केन्द्रीय भूमिजल बोर्ड

जल शक्ति मंत्रालय, जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

भारत सरकार

Central Ground Water Board

Ministry of Jal Shakti,
Department of Water Resources, River Development
and Ganga Rejuvenation
Government of India

Report on

AQUIFER MAPPING AND MANAGEMENT PLAN

Pandavapura Taluk, Mandya District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

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जल शक्ति मंत्रालय
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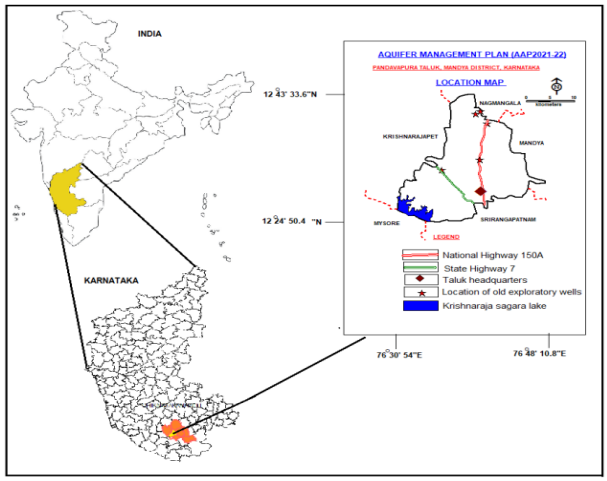
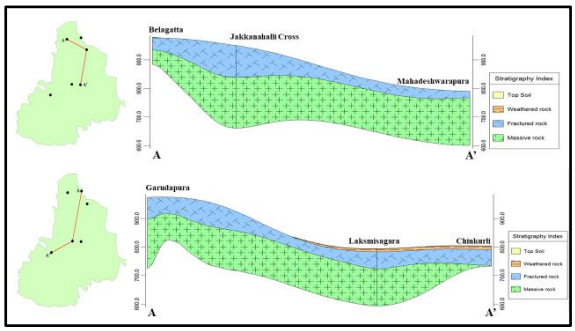
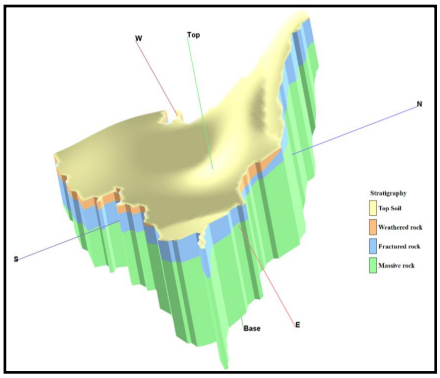
AQUIFER MAPS AND MANAGEMENT PLAN, PANDAVAPURA TALUK, MANDYA DISTRICT, KARNATAKA STATE

(AAP: – 2021-2022)







By

Dr.Suchetana Biswas, Scientist 'B', CGWB, SWR, Bengaluru

AUGUST2022

AQUIFER MAPS AND MANAGEMENT PLAN, PANDAVAPURA TALUK, MANDYA DISTRICT, KARNATAKA STATE

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AQUIFER MAPS AND MANAGEMENT PLAN, PANDAVAPURA TALUK, MANDYA DISTRICT, KARNATAKA STATE

1SALIENT INFORMATION

Name of the Taluk:**PANDAVAPURA**

District:Mandya

State:Karnataka

Area:522sq.km

Population:183352

Annual NormalRainfall:688mm

1.1 AquiferManagementstudyarea

Aquifer mapping studies were carried out in Pandavapura taluk, Mandya district of Karnataka, covering an area of 522sq.km under National Aquifer Mapping Project. Pandavapura taluk ofMandya district is located between North latitude 12°24'50.4" to 12°43'33.6"&East longitude 76°30'54" to 76°48'10.8" and is covered in parts of Survey of India Toposheet Nos.57 D/10, 57D/11 and 57D/14.Pandavapuratalukis bounded by Nagamangala Taluk on North, Mandya taluk on East, Krishnarajapet taluk on West, Srirangapatna taluk on South and South-East and Mysore district on South side. Location map of Pandavapura taluk of Mandya district is presented in **Figure 1.**Taluk administration of Pandavapura is divided into 03 Hoblies and 24 Gram Panchayats. There are 140 inhabited and 29 uninhabited villages in the Taluk.

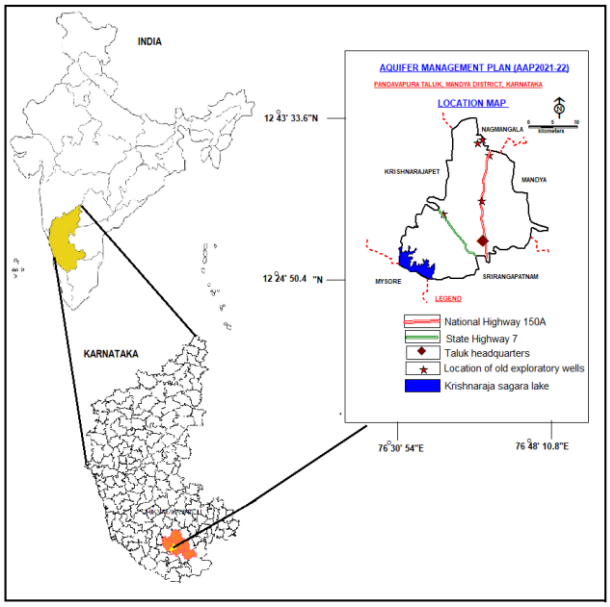

Figure 1:LocationMap

1.2Population

According to 2011census, the population in Pandavapura taluk is 1,83,352 of which 92038 male and 91314 femalepopulation.

1.3 Rainfall

There arethree(03) rain gauge station located in Pandavapura taluk. Normal annual rainfall is 688mm.Actual annual rainfall for 2019 was 859mm.The annual rainfall data from 2001 to 2019 is given in **Table 1**.Highestrainfall of 1174 mm was received in 2005 and lowest rainfall of 369mm was received in 2016. The yearwise rainfall variability graph is given in **Figure-2.**

Table 1: The annual rainfall data from 2001 to 2019

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Rainfall in mm	613	451	476	829	1174	510	703	518	933	935	884	548	594	696	696	369	932	652	859

