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Ground Water Status : An Analysis in Drought Prone Area of Kalyandurg Mandal in Anantapuramu District of Andhra Pradesh using Geo-Spatial Technologies

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ABSTRACT

Ground water is a replenishable and dynamic vital natural resource widely distributed on the earth.The rapid growth in population, indiscriminate industrial and agricultural and urban expansion has led to severe exploitation of this natural resource. In some parts of the world such as large areas of the Southern India, ground water is the unique source of water. The present paper examines the ground water status in drought prone area of Kalyandurg mandal in Anantapuramu District, Andhra Pradesh. The main objectives are : To examine the rainfall pattern and situation related to the density of wells in the study area. To analyze the assessment of ground water availability, recharge, spatial concentration and decade-wise construction of wells in the study area. This study discusses the spatial concentration of well location points which are drawn precisely. With the advent of high resolution satellite data, site-specific recommendations are put forward for ground water exploration, spatial concentration, command, non-command areas, existing ground water for domestic, irrigation and other industrial usage of water supply and ground water development in the study area. The stage of ground water development in command area is 33% while non-command area is 35% and the distribution average annual recharge from precipitation in monsoon period is1,534 ha.m whereas in non-monsoon period it is 694 ha.m. The study found that ground water extraction has increased for the last 10 years, ground water levels have fallen, shallow wells failed and deep bore wells have been constructed in the study area.

Keywords Ground water, Natural resource, Remote sensing, Geographical information system, Recharge.

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INTRODUCTION

Ground water is a replenishable and dynamic vital natural resource widely distributed on the earth. About 97% of water on earth is in the form of salt water and out of the remaining 3% freshwater, 69% is trapped in the form of icecaps and glaciers. With 30% fresh water locked under the earth surface as the ground water, only 1% is directly accessible to us in the form of lakes and rivers (CGWB 2017, 1993, 2007, 2010–2011).The rainfall condition all over the world is uneven, scanty and unpredictable. It is by far the largest unfrozen volume of fresh water in the world. It is estimated that approximately one third of the world's population use ground water globally for drinking. Since majority of human habitat have no direct access to the fresh surface water sources, ground water becomes the only available and reliable source of drinking water for millions of rural and urban families, besides catering to the irrigation and industrial needs (Sunitha et al. 2012, Ganesh et al. 2015). The rapid growth in population, indiscriminate industrial and agricultural and urban expansion has led to severe exploitation of this natural resource. In some parts of the world such as large areas of the Southern India, ground water is the unique source of water. The Southern and Western parts of India are confronted by multiple water-related problems such as drought and environmental degradation from over exploitation of aquifers. In general, the State of Andhra Pradesh is characterized by scarcity of water and rapid growth in population. In the state of Andhra Pradesh, Anantapuramu district has been one of the most chronic drought prone and rain shadow area part and also the most backward area with scanty rainfall and dependence on surface and ground water for drinking, domestic, irrigation industrial purpose (CI 2011). Water is, therefore, the most important constraint for future development in this region. However, it is anticipated that the process of development will continue, resulting in greater demands for fresh water and declining ground water level.

Significance of the study

Ground water monitoring is an essential element in any environmental information system. Based upon-validated ground water monitoring data, information is derived on which decisions can be made. Constant monitoring provides the necessary data input for the smart environment and is the basis of the decision making process concerning spatial planning and climate change adaptation. As in all cases the rule applies ; one measurement is no measurement. In all, constant ground water monitoring is essential to maintain or improve our water quality and to ensure a constant water quantity.

Today ninety-five percent of population in rural areas are dependent on their own wells to provide all their water needs. Many town and city dwellers also drink ground water, as the vast majority of public water supply systems use ground water too. In addition to rural households and public water supplies that depend on wells and ground water, farmers too use ground water for irrigating crops and for their animals. Other industries rely on clean ground water for the food, beverages and material production.

Objectives were to examine the rainfall pattern and wells density situation in the study area, to analyze the assessment of ground water availability, recharge, spatial concentration and decade wise construction of wells in the study area.

Study area

The present study area is Kalyandurg mandal which is located in Western part of Anantapuramu District that lies in Southwestern part of Andhra Pradesh. It is situated in 14°25´50´´ to 14°39´08´´ North latitude and 77°02´36´´ to 77°22´10´´ East longitude. It is bounded by Beluguppa mandal on the Northern side, Kambadur and Kundurphi mandals on the Southern side, Brahmasamudram and Settur on Western side, Atmakur and Kanaganapalli mandals on Eastern side. The total geographical stretch of the study area is 48,920 ha (Fig. 1), (Ramanaiah and Charles1988).

