation purposes.

1.10 Water level behavior:

The depth to water levels during pre and post monsoon and the rate of fluctuation of water level are in the **Table-7 and Figures 6 to 10.**

Table-7: Depth of water level of Aquifer I and II in Pavagada Taluk

Item	Depth to Water levels in Pavagada Taluk					
	Pre monsoon		Post monsoon		Water level fluctuation	
	Aquifer I	Aquifer II	Aquifer I	Aquifer II	Aquifer I	Aquifer II
Range	4.25 to 15.05	20.00 to 60.00	1.65 to 15.50	20.00 to 40.00	-0.86 to 1.84	
Average	7.39	-	7.55		2.33	

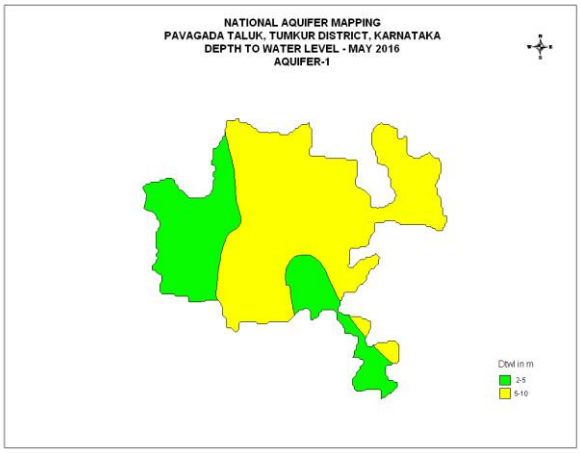


Fig-6: Pre monsoon DTW Map Aquifer I

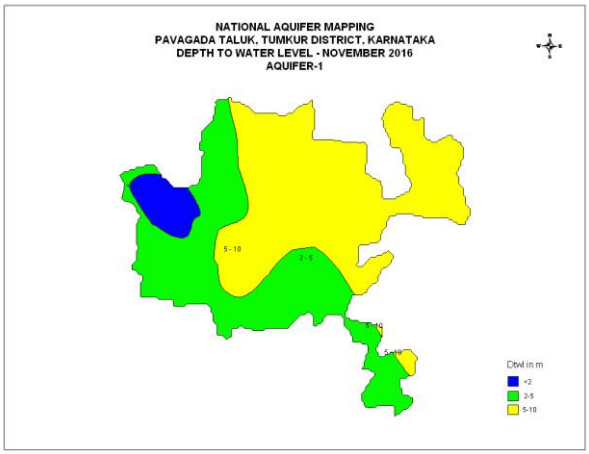


Fig-7 :Post monsoon DTW map Aquifer-I

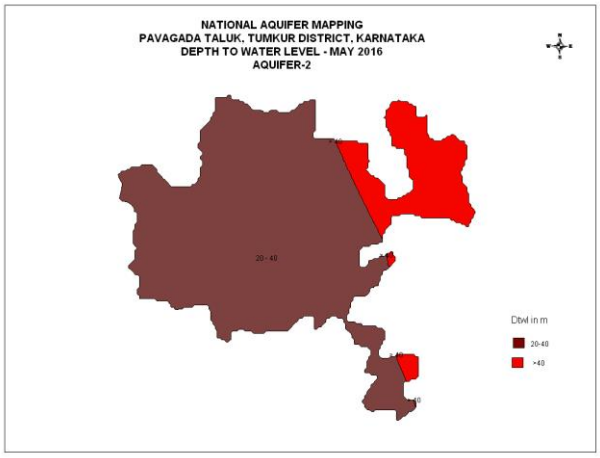


Figure-8: Pre monsoon DTW Map Aquifer II

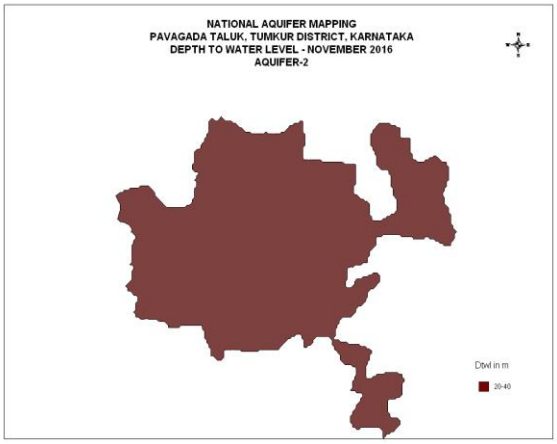


Figure-9: Post monsoon DTW map Aquifer II

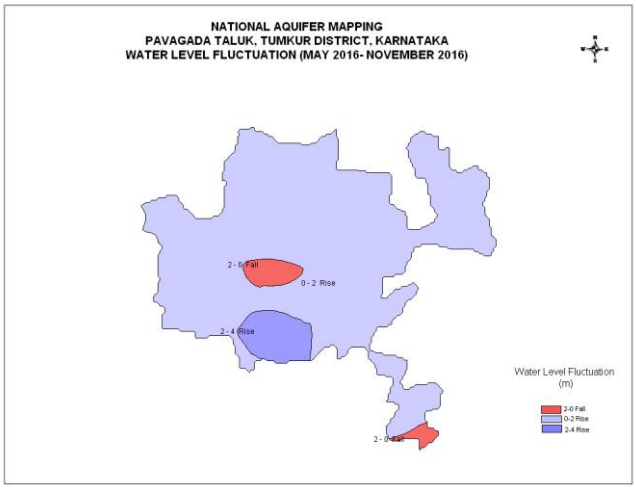


Figure-10 Water Level Fluctuation map Aquifer I

The analysis of long-term water level trend in Aquifer-1 indicates that in pre monsoon there is rising trend of 0.115 to 0.186 m/y with an average of 0.153m/y and falling trend of 0.202m/y. Similarly, during post monsoon showed rising trend in the range of 0.116 to 0.136m/y with an average of 0.252m/y. Falling trend during pre monsoon observed to be 0.202m/y and in post monsoon it is 0.157m/y. Overall trend indicates that rising trend is to the tune of 0.0.21 to 0.508m/y with an average of 0.416m/y and falling trend it ranged 0.249 to 3.166m/y with an average of 1.262 m/y.

2.0 Aquifer disposition