Source:KSNDMC

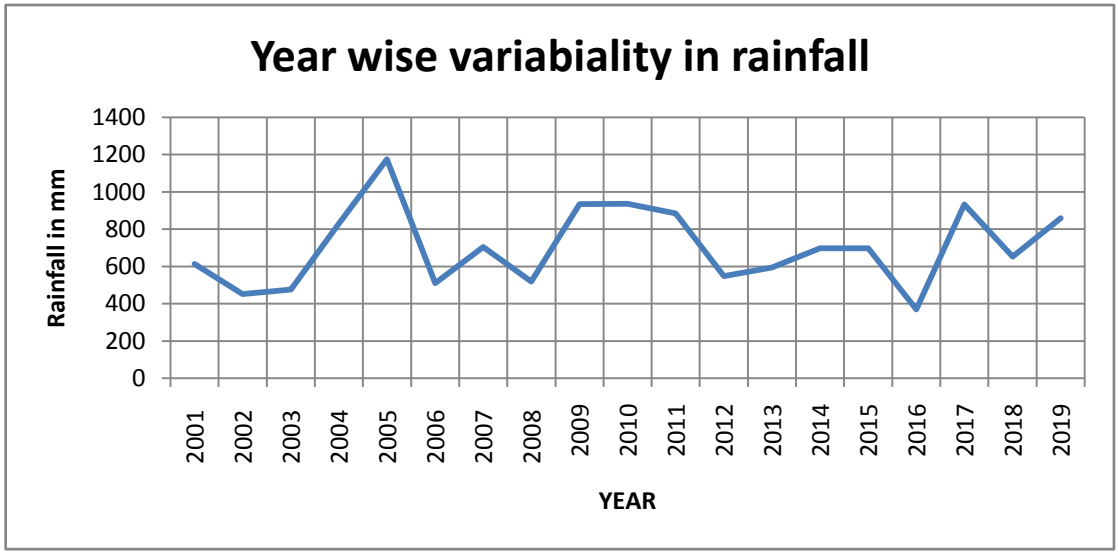

Figure 2: Yearwiseannual rainfall graph

Pandavapura taluk experiences semi-arid climate. Dryness and hot weather prevails in major part of the year. The area falls under Southern Dry agro-climatic zone of Karnataka state and is categorized as drought prone.

The climate of the study area is quite agreeable and free from extremes. The year is usually divided into four seasons: summer from March to May; rainy season or south-west monsoon season from June to September, post-monsoon season covering the months of October and November and dry or winter Season from December to February.

1.4Agriculture and Irrigation

Agriculture is the main occupation in Pandavapura taluk. Ragiis the major crop grown in the taluk in 8105ha area, followed by pulses (6613 ha),sugarcane (5566 ha), paddy (5045 ha) and vegetables (3779 ha) **(Table 2)**.

Table2: Cropping pattern in Pandavapura taluk2015-2016(Ha)

Paddy	Jowar	Maize	Ragi	Other minor millets	Pulses	Fruits	Vegetables	Oil seeds	Sugarcane	Cotton
5075	5	0	8105	0	6613	306	3779	199	5566	0

Source: Mandya District at a Glance 2015-16, Govt. of Karnataka

It is observed that net sown area accounts for about 42.5% of total geographical area, while area sown more than once is 19.12% of total geographical area in the taluk**(Table 3).** As per the data available, 10386ha net area is irrigated through canal water,48 tanks irrigate 1650ha net area,1478 dug wells irrigate 1158ha net area and 2674 borewells irrigate 1264 net area.Lift irrigation irrigates 143ha net area and other sources irrigate 233ha net area.The net area irrigated through surface water is 12179ha and net area irrigated through groundwater is 2422ha.Canals are the mainsource for irrigation in the taluk **(Table 4).** Landuse pattern of the taluk is represented as **Figure 3**.

Table 3: Details of landuse in Pandavapura taluk 2015-2016(Ha)

Total Geographical Area	Area under Forest	Area not available for cultivation	Fallow land	Net sown area	Area sown more than once
52200	2051	7778	11321	22185	9985

Source: MandyaDistrict at a Glance 2015-16, Govt. of Karnataka

Table 4: Irrigation details in Pandavapura taluk (Ha)

Source of Irrigation	Nos./Length	Net area irrigated (Ha)	Gross area Irrigated (Ha)
Canals	84km	10386	11943
Tanks	48	1650	2153
Lift Irrigation	31	143	143
Surface water Total		**12179**	**14239**
Wells	1478	1158	1418
Bore wells	2674	1264	1463
Groundwater Total		**2422**	**2881**
Other Sources	-	233	233
Total		**14834**	**17353**

1.5 Geomorphology, Physiography and Drainage

The taluk is located in the southern maidan region of the state. The surface topography is in theform of undulating plain situated at an average elevation of 750- 1000m amsl. There are fewsporadic out crops of rocks as hills and few fertile shallow valleys**(Figure 4)**. The Melukote range of hills fall as broken series of conspicuous peaks, which reach the altitude of 1159m amsl, 1064m amsl, 1050m amsl and 1046m amsl. The general slope in the taluk is in southeast direction. The Taluk is drained by Hemavathy river and Cauvery river.**(Figure 5).**