Hagiri River is flowing on Northern side and Penna River on the Eastern side of the study area. Soil cover is predominantly in red soils followed by black and alluvial soils. Natural vegetation is very thin and scanty and mostly of thorn shrub jungle type. The terrain is undulating and closely disclosing the characteristic feature of plateau topography (ICAR).

MATERIALS AND METHODS

In the present study on application of geospatial technologies likes remote sensing and GIS tech-

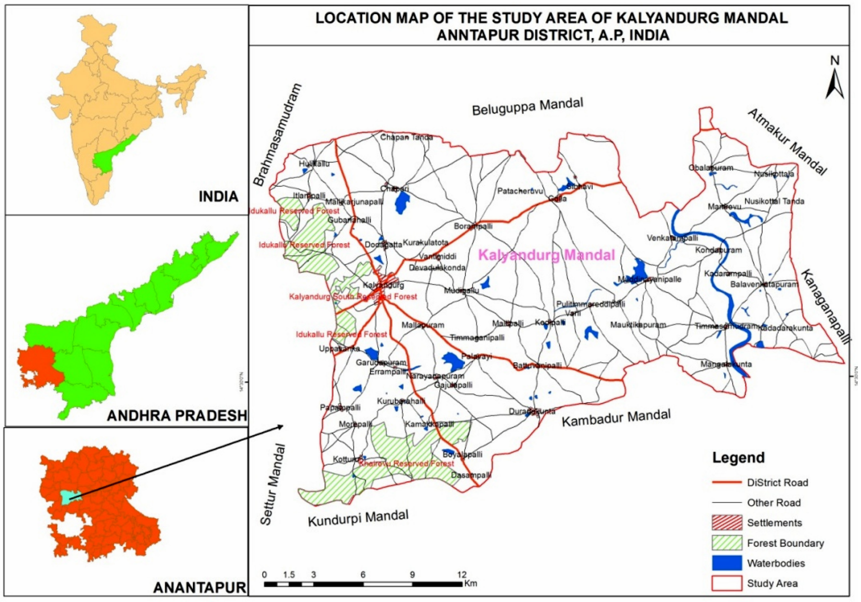

Fig. 1. Location map of the study area, map shows base features of roads, settlements, forest boundary and water bodies including streams and rivers.

niqueswere vigorously applied for evaluation of land resources in the area. ERDAS Imagine 9.6 and Arc GIS 10.1 Software were used for the preparation of all thematic layers and other resource maps. Survey of India topographic maps on 1 : 25, 000 scales has been used for preparation of base features of roads, settlements, forest boundaries and drainage layer. The drainage, canal and water body layers were initially derived from SOI topo sheet and subsequently updated using IRS Resourcesat-1 LISS-IV Satellite Data (NRSC, SOI, GOI, http: www. apsgwd.gov.in, http: //india–wris.nrsc.gov.in).

The study area falls under Survey of India topo sheet no. D43, K14, K15, L2, L3, L6 and L7 of 1 : 50,000 scale (latest series) and secondary data are collected from ground water for preparing the depth to ground Water level (DTW) maps (DDGWD 2012).

Base map and other maps are prepared using Survey of India topographic maps on 1 : 25,000 scale and depth to ground Water level (DTW) maps are prepared based on ground water samples collected from ground water department, initially spatial data using *Spline* with barriers tool prepared DTW maps (Interpolates a raster surface, using barriers, from points using a minimum curvature *Spline* technique. The barriers are entered as either polygon or polyline features–using Arc GIS 10.1tool and for geo-rectification of topo sheets used ERDAS 8.6.

Material from the reports of the State and Central Ground Water Department is also used extensively. In this contest about wells distribution, use, other well stsatistics and domestic water, was carried out in Kalyandurg mandal of the study area.