The data collected during Geophysical investigation, Ground water exploration were made use to delineate the aquifer system, Geometry and the extension of aquifer in terms of both lateral and vertical extent. The details of ground water exploration are in Table-8.

Table - 8: Details of Ground water Exploration in Pavagada Taluk

Sl. No.	Details	No/Range (up to 2017)	No/Range (2017-2018)
1	No of wells drilled	16	14
2	Depth range in 'm'	42.00 to 204.19	180.3 to 254.50
3	Depth of Casing in 'm'	7.60 to 21.77	13.5 to 43.00
4	Discharge in lps	0.01 to 15.03	0.20 to 21.00
5	S.W.L. in m	0.19 to 45.00	8.70 to 135.5
6	Transmissivity m^2/day	18 to 197	-

The yield analysis (up to 2017-2018) indicated that 62% of the wells showed above 5 LPS discharge followed by 25% are with less than 1 and 13% are with 1 to 5 LPS category. During 2017-2018 the drilling results indicate about 46.66% of the fractures are in the depth range of 30.00 to 100.00m followed by 33.33% of the wells with 100 to 200m. The yield analysis indicates 46% are with 0.00 to 1lps discharge followed by 23.33% with 2.00 to 3.00lps.

2.1 Number of aquifers: Based on the Ground water exploration data (2017-2018) in Pavagada Taluk, there are mainly two types of aquifer systems;

i. **Aquifer-I- (Phreatic aquifer)** comprising Weathered Gneiss / Granite which is dry.
ii. **Aquifer-II- (Fractured multi-aquifer system)** comprising Fractured Gneiss / Granite.

2.2 3 D aquifer disposition and basic characteristics of each aquifer:

The Exploration drilling data (2017-2018) utilised for generating aquifer disposition maps through Rock works soft ware. The output thus obtained is in Fig-11 to 14.

