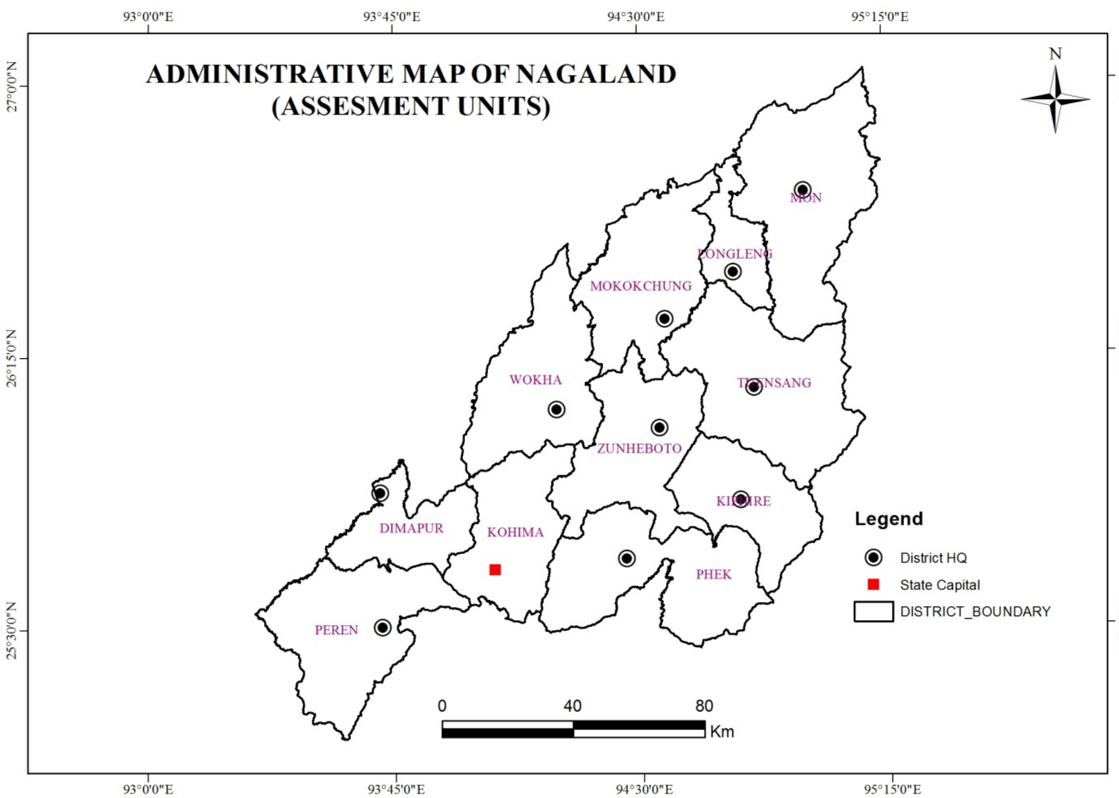
DYNAMIC GROUND WATER RESOURCES OF NAGALAND, 2022



CENTRAL GROUND WATER BOARD
NORTH EASTERN REGION
GUWAHATI
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Prepared by

Central Ground Water Board
North Eastern Region, Guwahati

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PREFACE

The State of Nagaland, situated in the Northeast of India, comprises of hilly terrain bordered in parts of the west by low lying, alluvial tracts adjoining the State of Assam. It has three neighbouring states, Arunachal Pradesh on north, Assam on west and Manipur on south. The State is located in the northern extension of the ArakanYoma ranges representing orogenic upheavals in this part of the country during Cretaceous and Tertiary periods. The state is largely a hilly region and the highest mountain in the state is Saramati which is 3841 m above mean sea level.

Nagaland has large multicoloured hilly terrain in the north eastern part of India. The hills are steep and are separated by rivers which flow either to the east orwest creating deep gorges between the hill ranges. Inspite of good rainfall in the state, the major part of rainfall is lost as surface run-off except Dimapur valley. Hence, there is acute shortage of water during the summer. The prominent sources of water are streams, small rivers, springs and nallas which also act as main contributors to the ground water storage. There is necessity to assess the ground water resource potential of the state periodically for scientific planning of its development. Keeping this objective in view, the ground water resource potential of Nagaland has been reassessed based on 'Ground Water Resource Estimation Methodology – 2015' (GEC'15).
This report presents the Dynamic Ground Water Resources of Nagaland estimated based on GEC'2015 in web based IN-GRESS software with base year as 2020. The present assessment has been done for eleven districts. The annual extractable groundwater resources is 1.95 BCM, of which annual allocation for domestic needs up to 2025 is 0.02 BCM and 1.93 BCM is available for irrigation and other uses. Present stage of ground water extraction in the state is only 1.04%.

The estimation of dynamic groundwater resources for Nagaland was jointly done by the Directorate of Geology and Mining, Govt. of Nagaland and Central Ground Water Board, North Eastern Region. The efforts made by the scientists of Central Ground Water Board, North Eastern Region, Guwahati and Directorate of Geology and mining, Govt of Nagaland are commendable.
I firmly believe that the report will throw light on the Future Ground Water Availability for various uses including irrigation and domestic sectors and 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 Nagaland.

(Suresh Chandra Kapil)
REGIONAL DIRECTOR
CGWB, NER, GUWAHATI

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CHAPTER: 1

INTRODUCTION

1.1 Background for re estimating the Ground Water Resources of Nagaland State

Groundwater is an important resource for meeting the water requirements for irrigation, domestic and industrial uses. The groundwater is available in the zone of water level fluctuation which is active recharge zone and replenished annually, i.e., dynamic as well as in the deeper zone below the water level fluctuation i.e., in in-storage condition. The dynamic groundwater resources, which are being used regularly, are reflected in the fluctuation of water levels. Apart from this, there are huge groundwater reservoirs in the deeper zones below the active recharge zone and in the confined aquifers in the areas covered by alluvial sediments of river basins, coastal and deltaic tracts constituting the unconsolidated formations and productive fracture zones in hard rock areas. The in-storage groundwater resource can be considered for development only during the period of extreme drought condition, and that too probably only to meet drinking water supply.

The previous assessment of groundwater resources of Nagaland was carried out as on March 2020. The groundwater resource of the state of Nagaland as on March 2022 has been re-assessed based on the new methodology, i.e., 'Ground Water Estimation Methodology', 2015 (GEC 2015) and modified database. Dynamic Ground Water Resource of Nagaland was automated through IN-GRES software (India Groundwater Resources Estimation System), a software/web-based application developed by CGWB in collaboration with Vassar Lab, IIT-Hyderabad.

The Annual extractable ground water resource was worked out as 70,693.74 Ham**.** The current gross ground water extraction for all uses was estimated as 2,044.19 Ham and the Stage of Ground Water Development was 2.89%.

1.2 Constitution of State Level Committee

The State Level Committee for re-estimation ground water resources as on March 2022 has been constituted by the Nagaland State Government vide notification NO. GM-25/CGW-1/2010, dated; 20.01.2022 (Annexure- I).

CHAPTER: 2

HYDROGEOLOGICAL CONDITIONS OF NAGALAND

2.1 Description of rock types

Geologically the state is covered by rocks ranging in age from Pre-Cretaceous to Recent. The rock sequences comprise the geosynclinal facies, represented by the Disang Group, the Barail Group, the Surma Group, the Tipam Group, the Namsang formation and the Dihing Group. While the Disang and Surma Group of rocks are mainly argillaceous, the Barail and Tipam groups are arrenacious. The Girujan clay formation overlying the Tipam sandstones is characterised by typical blue, mottled clay and argillaceous sand stone beds. Older rocks occupy southern parts of the State whereas younger rocks are exposed in the northern parts. Narrow, intermontane and open valleys are found to occur in part bordering Upper reaches of Brahmaputra flood plains of Assam. The valleys are mostly structurally controlled. Rock types found in valley areas comprise clay, sand pebble, cobble and boulder assemblages of unconsolidated nature.

The consolidated formations are confined to the south eastern part of the State along the Burma (Myanmar) border and the unconsolidated alluvial plains in the northern part of the state.

2.2 Hydrometeorological Conditions

The state of Nagaland enjoys sub-tropical humid climate with maximum temperature upto 38^{o} C and minimum winter temperature goes down to 2.2^{o} C. Humidity is very high ranging from 74 to 87%. Nagaland experiences the influence of the South West Tropical monsoon which persists from May to September, with occasional winter showers. The average annual rainfall of the state is recorded to be 1738 mm. The average number of rainy days in the state is around 135 days, varying from 60 to 190 days.