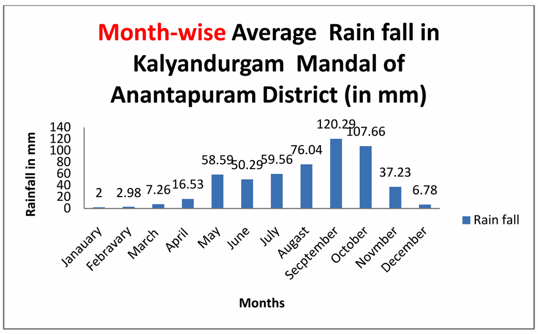

Fig. 2. Average annual rainfall of the study area of Kalyandurgam mandal, Anantapuramu District from 1995-96 to 2011-2012 (rainfall units in milli meter).

Table 1. Density of wells in the study area (2008-09). Source : Ground water department, AP.

Sl. No.	Geographical area (hectares)	No. of inhabitated villages	Total no. of wells	Well density per sq km
1	49023	14	3416	7
Total	49023	14	3416	7

RESULTS AND DISCUSSION

Rainfall pattern

The average annual rainfall varies between 370 mm and 760 mm. (Fig.2). The normal rainfall for the South-West monsoon period is 338 mm which forms about 61.2% of the total rainfall for the year. The rainfall for North-East monsoon period is156 mm, which forms 28.3% of annual rainfall (October to December) and annual temperatures vary between 21 and 42°C. In summer, temperatures will reach up to 42°C for three months from March to May. The aridity index is 73.8, with an average 5 run-off events per annum and PET is 2,140 mm. The normal on set of the monsoon is around June and could be delayed even up to the end of August.

The Tables 1 and 2 and Fig. 3 indicate that average annual rainfall registered was very low (261.4 mm to 540.3 mm) from 1995 to 2012 and 2005 to 2011 the rainfall registered up to 955.8 mm from 1995 to 2012 the highest rainfall is registered in Kalyandurg mandal was very low.

Table 3 indicates that the total rainy days are registered as 25 distributed in the month of April, May, July, August, September, October and November in Kalyandurg station. Generally South-West monsoon in the rainy season is getting rainfall from July to November. It is also found that the variations in the distribution of monthly rainfall are very striking which explain the precarious nature of rainfall occurrence.

Ground water

The arid and semi-arid regions depend more upon ground water for major part of the water requirements. The available ground water has to be investigated and developed on scientific lines. As different factors like morphology, slope, drainage pattern, rock type, attitude of the rock, joint patterns and texture and structure control the occurrence and distribution of ground water, in Anantapuramu District, ground water resource available is 60,578 ha. The total ground water resources available in command area are 60,278 MCM while in non-command area the volume stands at 1, 20,856 MCM. Gross annual draft is 411.85 ha. m and balance resource stage of ground water development in command area is 33%, while in non-command area it is 35%.

Spatial concentration of wells

The Table1indicates that Kalyandurg has distributed 3,416 wells and density of the wells per sq km is 7, well locations in the study area are concentrated along drains or rivers, about the well location, distribution of the wells and well construction time lines are studied in depth in the Kalyandurg mandal.

Table 2. Assessment of dynamic ground water resources in the study area. (GAP 2008–2009) (ha.m). C= Command, NC =Non–command and T=Total. Source: Ground water department, Andhra Pradesh.

Sl. No.	CNC total	Net annual availability of ground water	Existing gross GW draft for irrigation GW draft for irrigation	Existing gross GW draft for domestic and industrial water supply	Existing gross GW draft for all uses (11+12)	Provision for domestic and industrial requirement supply to 2025	Net GW availability for future irrigation development (10-11-14)	Stage of GW development (13/10/100)
	1	2	3	4	5	6	7	8
1	Command	0	0	0	0	0	0	0
2	Non-command	3384	2574	271	2845	218	583	84
	Total	3384	2574	271	2845	218	583	84

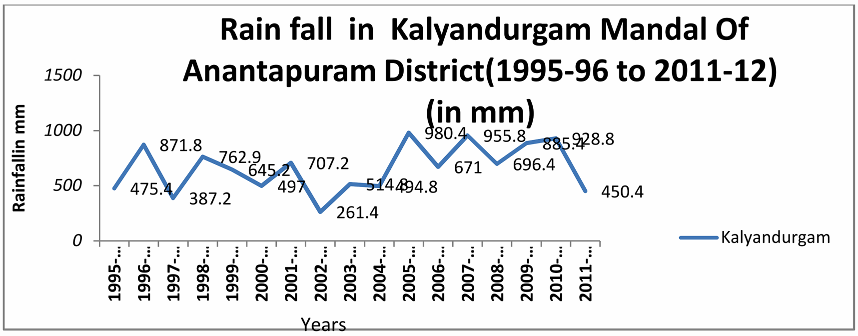

Fig. 3. Study area average annual rain fall graph from 1995 to 2011 (Source : Chief Planning Officer, Anantapuramu 2010).

