GOVERNMENT OF INDIA
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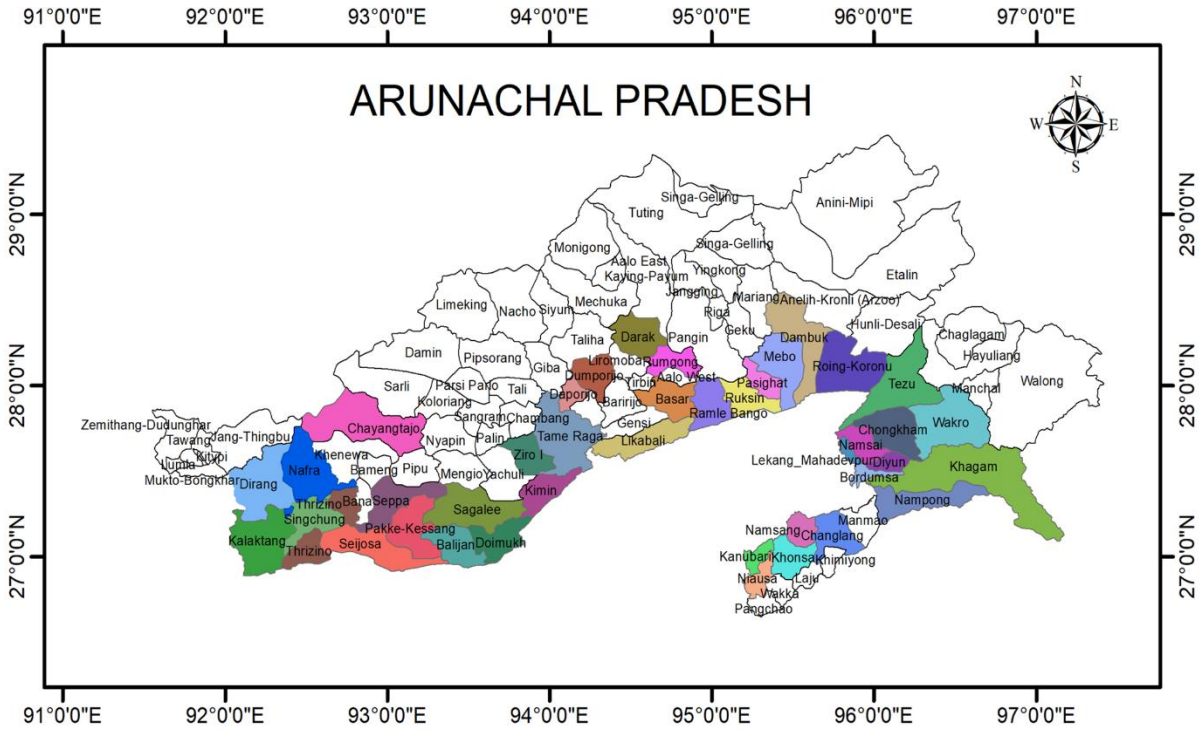
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION
CENTRAL GROUND WATER BOARD



DYNAMIC GROUND WATER RESOURCES OF ARUNACHAL PRADESH (as on March 2023)

CENTRAL GROUND WATER BOARD
NORTH EASTERN REGION
GUWAHATI

DECEMBER 2023

REPORT ON
DYNAMIC GROUND WATER RESOURCES OF ARUNACHAL PRADESH (2022-2023)

Jointly carried out by

WATER RESOURCES DEPARTMENT,
GOVERNMENT OF ARUNACHAL PRADESH,
ITANAGAR
&
CENTRAL GROUND WATER BOARD,
NORTH EASTERN REGION
GUWAHATI

DECEMBER 2023

PREFACE

Arunachal Pradesh is the biggest state in North Eastern Region bounded by longitude 91° 30' to 97°30`E and latitude 26°30` to 29°39`N, with a geographical area of 83,743 Sq. Km. As per 2011 census the state population is 10,96,702. With rapid growth of population in Arunachal Pradesh in general and in the foothill areas in particular, the demand of drinking as well as domestic water is increasing by leaps and bounds. Simultaneously the growing need for agricultural products is necessitating the need for ground water exploration as also its development in the valleys.

The sustainable development of ground water resource requires precise quantitative assessment based on reasonably valid scientific principles. The assessment of ground water resource is a complex task which involves computation and estimation of different parameters associated with the inflow and the outflow of this natural resource. To ascertain the ground water resource in the shallow aquifers that gets annually recharged through rainfall and other sources under various hydrogeological conditions in the country, scientific methodology following well defined norms, need to be adopted.

This report presents the Dynamic Ground Water Resources of Arunachal Pradesh estimated based on GEC'2015 in web based IN-GRES software as on March 2023.

The total ground water recharge of the state is estimated as 4.65 BCM (Billion Cubic Metre) and annual extractable groundwater resources are 4.16 BCM after deducting the natural discharge. The total annual extraction of ground water for various needs currently amounts to 0.2 BCM, with Domestic and irrigation comprising 0.01 BCM each. Based on the projected population data until 2025, a yearly allocation of 0.01 BCM has been assigned for Domestic use. At present the overall stage of ground water extraction in the state stands at a mere 0.42%.

The estimation of dynamic groundwater resources for Arunachal Pradesh was jointly done by the Water Resources Department, Govt. of Arunachal Pradesh, and Central Ground Water Board, SUO, Itanagar under the able guidance of North Eastern Region, Guwahati. The efforts made by the scientists of Central Ground Water Board, SUO, Itanagar as well as North Eastern Region, Guwahati in coordination with Water Resources Department, Govt. of Arunachal Pradesh, Itanagar are commendable.

I firmly believe that the present report will go a long way to help the planners and policy makers in the ground water sector to formulate future ground water extraction and sustainable management plan for the state of Arunachal Pradesh.

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CONTRIBUTORS

Estimation of Ground Water Resources of Arunachal Pradesh as on March 2023 has been carried out based on the data provided by the concerned State Govt. Departments of SLC. The computation of the resource and preparation of the report was carried out by Shri Rajat Gupta, Asst. Hydrogeologist of CGWB, SUO, Itanagar, Shri Tiamenba Longshir, Asst. Hydrogeologist and Dr. Dip Jyoti Khound, Scientist-D of Central Ground Water Board, North Eastern Region, Guwahati. A special thanks to Dr. S S Singh, Scientist-D & OIC, GWRA-NER, Shri Biplab Ray, Sc-E & HOO and Miss Mophi Milli, Sc-C, CGWB, NER, Guwahati for their constant support in finalisation of the report.

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CHAPTER 1

INTRODUCTION

1.1. Background for re-estimating the ground water resources

Arunachal Pradesh occupies the easternmost part of the country and is spread over an area of 83,743 sq. km. The state lies between Latitudes 26°30′N-29°30′N latitude and 91°30′E – 97°30′E longitude. The state is bounded on the north by China, on the east by Myanmar and on the west by Bhutan. In the south it is bounded by the state of Assam and Nagaland. The state has been divided into 16 districts, 51 Sub-divisions, 92 blocks and 190 circles as per census 2011.

The first assessment of ground water resources of Arunachal Pradesh was carried out in 1992 based on 'Ground Water Estimation Methodology', 1984 (GEC'84 and was reassessed for the assessment year 2004 using 'Ground Water Resource Estimation Methodology – 1997' (GEC'97). For the current assessment year, 2022-2023, the dynamic groundwater resources of the state have been assessed block-wise for the first time based on GEC 2015 methodology.

The smallest administrative unit 'block' is taken as the unit of computation. Forty-Two nos. of blocks have been considered as assessment units considered during 2022-23. Total ground water recharge is estimated to be 4.65 BCM (Billion Cubic Metre) and annual extractable groundwater resources are 4.16 BCM after deducting the natural discharge. The Roing-Koronu block of Lower Dibang Valley district houses a maximum annual extractable groundwater resource reaching 0.46 BCM, whereas a minimum of 0.01 BCM is found in Tame Raga block under Lower Subansiri. Ground water extraction for various uses has been estimated for all the assessment units of Arunachal Pradesh. Gross annual ground water extraction for all uses is 0.02 BCM and annual groundwater allocation for domestic use up to 2025 is 0.01 BCM. Net groundwater availability for future use is 4.15 BCM. In terms of stage of groundwater extraction Ziro I block under Lower Subansari has the highest stage of groundwater extraction standing at 2.44 % and the lowest at recorded at Rumgong block under West Siang district. The overall stage of groundwater extraction in the state is 0.42 % and all the 42 assessment units in Arunachal Pradesh falls under **SAFE** category.

The Current assessment has been carried out based on revised ground water resource estimation methodology of 2015 (GEC' 2015)

1.2. Constitution of state level committee for ground water resources estimation

The State Level Committee for ground water resources estimation has been re-constituted and considered as permanent by the Government of Arunachal Pradesh and the 1st SLC meeting on GWRA 2022-2023 for Arunachal Pradesh held on 23.06.2023 **(Annexure A)**:

CHAPTER 2

HYDROGEOLOGICAL CONDITIONS OF ARUNACHAL PRADESH

2.0 DESCRIPTION OF ROCK TYPES WITH AREA COVERAGE

Hydrogeologically the state can be categorized into three units, viz-(i) Consolidated representing the crystalline formations and the (ii) Semi-consolidated and (iii) Unconsolidated units representing the Sedimentaries.

The consolidated formations (crystalline) occur along the high and moderate hill ranges of the state. These formations mostly comprise meta-sediments like gneiss and schist and fissured formations (i.e.-Phyllites, Schist, Quartzites etc.) belonging to Archean to Palaeozoic age. They act basically as run-off zone. The weathered part as well as the secondary pores developed in the form of joints, fissures etc in the consolidated formations have good ground water potential.

The semi-consolidated formations comprise the Tertiary Group of rocks represented by the Disang, Barail, Tipam, Siwalik and Dihing groups of rock. They are occupying the areas in the south and southwestern part of the state and show gradual decrease in altitude and behave as run-off, infiltration as also discharge zones. They contribute recharge to ground water depending on litho-character.

Ground water in both consolidated and semi-consolidated formations is manifested as springs. Springs in all geological formations are both seasonal and perennial in nature.