2.3 Ground Water conditions

Investigations carried out by CGWB shows that ground water development potentiality in valley fill and alluvial deposits are restricted to construction of open wells having depth of 15 to 20 metres and deep tube well down to 100 m depth which can give yield ranging from $10m^3$/day to 45 m^3/day with more than 5 m drawdown. Water bearing formations pertaining to Tertiary deposits are found to have moderate potentials which can sustain deep tube wells having yield prospects varying from 10 to 20 m^3/hr. The valleys underlain by Tipam sandstones form good aquifers with yield prospects varying from 30 to 80 m^3/hr. In the consolidated formations, ground water abstraction structures can be constructed in structurally weak zones.

Ground water at deeper levels is found to occur under semi-confined to confined conditions. Auto flow zones have also been identified in some parts of the state. Ground water emerges as perennial springs which are the main source of water supply for domestic needs in the state.

Exploration carried out by CGWB infers that yield potential of deep tube well in the valley fill and alluvial formations ranges from 3 to 62 m^3/hr for considerable drawdown. The transmissivity ranges from 9 m^2/day to more than 300 m^2/day and permeability range varies from 0.4 m/day to 5 m/day.

Hydrogeological studies conducted by the CGWB infer that the deep tube wells can be constructed in alluvial, valley fill deposits and structurally weak zones of the semi-consolidated and consolidated formations. Development of perennial springs and providing storage for better supply can be adopted in the hilly areas.

2.4 **Ground water quality**

Ground water in general is good and can be used for irrigation, drinking and other purposes. In valley areas in some localities iron content exceeds drinking water quality permissible limit and needs treatment before use.

CHAPTER 3

GROUND WATER RESOURCES ESTIMATION METHODOLOGY, 2015

Ground water resources assessment of the state was done based on the recommendations of Ground Water Estimation Committee – 2015 (GEC'15) as on March 2022.

The revised methodology GEC 2015 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 300m whichever is less. In case of hard rock aquifers, the depth of assessment would be limited to 100m. 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. If it is firmly established that there is no ground water extraction from this confined aquifer, then only in-storage resources of that aquifer has to be estimated.

3.1 Periodicity of assessment

Keeping in view of the rapid change in ground water extraction, the GEC 2015 recommends that the resources should be assessed once in every three years. In addition, there will be an estimation of ground water extraction after the second year of each assessment.

3.2 Ground water assessment unit

This methodology recommends aquifer wise ground water resource assessment. An essential requirement for this is to demarcate lateral as well as vertical extent and disposition of different aquifers. A watershed with well-defined hydrological boundaries is an appropriate unit for ground water resource estimation if the principal aquifer is other than 44 alluvium. Ground water resources worked out on watershed as a unit, may be apportioned and presented on administrative units (block/taluka/mandal/ firka). This would facilitate local administration in planning of ground water management programmes. Areas occupied by unconsolidated sediments (alluvial deposits, aeolian deposits, coastal deposits etc.) usually have flat topography and demarcation of watershed boundaries may be difficult in such areas. Even if the demarcation is done, this may lead to trans boundary movement of ground water because of excessive pumping in one of the watersheds. Until Aquifer Geometry is established on appropriate scale, the existing practice of using watershed in hard rock areas and blocks/mandals/ firkas in soft rock areas may be continued.

3.3 Ground water assessment sub-units

It is recommended that ground water recharge may be estimated for the entire assessment unit. Out of the total geographical area of the unit, hilly areas wherever slope is greater than 20% are to be identified and subtracted as these areas have more runoff than infiltration. The hilly areas wherever slope is more than 20% may be demarcated using DEM data and geomorphological maps. This would allow the valleys, terraces, plateaus occurring within >20% slope zone to be considered for recharge computations. It is quite likely that with hilly areas, densely forested area may also be excluded; this may affect to some extent ground water losses caused due to transpiration by deep rooted trees in the area of assessment. Apart from this it is also important that the areas where the quality of ground water is beyond the usable limits (for drinking water in particular) in terms of salinity is to be identified and handled separately. This methodology recommends that after the assessment is done, a quality flag may be added to the assessment unit for parameters salinity, fluoride and arsenic.

In inhabited hilly areas, where surface and sub-surface runoff is high and generally water level data is missing, it is difficult to compute the various components of water balance equation. Hence, it is recommended that wherever spring discharge data is available, the same may be assessed as a proxy for 'ground water resources' in hilly areas. The assessment of spring discharge would constitute the 'replenishable potential ground water resource' but it will not be accounted for in the categorization of ground water assessment, at least not in the near future.

The ground water resource beyond the permissible quality limits in terms of the salinity has to be computed separately. The remaining area after excluding the area with poor ground water quality is to be delineated as follows:

(a) Non-command areas which do not come under major/medium surface water irrigation schemes. (command area <100 Ha in the assessment unit should be ignored)

(b) Command areas which come under major/medium surface water irrigation schemes which are actually supplying water (>100 Ha of command area in the assessment unit.)

It is proposed to have all these areas of an assessment unit in integer hectares to make it national database with uniform precision.

3.4 Ground water resources of an assessment unit

The ground water resources of any assessment unit is the sum of the total ground water availability in the principal aquifer (mostly unconfined aquifer) and the total ground water availability of semi-confined and confined aquifers existing in that assessment unit. The total ground water availability of any aquifer is the sum of dynamic ground water resources and the in-storage or static resources of the aquifer.

3.5 Methodology for calculation

3.5.1. Ground water assessment of unconfined aquifer:

As mentioned earlier, assessment of ground water includes assessment of dynamic and in-storage ground water resources. The development planning should mainly depend on dynamic resource only as it gets replenished every year. Changes in static or in-storage resources reflect impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper recharge planning in the succeeding excess rainfall years.

3.5.2. Assessment of annually replenishable or dynamic ground water resources:

The methodology for ground water resources estimation is based on the principle of water balance as given below –

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

Equation 1 can be further elaborated as -

$$\Delta S = R_{RF} + R_{STR} + R_C + R_{SWI} + R_{GWI} + R_{TP} + R_{WCS} \pm VF \pm LF - GE - T - E - B$$

Where,

ΔS – Change is storage

Inflow:

Recharge from Rainfall (Main source)

R_{RF} – Rainfall recharge

Recharge from other sources (Command and non command area)

R_{STR}- Recharge from stream channels

R_C– Recharge from canals

R_{SWI} – Recharge from surface water irrigation

R_{GWI}- Recharge from ground water irrigation
R_{TP}- Recharge from Tanks& Ponds
R_{WCS} – Recharge from water conservation structures
VF – Vertical inter aquifer flow
LF- Lateral flow along the aquifer system (throughflow)

Outflow:
GE-Ground Water Extraction
T- Transpiration
E- Evaporation
B-Base flow

3.5.3. Rainfall recharge

It is recommended that ground water recharge should be estimated on ground water level fluctuation and specific yield approach since this method takes into account the response of ground water levels to ground water input and output components. This, however, requires adequately spaced representative water level measurement for a sufficiently long period. It is proposed that there should be at least three spatially well distributed observation wells in the assessment unit, or one observation well per 100 sq. Km.

Water level data should also be available for a minimum period of 5 years (preferably 10years), along with corresponding rainfall data. Regarding frequency of water level data, two water level readings, during pre and post monsoon seasons, are the minimum requirement. It would be ideal to have monthly water level measurements to record the peak rise and maximum fall in the ground water levels. In units or subareas where adequate data on ground water level fluctuations are not available as specified above, ground water recharge may be estimated using rainfall infiltration factor method only. The rainfall recharge during non-monsoon season may be estimated using rainfall infiltration factor method only.

3.5.3.1. Ground water level fluctuation method

The ground water level fluctuation method is to be used for assessment of rainfall recharge in the monsoon season. The ground water balance equation in non-command areas is given by
$\Delta S= R_{RF}+R_{STR}+R_{SWI}+R_{GWI}+R_{TP}+R_{WCS}\pm VF \pm LF -GE-T-E-B$
Where,
ΔS – Change is storage
R_{RF} – Rainfall recharge
R_{STR} - Recharge from stream channels
R_{SWI} – Recharge from surface water irrigation (Lift Irrigation)
R_{GWI} - Recharge from ground water irrigation
R_{TP} - Recharge from tanks& ponds
R_{WCS} – 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
B-Base flow
Whereas the water balance equation in command area will have another term i,e,
Recharge due to canals (RC) and the equation will be as follows:
$\Delta S= R_{RF}+R_{STR}+R_{C}+R_{SWI}+R_{GWI}+R_{TP}+R_{WCS}\pm VF \pm LF -GE-T-E-B$
The change in storage can be estimated using the following equation:

$$\Delta S = \Delta h * A * SY$$

Where

ΔS – Change is storage

($\Delta S = R_{RF}+R_{STR}+R_{SWI}+R_{GWI}+R_{TP}+R_{WCS} \pm VF \pm LF - GE - T - E - B$)

Δh - rise in water level in the monsoon season

A - area for computation of recharge

Sy - Specific Yield

Hence,

$R_{RF}= h \times Sy \times A - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B$

$R_{RF}= h \times Sy \times A - R_{STR} - R_{C} - R_{SW}I - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B$

Normalization of Recharge due to rainfall during Monsoon season

Two methods as proposed by GEC 1997 can be employed

- Y=mx
- Y=mx+c equation

3.5.3.2 Rainfall Infiltration Factor method

The rainfall recharge estimation based on Water level fluctuation method reflects actual field conditions since it takes into account the response of ground water level. However the ground water extraction estimation included in the computation of rainfall recharge using water level fluctuation approach is often subject to uncertainties. Therefore, it is recommended to compare the rainfall recharge obtained from water level fluctuation approach with that estimated using rainfall infiltration factor method. Recharge from rainfall is estimated by using the following relationship –

$R_{rf} = R_{FIF} * A * (R - a)/1000$

Where,

R_{rf}= Rainfall recharge in ham

A = Area in Hectares

R_{FIF} = Rainfall Infiltration Factor

R = Rainfall in mm

a = Minimum threshold value above which rainfall induces ground water recharge in mm.

