IDENTIFICATION OF GROUND WATER POTENTIAL ZONE USING GIS & REMOTE SENSING
A CASE STUDY OF MORANG DISTRICT (BIRATNAGAR) Nepal

A DISSERTATION

Submitted in partial fulfilment of the requirement for the award of the degree of

Master of Technology in
Water Resources Development & Management

By
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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this thesis, entitled, **"**Identification Of Ground Water Potential Zone Using GIS and Remote Sensing Of Morang District, Nepal **"**, in the partial fulfilment of requirements for the award of the degree of **M. Tech.** in **"Water Resources Development "**, submitted in the Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee is an authentic record of my own work carried out during a period from August 2018 to Nov 2018 under the supervision of **Dr. Ashish Pandey , Associates Professor,** Department of Water Resources Development and Management, Indian Institute of Technology Roorkee (IITR), Roorkee, India.

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CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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ABSTRACT

In this study thematic maps are analysed to decide groundwater potential zones utilizing combination of RS and GIS tools. The parameters which are considered for distinguishing the ground water potential zone are topography, DEM, land cover, geomorphic units and lineament etc. Reasonable positions are allotted for every classification of these parameters. For the different geomorphic units, weight elements are chosen dependent on their capacity to store groundwater. This technique is done for the various layers and resultant layers are renamed. The groundwater potential zones are grouped into five classes like exceptionally poor, poor, moderate, great and incredible. The utilization of recommended approach is exhibited for Morang District.

Nepal is considered as most extravagant in as far as accessible water assets. Its tremendous water assets if appropriately used can be greatest wellspring of national riches. Agriculture is spine of Nepalese economy with over 80% of provincial populace effectively occupied with agribusiness as a calling for their living. It is known that water system can assume impetus job in expanding farming profitability. Water system expands agriculture profitability and empowers to develop numerous harvests, decreases the danger of yield disappointment because of dry season and balances out the nourishment generation by limiting rainfall-instigated variance.

Nepal has 26000 km2 of land which is cultivable, however, just 18000 km of land is irrigable. The present ground water improvement establishes just a little division of potential as it was. The condition is unused tremendous ground water potential is because of absence of profound analysis, lack of inspiration and sponsorships for farmers, lack of satisfactory supporting approaches from government. Using model of GIS and Remote Sensing, it has been discovered that the Morang area holds a decent measure of ground water assets, which can be used for the overall advancement. At present, the ground water use is far beneath the accessible sum limit. It appears that mostly the water extraction is just for gathering household needs. There is colossal degree for the administrative projects which can make condition for use of ground water resources to quicken the agribusiness efficiency and industrial growth. The open water supply and sanitation offices can be improved and increases with appropriate management of water resources.

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CHAPTER – 1: INTRODUCTION

1.1 General

Nepal is considered as one of the most extravagant nations on the planet as far as accessible water assets. Its huge water assets, if, appropriately used, can be the greatest wellspring of national riches. The colossal volume of water courses through several of all shapes and sizes streams all through the nation. Amid the blustery season, they make genuine dangers of high floods and immersion. Limiting these unfriendly impacts require enormous measure of specialized and budgetary assets. Up until this point, neither have these streams been appropriately prepared to limit their antagonistic impacts nor have their water assets been completely used. Agriculture and Horticulture is the foundation of Nepalese economy with over 80% of country populace effectively occupied with agribusiness as a calling for their living. It is known that water system can assume a synergist job in expanding agrarian profitability. Water system increments agricultural efficiency and empowers to develop different yields, lessens the danger of harvest disappointment because of dry spell and balances out the nourishment creation by limiting precipitation incited vacillation. Along these lines, government has been making considerable budgetary portions in water system improvement to empower surplus generation to meet nourishment shortage, increment salary of rustic ranchers and consequently upgrade their personal satisfaction.

Nepal has 26,000 km^2 of land which is cultivable however just 18,000 km^2 of land is irrigable. In the present setting 13,900 km^2 of land is accepting water system. The running break three years' arrangement for 2016/017 to 2019/020 has taken an objective of expanding the water system in addition to 860 km^2 of land and out of which 590 km^2 will be through ground water system [Fourteenth Multi Year Between time Plan, Nepal, 2016] Groundwater extraction with more up to date innovations and its utilization in Nepal is exceptionally later when contrasted with some other South Asian nations. The potential in the plain territory of Nepal evaluated to be 2500 km^2. Moreover, there is a potential for groundwater advancement for conjunctive use in the surface direction territories of around 1500 km^2. The present groundwater advancement establishes just a little portion of the absolute potential [Pradhan and Thapa 2000].

This state of unused gigantic groundwater potential is because of absence of profound examination, inspiration, and endowments for the ranchers, absence of satisfactory supporting approaches and so forth.

There are six thousand streams in Nepal spilling out of north to south of the nation. Waterways of Nepal can be grouped on their birthplace, age, geology and character. There are some exceptionally old waterways like the Koshi, Narayani, Gandaki and Karnali. These streams have unmistakable routine stream with profound cut and vertically sharp chasms. Indeed, their beginning is accepted to be from as right on time as that of the northern Himalayas

Based on the spot of starting point, waterways of Nepal can be assembled in four classes as pursues:

i. Rivers began from higher Himalayas (perpetual waterways) ii. Rivers began from Mahabharat and internal Terai (perpetual waterways) iii. Rivers started from Churiya Slopes (fleeting streams) iv. Rivers started from the Terai (southern waterways)

Himalayan streams are snow sustained waterways having exceptionally huge release. Extraction of water from these waterways requires abnormal state of specialized and pressure driven investigation. These waterways are outstanding on the planet for their immense release and the degree of harm they every now and again cause.

Streams starting from the Mahabharat extend are the medium size waterways. Release of these waterways comes to as high as 8000 to 10000 cumec. While going through the sloping locales of Nepal, they convey a colossal amount of the dregs including rich soil. There are huge quantities of little, generally youthful waterways starting in the Churiya slope in the southern level plain of the Terai. These streams start from the southern essence of the Churiya extend. Their catchment regions are between 30 km2 to 200 km2 Length of these streams, from their cause up to Indian outskirt, ranges from 25 to 40 km. Run-off of streams of this sort happens inside 2-3 months of the storm seasons among July and September. They are totally dry amid rest of the year. A large portion of the spillover happens as short and high blaze flood enduring just 1 to 2 hours. The yearly flood ranges from 100-300 cumec. Hundred-year flood in certain waterways may achieve 1000 cumec. Waterways starting from high elevation locales convey overwhelming residue loads. A large portion of the waterways procure high angle before going into Terai, driving them to transport substantial residue load. As they enter the Gangetic plain, the streams spread out and their slopes decline unexpectedly.

1.2 Ground Water

The water beneath the ground surface existing in the different arrangements of earth is known as ground water. Wherever, we stand we will discover ground water underneath the earth in any case, the amount might be pretty much. It is valuable and broadly dispersed asset not at all like some other mineral asset. It gets its yearly renewal from the brilliant precipitation. The all out water assets of the world are evaluated at 1.37×108 million ha-m. Out of this worldwide water assets about 97.2% is salt water for the most part in seas and just 2.8% is accessible as new water whenever on the earth. Out of this 2.8%, about 2.2% is accessible as surface water and 0.6% as ground water. Indeed, out of this 2.2% of surface water, 2.15% is crisp water in icy masses and icecaps and just of the request of 0.01% is accessible in lakes and repositories and 0.0001% in streams; the remaining being in different structures 0.001% as water vapour in environment and 0.002% as soil dampness in the top 0.6 m. Out of 0.6% put away ground water, just about 0.3% can be financially separated with the present penetrating innovation, the remaining being inaccessible as it is arranged beneath a profundity of 800 m [Shiklomanov, 1993]

1.3 Groundwater Potential in Nepal

A specialized unit under the Branch of Water system had started the Groundwater assets investigation and ID exercises in Nepal in the time of 1967. Administration of Nepal has set up Groundwater Assets Advancement Board (GWRDB) to upgrade groundwater study and examination exercises and to depict potential zone for groundwater water system improvement.

The board had completed numerous investigations, reviews and looks into which shows that around 7,26,000 ha. land has great potential for shallow aquifer advancement and what's more 3,05,000 ha. place that is known for the Terai area of Nepal has minimal potential. Essentially, around 1,90,000 ha. place that is known for the Terai can be watered through siphoning from profound aquifer. Duba (1992), did groundwater assessment of the Terai area of Nepal with the help of Canadian Co-activity. They assessed that the energize rates and guaranteed a yearly unique revive of 11,598 MCM. About 33% or 2761 MCM of this energize happens in the Bhabar zone and the staying in the fundamental Terai fields. Later examination done by Nellis et al. (1993) assessed that 8,800 MCM as the allout yearly energize for the entire Terai locale of Nepal. In the continuation, another examination done by Ground Water Improvement Advisor (GDC) in 1994, the complete yearly revive in the Terai locale of Nepal was observed to be 14,300 MCM.

1.4 Groundwater Management

Water security isn't just about an adequacy of water yet in addition about perceiving the genuine estimation of water and overseeing it appropriately [Water Resources Group, 2009]. There is a requirement for better administration and the executives at all scales [WWDR3 Ch 15. Administering Water Wisely for Sustainable Development]; worldwide, provincial, national, nearby, just as at the catchment level and a requirement for collaboration between them. In circumstances where streams cross national limits or lakes are shared between nations, trans-limit understandings for water portion and sharing should be treasured inside global bargains. Handling dangers to worldwide water security requires reactions customized to the individual nation's political, social, monetary, ecological, budgetary and social conditions however with a system of global coordination. Groundwater supplies are a significant supply of water for agrarian and residential use; 1.2 billion urban tenants depend on groundwater for their water supply [UNESCO, 2003]. All through the world, noteworthy quantities of aquifers are being drawn upon at a rate that surpasses the normal energize. Our comprehension of aquifers yield is restricted by their unpredictable communications with surface water and associations between various aquifers. This is plainly a territory for more examination into economical works on identifying with groundwater withdrawals, the incorporated administration of groundwater and surface water frameworks and activities to upgrade characteristic and fake aquifer energize

1.6 Research Gap

Constrained examinations have done relating GIS and Remote Sensing use in Groundwater Potential Mapping. Utilization of GIS and Remote Sensing Models in the field of ground Water part isn't normal in the Nepalese setting. Nepal has 2.6 million hectares of land which is cultivable, out of which just 1.8 million hectares of land is irrigable. In the present setting 1.39 million hectares of land is accepting water system office. The running interval three years' arrangement for 2016/017 to 2019/020 has taken an objective of expanding the water system offices to in addition to 86 thousand hectares of land and out of which 59 thousand will be through investigating ground water system Groundwater extraction with more up to date advances and its utilization in Nepal are exceptionally later when contrasted with some other South Asian nations. The potential in the Terai belt of Nepal is assessed to be 250000 hectares. Likewise, there is a potential for groundwater advancement for conjunctive use in the surface direction zones is around 150000 ha. The present groundwater advancement comprises just a little part of the all-out potential.

This state of unused tremendous groundwater potential is because of absence of profound investigation, absence of inspiration and endowments for the ranchers, absence of satisfactory supporting strategies and so forth

1.7 Objectives

The examination territory has colossal potential for ground water arranged at the lower region of Churiya slopes and the channels going out from the Churiya area gives chance to more readily energize. Likewise, the spot is arranged close West Bengal from where it gets the early influx of rainstorm and better precipitation is won there. It is one of the significant sustenance delivering terai field area. The main objectives of this study are as follows:

i. Preparation of various thematic maps pertaining to the study area.
ii. Assessment of ground water potential zones in the Morang District.

CHAPTER – 2: LITERATURE REVIEW

2.1 Groundwater Development

A ground water framework comprises of a mass of water existing inside the different arrangements of the sub-surface beneath the earth. This mass of water is in movement. The putting away water is expanding because of different sources and furthermore continues diminishing because of extraction for various purposes. The outside sources which causes expanding ground water asset are surface water bodies, precipitation, snowfall, and snowmelt. The ground water extractions are for drinking or local purposes, industry, water system and so forth. The recharge rate and of release rate for ground water is extraordinary and is reliant upon the outside elements viz. rate of precipitation, area of streams and other surface water bodies, rate of evapotranspiration. In any case, one normal factor for all ground water framework is that the rate of measure of water entering, leaving and being put away in the framework must be put away and monitored. Management of all the water entering the framework, the water leaving the framework and the subsequent changes away is known as a water spending plan.

The utilization or withdrawal of water by people for different purposes like for household utilizes, farming purposes, modern uses change the characteristic stream designs. These progressions must be calculated for the assurance of water spending plan. There is a characteristic setup, water entering and leaving of ground water framework some place as accessible favouring normal geology however the human mediation or exercises influence the sum and rate of development of water in the framework, entering the framework and leaving the framework.

A water plan for the characteristic conditions before people utilized the water is the preadvancement water plan for a ground water framework. A pre-improvement water plan can be utilized to decide the measure of water accessible for extraction or safe yield. Here the advancement of ground water framework is viewed as sheltered if the rate of withdrawal of ground water approaches the rate of energize.

As human intercession changes the common setup, the different parts of water spending plan – changes away, inflows and surges additionally will change. These progressions must be determined for in any administration choice. Understanding the water plans and how they change because of human mediations is a significant for ground water hydrology.

Bagyarajet al. (2012) have carried out groundwater study in the Dindigul district of Kodaikanal hill which is hilly terrain in the Western Ghats of Tamilnadu. Ground water potential zones have been analysed with the help of remote sensing and Geographical information (GIS) techniques. All thematic maps are generated using the resource sat (IRS P6 LISS IV MX) data and Inverse distance weight (IDW) model is used in GIS data to identify the groundwater potential of the study area. For the various geomorphic units, weight factors were assigned based on their capability to store groundwater.

Mukherjee et al. (2012) made an attempt to determine the groundwater potential zones within an arid region of Kachchh district, Gujarat. Thematic layers have been generated by using ancillary data and digital satellite image. The potential zones have been obtained by weighted overlay analysis, the ranking given for each individual parameter of each thematic map and weights were assigned according to their influence.

Machiwal et al. (2010) proposed a standard methodology to delineate groundwater potential zones using integrated RS, GIS and multi-criteria decision making (MCDM) techniques. The methodology is demonstrated by a case study in Udaipur district of Rajasthan, western India. Initially, ten thematic layers have been considered. Weights of the thematic layers and their features then normalized by using AHP (analytic hierarchy process) MCDM technique and eigenvector method. Finally, the selected thematic maps were integrated by weighted linear combination method in a GIS environment to generate a groundwater potential map.

Lee et al. (2008) proposed that assessing the potential zone of groundwater recharge is extremely important for the protection of water quality and the management of groundwater systems. Further groundwater potential study was carried out in Taiwan with the help of remote sensing and the geographical information system (GIS) by integrating the five contributing factors: lithology, land cover/land use, lineaments, drainage, and slope. The weights of factors contributing to the groundwater recharge are derived using aerial photos, geology maps, a land use database, and field verification.

Thomas et al. (2011) determined groundwater potential zone in tropical river basin (Kerala, India) using remote sensing and GIS techniques. The information on geology, geomorphology, lineaments, slope and land use/land cover was gathered from Landsat ETM + data and Survey of India (SOI) toposheets of scale 1:50,000 in addition, GIS platform was used for the integration of various themes. The composite map generated was further classified according to the spatial variation of the groundwater potential. The spatial variation of the potential indicates that groundwater occurrence is controlled by geology, structures, slope and landforms.

2.2 Groundwater Recharge

Ground water energize is a hydrologic procedure where water moves infiltrated by the activity of penetration from surface water to groundwater. Energize is the essential technique that water enters an aquifer. This procedure for the most part happens in the vadose zone underneath plant roots and is regularly communicated as a motion to the water table surface. Revive happens both normally and through anthropogenic procedures, where water and/or recycled water is directed to the subsurface.

Counterfeit groundwater energize is winding up progressively significant in these days, where over-siphoning of groundwater by ranchers and all other water users has prompted underground assets getting to be drained. The International Water Management Institute, in 2007, has prescribed to the Indian government and dispensed Rs. 1800 crore (US$400million) to reserve dove well revive extends in 100 areas inside seven states where water put away in hard shake aquifers had been over abused. Another ecological issue is the transfer of waste through the water motion, for example, dairy ranches, modern and urban overflow.

The different techniques for deciding groundwater revive are physical, synthetic and numerical models.

2.3 Groundwater Management

Step by step, the need of water is expanding and together with its misusing, ill-advised use, sullying is additionally expanding. This thusly has centred to the need of its administration fusing numerous difficulties too.

The executives of groundwater framework implies, settling on such choices as:

• The total volume of water that perhaps isolated each year from the aquifer

• The position or region of siphoning and fake resuscitate wells and their rates • Choice stressed over groundwater quality

The framework created for the groundwater the administrators must have the ideal plans and use techniques for the followings:

• Conjunctive and Sustainable Use of Groundwater

• Maximizing Water Efficiency and Water Management

• Groundwater Legislation and Pollution

Step by step, the need of water is expanding and together with its misusing, inappropriate use, pollution is likewise expanding. This thus has cantered to the need of its administration consolidating numerous difficulties too.

The board of groundwater framework implies, settling on such choices as:

• The complete volume of water that possibly extracted every year from the aquifer

• The position or area of siphoning and fake energize wells and their rates

• Decision worried about groundwater quality

Step by step, the need of water is expanding and together with its misusing, ill-advised use, sullying is likewise expanding. This thusly has centred to the need of its administration joining numerous difficulties too.

The board of groundwater framework implies, settling on such choices as:

• The overall volume of water that perhaps removed every year from the aquifer

• The position or area of syphoning and fake revive wells and their rates

• Decision on worried about groundwater quality

The system produced for the groundwater the executives must have the best possible plans and usage techniques for the followings

- Conjunctive and Sustainable Use of Groundwater
- Maximizing Water Efficiency and Water Management
- Groundwater Legislation and Pollution

2.4 Sustainable Development

One individual can have any kind of effect and everybody should attempt (J. F. Kennedy). Reasonable improvement is only more than thinking about the world and condition or producing financial development. Advancement is manageable on the off chance that it "addresses the issue of present without trading off the capacity of future ages to address their own issues" (The 1987 Brundtland Commission, set up by the United Nations General Assembly). Feasible improvement relies on the logical and productive utilization of assets. It is the crossing point of three columns; condition, economy and society. When we consider reasonable improvement, we should think about a framework where choices taken to guarantee that each part of the framework; living creatures (man, creature, trees), condition, society, riches is equipped for thriving without blocking the limit of the other segment to do as such, regardless of whether in the present or later on reasonable improvement requires the dynamic cooperation all things considered; government, NGOs, INGOs, private area yet in addition common society. It isn't simply government officials or arrangement producers who simply choose what feasible advancement should like. The most significant partner in supportable improvement are we. We need to remind strategy producers to settle on choices which ensure our future; we can advise them that we need better employments, cleaner urban communities, increasingly impartial asset dispersion or more each of the a certification that our future is secure, brimming with circumstances, a wonderful world to live in and a sound planet.

The test is to devise strategies which equalization financial development, natural security and social fairness and which take a gander at the long haul. Built up pointers must be utilized to gauge advancement of practical improvement arrangements so we can assess if all the more should be finished. Along these lines, we have to consider some fresh possibilities and consider others and view our commitment as a piece of framework, where we are helping supportable advancement arrangements accomplish objectives that are useful to everybody.

2.5 Key Reviews from Journals and Reports

- **Duba** (1992. completed groundwater assessment of the Terai area of Nepal with the help of Canadian Co-activity. They had assessed the revive rates and asserted a yearly unique energize of 11,598 MCM

- In 1987, GDC organized ground water advancement techniques for water system in Terai locale of Nepal supported by World Bank.
- The Ground Water Resources Development Board (GWRDB) figured out how to get the legislative and WB fund. At that point it has extended the profound aquifer examination program all through in Terai and this program is as yet proceeding. Geophysical reviews likewise are done in numerous pieces of the Terai areas of Nepal
- In Terai area, inside the time of 1987 and 1992, shallow aquifer examinations were completed with the help from UNDP
- Ground Water Development Consultant (GDC), in 1994, had reassessed the GW improvement methodologies for water system in Terai& inward Terai valleys. The work had been overseen under World Bank fund
- A detailed and profound aquifer examination was done in Jhapa, an area of Terai, under the sponsorship of JICA, inside the time of 1993 to 1995
- Making an arrange inside an immersed zone has 3 sizes of stream frameworks: a nearby stream framework, which is the most close to the surface, a middle of the road stream framework and a local stream framework, which is the most profound and ventures to every part of the best separation (Brunke and Gonser 1997, Winter et al. 1998, Fetter 1994).
- Current research has proposed that surface water and ground water associations may conceivably happen up to 2 km from the stream channel (Stanford 1994, Gilbert et al., 1997). By and large, streams and ground water are not in every case very much associated but rather when they are, the cooperation zone might be broad and always well connected but when they are, the interaction zone may be extensive.
- The nearby topographic highlights, for example, dunks or sorrows in the scene are driving components for the neighbourhood stream pathways. In neighbourhood stream pathways, ground water streams most close to the surface and dwells inside the stream way for the briefest term of time. This pathway is most powerless to changes and is well on the way to be affected by human exercises.