The older alluvium comprising the terrace deposits of Pleistocene and also the terrace and alluvial fan deposits of Holocene age form the unconsolidated formation. They are distributed as thin layers in intermontane valleys and with considerable thickness in open and wide valleys joining Brahmaputra Alluvial plains. Deposition shows poor sorting in distribution of grains. High or low rate of infiltration is observed depending on physical geometry and matrix of formation. Terrace types of deposits are found extending in and along the foothill zone. It is commonly referred to Bhabar belt, comprising sand, gravel, pebble and boulder. The zone contains one or more aquifers, which have fair to good ground water potential. The aquifers at places tend to be artesian in nature. Unconsolidated Quaternary and Upper Tertiary formations form the main hydrological units in the state.

2.1. Rock Types

The state constitutes rocks from Archaean to Recent. Major part is covered with consolidated crystalline rocks and meta-sediments of Precambrian and Palaeozoic times, while

Tertiary sediments consisting semi-consolidated argillaceous assemblage occupy periphery areas bordering Assam. Unconsolidated Quaternary sediments comprising Alluvium prevail in the fringe valley areas and as thin carpet in isolated structural valleys. More than 90% of the area is covered by hilly terrain.

Unconsolidated Quaternary and Upper Tertiary formations form the main hydrological units for ground water recharge in the state. Other than this, semi consolidated Lower Tertiary and Upper Paleozoic formations are important from Ground Water development point of view.

2.2 Hydrometeorological Conditions

The climate of the state is mainly influenced by orography. It is sub-tropical, wet and highly humid in nature in the foothill regions and cold in higher elevations. The temperature falls below freezing point during extremely cold period. The maximum temperature ranges from 27^{o}C and minimum winter temperature in the higher altitude goes down below freezing point. Humidity is very high. Heavy rainfall is received during summer and occasional rainfall during winter. January and February are the driest months. The rainfall received during summer is under the spell of South-West monsoon. The onset of South-West monsoon in the region occurs by the end of May or the first week of June and withdraws by late September or early October. But, very often pre-monsoon showers are experienced during March and April. Copious rainfall is received in the southern, eastern and northeastern part of the state during the summer. From March to May, the region comes under the influence of equatorial Westerlies and receives precipitation with occasional thundershowers.

The average annual rainfall in different stations of the state varies from 2000 to 5000 mm with some variation.

2.3 Description of Hydrogeological Units

The unconsolidated alluvial sediments in the valley areas act as good repositories for ground water development. Valleys adjoining Assam are most promising where good thickness of granular aquifer zones is distributed. However, physical parameters of heterogeneous aquifer sediments with variable matrix play an important role in determining permeability, transmissibility and specific capacity of aquifer zones. Intervening clay layers found with arenaceous sediments indicate leaky aquifer system. Auto-flow conditions seen at places are promoted due to high hydraulic head. In the intermontane valleys thickness of alluvium and weathered residium are important factors. Potential aquifer zones are likely to prevail Semi-consolidated Tertiary formations are likely to give moderate or poor yield and expected to be controlled by aquifer geometry and structural features.

In consolidated formations ground water potentiality appears to be very much limited. However, highly weathered, and fissured formation in pockets may offer some scope for development.

Ground water exploration studies were carried out by Central Ground Water Board (CGWB) in the state revealed that water bearing formations are observed in Unconsolidated Alluvium of Quaternary Age, Primary/Secondary porosity of semi-consolidated sandstone of Tertiary Age, Secondary porosity of granite, schist, gneiss, phyllite of Archean to Pre-Cambrian Age. Discharge of the deep tube wells varies from 1.4 m^3/hr to 54 m^3/hr while transmissivity ranges from 1.14 to 661 m^2/day. Storativity ranges from 0.35 x 10^{-3} to 6.65 x10^{-3}.

Table 2.1: Ground Water Potential in different Hydrogeological formations of Arunachal Pradesh

Formation	Lithology	Groundwater potential
Unconsolidated	sand, clay, silt, gravel, pebble, cobble and boulder	Moderate yield, 30-50m^3/hr. Drawdown within 10 to 15m.
Semi-consolidated	Shale, siltstone, sandstone, interbedded with coal seams and limestone	Low yield, up to 20m^3/hr. Drawdown within 25m.
Consolidated		
Fissured Formation	Phyllites, schist, slates, quartzites	Low yield, 5 to 15m^3/hr.
Metasediment	Gneissic complex with acid and basic intrusive	Yield up to 5m^3/hr.

2.4 Ground Water level conditions

Major part of the state, Arunachal Pradesh is hilly and monitoring stations are located along the southern boundary. The depth to water level in the pre-monsoon period is restricted to 10m. However, water levels within 5 mbgl have been recorded in most of the stations. In the post monsoon period also the depth to water level has been found within 10m. There is no significant decline in water level is observed in pre- and post-monsoon seasons.

2.5 Ground Water Quality

Analysis of water samples collected from the tube wells indicated that ground water in the area is suitable for both drinking and irrigation purposes. Almost all the constituents are within the permissible limit barring high iron concentration in some areas. Chemical analysis of Ground Water samples collected during the various studies conducted by CGWB indicate that the quality of ground water is good for domestic, industrial and agricultural use. No toxic element has been reported so far from any parts of the state.

CHAPTER 3

GROUND WATER RESOURCES ESTIMATION BY AUTOMATION

3.0. INTRODUCTION

While analyzing 2017 dynamic GW resources of India, it was felt that there is an urgent need for automation of Ground Water Resource Estimation to make the assessment frequent and effective. This will provide a common and standardized platform using GEC-2015 methodology. This includes a web-based application and its pan-India operationalization. A GEC dashboard as a final output of automation for the entire India, will be able to show all type of recharges and discharge components reflecting the overall stage of extraction at the selected Level (District, tehsil, block, Mandal, blocks, etc.). This will not only help the Decision makers to make decisions but also empower the stakeholders with knowledge to take part in the decision-making process. In this context, a project was assigned by the Ministry of Jal Shakti to IIT Hyderabad who in technical support of Vassar Labs IT Solution, Hyderabad prepared web-based software known as "INGRES" (INDIA GROUNDWATER RESOURCE ESTIMATION SOFTWARE) (http://ingres.iith.ac.in).

The GEC 2015 methodology recommends aquifer wise ground water resource assessment. Ground water resources have two components – Replenishable ground water resources or Dynamic ground water resources and in-storage resources or Static resources. GEC 2015 recommends estimation of Replenishable and in-storage ground water resources for both unconfined and confined aquifers. Wherever the aquifer geometry has not been firmly established for the unconfined aquifer, the in-storage ground water resources have to be assessed in the alluvial areas up to the depth of bed rock or 300 m whichever is less. In case of hard rock aquifers, the depth of assessment would be limited to 100 m. In case of confined aquifers, if it is known that ground water extraction is being taken place from this aquifer, the dynamic as well as in-storage resources are to be estimated.

3.1 Advantages of Automation using INGRES:

The process of automation has the following advantages

1. In-GRES is the common portal to input, estimate, analyze, and access static and dynamic groundwater resources
2. Recharge (in-fluxes) and Extraction (out-fluxes) of groundwater resources are automated.

3. Removes all the hurdles associated with manual data entry, computations, report generation, approvals, and visualization
4. In-GRES is a user-friendly software to dynamically characterize the administrative/assessment units based on GEC-2015

GEC 2015 Methodology: In-GRES software is based on GEC 2015 methodology for ground water resources estimation for 3 types of Aquifers: Unconfined Aquifer, Semi-Confined Aquifer and Confined Aquifer. The resource estimation for an Unconfined Aquifer is based on the principle of water balance:

Inflow – Outflow = Change in Storage (of an aquifer)

This equation can be further elaborated as:

$$\Delta S = RRF+RSTR+RC+RSWI+RGWI+RTP+RWCS \pm VF \pm LF - GE - T - E - B$$

Where,

ΔS – Change is storage, RRF – Rainfall recharge, RSTR – Recharge from stream channels,
RC – Recharge from canals, RSWI – Recharge from surface water irrigation,
RGWI – Recharge from ground water irrigation, RTP – Recharge from tanks & ponds
RWCS – Recharge from water conservation structures, VF – Vertical inter aquifer flow
LF – Lateral flow along the aquifer system (throughflow), GE – Ground Water Extraction
T – Transpiration, E – Evaporation and B – Base flow.

India GEC system is divided into 3 modules – Input, Computation and Output.

1. Input module – Input Module refers to the Data Entry module at an Assessment Unit level. Data Input is done via 2 methods i.e.

i) Excel based input – In this, the user needs to download District level data sheet template where he/she can fill the data at an Assessment Unit level. User now needs to upload their fully filled excel sheet into the system.

ii). Form based input – In this, the user is shown a form and he/she can fill/edit the data in data sheet in an online mode. Once user is done with editing online, he/she can Submit the data file.

2. Computation module – Computation Module refers to the ground water calculations for an assessment unit. These computations are based on GEC 2015 methodology and are used to calculate Annual Extractable Ground Water Resource, Total Current Annual Ground Water Extraction (utilization) and the percentage of ground water utilization with respect to recharge (stage of Ground Water Extraction) for an assessment unit. Based on these percentages an

assessment unit is categorized into SAFE, SEMI-CRITICAL, CRITICAL AND OVEREXPLOITED categories.

3. **Output module**: Once categorized, the data is shown in two views:

i) MIS Dashboard – MIS dashboard shows the results of the assessment for the entire India, and also State wise in tabular form. The MIS dashboard shows all type of recharges, extractions, inflows and outflows computed for both monsoon and non-monsoon periods of the year and then reflect the overall stage of extraction at the selected Geo-Zoom Level.

ii) GIS Dashboard – GIS dashboard shows the data in Web Geo-Server format, implemented in interactive GIS platform allowing user to all GEC related information in the map itself. GIS view represents the data on India map and color codes of each District/Assessment unit based on the categorization.

The important input data files containing types of data in INGRES and computed parameters using the input data are shown in Table 3.1 in abridged form.