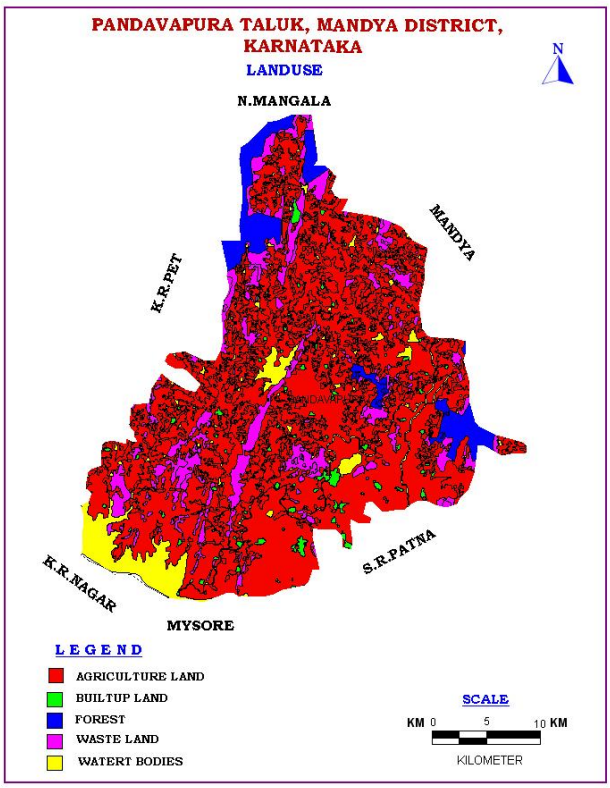

Figure 3: Landuse Map

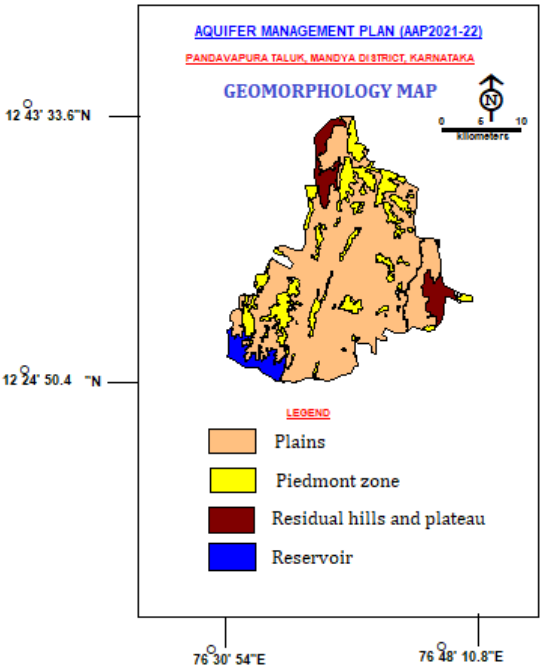

Figure 4: Geomorphology map

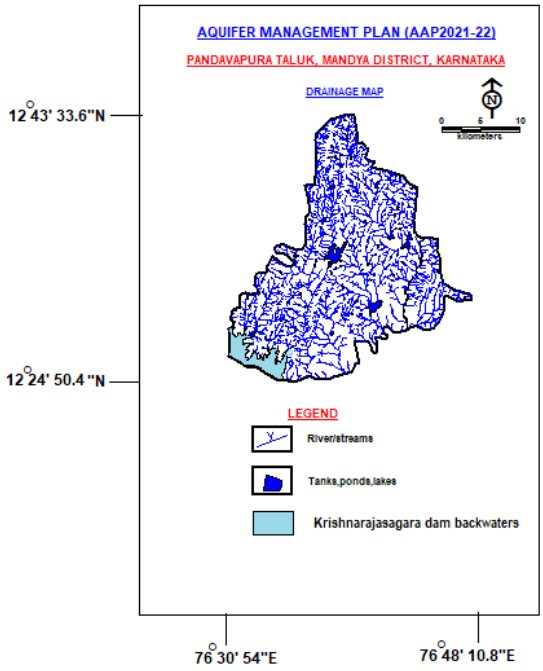

Figure 5: Drainage map

1.6Soil

The soils range from red sandy loams to red clay loams which occur in very thin in ridges at higher elevations and comparatively thick in valley portions. Thesoils under the old channel areas are high in clay. **(Figure6).**

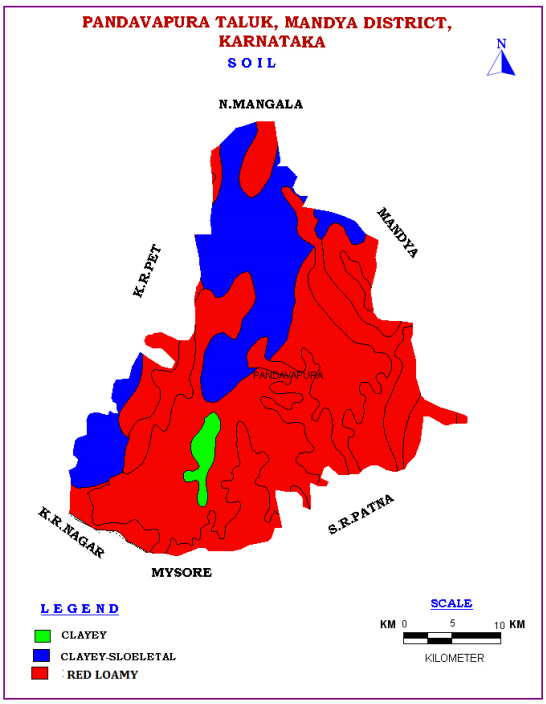

Figure 6: Soil map

1.7Existing and future water demands (as per GWRA-2020)

The details of dynamic (Phreatic) ground water resources for Pandavapura taluk as on March 2020 is shown in Table.5. The annual extractable water resource is 8125.09ham.Total groundwater extraction for irrigation and domestic use is 5049.17ham. Annual GW Allocation for domestic use as on 2025 is 935.08ham. Net Ground Water Availability for future use is 3393.99ham.

Table.5 Detail of Dynamic Ground Water resource, Pandavapura taluk, (as on March 2020)

Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)
Ham	Ham	Ham	Ham	Ham	Ham	Ham	%
8125.09	4263.20	0.00	785.96	5049.17	935.08	3393.99	62.14

1.8Water level behaviour

The water level data have been monitored from the representative dug well and borewells for both pre and post-monsoon seasons (Table 6). During pre-monsoon season in i) aquifer-I (phreatic) water level ranges from 0.96 to 10.17mbgl, ii) aquifer-II (fractured) water level ranges from 6.65 to 23.70 mbgl, whereas in post-monsoon it varies from 1.12 to 5.34 m bgl in aquifer-I (phreatic) and 3.55 to 13.0 mbgl in aquifer-II (fractured) . The seasonal water level fluctuation in aquifer-I is fall in the range of 0.16 m to 2.17 m and rise in the range of 0.28m to 5.78m.The seasonal water level fluctuation in aquifer-II is rise in the range of 3.1m to 10.17m. The pre-monsoon decadal average water level for aquifer-I varies from 0.96 to 16.77mbgl. The post-monsoon decadal average water level for aquifer-I varies from 0.98 to 6.68mbgl.

(a) Depth to water level

Aquifer-I

Pre-monsoon: 0.96-10.17mbgl (May 2019) **(Figure 7)**

Post-monsoon: 1.12-5.34 mbgl (Nov 2019) **(Figure 8)**

Aquifer-II

Pre-monsoon: 6.65-23.70 mbgl (May 2019)

Post-monsoon: 3.55-13.01mbgl (Nov 2019)

(b) Water level fluctuation

Aquifer-I

Seasonal Fluctuation: Fall in the range of 0.16 m to 2.17 m and rise in the range of 0.28m to 5.78m. **(Figure 9)**

Aquifer-II

SeasonalFluctuation:Rise in the range of 3.1m to 10.7m.

Table 6: Depth to water level (Pre & Post monsoon 2019)

Sl. No.	Well type	Village name	DTWL (m bgl) (Pre-monsoon 2019)	DTWL (m bgl) (Post-monsoon 2019)
1	Dugwell	Ankegowdanakoppalu	10.17	4.39
2	Dugwell	Bydarahalli	4.30	2.73
3	Dugwell	Darasaguppe	3.64	2.07
4	Dugwell	DevegowdanaKoppalu	1.48	1.20
5	Dugwell	Haralahalli-A	3.17	5.34
6	Dugwell	Haravoo	4.46	5.03
7	Dugwell	Kyatanahalli	0.96	1.12
8	Dugwell	Melukote-1	5.63	2.22
9	Dugwell	Pandavapura	2.70	2.2
10	Dugwell	Yelekere	3.85	2.05
11	Borewell	Amuruthi	13.05	3.72
12	Borewell	Sayappanahalli	23.70	13.01
13	Borewell	Pandavapura	6.65	3.55
14	Borewell	Chinakurali	18.43	9
15	Borewell	Melukotepz	14.3	12.8

