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Identifying Groundwater Potential Zone and Recommending Artificial Recharge Structure in Ongur Sub-basin of Varahanadhi Basin, Tamil Nadu using GIS and Remote Sensing

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Abstract:

Integration of remote sensing data and GIS for the exploration of groundwater resources has become a breakthrough in the field of groundwater exploration. In this present paper various groundwater potential zones for the assessment of groundwater availability and using various thematic maps layers viz. lithology, slope, landuse, lineament, drainage, soil and rainfall were transformed to raster data using feature to raster converter tool in Arc-GIS for each weighted thematic layer is statistically computed to get the groundwater potential zones. The groundwater potential zones thus obtained into four categories viz. very poor, good and very good zones. The result depicts the groundwater potential zones in the study area and found to be helpful in better planning and management of ground water resources.

Key Words: Groundwater potential zones, lithology, Arc-GIS, Planning and management, RS and GIS

Introduction

The Varahanadhi basin is one of the 17 river basins of Tamil Nadu and is third river basin from north to south order. It is bounded by Palar Basin in the north and Pennaiyar basin in the South and West and Bay of Bengal in the east. It spreads over Villupuram,Thiruvannamalai, ancheepuram and Cuddalore districts of Tamil Nadu and Union territory of Puducherry. Varahanadhi basin constitutes three sub basins, namely Varahanadhi sub basin in the south, Nallavur Sub basin in the middle and Ongur sub basin in the northern part of this major river basin.

Ongur Sub basin is located between longitude of 79^0 30’ 0”E to 80^0 E and Latitude of 12^0 30’ 0” N to 12^0 10’ 0” N. The total area of the Ongur sub basin is 1274.73sq km. Ongur River is the major river drains in ongur sub basin.(Fig.1)

The surface water bodies such as reservoirs and tanks depends only on monsoon rains. But due to vagaries of monsoon, these structures do not get adequate filling and could not cater the needs of entire command areas. The capacity of these structures is also reduced due to various reasons resulting in poor storage conditions during monsoon seasons. The indiscriminate pumping of groundwater and poor storage in the surface water structures cause great concern in lowering trend of groundwater level in many parts of the State over a period of three decades.

The potential groundwater zones for further development can be identified by using remote sensing data with GIS analysis.

Physiography:

Generally the ongur sub basin is very gentle sloping terrain. The topographic trend of this sub basin is towards south east and east. The western part is the elevated terrain whereas the eastern boundary forms the coastal belt. The coastal length of this sub basin is 31 kms. There are several hillocks are observed in the central part of the sub basin. The highest elevation contour passes through this basin is 180 m in the western part of the basin and the lowest is subzero mts. There is a backwater environment in the eastern coastal terrain where sea water flows in to the land at the time of hide tide and in the low tide time fresh water from Nallavur and Ongur empties in to the sea. The contours shown in the physiography map of Ongur sub basin is generated from the SRTM DEM data for an interval of 5 m. The generated contours are even though exactly follow the 20 m contours of Survey of India Topographic sheet contours of 20 m intervals. However it shows the exact topographic trend of the terrain for which these contours are generated.

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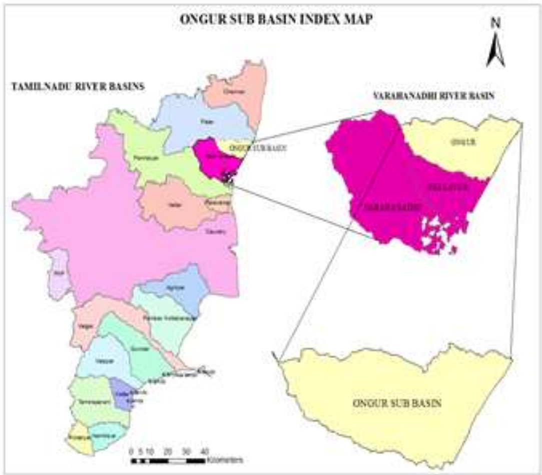
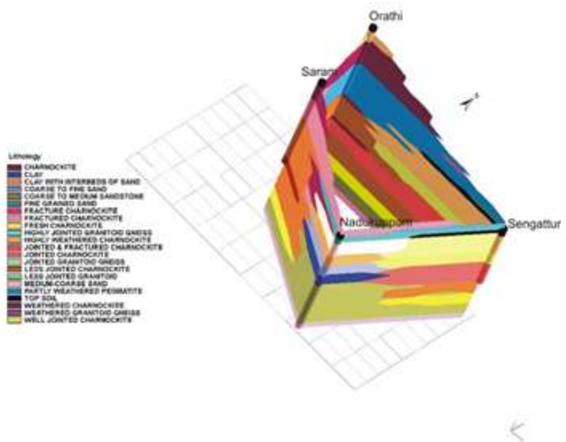


