केंद्रीय भूमि जल बोर्ड
जल संसाधन, नदी विकास और गंगा संरक्षण
विभाग, जल शक्ति मंत्रालय
भारत सरकार
Central Ground Water Board
Department of Water Resources, River
Development and Ganga Rejuvenation,
Ministry of Jal Shakti
Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

ALAND TALUK

KALABURAGI DISTRICT, KARNATAKA

दक्षिण पश्चिमी क्षेत्र, बैंगलोर
South Western Region, Bengaluru

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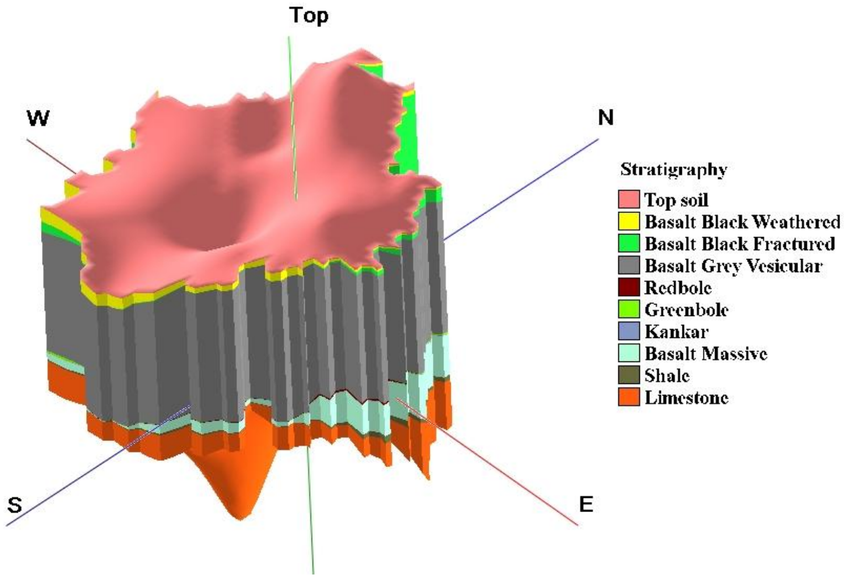
GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES
RIVER DEVELOPMENT & GANGA REJUVENATION

AQUIFER MANAGEMENT PLAN FOR ALAND TALUK KALABURAGI DISTRICT, KARNATAKA STATE



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May 2021

AQUIFER MANAGEMENT PLAN, ALAND TALUK,
KALABURAGI DISTRICT, KARNATAKA STATE

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AQUIFER MANAGEMENT PLAN, ALAND TALUK, KALABURAGI DISTRICT, KARNATAKA STATE

1. SALIENT INFORMATION

National Project on Aquifer Mapping (NAQUIM) initiated by Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India with a vision to identify and map the aquifers at the micro level with their characteristics, to quantify the available groundwater resources, to propose plans appropriate to the scale of demand and institutional arrangements for participatory management in order to formulate a viable strategy for the sustainable development and management of the precious resource which is subjected to depletion and contamination due to indiscriminate development in the recent past.

Groundwater is being increasingly recognized as a dependable source of supply to meet the demands of domestic, irrigation and industrial sectors of the country. The development activities over the years have adversely affected the groundwater regime in many parts of the country. Hence, there is a need for scientific planning in development of groundwater under different hydrogeological situations and to evolve effective management practices with involvement of community for better groundwater governance.

Aquifer Mapping has been taken up in Aland taluk, Kalaburagi district in a view to formulate strategies for sustainable management plan for the aquifer system in accordance with the nature of the aquifer, the stress on the groundwater resource and prevailing groundwater quality which will help in drinking water security and improved irrigation facility. It will also result in better management of vulnerable areas.

1.0. Objectives

The objectives of the aquifer mapping in Aland taluk, Kalaburagi district can broadly be stated as

- To define the aquifer geometry, type of aquifers and their lateral and vertical extent
- To determine the groundwater regime scenario
- To determine the hydrogeochemical characteristics of the aquifer units
- To define 2D and 3-D dispositions of the aquifer units
- To estimate the availability of groundwater resources in the aquifer system
- To develop a sustainable groundwater management plan for the aquifer system

1.1. Scope of the Study

The important aspect of the aquifer mapping programme is the synthesis of the large volume of data already generated during specific studies carried out by CGWB and various Government organizations with a new data set generated that broadly describe the aquifer system. The available generated data are assembled, analyzed, examined, synthesized and interpreted from available sources. These sources are predominantly non-computerized data, which is to be converted into computer based GIS data sets.

Data gaps have been identified after proper synthesis and analysis of the available data collected from different state organizations like GWD, Watershed Department, etc. In order to bridge the data gap, data generation programme has been formulated in an organized way in the study area. Exploration work has been carried out in different segments of the regions and aquifer parameters have been estimated. Groundwater monitoring regime has been strengthened by establishing/adding State agencies additional monitoring wells. 2D and 3D sections have been prepared to bring out more realistic as the data points are more closure to the field.

1.2. Issues of the study area

The main issues pertaining to the Aland taluk is as follows

a. Declining groundwater Level trends in about 50% of wells analysed tapping phreatic aquifer during pre and post monsoon periods.

b. Ground Water quality: High fluoride concentration in some pockets

1.3. Approach & Methodology

Integrated multi-disciplinary approach involving geological, geophysical, hydrological and hydrogeological and hydrogeochemical components were taken up in 1:50000 scale to meet the objectives of study. Geological map of the study area has been generated based on the GSI maps, geophysical data have been generated through vertical electrical soundings and geoelectrical layers with different resistivity have been interpreted in corroboration with the litho stratigraphy of the observation wells and exploratory wells down to depths of 302.3m bgl. Hydrological and Hydrometeorological data have been collected from Statistical department, Govt of Karnataka. Drainage, Soil and Geomorphology of the taluk were prepared based on the satellite data interpreted by KSRSAC.

Based on the data gap analysis data generation process has been scheduled through establishing key observation wells, integrating Ground Water Directorate observation wells, pinpointing exploratory sites for drilling through in-house and outsourcing, collecting geochemical samples in order to study groundwater regime, geometry of the aquifer and aquifer parameters, and quality of the groundwater respectively. Groundwater recharge and draft have been computed through different methods and resources of the aquifer system estimated through groundwater balance method.

Based on the above studies Management strategies both on the supply side through augmentation of groundwater through artificial recharge and water conservation and on demand side through change in irrigation pattern have been formulated for sustainable management of the groundwater resource.

1.4. Study area

Aland covering an area of 1752 sq.km and situated between latitudes 17°19'33” N - 17°46'11”N and longitudes 76°19'53”E - 76°56'33”E. The area is bounded on the north by Basavakalyan taluk and Maharashtra State, on the west by the districts Maharashtra State, on the east by the Gulbarga taluk and on the south by the Afzalpur taluk. The taluk has 134 inhabited and 2 uninhabited villages. Aland is the taluk headquarters.

The area has an intricate drainage network comprising Bhima River and its tributaries. The area falls in Bhima sub-basin of Krishna River basin. These tributaries irrigate its banks and carry only the flood discharge during the monsoon period for a few days. The Location map of the Aland Taluk is presented as **Figure 1**.

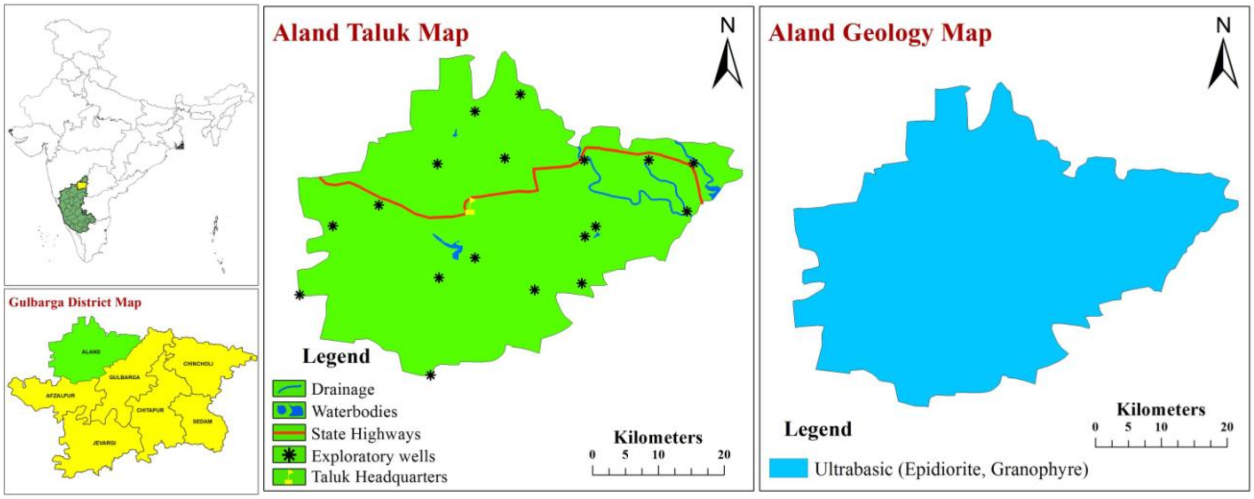

Fig 1: Location Map of Aquifer Mapping Study area, Aland taluk

1.5. Data availability

During the aquifer mapping period, existing data of CGWB i.e. exploration, depth to water level, water quality, geophysical logging and groundwater resource data have been collected and compiled. In addition to this, borewell data, water quality & water level data have been collected from Ground Water Directorate, Govt.of Karnataka. Cropping pattern and soil data has been compiled from Statistical Handbook of Kalaburagi district, which is available in Kalaburagi district website. Groundwater level and groundwater exploration data have been collected from Public Works Department. Thematic layers such as geology (GSI), soils, land use & land cover, geomorphology, etc., from various State Government agencies has been collected, complied and used in this study.

1.6. Data adequacy

Exploratory well data is available for 8 wells drilled by CGWB. Water level (19 Dug wells and three bore wells) and water quality monitoring data (14 Nos.) data are available for a long period i.e., more than ten years. 58 numbers of vertical electrical sounding (VES) data are available. Cropping pattern and soil data have been collected from Statistics Department. After plotting the available historical data on 1:50,000 scale maps, data gaps were identified and data generation process was taken up in those gap areas to complete the Aquifer map on the desired resolution of 1:50,000 toposheets. A proposal for construction of 10 wells through outsourcing has been identified to complete the gaps in the data.

1.7. Data Gap Analysis & Data Generation

As per the guidelines of data gap analysis for aquifer mapping, sufficient monitoring wells are existing in the taluk after integrating State Ground Water Directorate monitoring wells. Dug wells 19 Nos. are available to monitor the first phreatic aquifer and three bore wells are available to know the aquifer characters of semi-confined aquifer system which is extensively developed in recent years. Ground water quality monitoring is being done through 14 Nos. of established dug wells for first phreatic aquifer and through 18 Nos. of bore wells drilled by CGWB for the Semiconfined aquifer in order to assess the groundwater quality for drinking and irrigation purposes. Similarly, as per the proposed data gap analysis of aquifer mapping, 58 Nos. of VES have been taken up down to the depth of 219 m bgl to know the vertical characteristics of the aquifer. Location of ground water observation wells and exploration wells are presented in **Figure 2 & 3**.