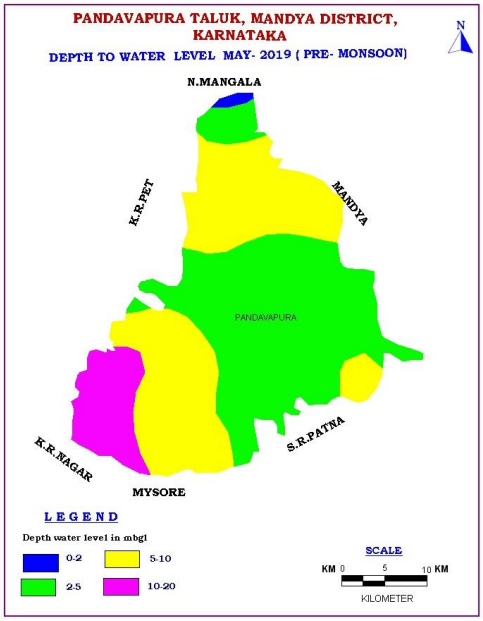

Figure 7: Aquifer-I Depth to water level map

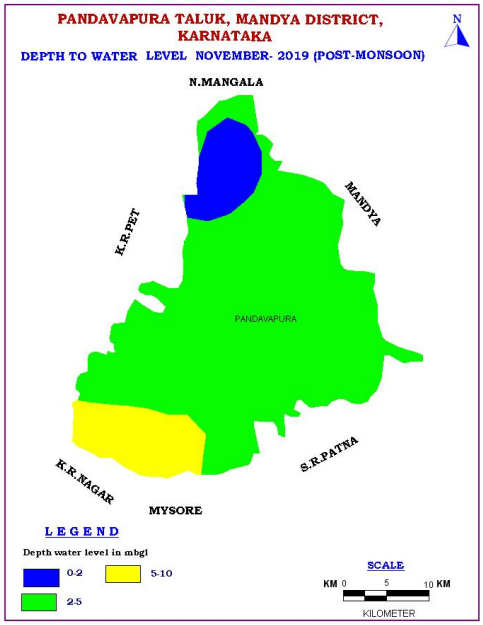

Figure 8: Aquifer-I Depth to water level map

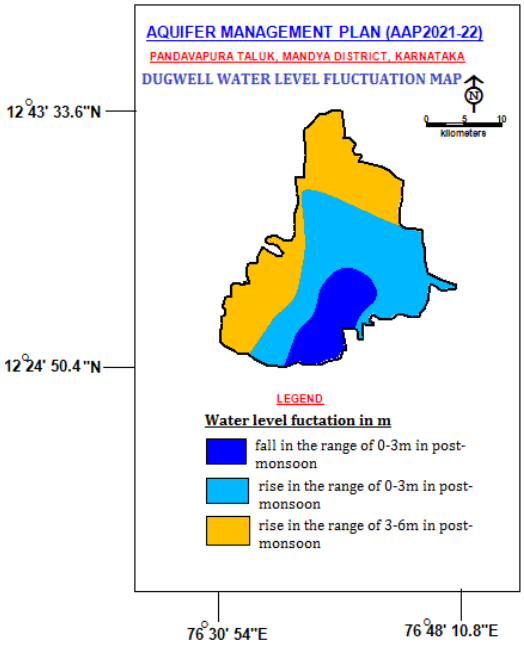

Figure 9: Aquifer-I Water level fluctuation map

The long term groundwater trend (2011-2020) for pre-monsoon period shows a fall in the range 0.08m/year to 0.65m/year and rise in the range of 0.0021m/year to 0.09m/year (Table 7).The long term groundwater trend (2011-2020) for post-monsoon period shows a fall in the range 0.011m/year to 0.12m/year and rise in the range of 0.0124m/year to 0.09m/year (Table 8). During pre-monsoon period monitoring stations are mostly showing falling trend and during post-monsoon period monitoring stations are mostly showing rising trend.

Table 7: Pre-monsoon Trend of Groundwater monitoring stations(2011 to 2020)

SL_No	LOCATION	RISE (M/YEAR)	FALL (MYEAR)	AQUIFER_TYPE
1	Ankegowdanakoppalu		0.6547	Unconfined
2	Darasaguppe		0.1598	Unconfined
3	DevegowdanaKoppalu	0.0915		Unconfined
4	Haralahalli-A	0.0021		Unconfined
5	Haravoo		0.2622	Unconfined
6	Melukote		0.0894	Semi-Confined
7	Melukote-1		0.1839	Unconfined

Table 8: Post-monsoon Trend of Groundwater monitoring stations (2011 to 2020)

SL_NO_	LOCATION	RISE (M/YEAR)	FALL(M/YEAR)	AQUIFER_TYPE
1	Ankegowdanakoppalu	0.0714		Unconfined
2	Bydarahalli	0.0796		Unconfined
3	Darasaguppe		0.1204	Unconfined
4	DevegowdanaKoppalu		0.0116	Unconfined
5	Haralahalli-A	0.0992		Unconfined
6	Haravoo	0.0124		Unconfined
7	Melukote	0.0359		Semi-Confined
8	Melukote-1		0.0269	Unconfined

2 AQUIFER DISPOSITION

2.1 Aquifer Types

In Pandavapura taluk, there are mainly two types of aquifer systems

Aquifer-I (Phreaticaquifer) comprising of weathered granitic gneiss

Aquifer-II(Fracturedaquifer) comprising fractured granitic gneiss

In Pandavapura taluk, fractured granitic gneiss is the major water bearing formation. A small portion is covered with granite, charnockite and schist **(Figure 10)**. Groundwater occurs within the jointed and fractured granitic gneiss under semi-confined to confined conditions. In Pandavapura taluk borewells were drilled from a minimum depth of 70.75mbgl to a maximum of 202.3mbgl **(Table9)**. Depth of weathered zone (Aquifer-I) ranges from 6.2mbgl to 20.8mbgl. Ground water exploration reveals that aquifer-II fractured formation was encountered between the depth of 30 to 100m bgl**.** Yield ranges from 0.2 to 2.4lps.

The2D aquifer cross-section diagram and3D Aquifer disposition models have been prepared and presented in **Figure 10,11a,b** respectively**.**