Fig. 1. Study Area

Geology:

The geology of the sub basin is made up of hard crystalline rock masses of Archean age for most part of the area. In some part, sedimentary rocks of upper Gondwana, Cretaceous, Tertiary and Quaternary age are found. The crystalline formation of ongur sub basin consists of The Arechean group of rocks are represented by the Charnokite group and migmatite complex. The charnockite group comprises of Charnockites and granulites. The largest group of rock of this sub basin is Charnokite. They occur as huge and massive formation and are grey to black in colour, medium to coarse grain texture with hypersthenes, plagioclase feldspar and quartz as predominant minerals.(Fig.2)



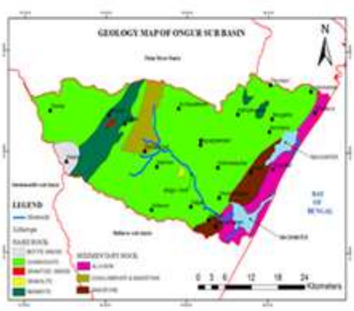


Fig. 2a Geology of the study area.

Migmatite is also seen in some areas of Ongur sub basin and it is a rock with a mixture of metamorphic rock and igneous rocks. It is formed when metamorphic rock such as gneiss which are partially melt and recrystallized. It forms a mixture of the unmelted metamorphic part with the recrystallized igneous part.

The Ongur sub basin Comprises of sedimentary rocks of

1. Gondwana super group of lower Gondwana age.
2. The Ariyalur group belonging to upper cretaceous age
3. Translational rocks between cretaceous and tertiary group belonging to the Mio-Pliocene age.
4. The Alluvium relating to quaternary age.

The conglomerate and sand stone patches are noted in the central upper part of the sub basin, whereas the sand stone patches are observed in the south eastern part of sub basin. Wide area of coastal alluvium is noted along the entire stretches of sub basin's eastern boundary.

Fence Diagram:

Fence Diagram is a graphical display of three-dimensional data and interpretation in a two-dimensional perspective view. Geologic cross sections can be displayed in a network to form a fence diagram.

The software Rockwork was used to create the fence diagram. The fence diagram was created using four bore wells namely Orathi, Saram, Nadukkupam and Sengattur (Fig.3b fence diagram).

Fence diagram are effective at demonstrating changes in facies, pinchouts and truncations of units, unconformities and stratigraphic relationships occurring in that region.

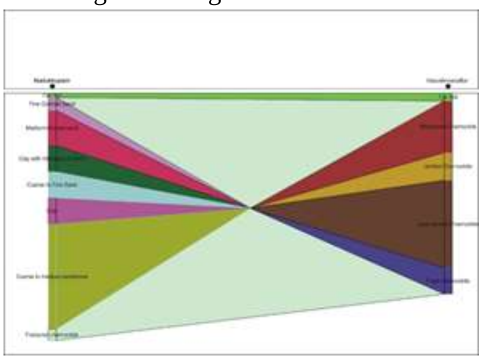


Fig. 3 Fence diagram

Journal of Engineering Sciences
Vol 11, Issue 7,July/2020
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Depth of Weathered Rock Formation

This layer in combination with jointed or fractured formation forms the primary or shallow aquifer in hard rock area. This layer is further subdivided into 5 sub layers based on depth of occurrence and thickness of layer in the basin.The shallow depth of weathered rock (5 -10 meters bgl) exists in limited places of the basin. Mostly the southern part of the subbasin is having weathered formation at shallow depth. The area around Kilsevur and Nagar villages and eastern part of Padiri village are encountering the shallow weathered formations at 5 - 10 m bgl. The aquifer in those areas are not significantly holding water.

The weathered formations at depth of 10-15 meter bgl is observed in several part of the subbasin. most of the villages viz. Kambur, Sittamur, kayapakka, Puthirankottai, Vedal, kattudevalur, Sengattur, Ammanur, Mugaiyur and Pavunjur are meeting weathered formation at 10 - 15 m. this shows that most of the subbasin is having aquifer that is holding most of the groundwater at 10 - 15 m bgl.

The formations having moderately appreciable depth and thickness of weathering ie.15- 25 meter bgl is observed mainly in western, eastern and northern side of the subbasin. The locations that have this appreciable thickness of weathered portion are Thellar, Amudur, Orathi, Karusangal, Olakkur, Alattur, Kurumbaram, Chunambedu and Vilamur. These weathered formation form a good aquifer holding a considerable amount of groundwater for the water needs.