Table 3.1: Comparison and recommendations of GEC 2015 with GEC 97

S. N	Input Data File in INGRESS	Type of Data	Parameters Computed
1	Basic data sheet	Recharge Worthy Area, Non-Recharge Worthy Area, Type of Soil, Specific Yield, Rainfall Infiltration Factor	
2	Aquifer Data	Aquifer information of the assessment unit i.e. Principal Aquifer, Major Aquifer and its code	
3	Rainfall Data File	1. Rainfall data assessment unit wise 2. Rain Gauge Data 3. IMD Grid Data 4. Time Series Data	Rainfall Recharge by Rainfall Infiltration Method (RIF)
5	Ground Water Well Data File	1. Assessment unit wise data 2. Well wise data 3. Time series data	Monsoon Rainfall Recharge by Water Level Fluctuation Method
5	Recharge Data File	1.Surface Water Irrigation – Canal Outlet 2. Surface Water Irrigation – Crop Water Requirement 3. Canal Seepages 4. Tanks & Ponds 5. Water Conservation Structures	Recharge from other sources

		6. Water Conservation Structures 7. Ground Water Irrigation	
6	Draft Data File	Domestic **(i)** Unit Draft **(ii)** Consumptive Use Method Irrigation (i) Unit Draft (ii) Power consumption Industrial (i) Unit Draft (ii) Power consumption	Groundwater extraction calculation for (i) Domestic (ii) Irrigation (iii) Industrial
7	Inflows and Outflows Data File	**1.** Base Flow **2.** Additional Base Flow **3.** Vertical inter Aquifer flow **4.** Lateral Aquifer flow **5.** Evapotranspiration **6.** Evaporation **7.** Transpiration **8.** Stream Channels	
8	Additional Potential Resources Data File	i) Shallow Water Areas ii) Flood Prone Areas iii) Spring Discharges	
9	Resources of Confined and Semi-Confined Aquifer Data File	Confined & semi-confined aquifer piezometer data	
10	Urban Area Resource – Pipelines and Sewages		

User Management: INGRES system has multi-level user to input data, trigger computations and approval to accept data and estimation of resource. In INGRES, the data validation and approval of resource computation starts from district level and ends at the Ministry level after which only the final resource is available in public domain. State, Central Ground Water Board (CGWB) and Central Level Expert Group (CLEG) act as intermediary admin in between district and Ministry. The hierarchy is as follows:

- **District Admin:** District admin will either approve district level field user input data and computations to State Admin or rejects and reverts to field user.
- **State Admin:** State admin initiate the process of resource estimation by uploading the assessment unit shape file in In-GRES. State admin also upload the Basic Data file. It either approves the data and computations to State Level Committee (SLC) for

estimation of dynamic groundwater resource of the state or rejects and reverts to district admin.

- **SLC Admin:** SLC admin after examining the resource will either approves the data and computations to CGWB admin or rejects and reverts to state admin.
- **CGWB Admin:** CGWB admin if satisfied with the computations will approve GWRE to CLEG or if not satisfied then reverts it to SLC admin.
- **CLEG Admin:** After CLEG's approval, the report moves to Ministry admin user for approval.

CHAPTER 4

GROUND WATER RESOURCES ESTIMATION IN ARUNACHAL PRADESH THROUGH INGRES

4.0 INGRES USER MANAGEMENT

The Central Ground Water Board, SUO, Itanagar in coordination with North Eastern Region, Guwahati has completed the task of uploading the shape files of assessment units, data entry, triggering computation and validation of computation at super admin level in INGRES.

4.1 Ground water assessment unit

Earlier GWRE had been carried out considering districts of Arunachal Pradesh as assessment unit which is due to non-availability of block level shape files as well as other relevant data are difficult to obtain. But to bring uniformity in the GWRE 2023 throughout the country, the permanent SLC of Arunachal Pradesh has recommended to consider block as the assessment unit in place of district. However, due to non-availability of block level shape file with the state authorities, the SLC recommended to prepare block map from the existing village level map of Govt. of India Census 2011 with a disclaimer that this block level map is prepared only for groundwater resource estimation purpose. Administrative map showing block boundary (assessment unit) is given in **Plate I**.

Out of the total geographical area of an assessment unit, hilly areas i.e. having slope > 20% (78021.62 sq.km.) are identified and subtracted from the total geographical area (83743 sq. km.) of the districts (Geographical area is as per 2011 Census) as these areas have more run-off than infiltration. Remaining 5721.38 sq. km. area is considered as recharge worthy area and accordingly ground water resource for that area is calculated. Hydrogeological map of the district showing various formations is given in **Plate II**.

4.1.1 Hilly and recharge worthy area:

The blocks that fall under the 5 hilly districts out of 16 districts, namely Upper Siang, Anjaw, Dibang Valley, Kurung Kumey and Tawang are excluded from ground water resources estimation exercise as the slope of these districts are more than 20%. There are also 28 number of blocks in the remaining 11 districts which are not considered for estimation due to its hilly nature. Recharge worthy area, i.e., areas where slope is less than 20% is very limited and restrict in the foothill parts of the state. The recharge worthy areas are found out by subtracting the hilly area from total geographical area of the assessment unit.

4.1.2 Resource Assessment for Command and Non-Command Area

Preliminary data required for resource assessment in command area are geographical boundary of the command area in an assessment unit, population under command area, season wise area cultivated, number of ground water structures etc. which are not available with State Govt. The entire recharge worthy area has been considered as non-command area. Within the assessment area in each district **"Hard rock"** and **"Soft rock"** areas are tentatively demarcated based on available map and resource for both the said areas are assessed separately for estimating dynamic and in-storage resource of the un-confined zone.

4.1.3 Poor quality area/ command and non-command area

There is no quality hazard in Arunachal Pradesh as listed in GEC 2015. Therefore, there is no assessment for poor quality area.

There is no major and medium irrigation scheme in Arunachal Pradesh and as such entire state is considered as non-command area in the present assessment.

4.2 Rainfall Recharge

Rainfall recharge is estimated in the present assessment by two prescribed methods: rainfall infiltration factor and ground water level fluctuation methods. However, ground water level fluctuation method could be used only for selected blocks of six districts, viz., Papum Pare, Lower Subansiri, East Siang, Lohit, Changlang and Tirap. There are no water level monitoring stations in remaining five districts.

Rainfall infiltration factor is used to estimate rainfall recharge by considering recommended rainfall infiltration factor of 22%. The normal rainfall data of Indian Meteorological Dept. (IMD) is readjusted for resource calculation based on minimum and maximum threshold values.

Rainfall recharge during monsoon season computed by Rainfall Infiltration Factor (RIF) method is compared with recharge calculated by Water Level Fluctuation (WLF) method to determine "**PD**" factor. When PD factor is not within the range of -20% to 20% than rainfall recharge estimated by rainfall infiltration factor method is adopted after multiplying with weightage factor of 0.8 (if >-20%) or 1.2 (if >20%). If PD factor is within a range of - 20% and +20%, rainfall recharge calculated through water table fluctuation method is adopted.

During estimation of GWRE 2023 for Arunachal Pradesh, recharge calculated through the two methods are compared. After comparison rainfall recharge estimated by water level fluctuation is adopted for Pasighat and Ruksin block of East Siang, Namsai of Lohit and Tame Raga of Lower Subansiri district.

4.2.1 Recharge During Monsoon Season

The sum of normalized monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into & out of the sub unit and stream inflows & outflows during monsoon season is the total recharge/ accumulation during monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

4.2.2 Recharge During Non-Monsoon Season

The rainfall recharge during non-monsoon season is estimated using rainfall infiltration factor Method only when the non-monsoon season rainfall is more than 10% of normal annual rainfall. The sum of non-monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into & out of the sub unit and stream inflows & outflows during non-monsoon season is the total recharge/ accumulation during non-monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

4.3 Total Annual Ground Water Recharge or Accumulation

The total annual ground water recharge is the sum-total of monsoon and non-monsoon recharge. An allowance is kept for **Environmental Flow** (un-accounted natural discharge as per GEC'97) in the non-monsoon season by deducting 5% of total annual ground water recharge, where WLF method is employed to compute rainfall recharge during monsoon season and 10% of total annual ground water recharges where RIF method is employed before getting the annual extractable ground water resource.

4.4 Annual Extractable Ground Water Resource (EGR)

The Annual Extractable Ground Water Resource (EGR) is computed by deducting the Total Annual Natural Discharge from Total Annual Ground Water Recharge.

The ground water base flow contribution limited to the ecological flow of the river should be determined which will be deducted from Annual Ground Water Recharge to determine Annual Extractable Ground Water Resources (EGR). The ecological flows of the rivers are to be determined in consultation with Central Water Commission and other concerned river basin agencies. In case base flow contribution to the ecological flow of rivers is not determined then following assumption is to be followed.

In the water level fluctuation method, a significant portion of base flow is already accounted for by taking the post monsoon water level one month after the end of rainfall. The base flow in the remaining non-monsoon period is likely to be small, especially in hard rock areas. In the assessment units, where river stage data are not available and neither the detailed data for quantitative assessment of the natural discharge are available, present practice (GEC

1997) of allocation of unaccountable natural discharges to 5% or 10% of annual recharge may be retained. If the rainfall recharge is assessed using water level fluctuation method this will be 5% of the annual recharge and if it is assessed using rainfall infiltration factor method, it will be 10% of the annual recharge. The balance will account for Annual Extractable Ground Water Resources (EGR).

4.5 Estimation of Ground Water Extraction

Ground water draft or extraction is to be assessed as follows.

$$G_{ALL} = GE_{IRR} + GE_{DOM} + GE_{IND} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

GE_{ALL} = Ground water extraction for all uses
GE_{IRR} = Ground water extraction for irrigation
GE_{DOM} = Ground water extraction for domestic uses
GE_{IND} = Ground water extraction for industrial uses

4.5.1 Ground Water Extraction for Irrigation (GE_{IRR})

The methods for estimation of ground water extraction are as follows.

Unit Draft Method: **–** In this method, season-wise unit draft of each type of well in an assessment unit is estimated. The unit draft of different types (e.g. Dug well, Dug cum bore well, shallow tube well, deep tube well, bore well etc.) is multiplied with the number of wells of that particular type to obtain season-wise ground water extraction by that particular structure.

Crop Water Requirement Method: **–** For each crop, the season-wise net irrigation water requirement is determined. This is then multiplied with the area irrigated by ground water abstraction structures. The database on crop area is obtained from Revenue records in Tehsil office, Agriculture Census and also by using Remote Sensing techniques.

Power Consumption Method: **–**Ground water extraction for unit power consumption (electric) is determined. Extraction per unit power consumption is then multiplied with number of units of power consumed for agricultural pump sets to obtain total ground water extraction for irrigation.