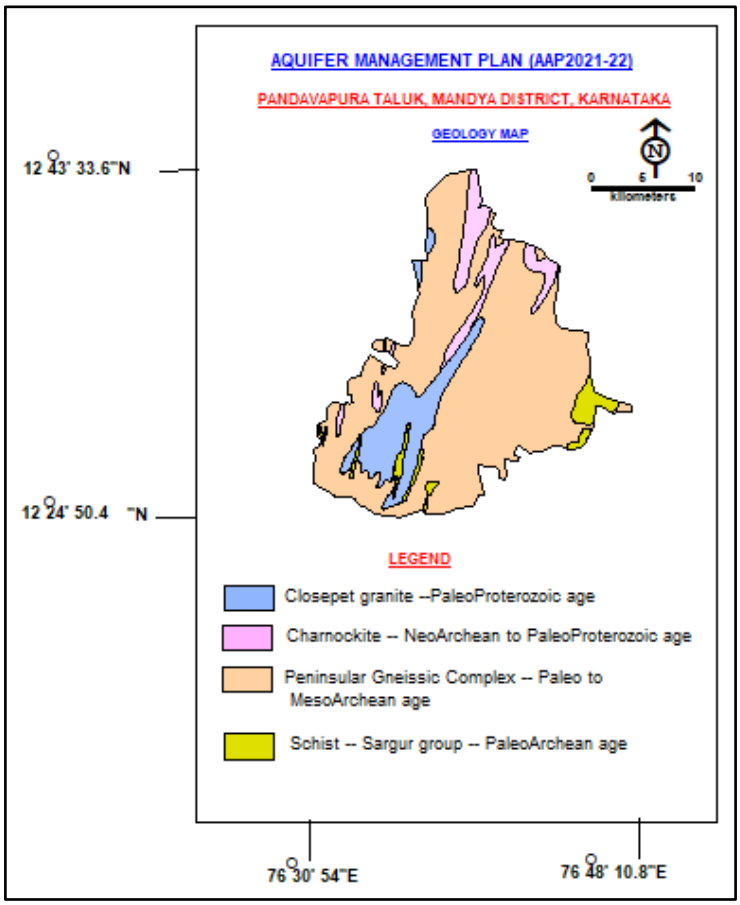

Figure 10: Geology Map

Table 9:Details of Ground water Exploration

Sl. No.	Location	Latitude (N)	Longitude (E)	Depth Drilled (m bgl)	Casing Depth (m bgl)	Fracture Zones (mbgl)	SWL (mbgl)	Q (lps)	DD (m)
1.	Mahadeshwarapura	12.5708333	76.670833	177.02	9.60	13.25-31	3.12	6.3	9.635
2.	Jakkanahalli Cross	12.6569444	76.686111	192	13.1	13.25-31, 43, 48-51, 55-58, 71.1-72.0	6.14	6.65	9.94
3.	Garudapura	12.6861111	76.672222	200	20.8	34.5-36.0, 55-58, 67-68	6.96	0.92	35.93
4.	Belagatta	12.67916667	76.66388889	89	6.2	34.05-45	0.849	0.2	-
5.	Chinkurli	12.54583333	76.59722222	70.75	12.35	13.25-31, 43, 48-51, 55-58, 67-68	7.846	2.4	6.374
6.	Laksmisagara-Ew	12.5720	76.6497	202.3	12.0	34.5-36.0, 52.8-53.0,71.1-72.0	41.35	0.75	-