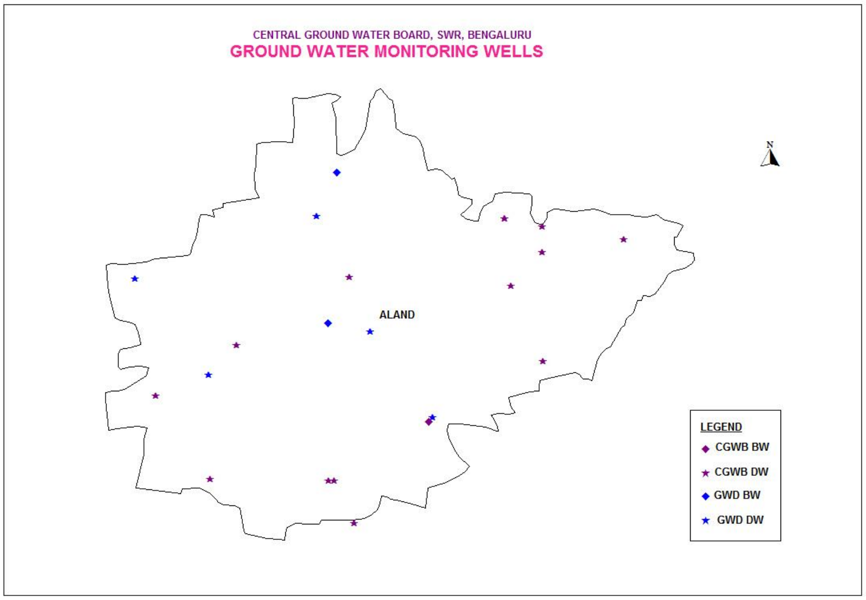

Fig 2: Location Map of Ground water monitoring well

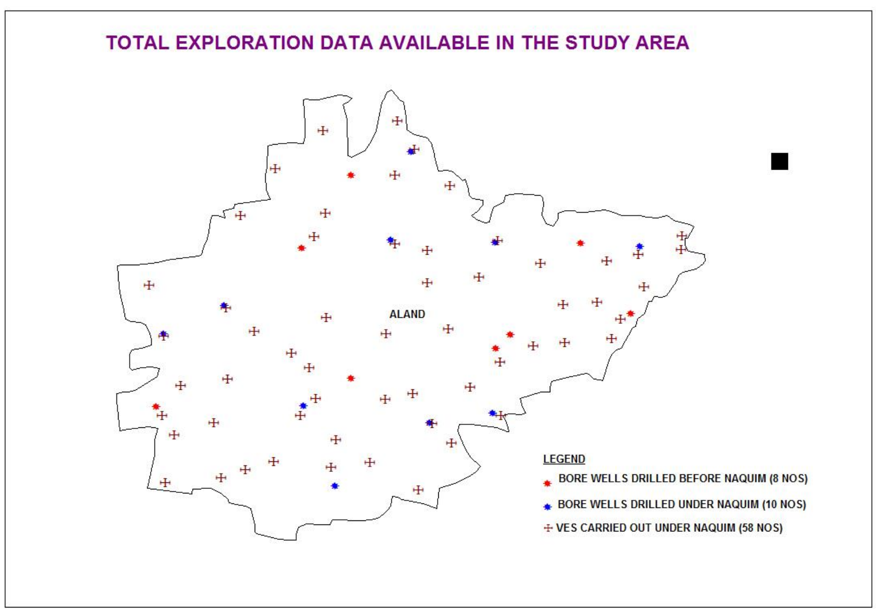

Fig 3: Exploration wells drilled in Aland taluk

1.8. Climate and Rainfall

The Aland taluk enjoys semi-arid climate. Dryness and hot weather prevail in major part of the year. The area falls under Northern 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.

There is one rain gauge station located in Aland taluk **(Table.1)**. The data in respect of this station from the year 1981 to 2010 is analysed and presented in **Table 2.** The data pertaining to these gauges is of long-term nature and are well maintained. It is presumed that they are representative of the taluks and the same is used for analysis. Normal annual rainfall in Aland taluk for the period 1981 to 2010 is 776 mm.

Table 1: Raingauge and its location in Aland taluk

Station	Latitude	Longitude	Altitude
Aland	17.42	76.58	786.3

Statistical analysis

Computations were carried out for the 30year blocks of 1981- 2010 on Mean, Standard deviation and coefficient of variation of each month pre monsoon, monsoon, post monsoon and annual and are shown in **Table 2**. The mean monthly rainfall at Aland taluk is ranging between 2mm during February to 186mm during September. The CV percent for pre monsoon, monsoon and post monsoon season is 79, 40 & 66 percent respectively. Annual CV at this station works out to be 31 percent.

Table 2: Statistical Analysis of Rainfall Data of Aland Taluk for the Period 1981 to 2010

STATION		JAN	FEB	MAR	APR	MAY	PRE MONSOON	JUN	JUL	AUG	SEP	SOUTH WEST MONSOON	OCT	NOV	DEC	NORTH EAST MONSOON	ANNUAL RAINFALL
ALAND TALUK	al Rainf all	6	2	8	18	29	64	112	131	157	186	585	102	19	6	127	776
	STDEV	14	7	22	22	33	50	71	69	92	131	232	79	28	10	83	242
	CV%	221	314	265	124	112	79	64	53	59	70	40	77	151	186	66	31

Assessment of Drought

Rainfall data of Aland taluk has been analysed for 56 years to assess the drought condition in the taluk. The results of the classification are listed in the **Table 3**. It is observed that the Aland taluk has experienced alternating no drought to severe drought conditions over the years.

Table.3: Classification of drought and its periodicity (IMD, 1971)

% Deviation (Di)		>0	0 to -25	-25 to -50	50 to -75	<-75	Probability of drought occurrences
Category		No drought	Mild (Normal)	Moderate	Severe	Acute	
		Years					
Taluk	Aland	11	37	5	3	0	Once in **7** years

The details of the drought assessment are discussed as herein under. Out of 56 years of analysis in Aland taluk, "No Drought" condition is experienced in 11years, "Mild Drought" condition is experienced in 37 years and "Moderate Drought" condition experienced in 5 years. Further it is observed that "Severe Drought" condition is experienced in 3 years i.e., during 1972, 1984 and 2015 in Aland taluk. 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 7 years** at Aland taluk.

1.9. Drainage

The term physiography deals with the actual existing in-situ conditions of the land, depending upon the structures and formational changes. Physiographically, the study area drained by of tributaries of Bhima River **(Figure 4).** These mostly flow from west to east. The River Bhima originates from Maharashtra state whereas the area has an intricate drainage network comprising Bhima River and its tributaries. The area falls in Bhima sub-basin of Krishna River basin. Drainage pattern is dendritic and trellis type, which are typical of black cotton soils and Deccan trap country.

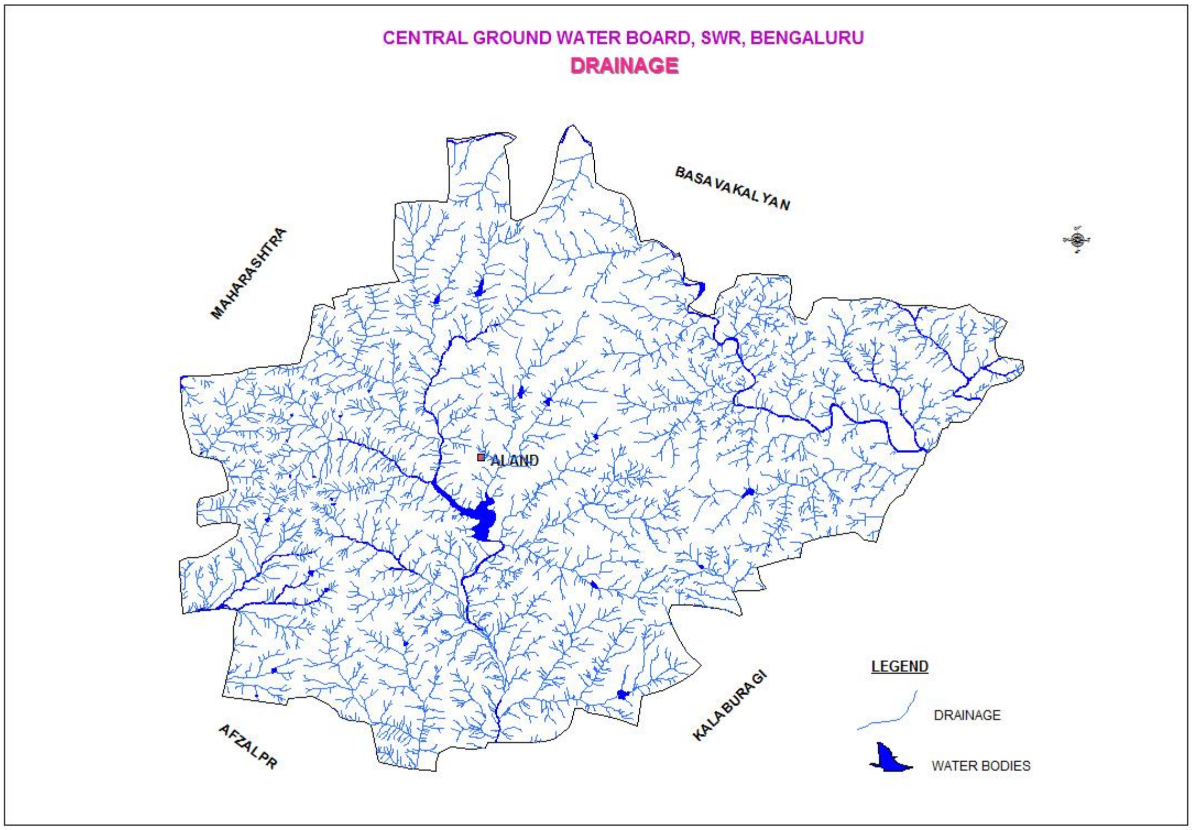

Figure 4. Drainage of the Aland taluk

1.10. Geomorphology

The geomorphology of an area is the external appearance of landforms that gives a reliable picture of the underground strata and its physio-chemical condition. The different formations and the layer confirm and cogent to its geomorphology. The area presents a gently rolling topography and vast stretches topped by block cotton soil. Broad valleys with intervening flat-topped country are by far the most predominant geomorphic feature in the terrain. In general, the area exhibits an undulating topography with table lands characteristics of Deccan traps in the north of the study area. The general slope of the area is towards south direction **(Figure.5).**