- The basin morphology governs the large scale regional flow pathway. Ground water would flow below ground, without surfacing, from mountains to the outwash plain.
- Ground water will prematurely rise to the surface with the compaction of soil particles, which would allow solar radiation to warm the water and would prevent it from passing its cooling effects onto the stream (Gilbert et al. 1994).

CHAPTER – 3: STUDY AREA

In this chapter, description of study area has been discussed including ecological profile, physiography, hydrogeology, geology, ground water status, rainfall and ground water recharge potential.

3.1 Study Area

Morang District is situated in Koshi Zone of the Eastern Development Region of Nepal. It outskirts with Bihar (India) toward the South, Jhapa region toward the East, Dhankuta and Panchthar locale toward the North and Sunsari area toward the west. The area has one sub metro politian city (Biratnagar), eight Municipalities and 65 VDCs. The all out territory of the area is 1,825 km2. The present populace of the locale is 9,65,370 and the normal populace thickness is around 520 individuals for every square kilometre till 2011. The most reduced rise point is 60 meter and the most elevated height point is 2410 meter above mean ocean level. The area headquarter is associated by Koshi National High route toward the East-West Mahendra National Highway at Itahari. The region is additionally associated with the Hilly pieces of the eastern area of Nepal. T The area has an assorted variety of societies and religions. A topographical area of 26.6799° N, 87.4604° E. what's more, is situated in the in Koshi Zone of the eastern-most Terai area of Nepal. It lies 399 km east of District Capital 6 km north of the Jogbani outskirt of the Indian province of Bihar and 120 km of south east of Indian state West Bengal. Study zone Morang region has spread more than 1,825 km2 which contains lower tropical (80.9%), upper tropical (11.55%), subtropical (7.4%) and mild (0.2%). The most minimal and most astounding elevations of Morang area recorded are 60 m msl and 2410 m msl, separately. As the region has involved both Tarai and southern incline of Mahabharat Hills enveloping Churiya Hills, both warmwater and cold-water. The vast majority of the waterways of this region take their source from the foot of the Mahabharat Hills and Churia Hills and make their courses towards south. The waterways, streams and other water bodies regular water sources referenced above, man-made lakes, supplies, trenches, trench, pools were additionally incorporated the significant water body and waterways are as Bakara stream, Judi daha, Keshaliya stream, Khadaradaha, Kukurpuladaha, Lohandra stream, Pichhadadaha , Singhia stream is the waterway in Morang locale. This region is the centre of Industrial division for the Eastern Development Region of Nepal and furthermore has the potential for agribusiness.

The area guide of the investigation region is appeared in Figure 3.2.

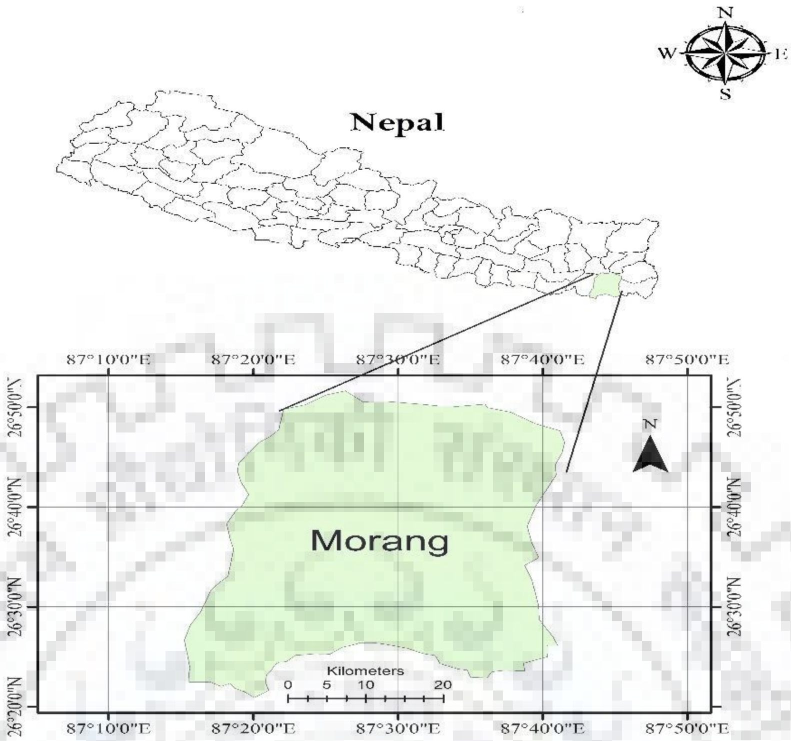

Figure 3.1: Location Map of Study Area

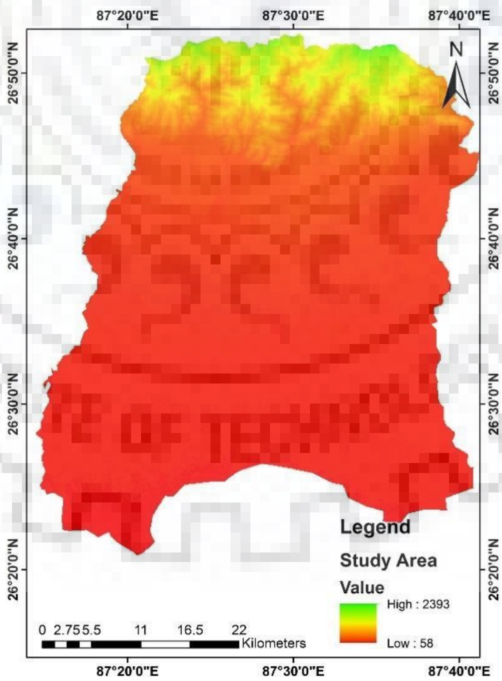

Figure 3.2: Location Map

As indicated by the Census 2011, the all-out populace of the region includes 51.6% female and 48.4% male living in 2,13,997 families. The normal family unit size is 4.51 people. The area populace development rate is 1.35%. Movement is quickly expanding every day from provincial regions to this area in the inquiry of better occupation and training. Future of the general population is 69.6 years. The education rate is about 70.63% and 78.73% for male and female separately. This locale has multi ethnic structure; dominant parts are Brahmins, Chetri, Limbu, Rajput, Rajbanshi, Tamang, Kami, Damai. As far as religion, Hindus are 80.1%, Kirat 7.3%, Muslim 4.4%, Buddhist 4.4%, Christian 0.8% and other 2.8%. The principle dialects are Nepali trailed by Maithili, Rajbansi, Tharu, Rai, Limbu, Santhali, Bhojpuri and other.

3.2 Ecological Profile

Practically all the region inside Biratnagar region local is under development and developed region. There is regular timberland region with tremendous size aside from a couple of patches of plantation and nurseries dispersed in better places. The vegetation species found in Morang territory are Siris (Albiziaprocera), Kadam (Anthocephaluschinensis), Bakaino (Melia azederach), Sisau (Dalbergia sissoo), Simal (Bombax ceiba), and forests of Bamboo (Dendrocalamushamiltoni). Other grub tree species detailed arePadari (Stereospermumpersonatum), Amaltas (Cassia fistula), and Pipal (Ficusreligiosa). Forests of bamboo are regular in the area. Paddy, Jute, Rabi and occasional vegetables are developed in Morang district principally well known for paddy rice, Jute and wheat as shown in figure 3.3.

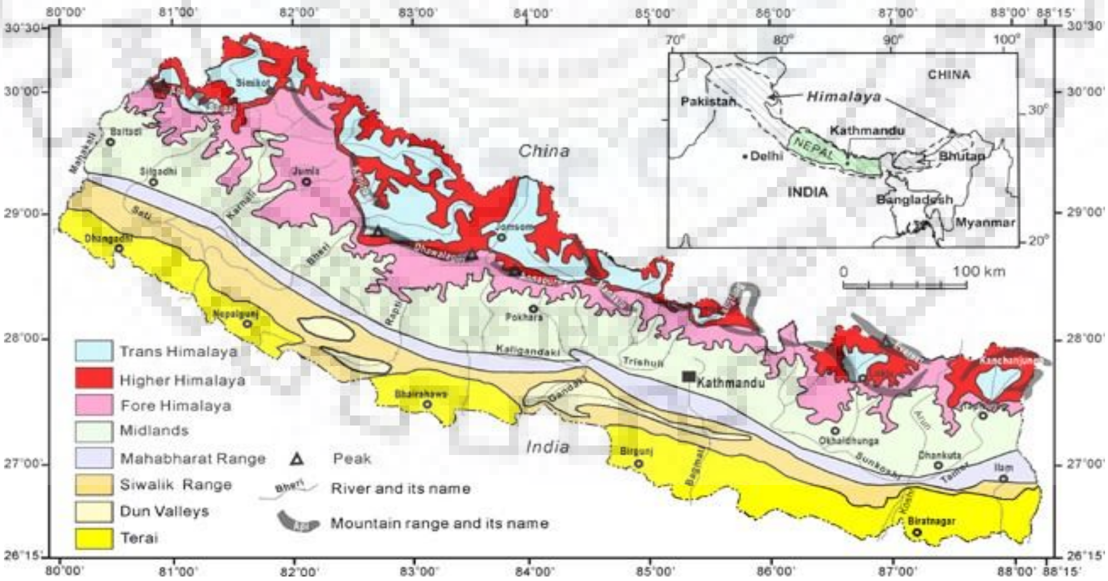

Figure 3. 3: Physiography of the Nepal Himalaya (after Dahal and Hasegawa, 2008)

3.2.1 Physiography

In 1950, Tony Hagen had successively divided Nepal into eight well-defined geomorphic units running parallel from northwest to southeast (Table 3.2). Figure 3.4 and Figure 3.5 illustrates the generalized physiographic profile of the Nepal. **Table 3. 1: Physiographical division of the Nepal Himalaya**

SN	Geomorphic Unit	Width (km)	Altitudes (m)	Main Rock Types	Age
1	Terai (Northern edge of the Gangetic Plain)	10 - 50	100-200	Alluvium: coarse gravels in the north near the foot of the mountains, gradually becoming finer southward	Recent
2	Churia Range (Siwaliks)	10 - 50	200-1300	Sandstone, mudstone, shale and conglomerate.	Mid Miocene to Pleistocene
3	Dun Valleys	5 - 30	200-300	Valleys within the Churia Hills filled up by coarse to fine alluvial sediments	Recent
4	Mahabharat Range	10 - 35	1000-3000	Schist, phyllite, gneiss, quartzite, granite and limestone belonging to the Lesser Himalayan Zone	Precambrian and Paleozoic occasionally also Cenozoic
5	Midlands	40 - 60	300-2000	Schist, phyllite, gneiss, quartzite, granite, limestone geologically belonging to the Lesser Himalayan Zone	Precambrian and Paleozoic to Mesozoic
6	Fore Himalaya	20 - 150	2000-5000	Gneisses, schists, phyllites and marbles mostly belonging to the northern edge of the Lesser Himalayan Zone	Precambrian
7	Higher Himalaya	22-90	>5000	Gneisses, schists, migmatites and marbles belonging to the Higher Himalayan Zone	Precambrian
8	Inner and Trans Himalaya	10 - 60	2500-4500	Gneisses, schists and marbles of the Higher Himalayan Zone and Tethyan sediments (limestones, shale, sandstone etc.) belonging to the Tibetan-Tethys Zone	Precambrian and Cambrian to Cretaceous

Source: B. N. Upreti, 1999

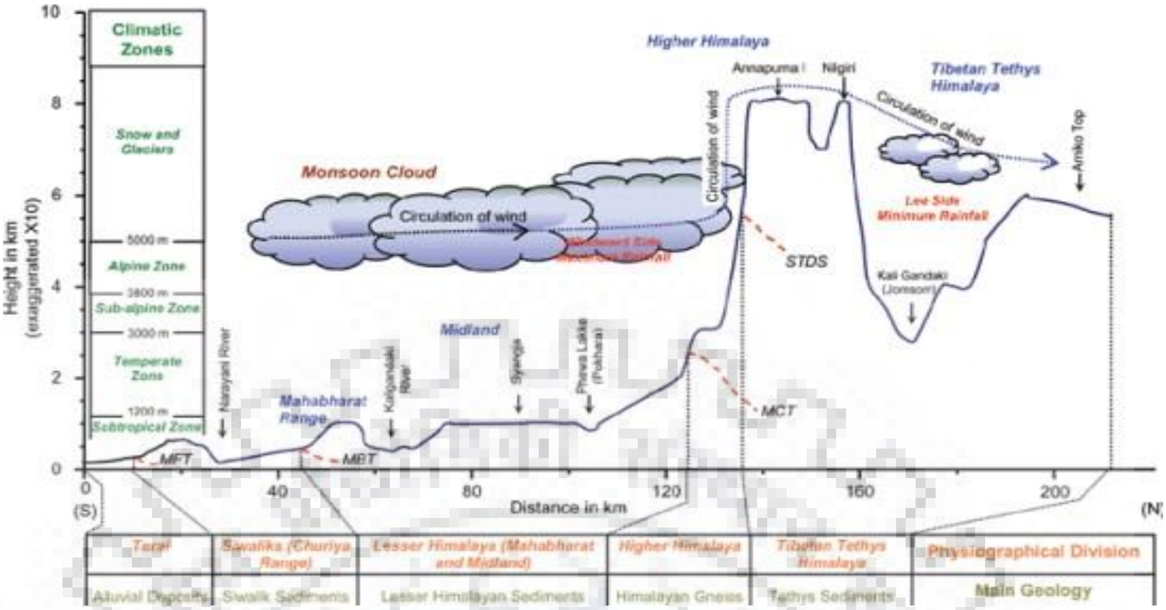

Figure 3. 4: Generalized geographical cross section of the Nepal Himalaya
(Modified after Dahal 2006)

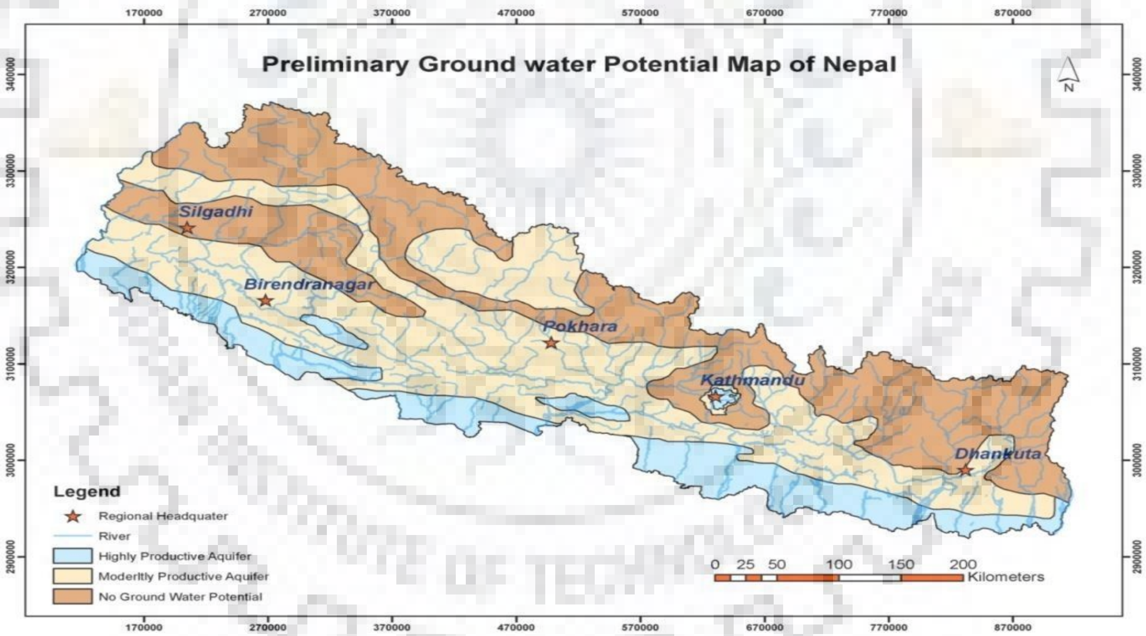

Figure 3. 5: Ground Water Potential Map (modified after Grimmelmann, W. F. 1984)

3.2.2 General Hydrogeology

The essential goal of the investigation is to contribute towards methodical groundwater studies using Remote Sensing and Geographic Information Systemic (GIS) in recognizable proof of groundwater potential zone regions. The present investigation region is situated in Morang, Nepal, the accompanying term are concentrated to do to get result

3.2.3 Geology

A huge piece of the locale is involved of rocks like the mud to shake type arrangement spoken to by of most even magma streams of basaltic synthesis, traps attributable to their predominant event in the territory, and the progression like appearance of their exposures. They have a general inclination to shape level beat slopes offering ascend to levels, containing a few magma streams, each running from a couple of meters 10 to 50 meters in thickness. The different lithological units shaping a stream might be separated from each other from their physical attributes, for example, their surface, jointing improvement, and mineralogical idiosyncrasies. When all is said in done, the highest points of these streams are portrayed by the nearness of a red ferruginous bed, which maybe, speaks to a modified ferruginous elite of a stream. The devices when all is said in done show commonplace spheroidal enduring, concentric layers reproducing an onion being created in endured stones. A portion of these streams are described by the nearness of a unit containing great created columnar joints giving pentagonal segments representing a few meters in stature. Swells extensively on expansion of water and evaporates with unmistakable breaks on losing the dampness. Another result of enduring is laterite which is infrequently seen topping the high slopes in the area. It is a permeable, hollowed, clayey shake with, darker, dim mottled hues and with a slim limonitic covering superficially.

3.2.4 Groundwater

The uneven nation gets the most extreme precipitation. The groundwater is generally tapped from percolation in wells and springs. The fields involving the Singhia, Budi Khola, Keshalia stream valleys, have adequate water supply and might be said to be wellinundated tracts of the area. Nearness of streams and firmly divided arrangement of joints in hard and gigantic basalts help the permeation of water and wells arranged close both of these appropriate conditions, have satisfactory water supply

3.2.5 Hydrogeology

Under semi bound conditions in the streams at more profound dimension. Lithological imperatives manage that groundwater is available in the pore spaces of the vesicular basalt and in the joint and crack segments of gigantic pieces of the streams. The essential porosity in the basalts is related with the vesicles, which are the pore spaces created because of the departure of unstable and gases when the magma emits superficially as a magma stream.

This essential porosity in the basalt is normally restricted and identified with the quantum of gasses/unpredictable in the eruptive stage, which brought about the basalt stream. The groundwater in the examination region in this way is confined generally to the zones of optional porosity created in these stones because of breaks, joints and enduring. From the hydrogeological perspective, the recurrence and degree of jointing, breaking and the stream contacts and enduring along them are the most noteworthy parameters granting porousness and porosity for framing appropriate groundwater stores in Morang zone. Groundwater is found in many pieces of the nation. Just the sum and profundity differ from spot to put. The primer hydrogeological mapping proposes that aside from the unfractured rock, gneiss and meta-silt of higher changeable evaluation in midland and higher Himalaya, the remainder of the topography has potential for groundwater. Among the potential, free residue of Terai and internal Terai, karstified and cracked carbonate rocks of midland and Tethys gathering are viewed as exceedingly beneficial aquifers. Furthermore, unconsolidated stores of Kathmandu and Surkhet (Birendranagar territory) valleys, Siwalik rocks, non-karstic however cracked carbonate shakes in lower Himalaya, Crystalline Complex and Tethys gatherings are translated as tolerably gainful aquifers. The Terai contains different layer of good aquifers of which many are interconnected. Transmissivity estimations of in excess of 1000 m2/day are normal. Well yields extend by and large somewhere in the range of 5 and 60 l/s. Groundwater stream is dominatingly towards south. The groundwater capability of the Kathmandu Valley has not been completely evaluated up 'til now. Poor aquifers appear to prevail in the focal point of the territory. Transmissivity estimations of 200-7000 m2/h were found in the northern piece of the valley. Energize happens for the most part in the lower region territory however at a somewhat low rate. Recommendations with respect to incited revive have been made. The lower Himalayan Series and the Crystalline Complexes represent the best issues as to groundwater appraisal. Inside this gathering, the best aquifers are carbonates shake of which extraordinary parts have been now mapped. The Lower Himalayan Series (except for carbonates) contains a significant level of incompletely broken hard shakes. In this gathering of topographical unit the event of groundwater is limited just locally. The higher transformed Crystalline Complexes contains no groundwater assets worth referencing, however there are (aside from carbonates) some porous shakes in any event in the upper piece of the progression. Rocks and Gneisses have been delegated being commonly very poor aquifers on the grounds that the vast majority of indicated low evaluations of breaking. The Tethys Group contains some great aquifers of generous thickness, primarily limestone and quartzite however there are additionally thick progressions which are practically impenetrable. As itemized maps are accessible for just a piece of the outcrop region the unit in general must be named having 'neighborhood event' of groundwater as below figure 3.6.