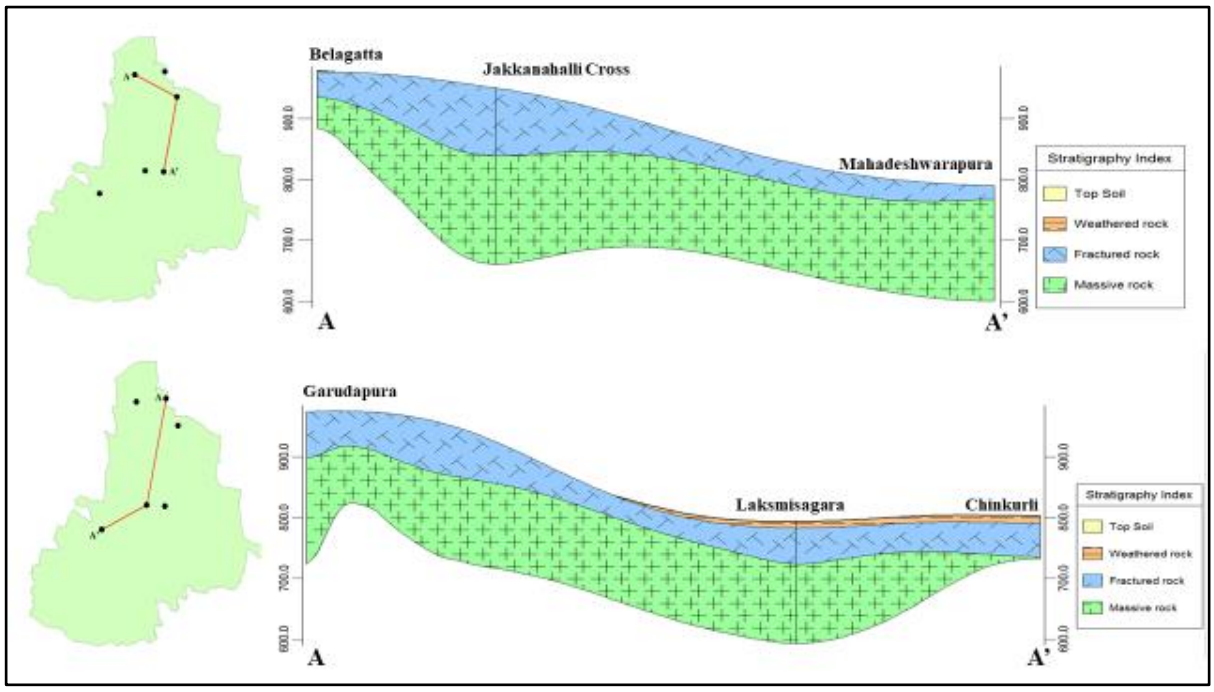

Figure 11:2D Cross section of exploration wells drilled in Pandavapura taluk

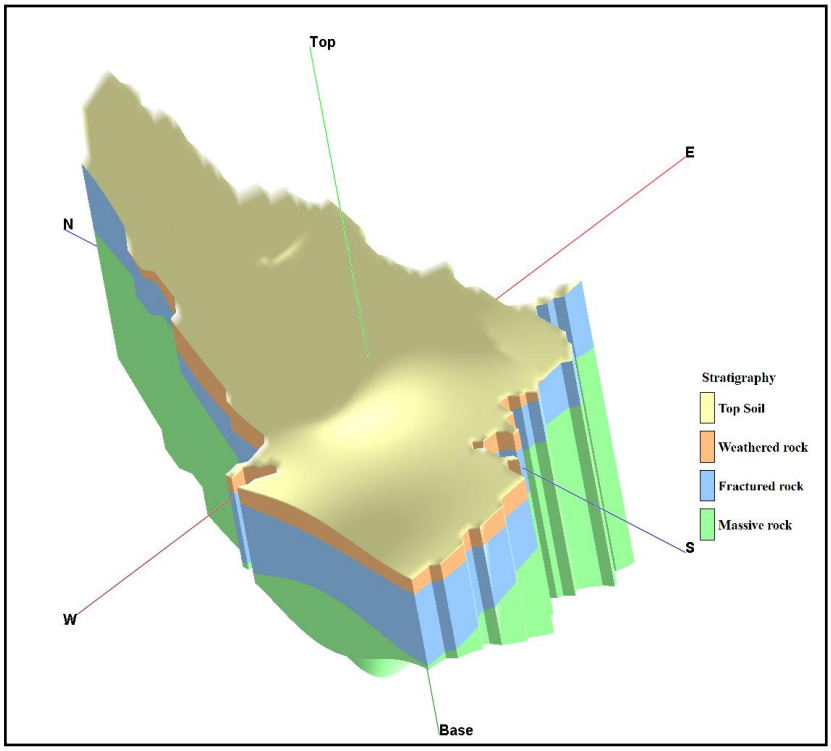

Figure 12(a):3D aquifer disposition

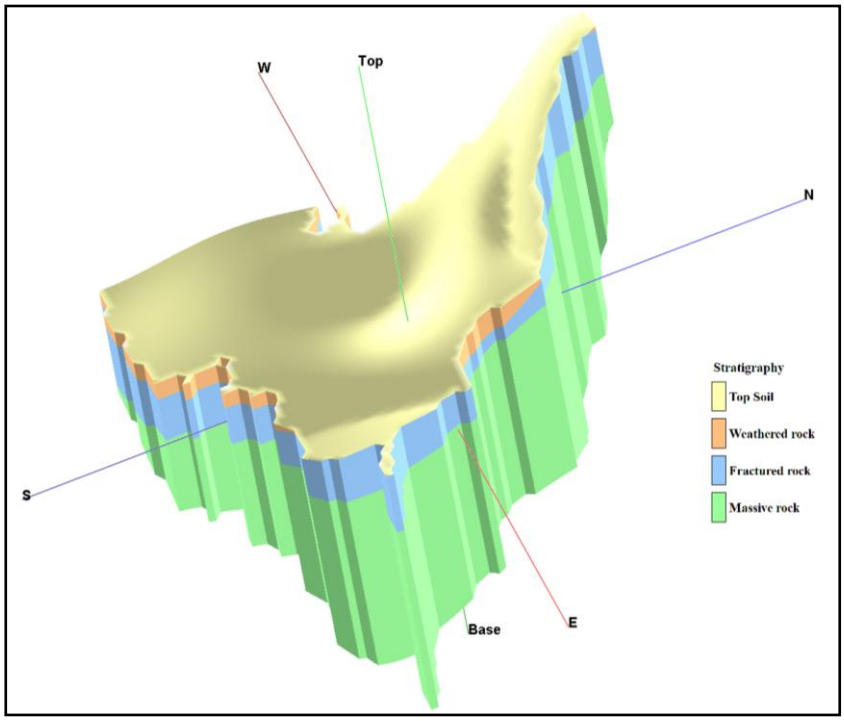

Figure 12(b):3D aquifer disposition

3GROUND WATER RESOURCE, EXTRACTION, CONTAMINATIONAND OTHER ISSUES

3.1 Comparison of Ground Water Resource and Extraction

The comparison of the resource as on 2013, 2017 and 2020 are summarised below in **Table 10**. It is observed that the ground water availability is more during the year 2020 as compared to 2017. It is attributable to good rains, the improvement in irrigation practice, influence of command area and also due to the water conservation / recharge activities carried out in the taluk by various state govt. and other agencies.

Table 10: Comparison of Ground Water Availability and Draft Scenario in Pandavapura taluk

Taluk	GW Availability (Ham)	GW Draft (Ham)	Stage of GW Development (%)	GW Availability (Ham)	GW Draft (Ham)	Stage of GW Development (%)	Annual extractable GW resource (Ham)	Total GW Extraction (Ham)	Stage of GW Extraction (%)
	2013			2017			2020		
Pandavapura	20920	6483	31	7468	4361	58	8125.09	5049.17	62.14

3.2Chemical Quality of Ground Water and Contamination

Ground Water Quality (Pre-monsoon 2019 and 2022)

Interpretation from Chemical Analysis of Aquifer - I results in Pandavapura taluk **(Table 11)** shows that the Electrical Conductivity ranges from 439 to 2250 µ/mhos/cm in the aquifer-I at 25^{o}C (Fig. 12) while Total Hardnessconcentration ranges from 90 to 445 mg/L. The Nitrate value ranges from 15 to 32 mg/l and Fluoride concentration in groundwater ranges between 1.16 – 1.48 mg/l.

Table 11: Hydro-chemical data of water samples analysed 2019

SITE_NAME	Type of well	PH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
Bydarahalli	DW	8.29	1347	230	22	43	198	1	0	244	167	154	32	1.16
DevegowdanaKoppalu	DW	7.93	1120	215	30	34	126	12	0	288	114	100	23	1.18
Haralahalli-A	DW	10.01	851	90	10	16	122	8	30	152	54	114	15	1.16
Kyatanahalli	DW	8.24	439	135	10	27	52	4	0	149	45	44	25	1.18
Melukote-1	DW	8.01	1359	445	34	88	154	7	0	430	182	121	25	1.48

Interpretation from Chemical Analysis of Aquifer - I results in Pandavapura taluk **(Table 12a)** shows that the Electrical Conductivity ranges from 870 to 2250 µ/mhos/cm in the aquifer-Iat 25^{o}C **(Fig. 13)** while Total Hardness concentration ranges from 265 to 600 mg/L. The Nitrate value ranges from 0 to 231 mg/l and Fluoride concentration in groundwater ranges between 0.58 – 1.30 mg/l.

Interpretation from Chemical Analysis of Aquifer - II results in Pandavapura taluk (**Table 12a**) shows that the Electrical Conductivity ranges from 370 to 1650 µ/mhos/cm in the aquifer-Iat 25°C while Total Hardness concentration ranges from 150 to 720 mg/L.

The Nitrate value ranges from 0 to 90 mg/l and Fluoride concentration in groundwater ranges between 0.26 – 1.20 mg/l.

Interpretation from Chemical Analysis of river water results in Pandavapura taluk **(Table 12b)** shows that the Electrical Conductivity ranges between 360 to 430 µ/mhos/cm in the aquifer-Iat 25°C while Total Hardness concentration ranges from 125 to 135 mg/L. The Nitrate value is 1 mg/l and Fluoride concentration in groundwater ranges between 0.48 – 0.54 mg/l.

During 2022 period there is higher concentration of Total hardness(TH) and Nitrate in both aquifer-I as well as Aquifer-II.Nitrate>45mg/L is found in dugwell water of Talekere and G.Shettihalli and borewell water of Bellale and Kurubaramallenahalli.