It is suggested that 10% of Normal annual rainfall may be taken as minimum rainfall threshold and 3000 mm as maximum rainfall limit. While computing the rainfall recharge, 10% of the normal annual rainfall is to be deducted from the monsoon rainfall and balance rainfall would be considered for computation of rainfall recharge. The same recharge factor may be used for both monsoon and non-monsoon rainfall, with the condition that the recharge due to non-monsoon rainfall may be taken as zero, if the normal rainfall during the non monsoon season is less than 10% of normal annual rainfall. In using the method based on the specified norms, recharge due to both monsoon and non monsoon rainfall may be estimated for normal rainfall, based on recent 30 to 50 years of data.

3.5.4. Recharge from other Sources

Recharge from other sources constitutes recharges from canals, surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures in command areas where as in non-command areas it constitutes the recharge due to surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures are possible.

3.5.4.1 Recharge from Canals:

Recharge due to canals is to be estimated based on the following formula:

R_C=WA * SF * Days

Where:

R_C= Recharge from Canals

WA=Wetted Area = Wetted Perimeter X Length of Canal Reach.
SF= Seepage Factor
Days= Number of Canal Running Days.

3.5.4.2 Recharge from Surface Water Irrigation:

Recharge due to applied surface water irrigation, either by means of canal outlets or by lift irrigation schemes is to be estimated based on the following formula:

R_{SWI} =AD*Days*RFF

Where:

R_{SWI} = Recharge due to applied surface water irrigation
AD= Average Discharge
Days=Number of days water is discharged to the Fields
RFF= Return Flow Factor

3.5.4.3 Recharge from Ground Water Irrigation:

Recharge due to applied ground water irrigation is to be estimated based on the following formula:

R_{GWI} =GEIRR*RFF

Where:

R_{GWI} = Recharge due to applied ground water irrigation
GEIRR= Ground Water Extraction for Irrigation
RFF= Return Flow Factor

3.5.4.4 Recharge due to Tanks & Ponds:

Recharge due to Tanks &Ponds is to be estimated based on the following formula:

RTP =AWSA*N *RF

Where:

RTP = Recharge due to Tanks & Ponds
AWSA= Average Water Spread Area
N=Number of days Water is available in the Tank/Pond
RF= Recharge Factor

3.5.4.5 Recharge due to Water Conservation Structures:

Recharge due to Water
Conservation Structures is to be estimated based on the following formula:

RWCS =GS*RF

Where:

RWCS = Recharge due to Water Conservation Structures
GS= Gross Storage = Storage Capacity multiplied by number of fillings.
RF= Recharge Factor

3.6. Evaporation and transpiration

It is recommended to compute the evaporation through field studies. If field studies are not possible, for areas with water levels within 1.0mbgl, evaporation can be estimated using the evaporation rates available for other adjoining areas. If depth to water level is more than 1.0mbgl, the evaporation losses from the aquifer should be taken as zero. Transpiration through vegetation can be estimated if water levels in the aquifer are within the maximum root zone of the local vegetation. Even though it varies from place to place depending on type of soil &vegetation, in the absence of field studies the following estimation can be followed. If water levels are within 3.5m bgl, transpiration can be estimated using the transpiration rates available for other areas. If it is greater than3.5m bgl, the transpiration should be taken as zero.

3.7 Total ground water recharge
The sum of the recharge/ accumulations during monsoon and non-monsoon seasons is the total annual ground water recharge/ accumulations for the sub unit.

3.7.1 Recharge/ Accumulations 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.

3.7.2 Recharge/ Accumulations 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.

3.8 Annual extractable ground water resource (EGR)
The Total Annual Ground Water Recharge cannot be utilised for human consumption, since ecological commitments need to be fulfilled, before the extractable resources is defined. The National Water Policy, 2012 stresses that the ecological flow of rivers should be maintained. Therefore, 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.

EGR= TAGWR-B
Where,
ERG= Annual Extractable Ground Water Recharge
TAGWR= Total Annual Ground Water Recharge
B= Base Flow
(5% or 10% of annual recharge)

3.9 Estimation of ground water extraction
Ground water draft or extraction is to be assessed as follows.

$GE_{ALL} = GE_{IRR} + GE_{DOM} + GE_{IND}$

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

3.9.1 Ground Water Extraction for Irrigation (GEIRR)
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 (eg. 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.
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.

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

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 X Consumptive Requirement X Lg 24
Where,
Lg = 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.

3.9.3 Ground water Extraction for Industrial use (GEIND):

Unit Draft Method: In this method, unit draft of each type of well is multiplied by the number of wells used for industrial purpose to obtain the industrial ground water extraction.
Consumptive Use Pattern Method: In this method, water consumption of different industrial units is determined. The number 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 X Unit Water Consumption X Lg 25
Where,
Lg = Fractional load on ground water for industrial water supply
The load on ground water for industrial water supply can be obtained from water supply agencies in the Industrial belt.

3.10 Stage of ground water extraction

The stage of ground water extraction is defined by,

$$\text{Stage of Ground Water Extraction (\%)} = \frac{\text{Existing gross ground water extraction for all uses}}{\text{Annual Extractabl e Ground water Resources}} \times 100$$

3.11 Validation of stage of ground water extraction

The estimation of ground water extraction is likely to be associated with considerable uncertainties as it is based on indirect assessment using factors such as electricity consumption, well census and area irrigated from ground water. Annual Extractable Ground Water Resources also has uncertainties due to limitations in the assessment methodology, as well as uncertainties in the data. In view of this, it is desirable to validate the 'Stage of Ground Water Extraction' with long term trend of ground water levels.

SOGWE	Ground Water Level Trend	Remarks
$\leq$70%	Significant decline in trend in both pre-monsoon and post-monsoon	Not acceptable and needs reassessment
>100%	No significant decline in both pre-	Not acceptable and

	monsoon and post-monsoon long term trend	needs reassessment

Categorization of Assessment Units

Stage of Ground Water Extraction	Category
≤70%	Safe
>70%and ≤90%	Semi-Critical
>90%and ≤100%	Critical
> 100%	Over Exploited

Categorisation of Assessment Units Based on Quality

Sub unit	Category
Command	Fresh
Non command	Fresh
Poor ground water quality- Salinity	Poor-Salinity hazard
Poor ground water quality- Fluoride	Poor-Flouride hazard
Poor ground water quality- Arsenic	Poor-Arsenic hazard

3.12 Allocation of ground water resource for utilization

Alloc = 22 * N * L_g mm per year

Where

Alloc=Allocation for domestic water requirement

N = population density in the unit in thousands per sq. km.

Lg = fractional load on ground water for domestic water supply (≤1.0)

3.13 Net annual ground water availability for future use

The 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.

3.14 Additional potential resources under specific conditions

3.14.1 Potential Resource Due to Spring Discharge:

The spring discharge is equal to the ground water recharge minus the outflow through evaporation and evapotranspiration and vertical and lateral sub-surface flow. Thus, Spring Discharge is a form of 'Annual Extractable Ground Water Recharge'. It is a renewable resource, though not to be used for Categorization.

Potential ground water resource due to springs (PRS) = Q x No of days

Where

Q= Spring Discharge

No of days= No of days spring yields

3.14.2 Potential Resource in Waterlogged and Shallow Water Table Areas:

In the area where the ground water level is less than 5m below ground level or in waterlogged areas, the resources up to 5m below ground level are potential and would be available for development in addition to the annual recharge in the area. It is therefore recommended that in such areas, ground water resources may be estimated up to 5m bgl only assuming that where water level is less than 5m bgl, the same could be depressed by pumping to create space to receive recharge from natural resources.