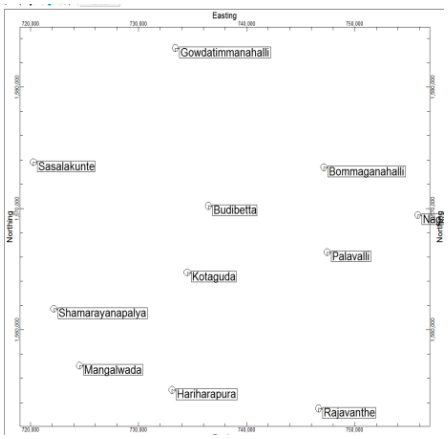


Fig-11 Location map of EW/OW

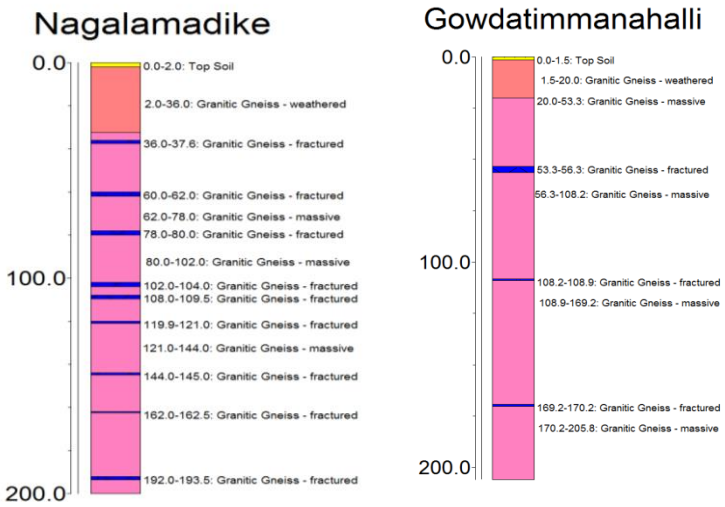


Fig-12 Log diagram of Exploratory wells

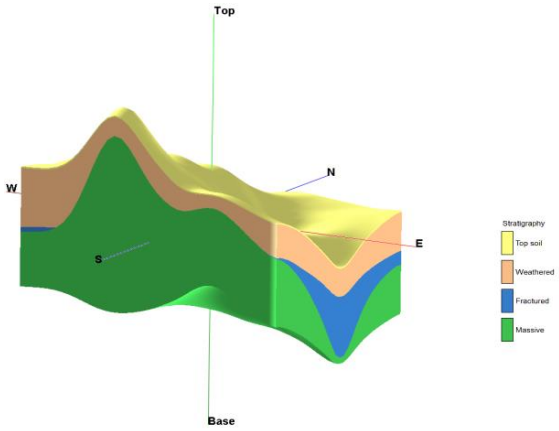


Fig-13A

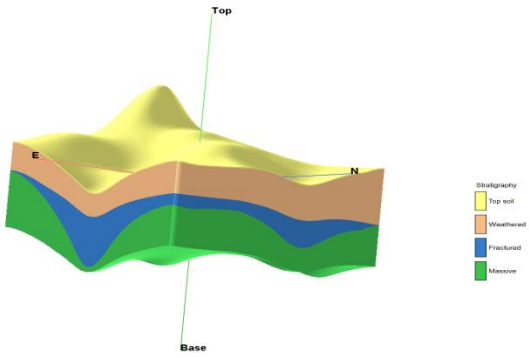


Fig-13B

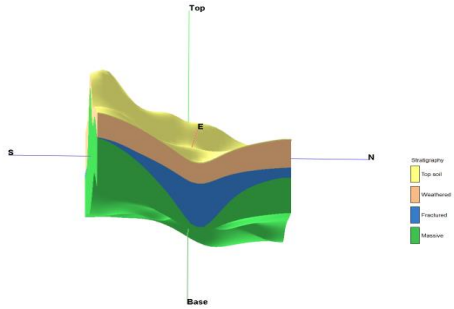


Fig-13C

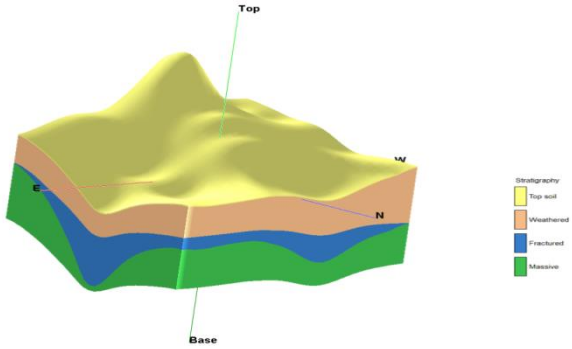


Fig-13D

Fig-13 _A to 13D 3-d Aquifer model

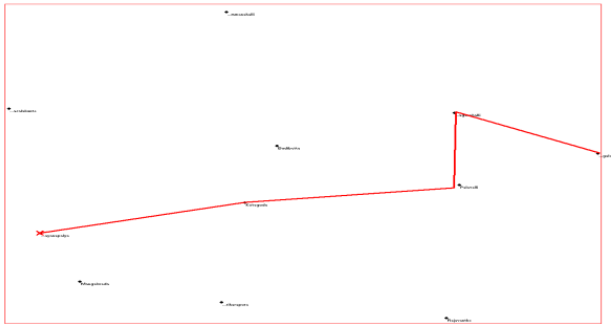


Fig-14A. Data Location 3 D Diagram Cross section East-West

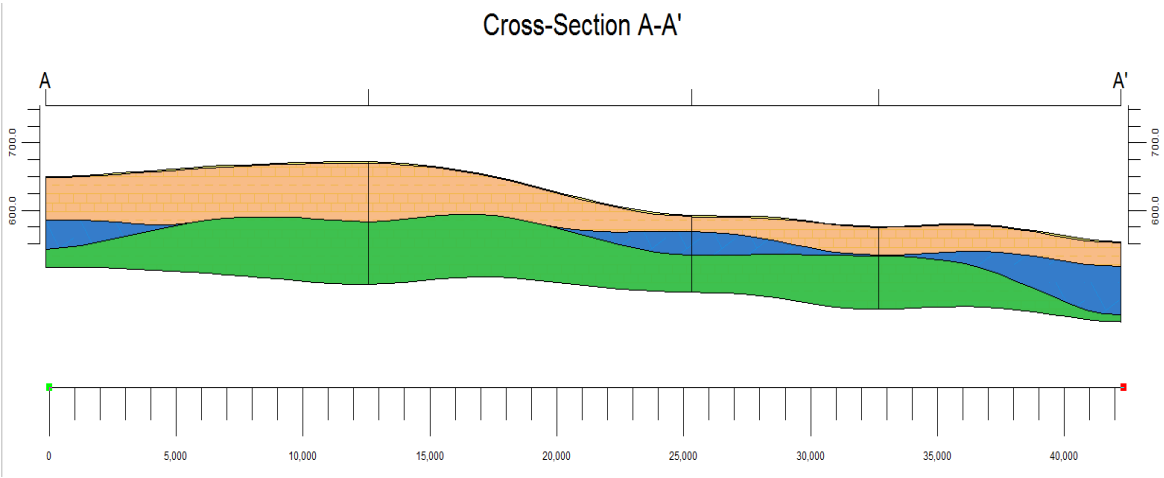


Figure-14B. Aquifer disposition 3 -D Diagram Cross section East-West

3. Ground water resource, extraction and contamination

3.1 Aquifer wise resource availability and extraction:

Aquifer wise ground water resource (2011) has already been discussed in above chapter (1.8 & 1.9). However overall Groundwater resource estimation in Pavagada Taluk as on 2011 & 2013 indicating present and future scenario (2025), Stage of ground water development and categorization is presented in the below **Table-9**.