Table 12(a): Hydro-chemical data of water samples analysed 2022

Sl. No.	Location	Type of well	pH	E C in ⍰ S/cm	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	NO_3	F	TDS	Uranium (ppb)
PHREATIC AQUIFER-I(DUGWELL)																	
1	Talekere	DW	8.12	2250	600	144	58	100	232	0	390	213	280	231	0.58	1497	37.30
2	Melukote	DW	7.86	1450	300	84	22	169	30	0	451	106	130	50	1.30	868	30.70
3	Jakkanahalli	DW	8.12	2100	380	120	19	164	208	0	683	184	140	0	0.58	1253	5.92
4	G.shettihalli	DW	7.98	1130	440	60	70	51	5	0	354	121	50	64	0.88	638	6.24
5	Katteri	DW	7.76	870	265	54	32	51	26	0	305	71	55	31	0.73	506	5.31
FRACTURED AQUIFER-II																	
6	Mahadeshwarapura	BW	7.55	1650	720	172	70	50	4	0	451	170	210	0	1.01	953	9.80
7	Anavalu	BW	7.60	850	29	66	32	30	16	0	354	50	30	3	0.5	442	2.42

					5										8		
8	Bellale	BW	7.55	860	300	44	46	53	1	0	262	35	70	**90**	0.82	500	3.52
9	Beerasettihalli	HP	7.79	490	185	52	13	19	2	0	177	18	25	34	0.26	271	0.55
10	Kurubarabettahalli	HP	7.73	990	325	46	51	67	9	0	384	46	60	35	1.20	549	2.39
11	Kurubaramallenahalli	HP	7.72	950	350	52	53	51	6	0	329	71	80	12	1.20	527	118.10
12	Pandavapura	BW	8.04	370	150	22	23	17	4	0	73	35	25	**57**	0.29	228	4.28
13	Bannangadi	BW	7.54	1100	315	74	32	92	19	0	415	85	50	21	1.20	627	101.20

Table 12(b): Hydro-chemical data of water samples analysed 2022

Sl. No.	Location	Type of well	pH	E C in µ S/cm	T H	Ca	M g	Na	K	C O 3	HCO_3	Cl	S O_4	N O_3	F	TD S	Urani um (ppb)
RIVER WATER																	
14	Bastihallikere	Surface water	7.86	430	135	26	17	32	3	0	177	25	30	1	0.54	242	3.49
15	Anavalu canal	Surface water	7.86	360	125	30	12	20	2	0	146	25	25	1	0.48	204	0.75

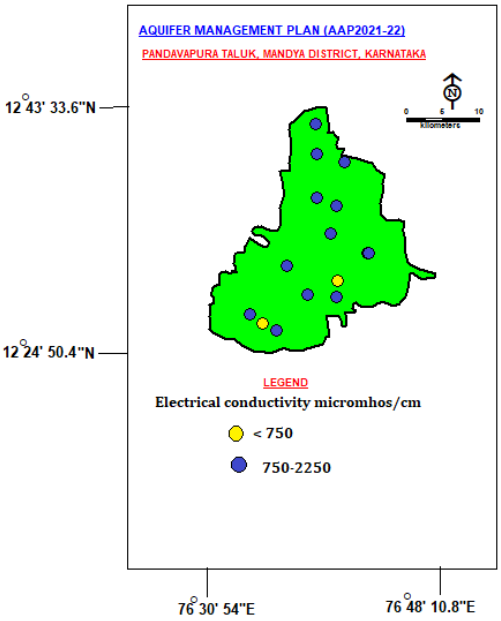

Figure 13: Distribution of EC

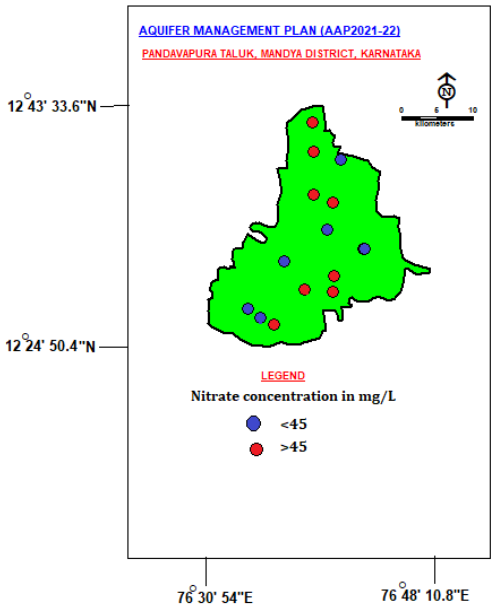

Figure 14: Distribution of Nitrate

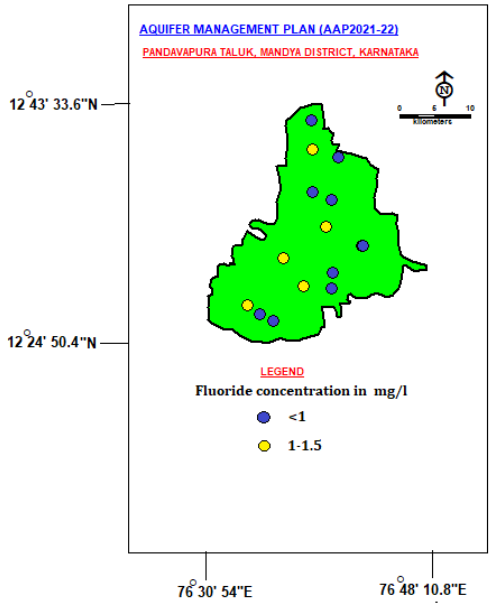

Figure 15: Distribution of Nitrate

4 GROUNDWATER RESOURCE ENHANCEMENT AND SUPPLY SIDE INTERVENTIONS

4.1 Resource Enhancement by Supply Side Interventions

The overall stage of ground water development is 62.14% as per GEC 2020. Considering the everincreasing demand for groundwater resource and erratic annual rainfall pattern, it is proposed to construct artificial recharge (AR) structures to recharge phreatic aquifer and enhance the ground water resources. The area feasible for recharge in the taluk is worked out as 360 sq.km. and the surface surplus non-committed runoff availability is 153.3 ham, which is considered for planning of AR structures. For this, a one(1)percolation tankis proposed. The volume of water expected to be conserved/recharged @75% efficiency is 115ham through these AR structures. The approximate cost estimate for construction of these AR structures is Rs. 28.47 Lakhs. However, the figures given are tentative and pre-field studies / DPR are recommended prior to implementation of these recharge structures.

The details pertaining to proposed recharge structures, cost estimates and likely Recharge benefits for Pandavapura taluk, Mandya district have been carried out and given in below Table 13.

Table 13: Quantityofnon-committedsurfacerunoffandexpected rechargethroughARstructures

Artificial Recharge Structures	**Pandavapura taluk**
Area Feasible for Artificial Recharge	360 sq km
Non-committed monsoon runoff available(Ham)	153.3
Number of Check Dams	0
Number of Percolation Tanks	1
Number of Point Recharge structures	0
Tentative total cost of the project(Rs. In lakhs)	28.417
Expected recharge(Ham)	115
Cost Benefit Ratio(Rupees /cu.mof water harvested)	2.47

Table 14:Improvement in GW availability due to Recharge, Pandavapura taluk

Sl.no.	**Resource Details**	**As per GWRA 2020 Estimation**
1.	Annual extractable GW resource in HAM	8125.09
2.	Total GW extraction for all uses in HAM	5049.17

3.	Existing stage of groundwater extraction in percentage	62.14
4.	Expected recharge from artificial recharge structures in HAM	115
5.	Cumulative groundwater availability for extraction in HAM	8240.09
6.	Expected improved stage of groundwater extraction in percentage	61.28%

After implementation of artificial recharge structures for groundwater recharge, the net annual groundwater availability will increase from 8125.09 ham to 8240.09ham and the expected improvement in stage of development is 0.86% from 62.14% to 61.28 %(**Table 14**).