The observations are made based on the Table 2

Annual GW availability is 3,384 ha. m in the non-command (NC) area of the study area i.e. Kalyandurg, existing gross GW draft for irrigation in command area is nil and in the non-command area is 2,574 ha. m. Existing gross GW draft for domestic and industrial water supply is 271 ha.m; provision for domestic and industrial requirement supply to 2, 025 is 218 ha. m in the non-command area (NC) of Kalyandurg respectively. Net GW availability for future irrigation development is 593 ha. m in the command area of the Kalyandurg mandal.

Table 3 indicates that the distribution of average annual recharge from precipitation in monsoon period varies in Kalyandurg is1,534 ha.m, in non-monsoon period 1,012 ha.m, 661 ha.m, 390 ha. m, in Kalyandurg, total annual ground water recharge 3, 575 ha. m.

A small increase is observed in ground water extraction for irrigation during the last ten years in Study Area. As a result, ground water levels have fallen and in Kalyandurg in particular, shallow wells have failed as deep bore wells have been constructed and as extraction from deeper aquifers has become the norm. Although the number and density of wells in Kalyandurg levels of ground water extraction are around 10 to 20 % higher. In the present ground water analysis pertaining to spatial points of well locations, well construction- time line, well failures and use of wells, an in depth study is made only for Kalyandurg mandal.

Figure 4 shows the location of well in Kalayandurg. The data were collected as part of the well survey carried out by the Andhra Pradesh ground water department (DMGGAP 2018). This Fig.5 shows the preference for siting wells near to drainage lines. In general, the options of wells in certain areas can be explained in terms of either unfavorable geological conditions or poor ground water quality.

Table 3. Assessment of ground water recharge in the study area (in ha. m.) 2008—2009. Source : Ground water department, Andhra Pradesh.

Sl. No.	C/CN/ Total 1	Recharge from rainfall during monsoon season 2	Recharge from other source during monsoon season 3	Recharge from rainfall during monsoon season 4	Recharge from rainfall during non-monsoon season 5	Total annual ground water recharge (3+4+5+6) 6	Provision for natural discharging 7	Net annual ground water availability 8
1	C	0	0	0	0	0	0	0
2	NC	1534	335	1012	694	3575	190	3384
	Total	1534	335	1012	694	3575	190	3384

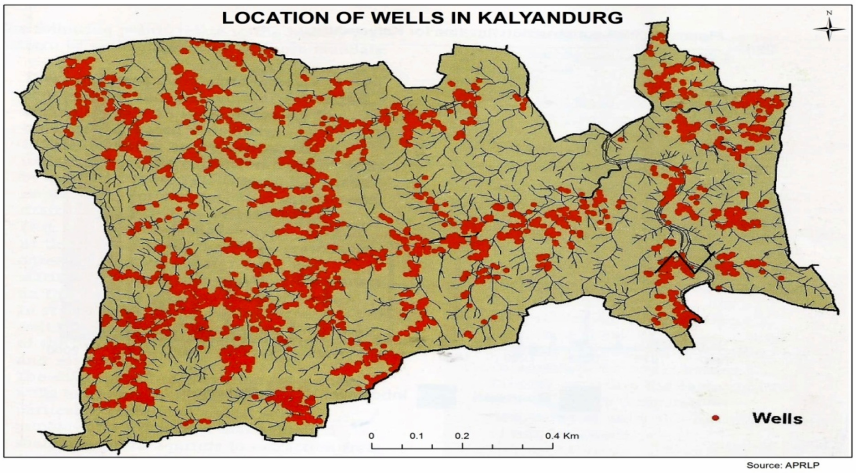

Fig. 4. Location of well in the study area (Source : APRLP).

The information as on date related to the construction of wells was elicited in part from local people; information for the first part of the century is presented on a decadal basis. The peaks in well construction during the first part of the century are, therefore, misleading and the reality was that the rate of well construction was more uniform during these decades. In contrast, peaks during the last 25 years were related primarily to government grants and loans that encouraged sudden spurts in well construction.