Potential ground water resource in shallow water table areas = (5-D) * A * SY

Where,

D = Depth to water table below ground surface in pre-monsoon period in shallow aquifers.

A = Area of shallow water table zone.

S_Y = Specific Yield

3.14.3 Potential Resource in Flood Prone Areas:

Ground water recharge from a flood plain is mainly the function of the following parameters-

- Areal extent of flood plain
- Retention period of flood
- Type of sub-soil strata and silt charge in the river water which gets deposited and controls seepage

Since collection of data on all these factors is time taking and difficult, in the meantime, the potential resource from flood plain may be estimated on the same norms as for ponds, tanks and lakes. This has to be calculated over the water spread area and only for the retention period using the following formula.

Potential ground water resource in Flood Prone Areas = 1.4 *N * A/1000

Where

N = No of Days Water is Retained in the Area

A = Flood Prone Area

CHAPTER: 4

PROCEDURES FOLLOWED IN THE PRESENT ASSESSMENT

4.1 Ground water assessment unit

This methodology recommends aquifer wise ground water resource assessment. An essential requirement for this is to demarcate lateral as well as vertical extent and disposition of different aquifers. Aquifer wise resource assessment of the state of Nagaland is not possible due to unavailability of adequate data.

Also as per the recommendations Ground water resources worked out on watershed as a unit, is to be apportioned and presented on administrative units (block/taluka/mandal/ firka) but the required block level information is not available for the state for the assessment of resources ob block level. At present there are 16 districts in Nagaland but due to paucity of data reassessment of ground water resources as on March 2022, only 11 districts (as per census 2011) has been considered as assessment units. The areas having a slope of more than 20% are identified and subtracted from the total geographical area (area as per 2011 census) of the district as these areas have more runoff than infiltration. The remaining area of each district is considered as recharge worthy area and accordingly ground water resource for that area in each district is calculated.

4.2 Resource Assessment for Command and Non command area

It is recommended that ground water recharge may be estimated for the entire assessment unit. Out of the total geographical area of the unit, hilly areas wherever slope is greater than 20% are to be identified and subtracted as these areas have more runoff than infiltration. The hilly areas wherever slope is more than 20% may be demarcated using SRTM-DEM data and geomorphological maps.

4.3 Resource Assessment for poor Water Quality Area

No poor ground water quality zone has been demarcated in the state.

4.4 resource assessment for Unconfined and confined aquifer

4.5 Ground water extraction:

As per GEC'15 methodology Ground water draft is renamed as ground water extraction. Gross ground water extraction includes ground water extraction from all existing ground water structures from irrigation and domestic uses and from industrial uses both during monsoon and non monsoon season.

4.5.1 Domestic extraction:

The domestic draft for the state of Nagaland has been calculated as per data and information on drinking water status in rural from 2011 census.

4.5.2 Irrigation extraction:

The total number of irrigation structures is taken from 5th Minor Irrigation Census, Nagaland (2013-2014).

4.5.3 Industrial extraction:

The district wise average unit draft for industries is calculated from ground water extraction demand placed by various industries for issuance of no objection certificate (NOC) from Central Ground Water Authority. The industrial draft has been calculated only for Dimapur and Kohima districts since data is available only for these two districts.

4.6 Ground water Recharge

The resources assessment during monsoon season is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying water level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. During non-Monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-Monsoon recharge. In case of areas receiving less than 10% of the annual rainfall during non-monsoon season, the rainfall recharge is ignored.

4.7 Total annual ground water recharge or accumulation

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

4.8 Stage of ground water development & Categorization of units

The stage of Ground water Development is defined by,

$$\text{Stage of Ground water Development (\%)} = \frac{\text{Existing Gross Ground water Draft for all uses}}{\text{Net annual Ground water Availability}} \times 100$$

Water level data is available only for the district Dimapur but the results could not be validated using water level fluctuation method because the data is not continuous.

4.9 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, 2012, 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 kilometer.

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 for spring discharge could not be calculated as requisite data like spring discharge/number of days running is not available.

CHAPTER: 5

COMPUTATION OF GROUND WATER RESOURCES ESTIMATION AS ON MARCH 2022

5.1 Total Resources of the state

The total annual ground water recharge in the state of Nagaland is 78,548.63 Ham. The Annual extractable ground water resource of the state worked out to be 70,693.74 Ham after deducting the natural discharge during non-monsoon season. Current annual gross ground water extraction for all uses is 2,044.19 Ham. The Net Ground water availability for future use is estimated to be 68,530.17 Ham.

5.2 Spatial variation of resources

The over-all stage of ground water development of the state is 2.89%. All the districts of the state fall under safe category.

5.3 Comparison with the earlier ground water resources estimate and reasons for Significant departure from earlier estimates

A comparison is made between the previous estimate based on GEC'15 as on 2020 and present estimate based on GEC'15 as on March, 2022 and presented in tabular statement given below. The recharge worthy area has been demarcated using srtm digital elevation model for the assessment of ground water resources as on March 2022. Therefore, total recharge worthy area decreased by 1023641 Ha as compared to the previous assessment year.

The comparison depicts that there is a decrease in total annual net ground water recharge by about 138104.88 Ham in the 2022 estimate. This change in ground water recharge is mainly due to refinement of recharge worthy area.

Comparison between ground water resources estimation for Nagaland for 2020 and 2022 (based on GEC'15)

Sl. No.	ITEM	GEC'15 (2020)	GEC'15 (2022)	COMPARISON
1	Recharge worthy area	1409148	385507	Decreased by 1023641 Ha
2	Total annual ground water recharge	216653.51	78,548.63	Decrease by 138104.88 Ham
3	Annual extractable ground water resource (HAM)	194988.14	70,693.74	Decrease by 124294.4 Ham
4	Current annual gross Ground Water extraction for all uses (HAM)	2023.18	2,044.19	Increase by 21.01 Ham
5	Annual allocation of ground water for domestic water supply as on 2025 (HAM)	1970.08	1,961.80	Decrease by 8.28 Ham
6	Net Ground water availability for future use (HAM)	192805.8	68,530.17	Decrease by 124275.63 Ham
7	Stage of Ground Water extraction (HAM)	1.04%	2.89%	Increase by 1.85%

5.4 Ground water recharge in poor ground water quality zone

No poor ground water quality zone has been demarcated in the state.

5.5 Additional Annual Potential Recharge in Shallow Water and flood prone areas

Additional annual potential recharge in shallow water areas has not been calculated due to non-availability of data.

CHAPTER 6
AUTOMATION OF ESTIMATION OF DYNAMIC GROUND WATER RESOURCES USING GEC-2015 THROUGH IN-GRES

The Automation of dynamic ground water resource estimation of Nagaland for the year 2021-22 has been done through IN-GRES software (India Ground Water Resource Estimation System). IN-GRES is the common portal to input, estimate, analyze, and access static and dynamic groundwater resources. India GEC system will take Data Input through Excel as well as through Forms, compute various Ground water components (recharge, draft, flux, etc.), classify assessment unit into appropriate categories, develop visibility dashboards for each of the components. System allows user to view the data in both MIS as well as GIS view. User can also download the reports in formats like CGWB, etc.

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

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

a. 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.

b. 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.

ii. 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 Over-exploited categories.

iii. Output module-Once categorized the data is shown in two views:

a. 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.

b. 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 each District/Assessment unit based on the categorization.

ANNEXURE I

GOVERNMENT OF NAGALAND
GEOLOGY & MINING DEPARTMENT
NAGALAND:KOHIMA

NOTIFICATION

Dated Kohima the, Oct.2020

NO.GM-25/G&M/1/2020: : In supersession of this Department's notification of even number dated 24th August, 2017 , the Governor of Nagaland is pleased to constitute the State Level Committee for Assessment of Dynamic Ground Water Resources, 2020 of Nagaland with the following members :-

1.	Principal Secretary, G&M	-	Chairman
2.	Regional Director, CGWB (NER) Guwahati	-	Member Secy.
3.	Representative, P.H.E. Deptt.	-	Member
4.	Representative, Soil & Water Conservation Deptt.	-	Member
5.	Representative, Water Resource Deptt.	-	Member
6.	Representative, Urban Development Deptt	-	Member
7	Shri Nitovi Chishi, Jt. Director Nodal Officer i/c Ground Water	-	Member

Sd/- **S.RADHAKHRISHNAN,IAS**
Principal Secretary to the Govt. of Nagaland

NO.GM-25/G&M/1/2020 /225
Dated Kohima the, Oct.2020

Copy to:-

1. The OSD to the Chief Secretary, Nagaland, Kohima.
2. All members of the State Level Committee
3. Office copy/Guard File

19/10/2020
(KEKHREIZAVI LEA)
OSD to the Govt. of Nagaland

ANNEXURE II

MINUTES OF THE MEETING OF STATE LEVEL COMMITTEE FOR RECONCILIATION OF DYNAMIC GROUND WATER RESOURCES ASSESSMENT OF NAGALAND, as on March 2020

Date: 23.03.2021

Time: 13 hrs.