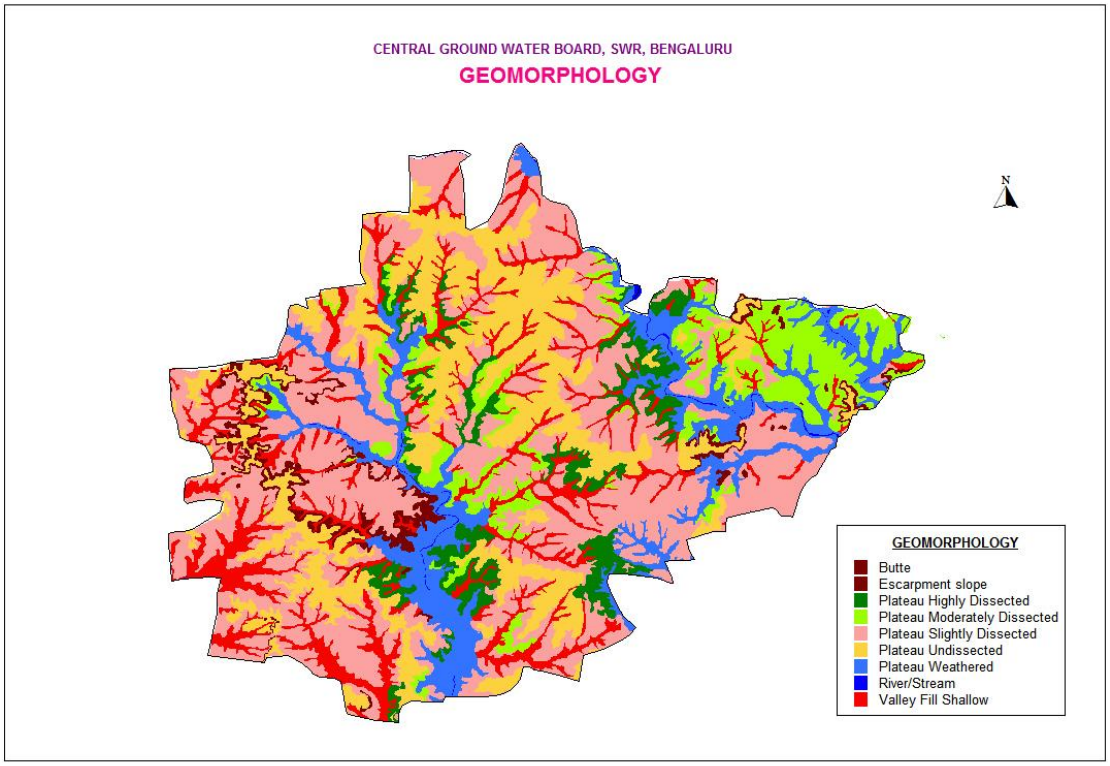

Figure 5. Geomorphology of Aland taluk

1.11. Landuse and Land cover

As per the statistical figures of the taluk for the year 2015-16, nearly 1,07,750 hectares form the net area sown, which is about 61.5% of the area of the taluk. Agriculture is the main occupation in Aland taluk. Landuse/Land cover map of Aland Taluk is shown in **Figure 6**.

2

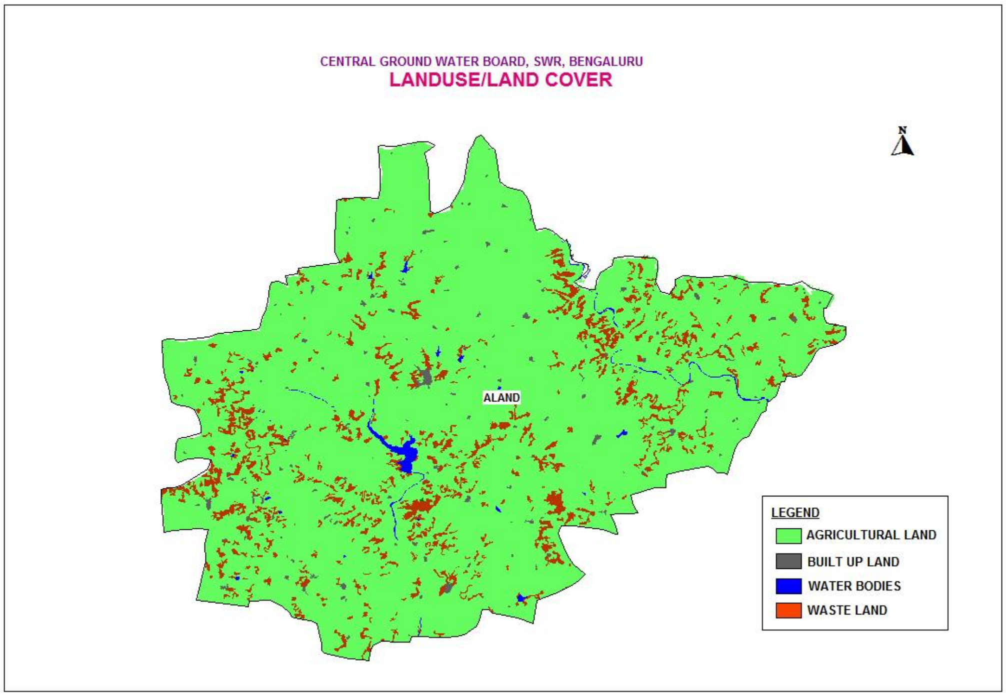

Figure 6. Landuse/Land cover of Aland Taluk

1.12. Soils

Soils play a major role in hydrologic control of the infiltrating water. Soils are generally classified by taking their color, texture, fertilities and chemical combinations includes salts, minerals and the solution effect over them. Most of the area consists of black cotton soils with patches of Clayey and Loamy soils. Clayey skeletal soil is noticed in north western part of the taluk **(Figure 7).**

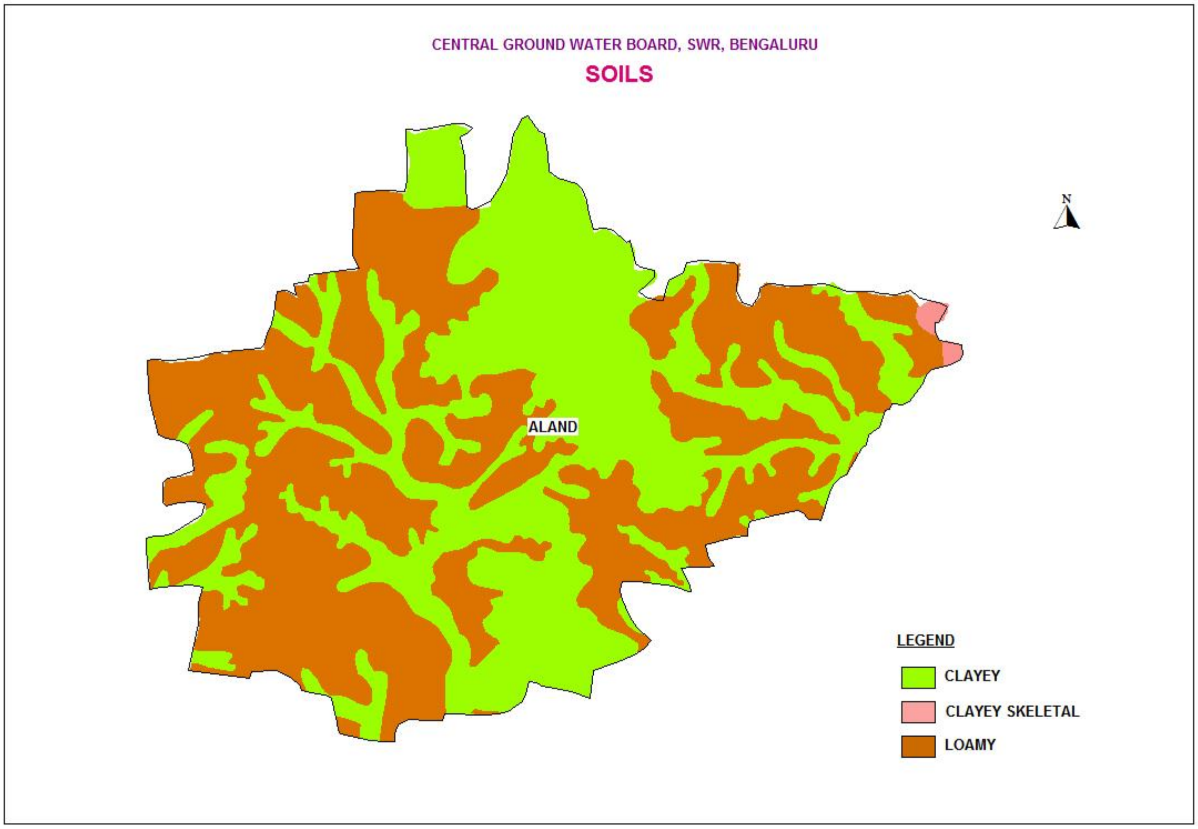

Figure 7: Soil Map of Aland Taluk

1.13. Agriculture

Agriculture is the main stay of the rural population in the entire study area. The main crops grown in the area are jowar, wheat, bajra, oilseeds, cotton and pulses. The pulses are grown in 94760 hectares and jowar in 34830 hectares.

1.14 Irrigation

Groundwater accounts for about 78% of the net area under irrigation and thus, ground water forms the main source of irrigation in the Aland taluk. The net sown area under irrigation is 107750 Ha. Total irrigated area in Aland taluk is 21114 Ha. The net area under ground water irrigation is 16544 Ha **(Table 4 to 6)**.

Table 4: Details of land use in Aland taluk (2016-2017 in Ha)

Total Geographical Area	Area under Forest	Area not available for cultivation	Fallow land	Net sown area	Area sown more than once
175200	2852	11369	14845	107750	12011

Source: District at a glance 2016-17, Govt. of Karnataka

Table 5: Source wise irrigation (Ha)

Source of Irrigation	Net area irrigated (Ha)
Canals	0
Tanks	324
Wells	2654
Tubewells	13890
Lift Irrigation	3285
Other Sources	961
Total	**21114**

Table 6: Source wise irrigation (Ha)

Total Geographical Area	Net Sown Area (Ha)	Net irrigated Area (Ha)	Total Un-irrigated area (Ha)	Ground water irrigated area (Ha)
175200	**107750**	**21114**	**84883**	**16544**

1.15 Geology

The Aquifer Mapping Study area is underlain by granitic gneisses of Archaean which are overlain by Shales and Limestones of Bhimas of Proterozoic age and basalts of Deccan traps (Eocene to Upper Cretaceous).

Peninsular gneisses are not exposed in the area and not encountered till the depth of 300 mbgl. **The Bhima formations** are represented by Shales and Limestones and they are encountered in the study area. Limestones are flaggy, bedded, fine grained and variegated colors. They occur at depths ranging from 130 mbgl near Ladmugli to about 300 mbgl near Korali. Shales are encountered in two borewells with depth ranging from 145 mbgl to 239 m bgl.

Between the Bhima Group of rocks and the overlying Deccan traps occurs a red bole horizon, varying in thickness from 2.0 m to 6.0 m. The basalts of first flow overlie the Bhima group with a parallel unconformity and are separated by red bole horizon.

Deccan Traps: Basaltic rocks of different flows overlie the Bhima formations and they occupy the entire area of the Aquifer Mapping Study in Aland taluk. Basaltic flows were differentiated in the elevation range 276 to 576 m above msl. The red bole and green bole bed is a red colored clayey material and occurs as horizontal bands, varying in thickness from a two meters to six meters in the study area. The Deccan traps comprise numerous flows, each of which erupted separately.

During the interval until the next eruption took place, the weathering of the exposed flows continued and sediments were deposited. The sedimentary beds were overlain by the subsequent flows. These inter-trappeans are generally porous and help in the recharge of groundwater. The Deccan trap flows show considerable lateral variation.

2. DATA COLLECTION AND GENERATION

Periodical data pertaining to groundwater levels, quality, pumping tests were collected during aquifer mapping studies apart from water sample collection to assess the groundwater quality. In addition, Geophysical data has been generated through conducting Vertical electrical soundings after evaluation of data gap analysis.