There have been not many examinations done on the groundwater asset potential and its advancement in Nepal. The clients, specialists and arrangement creators are not ready to manage the administration issues identifying with groundwater the executive techniques, satisfactory strategy plan and usage predominantly because of poor comprehension of the groundwater attributes, quality and amount.

3.3 Groundwater Occurrence in Terai Plain of Nepal

The Terai plain (Figure 3.6) is a continuation of Indo-gangetic plain, lies southern piece of mountain scope of Nepal. Complete zone of Terai Plain is about 29000km^2. The Terai involves about 23% of the nation's all out region and is the southernmost physiographic division of Nepal. A portion of the Terai fields happen in structural strike valleys north of the low Churia lower regions.

The Terai aquifers happen in the accompanying two hydro-topographical noteworthy depositional units:

- Bhabar zone is arranged in the lower region of the Siwalik range comprising of alluvial and colluvial coarse silt (rock, cobble and stones). This is the major energize region of Terai plain. The Bhabar zone dregs comprise of porous, unconfined aquifer, profound water table. High precipitation happens in this zone around 1700 mm in contrast with the southern zone.
- The southern zone (Terai Plain), which comprises of thick residue of Indo-Gangetic floodplain, contains mud, residue, sand and rock, these silt are converged with Bhabar zone. Fine residue are transcendent towards the Indian outskirt. This zone gets moderately low precipitation in contrasted with the Bhabar zone; revive sum is high because of enormous territory of unconsolidated silt.

The Terai plain (Figure 3.7) is a continuation of Indo-gangetic plain, lies southern part of mountain range of Nepal. Total area of Terai Plain is about 29000km^2. The Terai occupies about 23% of the country’s total area and is the southernmost physiographic division of

Nepal. Some of the Terai plains occur in tectonic strike valleys north of the low Churia foothills.

The Terai aquifers occur in the following two hydro-geological significant depositional units:

- Bhabar zone is situated in the foothill of the Siwalik range consisting of alluvial and colluvial coarse sediments (boulder, cobble and pebbles). This is the major recharge area of Terai plain. The Bhabar zone sediments consist of permeable, unconfined aquifer, deep water table. High rainfall occurs in this zone about 1700 mm in compare to the southern area.
- The southern zone (Terai Plain), which consists of thick sediments of Indo-Gangetic floodplain, comprises clay, silt, sand and gravels, these sediments are merged with Bhabar zone. Fine sediments are predominant towards the Indian border. This zone gets relatively low rainfall in compared to the Bhabar zone; recharge amount is high due to large area of unconsolidated sediments.

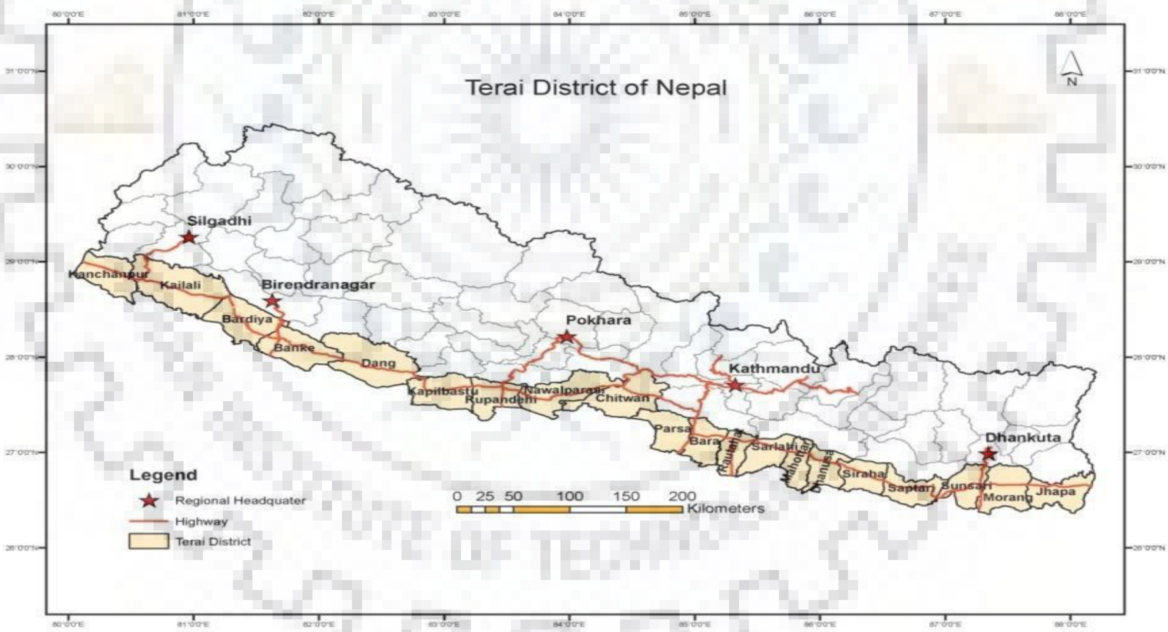

Figure 3. 6: Terai Districts of Nepal

For the most part two kinds of aquifers in the Terai are being tapped I) Shallow aquifer, (up to 50m), beneath groundwater level, unconfined to semi-restricted aquifers and ii) Deep aquifers, (regularly from 50m to 200m subterranean dimension), limited aquifers. The all out thickness of the residue heap under the Terai is as yet obscure. For water well examination reason, the most extreme boring profundity is 450m (bored by Department of Water Supply and Sewerage in Nepalgunj). It has been seen that more profound penetrating (up to 3500m) has occurred in eastern Terai for oil investigation reason bored by Department of Mines and Geology.

3.3.1 Rainfall:

The climate in Nepal is almost moderate, but also offers a few sultry months with high humidity and high temperatures. Several months of the year it is warm to hot at temperatures continuously above 25 degrees centigrade, sometimes up to 29 degrees. The lesser rain is in from October to April. The most rain days occur from May to September

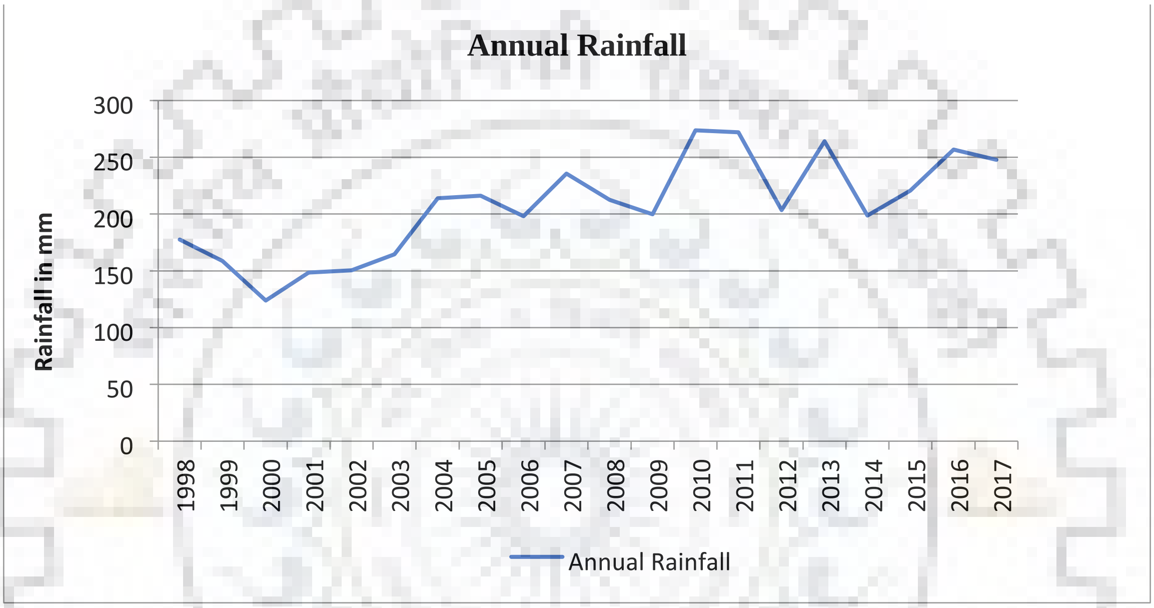

Figure 3. 7: Year wise Annual rainfall pattern

3.3.2 Water level depths

The Terai and the inward valleys in the slopes and mountains has a decent potential for groundwater extraction. A great part of the Terai and a few pieces of the Siwalik valleys has shallow or profound aquifers. Huge numbers of which are reasonable for extraction as wellsprings of water system and drinking waters.

Groundwater levels have been estimated since 1991 at around 400 shallow cylinder well which are appropriated over the Terai segment of Nepal. These information are gathered by the Groundwater Resources Development Board. In the greater part of the area the water level is estimated both in shallow and profound cylinder wells. Following tables demonstrates the greatest and least water level estimated in 2013/2014 in various wells in the Terai region of Nepal.

Table 3. 2: Details of water level in Terai District of Nepal

District	Water Level (mbgl)			
	Shallow		Deep	
	Min	Max	Min	Max
Banke	++	5.45	1.08	12.5
Bara	0.6	6.8	++	5.8
Bardiya	++	10.1	7.64	10.8
Chitwan	0.2	12.1	*NA*	
Dang	0.2	16.5	2.51	21.55
Dhanusa	++	12.29	*NA*	
Jhapa	++	3.78	0.35	4.85
Kailali	0.8	6.15	*NA*	
Kanchanpur	0.5	4.4	*NA*	
Kapilvastu	++	4.78	0.43	4.75
Mahottari	++	5.59	++	30.69
Morang	++	5	0.82	4.8
Nawalparasi	1.[illegible]3	13.1	*NA*	
Parsa	++	3.55	++	2.98
Rautahat	++	4.6	++	5.8
Rupandehi	++	16.33	++	5.5
Saptari	1.[illegible]3	11.13	4.4	27.51
Sarlahi	3.[illegible]1	11.26	*NA*	
Siraha	++	6.77	0.5	4.05
Sunsari	++	7.9	1.8	4.8

Sources: GWRDB

The information shows that the shallow water level fluctuates between streaming condition and about 16mbgl. The most profound water level is experienced at the Rupandehi area which lies at the western piece of the nation. The normal shallow water level is about 4.55mbgl. The gathered water level information of profound aquifer demonstrate that the normal water level is about 5.92mbgl. The most extreme water level (about 30.69mbgl) is experienced at Mahottari region which lies in focal piece of the nation. The Figure 3.9

demonstrates the provincial hydrographs of the profundity of water level in shallow aquifer in Terai part of Nepal. The plotted information incorporates the month to month water level information from January 2009 to December 2013.

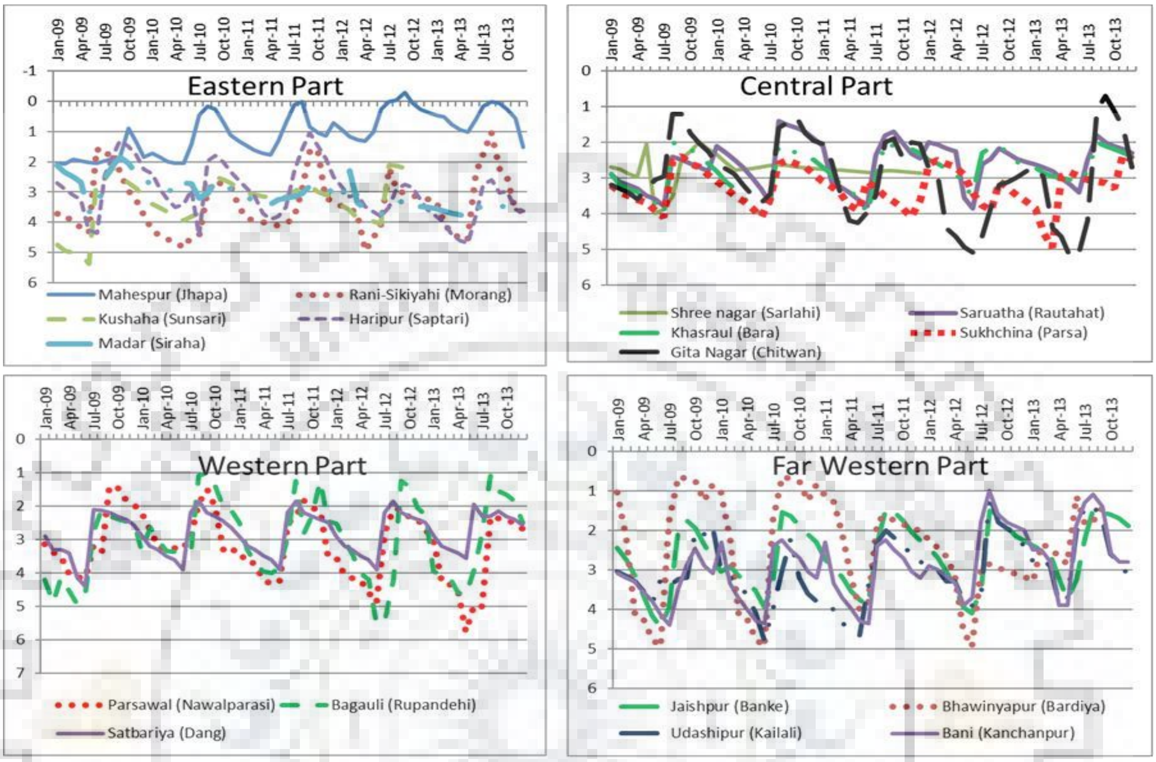

Figure 3. 8: Hydrographs of depth of water level in shallow aquifer

The profundity of water level crosswise over entire area did not show declining pattern. The hydrographs show that the variety in yearly vacillation is in the declining pattern. The abatement in regular variety might be because of the change in revive process which thus may be caused because of the environmental change. It is seen in late time that the precipitation example has been changed. Despite the fact that the yearly normal of the precipitation continues as before yet the stormy days has been decreased. The consequence of this is the precipitation force has expanded which results in increment in surface stream and less permeation to the groundwater table. It is seen over the area normal yearly variance in water level is about 3m.

3.3.2 Aquifer System

This plain was made about 1 million years prior when the Churia slopes appeared. The cellar comprises of hard shakes and happens at a profundity of about 6000m to 7600m from the surface in the Nepalese Terai (Mathur and Kohli-1963). Among this around

4500m is the Churia arrangement (C. K. Sharma) and rest about 1500m thick comprises of alluvium store. This thick grouping of alluvium comprises of sand and earth. The alluvium in the Terai Plain has been kept from the adjacent mountains by the waterway. Not all the waterway coursing through the Terai at present contributed in the testimony of alluvium. Just Antecedent River like Koshi, Gandaki, Karnali, Mahakali contributed in this marvel. Later on when other stream came to presence they began to store over it. The residue saved in the Terai plain comprise of thick layer of clastic stores of Quaternary and Pleistocene age. The statement of these materials is as yet going on till day. As indicated by the lithologic and hydrologic reason, these stores can be characterized into i) Bhabar Zone ii) Terai Plain

Bhabar zone are found along the base of the Siwalik at the northern edge of the Terai and furthermore along significant waterways rising above the Terai. The Bhaber zone in certain spots in Nepal is absent. It is assessed that the all out territory of Bhabar zone in Nepal is around 4700 km^2. The Bhabar zone is considered as the rule revive zone of the Terai. The silt found in the Bhabar zone comprise of in all respects ineffectively arranged coarse grained materials. The grain size shifts from sand to rocks. The thickness of the Bhabar layer ranges from few meters to in excess of a hundred meters.

Terai zone covers about 18800km2. The Terai plain dregs are contained materials which are dissolved from the Siwalik and the mountains toward the north. The Terai sediments are saved by a similar stream which saved the Bhabar zone. At the point when these waterways enter the Terai the angle changes and that causes just littler size dregs to be conveyed by it. The molecule size of the dregs ranges from earth to rock. The extent of better molecule (mud, residue and fine sand) contrast with the coarser materials is more.

In the Teraithe upper 50-60 m of residue give great profitable shallow zones and most groundwater generation happens in the upper 250 m. Between 20-half of screen able sand layers are unconfined to a profundity of 46 m.

The lithological cross segment of focal zone (Bara District) and Western region (Kapilvastu District) attracted north to south course demonstrates that that the thickness of the better residue toward the south is thicker. In the western piece of the Nepal Terai, nearness of shallow aquifer is restricted up to the focal part though in the focal zone of

Nepal Terai it is reached out up toward the southernmost segment. The segments show the nearness of profound aquifer inside the two zones. The profound aquifer material comprises of sand of different sizes and furthermore rock in certain regions. The water level information demonstrates that in the northern zone the static water level is more profound contrast with the southern part. The general heading of groundwater stream pursues the surface seepage design from north to south.

GDC (Groundwater Development Consultant, UK) (1994) characterized the shallow and profound aquifers in the Terai territory dependent on the level of aquifer and transmissivity esteems which were acquired from the examination and water system wells. The grouping is appeared in the table3.3.

Table 3. 3: Aquifer Classifications

Shallow Aquifer		Deep Aquifer	
Classification	Aquifer %	Classification	Transmissivity of 100m section (m^2/day)
Good Marginal Poor	> 40 20 – 40 <40	Good Fair Marginal	>2000 1000-2000 <1000

Source: GDC (1994)

GDC (1994) has also classified the aquifers into different development potential classes which are based on water table or piezometric surface, lithology and the suction limit of the surface mounted centrifugal pumps. The detail of this classification is given in the table3.4

Table 3. 4: Transmissivity values in District of Nepal Terai

District	**Transmissivity (m^2/day)**	
	Minimum	**Maximum**
Jhapa	100	1100
Morang	180	3100
Sunsari	900	4300
Saptari	10	7900

Siraha		40	5200
Mahottari		130	330
Sarlahi		10	14000
Rautahat		270	3500
Bara		250	7000
Parsa		40	1200
Chitwan		770	4600
Nawalparasi		60	1000
Rupandehi		50	16000
Kapilvastu		3	750
Dang	Dekhuri Valley	990	9900
	Dang Valley	30	5600
Banke		180	1000
Bardiya		260	610
Kailali		160	4000
Kanchanpur		120	6200

Source: Technical Reports, GWRDB

3.4 Groundwater Recharge Potential

In Terai of Nepal wellspring of ground water revive is the precipitation. Energize to the ground water happens through direct invasion of precipitation, by subsurface inflow from stream valleys entering the zone, by leakage misfortunes, horizontal revive from Bhabar zone. The Bhabar zone is especially responsive to guide permeation to the water table in view of the huge grain estimate. The precise outline and region of the Bhabar zone and the fundamental energize region for the Terai is so far not known. Bhabar zone are viewed as the essential energize region to the profound aquifers of the Terai territory.

Different appraisals are accessible for the groundwater revive in Terai area. As per Duba (1982) which depended on the permeation of precipitation, the all-out yearly unique revive is 9629 MCM in Terai; almost 33% or 3,114 MCM, of this energize happens in the Bhabar Zone (about 34% of precipitation permeates) and the staying 6,515 MCM in the fundamental Terai fields (about 22% of precipitation permeates).

GDC in 1987 and 1994 assessed that a normal of 600mm of revive happens every year in the Terai. Around 460 mm of revive is the commitment from direct precipitation permeation and rest 140 mm from spillage energize. The report accept that about 75% of yearly energize i.e.450mm can be securely abused. The complete volume of groundwater accessible for the advancement dependent on this presumption will be 10745 MCM in entire Terai.