Venue: Online through Google meet

A meeting of State Level Committee for reconciliation of Dynamic Ground Water Resources of Nagaland was convened on 23.03.2021 Online through goggle meet to approve the Dynamic Ground Water Resources Assessment of Nagaland, as on March 2020. The meeting was chaired by Sh. K. Libanthung Lotha, IAS, Commissioner & Secretary, Geology and Mining, Govt. of Nagaland.

The Regional Director, CGWB, NER, Guwahati & Member Secretary, State Level Committee for Assessment of Dynamic Ground Water Resource 2020, Nagaland welcomes all the members of the committee.

With due permission of the chair, Sri B. Ray, RD (i/c), CGWB, NER presented the report before the committee where he explained about new incorporation of INGRES software for estimation of the Ground Water Resource during 2020. He also discussed in detail on the methodology of resource estimation, various factors utilized/ considered as per norm or otherwise, constrains of non-availability of various field data, source of various field data utilized for resource calculation etc. At last he summarized the whole findings and discuss with a comparative status of ground water resource as on 2017 and 2020 as well as reasons for the difference.

Sh. Razuovolie Kelio, ACE, Water Resources Department, Government of Nagaland raised the question on site specific ground water problem in Peren district where PMKSY projects are been implemented. To this Regional Director, CGWB, NER, Guwahati pointed out that Ground Water resource estimation is a Pan India exercise guided by GEC-2015 norm. Site specific ground water issues may be resolved jointly by Govt. of Nagaland and CGWB. If any problematic area is there as per the State Govt., same can be accordingly considered during next assessment of the resource. After thorough discussion all the members of the State Level committee accepted and approved upon the figures in the draft report of Dynamic Ground Water Resources as assessed for the state of Nagaland (as on 31st March, 2020).

26/03/2021.

(SH. K. LIBANTHUNG LOTHA) IAS
Commissioner & Secretary
Geology and Mining,
Govt. of Nagaland
&
Chairman, State Level Committee for
Assessment of Dynamic Ground Resources, 2020 Nagaland

ANNEXURE III

RECONCILIATION OF DYNAMIC GROUND WATER RESOURCES ASSESSMENT OF Nagaland, as on March 2020

Date: 23.03.2021 Venue: Online through Google meet

Sl. No.	Name & Designation	Department
1	Sh. K. Libanthung Lotha, IAS	Commissioner & Secretary Geology and Mining, Govt. of Nagaland & Chairman, State Level Committee for Assessment of Dynamic Ground Resources, 2020 Nagaland
2	Kesonyu Yhome, IAS	Secretary PHED, Govt. of Nagaland
3	Mhathung Tungoe	Additional Secretary Department of PHE, Govt. of Nagaland
4	Er. Reiphang Longkumer	Chief Engineer Department of PHE, Govt. of Nagaland
5	Kekhreizavi Lea,	OSD Geology and Mining, Govt. of Nagaland
6	K. Zhekheto Awomi	Director Directorate of Soil and Water Conservation, Govt of Nagaland
7	Er. Razuovolie Kelio	Additional Chief Engineer Water Resources Deptt, Govt of Nagaland
8	Myinthungo Jami	Geologist Directorate of Geology and Mining, Govt. of Nagaland
9	Sh. Biplab Ray, Regional Director (i/c)	Central Ground Water Board, NER Guwahati & Member Secretary, State Level Committee for Assessment of Dynamic Ground Resources, 2020 Nagaland
10	Dr. S.S Singh, Scientist-C	Central Ground Water Board, NER Guwahati
11	Dr. D.J Khound, Scientist-B	Central Ground Water Board, NER Guwahati
12	V.Kezo, Scientist-B	Central Ground Water Board, NER Guwahati
13	Wonjano Mozhui, Scientist-B	Central Ground Water Board, NER Guwahati
14	Arijit Mitra, Scientist-B	Central Ground Water Board, NER Guwahati
15	Bibhuti Sahu, Scientist-B	Central Ground Water Board, NER Guwahati

Table 1: Type of Ground Water Assessment Unit and Characteristics of Ground Water Year		
Name of State / Union Territory		NAGALAND
Ground Water Assessment Year		2021-22
1	Predominant type of Aquifer System (Alluvial/ Non Alluvial)	Non-Alluvial
2	Predominant monsoon (South-west/ North-east/ Both)	South-West
3	If predominant monsoon is, 'South – west', The time when it usually commences (late May or early June/ late June or early July)	Late May or Early June
4	Type of Ground Water Assessment Unit (Block / Taluka / Mandal / Firka/ Watershed)	District
5	Ground Water Year (June to May / July to June October to September)	June to May
6	Monsoon Season (June to September / July to October / October to December / June to December)	June to September
7	Non – monsoon Season (October to May / Novermber to June / January to September / January to May)	October to May
8	Month of Pre – monsoon Monitoring (May / June / September)	March
9	Month of Post – monsoon Monitoring (October / November / January)	November

TABLE 2: GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF NAGALAND (as on March, 2022)

(in ham)

Sl No	**Name of Ground Water Assessment Unit**	**Type of rock formation**	**Areal extent (in hectares)**						
			Total Geographical Area	**Hilly Area**	**Ground Water Recharge Worthy Area**			**Shallow Water Table Area**	**Flood Prone Area**
					Command area	**Non-command area**	**Poor ground water quality area**		
	District								
1	Kohima	Semi-consolidated (Tertiary)	146300	118036.43	Nil	122877	NA	NA	NA
2	Dimapur	Alluvium/ Semi-consolidated	92700	29654.33	Nil	71167	NA	NA	NA
3	Phek	Semi-consolidated (Tertiary)	202600	191291	Nil	182492	NA	NA	NA
4	Mokokchung	- do -	161500	106457.04	Nil	136933	NA	NA	NA
5	Zunheboto	- do -	125500	116514.53	Nil	102786	NA	NA	NA
6	Wokha	- do -	162800	95879.38	Nil	139599	NA	NA	NA
7	Tuensang	- do -	253600	243476.57	Nil	229966	NA	NA	NA
8	Mon	- do -	178600	117087.56	Nil	155100	NA	NA	NA
9	Peren	- do -	165100	101261.56	Nil	141527	NA	NA	NA
10	Kiphire	- do -	113000	109423.8	Nil	90312	NA	NA	NA
11	Longleng	- do -	56200	43310.38	Nil	36389	NA	NA	NA
	Total	-	**1657900**	**1272392.58**		**1409148**			

TABLE 3: DATA VARIABLES USED IN DYNAMIC GROUND WATER RESOURCES OF NAGALAND (as on March, 2020)

Sl No	Assessment Unit	Command/Non-command/Poor GW Quality	Rainfall (mm)	Average Pre-monsoon Water level (mbgl)	Average Post-monsoon Water Level (mbgl)	Average Fluctuation (m)
1	Kohima	Command	NA	NA	NA	NA
		Non-Command	1779.3	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
2	Dimapur	Command	NA	NA	NA	NA
		Non-Command	1744.96	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
3	Phek	Command	NA	NA	NA	NA
		Non-Command	1295.1	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
4	Mokokchung	Command	NA	NA	NA	NA
		Non-Command	2080.4	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
5	Zunheboto	Command	NA	NA	NA	NA
		Non-Command	2080.4	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
6	Wokha	Command	NA	NA	NA	NA
		Non-Command	2166.76	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
7	Tuensang	Command	NA	NA	NA	NA
		Non-Command	2079.5	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
8	Mon	Command	NA	NA	NA	NA
		Non-Command	1469.1	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
9	Peren	Command	NA	NA	NA	NA
		Non-Command	1394.2	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
10	Kiphire	Command	NA	NA	NA	NA
		Non-Command	1074.1	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA
11	Longleng	Command	NA	NA	NA	NA
		Non-Command	1879.5	NA	NA	NA
		Poor GW Quality	NA	NA	NA	NA

TABLE 4: POPULATION PROJECTION FOR 2020

Sl no	District	Population 2011	Decadal growth	Projected Population as on 2022
1	Kohima	267988	21.72	332016
2	Dimapur	378811	22.92	474317
3	Phek	163418	10.27	181879
4	Mokokchung	194622	-16.1	160069
5	Zunheboto	140757	-8.85	126899
6	Wokha	166343	3.18	172162
7	Tuensang	196596	5.7	208923
8	Mon	250260	-3.99	239276
9	Peren	95219	4.91	100362
10	Kiphire	74004	-30.6	49119
11	Longleng	50484	-58.5	18009