Table-9: Ground water resource in 2011 and 2013

Sl. No	Resource details	As per 2011 Estimation	As per 2013 Estimation
1	Net Ground Water Availability in HAM	8017.19	8172
2	Existing Gross Ground Water Draft for Irrigation in HAM	5730.40	5845
3	Existing Gross Ground Water Draft for Domestic and Industrial Water Supply in HAM	656.39	685
4	Existing Gross Ground Water Draft for all use in HAM	6386.79	6530
5	Allocation for Domestic and Industrial Use for next 25 years in HAM	765.49	1167
6	Net Ground Water Availability for future Irrigation Development in HAM	1793.88	1419
7	Existing Stage of Ground Water Development in percentage	80	80
8	Categorization	Semi critical	Semi critical

3.2 Chemical quality of ground water and contamination

The chemical quality of ground water in Pavagada Taluk is assessed from the analysis results of 10 samples from dug wells (Aquifer-I). The variation range and average of the different chemical constituents are presented in the table-10 and the distribution of chloride, EC, Nitrate and Fluoride is presented in the **Figure-15 to 18.**

Table-10 Variation range and average of chemical constituents in Ground water.

→ Chemical constituents in PPM	P^h	EC in m/mhos/cm at 25 ^{0} c	Total hardness as $CaCO_3$	Ca^{++}	Mg^{++}	Na^+	K^+	HCO_3	Cl	SO_3	NO_3	F
Range	8.09 to 8.59	720 to 1230	100 to 290	16 to 90	12.19 to 43.82	75 to 180	1.2 to 3.9	159 to 329	36 to 163	11 to 41	0.60 to 76	0.92 to 3.25
Average	8.33	875	181.50	34	23.50	112	2.00	247.70	78.6	24.81	29.42	1.97