Conjunctive use of both surface water and groundwater

The total canal command area is18037ha. Water logged area under Hemavathy project is 22 Ha. No area has been reclaimed, so balance area to be reclaimed is 22 Ha. Conjunctive use plan is recommended to benefit the water deficit and tail end area of the irrigation command as a part of management. Raised Bed Farming, surface and sub-surface drainage and bio drainage are some of the interventions proposed to combat water logging problem.

- The taluk is irrigated by water from Krishnarajasagar and Hemavathi dams and other small tanks. Most distributaries/ field channels are unlined and there is great scope to improve the irrigation efficiency by proper lining to these structures, and attending to other canal maintenance works timely.

4.2 DEMAND SIDE INTERVENTIONS

4.2.1 Water Use Efficiency by Micro Irrigation Practices

It is observed that presently in the command areas, canals are the source of irrigation and in non-command areas ground water through dug wells and borewells is used for irrigation purpose in the taluk.Water use efficiency measures have to be adopted for saving the ground water resources.

Efficient irrigation practices like drip irrigation and sprinkler has to be adopted by the farmers in the existing 2881 ha of gross irrigated area. Presently, draft through irrigation is 4263.20ham. Implementation of efficient irrigation techniques will contribute in saving groundwater by 1278.96 ham and thus,will improve stage of development by 9.1% from 62.14 %to 53.04% **(Table15).**

Table15: Improvement in GW availability due to saving by adopting water use efficiency

Sl.no.	Resource Details	As per GWRA 2020 Estimation
1.	Annual extractable GW resource in HAM	8125.09
2.	Total GW extraction for all uses in HAM	5049.17
3.	Existing stage of groundwater extraction in percentage	62.14
4.	Expected recharge from artificial recharge structures in HAM	115
5.	Cumulative groundwater availability for extraction in HAM	8240.09
6.	Expected improved stage of groundwater extraction in percentage	61.28%
7.	Saving due to using Water Use Efficiency technique in HAM	1278.96
8.	Cumulative groundwater availability for extraction in HAM	9519.05
9.	Expected improved stage of groundwater extraction after implementation of project	53.04%

4.2.2 Change in cropping pattern

In Pandavapura taluk the water intensive crops grown are paddy and sugarcane. Paddy is grown in 5075 hectares andsugarcane is grown in 5566 hectares which can be reduced by using less water intensive crops.

- **Additional area of irrigation**

After adopting various water use efficiency techniques and recharge measures and its resultant savings, the stage of extraction is expected to be 53.04% in the taluk, indicates the taluk will continue to remain in safe category. Hence 0.001lakh hectare additional area may be brought under irrigation after implementing artificial recharge plan.

- **Regulation and Control**

Groundwater recharge component needs to be made mandatory in the taluk to manage the aquifer.

➢ **Other interventions proposed:**

- Water use efficiency practices like tensiometer device in paddy cultivation and point irrigation for sugarcane cultivation, plastic mulching should be adopted to prevent soil erosion and evaporation**.**
- Periodical maintenance of artificial recharge structures should also be incorporated in the Recharge Plan.
- Build up awareness among local village/urban community about proper disposal of sewage/runoff from chemical fertilizers contributing to nitrate.
- Mandatory roof top rain water harvesting in urban and semi-urban areas.

5 SUMMARY AND RECOMMENDATIONS

The main ground water issues are Limited Ground Water Potential / Limited Aquifer Thickness / Sustainability, Deeper Water Levels particularly in Aquifer-II in some parts, Inferior Ground Water Quality due to nitrate contamination in some pockets and water logging in canal command area. The summary of ground water management plan is given in **Table-16.**

Table 16: Summary of Management plan of Pandavapura taluk

Stage of GW Extraction and Category (2020)	62.14 %, Safe
Annual Extractable GW Resource (Ham)	8125.09
Total Extraction (Ham)	5049.17
Ground Water Draft for Irrigation (Ham)	4263.20
Ground Water Resource Enhancement by Supply side Interventions	
No of Proposed AR structures SSD PT CD Filter Beds	 0 1 0 0
Expected Additional Recharge to GW due to AR (Ham)	115
Additional Irrigation Potential that can be created (Ha)	0.001
Total Estimated Expenditure (Rs. in lakhs)	28.4
Ground Water Resource Savings by Demand side Interventions	
Expected Saving due to adopting WUE (Ham)	1278.96
Change in Stage of GW development (%)	62.14 to 53.04
Ground Water Quality – Nitrate contamination	Improving quality by proper drainage of sewage and Limited usage of Nitrogenous fertilizers

As per the resource estimation – 2020, Pandavapura taluk falls under safe category with the stage of ground water extraction is 62.14 %. But there is need to formulate management strategy to tackle the water scarcity related issues in the taluk in the summer days to avoid water crisis in the future. It is suggested to adopt a scientific and multi-pronged ground water management strategy covering supply side interventions, demand side interventions, ground water development interventions and ground water quality protection aspects as mentioned in the management plan suggested above .

Conjunctive use of both surface water and groundwater

Conjunctive use plan is recommended to benefit the water deficit and tail end area of the irrigation command as a part of management. Raised Bed Farming, surface and sub-surface drainage and bio drainage are some of the interventions proposed to combat water logging problem. The taluk is irrigated by water from Krishnarajasagar and Hemavathi dams and other small tanks. Most distributaries/ field channels are unlined and there is great scope to improve the irrigation efficiency by proper lining to these structures, and attending to other canal maintenance works timely.

Ground water resource enhancement by supply side interventions: The area feasible for recharge in the taluk is worked out as 360 sq.km. and the surface surplus non-committed runoff availability is 153.3 ham, which is considered for planning of AR structures. For this, a one (1)percolation tank is proposed. The volume of water expected to be conserved/recharged @75% efficiency is 115ham through these AR structures. The approximate cost estimate for construction of these AR structures is Rs. 28.47 Lakhs. However, the figures given are tentative and pre-field studies / DPR are recommended prior to implementation of these recharge structures.

Ground water resource enhancement by demand side interventions: At present maximum irrigation is by canal water. In non-command areas,borewells are extensively used for irrigation.The micro irrigation practices like drip and sprinkler irrigation are practiced to less extent in comparison with traditional mode of irrigation. However, in long run the practice of efficient irrigation techniques will add to the ground water resource in large extent.

Change in cropping pattern: In Pandavapura taluk the water intensive crops grown are paddy and sugarcane. Paddy is grown in 5075 hectares and sugarcane is grown in 5566 hectares which can be reduced by using less water intensive crops.

Finally, Roof top rain water harvesting, mass awareness programmes are suggested for better management of groundwater resources.