TABLE 5: GROUND WATER EXTRACTION FOR ALL USES (AS ON MARCH 2022)

(in ham)

Sl no	Ground Water Assessment Unit	a. Irrigation			b. Domestic Water Supply			c. Industrial Water Supply			d. 'All Uses'		
		Monsoon	Non-Monsoon	Annual	Consumptive Use Method			Unit Draft Method		Annual	[(1a) + (1b) +(1c)]		Annual
					Monsoon	Non-monsoon	Annual	Monsoon	Non-monsoon		Monsoon	Non-monsoon	
1	Kohima	0	0	0	**95.49**	**132.31**	**227.8**	**0.24**	**0.36**	0.6	95.73	132.67	228.4
2	Dimapur	60.5	139.26	199.76	**355.04**	**491.96**	**847**	**0.58**	**0.86**	**1.44**	416.12	632.08	1048.2
3	Phek	0	0	0	**17.05**	**23.62**	**40.67**	0.00	0.00	0.00	17.05	23.62	40.67
4	Mokokchung	0	0	0	**29.18**	**40.44**	**69.62**	0.00	0.00	0.00	29.18	40.44	69.62
5	Zunheboto	0	0	0	**27.28**	**37.8**	**65.08**	0.00	0.00	0.00	27.28	37.8	65.08
6	Wokha	0	0	0	**77.79**	**107.79**	**185.58**	0.00	0.00	0.00	77.79	107.79	185.58
7	Tuensang	0	0	0	**38.45**	**53.28**	**91.73**	0.00	0.00	0.00	38.45	53.28	91.73
8	Mon	0	0	0	**83.67**	**115.93**	**199.6**	0.00	0.00	0.00	83.67	115.93	199.6
9	Peren	0	0	0	**38.01**	**52.67**	**90.68**	0.00	0.00	0.00	38.01	52.67	90.68
10	Kiphire	0	0	0	**4.47**	**6.2**	**10.67**	0.00	0.00	0.00	4.47	6.2	10.67
11	Longleng	0	0	0	**5.85**	**8.11**	**13.96**	0.00	0.00	0.00	5.85	8.11	13.96
	Total			199.76			1,842.40			2.04			2044.19

TABLE 6: RAINFALL

Sl no	Ground Water Assessment Unit	Rainfall (Normal) 2022			10% of annual normal RF
		Monsoon	Non-monsoon	Total	
1	Kohima	1400.4	378.9	1779.3	177.93
2	Dimapur	1400.4	419.0	1819.4	181.94
3	Phek	924.1	371.0	1295.1	129.51
4	Mokokchung	1508.5	571.9	2080.4	208.04
5	Zunheboto	1508.5	571.9	2080.4	208.04
6	Wokha	1601.4	565.36	2166.76	216.676
7	Tuensang	1508.5	571.0	2079.5	207.95
8	Mon	1112.6	356.5	1469.1	146.91
9	Peren	1015.3	378.9	1394.2	139.42
10	Kiphire	703.1	371.0	1074.1	107.41
11	Longleng	1508.5	371.0	1879.5	187.95
	Total	**14191.3**	**4926.46**	**19117.76**	

TABLE 7: RAINFALL RECHARGE BY RAINFALL INFILTRATION FACTOR METHOD

Sl no	Ground Water Assessment Unit	Area of the sub unit (ha)	Normal rainfall during		Minimum Threshold Rainfall in mm	Maximum Threshold Rainfall in mm	Rainfall infiltration factor as a fraction	Rainfall recharge in non-command area by rainfall infiltration factor method in hectare meters during	
			Monsoon season in mm	Non - monsoon season in mm					
		1	2a	2b	2c	2d	3	a) Monsoon season [(1) * {(2d)-2c)} * (3) if (2a)> (2d) (1) * {(2a)-2c)} * (3) if (2a) <=(2d)]	b) Non - monsoon season [= 0 if (2b) <=(2c) = (1) * {2b)-(2c)} * (3) if (2b)> (2c)]
1	Kohima	28,264	1400.4	378.9	177.93	3000	0.06	2073.082	340.81
2	Dimapur	63,046	1400.4	419	181.94	3000	0.22	13602.63	2,358.74
3	Phek	11,309	924.1	371.0	129.51	3000	0.06	539.1611	**163.86**
4	Mokokchung	55,043	1508.5	571.9	208.04	3000	0.06	4294.8701	1201.68
5	Zunheboto	8,985	1508.5	571.9	208.04	3000	0.06	**701.1147**	**196.17**
6	Wokha	66,921	1601.4	565.36	216.68	3000	0.06	**5559.995**	**1400.05**
7	Tuensang	10,123	1508.5	571	207.95	3000	0.06	789.96161	**220.52**
8	Mon	61,512	1112.6	356.5	146.91	3000	0.06	3564.1169	773.54
9	Peren	63,838	1015.3	378.9	139.42	3000	0.06	3354.8888	917.28
10	Kiphire	3,576	703.1	371	107.41	3000	0.06	127.82	56.56
11	Longleng	12,890	1508.5	371	187.95	3000	0.06	1021.2833	141.57
	Total	3,85,507			1911.78	33000		35628.924	7770.77

TABLE 8: ANNUAL EXTRACTABLE GROUND WATER RESOURCE IN NON-COMMAND AREA (AS ON MARCH 2022)

Sl. No	Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	Recharge from Rainfall-Monsoon Season	Recharge from Other Sources-Monsoon Season	Recharge from Rainfall-Non Monsoon Season	Recharge from Other Sources-Non Monsoon Season	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
1	Dimapur	92,700	63,046	13602.63	**17175.46**	2,358.74	1754.6	34891.43	3489.143	31,402.29
2	Kiphere	109,424	3,576	127.82	**4797.3**	56.56	246.78	5228.46	522.846	4,705.61
3	Kohima	118,036	28,264	2073.082	**6448.32**	340.81	326.16	9188.3698	918.83698	8,269.53
4	Longleng	56,200	12,890	1021.2833	**3431.34**	141.57	176.04	4770.23	477.023	4,293.21
5	Mokokchung	161,500	55,043	4294.8701	**6511.14**	1201.68	480.6	12488.286	1248.8286	11,239.46
6	Mon	178,600	61,512	3564.1169	**8138.04**	773.54	1100.28	13575.98	1357.598	12,218.38
7	Peren	165,100	63,838	3354.8888	**6352.62**	917.28	565.44	11190.231	1119.0231	10,071.21
8	Phek	202,600	11,309	539.1611	**2360.16**	**163.86**	**462.78**	3525.9617	352.59617	3,173.37
9	Tuensang	253,600	10,123	789.96161	**7117.02**	**220.52**	**450.9**	8578.4003	857.84003	7,720.56
10	Wokha	162,800	66,921	**5559.995**	**7516.68**	**1400.05**	**437.4**	14914.124	1491.4124	13,422.71
11	Zunheboto	125,500	8,985	**701.1147**	**6283.98**	**196.17**	**240.84**	7422.1018	742.21018	6,679.89

TABLE 9: STAGE OF GROUND WATER DEVELOPMENT (AS ON MARCH 2022)

Sl no	Ground Water Assessment Unit	Area of the sub unit (ha)	Annual Extractable Ground Water Resource in hectare meters	Current annual gross ground water extraction for all uses in hectare meters	Stage of Ground Water Extraction as a percentage [(5) / (4) * 100]	Poor Ground Water Quality Area	Categorization of the sub-unit (Safe/Semi- critical / Critical / Over-exploited)
1	2	3	4	5	6	7	8
1	DIMAPUR	63045.7	26321.77	1048.2	3.982	Nil	Safe
2	KIPHIRE	3576.2	165.94	10.67	6.430	Nil	Safe
3	KOHIMA	28263.6	2172.5	228.4	10.513	Nil	Safe
4	LONGLENG	12889.6	1046.56	13.96	1.334	Nil	Safe
5	MOKOKCHUNG	55043	11239.46	69.62	0.619	Nil	Safe
6	MON	61512.4	3903.9	199.6	5.113	Nil	Safe
7	PEREN	63838.4	10071.21	90.68	0.900	Nil	Safe
8	PHEK	11309	632.71	40.67	6.428	Nil	Safe
9	TUENSANG	10123.4	909.43	91.73	10.087	Nil	Safe
10	WOKHA	66920.6	13422.71	185.58	1.383	Nil	Safe
11	ZUNHEBOTO	8985.47	807.55	65.08	8.059	Nil	Safe
	Total	385507	70693.74	2044.19	2.892	Nil	Safe