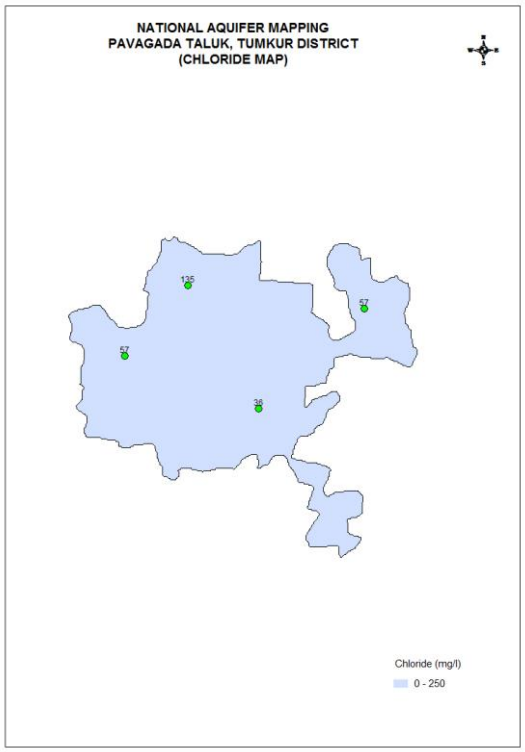


Figure-15: Distribution of Chloride

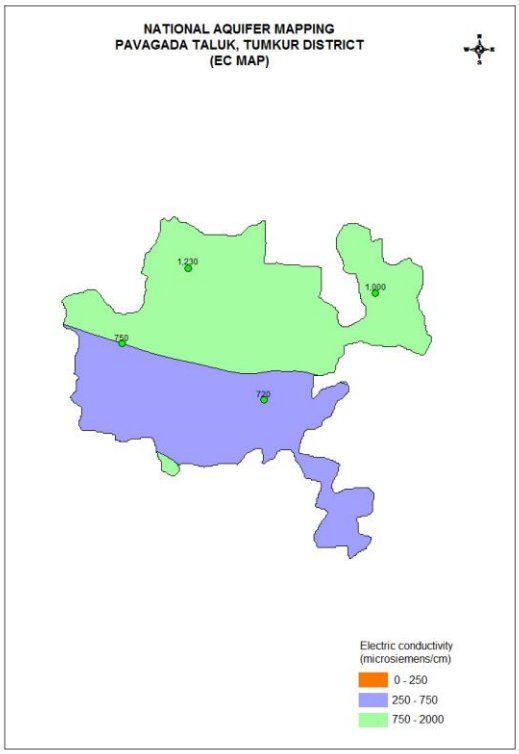


Figure-16: Distribution of EC

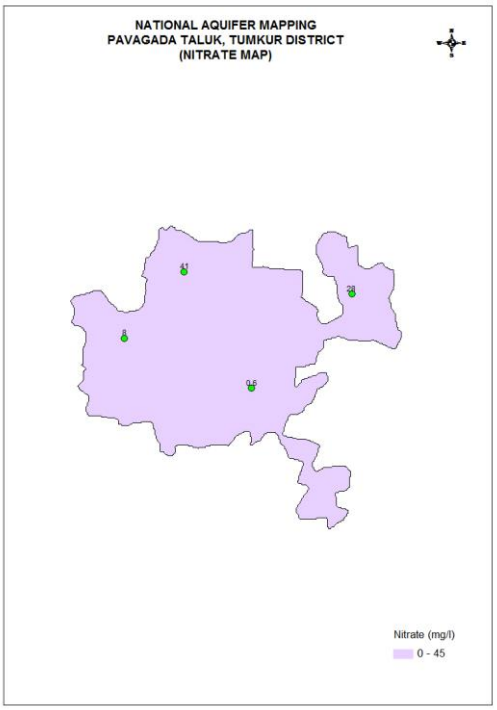


Figure-17: Distribution of Nitrate

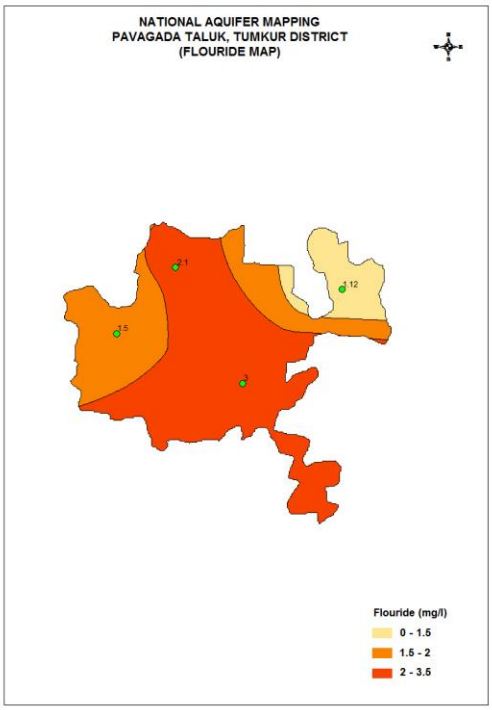


Figure-18: Distribution of Fluoride

3.2.1. Suitability of ground water for **drinking purposes** is assessed as per Indian Standard Drinking water specification (IS 10500:2012) which indicates that water is potable and all the required chemical constituents is within the desirable/permissible limits except Fluoride which is in higher range. The range of chemical constituents (under NAQUIM) in ground water of the Taluk is plotted in Piper diagram **Figure-19.**

3.2.2. Suitability of ground water for **irrigation purposes** was assessed and the chemical analysis of the Taluk is plotted in United States Regional Salinity Labaratory (1954) classification and presented in the diagram-**Figure-20**