The sub layer at depth of 25-35 meters depth below ground level exists mainly at the eastern part of subbasin where the sedimentary formation forms the base. This occurs mainly around the back water area. (Fig.4)

The sub layer of weathered formations occurring at depths of 35- 75 meter below ground level is mainly observed in south eastern side of the subbasin as a small around the backwater. These formations eventhough have high weathered thickness, the groundwater mostly saline because of the seawater intrusion.

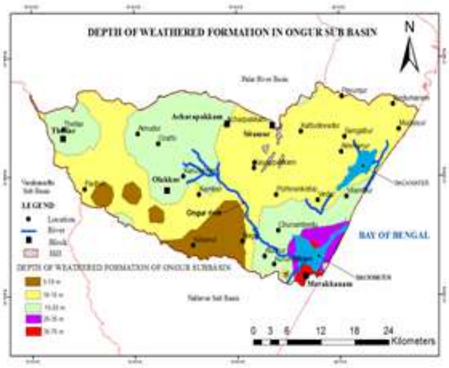

Fig. 4 Depth of weathered formation of the study area

Drainage

The river ongur originates in Acharapakkam block of Kancheepuram district and olakkur Block of Villupuram District. In the initial reach it has two arms. The right arm originates from the surplus course of vairapuram tank which is fed by a number of upper tanks and empties into Saram eri (tank). It also receives water from number of tanks on either sides. The surplus course of Saram eri flows towards the North - eastern direction.

Similarly the left arm called Nariyar odai originates from surplus course of olakkur melpadi eri, which is fed by surplus water of number odais of ongur village and from this point, the river is called Ongur River.

After this, a local stream, Nedungal river joins with ongur River on its left side which originates from the surplus course of Kalathur and Kilathivakkam tank which receives surplus water from a number of tanks of Kancheepuram district. It joins the ongur river near veliyambakkam village of Maduranthagam taluk. The total length of the stream is of about 6 km. Then the river flows towards the Southeast until it falls into yedayanthittu kaluveli tank (Back water) and the surplus water joins the Bay of Bengal. The length of Ongur River from its origin till its confluence with the sea is about 43 kms.

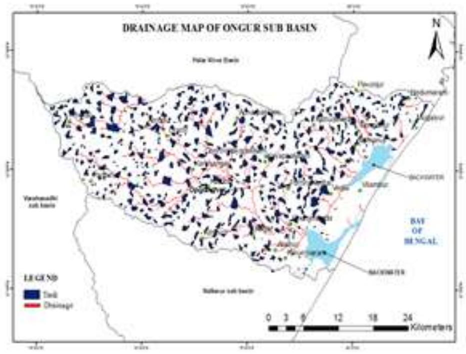

Fig. 5 Drainage Map of the study Area

Journal of Engineering Sciences

Vol 11, Issue 7,July/2020

ISSN NO:0377-9254

Rainfall

Rainfall data are being collected from 4 rain gauge stations by Sate Ground Water Resources Data Centre, Chennai. Within the study area, there is only 1 rainguage station at Marakanam. It lies at 12.2°N to and 79.96°E with an elevation of 41 feet. Surrounding rain gauge stations are located at Madurantakam, Thindivanam and Vandavasi.

The annual rainfall of July 2019 was collected. The annual rainfall at Marakanam rain gauge station is 1232mm. The pre monsoon rainfall was generated by correlating the rainfall details of Madurantakan, Marakanam, Thindivanam and Vandavasi rain gauge stations.(Fig.6)

Fig. 6 Rainfall Map of the Study area

Groundwater level

In order to understand the spatial distribution of the groundwater level in the subbasin, water level values are interpolated in the ArcGIS tool by IDW method. Before that, the data available for the subbasin area collected for July 2018 (Premonsoon) and January 2018 (Post Monsoon). The water level below ground level is converted to mean sea level with the help of elevation for each bore well.

In the premonsoon, 20 bore wells data are used. the fig prepared for the water level in premonsoon is shown in fig 7a. The distribution shows that groundwater level follows the topography i.e. the western part of the sub-basin has water level at 50 - 90 m msl, followed by the middle portion (20 - 50 m.MSL) fig.7b and the eastern part of the subbasin is encountering groundwater at shallow depths ranging from 0 - 20 m msl.

In the subbasin after the monsoon, the groundwater level has been increased with respect to mean sea level. There is a significant trend in the improvement of the water level in the south of karsangal, west of pudirankottai and north of ammanur.