2.1. Hydrogeological data

In the study area, 19 Nos. of groundwater monitoring wells (which included 14 CGWB monitoring wells, five GWD wells) and three piezometers (One CGWB & two GWD wells) are monitored periodically. The locations of monitoring wells are presented as **Figure 2.**

2.2. Hydrochemical data

The groundwater quality of the Aland taluk was studied by analysing available water quality data i.e. CGWB monitoring dug wells 14 numbers and five GWD dug wells.

2.3. Geophysical data

The geophysical survey was conducted in the study area consisting of Vertical Electrical Soundings (VES). The objective of the study is to decipher the sub surface conditions such as weathered and fractured layer resistivities, thicknesses and massive formations up to the depth of 200 m bgl. A total number of 58 VES were carried out and geo electric layers inferred through interpretation of the results obtained. The locations of the VES are presented in **Figure 3.**

2.4 Groundwater Exploration data

Data of 8 Nos. of exploratory wells were drilled in the study area prior to National Aquifer Mapping project was compiled and analysed (**Figure 3**). These wells were plotted on the 1:50,000 scale topographical map and as per the NAQUIM guidelines for the hard rock& soft rocks, data requirements were identified on the plotted topographical map. Based on the data requirements, 10 Nos. of exploratory wells have been recommended for drilling through outsourcing activity as part of the data generation. The data such as lithology, fracture depth, yield, water level, aquifer properties were generated and utilised to depict the prevailing aquifer systems of the taluk.

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Hydrogeological Data Interpretation and aquifer disposition

Aquifer system in the study area is divided into weathered and fractured aquifers. Basalt forms the productive aquifer in the study area. Salient features of the aquifers are given in **Table.8**

3.1.1. Weathered Aquifer:

The weathered aquifer unit occurs from the ground level and has a minimum thickness of 6 m and maximum thickness of 48.6 m with average thickness of 10 m. The eastern part of the taluk is influenced by deep weathering. In western part of the taluk, the weathering thickness is less. Yield of this weathered aquifer unit ranges from 0.83 to 8.352 m^3/hr. During monsoon period the wells tapping this aquifer unit sustains for one to 2 hrs/day of pumping, while during non-monsoon period (May to July) wells sustains for less than 1 hour/day of pumping. Groundwater occurs in unconfined condition. Weathering thickness of Aquifer unit-I, Aland taluk is shown in **Figure 8**. Fluoride above permissible limit values are observed in some parts of Aland taluk.

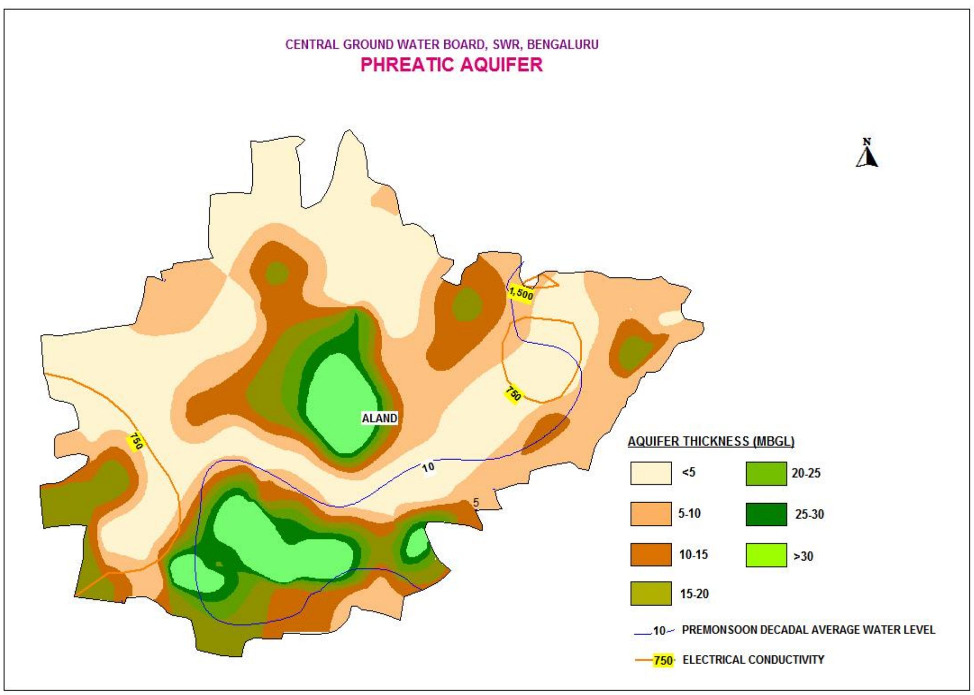

Figure 8. Phreatic aquifer, Aland taluk

3.1.2. Fractured/Jointed Aquifer

This aquifer unit comprises of Vesicular and fractured Basalt. Top of this aquifer unit occurs from 18.6 to 263.6 m bgl. Based on the analysis of the 18 bore wells and 58 Vertical electrical sounding data it is observed that there is a possibility of occurrence of 1 to 2 Fractures. Most of the productive fractures are likely to be exit only up to 150 m bgl. The distribution of the fractures with depth is given in **Table 7**. The yield of this aquifer unit II ranges from 0.3 to 59.4 m^3/hr and dry at some places. During monsoon period the wells tapping this aquifer unit sustains for 2 to 4 hrs /day of pumping, while during non-monsoon period (May to July) sustains for 1 to 3 hour/day of pumping**.** In general ground water in fractured aquifer is potable. Hydrogeology of fractured aquifer is shown in **Figure.9.**

Table 7. Distribution of fractures in Aland Taluk

Fractures Encountered (mbgl)						Yield (m^3/hr)
Nil	**Up to 50**	**50-100**	**100-150**	**150-200**	**> 200**	
6 Nos (25%)	5 Nos (21%)	2 Nos (8%)	4 Nos (17%)	6 Nos (25%)	1 No (4%)	0.3 to 59.4

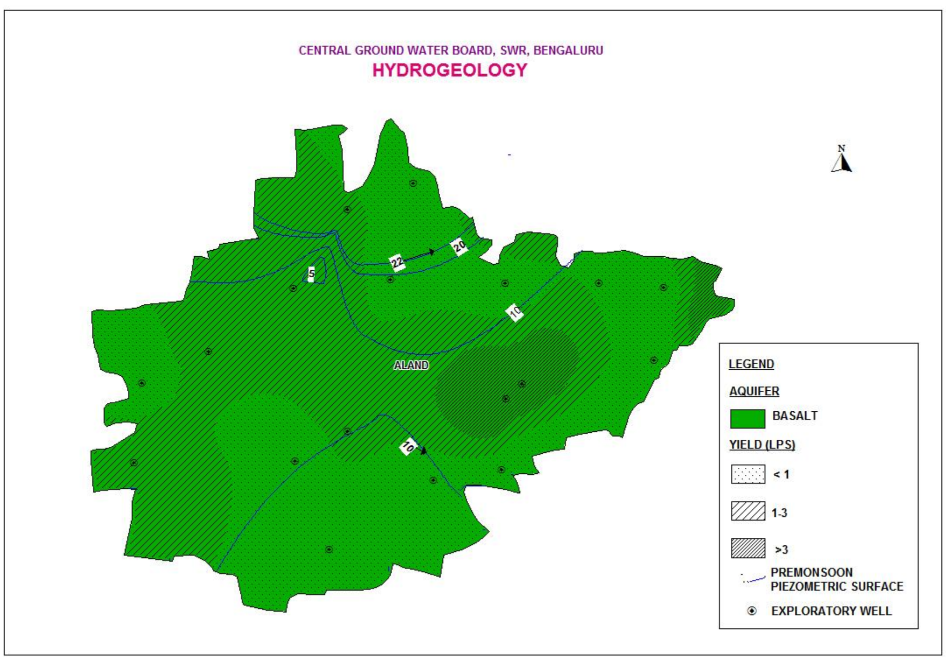

Figure 9. Hydrogeology of fractured aquifer, Aland taluk

Table 8. Salient features of the aquifer units in the Aland taluk

Aquifer Unit	Aquifer depth ranges (mbgl)	occurrence of fractures (m)	Range of Yield (m3 /hour)	Sustainability (hrs)	Aquifer parameter (Transmissivity – m^2/day)	Groundwater quality EC values (µs/cm)	Suitable for Drinking
Weathered Zone	1-48.6		0.84-8.352	Monsoon 1 to 2 hrs Non monsoon 1 hr		Within permissible limit	High fluoride and Nitrate values recorded in Aland taluk
Vesicular Basalt	18.6-263.6	48-183	0.288-15.34 (Nil at some places)	Monsoon 1 to 2 hrs Non monsoon 1 hr	0.8-330	Within permissible limit	-do-
Fractured Basalt	16.6-261.6 Nil at some places	GW potential fractures 1 to 2 sets up to the depth of 150 m bgl.	0.288 – 59.4 (Nil at some places)	Monsoon: 2-4 hrs & Non monsoon 1 to 3 hrs	0.8-35		Suitable

3.2. GROUNDWATER LEVEL

During Aquifer Mapping studies in Aland taluk, 22 Groundwater monitoring wells which were monitoring regularly in phreatic and fractured aquifers in order to know the behavior of the groundwater regime. The water levels were monitored from May 2010 to January 2019 (four times in a year). The depth of dug well ranged from 11 to 22 m bgl. The depth of bore wells ranged from 38 to 80.9 m bgl.

3.2.1. Depth to Water level for Phreatic aquifer (May 2019)

The water level data pertaining to the period of May 2019 (pre monsoon) was used for the preparation of depth to water level map of the basin. The depth to water level during May 2019 is varied from 6.6 to 20.83 m bgl. Major part of the basin shows water level in the range of 10 to 20 m bgl. Patches recorded water level in the range of 5 to 10 m bgl and found as isolated patches in the taluk. Water levels ranging more than 20 m bgl is observed in Darga Sirur villages in western parts as a small isolated patch. The depth to water level during pre monsoon is shown in **Figure 10**.