4.5.2 Ground Water Extraction for Domestic Use (GE_{DOM})

There are several methods for estimation of extraction for domestic use (GE_{DOM}). Some of the commonly adopted methods are described here.

Unit Draft Method: **–** In this method, unit draft of each type of well is multiplied by the number of wells used for domestic purpose to obtain the domestic ground water extraction.

***Consumptive Use Method:* –** In this method, population is multiplied with per capita consumption usually expressed in litre per capita per day (lpcd). It can be expressed using following equation

$$GE_{DOM} = Population \times Consumptive\ Requirement \times L_g \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$L_{g=}$ Fractional Load on Ground Water for Domestic Water Supply.

The Load on Ground water can be obtained from the Information based on Civic water supply agencies in urban areas.

***Consumptive Use Pattern Method:* –** In this method, water consumption of different industrial units is determined. Numbers of Industrial units which are dependent on ground water are multiplied with unit water consumption to obtain ground water extraction for industrial use.

$$GE_{IND} = Number of Industrial Units \times Unit Water Consumption \times Lg \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,

$L_{g=}$ Fractional Load on Ground Water for Domestic Water Supply.

The load on ground water for industrial water supply can be obtained from water supply agencies in the Industrial belt.

Ground water extraction obtained from different methods need to be compared and based on field checks, the seemingly best value may be adopted. At times, ground water extraction obtained by different methods may vary widely. In such cases, the value matching the field situation should be considered. The storage depletion during a season, where other recharges are negligible can be taken as ground water extraction during that particular period.

4.5.3 Stage of Ground Water Extraction

The stage of ground water extraction is defined by,

$$Stage\ of\ GW\ Extraction = Existing\ Gross\ GW\ Extraction\ for\ all\ Uses / Annual\ Extractable\ GW\ Resources \times 100 \quad \ldots\ldots\ldots\ldots (4)$$

The existing gross ground water extraction for all uses refers to the total of existing gross ground water extraction for irrigation and all other purposes. The stage of ground water extraction should be obtained separately for command areas, non-command areas and poor ground water quality areas.

4.5.4 Categorisation of Assessment Unit Based on Quantity

The categorisation based on status of ground water quantity is defined by Stage of Ground Water Extraction as given below:

Stage of Ground Water Extraction	**Category**
≤ 70%	Safe
>70% and ≤90%	Semi Critical

> 90% and ≤100%	Critical
> 100%	Over Exploited

4.5.5 Ground water extraction

Ground water extraction includes extraction for domestic, industrial and irrigation use. GEC 2015 methodology recommends following methods, i.e., unit draft method, power consumption consumptive use method and consumptive use pattern method for estimating extraction.

In the present assessment domestic extraction is calculated by consumptive use method. The data set for this estimation is Population census of 2011. As there is no input of groundwater dependency data from state government, it is calculated from village amenities part of census 2011. Dependency for each assessment unit is the ratio of number of households extracting groundwater from various sources (covered well, uncovered well, hand pump, tube well and spring) to the total number of households.

Water Resources Department, Govt. of Arunachal Pradesh has published district irrigation plan and provided data of Ground water irrigation through PMKSY. Groundwater extraction for irrigation is estimated by unit draft method.

Industrial extraction is estimated only for food and beverage industry. Central Ground Water Authority database is used for estimating the unit draft.

4.6 Recharge from Other Sources

In the present assessment only the recharge from surface water irrigation and Ground Water irrigation is considered. Surface water & Ground water irrigation data as mentioned district irrigation plan and provided by WRD, Govt. of Arunachal Pradesh is utilized in the current resource estimation.

The area irrigated by surface irrigation scheme during Kharif and Rabi seasons is considered for recharge during monsoon and non-monsoon season. Recharge from irrigation through return flow is calculated for minor irrigation only. Crop wise area brought under irrigation for monsoon and non-monsoon seasons are not available. Therefore, crop under monsoon irrigation by surface sources is considered as paddy being major crop while during non-monsoon season crops other than paddy is considered.

4.7 Inflow and Outflow Components

The inflow components are lateral flow along the aquifer system, vertical flow from hydraulically connected aquifers. Base flow, stream recharge, evaporation and transpiration are the outflow components. In the present assessment the lateral and vertical flow components

could not be determined due to lack of aquifer parameters. Base flow and stream recharge are also difficult to determine due to lack of stream gauge discharge data. Only two outflow components are determined in the present assessment, i.e. evaporation and transpiration.

Since field study results of evaporation are not available, it is considered as per guidelines of GEC 2015 that aquifer losses water through evaporation if the depth of water is within 1.0mbgl while aquifer losses water through transpiration if the depth of water is within 3.5mbgl. Evaporation and transpiration losses from aquifer are considered as zero when depth to water level is more than 1 mbgl and 3.5 mbgl respectively. Rate of evaporation is considered as 1mm/day as per guidelines. Evaporation and transpiration areas are determined from monsoon and non-monsoon depth-to-water level contour.

4.8 Allocation of Ground Water Resource for Utilization

The net annual ground water availability is to be apportioned between domestic, industrial and irrigation uses. Among these, as per the National Water Policy, 2002, requirement for domestic water supply is to be accorded priority. The ground water requirement for domestic water supply is to be kept based on projected population to 2025. The GEC' 15 methodology provides following empirical formula for allocation of ground water for domestic requirement

$$\mathbf{A = 22 * N * L_g}$$

Where,

A = Allocation for domestic in mm/year.

N = Projected Population density in assessment unit in thousands per square kilometre.

L_g= Fractional Load on ground water for domestic and industrial water supply

(≤ 1.0)

The net ground water available for future use is obtained by deducting the allocation for domestic use and current extraction for Irrigation and Industrial uses from the Annual Extractable Ground Water Recharge.

4.9 Additional Potential Recharge

Additional potential recharge is calculated as per GEC'15 methodology for water logged and shallow water table areas. Springs are not monitored regularly and systematic spring discharge data is not available for potential resource calculation.

- ✓ **Potential Resource in Water Logged and Shallow Water Table Areas:**

For calculation of potential resource, water logged and shallow water table areas has been delineated from depth to water (DTW) level map prepared from five years average pre-monsoon depth-to-water level within 5 m bgl.

CHAPTER 5

DYNAMIC GROUND WATER RESOURCES

The ground water resource estimation of the state is done on block-wise basis. Resource has been calculated for 42 blocks in 11 districts of the state. The data used for resource estimation has been collected in the year 2022-2023. Assessment of ground water resource of the state has been estimated for the year 2023.

The resource has been computed block-wise (Annexures). Rainfall recharge has been estimated by employing both Water Level Fluctuation method and Rainfall Infiltration Factor methods. However, WLF could be used for those blocks where ground water monitoring stations could be established. Presently only six districts, namely, Papum Pare, Changlang, Tirap, Lohit, Lower Subansiri and East Siang have GWMS. Sub-unit-wise computation could not be carried out due to paucity of data.

Table 5.1: Assessment unit wise Water Level data of Arunachal Pradesh of the year 2022

District	Assessment Unit	Pre monsoon WL	Post monsoon WL
PAPUM PARE	Balijan	6.38	4.77
PAPUM PARE	Doimukh	1.29	0.99
CHANGLANG	Khagam	4.74	4.18
TIRAP	Khonsa	5.55	6.44
PAPUM PARE	Kimin	0.94	0.77
LOHIT	Namsai	4.1	2.97
EAST SIANG	Pasighat	6.91	4.27
EAST SIANG	Ruksin	2.64	1.22
LOWER SUBANSIRI	Tame Raga	4.71	1.62

In the present assessment inflow and outflow components are estimated following guidelines of GEC 2015 (Fig.5.1). Total annual ground water recharge of the state is 465135.96 ham. Rainfall recharge is 317521.21 ham and recharge from other sources is 147614.75 ham. The outflow components, i.e. evaporation and transpiration together amount 4136.94 ham. Total natural discharge is 48824.76 ham. So, the annual extractable ground water resources of the state have been assessed to be 416311.2 ham.

The existing ground water extraction for all uses is 1732.83ham. Of which extraction for irrigation use is maximum. Extraction for domestic is 699.55ham and industrial extraction is 38.98 ham. Allocation of ground water for domestic use is worked out to be 757.72ham. The net ground water availability for future use is 414520.22 ham. Overall ground water extraction is less than 1%.

Table 5.2: Comparison between Ground water resources of Arunachal Pradesh (based on GEC'2015) for the current (2022-2023) and previous (2021-2022) year

S. N.	ITEM	Year of Estimation (2021-2022)	Year of Estimation (2022-2023)	Comparison
1	2	3	4	5(4 – 3)
1.	Total Annual Ground Water Recharge (Ham)	447958.02	465135.96	17177.94
	Total Natural Discharges (Ham)	41342.76	48824.76	7482
2.	Annual Extractable Ground Water Resource(HAM)	406615.26	416311.2	9695.94
	Existing Gross Extraction (HAM)	3209.20	1732.83	-1476.37
	Irrigation uses (HAM)	2330.28	994.31	-1335.97
	Domestic uses (HAM)	809.98	699.55	-110.43
3.	Industrial uses (HAM)	68.92	38.98	-29.94
4.	Stage of GW Extraction (%)	0.79	0.42	-0.37
5.	Provision for domestic (HAM)	893.48	757.72	-135.76
6	Provision for future use (HAM)	403322.57	414520.22	11197.65

From the comparison table it is observed that estimated total replenishable ground water resource as on March 2023 is more than 2022 estimate by **9695.94 ham** (or nearly 2.38%). Except extraction for irrigation, other components of GWRE show minor change mainly due to refinement of data.

ANNEXURE A

MINUTES OF THE 1ST SITTING MEETING OF STATE LEVEL COMMITTEE ON GROUND WATER RESOURCES ASSESSMENT OF ARUNACHAL PRADESH FOR THE ASSESSMENT YEAR 2022-23 AS ON MARCH 2023

Date: 23rd June 2023 **Time: 11.00 hrs.**

Meeting Platform: Online Mode

The 1st sitting of the State Level Committee (SLC) on Ground Water Resources of Arunachal Pradesh as on March 2023 was convened on 23rd June 2023 at 11.00 hrs through Online Mode.

The meeting was chaired by Ms Sadhana Deori, IAS Secretary to the Govt. of Arunachal Pradesh, Water Resource Department & Chairman of SLC. The Chairman of the SLC welcomed all the members of SLC present in the meeting. List of members attended in the meeting is enclosed as Annexure-I.