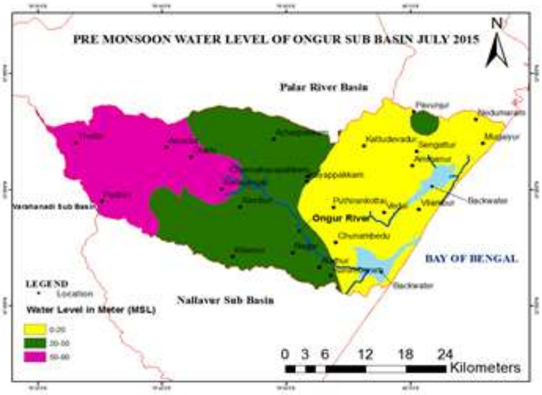

Fig. 7a Groundwater level Map of the study area (Pre-Monsoon)

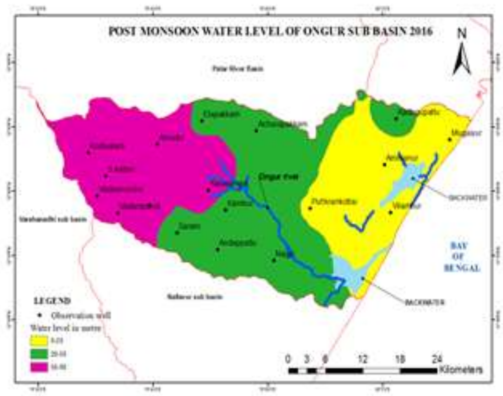

Fig.7b Groundwater level Map of the Study Area (Post-Monsoon)

Soil

Soil is one of the natural resources consisting of layers or horizons of minerals and organic constituents of variable thickness, which differ from the parent material in morphological, physical, mineralogical and biological characteristics.

Soil texture is an important characteristic of soil that influences storm water infiltration rates. The textural class of a soil is determined by percentage of sand, silt and clay. Soil texture determine the rate at which the water drain through a saturated soil; water moves more freely through sandy soils that it does through clay soils.

In the study area the soil types are Inceptisols, Vertisols and Histsols. The salient features of these soil types are presented in the following passage:

- **Inceptisols** – These soils comprises of immature soil that exhibit mineral horizon development. These soils of semi-arid to humid environment that generally exhibit only moderate degrees of soil weathering and development. These soil have a wide range in characteristics and occur in a wide variety of climate.

Journal of Engineering Sciences
Vol 11, Issue 7,July/2020
ISSN NO:0377-9254

- **Vertisols**: Vertisols have a high content of expanding clay minerals. They undergo pronounced changes in volume with changes in moisture. They have cracks that open and close periodically and that show evidence of soil movement in the profile. They tend to be fairly high in natural fertility.
- **Histosols**: They have a high content of organic matter and no permanent frost, and also called as bogs, moors, peats or mucks. They are formed from the decomposed plant remains that accumulates in water, forest litter or mess faster than they decay.

Some of the soil textures found in the sub basins are sandy loam sandy clay, clay, clay loam, loamy sand, sand and loamy sand

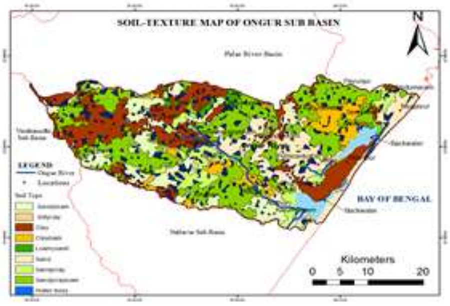

Fig. 8.Soil Texture Map of the study area

Methodology General:

The general methodology adopted for the project study in Ongur sub basin, Tamil Nadu includes data collection from Geological Survey of India, SRTM, water level, water quality, rainfall, landuse, borewell, lithological and yield data from state ground and surface water Resource Data Centre, Tharamani, Chennai, Tamil Nadu.

DATA PRODUCT:

PHYSIOGRAPHIC DATA

- Toposheets from GSI, degree sheets 1:250,000 SRTM data are used.

SETELLITE DATA USED

- 1-IRS- LISS IV(March 2015)

HYDROMETEOROLOGICAL DATA

- Rainfall data
- Landuse data

HYDROLOGICAL DATA

- Borewell data
- Groundwater level data
- Groundwater quality data

INTERPRETATION TECHNIQUES

Visual Interpretation:

Identification of objects and their classification visually from the hard copy (photographic prints), based on the image characteristics such as, shape, size, tone, texture, pattern, location association, shadow and these aspect are commonly known as visual interpretation.

These are strong interlinks between various photo elements to derive information from remotely sensed data. This clearly shows that no single element can exclusively use for full information extraction. It is the combination of all photo elements and change detection that maximize translation of raw data into information. Using visual interpretation techniques, different themes like geomorphology, landuse of different lineament and intersection, maps were prepared. Apart from this, base map, physiographic, drainage, watershed and texture map etc. were generated using topographical data.