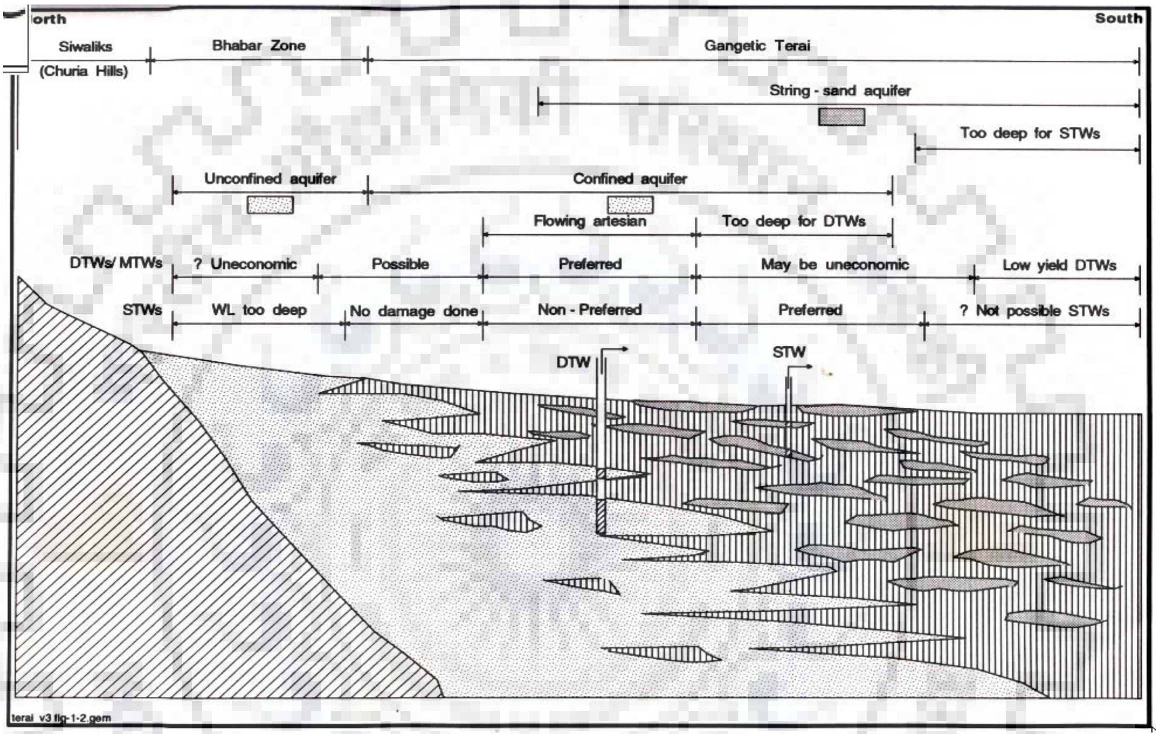

Figure 3. 9: General Aquifer system of Terai Nepal (Source: GDC, 1994)

Correspondingly, Electrowatt in 1984 evaluated around 465 mm of yearly energize in the Bhabar zone. Then again, Tahal Consultant, Israel (1992) evaluated more than 1,100 mm of yearly energize including about 42% from precipitation and the staying from the later revive from streams that cross the Bhabar zone to achieve aquifer.

Shallow Aquifer Investigation in Terai Project (GWRDB/UNDP) assessed yearly groundwater energize. In the report the energy is determined in three distinct ways and the result esteems are very extraordinary with one another. The most traditionalist estimation has determined the yearly energize in the entire Terai of Nepal to be 5800 MCM. The most acknowledged energize estimation in Terai of Nepal is the one dependent on the occasional variety in water level and the particular yield factor of the silt. Utilizing this strategy, the absolute yearly groundwater energize in the Terai is determined as 8800 MCM (McNellis et al 1993). Most the writing utilized this incentive to be the yearly energize in the Terai.

3.5 Groundwater Quality

The nature of groundwater in Terai is commonly reasonable for water system just as drinking reason and for irrigation purpose. Particularly for drinking reason, the groundwater from kept aquifers is superior to that structure-unconfined aquifer. In the Terai area, the nature of shallow groundwater depends, to a huge degree, on the lithology of the silt (BGS, 2001). All the accessible examinations results show that the groundwater from profound aquifer are somewhat antacid in nature and are wealthy in bicarbonate and calcium/magnesium content in Terai (Kansakar). Sodium substance is low and normal electric conductivity is 470 micro ohms in the groundwater from profound aquifer. Then again, iron and sodium content when all is said in done is higher in the shallow aquifer (GDC 1994, Nippon Koeu 1993, JICA 1995, GWRDB/UNDP Technical Reports). The Sodium Adsorption Ration (SAR) which shows the alkalinity peril list, of shallow aquifer is extremely low. As indicated by the Duba (1982) higher SAR qualities were seen in profound aquifer water test from Bheri and Narayani Zones. A noteworthy groundwater quality issue identifies with arsenic tainting in the Terai. In the Terai, a few groundwater quality overviews demonstrated that arsenic in certain examples surpasses attractive cut-off points. This tainting is a characteristic marvel and its relief requires an expansive methodology. Other potential regular groundwater quality issues are related with high groupings of broke down methane, manganese and iron. Diffuse groundwater contamination from farming pesticides and composts may likewise turn into an issue in the Terai. As per the examination led by National Arsenic Steering Committee (Nepal) and Environment and Public Health Organization (Nepal) undertaking a venture supported by USGS through a US Government Public Diplomacy Grant from the US Embassy in Kathmandu, most of cylinder wells, 76.3%, are beneath the WHO Guideline of 10 µg/l. Around 7.4% of all cylinder wells tried higher than the Nepal Interim Standard of 50 µg/l of arsenic focus and 16.3% of cylinder wells contained 11-50 µg/l of arsenic fixation. In this manner, 23.7% of cylinder wells in the Terai are above WHO Guideline. The vast majority of the cylinder wells with high arsenic esteems are under 50 m profound and most of cylinder wells further than 50 m have arsenic esteems beneath 50 µg/l (The State of

Arsenic in Nepal, 2003-National Arsenic Steering Committee and Environment and Public Health Organization, undertaking a venture subsidized by USGS). The most elevated level of polluted wells is found from 11 to 30 m profound. The wellsprings of arsenic in the ground water are accepted to be of geologic birthplace. In any case, the procedures that concentrate arsenic to naturally perilous dimensions in the shallow aquifers are inadequately comprehended. It isn't yet certain whether pollution is totally regular or is quickened by human exercises.

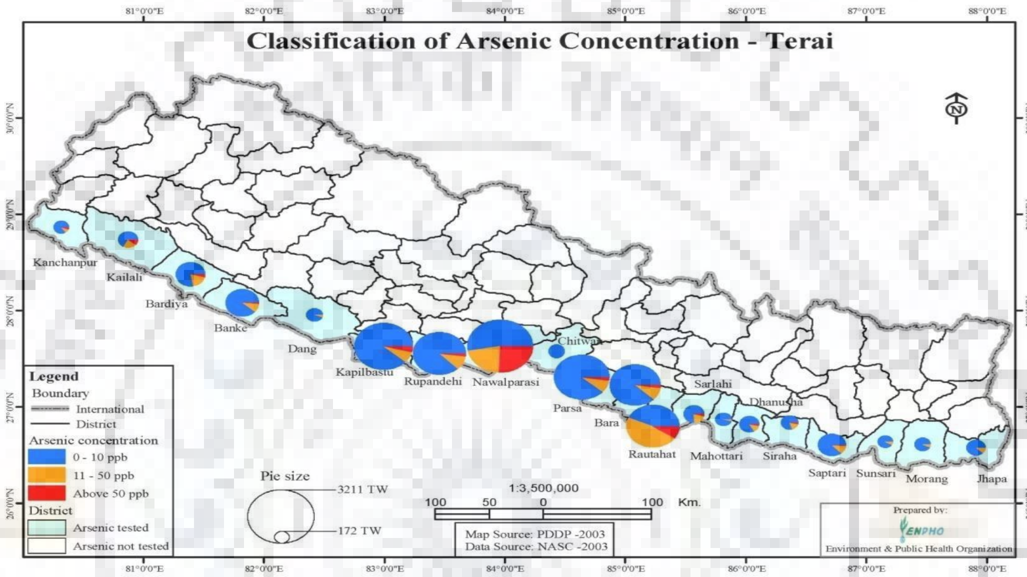

Figure 3. 10: Arsenic Classification Map (Source: The State of Arsenic in Nepal – 2003)

3.6.4 Agriculture Perspective Plan (APP)

Agriculture Perspective Plan (APP), which is a long haul (1995-2015) point of view of rural advancement of the nation, gives high need to groundwater improvement for its water system necessity. Farming Perspective Plan (APP), has concentrated on ground water Irrigation as a key contribution for agribusiness generation and has focused to create 8800 STW every year. The primary actualizing offices for these STWs improvement are GWRDP/DoI, DOA/MOA and ADB/N. The ebb and flow undertaking and program under DoI, ADB/N DoA/MoA couldn't coordinate the figure of 8800 STWs, so to finish the establishment of staying number of STW, Ground Water Irrigation Project (GWIP), Chitwan has given the duty to introduce the STWs. Along these lines GWIP, Chitwan was set up in FY 2055/56 to assist ground water system according to the APP record. Under APP in Sunsari region along 1238 STW had been introduced to flood 3280 ha.

Furthermore, 13 nos. of DTW had been developed to inundate 520 ha. Under Groundwater STW Irrigation Project and Groundwater DTW water system venture separately. There are no records of co-ordinates of the majority of the APP cylinder wells. In any case, records of the tubewells built amid past two financial years (Fiscal years 2066/67 and 2067/068) have arranges in it the figure underneath shows dissemination of APP STW in Jhapa, morang and Sunsari locale.

Table 3. 5: Year wise progress of the Groundwater Shallow Tube Well Irrigation Project (APP)

DISTRICTS	2055/56		2065/66		2066/67		2067/68		2068/69		2069/70		2070/71/71-72		**Total**	
	STW	Ha.	STW	Ha.	STW	Ha.	STW	Ha.	STW	Ha.	STW	Ha.	STW	Ha.	**STW**	**Ha.**
SUNSARI	15	37.5	300	750	213	533	360	900	350	875	265	662.5	140	350	**1643**	**4108**
MORANG	428	1070	400	1000	160	400	450	1125	400	1000	245	612.5	266	662	**2349**	**5869.5**
JHAPA	252	630	600	1500	290	725	450	1125	450	1125	405	1025	270	675	**2717**	**6805**
ILAM	-	-	-	-	-	-	-	-	45	112.5	50	125	35	87.5	**130**	**375**
TOTAL	**695**	**1738**	**1300**	**3250**	**663**	**1658**	**1260**	**3150**	**1200**	**3112.5**	**965**	**2425**	**711**	**1774.5**	**6839**	**17157.5**

3.7 Status of STW Irrigation

3.7.1 Shallow Tube -Well Irrigation

A shallow tube well is a well to tap ground water from permeable zones. In sedimentary developments of Terai Zone of Nepal, a well of 2-4 inches (5.08 to 10.16 cm) distance across, up to 50 meters (164 foot). These tube wells are either pit tube-wells or strainer tube wells. These are normally penetrated by percussion technique utilizing hand exhausting sets and once in a while percussion rigs. Achievement and ubiquity of the plan relies upon how shabby they are. Electric Operated or diesel worked divergent siphon of 3-10 HP are utilized to concentrate water from the shallow tube wells. Diverse Project have been propelled for STW water system advancement in the zone since the foundation of the GWRDB, GBO Biratnagar, specifically they are UNDP examination, CSTIP, CGISP, EFDRP and APP. The aggregate figure very much bored under APP Project upto Fiscal year 2070/071 in the working regions is 6839 nos. of STWs. Which flood around 17097 ha of land. Other than APP, CSTIP, CGISP, Indian give ADB/N and had introduced shallow cylinder wells in Sunsari, Morang Jhapa and Ilam locale. The total figures of

STWs introduced in these areas are around 11889 which inundates around 33863 ha. of land. This is organized beneath.

Table 3. 6: STW Irrigation in Jhapa, Morang, Sunsari and Ilam Districts

S. No.	Project	STW Numbers	Irrigated Area (Ha.)
1	Community Shallow Tube Well Irrigation Project (CSTIP)	139	936
2	Community Groundwater Irrigation Project (CGISP)	3861	13520
3	APP (Groundwater STW Irrigation Project)	6839	17097
4	Emergency Flood Damaged Rehabilitation Project	1050	2310
TOTAL		**11889**	**33863**

3.7.2 Deep Tube-well Irrigation

Jhapa, Morang, Sunsari and Ilam districts are one of the highly potential districts for Deep Tubewell Irrigation development. APP and Farmers Managed Deep Tub-well Irrigation Project (Indian grant) are the major projects implemented in the district for development of deep tube wells for irrigation in the Siraha district.

Cumulative figure of DTW irrigation in the district up to fiscal year 2070/071 is tabulated below (Table 3.7).

Table 3. 7: DTW Irrigation in Sunsari, Morang and Jhapa District

S. N.	Project	DTW Numbers	Irrigated Area (Ha.)
1	Farmers Managed DTW Irrigation system (Indian grant)	10	400
4	Deep Tubewell Irrigation Project (APP)	16	640
TOTAL		**26**	**1040**

CHAPTER – 4: METHODOLOGY

This chapter presents the methodology adopted to carry out ground water potential zonation in the study area followed by a detailed description of factors affecting ground water.

4.1 METHODOLOGY

This include different activities such as preparation of base maps, LULC map, Digitization and image processing using software and interpretation of the outputs. First stage includes development of spatial database by using Landsat 8 satellite data. GIS and remote sensing technology is applied to prepare various thematic maps with reference to groundwater like drainage density, contour, and stream length. First stage incorporates advancement of spatial information base by utilizing Landsat 8 satellite information. GIS and remote detecting innovation is connected to plan different topical maps with reference to groundwater like waste thickness, shape, and stream length. Furthermore, the Land Utilization Survey Database, geologic maps and on location examination are received to quantitatively and subjectively depict the hydro-geo-sensible states of the zone. The Landsat 8 satellite information downloaded from earthexplorer.usgs.gov has been utilized to discover the land use and land spread example of study zone. Rainfall information downloaded from the CRU website (CRU TS Version 4.02) from 2011 to 2017. The second stage included planning of computerized rise model (DEM). The height information has been downloaded from ASTER GDEM and this has been utilized as base to make the rise and incline, at that point utilizing the rise information the seepage system has been made. DEM is utilized to get ready incline, slope, aspect, flow accumulation and stream order. Strategy is broadly utilized for getting ready overflow potential guide for little to medium for geo-referencing & geometric correction. In the third stage, advanced picture handling of the satellite information is accomplished for geo-referencing and geometric adjustment. This is trailed by production of various topical layers utilizing unsupervised arrangement strategy. Every one of the qualities from the gathered information at that point summed to make the thematic map for agribusiness territory and settlement zone. It is then trailed by production of other significant information which is utilized to decide the ground water potential at the later stage like land use/land spread guide, soil guide and precipitation map. In the fourth stage every single above subject are additionally handled and investigated in overlay and positioning is given to assess appropriate groundwater potential zone. All the topical layers were overlaid by utilizing GIS to locate the last coordinated yield of groundwater potential zones. The detailed methodology for ground water potential zonation is provided in Figure 4.1.

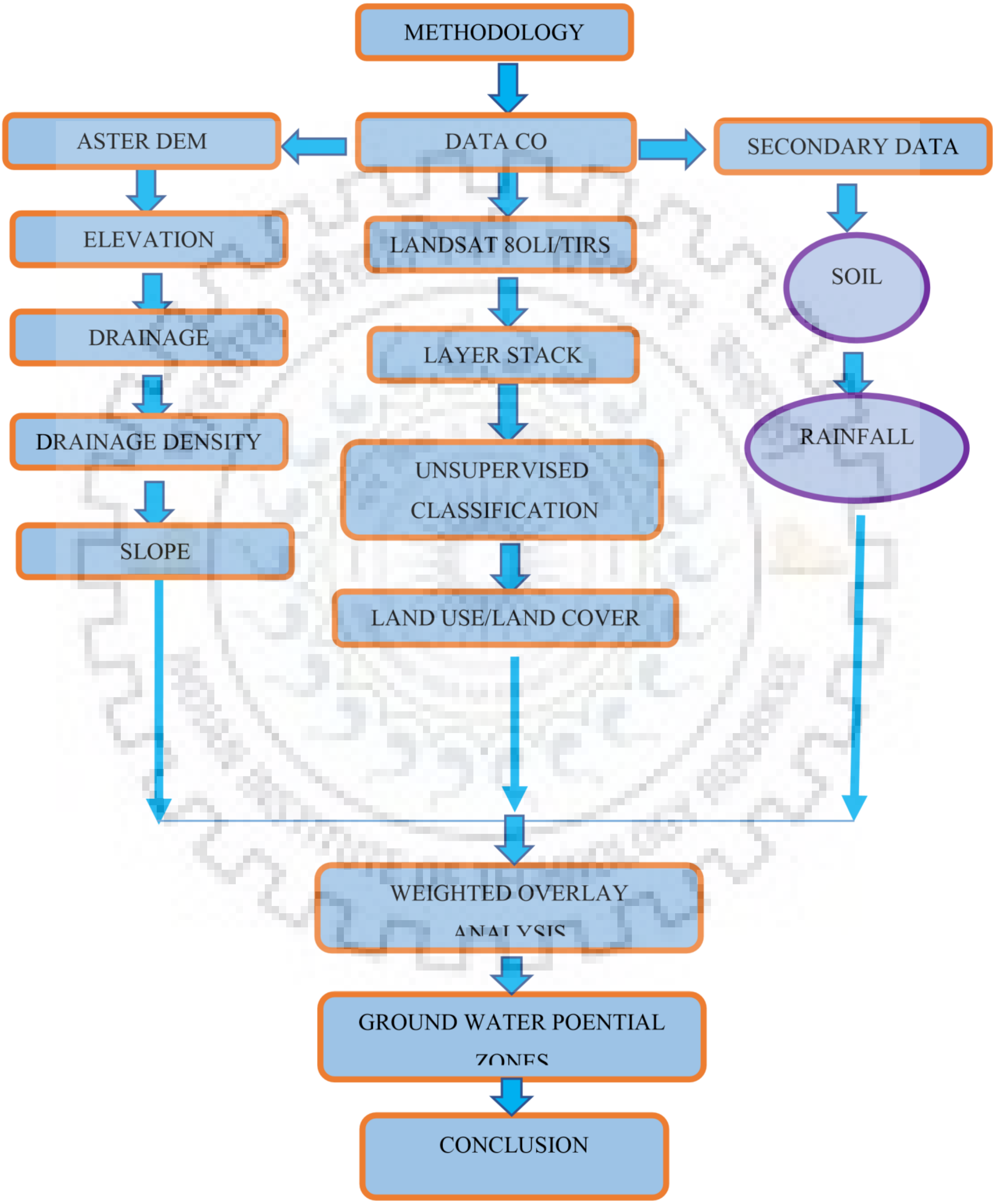

Figure 4. 1: Flow Chart for ground water potential zonation

4.2 FACTORS INFLUENCING GROUND WATER

4.2.1 Drainage and drainage density

A drainage basin is a natural draining runoff water to a certain lowest point. The map consists of water bodies, rivers, tributaries, perennial & ephemeral streams, ponds. The study area is fourth order basin connecting the rivers, tributaries based on topography.

Drainage network helps in delineation of watersheds. Drainage density, its type of drainage gives information about runoff, infiltration and permeability. Dendritic drainage shows homogenous rocks, the trellis, rectangular and parallel drainage patterns shows structural and lithological controls. Thus coarse drainage texture shows highly porous and permeable rock formations and fine drainage texture is for less pervious formations. Major faults, lineaments connect two or sometimes more drainage basins to form conduits (Interconnecting channel ways). Groundwater flowing along these poor zones is made fact. Drainage pattern shows surface characteristics and subsurface formation (Horton, 1945).

Drainage density (in terms of km/km^2) shows closing spacing of channel and nature of surface material, hence providing a quantitative measure of average length of stream channel of whole basin. It is observed from drainage density measurement in wide range of geologic and climatic type that a low drainage density is more happening to occur in region and highly resistant of highly permeable subsoil material in dense vegetative cover and relief is low. High drainage density is the result of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density shows to coarse drainage texture similarly high drainage density leads to fine drainage texture. The drainage density indicates the runoff in an area or in other words, the quantum of relative rainwater that could have infiltrated. Thus, lesser drainage density, the higher is the probability of recharge i.e. potential groundwater zone.

4.2.2 Slope Map

Slope is one of the important terrain parameters which indicates horizontal spacing of the contours. In vector form closely spaced contours indicates steeper slopes and sparse contours exhibit less slope although in elevation output raster every cell has a slope value. The lower slope values shows the flatter terrain (less slope) and higher slope values indicates to steeper slope of the terrain. In the elevation raster, slope is calculated by maximum rate of change in value from each cell to neighbouring cells. The slope value is measured in percentage or in degrees in both vector and raster analysis. The slope is calculated from digitized contours and spot heights have shown that elevation decreases from the northern part to the southern part with slope 0º to 33º in flat and in hilly terrain areas respectively. In the nearly level slope area (0-3) degree, the surface runoff is slow allowing more time for rainwater to infiltrate considering good groundwater potential zone and similarly strong slope area (33-64) degree, indicates high runoff allowing less residence time for rainfall water thus comparatively less infiltration and poor groundwater potential. The slope map is divided into five categories.

4.2.3 Soil

Soil is the one of the main factor that shows the amount of groundwater, the study of soil is to find out soil types and properties. Ground water movement and infiltration of surface water into ground dependent on the porosity and permeability. Thus the study of soil is important to determine the amount of ground water.