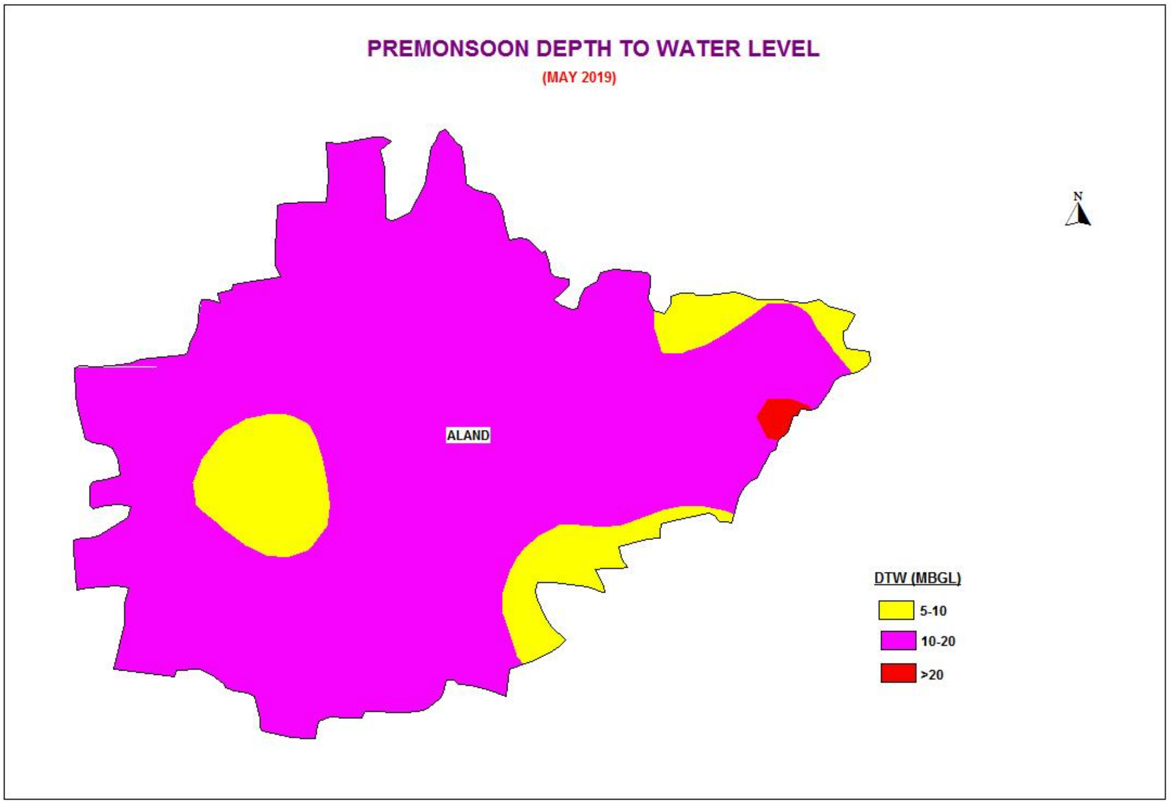

Fig 10: Pre-monsoon Depth to Water Level (Aquifer-I)

3.2.2. Depth to Water level For Phreatic aquifer (November 2019)

The depth to water level during November 2019 is varied from 0.97 to 13.62 mbgl. Water level in the range of 2 to 10 m bgl occupies major part of the study area. Water levels ranging less than 2 m bgl is observed as isolated patches in the north western part of the taluk. The depth to water level during premonsoon is shown in **Figure 11.** The comparison of pre and post monsoon water levels shows that rise in water levels throughout the taluk and thephreatic aquifer is responding to the rainfall and recharging the aquifers. Water level fluctuation between May 2019 and November 2019 is shown in **Figure 12.**

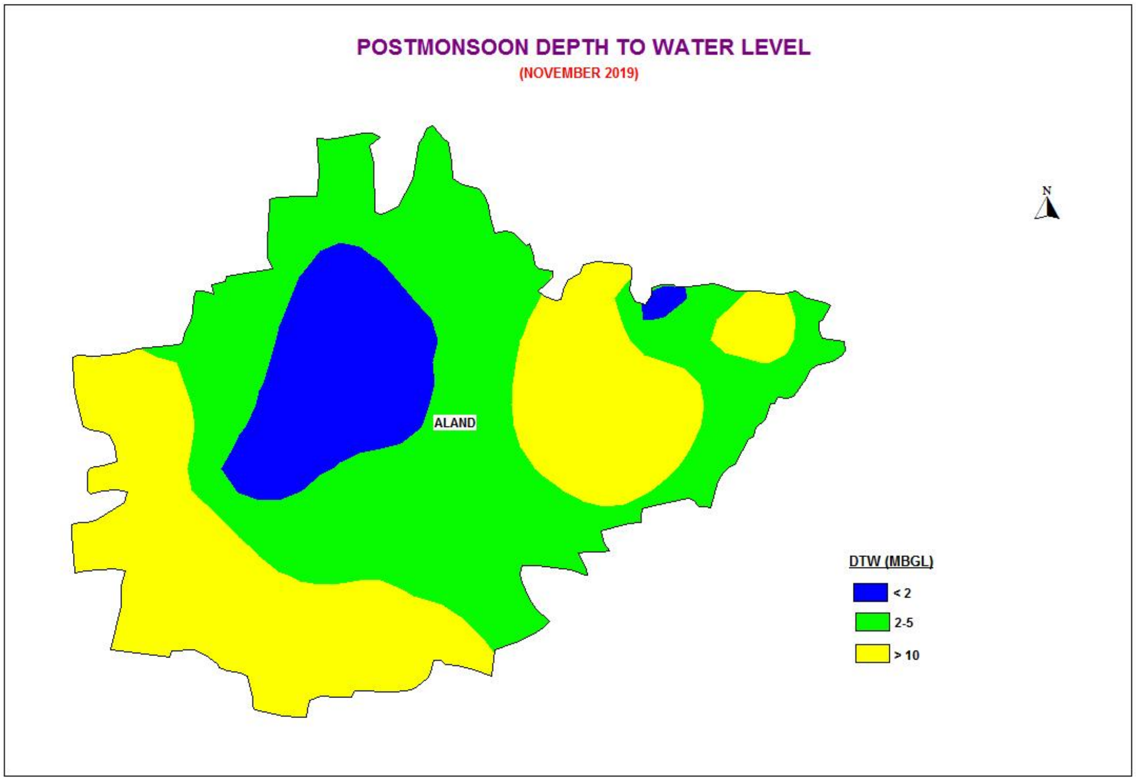

Fig 11: Depth to Water Level – Post-monsoon, Aquifer-I

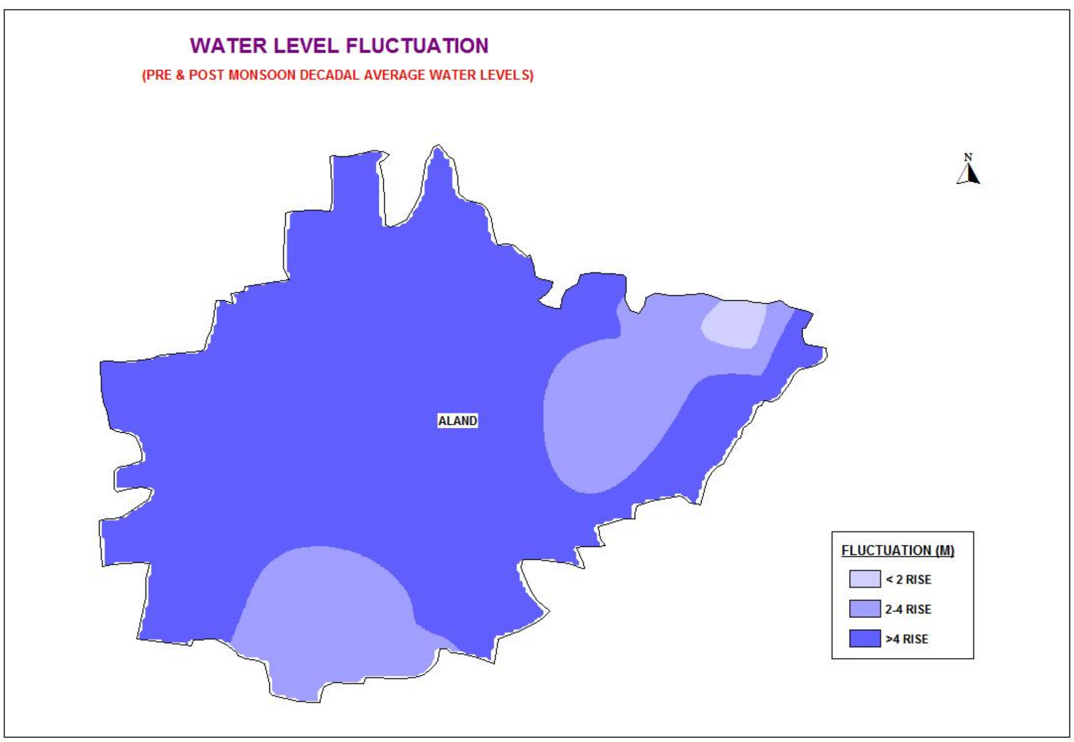

Fig 12: Water level fluctuation (pre & post 2019), Aquifer-I

3.2.3. Decadal Water Level Scenario of the phreatic aquifer

Decadal water level scenario maps are prepared for pre-monsoon and post-monsoon period. The analysis shows that during the Pre monsoon period (May 2010- May 2019) 44% of the wells have recorded water level between 5 and 10 m bgl and 56 % of the wells have recorded water level ranging between 10 to 20 m bgl. Whereas during the post monsoon period (November 2010 – November 2019) 44% of the wells have recorded water level between 2 and 5 m bgl, 38% of the wells have recorded water level ranging between 5 to 10 m bgl and and 18% of the wells have recorded water level in the range of more than 10 m bgl. The comparison of pre and post monsoon water levels shows that rise in water levels throughout the taluk and the phreatic aquifer is responding to the rainfall and recharging the aquifers. Decadal average water levels for pre and post monsoon periods of Aland taluk are presented in **Figures 13 & 14.** ***Hydrographs*** *representing Aland taluk are shown in* ***Figures 15 & 16.***