The following points relate to the history and pattern of well construction in the study area : There has been a spectacular increase in well construction and ground water extraction during the last 15 years primarily for ground water-based irrigation. Official statistics on well construction under estimate the current number of wells by a factor of two. This finding has major implications for estimation of ground water draft that uses well statistics. At the mandal level, there was reasonable agreement between water audit well statistics and statistics provided by Transco on the number of pump connections. In recent years, ground water extraction per well has increased substantially as a result of the availability of submersible pumps and electricity. The shift in well construction from open wells to bore wells in the study area represents a shift from ground water extraction that

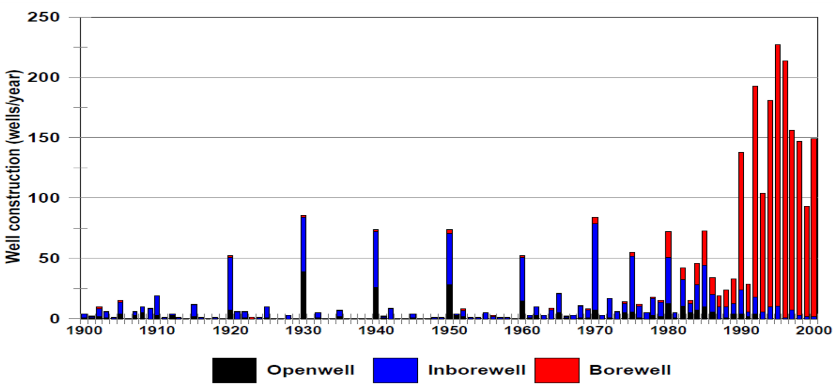

Fig. 5. Presents the number of wells of different types constructed during the 20th century in Kalyandurg.

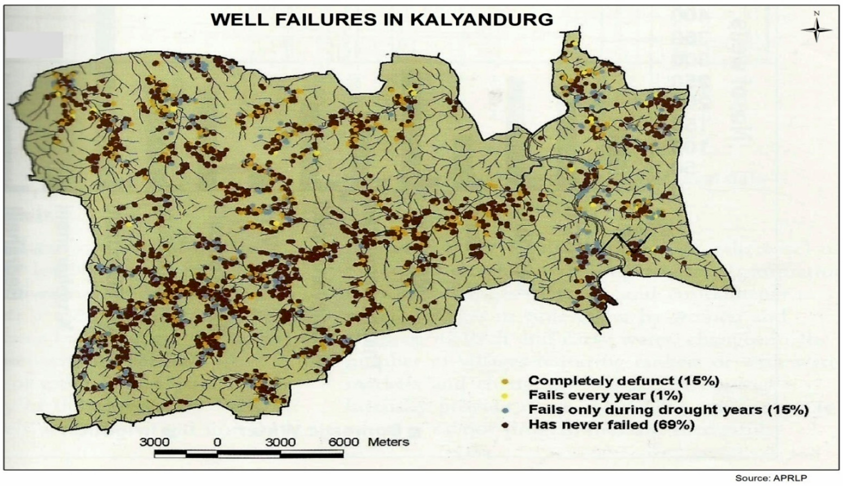

Fig. 6. Well failure rates in Kalyandurg mandal of Anantapuramu District (Source : APRLP).

exploited the shallow regolith aquifer to extraction from the deeper bedrock aquifer.

Figure 6 presents the status of wells surveyed in Kalyandurg which shows that in early 2001, 31% of the wells surveyed had either failed completely or unreliable. The wells that were completely defunct were predominantly open wells. Similar analysis for other two mandals of the study area indicated that less than 1% of wells were defunct and 7% of wells failed routinely, although the number and density of wells in Kalyandurg and other two mandals was similar.

Factors that have encouraged the increase in well construction

Markedly higher and more reliable returns that farmers get from irrigated cropping as opposed to rain-fed cropping. Government programs that have provided grants or soft loans for well construction Government policies that have led to the cost of electricity being subsidized. Improved drilling technology and competition between contractors. Both have ensured that the cost of bore well construction is relatively low. Competition for water between farmers accessing the same aquifer. This has led to deepening of open wells and/or construction of bore wells.