TABLE 10: WATER QUALITY

Sl no	Ground Water Assessment Unit	Area of the sub unit (ha)	Area effected by Salinity in mappable patches	Area effected by Fluoride in mappable patches	Area effected by Arsenic in mappable patches	Other Hazardous parameters present in the sub unit in mappable areas	Quality tag For the sub unit
1	DIMAPUR	63045.7	No	No	No	No	Fresh
2	KIPHIRE	3576.2	No	No	No	No	Fresh
3	KOHIMA	28263.6	No	No	No	No	Fresh
4	LONGLENG	12889.6	No	No	No	No	Fresh
5	MOKOKCHUNG	55043	No	No	No	No	Fresh
6	MON	61512.4	No	No	No	No	Fresh
7	PEREN	63838.4	No	No	No	No	Fresh
8	PHEK	11309	No	No	No	No	Fresh
9	TUENSANG	10123.4	No	No	No	No	Fresh
10	WOKHA	66920.6	No	No	No	No	Fresh
11	ZUNHEBOTO	8985.47	No	No	No	No	Fresh

TABLE 11: ALLOCATION OF GROUND WATER RESOURCES (AS ON MARCH 2022)

Sl No	Ground Water Assessment Unit	Area of the sub unit	Census 2011 Population	Yearly Growth Rate	Projected population on 2025	Projected population density as on 2025 in thousands per sq. km.	Extent of dependence on ground water to meet domestic water supply as a fraction (less than or equal to 1)	Annual allocation of ground water for domestic water supply per unit area in millimeters [22 * (6) * (7)]	Area in hectares	Annual allocation of ground water for domestic water supply in hectare meters [((8) * (9) / 1000]
	1	2	3	4	5	6	7	8	9	10
1	DIMAPUR	63045.7	378811	2.29	500364	0.793653	0.8154	14.24	63045.67	897.7703
2	KIPHIRE	3576.2	74004	-3.06	42332	1.183715	0.0992	2.58	3576.2	9.226596
3	KOHIMA	28263.6	267988	2.172	349478	1.236496	0.3133	8.52	28263.57	240.8056
4	LONGLENG	12889.6	50484	-5.85	9152	0.071003	0.354	0.55	12889.62	7.089291
5	MOKOKCHUNG	55043	194622	-1.61	150645	0.273686	0.1986	1.2	55042.96	66.05155
6	MON	61512.4	250260	-0.4	236280	0.384117	0.3809	3.22	61512.44	198.0701
7	PEREN	63838.4	95219	0.49	101764	0.159409	0.4126	1.45	63838.44	92.56574
8	PHEK	11309	163418	1.03	186914	1.65279	0.1021	3.71	11309	41.95639
9	TUENSANG	10123.4	196596	0.57	212284	2.096957	0.2005	9.25	10123.43	93.64173
10	WOKHA	66920.6	166343	0.32	173749	0.259634	0.4922	2.81	66920.62	188.0469
11	ZUNHEBOTO	8985.47	140757	-0.9	123120	1.370212	0.2339	7.05	8985.47	63.34756
	Total	385507	1978502	-4.948	2086082	9.481673	3.6027	54.58	385507.4	1898.572

TABLE 12: NET ANNUAL GROUND WATER AVAILABILITY FOR 'FUTURE USE'

Sl No	Ground Water Assessment Unit	Area in hectares	Annual Extractable Ground Water Resource in hectare meters	Current annual gross ground water extraction for Irrigation in hectare meters	Current annual gross ground water extraction for Industrial use in hectare meters	Annual allocation of ground water for domestic water supply as on 2025 in hectare meters	Net annual ground water availability for 'Future Use' in hectare meters [(2) - ((3) + (4) + (5))]	Net annual ground water availability for 'Future Use' per unit area in millimeters [((6) / (1)) * 1000]
		1	2	3	4	5	6	7
1	DIMAPUR	63045.7	26321.8	199.76	1.44	933.25	25187.3	399.509
2	KIPHIRE	3576.2	165.94	0	0	10.67	155.27	43.4176
3	KOHIMA	28263.6	2172.5	0	0.6	249.54	1922.37	68.0158
4	LONGLENG	12889.6	1046.56	0	0	16.91	1029.65	79.8821
5	MOKOKCHUNG	55043	11239.5	0	0	69.62	11169.8	202.929
6	MON	61512.4	3903.9	0	0	199.6	3704.3	60.2203
7	PEREN	63838.4	10071.2	0	0	92.57	9978.65	156.311
8	PHEK	11309	632.71	0	0	42.35	590.36	52.2027
9	TUENSANG	10123.4	909.43	0	0	93.9	815.54	80.5597
10	WOKHA	66920.6	13422.7	0	0	188.31	13234.4	197.763
11	ZUNHEBOTO	8985.47	807.55	0	0	65.08	742.47	82.6301
	Total	385507	70693.7	199.76	2.04	1961.8	68530.2	177.766

PLATE-1

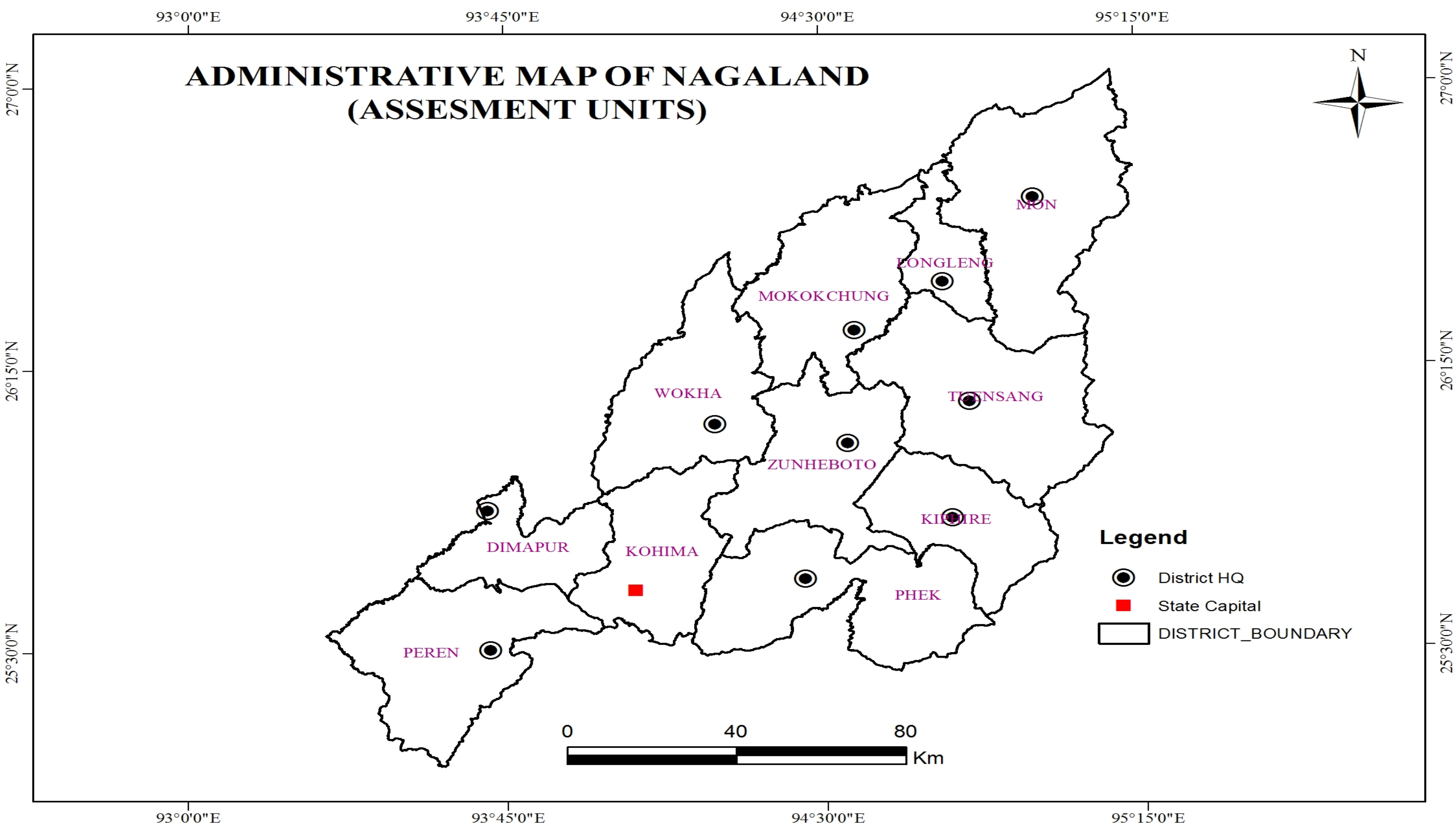

ADMINISTRATIVE MAP OF NAGALAND
(ASSESMENT UNITS)
93°0'0"E
93°45'0"E
94°30'0"E
95°15'0"E
27°0'0"N
26°15'0"N
25°30'0"N
N
MON
LONGLENG
MOKOKCHUNG
WOKHA
TUENSANG
ZUNHEBOTO
KIPHIRE
DIMAPUR
KOHIMA
PHEK
PEREN
Legend
District HQ
State Capital
DISTRICT_BOUNDARY
0
40
80
Km