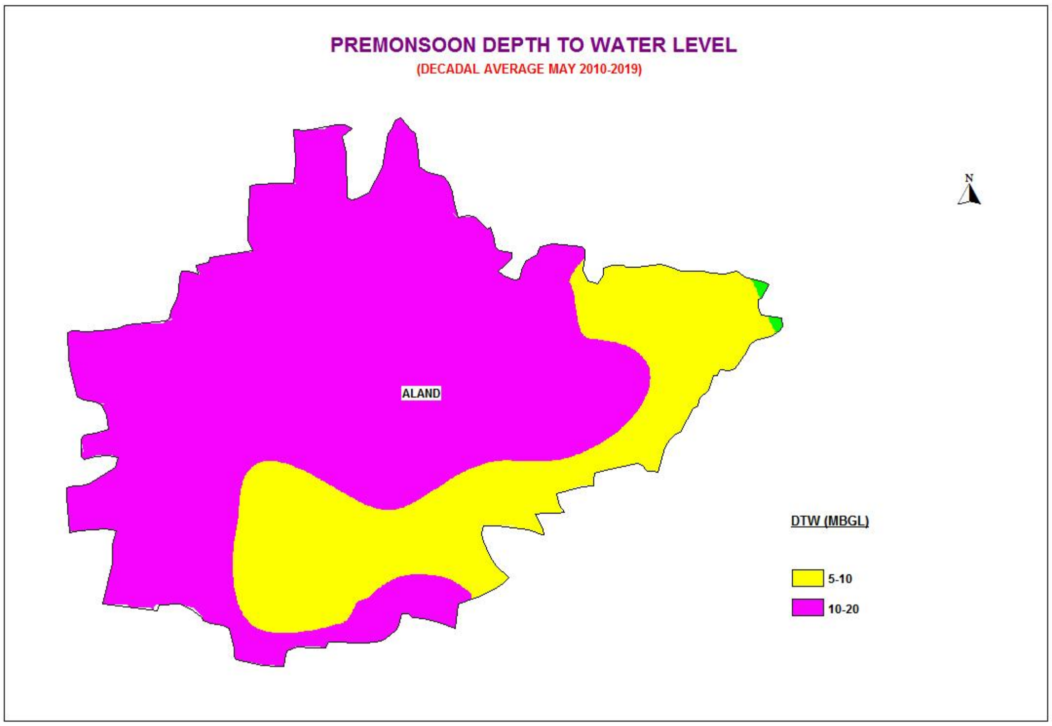

Fig 13: Decadal pre monsoon water levels, Aquifer-I

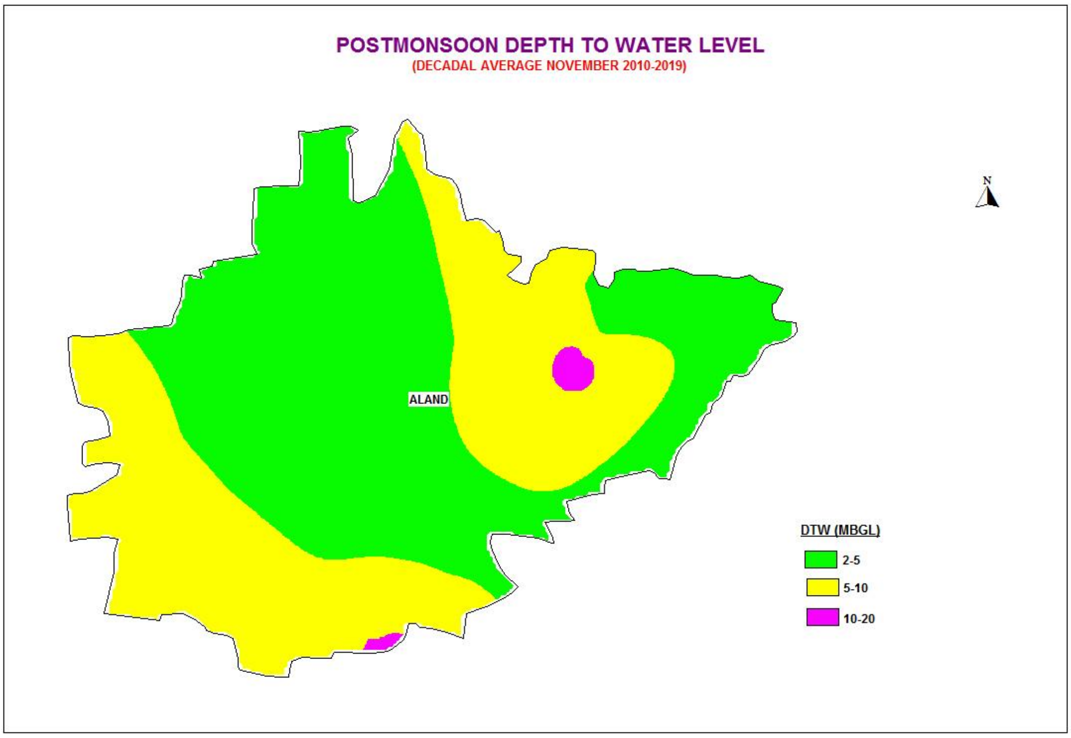

Fig 14: Decadal post monsoon water levels, Aquifer-I

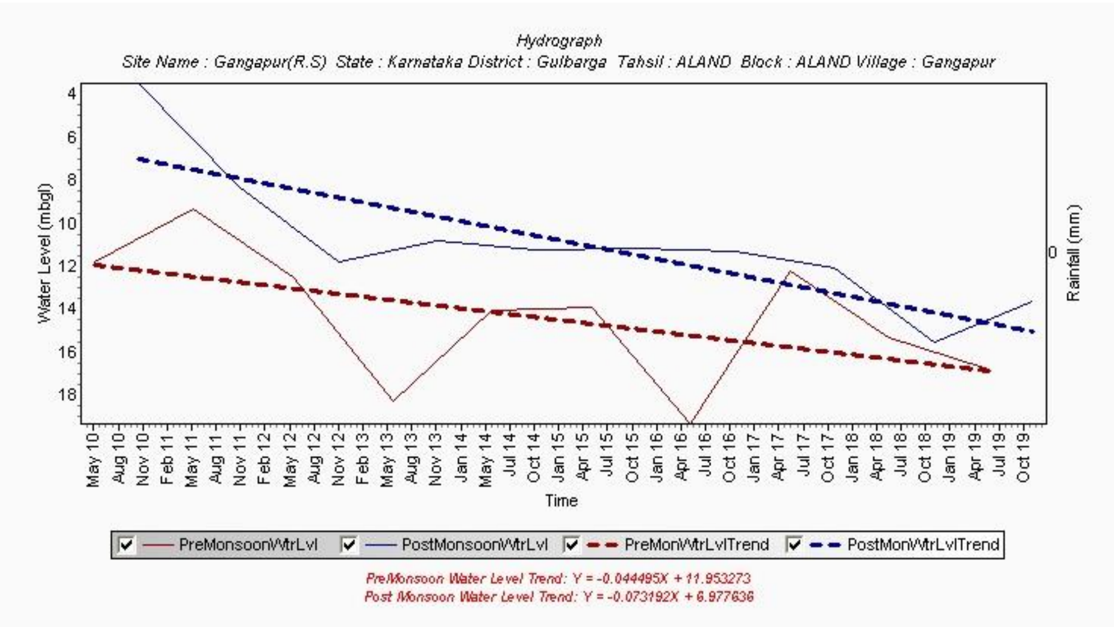

Fig 15: Hydrograph showing declining trend

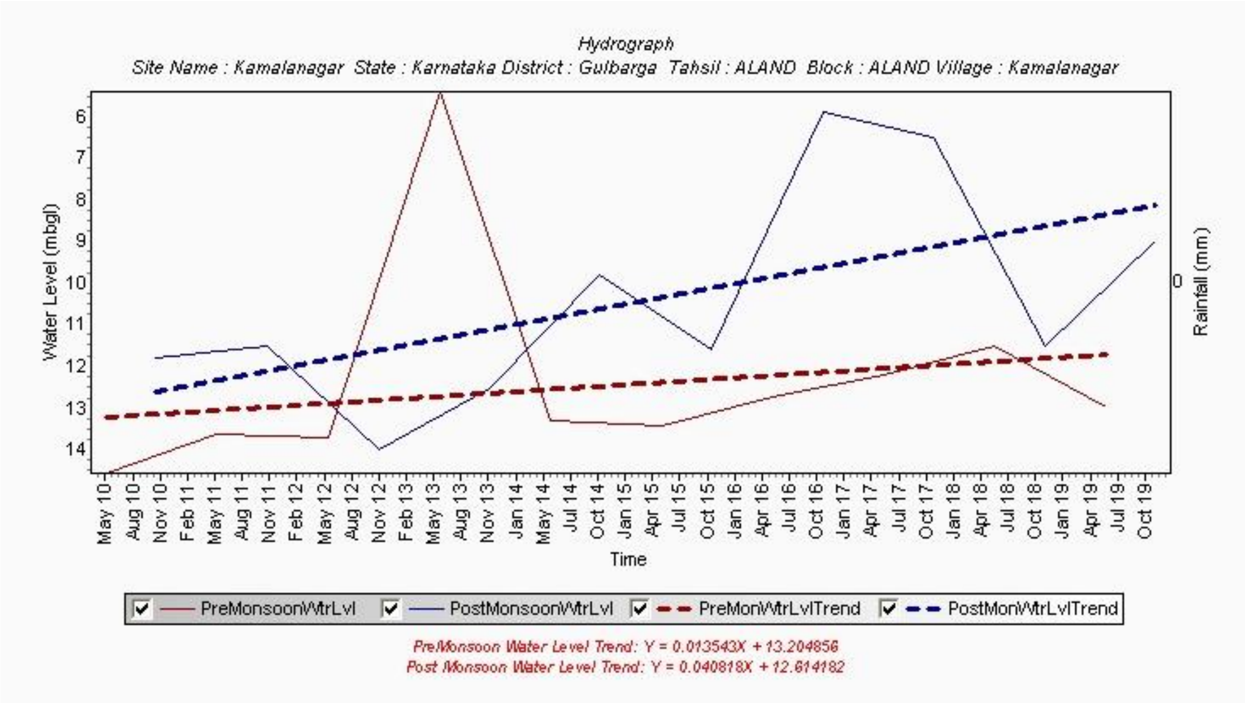

Fig 16: Hydrograph showing raising trend

3.2.4 Depth to piezometric surface Scenario of the fractured aquifer

The depth to piezometric surface during May 2019 is varied from 9.1 to 32.1 m bgl. The depth to piezometric surface during November 2019 is varied from 4.45 to 24 mbgl.

3.3 GROUNDWATER QUALITY

The quality of shallow ground water in Karnataka state has been evaluated by sampling and analysis of water sample collected from Ground Water Monitoring wells. About 1066 Ground Water Monitoring wells were monitored for water quality during May 2018 representing pre-monsoon water quality. The well wise chemical analysis data of the samples are given in the **Table 9**. The summarized results of ground water quality ranges are given in **Table 10**.

Electrical conductivity is the indicator of the total mineral content of water and hence it indicates the total dissolved solids (TDS) present in water. TDS of water determines its usefulness to various purposes. Generally, water having TDS <500 mg/L is good for drinking and other domestic uses. However, in the absence of alternative sources TDS up to 2000 mg/L may be used for drinking purposes. In phreatic aquifer groundwater quality is fresh, about 30% of wells have recorded EC less than 750 µs/cm at 25^o C. Remaining 70% of the samples shows EC value between 751 and 2250 µs/cm at 25^o C. In general, the ground water quality of phreatic aquifer is moderate.

All the groundwater samples of phreatic aquifer have recorded the chloride concentration less than 250 mg/l which is the desirable limit.

About 50% of the groundwater samples of phreatic aquifer has recorded the desirable limit of less than 1 mg/l. Remaining 50 % of wells have recorded beyond permissible limit of more than 1.5 mg/l.

The Nitrate content is less than 45mg/l in about 20 % of the sample analyzed and 80 % of sample shows more than 45 mg/l.

Table 9: Ground water quality of Aland taluk (May-2018)

GROUND WATER QUALITY OF ALAND TALUK (MAY 2018)						
Sl No	SITE_NAME	PH	EC (ms/cm at 25o C)	CHLORIDE	NITRATE	FLUORIDE
				mg/l		
1	BELAMAGI	8.01	1580	241	183	0.31
2	DARGA-SIRUR	8.21	990	107	90	1.60
3	GOBUR BUZURG	7.78	1370	234	84	0.85
4	HOSAHALLI(GULBURGA)	7.90	1430	192	61	2.20
5	KARAHARI	8.28	580	36	21	0.28
6	LADMOGLI	8.24	970	71	99	3.40
7	MADAN HIPPARGA	8.07	550	36	10	2.10
8	NIMBALA	8.03	660	43	500	1.70
9	NIMBARGA	7.69	1180	199	62	0.24
10	SALGAR	7.77	1570	206	109	0.26

Table 10: Summarized results of Ground water quality of Aland taluk (May-2018)

S. No	Parameters		Range	No. of sample	Percent age
1	Electrical Coductivity μs/cm at 25°c	Fresh	< 750	3	30
		Moderate	751- 2250	7	70
		Slightly mineralized	2251- 3000	0	0
		Highly mineralized	> 3000	0	0
2	Chloride mg/l	Desirable limit	< 250	10	100
		Permissible limit	251-1000	0	0
		Beyond permissible limit	> 1000	0	0
3	Fluoride mg/l	Desirable limit	< 1.0	5	50
		Permissible limit	1.1- 1.5	0	0
		Beyond permissible limit	>1.5	5	50
4	Nitrate mg/l	Permissible limit	<45	2	20
		Beyond permissible limit	> 45	8	80

3.4 Aquifer Maps

3.4.1. 2D & 3D models showing Aquifer Disposition

Aquifer Disposition (Vertical & Lateral) is generated based on the inputs of data collected through geological, geophysical, hydrogeological, and hydro chemical studies. In particular the aquifer disposition and aquifer characterization has been brought mainly by analyzing the data collected from different groundwater agenesis Bore well lithologs and Vertical Electrical Sounding data.2D & 3D aquifer disposition models of the aquifer system have been deciphered by using ROCKWORKS software and generate numbers of 2D cross section along different directions of the Aland taluk. All such 2D cross sections were verified and the model was calibrated to bring out the 3D aquifer disposition of the aquifer system. The type cross sections generated in different direction of the aquifer system is given in **Figures 17, 18, fence diagram in Figure 19** & the 3D aquifer disposition is show in **Figure 20.**

3.4.2. Aquifer Geometry- Phreatic and fractured aquifer

Based on the drilling data the occurrence of three types of aquifers viz., shallow weathered zone, vesicular and fractured aquifers have been inferred. The study of the fence diagram and 3-D block diagram indicates a broad classification of three types of aquifers viz.