Digital interpretation:

The digital image processing involves the manipulation and interpretation of images obtained in the digital form with the aids of computers. The digital data can be treated with various algorithm for enhancing the ground features for better interpretability and analysis. Initial understanding of the image data is obtained either by generating a theme band color composite called false color composite (FCC) or displaying each spectral band in black and white. Various processing technique are available for image analysis viz: Radiometric transformation, geometric correction, image enhancement, statistical analysis, clustering, filtration and classification for presentation of results.

The digital data pertaining to study area was processed to obtain false color composite (FCC). Supervised classification technique was employed to prepare landuse and wasteland maps. DEM (Digital Elevation Model) of Ongur sub basin has been generated using topographic elevation contours, spot heights, and slope components. Finally the satellite image draped over to have true representation of terrain.

MAP PREPARATION

Different theme interpreted from satellite and topographical data on 1:50,000 scale were converted into raster format using color scanner. These raster maps were geometrically rectified using Ground

Control Points (GCP) and converted into vector format by on screen digitization method using Arc GIS software. These vectorised themes were put into GIS environment using common projection coordinates so as to obtain better results in overlay analysis.

Geomorphology

The study of the geomorphology of an area can be identified by studying the satellite imageries through visual interpretation as well as with the aid of dedicated softwares and hardwares. From this studies, we can identified various landforms formed due to the activities of various geomorphic agents ie. Fluvial, Aeolian and Coastal actions such as erosion, transportation and depositional on earth's surface.

In the ongur sub basin, both sedimentary and hard rock landforms are developed. The sedimentary and marine landforms are mostly covered in the Eastern part whereas the western part is covered by hard rock terrain landforms which exhibits denudation landforms. Most of the area is predominantly covered by pediments.

The major geomorphologic units of the study area, the Ongur sub basin are as follows:-

1. Pediment –Buried (shallow and moderate)
2. Structural Hill and Inselberg
3. Flood plain sedimentary ground- High and Low ground
4. Sedimentary Plain
5. Coastal plain
6. Coastal High ground
7. Salt flat
8. Mud flat
9. Swamp
10. Backwater
11. Beach and Beach ridges

All these geomorphic units are delineated by using IRS-ID satellite imagery of LISS-IV sensor. Some of the geomorphic units of this sub basin are

- Pediment is observed throughout the sub basin as patches. It is an eroded bedrock surface with a thin soil cover.
- Buried Pediment is bifurcated in to two, based on the thickness of the sediments or the weathered formations. They usually located away from the mountains, the thickness of soil cover increases with weathered mantle and more so in areas of low relief bordering the streams or tanks. Buried pediment with moderate weathered thickness is predominantly occupied in this sub basin whereas the buried pediment with good amount of weathered thickness if found in very few locations in south of Ongur river.
- Structural hill is the high or low relief hills which exhibits structures such as folds, faults, joints, ridges and escarpments etc. In this basin it is seen found in north and north eastern part.
- Inselbergs are the remains of the original mountain mass which are now isolated hills surrounded by vast plain. They are found in the north east of Pathiri village, north, north east of Adhanur village, North West of Vellur and north of Nallur village.
- Flood plain is the veneer of alluvium over a bed rock which has been cut by lateral erosion. River from north east of Pathiri and north of Kanthadu village.
- Sedimentary ground- High and Low ground and Sedimentary plain are the area of up and low land of sedimentary formations. In Ongur sub basins they are made up of sandstones and form as a good aquifers. They occur in southeast and southwest of Kanthadu village, southeast of Vellur village and west of Mugaiyur village.
- Coastal high ground occurs parallel to the coast of this sub basin. Salt flat, mud flat beach and beach ridges are the coastal land forms out of which salt flat alone is the man made salt pan.
- Back Swamp / Swamp are the deposits that were laid down in the flood basins back of natural waves.They consists of extensive layers of silt and clay. Kaluveli Tank and Yeddayan thittu Kaluveli, located in the eastern side of the basin is swampy in condition which receives backwater at the time of high tide and deposits silts and clays.

The benefit of Geomorphology is, it plays an important role for a significant control over the groundwater regime, relief, and slope, depths of weathering, thickness of the deposition, nature of deposited material and assemblages of different landforms. The geomorphological landforms acts in the synthesis of related components like soil, lithology, structures, lineation and other related hydrological information available in the sub-basin. These Geomorphic units can signify the vital information about the occurrence Groundwater in the area.