Sri Biplab Ray, Regional Director & Member Secretary, of SLC welcomed all the representative members of the SLC-2023, Arunachal Pradesh who have attended in the meeting. He highlighted that Ground Water Resources of Arunachal Pradesh has been carried out jointly by Central Ground Water Board, NER, Guwahati, and Water Resource Department (State Nodal Department), Arunachal Pradesh in coordination with other members/departments of SLC, Arunachal Pradesh.

Rajat Gupta, Asst.HG, CGWB, SUO, Naharlagun gave a detailed power point presentation on agenda items like consideration of block as an assessment unit, timeline of assessment, INGRES software, data requirement for calculating Dynamic Ground Water Resource of the year 2023. He pointed out that for more accurate estimation of ground water resource of the state, the concerned departments should provide all the required data. He also informed that 10 nos. of blocks as per 2011 census are missing in the block wise map provided by WRD, Arunachal Pradesh.

A detailed discussion on Dynamic GWRE was held where various queries were addressed. The assessment of Dynamic Ground Water Resources of Arunachal Pradesh as on March 2023 is to be completed as per the timeline of GWRE-2023. Committee members discussed in detail on the methodology GEC 2015 and constraints of non-availability of various field data etc.

Er. Likar Angu, Chief Engineer (P&D), WRD, Arunachal Pradesh informed that the available Shape Files of the Blocks have already been shared with CGWB. However, block wise collection of various data may take some more time.

Chairman of the SLC suggested to estimate GW resources of the state taking into consideration of newly created districts/blocks. She also pointed out that if estimation of GWR 2023 is carried out based on 2011 census, then GW resource status of

majority of the districts/blocks (newly created) will not be reflected. She further informed that there are 25 districts now in Arunachal Pradesh and suggested to update the report accordingly.

In reply to chairman's observation Shri B. Ray, H.O.O informed that if all the districts and block boundaries of the state along with relevant data can be provided by the state then only resource can be estimated as desired by the chairman. He also informed that the GWRE 2023 need to be completed within the stipulated time, i.e., by September 2023. Therefore, all aforesaid information needs to be shared by the state within 15th of July 2023 so that data processing can be initiated and completed in time.

Dr. DJ Khound, Scientist-D emphasised the need for a block level map based on census 2011 as 2021 census is yet to be conducted. He informed that population, dependency on groundwater is estimated using village level amenities data of census 2011. If assessment units are considered based on newly created districts/blocks after 2011 census, projection of population, estimation of dependency on GW will be difficult.

In this regard, Dr. S S Singh, Scientist-D (HG) & OIC of GWRA stressed on completing resource estimation in time by adopting block map as per 2011 census. He informed that if state government is not in a position to supply block map as per 2011 census, then a block map can be generated based on 2011 census by adopting either of the following two options:

a. The list of the villages falling in the Block as per the Local Government Directory (village map in SOI) may be used to generate the Shape File by collecting existing information from State as well as from CGWB.

b. If the Block level maps are available only in physical form, the same may be digitized and the Shape Files may be shared with CGWB.

He pointed out that these Shape Files are to be used only for the purpose of Resource assessment exercise. A standard disclaimer will be mentioned in the National Compilation of Dynamic Ground Water Resources of India-2023 to be published by CGWB. He

Chairman, SLC emphasised that data/information required for the GWRA 2023 in block level needs to need to be collected from the concerned state departments urgently. In this regard, she has instructed WRD, Arunachal Pradesh to explore the possibilities to collect latest block boundary map from the State Remote Sensing Application Centre.

The meeting ended with a vote of thanks.

Annexure-I

1ST SITTING MEETING OF STATE LEVEL COMMITTEE ON GROUND WATER RESOURCES ASSESSMENT OF ARUNACHAL PRADESH FOR THE ASSESSMENT YEAR 2022-23 AS ON MARCH 2023

List of members attended in the meeting

1. Ms Sadhana Deori, IAS, Secretary to the Govt. of Arunachal Pradesh, Water Resource Department & Chairman of SLC on GWRA
2. Sri Biplab Ray, Regional Director (i/c), CGWB, NER & Member Secretary, SLC on GWRA
3. Er. Likar Angu, Chief Engineer (P&D), Water Resource Department, Arunachal Pradesh
4. Er. G Borang, Chief Engineer (West), Water Resource Department, Arunachal Pradesh
5. Er. Modak Ngomdir, Chief Engineer (East), Water Resource Department, Arunachal Pradesh
6. Er. Taka Tapak, Chief Engineer (P & D), PHE & WS, PHED, Arunachal Pradesh
7. Sri Pallab Dey, Director, State Planning, Arunachal Pradesh
8. Sri Karbom Riram, Joint Director, Agriculture, Arunachal Pradesh
9. Dr. S S Singh, Scientist-D & OIC-GWRA, CGWB, NER, Guwahati
10. Dr, Dipjyoti Khound, Scientist-D, CGWB, NER, Guwahati
11. Sri Rajat Gupta, AHG, CGWB, SUO, Naharlagun

ANNEXURE - Block wise Ground Water Resources of Arunachal Pradesh (in Ham)

Sl. No	District	Assessment Unit (Block Name)	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/Critical/Semi-Critical/ Safe/Saline)
1	CHANGLANG	Bordumsa	8692.01076	8549.66704	14505.79	1450.58	13055.21	30.08	0	66.7657161	96.85	70.86	12954.27	0.74184942	safe
2	CHANGLANG	Changlang	56798.7519	3136.6862	12028.44	1202.84	10825.6	28.2	0	0.99768735	29.2	1.06	10796.34	0.26973101	safe
3	CHANGLANG	Diyun	14899.2299	7622.61155	14085.04	1408.5	12676.54	37.6	0	51.6598005	89.26	54.82	12584.12	0.70413536	safe
4	CHANGLANG	Khagam	244022.18	25855.1947	22424.97	2242.5	20182.47	33.84	0	52.675194	86.51	55.9	20092.74	0.42863931	safe
5	CHANGLANG	Nampong	81057.33	7835.84055	14176.67	1417.66	12759.01	24.44	0	5.42296013	29.86	5.76	12728.81	0.2340307	safe
6	EAST KAMENG	Chayangtajo	111004.841	6361.99993	4387.66	438.77	3948.89	45.3	0	4.89207675	50.19	5.68	3897.91	1.27099008	safe
7	EAST KAMENG	Pakke-Kessang	55529.0064	6151.32772	2326.08	232.61	2093.47	30.2	0	0.57338215	30.77	0.67	2062.6	1.4698085	safe
8	EAST KAMENG	Seijosa	69182.795	14737.3383	5563.45	556.34	5007.11	51.34	0	2.572812	53.91	2.99	4952.78	1.07666898	safe
9	EAST KAMENG	Seppa	51358.7011	3999.33409	3496.71	349.67	3147.04	39.26	0	5.95854105	45.22	6.92	3100.86	1.43690579	safe
10	EAST SIANG	Mebo	78432.6612	50854.2455	38271.9	3827.19	34444.71	44.5	0	19.2489941	63.75	20.08	34380.13	0.18507922	safe
11	EAST SIANG	Pasighat	29279.4802	21043.1995	17583.62	1089.93	16493.69	48.06	0	18.6605958	66.72	19.47	16426.16	0.40451833	safe
12	EAST SIANG	Ramle Bango	51639.5803	9317.14847	9593.59	1159.23	8434.36	39.16	0	7.64797275	46.81	7.98	8387.22	0.55499172	safe
13	EAST SIANG	Ruksin	45589.2631	28885.4065	19854.82	2753.29	17101.53	46.28	0	17.3764784	63.65	18.13	17037.13	0.37218892	safe
14	LOHIT	Chongkham	86456.9595	66920.4967	36930.32	3697.19	33233.13	24.8	0	41.2977279	66.1	43.56	33164.77	0.19889791	safe
15	LOHIT	Lekang_Mahadevpur	10672.6856	10620.012	7171.05	744.25	6426.8	29.45	0	61.1349998	90.59	64.49	6332.85	1.40956619	safe
16	LOHIT	Namsai	41618.2053	35190.6897	18931.92	1195.51	17736.41	26.35	8.16	96.8821106	131.39	102.19	17599.71	0.74079253	safe
17	LOHIT	Tezu	174097.334	58688.0095	32579.87	3257.99	29321.88	27.9	0.24	17.6992844	45.84	18.67	29275.07	0.15633377	safe
18	LOHIT	Wakro	208354.816	28580.7921	16666.09	1666.61	14999.48	31	0	7.7357808	38.73	8.16	14960.33	0.25820895	safe
19	LOWER DIBANG VALLEY	Dambuk	117961.546	45289.8935	33659.9	3365.99	30293.91	56.84	0	9.22528558	66.07	9.43	30227.64	0.21809664	safe
20	LOWER DIBANG VALLEY	Roing-Koronu	122994.661	74710.1065	51819.52	5181.95	46637.57	58	0	21.9816432	79.98	22.47	46557.1	0.17149264	safe