1. The top weathered zone, weathered basalt, which extends down to the depth of 48.6 m bgl and forms the shallow or phreatic aquifer, tapped mostly by dug wells, dug-cum-bore wells and shallow bore wells.
2. Vesicular basalt which lies below the shallow zone, extends to a depth of 263.6 m bgl.
3. Fractured aquifer, fractured basalt, limestones and shales which lies below the shallow zone, extends to a depth of 261.6 m bgl.

Deeper aquifer, the Bhima formations of shale and limestone, which are massive in nature, Shale formation encountered in two exploratory wells and occurs below and occurs below 145.7 to 239.2 m bgl depth. Limestone occurs below and occurs below 112 to 302.3 m bgl depth.

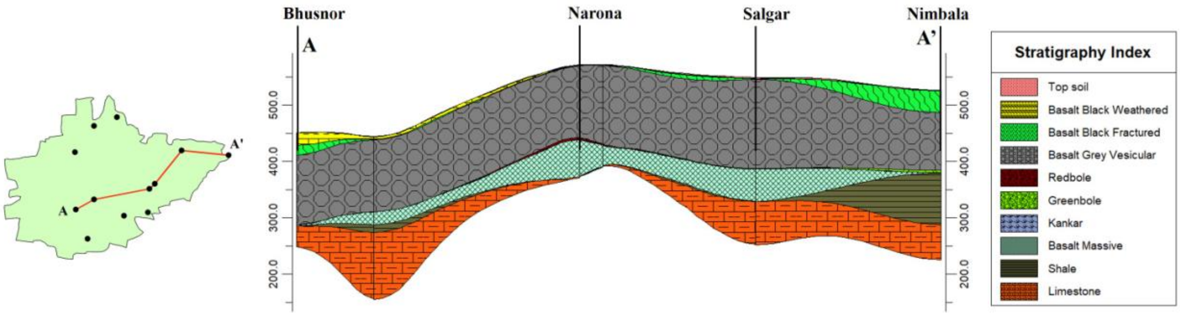

Fig 17: 2D cross section

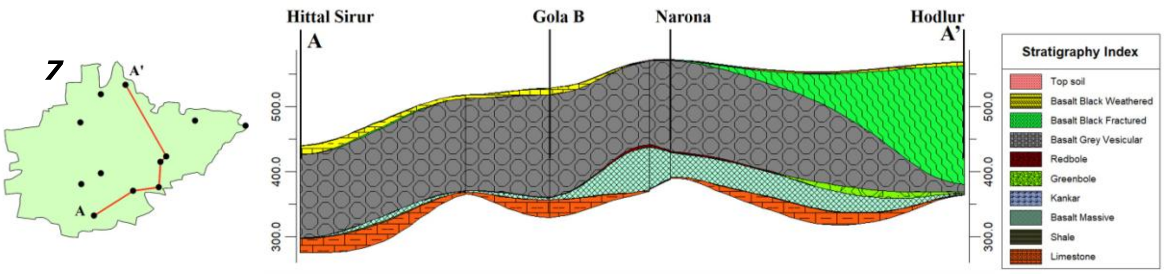

Fig 18: 2D cross section

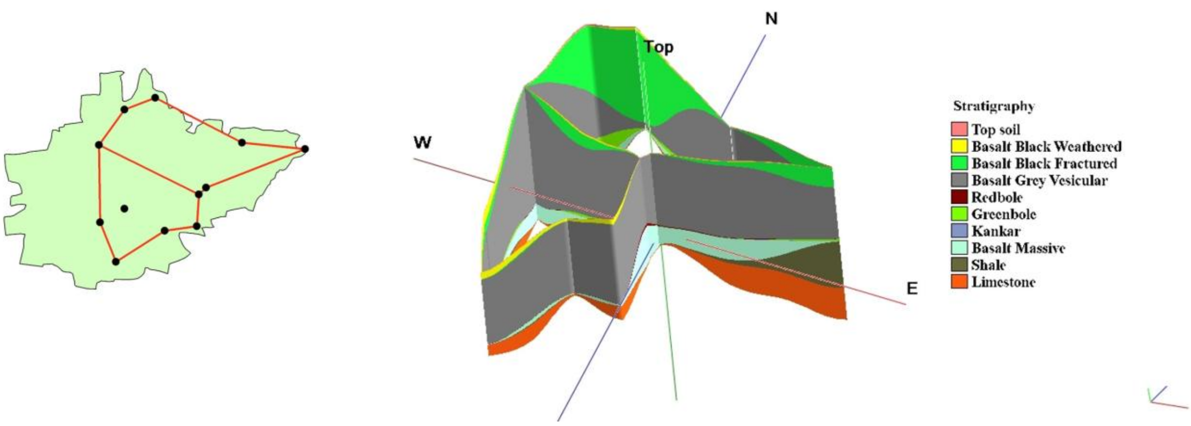

Fig 19: Fence diagram from top

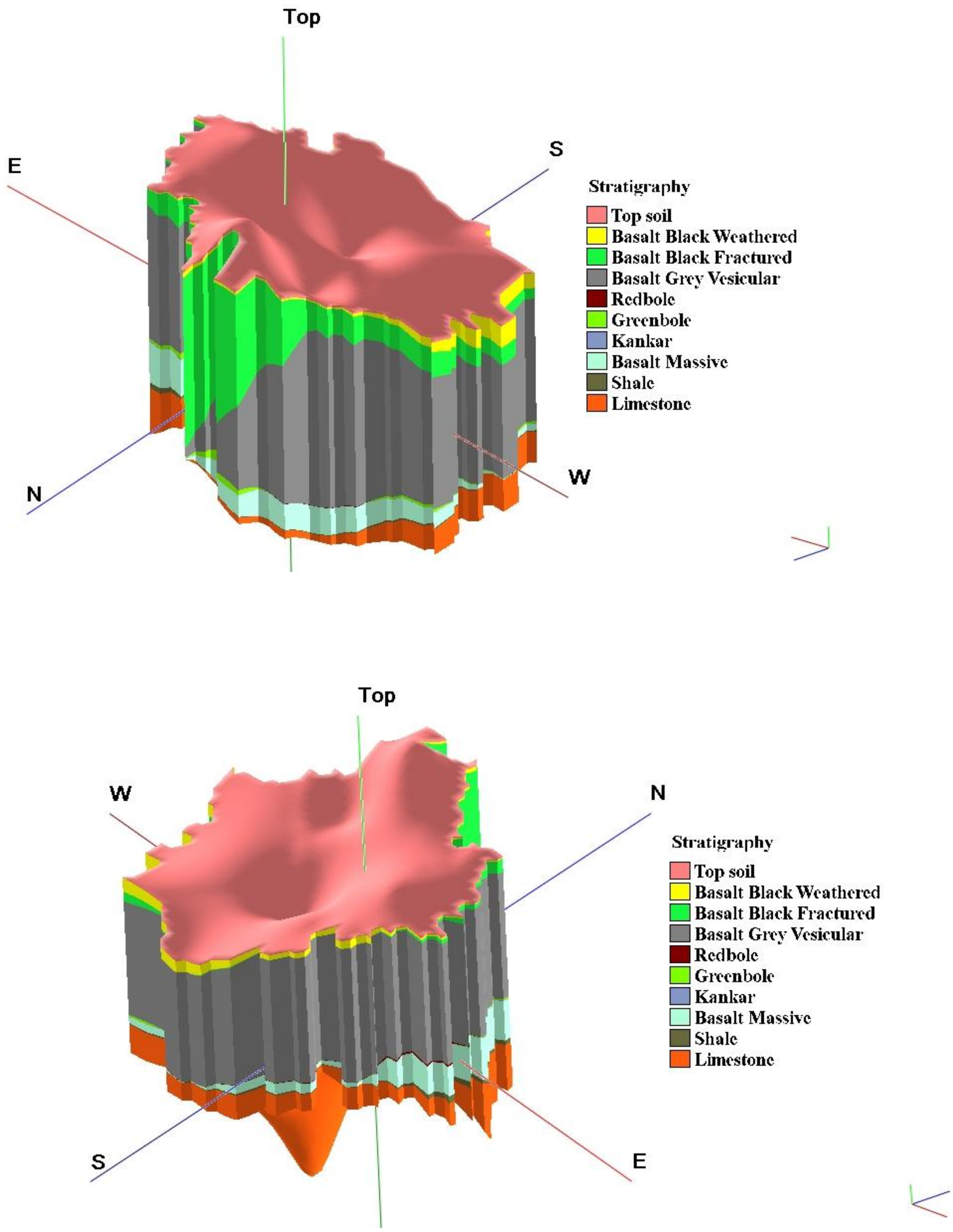

Figure. 20. 3D Aquifer Dispositions

4.0. GROUNDWATER RESOURCES

The dynamic groundwater resources have been estimated as on 2017 based on the methodology suggested by Ground Water Estimation Committee (GEC) 2015.

The groundwater recharge is calculated both by groundwater fluctuation-specific yield method and by rainfall infiltration method. The annual replenishable groundwater recharge is the summation of four components viz.,

i) Monsoon recharge due to rainfall
ii) Monsoon recharge from other sources
iii) Non-monsoon recharge due to rainfall
iv) Non-monsoon recharge due to other sources

Taluk wise dynamic groundwater resources have been taken from the approved resources estimation done as on March 2017, jointly by Ground Water Directorate of Karnataka and CGWB, to arrive at the total resources available in the taluk.

4.1. Net Groundwater Availability (NGWA)

The net groundwater availability refers to the available annual recharge after allowing for natural discharge in the monsoon season in terms of base flow and subsurface inflow/outflow. This annual groundwater potential includes the existing groundwater withdrawal, natural discharge due to base flow and subsurface inflow/ outflow in the monsoon season and availability for future development. As the groundwater development progresses the natural discharge gets suitably modified and comes down to negligible quantities due to interception by different groundwater structures. Hence, natural discharges in the monsoon season may not be considered and the total annual groundwater recharge may be taken as net groundwater availability. As per ground water estimation 2017, in Aland taluk the net annual ground water availability is 10034 Ham. The existing gross ground water draft for irrigation is 5291 Ham and draft for domestic and industrial water supply is 722 Ham. Thus, the total ground water draft for all uses amounts to 6013 Ham **(Table-11).**

Allocation for domestic and industrial water supply for next 25 years is 765 Ham. The net ground water availability for future irrigation development is 3979 Ham. The existing stage of ground water development is 60% is categorized under **'Safe'** category.