Journal of Engineering Sciences
Vol 11, Issue 7,July/2020
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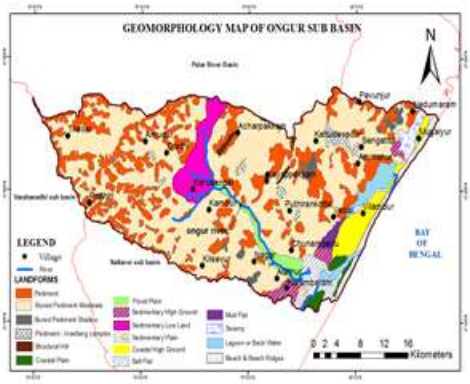

Fig.9 Geomorphology Map of the study area

Land use

With the advent of Remote sensing technology have passed the way to gather information about the earth's resources and various phenomenons', more accurately than conventional methods. Indian Remote sensing Satellite- IRS -P6's LISS IV (March 2019) data was analyzed for each object, shape, pattern, texture, spectral signature, etc. to classify the land use categories. The visual interpretations techniques were mainly applied to derive the relevant land use information of block and different land uses were categorized and mapped. The land use pattern has been assessed in relations to the groundwater development and irrigation practices of the block. The land use map was prepared and the different type of land uses was classified;

Build up land: this land composed of areas under intensive uses with much of the land covered by the settlements, villages and towns.

Agricultural Land: The agricultural lands are put into use for production of food and fodder. This category is further classified into wet and dry crop lands.

Forest land: This category includes dense, deciduous forest, scrubs and shrubs, which occupies a large portion of the basin.

Wasteland: Occurrence of wasteland is due to poor drainage pattern, elevated topography with poor soil and it is indicated by the absence of vegetative cover which is described as degraded land. Alkalinity / Salinity are included in the wasteland category. The salt affected land are also present in the block and is characterized as land that has adverse effects on the growth of plant due to the action or presence of excess of soluble salts. Alkaline sand is found around this sub basin sporadically.

Water bodies: This category includes rivers, streams, lakes, reservoirs, etc. Ongur River is the main river which flows from west to east and confluences with the back water.

The predominant land use classifications encountered in this sub basin are as follows.

The Reserved forest, the scrub and shrub forests are sporadically found throughout the sub basin, mainly in and around hillocks. The alkaline area is found in the northern and central part of the sub basin where the agricultural practices were abandoned and the quality of groundwater is also hard. Blue metal quarry is predominant in the southern side of the basin. The water logged cum swampy area is noticed in the eastern coastal region as Kaluveli tank and Idayanthittu kaluveli tank. Salt pan activities are high near Marakkanam village and adjacent to Idayan thittu Kaluveli. Dry crop area is predominant throughout this sub basin when compared to the wet crop area. Harvested land parcels are also observed sporadically.

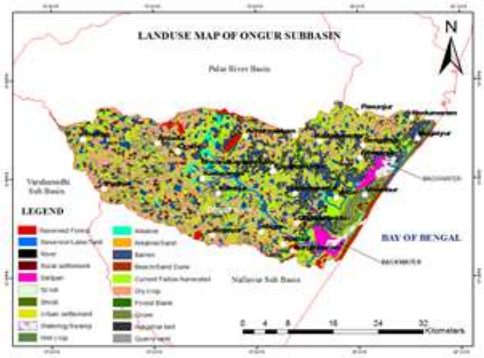

Fig. 10 Landuse Map of the study area

Geological Structures:

Lineament is the only geological structures noticed in the ongur sub basin. Lineament is the linear feature in a landscape which is an expression of underlying geological features or structures such as Fault and fractures. Typically lineament will comprised as a fault aligned valley, a series of fault on fold aligned hills, a straight coastline or indeed a combination of these features. Fractured zones, Shear zone and igneous intrusion such as dyke can also give rise to lineament. Lineaments are often apparent in geological or topographic maps and can appear obvious on aerial or satellite photographs. Lineaments are formed due to tectonic forces acting on the ground and structure or geological setting.

The lineaments are exhibits as linear and curvilinear outcrop pattern in the satellite imagery. Straight drainage course vegetation banding, long and linear dark tone contact and soil tone difference are the key factors for interpreting lineament from

Journal of Engineering Sciences
Vol 11, Issue 7,July/2020
ISSN NO:0377-9254

the satellite data. Lineament studies have been made on the nature of fold, fault and fractures.

In Ongur sub basin, lineaments are deciphered from the Aerial photographs and from satellite imageries by visual interpretations. More than 30 lineaments and linear fractures are identified in the study area and are the probable fractures. Based on their geometry and orientation the lineaments are grouped into three (3) sets. The first set of lineament is NW-SE direction, subsequently second set of lineament are aligned in NE-SW direction and the third set in NNW - SSE direction.

The intersection points of two or more lineaments are considered as potential zone for groundwater exploration since the formation at this juncture will be highly crumbled. This increases the water holding capacity of that formations. These lineament zones are influencing geomorphic units like buried pediment deep, uplands, old river courses toenrich more groundwater occurrence and distribution.