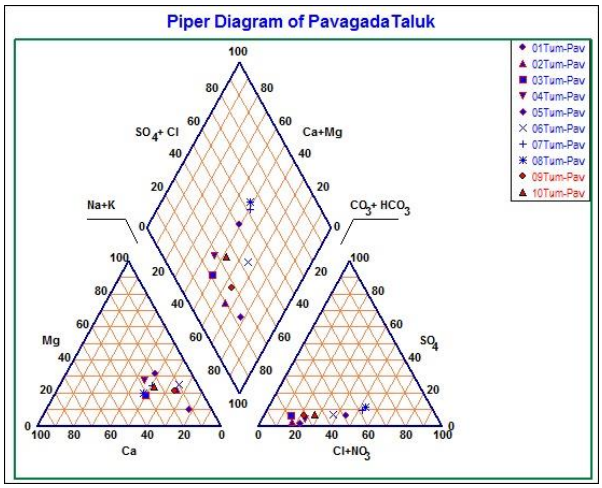


Figure-19 Chemical analysis Plot on Piper Diagram

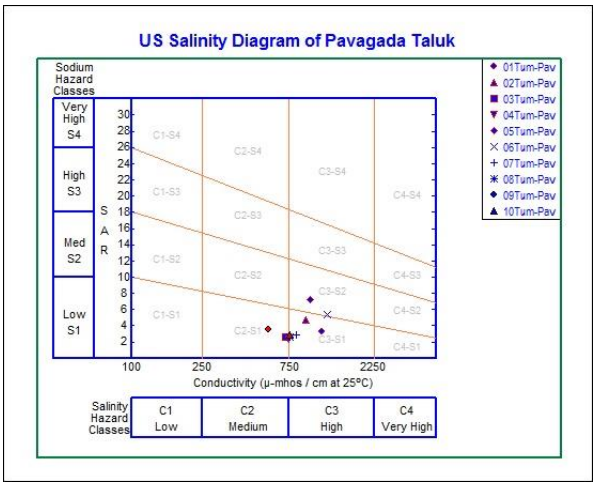


Figure-20 U.S. Salinity diagram

3.3.Ground water contamination :

Fluoride is the major ground water contamination for drinking purpooses over Pavagada Taluk. This is a quite an intriguing situation facing quality problem. Out of 10 samples analyzed for Fluoride of which 9 samples (90%) of the samples are with Fluoride beyond 1.5 ppm with an average of 1.97 ppm. Distribution of Fluoride is presented in **Figure-19**.

4.0 Ground water resource enhancement:

Continuous drought, increase in agricultural activity, subjected to excessive ground water withdrawal leading to depletion of ground water table, reduction in yield and deterioration of ground water quality etc., suggests a need for proper ground water management and enhancement of storage capacity of aquifers, protection of ground water quality and proper utilization of ground water.

To enhance the storage capacity of aquifers, the dewatered aquifers are to be recharged, for which the artificial recharge structures like Check dams, percolation tanks, point recharge structures etc have to be constructed (**Table-11**).

4.1 Aquifer wise space available for recharge and proposed interventions

4.1.1 Quantity of water available through non-committed surface run off :

The surplus non-committed monsoon run off is calculated to be 9.805 MCM this can be used to recharge the aquifer through suitable recharge structure which augments the net ground water availability in the Taluk. The details of types of structure/number for recharge are presented in the table-11.

Table-11 Details of Artificial structures

Artificial Recharge Structures available/Proposed	Pavagada Taluk	Resource available in MCM
Non committed monsoon run off available (MCM)	9.805	
Number of Check Dams	60	7.256
Number of Percolation Tanks	4	2.451
Number of Point Recharge structures	7	0.098
Tentative total cost of the project (Rs. in lakhs)	236.37	-
Excepted recharge (MCM)	5.555	-
Expected rise in water level (m)	0.227	-
Cost Benefit Ratio (Rupees/ cu.m. of water harvested)	4.255	-

Thus, considering above source water for ground water recharge the volume of water expected to be conserved or in the ground water resource enhancement is as detailed in the below table-12.

4.1.2 Proposed Yettinahole project:

Yettinahole water project is a flagship project of the Karnataka Government that intends to divert water from the west-flowing Nethravathi River to the drought-prone districts which includes Pavagada Taluk. The project proposal comprises two components namely, Drinking water and tank filling. On implementation of this project helps to recharge 602 HAM of water to ground water by which there will be increase in the ground water availability and stage of ground water development.

Table – 12 Details of resource enhancement after proposed artificial recharge & Yettinahole project

Sl. No	Resource details	As per 2013 Estimation
1	Net Ground Water Availability in HAM	8172
2	Existing Gross Ground Water Draft for All use HAM	6530
3	Existing Stage of Ground Water Development in percentage	80
4	Expected recharge from Artificial Recharge Projects HAM	555
5	Additional potential from proposed Yettinahole project	602
6	Cumulative ground water Availability HAM	9329
7	Expected improvement in stage of ground water Development after implementation of the project in percentage	70
8	Expected improvement in overall Stage of Ground water development in percentage	10
9	Expected additional irrigational potential in hectares	677.392

5. Demand Side Interventions:

5.1 Advanced irrigation practices:

Major crop of Pavagada Taluk is ground nut which is rain fed crop. Remaining crops like some of the pulses, Vegetables, Paddy and fruits are depending upon the ground water source.