The base data for the soil classification i.e. study has been obtained from FAO Data. The result of soil classification obtained that the study area has two types of major soils. The movement and infiltration of water in these two types and not same to each other based on its property as assigned weightages

4.2.4 Rainfall

Rainfall is the main source for ground water availability through the water cycle. The amount of rainfall varies based on the environment conditions of the place. The possibility of ground water is high if the rainfall is high and it is low if rainfall is low. The rainfall not only varies spatially it also varies temporally thus to determine the influence of rainfall in any region for long time period survey is done. The todays survey has been consider the annual mean rainfall from the year 1999 to 2018. The value of annual mean values have been plotted on the respective rain gauge stations and the interpolation method Kriging method is used to find out the distribution of rainfall in the study area. Once the spatial distribution of rainfall has been found the study area has been classified into five zones based on the equal interval then the suitable weightage has been assigned for each classes.

4.2.5 Elevation

Water generally stores at lower topography not in the higher topography. Higher the elevation lesser the ground water potential and vice versa (Gedebo,2005), for the present study elevation data having 30 meter spatial resolution is taken based on the

ASTER DEM. The study area's elevation ranges between 54 meters to 2354 meters from the mean sea level, this values distributed equally into five classes and as assigned weightage.

4.2.6 Land use/ Land cover

Land use/land cover mapping is major factor of remote sensing. Land use/land cover plays important role in the development of groundwater resources. It manages many hydrogeological processes in the water cycle viz., infiltration, evapotranspiration, surface runoff etc. surface cover provides surface roughness, reduce discharge thereby increases infiltration. In the forest areas, infiltration will be more and runoff will be less though in urban areas rate of infiltration may decrease. Remote sensing provides exact information with respect to spatial distribution of vegetation type and land use in less time and low cost in comparison to conventional data. LULC of study area has been analysed for ERDAS, GIS & Satellite image.

4.2.7 Landsat 8 is used to make images of LULC

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. The ultra-blue Band 1 is useful for coastal and aerosol studies. Band 9 is important factors for cirrus cloud detection. The resolution for Band 8 (panchromatic) is 15 meters. Thermal bands 10 and 11 is used in providing more accurate surface temperatures is at 100 meters gap. The approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi). [Barsi et al., 2014]

Table 4.1: Description of Landsat 8 Bands

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) *Landsat 9 will have these same bands.	**Bands**	**Wavelength (µm)**	**Resolution (meters)**
	Band 1 - Ultra Blue (coastal/aerosol)	0.435 - 0.451	30
	Band 2 - Blue	0.452 - 0.512	30
	Band 3 - Green	0.533 - 0.590	30
	Band 4 - Red	0.636 - 0.673	30
	Band 5 - Near Infrared (NIR)	0.851 - 0.879	30
	Band 6 - Shortwave Infrared (SWIR) 1	1.566 - 1.651	30
	Band 7 - Shortwave Infrared (SWIR) 2	2.107 - 2.294	30
	Band 8 - Panchromatic	0.503 - 0.676	15
	Band 9 - Cirrus	1.363 - 1.384	30

	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100 * (30)
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100 * (30)

* *TIRS bands are acquired at 100 meter resolution, but are resampled to 30 meter in delivered data product.*

Because Landsat 8 data has additional bands, the combined used to create RGB composites differ from Landsat 7 and Landsat 5. For instance, bands 4, 3, 2 are used to create a colour infrared (CIR) image using Landsat 7 and Landsat 5. To create a CIR composite using Landsat 8 data, bands 5, 4, 3 are used. Displayed below are some common band combinations in RGB comparisons Landsat 4-5, Landsat 7, and Landsat 8.

**NOTE: Landsat 9 will use the same bands as Landsat 8.*

CHAPTER – 5: RESULTS AND DISCUSSION

This chapter gives a detailed overview of the results in terms of generation of various thematic maps obtained followed by conducting analysis in GIS environment. Finally, groundwater potential zonation map has been generated.

5.1 Database Preparation

GIS (Geographic Information System) is a collection of computer hardware, software, and geographic data for managing, analysing, and displaying all forms of geographic information.

5.2 Three Views of a GIS

GIS is most associated and analyzed with maps. A map, however, is only one way one can work with geographic data in a GIS, and only one type of result generated by a GIS. This is important that a GIS can provide a great deal more problem-solving capabilities than using a simple mapping program or any other methods like adding data to an online mapping tool. A GIS can be viewed in 3 ways as described in following paragraphs 5.2.1 The Database View

A GIS is a unique kind way to analysed - a geographic database (geodatabase) which is an "Information System for Geography". Fundamentally, a GIS is based on a structured database which describes in geographic terms.

5.2.2 The Map View

A GIS is combined set of intelligent maps and other views that show features and their relationships on the earth's surface. Maps of the underlying geographic information can be made, analysed and used as "windows into the database" to support queries, analysis, and editing of the information and is called geovisualization.

5.2.3 The Model View

A GIS is a set of information and transformation tools which derive new geographic datasets from existing datasets. These geo processing functions takes information from existing datasets, used analytic functions, and get results into new derived datasets. In other term by combining data and applying some analytic rules, a model is created that helps answer the question. Thus these three views are critical parts of an intelligent GIS and used at varying levels in all GIS applications.

5.3 Location of Observation Wells

The observation wells taken for the study are shown on the map of the study area. Twenty shallow tube wells and seven deep tube wells are considered for study. The name and GPS coordinates of these observation wells are provided in the data sheet given in appendices. The design discharge of the shallow tube wells is 10 lit/sec and generally operated for 200 hrs./annual whereas the design discharge of the deep tube wells is 40 lit/sec and mostly operated for 1000 hrs./annual. Practically the discharge of the deep tube wells is found to be 30 lit/sec. As per observation a shallow tube well has the capacity to irrigate 2.5 hectares of land whereas a deep tube well could irrigate 40 hectares of land. The location of the observation wells is sown in Figure 5.1.

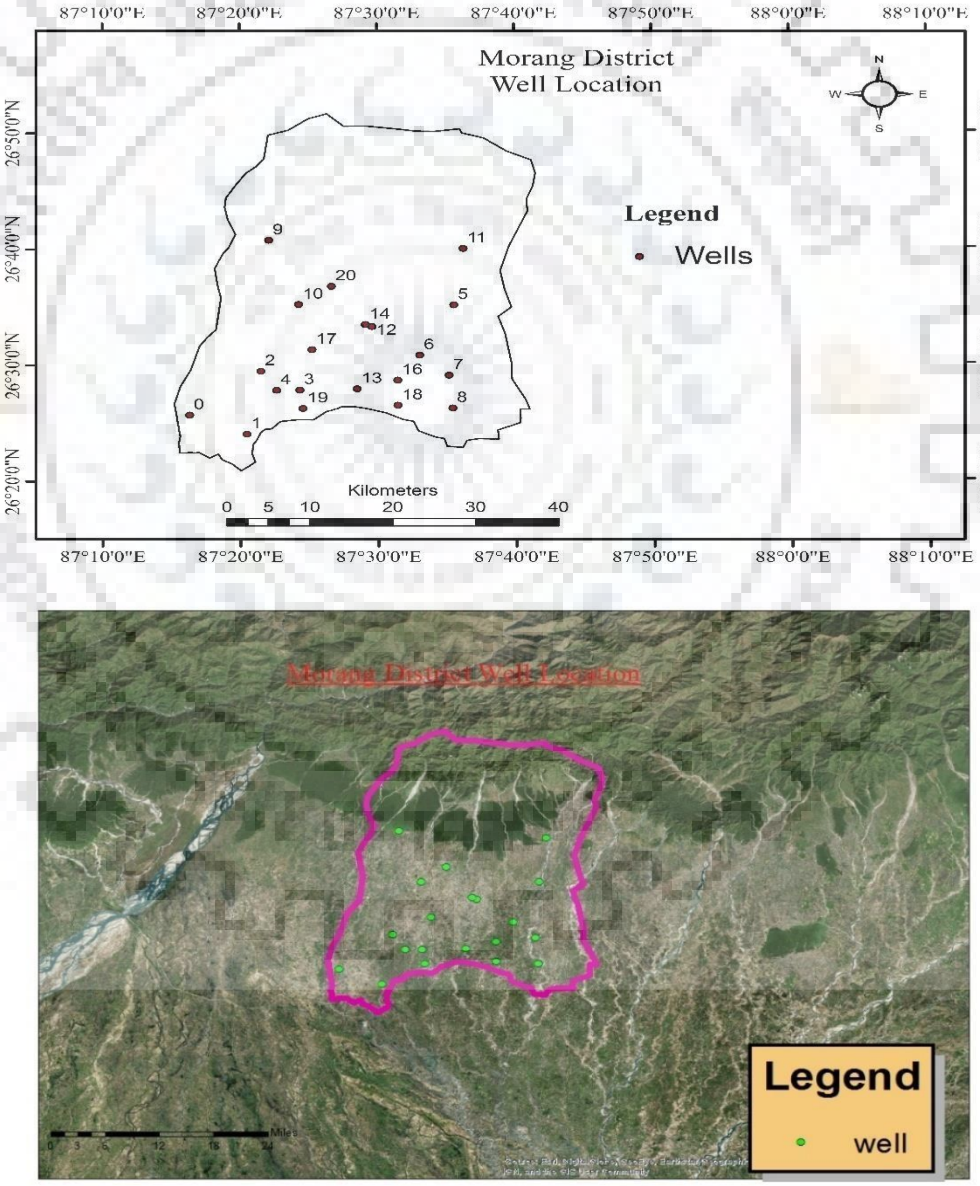

Figure 5. 1: Location of Observation Wells

5.4 Land Use and Land Cover Map

The land use and land cover map of the study area has been prepared from USGS, Landsat8 image of 2018. There are five classes of land use and land cover showing dense forest, low-dense forest, water body, settlements and agriculture land. The total study area is 1825 km^2 out of which agriculture land is 1177.53 km^2 followed by dense forest 349.75 km^2 and low dense forest 230.16 km^2.The agriculture land accounts for about 61% of the whole study area. The land use and land cover map is shown in Figure 5.2.

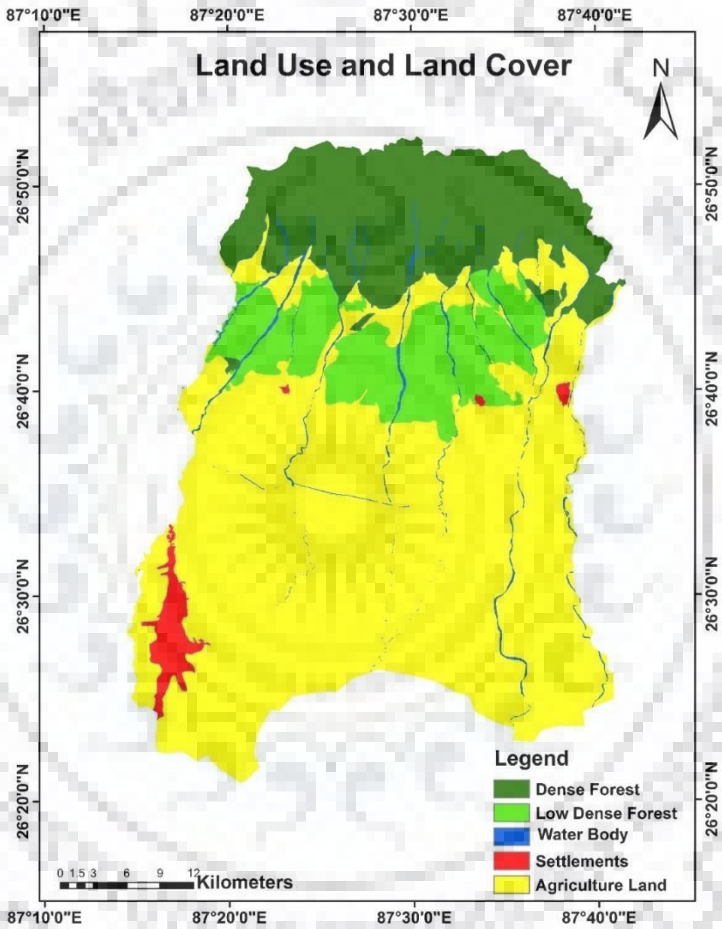

Figure 5. 2: Land Use and Land Cover Map of the Study Area

5.5 Soil Map

The soil map of study area shown in Figure 5.3 has been obtained from FAO world soil database and soil property has been taken from FAO world soil database. The prevailing property of the study area soil has been extracted from this database. The study area soil type is loam of category Ah12-2bc and Je77-1/2a with different contents of clay, silt and sand.

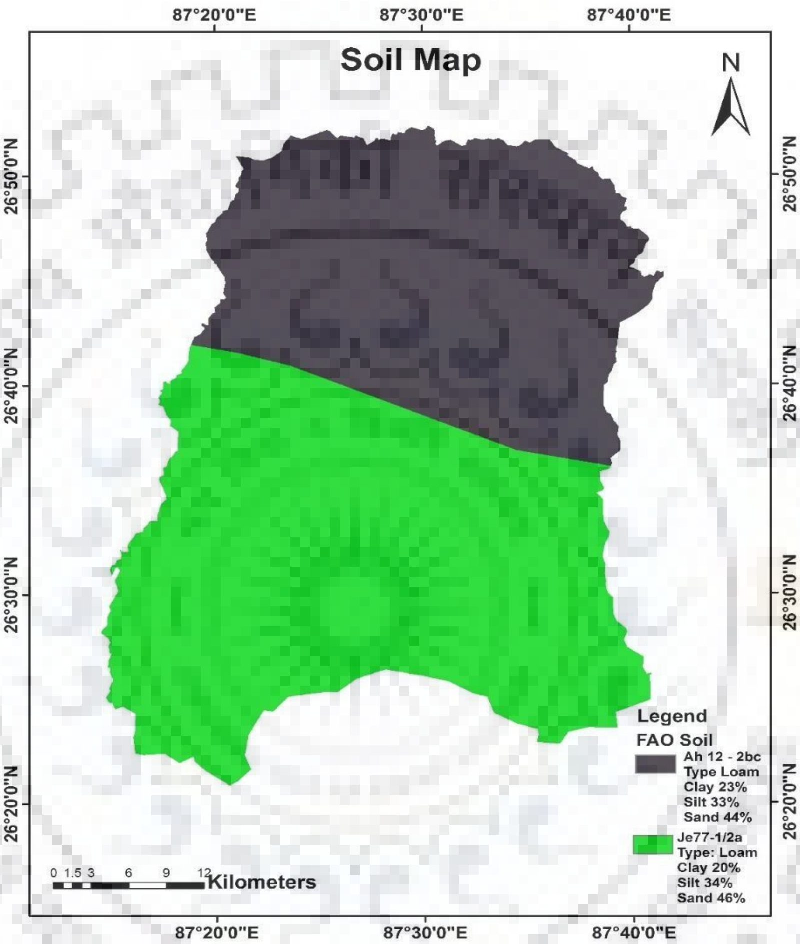

Figure 5. 3: Soil Map of Study Area

5.6 Digital Elevation Model

The DEM of the study area has been obtained from USGS Erath Explorer from ASTER Dataset. It has 30 m resolution. The different elevations of the land feature are shown on the map. The study area comprises highest elevation of 2,396 m and lowest elevation of 54 m from mean sea level.

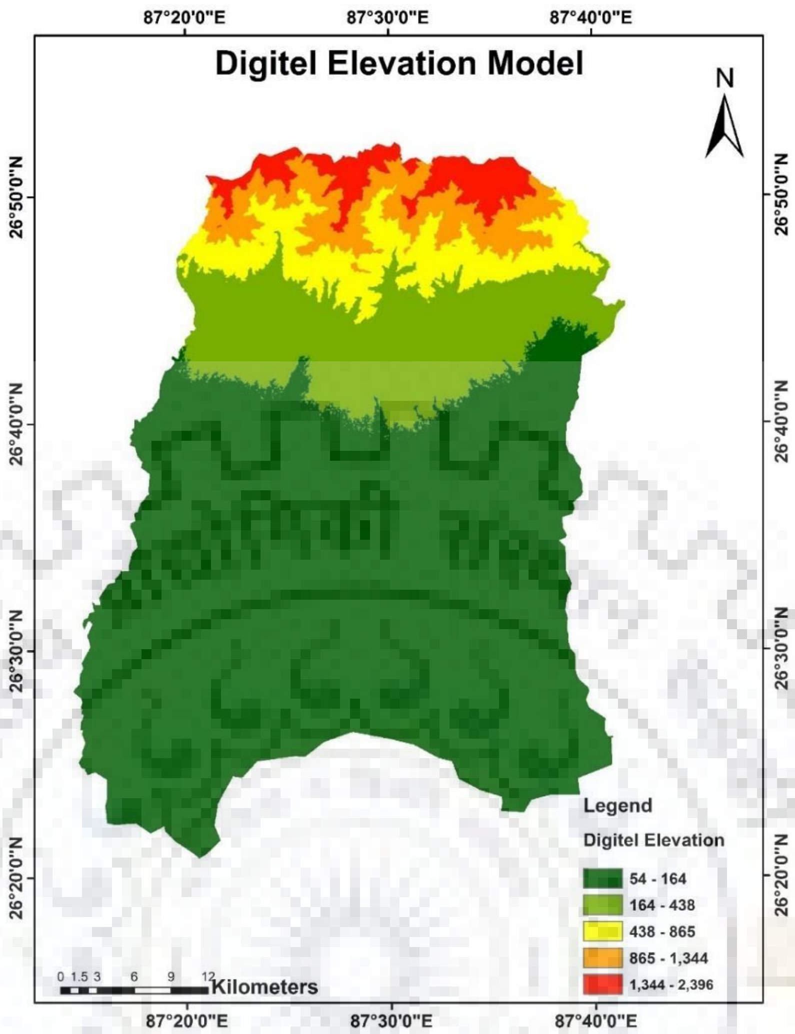

Figure 5. 4: Digital Elevation Model

5.7 Drainage

The drainage map of the study area has been prepared from ASTER digital elevation data. Hydrology tool of ArcGIS has been used to generate drainage from ASTER data. The existing drainage feature can be clearly observed from the map. Most of the streams are found in upper Siwalik range. These streams have fast flow of water at upper hills due to steep slope at upper hills. The path of first order stream is short before it meets to second order stream. Stream length is very less on mountain region. When stream reach to plain, length of stream start increasing as stream reach to end of the watershed density of stream starts decreasing.

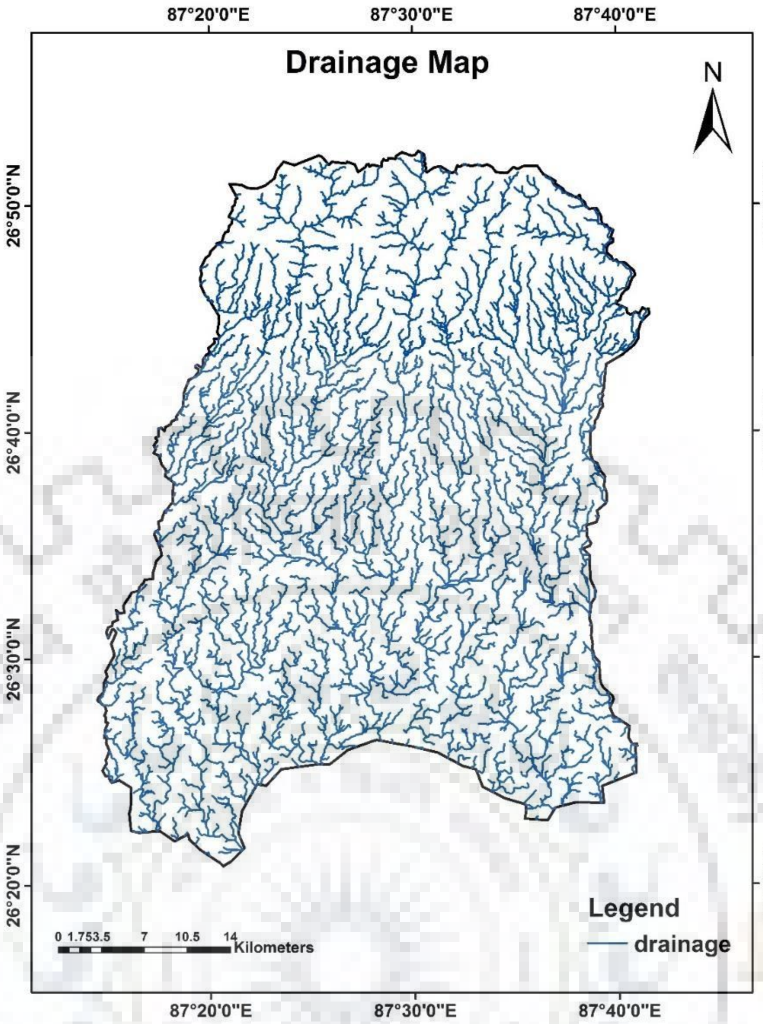

Figure 5. 5: Drainage Map

5.8 Drainage Density

The drainage density map has been prepared from drainage feature. Stream length is very less on mountain region. When stream reach to plain, length of stream start increasing and as stream reach to end of the watershed density of stream starts decreasing.