Fig. 11 Lineament Map of the study area

Groundwater potential and recharge evaluation under GIS environment

GIS plays a vital role in the evaluation of groundwater potential. It is a prime component for the integration and analysis of the spatial and non-spatial information. Using the GIS package, the specific application like map projection, geo-referencing of spatial data, merging, mosaicking, data clipping, data updating, data aggregation, queries, proximating analysis, attribute analysis, overlay analysis and integration analysis, the generation of groundwater potential zonation and artificial recharge zone are done.

ArcInfo and ArcView GIS software were used to create database for spatial and non-spatial data for the study area. TIN model was used for interpolation of data like water level, rainfall for generating the raster output to incorporate in the potential and recharge zonation maps. GIS query system under spatial analysis module is used for raster overlay analysis and the final output maps of groundwater potential and recharge zonation maps were generated.

RANK	POTENTIAL ZONE	RECHARGE ZONE
Good	Central part and towards East	Central part and Southern as well as South-Eastern part
Moderate	All over the sub basin in lesser percentage	Mostly North-Eastern part and Western partly (scarcely)
Poor	All over the sub basin(Scarcely) and Much lesser in Southern part	Western and North-Eastern part
Very poor	Nil	Western and North-Eastern part

Tab. – 1 Classification of Groundwater Potential and Recharge.

The groundwater potential and ground water recharge zonation maps have been prepared by integrating the information from geomorphology, geology, lineament, annual rainfall, Pre monsoon water level, depth to weathered rock, soil and landuse by giving appropriate weightages. The phenomenon of map layers and its uses are summarized in the Table 2.Phenomenon and need for the thematic layers

Sl. No.	Map Layer	Phenomenon	Need
1	Geomorphology	Physical processes on the earth's surface that produce different landforms	A geomorphic unit is a composite unit that has specific characteristics
2	Lineament (including Fault & Shear zone)	Planes/Zones of structural weakness in the rocks	Easy movement of water along weak planes

Journal of Engineering Sciences

Vol 11, Issue 7,July/2020

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3	Rainfall	Rainfall	Major source of water
4	Pre monsoon Water Level	Depth at which water occurs in the unconfined zone (top zone) below ground level	Accessible of water
5	Soil	Soil	Result of physical surface processes and the lithology
6	Landuse	Purpose for which land has been put to use	Indicates the state of current use.
7	Depth to Bed rock	Massive rock below the soil and the weathered zone	Indication of the thickness of the unconfined aquifer
8	Geology	Lithology	Controls the movement of water (surface and ground)

Tab. – 2 Thematic Layers.

Interpolation of Point Data

The data available for the present study was in two forms – vector data (derived from existing map sources) and raster data (interpolated from point data or classified from satellite images). Four point data sources were available from which layers were created to represent the study area, namely, rainfall, depth to weathered rock, water level and elevation. The Inverse Distance Weighted (IDW) method was used for creating rainfall, depth to weathered rock and water level map layers. IDW method with four nearest points was used in finding out the values for the unknown. In this technique, input data points surrounding a raster position are given a weight that is inversely proportional to the specified power of their distance from the pixel. Distance threshold could have been a better method but could not be used here, as the point data was sparse and distributed.

Data Preparation For Analysis

Weighted overlay analysis was done in the raster form because of the excellent depth, speed and flexibility. Moreover, assigning the scores for individual classes in the map layers and the weightings for individual map layers is possible in raster form in this technique.

Raster data is a two-dimensional array of square grid cells. The various thematic grid layers were organized into a GIS database. The layers having various classes were organized into manageable classes through reclassification (using ArcView GIS Spatial Analyst software). Reclassification re-coded the existing attribute value for each grid cell, more appropriate to the queries being asked when the decisions to be made.

Each grid cell was given a score that described its capability in terms of groundwater potential and groundwater recharge. Mathematical addition of the grid layers in an overlay is not directly possible because it is not logical to add rainfall in units of mm, depth to weathered rock in units of meters and so on. Moreover, the influence of each layer towards the potential and recharge varies. Hence, the Nominal Group Technique was used to assign the scores and weights for the classes and layers, respectively. All data used for this study was converted into raster form. This was necessary as scores and weights assigned for each class in a map layer and a layer, respectively, needs to be incorporated in the analysis. The final result is in the form of a raster layer, where each grid cell acquired a value through the additive overlay process. The higher value of the grid cell is more preferred for Groundwater Potential Zone. For interpreting the results, the final grid cell values have to be scaled in accordance with the possible minimum and maximum values that a grid cell can contain. The details of weights, classes and scores of the map layers are shown in Table.3 Weights, classes and scores for map layers