Sl. No	District	Assessment Unit (Block Name)	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	Total Annual Ground Water (Ham) Recharge	Total Natural Disharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/Critical/Semi-Critical/ Safe/Saline)
21	LOWER SUBANSIRI	Tame Raga	195220.791	2267.60995	1344.74	300.13	1044.61	10.15	0	7.30619588	17.45	9.03	1025.44	1.67047989	safe
22	LOWER SUBANSIRI	Yachuli	93518.7715	4094.29111	1937.35	193.74	1743.61	36.25	0	4.8582303	41.11	6	1701.36	2.35775202	safe
23	LOWER SUBANSIRI	Ziro I	62060.4379	3773.09894	1813.97	181.4	1632.57	30.45	0	9.45100888	39.9	11.68	1590.44	2.44399934	safe
24	PAPUM PARE	Balijan	60904.0241	3562.66992	5386.43	702.04	4684.39	27.48	0	19.604442	47.09	23.65	4633.25	1.00525362	safe
25	PAPUM PARE	Doimukh	49495.808	7651.94449	7786.94	1860.18	5926.76	25.19	29.4	70.3019675	124.89	84.8	5787.37	2.10722216	safe
26	PAPUM PARE	Kimin	52633.5901	2814.14267	4943.78	1735.28	3208.5	20.61	0	10.345049	30.96	12.48	3175.41	0.96493689	safe
27	PAPUM PARE	Sagalee	116788.892	3790.24291	5520.07	578.85	4941.22	27.48	0	1.8323657	29.31	2.21	4911.53	0.59317335	safe
28	TIRAP	Kanubari	23376.1426	2410.76808	1577.57	157.76	1419.81	6.64	0	9.9609741	16.61	10.32	1402.84	1.16987484	safe
29	TIRAP	Khonsa	61554.7024	3498.86872	2239.33	223.93	2015.4	4.98	0	5.7396834	10.72	5.95	2004.47	0.53190434	safe
30	TIRAP	Namsang	33618.923	4658.75475	2944.77	294.47	2650.3	3.32	0	13.6350605	16.96	14.13	2632.85	0.63992756	safe
31	TIRAP	Niausa	33248.7399	1931.60845	1283.59	128.36	1155.23	1.66	0	18.9736052	20.63	19.66	1133.91	1.78579157	safe
32	UPPER SUBANSIRI	Daporijo	25680.6804	320.33	7095.09	709.51	6385.58	10.56	0	1.27287545	11.83	1.59	6373.43	0.18526117	safe
33	UPPER SUBANSIRI	Dumporijo	53039.1705	379.67	7112.56	711.25	6401.31	8.8	0	2.23832235	11.04	2.8	6389.71	0.1724647	safe
34	WEST KAMENG	Dirang	191769.324	1367.98299	3831.71	383.17	3448.54	1.16	0	4.5574265	5.72	4.74	3442.64	0.16586729	safe
35	WEST KAMENG	Kalaktang	175068.906	1648.48541	3955.67	395.57	3560.1	0	0	0.797379	0.79	0.83	3559.28	0.02219039	safe
36	WEST KAMENG	Nafra	165211.402	1160.54373	3739.65	373.97	3365.68	1.16	0	1.588334	2.75	1.65	3362.87	0.08170711	safe
37	WEST KAMENG	Singchung	98915.8823	583.463443	3483.04	348.31	3134.73	0	0	3.15745623	3.15	3.28	3131.46	0.10048712	safe
38	WEST KAMENG	Thrizino	111234.486	1414.52443	3852.88	385.29	3467.59	2.32	0	1.18020925	3.5	1.23	3464.04	0.10093465	safe
39	WEST SIANG	Basar	68943.1035	2676.41624	4842.63	484.26	4358.37	14.1	0	0.3189516	14.42	0.33	4343.94	0.33085764	safe
40	WEST SIANG	Darak	74531.0147	1566.22595	4267.19	426.72	3840.47	0	0	0.16106173	0.16	0.17	3840.3	0.00416616	safe
41	WEST SIANG	Likabali	83026.8097	2980.45644	4996.41	499.65	4496.76	9.4	1.18	1.69888703	12.28	1.74	4484.44	0.27308551	safe
42	WEST SIANG	Rumgong	43265.472	3235.90136	5123.18	512.32	4610.86	0	0	0.15716718	0.16	0.16	4610.7	0.00347007	safe

ANNEXURE 1

DYNAMIC GROUND WATER RESOURCES OF Arunachal Pradesh, 2023															
Arunachal Pradesh (in BCM)															
S.NO	States / Union Territories	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for Domestic use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)
		Monsoon Season		Non-Monsoon Season		Total Annual Ground Water Recharge			Irrigation	Industrial	Domestic	Total			
		Recharge from rainfall	Recharge from other Sources	Recharge from Rainfall	Recharge from other Sources										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	ARUNACHAL PRADESH	2.11	0.66	1.06	0.81	4.65	0.49	4.16	0.01	0.0003	0.01	0.02	0.01	4.15	0.42
	Total(bcm)	2.11	0.66	1.06	0.81	4.65	0.49	4.16	0.01	0.0003	0.01	0.02	0.01	4.15	0.42

ANNEXURE 2 - District wise Ground Water Resources of Arunachal Pradesh (in Ham)

DYNAMIC GROUND WATER RESOURCES OF Arunachal Pradesh, 2023															
ARUNACHAL PRADESH (in Ham)															
S.NO	Name of District	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for Domestic use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)
		Monsoon Season		Non-Monsoon Season		Total Annual Ground Water Recharge			Irrigation	Industrial	Domestic	Total			
		Recharge from rainfall	Recharge from other Sources	Recharge from Rainfall	Recharge from other Sources										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	CHANGLANG	16679.04	23267.1	7569.09	29705.68	77220.91	7722.08	69498.83	154.16	0	177.52	331.68	188.4	69156.28	0.48
2	EAST KAMENG	8567.56	1766.35	3180.99	2259	15773.9	1577.39	14196.51	166.1	0	14	180.09	16.26	14014.15	1.27
3	EAST SIANG	58602.28	5556.8	14046.82	7098.03	85303.93	8829.64	76474.29	178	0	62.93	240.93	65.66	76230.64	0.32
4	LOHIT	62562.81	3416.79	41934.2	4365.45	112279.25	10561.55	101717.7	139.5	8.4	224.75	372.65	237.07	101332.73	0.37
5	LOWER DIBANG VALLEY	41521.92	5011.42	32545.92	6400.16	85479.42	8547.94	76931.48	114.84	0	31.21	146.05	31.9	76784.74	0.19
6	LOWER SUBANSIRI	2475.32	516.76	1442.42	661.56	5096.06	675.27	4420.79	76.85	0	21.62	98.46	26.71	4317.24	2.23
7	PAPUM PARE	8131.72	5784.91	2332.98	7387.61	23637.22	4876.35	18760.87	100.76	29.4	102.08	232.25	123.14	18507.56	1.24
8	TIRAP	5952.27	190.74	1658.41	243.84	8045.26	804.52	7240.74	16.6	0	48.31	64.92	50.06	7174.07	0.9
9	UPPER SUBANSIRI	141.52	7558.08	73.65	6434.4	14207.65	1420.76	12786.89	19.36	0	3.51	22.87	4.39	12763.14	0.18
10	WEST KAMENG	2342.96	7081.88	397.31	9040.8	18862.95	1886.31	16976.64	4.64	0	11.28	15.91	11.73	16960.29	0.09
11	WEST SIANG	4445.28	6091.03	916.74	7776.36	19229.41	1922.95	17306.46	23.5	1.18	2.34	27.02	2.4	17279.38	0.16
12	Total(Ham)	211422.68	66241.86	106098.53	81372.89	465135.96	48824.76	416311.2	994.31	38.98	699.55	1732.83	757.72	414520.22	0.42
13	Total(Bcm)	2.11	0.66	1.06	0.81	4.65	0.49	4.16	0.01	0.0003	0.01	0.02	0.01	4.15	0.42

ANNEXURE 3A

CATEGORIZATION OF BLOCKS/ MANDALS/ TALUKAS IN ARUNACHAL PRADESH (2023)												
S.No	States / Union Territories	Total No. of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1	ARUNACHAL PRADESH	42	42	100.0	-	-	-	-	-	-	-	-
	Grand Total	42	42	100.0	-	-	-	-	-	-	-	-

ANNEXURE 3B

DYNAMIC GROUND WATER RESOURCES OF ARUNACHAL PRADESH, 2023												
ARUNACHAL PRADESH												
S.No	Name of District	Total No. of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			No	%	No.	%	No.	%	No.	%	No.	%
1	CHANGLANG	5	5	100.0	-	-	-	-	-	-	-	-
2	EAST KAMENG	4	4	100.0	-	-	-	-	-	-	-	-
3	EAST SIANG	4	4	100.0	-	-	-	-	-	-	-	-
4	LOHIT	5	5	100.0	-	-	-	-	-	-	-	-
5	LOWER DIBANG VALLEY	2	2	100.0	-	-	-	-	-	-	-	-
6	LOWER SUBANSIRI	3	3	100.0	-	-	-	-	-	-	-	-
7	PAPUM PARE	4	4	100.0	-	-	-	-	-	-	-	-
8	TIRAP	4	4	100.0	-	-	-	-	-	-	-	-
9	UPPER SUBANSIRI	2	2	100.0	-	-	-	-	-	-	-	-
10	WEST KAMENG	5	5	100.0	-	-	-	-	-	-	-	-
11	WEST SIANG	4	4	100.0	-	-	-	-	-	-	-	-
12	Total	42	42	100.0	-	-	-	-	-	-	-	-

ANNEXURE 3C

ANNUAL EXTRACTABLE RESOURCE OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES, 2023												
S.No	State/Union Territories	Total Annual Extractable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%
1	ARUNACHAL PRADESH	4163.11	4163.11	100	-	-	-	-	-	-	-	-
	Grand Total (in mcm)	4163.11	4163.11	100	-	-	-	-	-	-	-	-

ANNEXURE 3D

DYNAMIC GROUND WATER RESOURCES OF ARUNACHAL PRADESH, 2023												
ARUNACHAL PRADESH												
S.No	Name of District	Total Annual Extractable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%
1	CHANGLANG	694.99	694.99	100	-	-	-	-	-	-	-	-
2	EAST KAMENG	141.97	141.97	100	-	-	-	-	-	-	-	-
3	EAST SIANG	764.74	764.74	100	-	-	-	-	-	-	-	-
4	LOHIT	1017.18	1017.18	100	-	-	-	-	-	-	-	-
5	LOWER DIBANG VALLEY	769.31	769.31	100	-	-	-	-	-	-	-	-
6	LOWER SUBANSIRI	44.21	44.21	100	-	-	-	-	-	-	-	-
7	PAPUM PARE	187.61	187.61	100	-	-	-	-	-	-	-	-
8	TIRAP	72.41	72.41	100	-	-	-	-	-	-	-	-
9	UPPER SUBANSIRI	127.87	127.87	100	-	-	-	-	-	-	-	-
10	WEST KAMENG	169.77	169.77	100	-	-	-	-	-	-	-	-
11	WEST SIANG	173.06	173.06	100	-	-	-	-	-	-	-	-
	Grand total (in mcm)	4163.11	4163.11	100	-	-	-	-	-	-	-	-