The ground water for irrigation is being developed through 34 irrigation dug wells and 5984 irrigation bore wells. The existing advanced irrigation practices and the irrigation potential created over the Taluk is as detailed in the below **Table-13**.

Table-13 Details of Irrigation practices in Pavagada Taluk

Sl. No	Advanced Irrigation practices	No. of Irrigation Dug wells and potential utilized area in hectares		No. of Irrigation Bore wells and potential utilized area in hectares		Total	
		No. Dug wells	potential utilized (Ha)	No. of Bore wells	Potential utilized (Ha)	Total no of structures	Total potential Utilized (Ha)
1	Open water channel	27	32	4027	7474	4054	7474
2	Underground pipe	5	9	1656	2584	1661	2584
3	Surface pipe	1	3	237	404	238	404
4	Drip irrigation	1	3	47	103	48	103
5	Sprinklers	0	0	15	39	15	39
6	Others	0	0	2	0	2	0
	Total	**34**	**47**	**5984**	**10604**	**6018**	**10604**

Source: 4th Census of Minor Irrigation schemes, Department of Minor irrigation, Bangalore, March 2011

Perusal of the above table indicate that the irrigation practices like Drip irrigation & sprinklers as water distribution system is comparatively very less with less irrigation potential utilized when compared to other distribution systems resulting in difficulty in economy of water conservation. If these methods of drip and sprinkler irrigation systems increased, maximum available ground water can be conserved judiciously. This ultimately enhances the area under irrigation potential.

5.2 Change in cropping pattern

Farmers are facing inadequacy of groundwater for agriculture so have to change their cropping pattern and water economy irrigation practices like drip irrigation and sprinkler irrigation which are negligible number. If they also adopt the water use efficient irrigation practices like mulching-plastic sheeting, spread on the ground around plants to prevent excessive evaporation or erosion, enrich the soil, etc., and there will be additional saving in water. Therefore, encouragement from government is essential for achieving full target of water use efficiency in the Taluk.

5.3. Alternate water sources:

As per the resource estimation – 2013, Pavagada Taluk falls under Semi critical category with the stage of ground water development of 80 % leading towards water scarcity problem. So, there is need to formulate management strategy to tackle the water source scarcity in the Taluk.

If the artificial recharge projects as proposed is implemented the Surplus non committed monsoon runoff water available-through artificial recharge structures about 9.805 MCM of water can be conserved. This alternate water sources will cope up additional irrigational potential of 1002.05ha of agricultural land and there will be rise in water level of 0.410m (Table-11&12). Addition to this additional ground water potential of 602HAM from proposed Yettinahole project is available for drinking water purposes.

5.4. Regulation and control:

Considering the current existing ground water draft for all use – 6530 HAM with the stage of ground water development up to 80%, it is mandatory to plan to augment the ground water through artificial recharge besides use of ground water judiciously. Apart from this it is mandatory to adopt advanced irrigation practices like drip irrigation, sprinklers and other practices which are reported to be in no/negligible number and management of ground water for irrigation with water use efficiency methods.

5.5 Other Interventions proposed:

The major issue in the Taluk is water scarcity for drinking and irrigation. To mitigate this critical issue of scarcity for safe drinking water, construction of rain water harvesting units at the family level are must implementation of artificial structures as proposed to recharge the ground water.

Excess Fluoride contamination in ground water requires dilution of Fluoride rich ground water through roof top rain water harvesting. The roof top rain water harvesting, direct aquifer recharge, excavation of farm ponds bore well recharge and timely water quality analysis etc will reduce the Fluoride level in water. It is also be achieved through adoption of standard filtration/ removal techniques like Reverse Osmosis filtration, activated alumina de-fluoridation filter and distillation filtration is strongly recommended. Other methods like Nalgonda techniques, Ion exchange process, and adsorption methods like activated carbon, Tri calcium phosphate and activated alumina may be used.