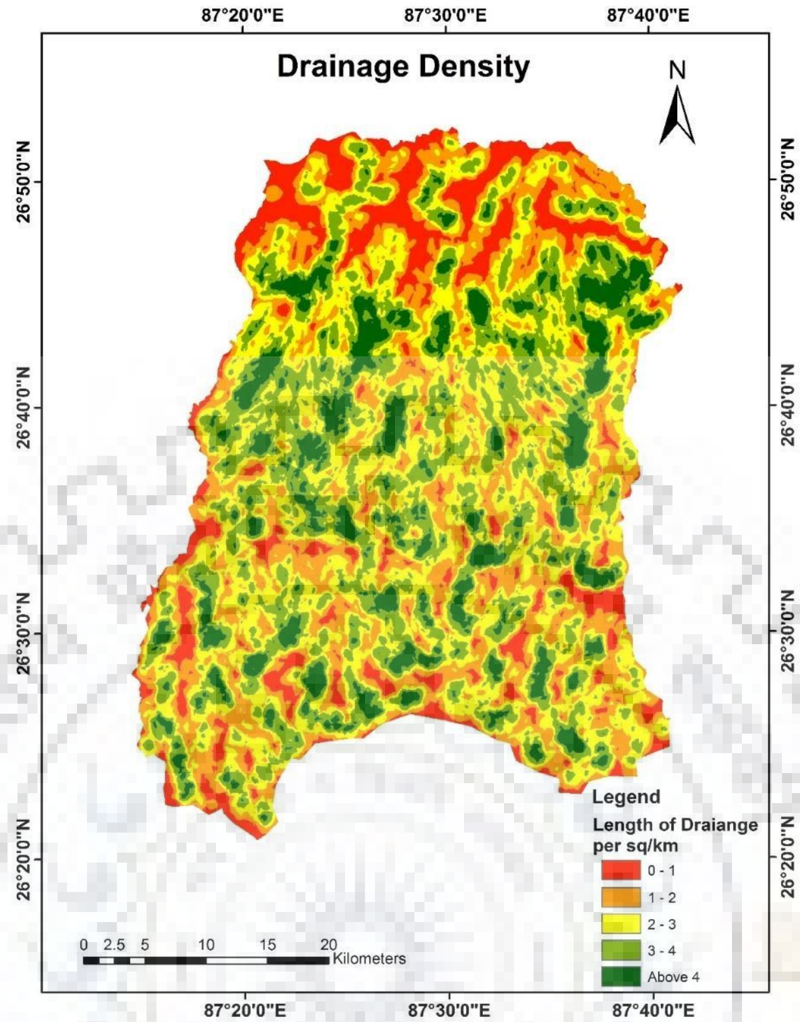

Figure 5. 6: Drainage Density Map

5.9 Slope

Slope determines the rate of infiltration and runoff of surface water, the flat surface areas can hold and drain the water inside of the ground, which can increase the ground water recharge whereas the steep slopes increase the runoff and decrease the infiltration of surface water into ground. The slope of the study area has been calculated in degrees based on the DEM model which was based on the ASTER data. The slope has been classified into five classes (Figure: 5.7) and each class weightage has been assigned.

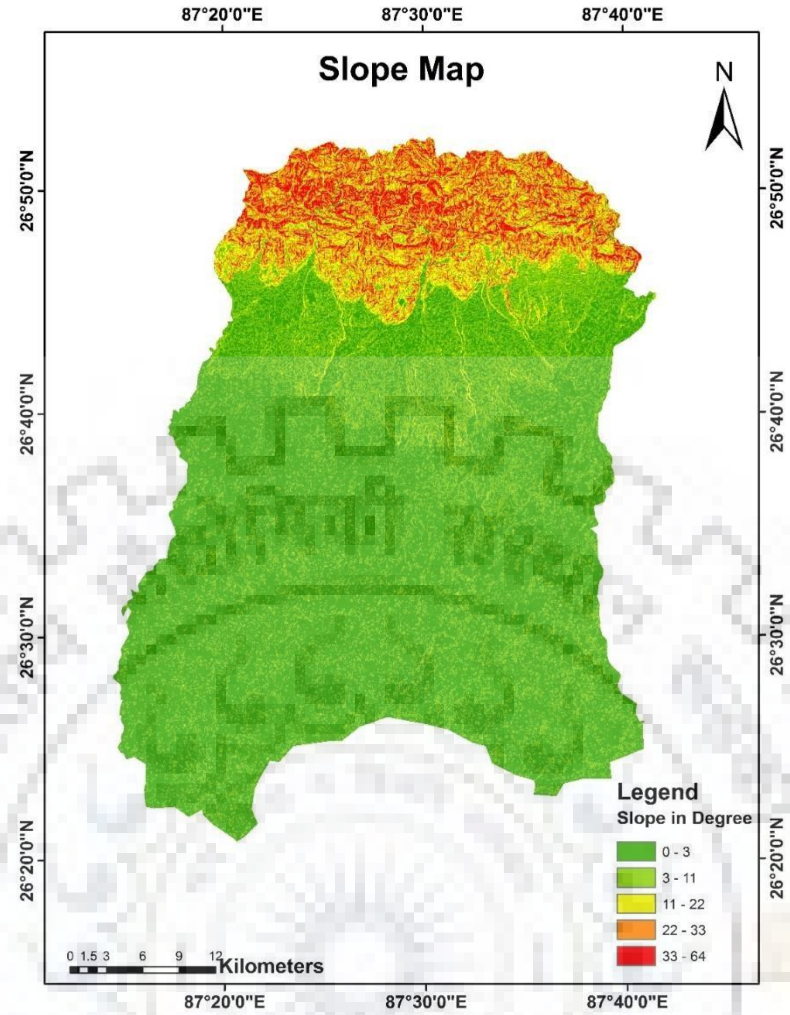

Figure 5. 7: Slope Map

5.10 Rainfall

Rainfall is a primary source of water for groundwater recharge in this area. Based on the rainfall, the region was classified into five zones, as shown in Figure 5.8. The central and north-eastern parts of the study region receive comparatively more rainfall. The southwest part receives the lowest amount of rainfall. The maximum rainfall of 1600 mm was observed in the northeast part of the study area. Receiving more rainfall is favourable for the presence of more groundwater.

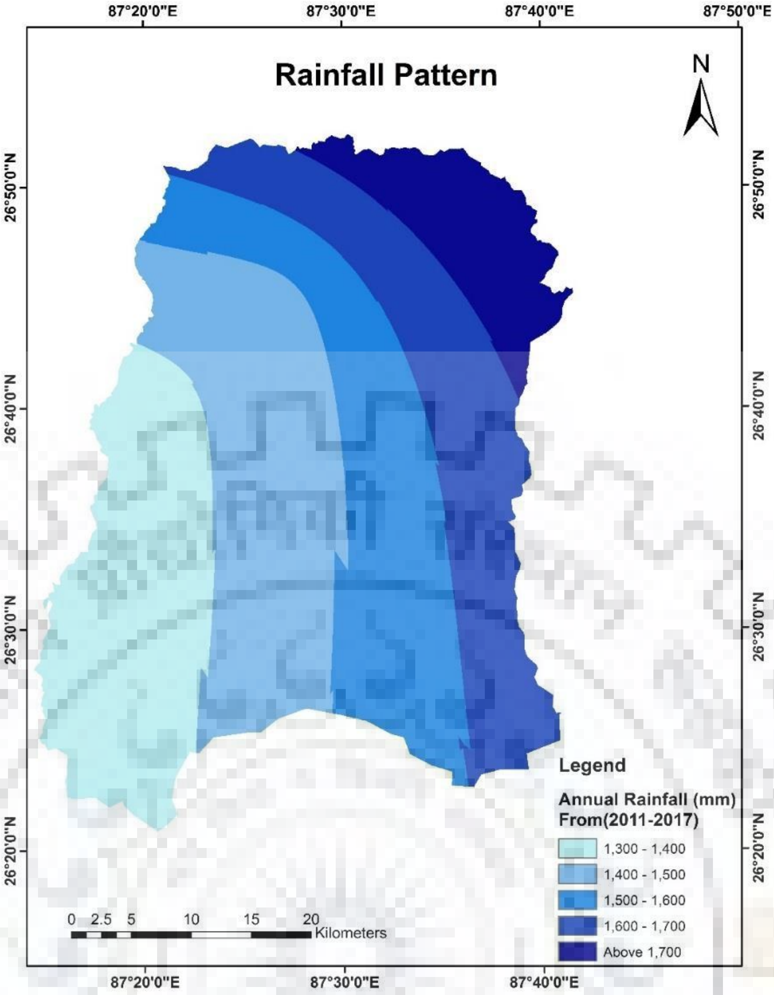

Figure 5. 8: Rainfall Map Rainfall:

Month	Average Rainfall
Jan	14.38
Feb	17.3
Mar	16.54
Apr	74.16
May	191.36
Jun	347.62
Jul	610.71
Aug	406.97
Sept	302.7
Oct	93.4
Nov	8.43
Dec	9.93

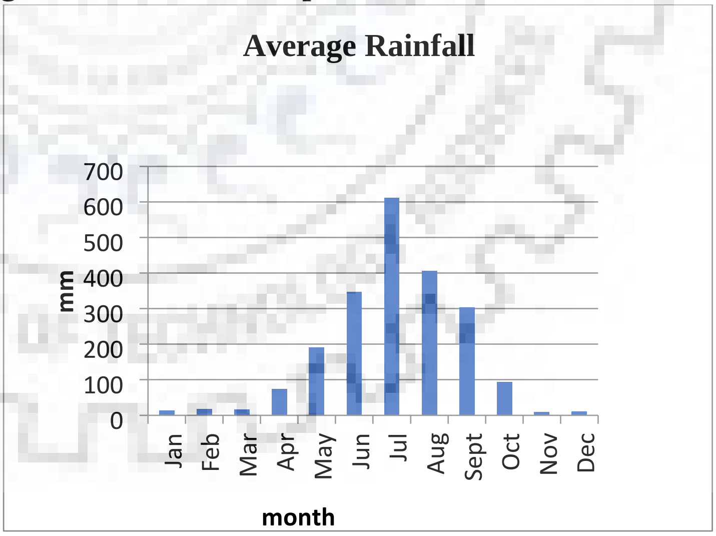

Figure 5.9: Average Rainfall Pattern

Temperature:

Month	Mean Max Temp	Mean Min Temp
Jan	22.61	8.96
Feb	26.08	11.11
Mar	30.95	15.66
Apr	33.89	20.43
May	33.34	23.27
Jun	32.89	25.14
Jul	32.04	25.59
Aug	32.5	25.73
Sept	32.13	24.66
Oct	31.58	21.18
Nov	29.27	15.32
Dec	25.33	10.61

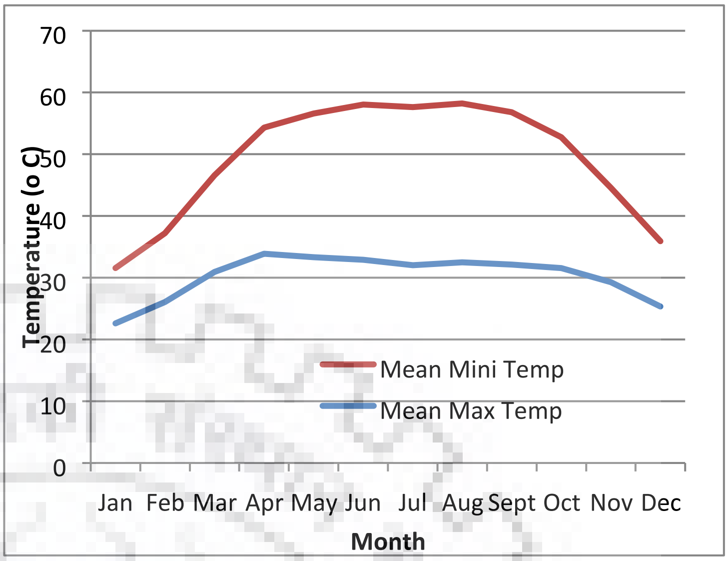

Figure 5.10: Average Temperature Pattern

5.11 GW Table in Different Season (Pre and Post Monsoon)

The data regarding to the ground water table of the observation wells considered are provided by the district ground water office of Morang District. The data are from the year 2000 to 2015. The ground water elevation of the years 2015 has been presented here. In the map, we can see that water table elevation varies from 1.69 m to 5.63 m in the year 2015. The most of the degradation in water table elevation has been observed in the range of 2.61 m to 3.44 m and which has very much recharged after monsoon as shown below

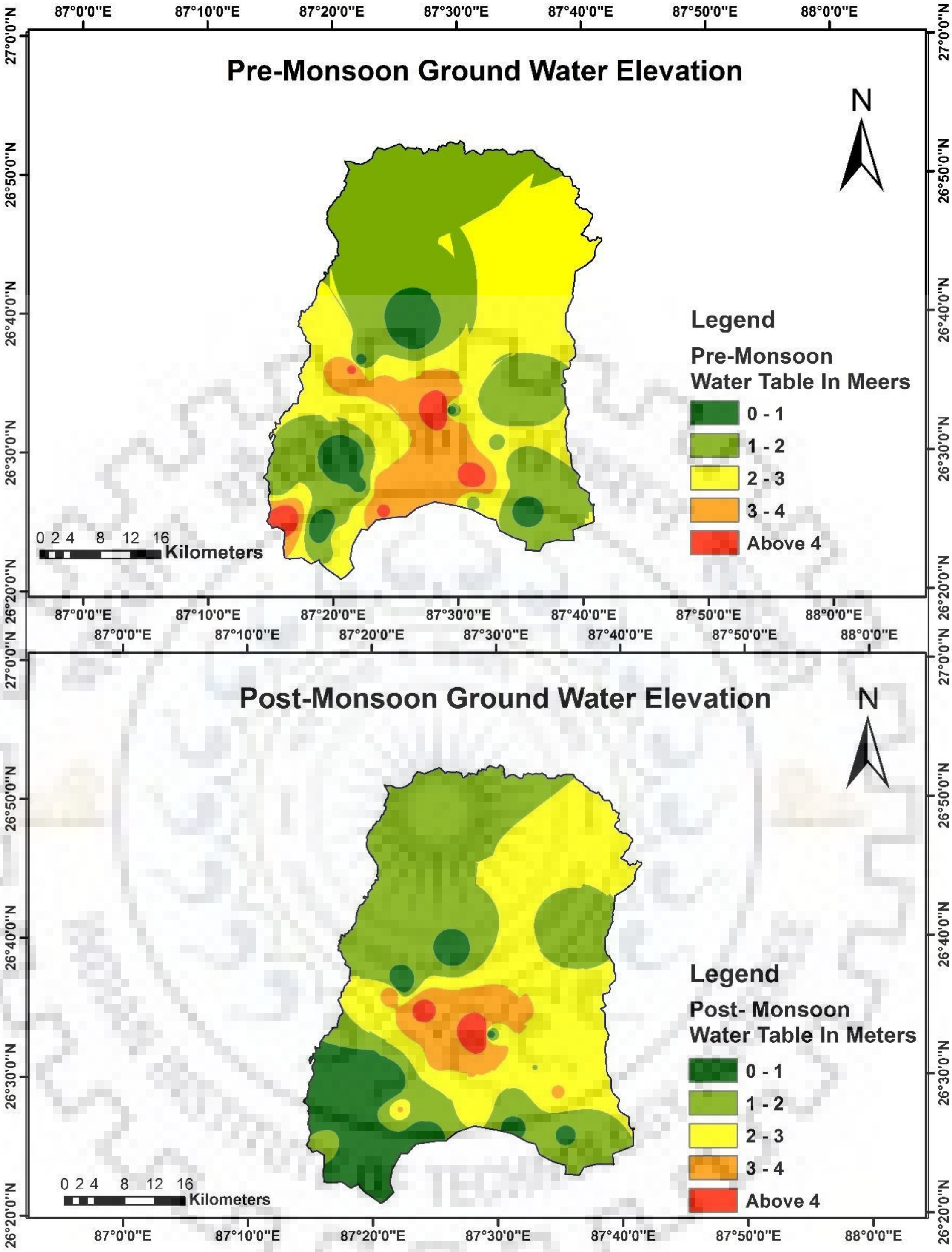

Figure 5.11: Pre-monsoon & Post-monsoon GW Elevation

5.12 GW Table Fluctuation Map

The ground water table fluctuation map has been generated by subtracting post- monsoon raster from pre-monsoon raster. The ground water fluctuation is more near the settlements and very less in central part of the district were the settlements are dispersed. Obviously, the demand and extraction of ground water is high at the human populated areas, the fluctuation has gone about 2 m as shown on the map.

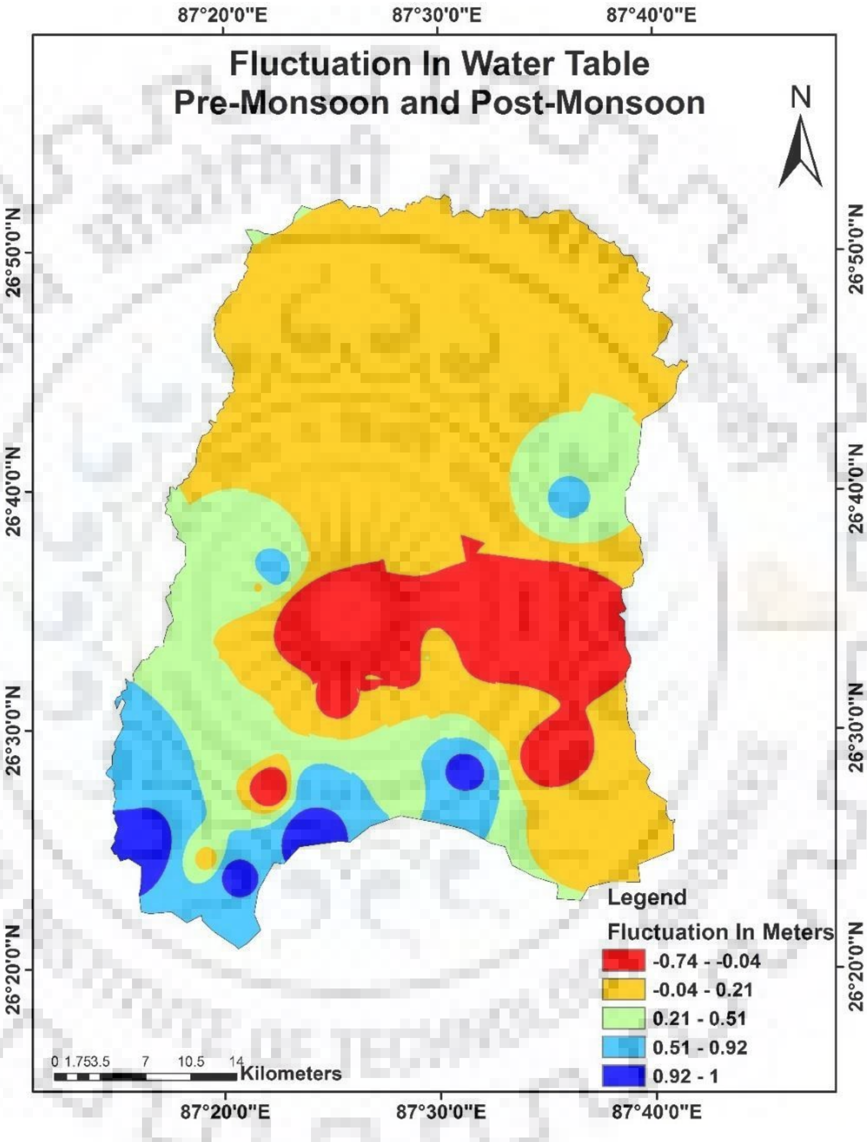

Figure 5.12 GW Table Fluctuation Map

CHAPTER – 6: IDENTIFICATION OF DIFFERENT GROUND WATER POTENTIAL ZONES

6.1 Ground Water Potential Zones

GIS technique has been used and adopted for the evaluation of groundwater potential zones of the Morang District. Use of weighted overlay method is done to be very fruitful in mapping of groundwater potential zones of the study area. The relative importance of various thematic layers and their corresponding classes used for generation of groundwater potential zones map. The tool 'Weighted Overlay' in Overlay Toolset which is built inside of Spatial Analyst Tools in ArcGIS is used to perform an overlay analysis. The weighted overlay tool overlays several raster using a common measurement scale and weights each according to its important (ESRI).