ANNEXURE 3E

AREA OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES IN ARUNACHAL PRADESH (2023)													
				Safe		Semi-Critical		Critical		Over-Exploited		Saline	
S.No	States / Union Territories	Total Geographical Area of Assessed Units (in sq km)	Recharge Worthy Area (in sq km)	Recharge Worthy Area in sq km	%	Recharge Worthy Area in sq km	%	Recharge Worthy Area in sq km	%	Recharge Worthy Area in sq km	%	Recharge Worthy Area in sq km	%
1	ARUNACHAL PRADESH	83743	5721.38	5721.38	100	-	-	-	-	-	-	-	-
	Total	83743	5721.38	5721.38	100	-	-	-	-	-	-	-	-
	Grand Total	83743	5721.38	5721.38	100	-	-	-	-	-	-	-	-

ANNEXURE 3F

DYNAMIC GROUND WATER RESOURCES OF ARUNACHAL PRADESH, 2023												
ARUNACHAL PRADESH												
			Safe		Semi-Critical		Critical		Over-Exploited		Saline	
S.No	Name of District	Total Recharge Worthy Area of Assessed Units (in sq.km)	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%
1	CHANGLANG	530.0	530.0	100.0	-	-	-	-	-	-	-	-
2	EAST KAMENG	312.5	312.5	100.0	-	-	-	-	-	-	-	-
3	EAST SIANG	1101.0	1101.0	100.0	-	-	-	-	-	-	-	-
4	LOHIT	2000.0	2000.0	100.0	-	-	-	-	-	-	-	-
5	LOWER DIBANG VALLEY	1200.0	1200.0	100.0	-	-	-	-	-	-	-	-
6	LOWER SUBANSIRI	101.35	101.35	100.0	-	-	-	-	-	-	-	-
7	PAPUM PARE	178.19	178.19	100.0	-	-	-	-	-	-	-	-
8	TIRAP	125.0	125.0	100.0	-	-	-	-	-	-	-	-
9	UPPER SUBANSIRI	7.0	7.0	100.0	-	-	-	-	-	-	-	-
10	WEST KAMENG	61.75	61.75	100.0	-	-	-	-	-	-	-	-
11	WEST SIANG	104.59	104.59	100.0	-	-	-	-	-	-	-	-
	Total	5721.38	5721.0	100.0	-	-	-	-	-	-	-	-

ANNEXURE 4A

CATEGORISATION OF ASSESSMENT UNIT, 2023							
ARUNACHAL PRADESH							
S.NO	Name of District	S.NO	Name of Semi-Critical Assessment Units	S.NO	Name of Critical Assessment Units	S.NO	Name of Over-Exploited Assessment Units

ABSTRACT			
Total No. of Assessed Units	Number of Semicritical Assessment Units	Number of Critical Assessment Units	Number of Over Exploited Assessment Units
42	0	0	0

ANNEXURE 4B

QUALITY PROBLEMS IN ASSESSMENT UNITS, 2023							
ARUNACHAL PRADESH							
S.NO	Name of District	S.NO	Name of Assessment Units affected by Fluoride	S.NO	Name of Assessment Units affected by Arsenic	S.NO	Name of Assessment Units affected by Salinity

ABSTRACT			
Total No. of Assessed Units	Number of Assessment Units affected by Fluoride	Number of Assessment Units affected by Arsenic	Number of Assessment Units affected by Salinity
0	0	0	0

Categorisation Map of Arunachal Pradesh

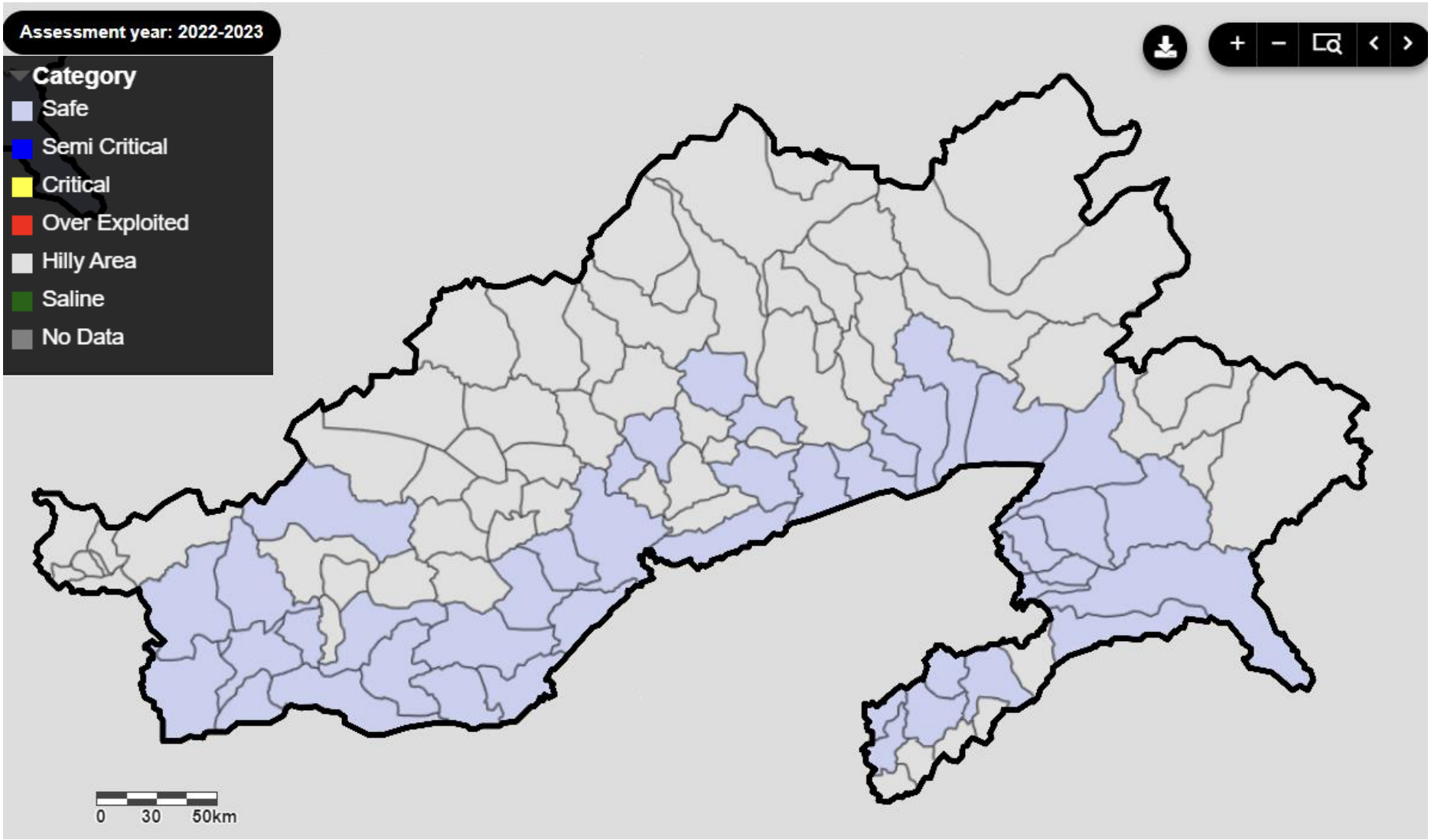


Plate I : Administrative map showing block boundary (assessment unit)