Layer Name	Class (category)	Buffer width (m)	Weightage	Score for Potential	Score for Recharge
Geomorphology	Sedimentary high ground	-	22	6	7
	Linear Curvilinear ridge	-	22	3	2

Vol 11, Issue 7,July/2020
ISSN NO:0377-9254

	Buried Pediment Deep	-	22	8	8
	Buried Pediment Moderate	-	22	5	4
	Buried Pediment Shallow	-	22	3	2
	Pediment	-	22	2	1
	Flood Plain	-	22	9	9
	Structural Hill/ inselberg / residual hill	-	22	1	1
	Tertiary upland		22	5	6
Geology	Charnockite	-	7	4	4
	Conglomerate sandstone	-	7	4	3
	Sand and silt (Alluvium)	-	7	5	6
Lineament		75		3	4
Wt. For potential :		75		4	3
Wt. For recharge :		75		5	6
Soil	Sandy Loam		15	5	5
	Silty Clay		15	3	3
	Clay		15	4	3
	Clay Loam		15	5	6
	Loamy Sand		15	6	7
	Sand		15	8	9
	Sandy Clay		15	6	5
	Sandy Clay Loam		15	7	6
	Water Body		15	9	9
Landuse	Reserved Forest		10	8	7
	Tank		10	9	9
	River		10	8	5
	Settlement		10	3	2
	Salt pan		10	4	3
	Scrub		10	5	6
	Shrub		10	6	5
	Swamp		10	3	3
	Wet Crop		10	8	3
	Alkalinity /Salinity		10	4	6
	Alkaline Sand		10	4	6
	Barren		10	4	5
	Beach/Sand Dune		10	6	6
	Current Fallow		10	7	7
	Dry Crop		10	8	7
	Forest Blank		10	6	6
	Grove		10	7	7
	Industrial belt		10	3	3

Journal of Engineering Sciences
Vol 11, Issue 7,July/2020
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	Quarry Land		10	3	3
Depth To weathered Rock	5-10 m		7	3	3
	10-15m		7	4	4
	15-25m		7	5	6
	25-35m		7	6	7
	35-75m		7	7	8
Drainage	River		2	9	8
	Tank		2	8	9
Pre Monsoon Water Level	0-20 m		5	8	4
	20-50 m		5	7	6
	50-90 m		5	5	8
Annual Rainfall	<1390 mm		6	5	7
	1390-1570 mm		6	7	5
	1570-1810 mm		6	8	6

Table.3 Weights classes and scores for map layers

This exercise using the GIS environ helped to generate groundwater potential and artificial recharge zonation maps (Fig.12)and (Fig.13). The artificial zonation map shows the area in the study area that could sustain for the recharge possibilities. This may be used for further planning to improve the storage condition for future optimal groundwater development.

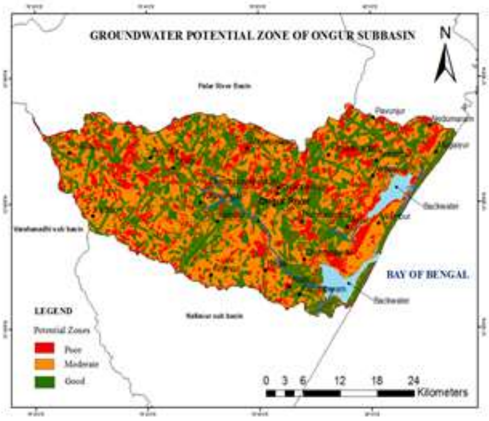

Fig. 12 Groundwater Potential Map of the study area

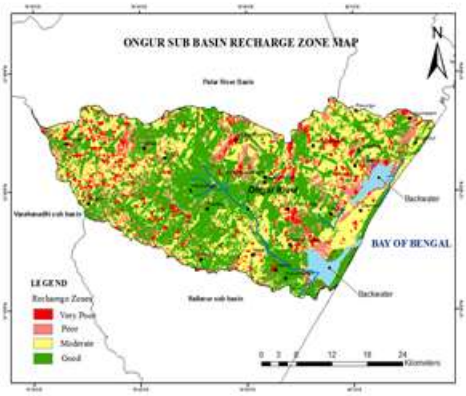

Fig. 13 Recharge Zone Map of the study area

CONCLUSION

The Groundwater Potential zone map shows that the good potential zones are distributed mostly in the Central part as well as towards the Eastern part of study area. Moderately potential zones are spread all over the study area but the poorly potential zones are scarcely distributed in the region and are lesser in the Southern part.

The Recharge zone map shows that good recharge zones are distributed mostly at the central part as well as South-Eastern part of the study area. Moderately rechargeable zones are located mostly in the North-Eastern part and also scarcely distributed in the Western part. Poor and very poor zones are spread mostly in the Western and North-Eastern part of the region.

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