During the weighted analysis, the ranks are given for each individual parameter of each thematic map and the weight is assigned according to the individual importance of the different parameters. The weights and rank is taken in consideration the works carried out by researchers such as (Krishnamurthty et al 1996, Saraf & Chowdhary 1998).

All the thematic maps are converted into raster format and superimposed by weighted overlay method (rank and weight wise thematic maps and integrated with one another through GIS (Arc/Info grid environment).For assigning the weight, the drainage density and DEM were assigned higher weight, similarly the slope was assigned lower weight. After assigning weights to different parameters, individual ranks are given for sub variable. In this process, the GIS layer on lineament density, slope and drainage density are analysed with attention and ranks are assigned to their sub variable (Butler et al., 2002, Asadi et al., 2007, Yammani, 2007).

The maximum value is given to the feature with highest groundwater potential and the minimum given to the lowest potential feature. In The DEM such as high elevations are given lower rank and higher rank is assigned for low elevation. For slope is concerned, the highest rank value is assigned for gentle slope and low rank value is assigned to higher slope. Among the various drainage density classes viz the very high drainage density category is assigned higher rank value as this category has greater chance for groundwater infiltration. As per the value is increasing of slope importance is increasing. Lower value assigned for very low drainage density. For rainfall higher rank for high rainfall and low value for low rainfall. In LULC high rank is assigned to agriculture land and water body low value is assigned to barren land. The overall analysis is tabulated below in Table 6.1.

Table 6.1: Rank and weight for different parameter of groundwater potential zone

Parameters	Classes	Ground water prospective	Weight (%)	Rank
Drainage Density	1-2 2- 3 3-4 4-5 >5	Very Poor Poor Moderate Good Very Good	30%	1 2 3 4 5
Rainfall	1300-1400mm 1400- 1500mm 1500- 1600mm 1600-1700mm >1700mm	Very Poor Poor Moderate Good Very Good	15%	1 2 3 4 5
DEM	54-164m 164-438m 438- 865m 865-1344m 1344-2396m	Very Poor Poor Moderate Good Very Good	20%	5 4 3 2 1
Slope	Nearly level $0-1^0$ Gentle slope 1^0-2^0 Lit Genle 2^0-3^0 Moderate Slope 3^0-4^0 Strong Slope >4	Very Poor Poor Moderate Good Very Good	5%	5 4 3 2 1
Soil	Ah 12 – 2bc(Loam) Je77 – 1/2a(Loam)	Good Very Good	10%	1 2
LULC	Dense Forest Barren Land Low Forest Water Body Settlement Agriculture Land	Poor Very poor Very Good Moderate Good Very Good	10%	2 1 5 3 4 6

In the present case, three categories of groundwater potential zones have been identified by the above said method with the help of GIS and Remote sensing. The three categories are: Good, Moderate and Poor.

The study also recommends the use of GIS technology with RS data for the further study of ground water, which can minimize the cost, time, human power with higher accuracy. From the result of classification it has been found that, 675 km^2 areas are having good, 1111 km^2 area are having moderate, 340 km^2 having poor potential of ground water.

Table 6.2: Groundwater Potential Zones

S No.	Potential Zones	Area km^2	Area in %
1	Poor	34.0227	1.86
2	Moderate	1111.23	60.86
3	Good	675.221	36.98
	Total area	1820.25	
Actual Area is 1825 km^2			

From the resulted map we can conclude that the Maximum groundwater potential zone lies in the Moderate zone. The very low potential zone has covered very least area of 340.227 km2. The eastern part the study area has higher potential ground water.

From this study, it is suggested to change of agricultural pattern as the present agricultural pattern fails due to the lack of water availability. Here below there is map of Ground Water Potential Zone which show the water resources condition of that area. It shows its **drainage** condition form where water flows to south from north **and soil** type is loam of category Ah12-2bc and Je77-1/2a with different contents of clay, silt and sand. Similarly **Slope** determines the rate of infiltration and runoff of surface water, the flat surface areas can hold and drain the water inside of the ground and its categorically divided in five groups viz. Nearly level 0-1^0,Gentle slope 1^0-2^0, Little Gentle 2^0-3^0 ,Moderate Slope 3^0-4^0 ,Strong Slope >4. **DEM** maps gives information of its surface elevation ranges from 54-164m ,164-438m ,438-865m ,865-1344m ,1344-2396m. It shows its lowest elevation is from 54 to highest is 2396. **Drainage density** gives the knowledge of its drainage pattern and condition. Of the surface. **Rainfall** is the important factor for ground water resources by infiltrating into soil its makes water level on that area. During June and July max rainfall occurs which is called in monsoon season in Nepal and less during January and February.

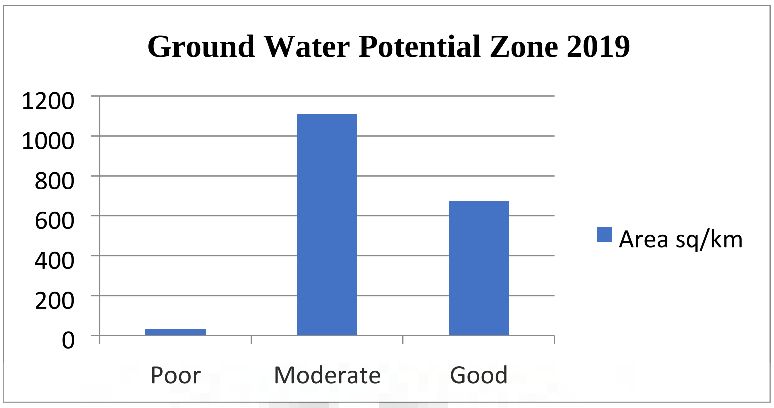

Figure 5.1 Ground Water Potential Zone 2019

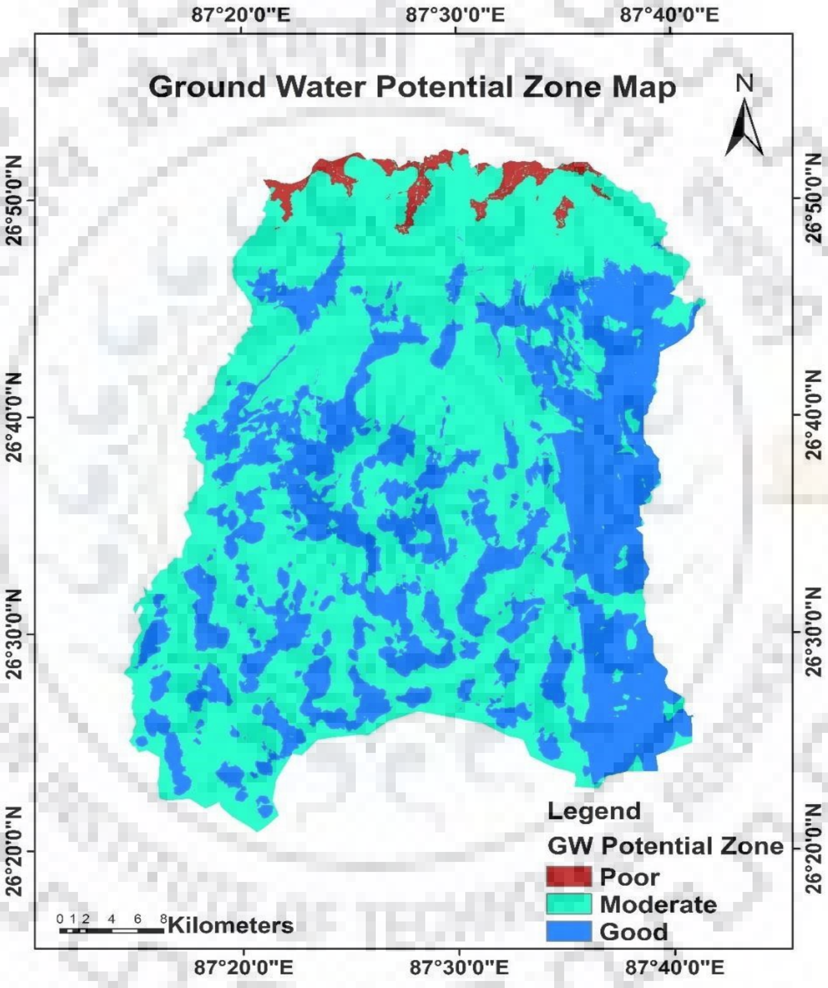

Figure 5.2 Ground water Potential Zone of Study Area

6.2 Discussion

With the help of GIS and Remote sensing it is easy to calculate for further plan of using water resources to get maximum output with maintaining sustainability and crop pattern can be identified for better in quantity and quality. Similarly drinking water can be used both in urban and rural areas seeing its water resources condition and ground pattern with the help of GIS and RE.

6.3 Recommendations

The groundwater management must be viewed from two aspects; one is the resource conservation and protection aspect, and the other is the proper and controlled utilization of the resource. The key recommendations are:

- Measures towards resource conservation and protection
- Proper understanding of the resources
- Identification and protection of recharge areas
- Checking groundwater degradation from point and non-point sources
- Optimal utilization of resources
- Plan for intensive and scientific development in well-defined and larger clusters or blocks for both STW and DTW irrigation.
- Develop and implement farmer friendly credit facility for tube well installation and operation
- Promote community based rural electrification as well as other programs
- Focus on agricultural extension support services and market development
- Targeted programs to high poverty incidence area
- GPS data of all tube wells constructed under different programs should be recorded after the completion of construction
- Strengthening data measurement techniques as well as sites
- Cluster wise data should be made and updated
- Yearly update of the maps prepared during present study should be made after the completion of fiscal year.

CHAPTER – 7: SUMMARY AND CONCLUSION

7.1 Summary and Conclusion

Drinking water availability has always been one of the biggest concerns in water sector. This study is based in Morang District which is situated in Koshi Zone of the Eastern Development Region of Nepal wherein assessment of ground water potential has been conducted.

Remote sensing data and GIS has been used to prepare various thematic maps of the region. Consequently ground water potential zoning is done. Thematic maps like LULC map, soil map, DEM, drainage density map, slope map, rainfall map, pre and post monsoon ground water levels and ground water table fluctuation map have been prepared for the analysis. Finally weighted overlay analysis has been carried out by assigning appropriate weights to all the above mentioned thematic layers to generate a ground water potential zone map.

As a result the entire study area has been classified into three zones/categories of ground water potential wherein 34 km^2 (1.86%), 1111 km^2 (60.86%) and 675 km^2 (36.98%) area falls under poor, moderate and good ground water potential zone respectively.

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ANNEXURE:

Annex – 1: Well Observation Record:

District: - Morang **Year: 2000**

				Static Water Level Data												
S.No.	**Location**	**Lat**	**Long**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Remarks**
	UN STWs.															
1	Rani Sikiyahi	26.42	87.27	7.26	7.21	3.50	3.56	3.60	3.49	3.35	2.26	2.38	2.51	2.63	2.88	
2	Daleli	26.55	87.49	2.39	2.34	2.36	2.41	2.56	2.60	2.57	2.50	2.55	2.62	2.69	2.73	
3	Darbesa	26.46	87.47	1.56	1.60	1.66	1.70	1.75	1.78	1.71	1.68	1.66	1.68	1.72	1.75	
4	Govindapur	26.48	87.58	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
5	Haraicha	26.6	87.36	8.87	8.78	4.05	4.14	4.20	4.26	4.21	4.19	4.20	4.23	4.29	4.40	
6	Hasandaha	26.58	87.59	2.32	2.30	2.28	2.33	2.43	2.38	2.30	2.25	2.31	2.36	2.40	2.47	
7	Jhapa Baijanthpur	26.56	87.55	1.55	1.50	1.52	1.58	1.59	1.40	1.39	1.35	1.42	1.25	1.10	1.16	
8	Kadmaha	26.46	87.37	1.25	1.28	1.31	1.36	1.39	1.40	1.32	1.16	1.28	1.38	1.49	1.57	
9	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	Karsiya	26.46	87.4	2.26	2.20	2.51	2.58	2.60	2.53	2.48	2.40	2.45	2.49	2.51	2.56	
12	Kaseni	26.58	87.4	1.94	1.92	2.35	2.43	2.54	2.64	2.59	2.50	2.56	2.63	2.72	2.81	
13	Keroun	26.55	87.48	2.38	2.32	2.48	2.57	2.63	2.00	2.68	2.61	2.63	2.67	2.74	2.81	
14	Kureli	26.43	87.59	2.24	2.21	2.30	2.33	2.38	2.47	2.41	2.35	2.42	2.49	2.61	2.69	
15	Majhare	26.4	87.34	3.09	3.01	2.76	2.90	3.43	3.32	3.25	3.15	3.36	3.41	3.50	3.51	
16	Pothiyahi	26.41	87.32	2.72	2.70	2.66	2.73	2.79	2.86	2.82	2.85	2.92	2.99	3.04	3.08	
17	Salakpur	26.55	87.48	1.31	1.30	2.08	2.18	2.25	2.36	2.32	2.28	2.29	2.34	2.41	2.50	
18	Surat	26.51	87.55	2.38	2.30	2.26	2.30	2.36	2.35	2.31	2.28	2.28	2.33	2.35	2.41	
19	Thalaha	26.49	87.35	2.11	2.10	2.10	2.18	2.24	2.19	2.16	2.12	2.23	2.28	2.35	2.43	
20	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	

District: - Morang **Year: 2001**

				Static Water Level Data												
S.No.	**Location**	**Lat**	**Long**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Remarks**
	UN STWs.															
1	Rani Sikiyahi	26.42	87.27	2.92	2.96	3.00	3.06	3.11	3.12	3.05	2.94	3.05	3.15	3.26	3.36	
2	Daleli	26.55	87.49	2.80	2.82	2.86	2.90	2.94	2.96	2.86	2.67	2.76	2.86	2.97	3.03	
3	Darbesaha	26.46	87.47	1.68	1.74	1.78	1.82	1.86	1.88	1.78	1.59	1.70	1.81	1.93	2.01	
4	Govindapur	26.48	87.58	2.54	2.59	2.61	2.65	2.70	2.72	2.64	2.48	2.60	2.72	2.81	2.90	
5	Haraicha	26.6	87.36	4.44	4.50	4.55	4.61	4.65	4.67	4.59	4.38	4.48	4.58	4.70	4.80	
6	Hasandaha	26.58	87.59	2.53	2.53	2.55	2.60	2.64	2.65	2.55	2.37	2.50	2.59	2.63	2.70	
7	Jhapa Baijanthpur	26.56	87.55	2.12	2.15	2.28	2.44	2.52	2.60	1.55	1.18	1.25	1.39	1.44	1.78	
8	Kadmaha	26.46	87.37	1.22	1.28	1.31	1.36	1.39	1.40	1.32	1.16	1.28	1.38	1.49	1.57	
9	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	Karsiya	26.46	87.4	2.63	2.65	2.69	2.74	2.78	2.80	2.69	2.48	2.58	2.68	2.77	2.84	
12	Kaseni	26.58	87.4	2.87	2.92	2.97	3.02	3.06	3.08	3.01	2.79	2.91	3.02	3.11	3.18	
13	Keroun	26.55	87.48	3.00	3.02	3.06	3.11	3.14	3.17	3.06	2.88	3.00	3.09	3.20	3.29	
14	Kureli	26.43	87.59	2.71	2.76	2.80	2.85	2.91	2.91	2.82	2.61	2.74	2.85	2.94	3.02	
15	Majhare	26.4	87.34	3.52	3.58	3.60	3.64	3.67	3.68	3.62	3.47	3.57	3.68	3.77	3.86	
16	Pothiyahi	26.41	87.32	3.15	3.20	3.25	3.30	3.35	3.38	3.29	3.08	3.18	3.24	3.32	3.40	
17	Salakpur	26.55	87.48	2.51	2.57	2.60	2.65	2.70	2.71	2.62	2.41	2.52	2.62	2.71	2.79	
18	Surat	26.51	87.55	2.43	2.50	2.54	2.61	2.65	2.67	2.58	2.41	2.52	2.63	2.72	2.81	
19	Thalaha	26.49	87.35	3.48	3.52	3.55	3.61	3.65	3.67	3.58	3.43	3.55	3.64	3.75	3.85	
20	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	

District: - Morang **Year: 2002**

				Static Water Level Data												
S.No.	**Location**	**Lat**	**Long**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Remarks**
	UN STWs.															
1	Rani Sikiyahi	26.42	87.27	2.90	2.95	3.00	3.06	3.11	3.12	3.05	2.94	3.05	3.15	3.30	3.46	
2	Daleli	26.55	87.49	2.79	2.82	2.86	2.90	2.94	2.96	2.86	2.67	2.76	2.86	2.97	3.10	
3	Darbesaha	26.46	87.47	1.65	1.74	1.78	1.82	1.86	1.88	1.78	1.59	1.70	1.81	1.93	2.10	
4	Govindapur	26.48	87.58	2.51	2.59	2.61	2.65	2.70	2.72	2.64	2.48	2.60	2.72	2.81	2.95	
5	Haraicha	26.6	87.36	4.43	4.50	4.55	4.61	4.65	4.67	4.59	4.38	4.48	4.58	4.70	4.85	
6	Hasandaha	26.58	87.59	2.51	2.53	2.55	2.60	2.64	2.65	2.55	2.37	2.50	2.59	2.63	2.76	
7	Jhapa Baijanthpur	26.56	87.55	2.11	2.15	2.28	2.44	2.52	2.60	1.55	1.18	1.25	1.39	1.44	1.77	
8	Kadmaha	26.46	87.37	1.21	1.28	1.31	1.36	1.39	1.40	1.32	1.16	1.28	1.38	1.49	1.60	
9	Kanchanbari	26.98	87.27	1.91	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.45	
10	Kanepokhari	26.65	87.44	2.00	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.55	
11	Karsiya	26.46	87.4	2.60	2.65	2.69	2.74	2.78	2.80	2.69	2.48	2.58	2.68	2.77	2.94	
12	Kaseni	26.58	87.4	2.85	2.92	2.97	3.02	3.06	3.08	3.01	2.79	2.91	3.02	3.11	3.22	
13	Keroun	26.55	87.48	2.89	3.02	3.06	3.11	3.14	3.17	3.06	2.88	3.00	3.09	3.20	3.30	
14	Kureli	26.43	87.59	2.70	2.76	2.80	2.85	2.91	2.91	2.82	2.61	2.74	2.85	2.94	3.05	
15	Majhare	26.4	87.34	3.51	3.58	3.60	3.64	3.67	3.68	3.62	3.47	3.57	3.68	3.77	3.95	
16	Pothiyahi	26.41	87.32	3.10	3.20	3.25	3.30	3.35	3.38	3.29	3.08	3.18	3.24	3.32	3.45	
17	Salakpur	26.55	87.48	2.45	2.57	2.60	2.65	2.70	2.71	2.62	2.41	2.52	2.62	2.71	2.81	
18	Surat	26.51	87.55	2.40	2.50	2.54	2.61	2.65	2.67	2.58	2.41	2.52	2.63	2.72	2.86	
19	Thalaha	26.49	87.35	3.45	3.52	3.55	3.61	3.65	3.67	3.58	3.43	3.55	3.64	3.75	3.88	
20	Urlabari	26.66	87.6	1.33	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.31	