Net ground water extraction for irrigation, domestic and livestock use for Kalyandurg mandal was estimated at 11.0% of mean annual rainfall. As the Andhra Pradesh ground water department estimate of ground water recharge in this area is approximately 10% of annual rainfall, this suggested that current levels of extraction in Kalyandurg were not sustainable. Analyses of village-wise ground water extraction showed large differences between the villages in the mandal. These were attributed in part to more favorable hydro-geological conditions in some villages and in part to variations in the historical pattern of development of both ground and surface water resources.

Figure 7 gives an indication of the number of-wells per revenue village in Kalyandurg that were being used as sources of water for irrigation and domestic supply. As might be expected, the number of irrigation wells now far exceeds the number of domestic supply wells. Annual ground water extraction for domestic and livestock use was estimated at being 0.6% of annual rainfall for Kalyandurg. If annual domestic and livestock use are considered in terms of average annual ground water recharge, it is apparent that currently 6% of average annual recharge is being used to meet these needs in Kalyandurg mandal. Taking a population growth rate of 2.5% and

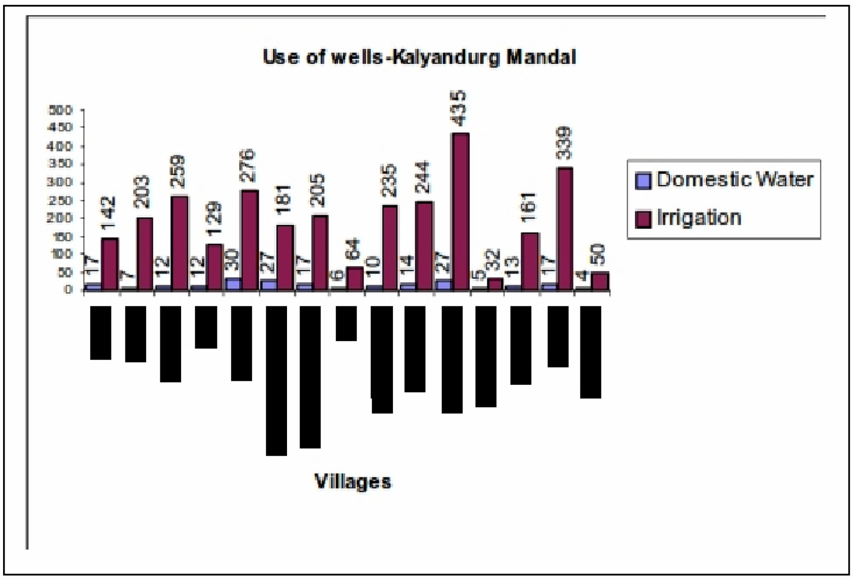

Fig. 7. Use of wells in the study area (Source : APRLP).

assuming that current per capita levels of water use are maintained, it can be estimated that ground water extraction for domestic and livestock use will double in the next 30 years. There is considerable variability in domestic water use with some revenue village areas (e. g. Kalyandurg town) having current levels of use well in excess of 20% of average annual recharge.

Domestic water use

Participatory assessments were made of the status of the 438 domestic water points (hand pumps and public taps) in Kalyandurg mandal. The following factors were considered when classifying each water point as being satisfactory or as having a problem. Functionality (i.e. no technical problems), distance to water point (i.e. less than 1.6 km), crowding (i.e. less than 250 people using the water point), adequacy of supply (i.e. 40 lpcd available 365 days/year), peak summer availability (i.e. similar time and effort needed to collect water in peak summer), accessibility(i.e. no social exclusion) and water quality (i.e. acceptable from users viewpoint).

CONCLUSION

The analysis of the study materials, methods and information have been developed using the Indian Remote Sensing Satellite (IRS P6 LISS-IV) data with a spatial resolution of 5.8 m which can be enlarged even up to 1 : 4000 scales. With the help of high resolution data, expansion of rural settlements, drainage and road network is updated. The spatial concentration of well location points are drawn precisely. With the advent of high resolution satellite data, site specific recommendations are presented for ground water exploration, spatial concentration command, non-command areas, existing ground water for domestic, irrigation and other industrial usage of water supply and ground water development, recharge wells for effective management of ground water resources at smallest possible revenue boundary i.e. Kalyandurg. The state ground water department estimated that annual ground water availability in the study area as 7,594 ha m. existing gross ground water draft for all uses is 6,821 ha.m, ground water balance is 945 ha.m, and stage of ground water development in the study area estimated as 91%.

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