PLATE - 2

HYDROGEOLOGY OF NAGALAND

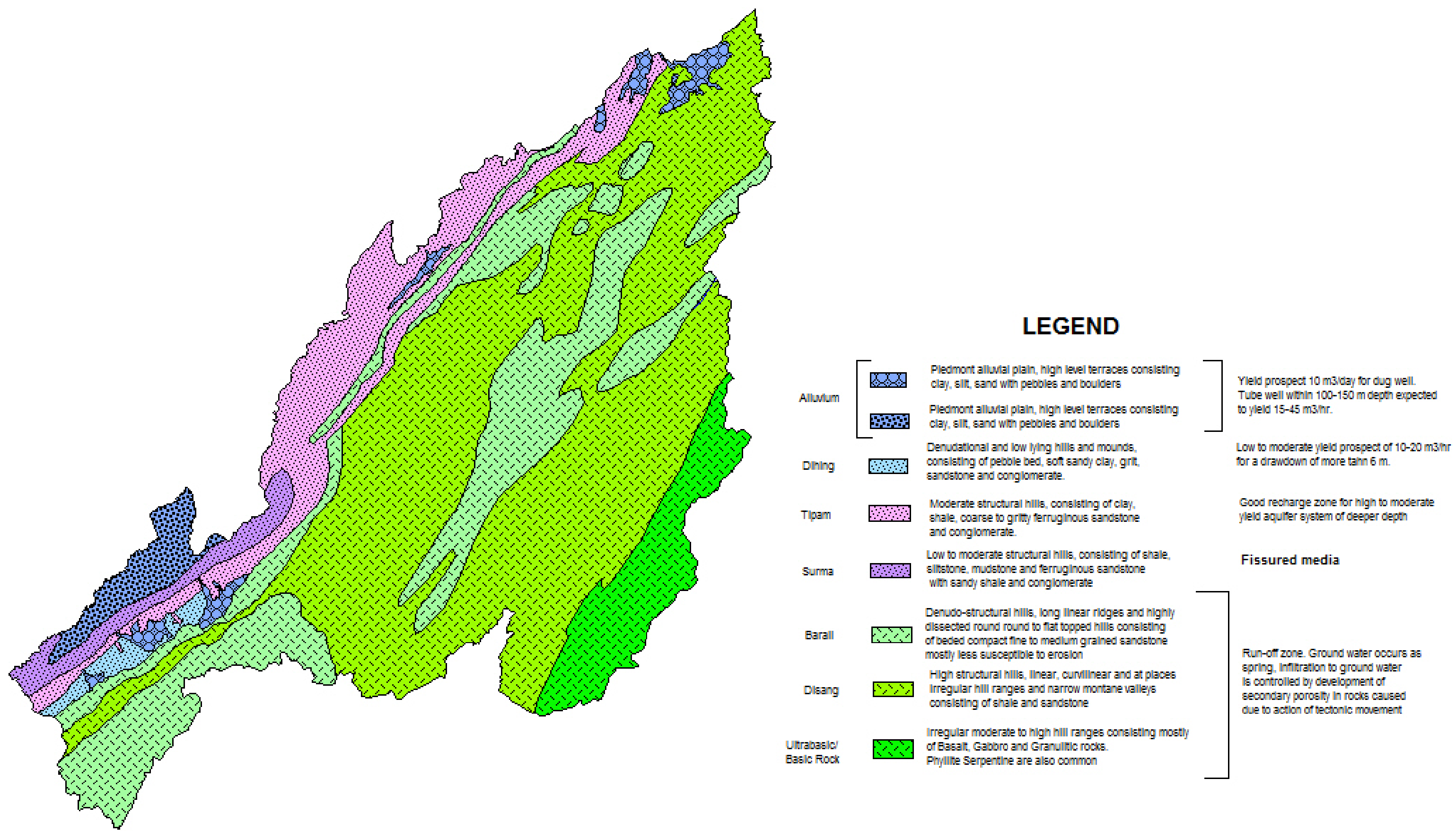
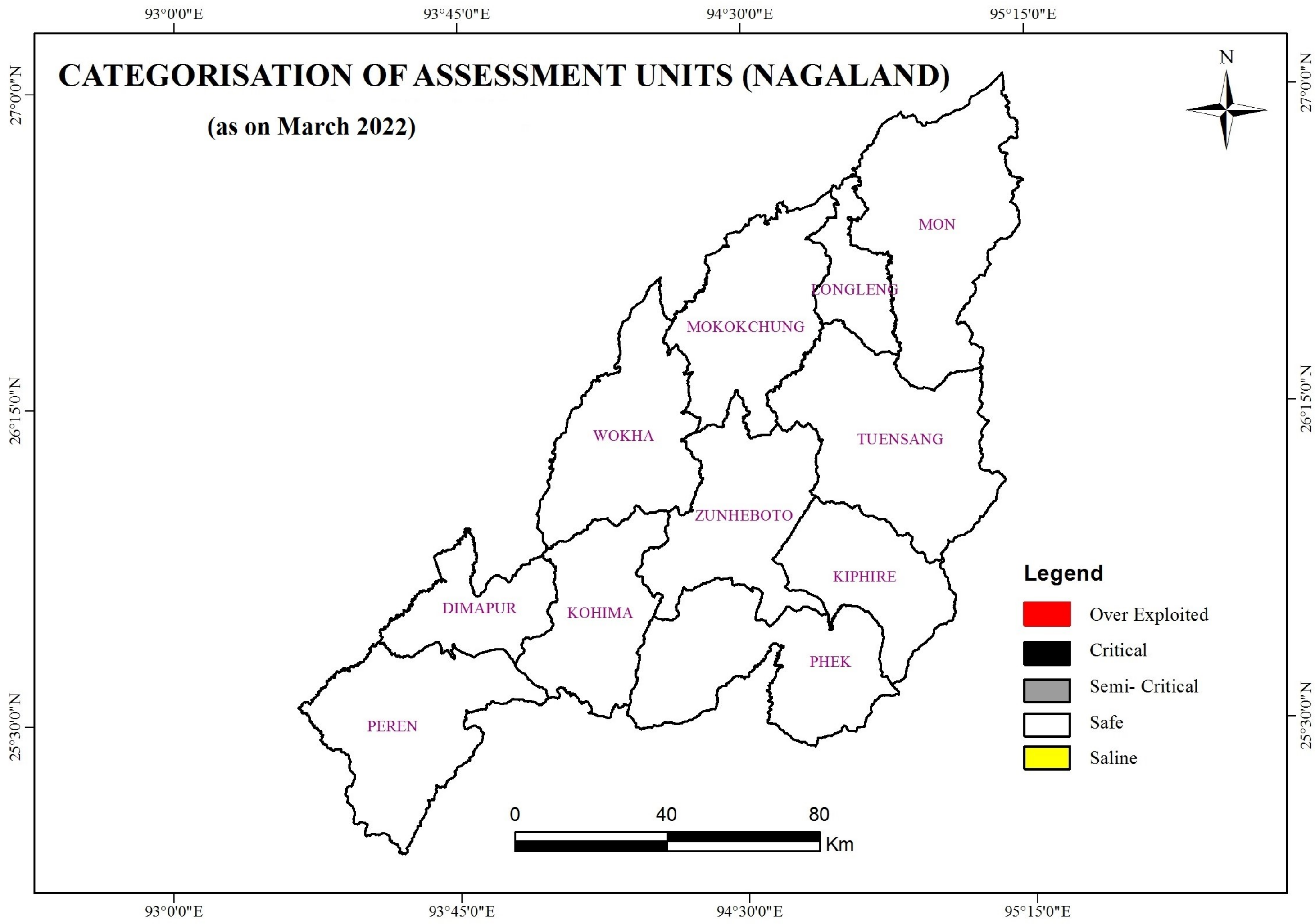


PLATE-3



93°0'0"E
93°45'0"E
94°30'0"E
95°15'0"E
27°0'0"N
26°15'0"N
25°30'0"N
CATEGORISATION OF ASSESSMENT UNITS (NAGALAND)
(as on March 2022)
N
MON
LONGLENG
MOKOKCHUNG
WOKHA
TUENSANG
ZUNHEBOTO
KIPHIRE
DIMAPUR
KOHIMA
PHEK
PEREN
Legend
Over Exploited
Critical
Semi- Critical
Safe
Saline
0
40
80
Km