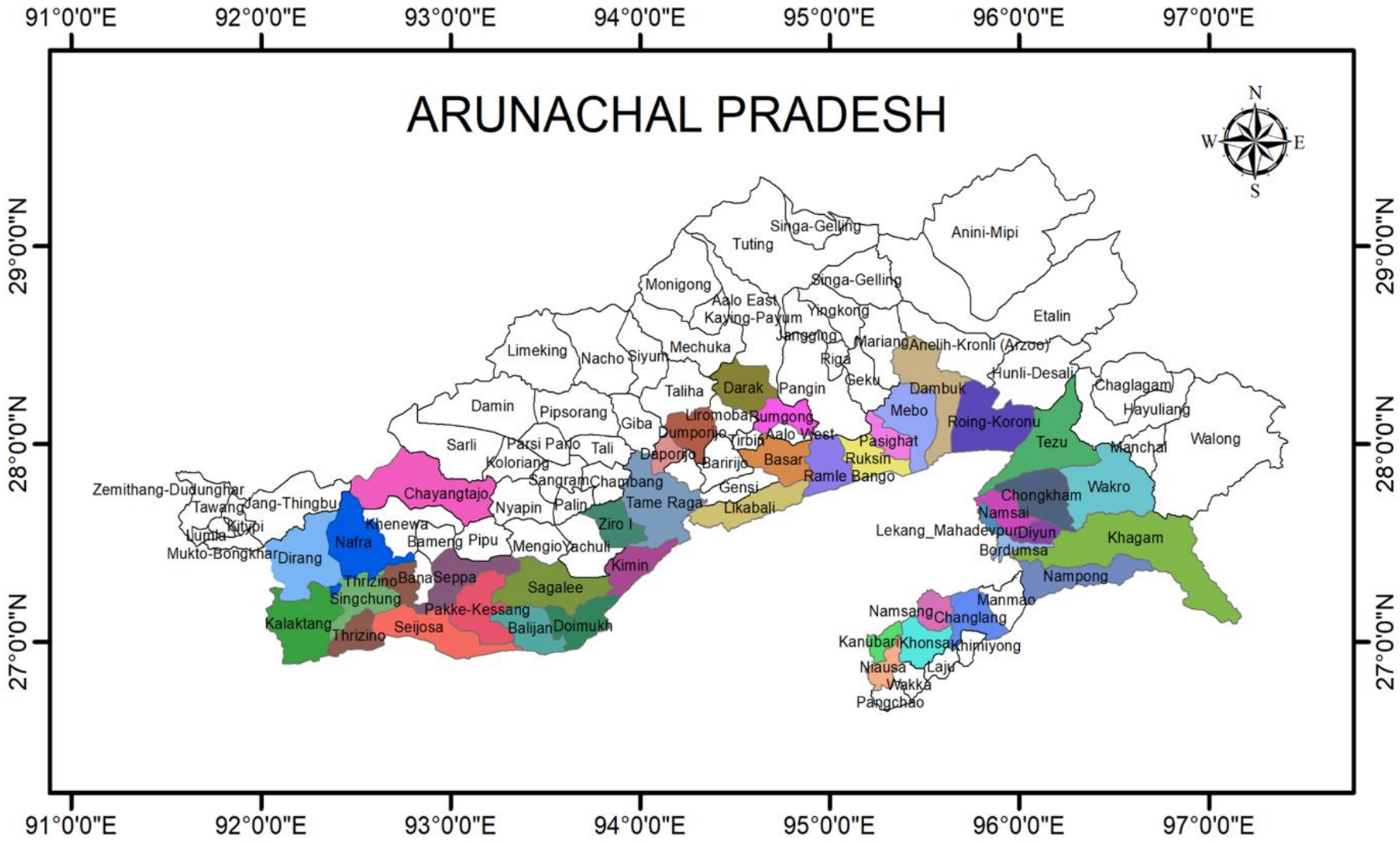
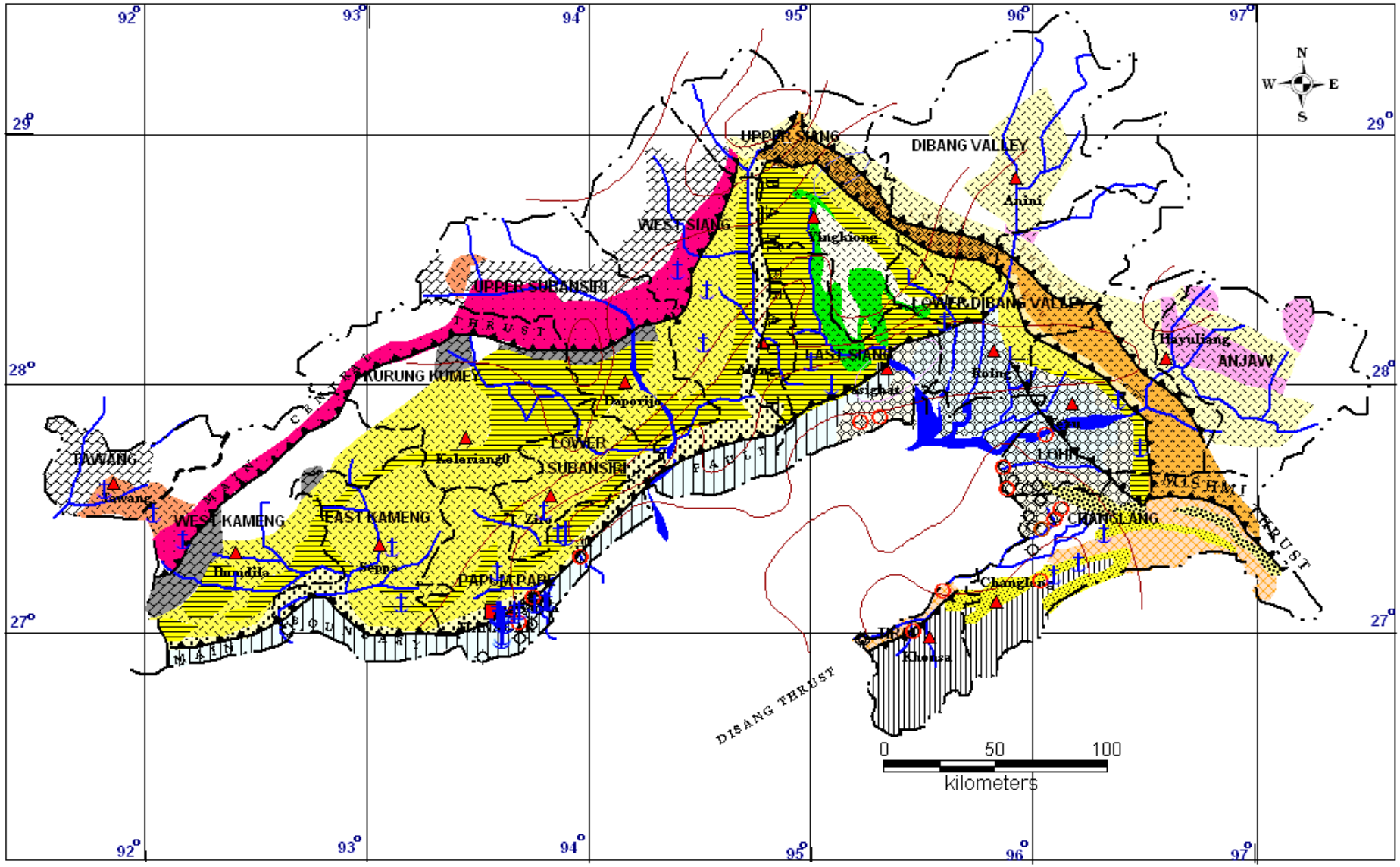


PLATE II: Hydrogeological Map of Arunachal Pradesh



Map Symbol	Description		Groundwater Potentiality
	Thrust		
	Newer Alluvium	Unconsolidated Formation	Moderate yield, 30-50m^3/hr. Drawdown within 10 to 15m.
	Older Alluvium		
	Namsang & Dihing Formations	Semi-consolidated Formation	Low yield, up to 20m^3/hr. Draw down within 25m.
	Siwalik Group		
	Surma & Naharkatia Groups		
	Barail Group	Consolidated Formation	Low yield, 5 to 15m^3/hr in fissured formation
	Disang Group		
	Yingkiong Group		
	Lower Gondwana Group		
	Dirang & Lumla Formations		
	Bomdila Group		
	Se La Group		
	Mishmi Formation		
	Tidding Formation		
	Yang Sangchu Formation		
IGNEOUS ROCKS			Yield up to 5m^3/hr in metasediments and igneous rocks
	Tertiary Tourmaline Granite		
	Lohit Granitoid		
	Abor Volcanic		
	Palaeoproterozoic		

Table 1: Rainfall (in mm)

S. No	Location Code	District	Assessment Unit	Monsoon	Non-Monsoon	Maximum threshold (in m)	Minimum threshold (10% of annual normal rainfall)	RIF
				*Normal (mm)	*Normal (mm)			
1	2	3	4	5	6	7	8	9
1	AR020300	CHANGLANG	Diyun	1690.4	909.1	2599.5	259.95	0.22
2	AR110200	LOWER SUBANSIRI	Yachuli	1276.3	860.6	2136.9	213.69	0.22
3	AR020100	CHANGLANG	Bordumsa	1690.4	909.1	2599.5	259.95	0.22
4	AR130500	PAPUM PARE	Sagalee	2408.0	928.8	3000.0	333.68	0.22
5	AR040800	EAST KAMENG	Seppa	1459.8	676.3	2136.1	213.61	0.22
6	AR130300	PAPUM PARE	Kimin	2408.0	928.8	3000.0	333.68	0.22
7	AR020200	CHANGLANG	Changlang	1690.4	909.1	2599.5	259.95	0.22
8	AR090300	LOWER DIBANG VALLEY	Roing-Koronu	1923.5	1583.5	3000.0	350.7	0.22
9	AR080400	LOHIT	Tezu	1750.1	1253.4	3000.0	300.35	0.22
10	AR020700	CHANGLANG	Nampong	1690.4	909.1	2599.5	259.95	0.22
11	AR110100	LOWER SUBANSIRI	Tame Raga	1276.3	860.6	2136.9	213.69	0.22
12	AR080300	LOHIT	Namsai	1750.1	1253.4	3000.0	300.35	0.22
13	AR180200	UPPER SUBANSIRI	Daporijo	1093.6	652.9	1746.5	174.65	0.22
14	AR190500	WEST KAMENG	Thrizino	1976.8	544.6	2521.4	252.14	0.22
15	AR160100	TIRAP	Kanubari	2510.4	949.0	3000.0	345.94	0.22
16	AR190200	WEST KAMENG	Kalaktang	1976.8	544.6	2521.4	252.14	0.22
17	AR040700	EAST KAMENG	Seijosa	1459.8	676.3	2136.1	213.61	0.22
18	AR160200	TIRAP	Khonsa	2510.4	949.0	3000.0	345.94	0.22
19	AR110300	LOWER SUBANSIRI	Ziro I	1276.3	860.6	2136.9	213.69	0.22
20	AR160400	TIRAP	Namsang	2510.4	949.0	3000.0	345.94	0.22
21	AR090100	LOWER DIBANG VALLEY	Dambuk	1923.5	1583.5	3000.0	350.7	0.22
22	AR180300	UPPER SUBANSIRI	Dumporijo	1093.6	652.9	1746.5	174.65	0.22
23	AR190100	WEST KAMENG	Dirang	1976.8	544.6	2521.4	252.14	0.22
24	AR080200	LOHIT	Lekang_Mahadevpur	1750.1	1253.4	3000.0	300.35	0.22
25	AR050100	EAST SIANG	Mebo	3397.0	1021.8	3000.0	441.88	0.22
26	AR130100	PAPUM PARE	Balijan	2408.0	928.8	3000.0	333.68	0.22
27	AR201100	WEST SIANG	Rumgong	2223.2	689.7	2912.9	291.29	0.22
28	AR050400	EAST SIANG	Ramle Bango	3397.0	1021.8	3000.0	441.88	0.22
29	AR080500	LOHIT	Wakro	1750.1	1253.4	3000.0	300.35	0.22
30	AR130200	PAPUM PARE	Doimukh	2408.0	928.8	3000.0	333.68	0.22
31	AR200700	WEST SIANG	Likabali	2223.2	689.7	2912.9	291.29	0.22
32	AR200300	WEST SIANG	Basar	2223.2	689.7	2912.9	291.29	0.22
33	AR200400	WEST SIANG	Darak	2223.2	689.7	2912.9	291.29	0.22
34	AR020400	CHANGLANG	Khagam	1690.4	909.1	2599.5	259.95	0.22
35	AR190300	WEST KAMENG	Nafra	1976.8	544.6	2521.4	252.14	0.22
36	AR080100	LOHIT	Chongkham	1750.1	1253.4	3000.0	300.35	0.22
37	AR050300	EAST SIANG	Pasighat	3397.0	1021.8	3000.0	441.88	0.22
38	AR160500	TIRAP	Niausa	2510.4	949.0	3000.0	345.94	0.22
39	AR040500	EAST KAMENG	Pakke-Kessang	1459.8	676.3	2136.1	213.61	0.22
40	AR040300	EAST KAMENG	Chayangtajo	1459.8	676.3	2136.1	213.61	0.22
41	AR190400	WEST KAMENG	Singchung	1976.8	544.6	2521.4	252.14	0.22
42	AR050600	EAST SIANG	Ruksin	3397.0	1021.8	3000.0	441.88	0.22