As on March 2017, the total ground water resource availability is 10034 ha, and fresh in-storage ground water resources in fractured aquifers up to the depth of 250 m is 1497 ham **(Table-12).**

Table 11: Ground Water Resources in Aland Taluk (2017) (in Ha.m.)

ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF KARNATAKA STATE - AMINISTRATIVE UNIT WISE RESOURCE (2017) (in Ham)

Net Annual Ground Water Availability	Existing Gross Ground Water withdrawal for Irrigation	Existing Gross Ground Water withdrawal for Domestic and Industrial Water Supply	Existing Gross Ground Water withdrawal for All Uses	Allocation for Domestic And Industrial Use for Next 25 Years	Net Ground Water Availability for future Irrigation Development	Existing Stage of Ground Water extraction
10034	5291	722	6013	765	3979	60

Tble-12: Availability of Total Fresh Ground Water Resources in Aland Taluk, Kalaburagi District (Ham)

Name of the Assessment Unit		Annual Replenishable Ground Water Resources	Fresh In-Storage Ground Water Resources		Total Availability of Fresh Ground Water Resources
District	Taluk		Phreatic	Fractured	Dynamic + Phreatic + Fractured
Kalaburagi	Aland	10034	0	1497	11534

5.0. GROUNDWATER RELATED ISSUES

5.1. Declining Groundwater level:

In the study area during pre and post monsoon periods about 82% of the wells analysed shows declining trend of water level. During Premonsoon, about 64 % of the wells analysed shows declining trend of 0 to 0.5 m/yr and 18% of wells analysed shows more than 0.5 m/year declining trend **(Figure 21).** Whereas during the post monsoon period 27% of the area shows declining trend of 0 to 0.5 m/yr and 18 % shows more than 0.5 m/yr (**Figure 22}**.

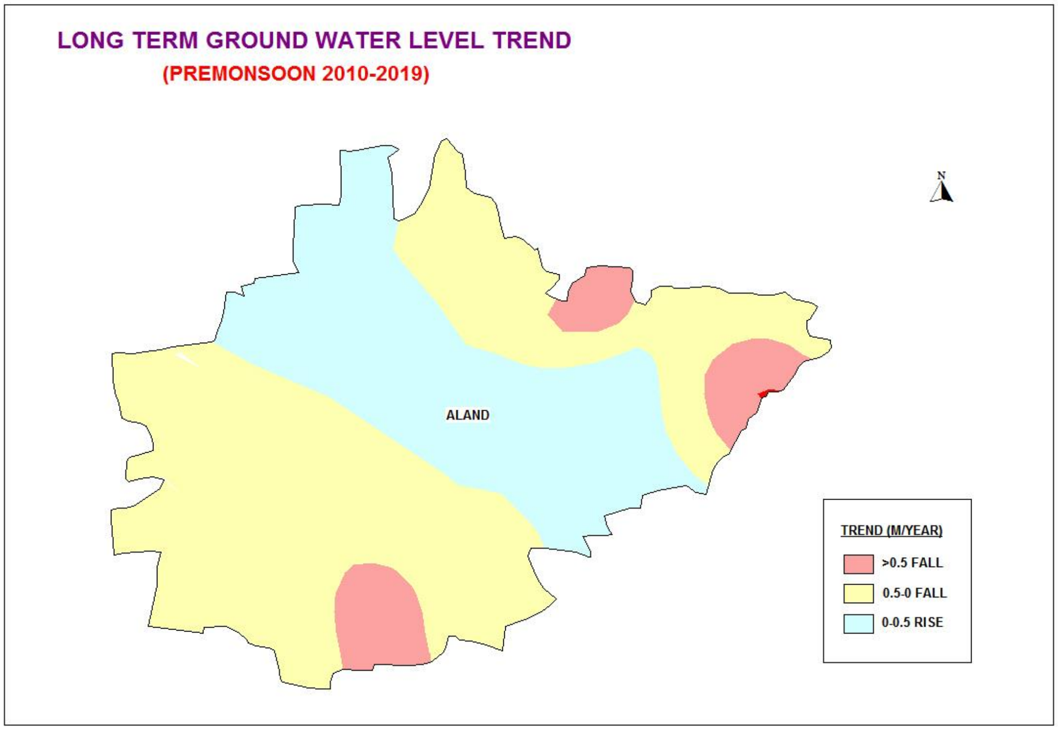

Figure. 21. Pre monsoon long term trend

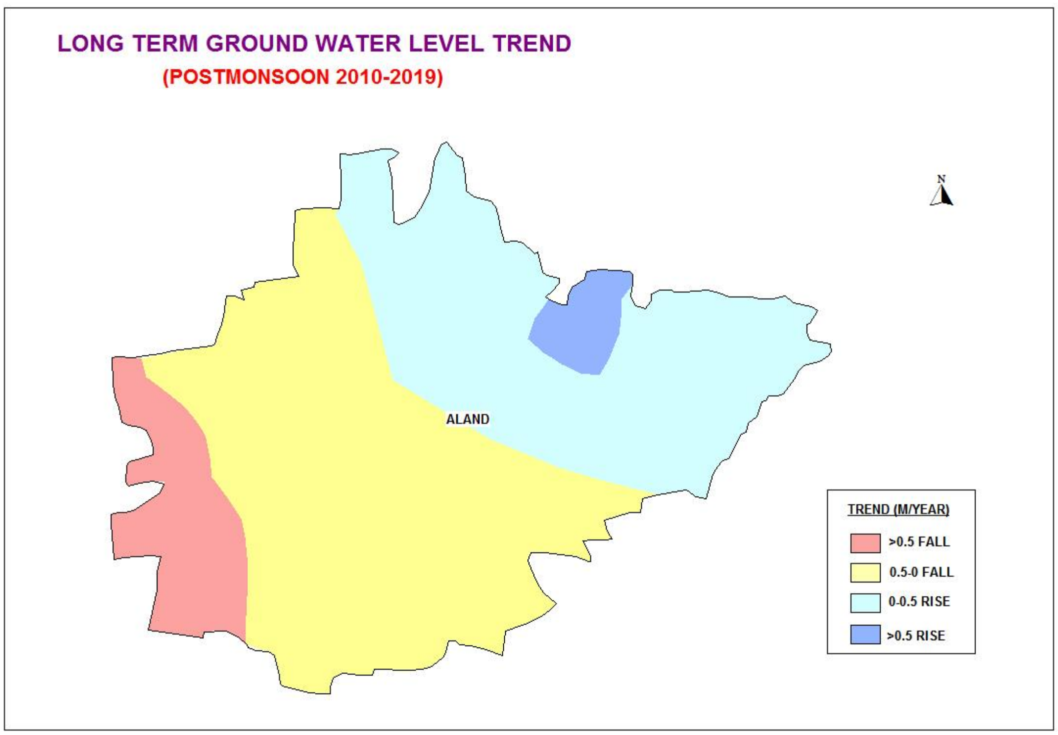

Figure. 22. Post monsoon long term trend

6.0 MANAGEMENT STRATEGIES

The groundwater management strategies are inevitable either when there is much demand to the resource than the available quantity or when the quality of resource deteriorates due to contamination in a given geographical unit. In recent years groundwater resources are used extensively for irrigation in the study area. The limited groundwater resources available in the less fractured and jointed aquifer system of the study area, unequal distribution of groundwater resources in these areas creates more demands for the resources. Hence, it is the need of the hour to formulate sustainable management of the groundwater resource in a more rational and scientific way. In the present study area of Aland taluk, the sustainable management plan for groundwater is being proposed after a thorough understanding of the aquifer disposition down to a depth of 200 m bgl in the basaltic area. Summarized issues, manifestation and management plans for Aland taluk is given in **Table.13.**

Table 13: GW issues, manifestation and management plans

ISSUES	***MANIFESTATION***	***MANAGEMENT PLANS***
1. Long term declining trends in GW	• **Lowering of water levels in about 50% of wells analyzed during pre and postmonsoon periods** • **Declining rate is not significant**	• **Recycling & Reuse through water treatment.** • **Implementation of artificial recharge projects through construction of water conservation structures viz., Check dams, sub-surface dykes, etc at scientifically selected locations** • **Adoption of water use efficiency methods like Drip irrigation and Sprinkler needs to be adopted for Irrigation** • **Artificial recharge structures should be periodically cleaned**
2. Ground water quality issues	• **High fluoride concentration in ground water in some pockets**	• **Can be tackled through installation of Defluoridation plants** • **Dilution of fluoride concentration by Construction of Artificial recharge structures**

6.1 Sustainable Management Plan

The groundwater resource of phreatic and fractured aquifers system has been estimated. Irrigation draft of 5291 ham is estimated for the entire study area as per the GEC 2017 against the Net availability of the resource of 10034 MCM. Therefore, only 53% of the annual replenishable groundwater resources have been developed. Availability of average annual rainfall of 776 mm in the study area is enough water for recharge. The draft can be maintained or reduced through application of water efficiency methods in irrigation sector and through changing the irrigation practices.

Augmentation of groundwater can be achieved through construction of percolation ponds, recharge pits and subsurface dykes. Recharge shafts can be constructed in the percolation ponds where the top soil zone is clayey which does not allow infiltration. Artificial Recharge and Water Conservation Plans are proposed in the taluk through utilizing the uncommitted surface runoff of 113.284 MCM **(Table 14)**. By constructing 416 check dams, 99 percolation ponds and 3 subsurface dykes in the taluks, 0.102 lakhs hectares of additional irrigation potential can be created **(Table 15)**. The existing 60% of stage of ground water extraction would reduce to 28% **(Table 16)**.

Table 14. Groundwater Management-Master plan for Artificial Recharge to Groundwater

Area feasible for AR (Sq.km)	Number of Proposed Recharge Structures			Cost of Recharge structures (Rs. In lakhs			Availability of surface un committed run off monsoon (MCM)
	Check Dam	Percolation Tanks	Sub surface dykes	CD (@ Rs.10 (lakhs)	PT (Rs. @ 20 (lakhs)	SSD (@ 20 lakhs)	
1619	416	99	3	4161.82	1979	60.42	**113.284**

Table 15. Expected Impact of artificial recharge structures

Recharge from each structure (MCM)			Total Recharge (MCM)	Total cost in lakhs	Expected Benefit of Artificial Recharge and RWH
Check Dam	Percolation Tanks	Subsurface dykes			Additional Irrigation Potential likely to be created (lakhs hectares)
28.321	56.642	16.993	113.284	6201.351	0.102

Table 16. Expected improvement in Ground Water extraction

Net annual ground water availability	Existing gross ground water extraction for all uses	Existing stage of ground water extraction	Expected recharge from proposed artificial recharge structures	Cumulative annual ground water availability	Expected stage of ground water extraction
HAM	**HAM**	**%**	**HAM**	**HAM**	**%**
10034	**6013**	**60**	**11328**	**21362**	**28**

6.3. Strategies to overcome the future stresses

Future stresses are only hypothetical. If the sustainable management is taken up in a true spirit in consultation with local village level bodies with the participation of farmers the groundwater depletion will not occur in future. However, it is very difficult to overcome gluttonous user attitude thrives for fullest use of the resource to get maximum output. In this process the vital resource is lost. Therefore, a thorough understanding of the consequences of indiscriminate usage of the water should be propagated among users mainly among farmers as they are bulk users of the resource in the study area.

The demand side strategies to overcome future stresses are mainly

- Promoting irrigation pattern change
- Agronomic Water Conservation
- Periodic cleaning of Artificial recharge structures