District: - Morang **Year: 2003**

S.No.	Location	Lat	Long	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Remarks
				Static Water Level Data												
	UN STWs.															
1	Rani Sikiyahi	26.42	87.27	3.16	3.20	3.24	3.27	3.31	3.33	3.29	3.27	3.26	3.28	3.31	3.34	
2	Daleli	26.55	87.49	2.73	2.77	2.81	2.85	2.90	2.93	2.86	2.84	2.83	2.85	2.90	2.93	
3	Darbesa	26.46	87.47	1.55	1.61	1.68	1.72	1.78	1.79	1.71	1.69	1.66	1.68	1.75	1.72	
4	Govindapur	26.48	87.58	2.66	2.71	2.75	2.74	2.83	2.85	2.79	2.78	2.77	2.78	2.80	2.83	
5	Haraicha	26.6	87.36	4.60	4.64	4.69	4.73	4.77	4.78	4.72	4.70	4.69	4.70	4.72	4.75	
6	Hasandaha	26.58	87.59	2.44	2.49	2.53	2.58	2.63	2.65	2.59	2.67	2.66	2.68	2.71	2.75	
7	Jhapa Baijanthpur	26.56	87.55	2.12	2.15	2.28	2.44	2.52	2.60	1.55	1.18	1.25	1.39	1.44	1.78	
8	Kadmaha	26.46	87.37	1.52	1.57	1.60	1.63	1.67	1.69	1.60	1.68	1.67	1.70	1.73	1.75	
9	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	Karsiya	26.46	87.4	2.81	2.84	2.86	2.9	2.92	2.5	1.6	1.43	1.4	1.66	1.97	1.91	
12	Kaseni	26.58	87.4	2.87	2.90	2.95	2.99	3.04	3.05	2.99	2.98	2.98	3.00	3.03	3.06	
13	Keroun	26.55	87.48	2.89	2.93	2.96	2.99	3.02	3.05	3.01	3.00	2.99	3.03	3.05	3.09	
14	Kureli	26.43	87.59	2.78	2.81	2.85	2.90	2.94	2.96	2.90	2.88	2.86	2.88	2.90	2.92	
15	Majhare	26.4	87.34	3.60	3.64	3.69	3.73	3.78	3.80	3.15	3.73	3.72	3.76	3.80	3.83	
16	Pothiyahi	26.41	87.32	2.80	2.85	2.90	2.94	2.98	3.00	2.92	2.90	2.88	2.90	2.93	2.95	
17	Salakpur	26.55	87.48	1.62	1.65	1.69	1.72	1.76	1.78	1.70	1.67	1.66	1.69	1.71	1.75	
18	Surat	26.51	87.55	2.61	2.67	2.82	2.85	2.88	2.90	2.82	2.80	2.80	2.82	2.85	2.89	
19	Thalaha	26.49	87.35	3.60	3.63	3.67	3.70	3.74	3.75	3.71	3.70	3.70	3.73	3.75	3.76	
20	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	
	DTW															
21	Amgachhi	26.44	87.52	1.84	1.90	1.93	1.98	2.01	2.05	1.97	1.95	1.93	1.95	1.99	2.03	
22	Babiyavesta	26.52	87.42	1.82	1.86	1.90	1.94	1.98	2.01	1.94	1.90	1.89	1.92	1.95	9.98	
23	Dangihhaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	Dharampuur	26.43	87.40	1.86	1.89	1.94	1.98	2.02	2.04	1.98	1.95	1.92	1.96	2.01	2.03	

25	Haraicha	26.61	87.37	1.75	1.79	1.83	1.85	1.88	1.90	1.83	1.80	1.80	1.81	1.84	1.87	
26	Rangeli	26.46	87.26	2.81	2.91	3	3.1	3.12	2.72	1.98	1.71	1.61	1.91	2.26	2.43	
27	Takutwa	26.47	87.52	2.06	2.10	2.15	2.18	2.20	2.23	2.16	2.13	2.11	2.15	2.20	2.24	

District: Morang

Year: 2004

				Static Water Level Data												
S.No.	**Location**	**Lat**	**Long**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Remarks**
1	Rani Sikiyahi	26.42	87.27	3.05	3.14	3.52	3.67	3.78	3.15	1.98	0.71	0.8	2.38	2.5	3.19	
2	Daleli	26.55	87.49	2.7	2.74	2.87	2.96	3.05	1.13	0.96	1.18	1.5	1.34	1.31	1.27	
3	Darbesha	26.46	87.47	1.74	1.82	1.89	1.95	1.98	2.12	0.95	0.78	1.02	1.43	1.69	1.64	
4	Govindapur	26.48	87.58	2.27	2.32	2.45	2.66	2.83	2.96	1.85	1.32	1.5	1.66	1.8	2.05	
5	Haraicha	26.6	87.36	4.58	4.62	4.75	3.75	3.97	4.05	0.75	0.63	0.99	1.18	1.31	1.65	
6	Hasandaha	26.58	87.59	2.35	2.42	2.6	2.79	2.91	2.97	1.3	0.78	0.95	1.12	1.27	1.63	
7	Jhapa Baijanthpur	26.56	87.55	2.12	2.15	2.28	2.44	2.52	2.60	1.55	1.18	1.25	1.39	1.44	1.78	
8	Kadmaha	26.46	87.37	1.52	1.57	1.60	1.63	1.67	1.69	1.60	1.68	1.67	1.70	1.73	1.75	
9	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	Karshiya	26.46	87.4	2.81	2.84	2.86	2.9	2.92	2.5	1.6	1.43	1.4	1.66	1.97	1.91	
12	Kaseni	26.58	87.4	3.18	3.22	3.3	3.41	3.45	3.22	2.03	1.81	1.8	1.93	2.21	2.14	
13	Keroun	26.55	87.48	2.78	2.84	2.96	3.03	3.12	3.25	2.05	0.85	0.99	1.5	1.82	2.09	
14	Kureli	26.43	87.59	1.8	1.85	1.99	2.16	2.28	2.5	0.45	0.35	0.65	0.75	0.96	1.48	
15	Majhare	26.4	87.34	3.52	3.6	2.99	3.15	3.3	3.43	1.93	0.56	0.6	1.1	2.05	2.7	
16	Pothiyahi	26.41	87.32	1.8	1.86	1.91	2.2	2.89	2.53	1.49	1.28	1.25	1.49	1.69	1.77	
17	Salakpur	26.55	87.48	1.56	1.61	1.72	1.87	2	1.78	1.7	1.55	1.6	1.61	1.64	2.12	
18	Surat	26.51	87.55	2.32	2.37	2.52	2.68	2.82	2.94	1.8	1.71	1.77	1.98	2	2.15	
19	Thalaha	26.49	87.35	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	
20	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	

	DTWs														
21	Amgachhi	26.44	87.52	2.28	2.35	2.58	2.82	3.1	3.36	1.98	0.68	0.8	0.87	1.18	1.95	
22	Babiyabirta	26.52	87.42	1.75	1.86	1.90	1.94	1.98	2.01	1.94	1.90	1.89	2.12	2.33	2.85	
23	Dengihaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	Dharampur	26.43	87.40	4.13	4.18	4.4	4.61	4.97	5.27	3.09	1.08	1.13	1.28	1.59	3.76	
25	Haraicha	26.61	87.37	1.74	1.80	1.83	1.85	1.88	1.90	1.83	1.80	1.80	1.81	1.85	1.91	
26	Rangeli	26.46	87.26	2.85	2.97	3.05	3.1	3.15	2.9	1.96	1.7	1.64	1.98	2.3	2.5	
27	Takuwa	26.47	87.52	3.47	3.51	3.75	3.98	4.55	3.08	2.19	2.35	2.18	2.22	2.64	3.15	

District: Morang

Year: 2005

				Static Water Level Data												
S.No.	**Location**	**Lat**	**Long**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Remarks**
1	Rani Sikiyahi	26.42	87.27	3.43	3.58	3.62	3.68	3.91	3.81	1.45	1.12	2	2.4	2.93	3.42	
2	Daleli	26.55	87.49	2.4	2.55	2.68	2.76	3.1	3.1	2.66	2.05	2.94	3.28	3.54	3.96	
3	Darbesha	26.46	87.47	2.84	2.9	2.17	2.31	2.36	2.02	1.13	0.99	0.96	1.21	1.43	1.35	
4	Govindapur	26.48	87.58	2.41	2.5	2.56	2.6	2.54	2.24	1.39	1.21	1.18	1.41	1.74	1.82	
5	Haraicha	26.6	87.36	2.01	3.63	3.7	3.82	3.98	4.03	2.95	1.8	2.4	2.79	3.04	3.3	
6	Hasandaha	26.58	87.59	2.04	2.19	2.32	2.41	2.72	2.69	0.71	0.62	1.6	1.98	2.33	2.78	
7	Jhapa Baijanthpur	26.56	87.55	2.12	2.15	2.28	2.44	2.52	2.60	1.55	1.18	1.25	1.39	1.44	1.78	
8	Kadmaha	26.46	87.37	1.52	1.57	1.60	1.63	1.67	1.69	1.60	1.68	1.67	1.70	1.73	1.75	
9	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	Karshiya	26.46	87.4	2.81	2.84	2.86	2.9	2.92	2.5	1.6	1.43	1.4	1.66	1.97	1.91	
12	Kaseni	26.58	87.4	3.18	3.22	3.3	3.41	3.45	3.22	2.03	1.81	1.8	1.93	2.21	2.14	
13	Keroun	26.55	87.48	2.48	2.55	2.6	2.69	2.9	2.9	1.85	1.46	2.45	2.81	3	3.22	

14	Kureli	26.43	87.59	1.91	2.09	2.11	2.2	2.38	2.44	1.56	0.57	1.45	1.81	1.9	2.25	
15	Majhare	26.4	87.34	3.01	3.3	3.48	3.55	3.74	3.78	0.78	0.9	1.9	2.2	2.8	3.38	
16	Pothiyahi	26.41	87.32	1.8	1.86	1.91	2.2	2.89	2.53	1.49	1.28	1.25	1.49	1.69	1.77	
17	Salakpur	26.55	87.48	2.21	2.39	2.44	2.52	2.7	2.7	0.59	0.55	1.5	1.82	1.96	2.3	
18	Surat	26.51	87.55	2.33	2.42	2.62	2.69	2.72	2.35	1.44	1.3	1.25	1.48	1.75	1.81	
19	Thalaha	26.49	87.35	1.6	1.76	1.85	1.88	1.98	2.03	1.05	0.85	1.55	1.87	1.27	1.76	
20	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	
	DTWs															
21	Amgachhi	26.44	87.52	2.4	2.68	2.8	2.84	2.93	2.99	2.18	0.92	1.88	2.31	1.99	2.9	
22	Babiyabirta	26.52	87.42	3.47	3.79	3.9	3.97	3.99	4.04	2.8	2.05	2.98	3.43	3.48	3.83	
23	Dengihaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	Dharampur	26.43	87.40	4.21	4.51	4.69	4.81	4.92	4.98	3.62	2.08	2.86	3.28	3.39	3.71	
25	Haraicha	26.61	87.37	1.64	1.78	1.83	1.85	1.88	1.90	1.83	1.80	1.80	1.81	1.88	1.98	
26	Rangeli	26.46	87.26	3	3.08	3.1	3.21	3.4	2.85	2.05	1.95	1.8	1.99	2.2	2.43	
27	Takuwa	26.47	87.52	3.97	4.05	4.19	4.22	4.32	4.39	3.15	2.46	3.18	3.52	3.32	3.66	

District: Morang

Year: 2006

				Static Water Level Data												
S.No.	**Location**	**Lat**	**Long**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Remarks**
1	Rani Sikiyahi	26.42	87.27	3.64	3.76	3.95	4.1	3.65	3.38	2.05	2	2.15	2.35	2.75	3.3	
2	Daleli	26.55	87.49	4.05	4.22	4.38	4.59	4.7	4.51	1.59	1.57	1.5	1.78	1.98	2.63	
3	Darbesha	26.46	87.47	2.84	2.9	2.17	2.31	2.36	2.02	1.13	0.99	0.96	1.21	1.43	1.35	
4	Govindapur	26.48	87.58	2.41	2.5	2.56	2.6	2.54	2.24	1.39	1.21	1.18	1.41	1.74	1.82	
5	Haraicha	26.6	87.36	2.58	2.65	2.67	2.71	2.8	2.52	2.56	1.35	1.3	1.51	1.73	1.8	
6	Hasandaha	26.58	87.59	2.96	3.1	2.35	3.46	3.78	3.8	2.87	2.8	2.7	2.98	3.39	3.97	
7	Jhapa Baijanthpur	26.56	87.55	2.12	2.15	2.28	2.44	2.52	2.60	1.55	1.18	1.25	1.39	1.44	1.78	
8	Kadmaha	26.46	87.37	1.52	1.57	1.60	1.63	1.67	1.69	1.60	1.68	1.67	1.70	1.73	1.75	

9	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	Karshiya	26.46	87.4	2.81	2.84	2.86	2.9	2.92	2.5	1.6	1.43	1.4	1.66	1.97	1.91	
12	Kaseni	26.58	87.4	3.18	3.22	3.3	3.41	3.45	3.22	2.03	1.81	1.8	1.93	2.21	2.14	
13	Keroun	26.55	87.48	3.38	3.57	3.75	3.25	4.1	4.13	0.8	0.76	0.7	1.02	1.32	1.62	
14	Kureli	26.43	87.59	2.05	2.14	2.27	2.46	3.2	3.3	2.1	2.02	2	2.33	2.68	2.81	
15	Majhare	26.4	87.34	2.86	2.97	3.01	3.1	3.14	2.71	1.73	1.55	1.5	1.85	2.21	2.3	
16	Pothiyahi	26.41	87.32	1.8	1.86	1.91	2.2	2.89	2.53	1.49	1.28	1.25	1.49	1.69	1.77	
17	Salakpur	26.55	87.48	2.49	2.6	2.71	2.85	2.95	2.63	0.95	0.95	0.94	1.15	1.45	1.89	
18	Surat	26.51	87.55	2.33	2.42	2.62	2.69	2.72	2.35	1.44	1.3	1.25	1.48	1.75	1.81	
19	Thalaha	26.49	87.35	1.95	2.13	2.3	2.48	2.65	2.58	1.35	1.3	1.22	1.45	1.96	2.35	
20	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	
	DTWs															
21	Amgachhi	26.44	87.52	2.66	2.95	3.06	3.35	3.4	2.88	1.82	1.8	0.96	1.25	1.32	1.5	
22	Babiyabirta	26.52	87.42	0.53	0.74	0.85	0.94	1.06	1.02	1	1.01	0.91	1.18	1.2	1.23	
23	Dengihaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	Dharampur	26.43	87.40	4.06	4.28	4.4	4.55	4.66	4.2	3.13	3.05	2.65	2.85	2.99	3.15	
25	Haraicha	26.61	87.37	1.65	1.78	1.83	1.85	1.88	1.90	1.83	1.80	1.80	1.81	1.90	1.96	
26	Rangeli	26.46	87.26	2.6	2.77	2.92	2.98	3.1	2.65	2.12	1.96	1.9	2.1	2.28	2.53	
27	Takuwa	26.47	87.52	3.91	4.14	4.26	4.32	4.47	3.99	3.05	3.1	2.55	2.74	2.85	3.03	

District Morang **Year: 2007**

				Static Water Level Data												
S.No.	Location	Lat	Long	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Remarks
1	Rani Sikiyahi	26.42	87.27	3.55	3.6	3.69	3.82	3.83	3.03	1.12	0.92	0.9	2.6	3.05	3.2	
2	Daleli	26.55	87.49	2.81	2.92	3	3.13	3.17	1.78	0.97	0.96	0.95	1.18	1.45	1.5	
3	Darbesha	26.46	87.47	2.84	2.9	2.17	2.31	2.36	2.02	1.13	0.99	0.96	1.21	1.43	1.48	Filled up
4	Govindapur	26.48	87.58	2.41	2.5	2.56	2.6	2.54	2.24	1.39	1.21	1.18	1.41	1.74	1.82	Pump fitting
5	Haraicha	26.6	87.36	2.58	2.65	2.67	2.71	2.8	2.52	2.56	1.35	1.3	1.51	1.73	1.8	Pump motor fitting
6	Hasandaha	26.58	87.59	4.15	4.19	4.26	4.38	4.45	4.05	2.55	2.2	2.16	2.35	2.67	2.75	
7	Jhapa Baijanthpur	26.56	87.55	2.12	2.15	2.28	2.44	2.52	2.60	1.55	1.18	1.25	1.39	1.44	1.52	
8	Kadmaha	26.46	87.37	2.84	2.9	2.98	3.05	3.09	2.7	1.75	1.59	1.5	1.72	2.01	2.15	
9	Kanchanbari	26.98	87.27	1.98	2	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.44	
10	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	Karshiya	26.46	87.4	2.81	2.84	2.86	2.9	2.92	2.5	1.6	1.43	1.4	1.66	1.97	2.05	
12	Kaseni	26.58	87.4	3.18	3.22	3.3	3.41	3.45	3.22	2.03	1.81	1.8	1.93	2.21	2.25	
13	Keroun	26.55	87.48	2.05	2.1	3.01	3.05	3.08	2.64	1.68	1.4	1.37	1.48	1.68	1.78	
14	Kureli	26.43	87.59	2.15	2.17	2.14	2.32	2.35	2.05	1.07	0.98	0.95	1.19	1.53	1.65	
15	Majhare	26.4	87.34	2.86	2.97	3.01	3.1	3.14	2.71	1.73	1.55	1.5	1.85	2.21	2.3	
16	Pothiyahi	26.41	87.32	1.8	1.86	1.91	2.2	2.89	2.53	1.49	1.28	1.25	1.49	1.69	1.77	
17	Salakpur	26.55	87.48	2.31	2.45	2.65	2.71	2.73	2.49	1.5	1.32	1.28	1.47	1.76	1.98	
18	Surat	26.51	87.55	2.33	2.42	2.62	2.69	2.72	2.35	1.44	1.3	1.25	1.48	1.75	1.81	
19	Thalaha	26.49	87.35	2.55	2.58	2.65	2.76	2.8	2.42	1.51	1.29	1.21	1.55	1.9	2.1	
20	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	
	DTWs															
21	Amgachhi	26.44	87.52	2.68	2.75	2.87	3.01	3.29	2.7	1.88	1.53	0.79	1.19	1.65	1.88	
22	Babiyabirta	26.52	87.42	1.35	1.36	1.4	1.48	1.5	1.08	0.98	0.96	0.95	1.29	1.61	1.9	
23	Dengihaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian

24	Dharampur	26.43	87.40	3.93	3.98	4.03	4.11	4.15	3.6	2.77	2.52	2.45	2.76	3.1	3.25	
25	Haraicha	26.61	87.37	2.46	2.51	2.6	2.68	2.72	2.3	1.68	1.5	1.44	1.82	2.18	2.38	
26	Rangeli	26.46	87.26	2.8	2.87	2.91	2.97	3.08	2.74	1.96	1.7	1.64	1.95	2.28	2.47	
27	Takuwa	26.47	87.52	3.77	3.81	4.02	4.19	4.28	3.9	2.8	2.54	2.5	2.85	3.15	3.3	

District: Morang

Year: 2008

					Static Water Level Data												Remarks
S.No.	**Well Type**	**Location**	**Lat**	**Long**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
		STW															
1	UN/STW	Rani-Sikiyahi	26.42	87.27	3.83	4.02	4.40	4.59	3.95	4.06	2.60	2.15	2.18	2.25	2.43	2.81	
2	FM/STW	Daleli	26.55	87.49	2.56	2.76	2.9	3.03	3.13	3.20	1.64	1.20	1.25	1.48	1.68	1.90	
3	FM/STW	Darbesha	26.46	87.47	2.09	2.25	2.36	2.47	2.55	2.62	1.26	1.11	1.18	1.30	1.39	1.66	
4	FM/STW	Govindapur	26.48	87.58	2.1	2.24	2.42	2.59	2.65	2.78	1.43	1.05	1.12	1.25	1.36	1.65	
5	FM/STW	Haraicha	26.6	87.36	2.06	2.17	2.34	2.48	2.6	2.67	1.32	1.08	1.13	1.30	1.48	1.78	
6	FM/STW	Hasandaha	26.58	87.59	3.02	3.19	3.37	3.53	3.62	3.70	2.30	1.45	1.53	1.70	1.87	2.15	
7	FM/STW	JH/Baijanathpur	26.56	87.55	2.12	2.15	2.28	2.44	2.52	2.60	1.55	1.18	1.25	1.39	1.44	1.78	
8	FM/STW	Kadamaha	26.46	87.37	2.39	2.57	2.74	2.88	2.95	3.05	1.00	1.30	1.35	1.46	1.65	1.95	
9	FM/STW	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	UN/STW	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	UN/STW	Karshiya	26.46	87.4	2.47	1.40	1.60	1.78	1.85	2.00	1.00	0.10	0.24	0.35	0.55	0.96	
12	UN/STW	Kaseni	26.58	87.4	2.60	2.79	2.86	2.98	3.09	3.15	1.90	1.06	1.15	1.32	1.52	1.76	
13	UN/STW	Keroun	26.55	87.48	2.55	2.70	2.85	2.96	3.07	3.16	1.68	1.22	1.27	1.40	1.52	1.68	
14	UN/STW	Kureli	26.43	87.59	2.02	2.24	2.45	2.57	2.66	2.70	1.42	1.10	1.16	1.35	1.55	1.80	
15	UN/STW	Majhare	26.4	87.34	3.65	3.75	3.91	4.08	4.18	4.22	2.72	2.20	2.25	2.75	2.90	3.20	
16	UN/STW	Pothiyahi	26.41	87.32	1.8	1.86	1.91	2.2	2.89	2.53	1.49	1.28	1.25	1.49	1.69	1.77	
17	UN/STW	Salakpur	26.55	87.48	1.85	1.95	2.17	2.35	2.42	2.47	1.32	1.04	1.15	1.28	1.42	1.74	
18	UN/STW	Surat	26.51	87.55	2.16	2.31	2.60	2.75	2.86	3.98	2.42	1.08	1.15	1.31	1.42	1.75	
19	UN/STW	Thalaha	26.49	87.35	1.45	1.67	1.86	2.87	2.98	3.01	1.56	1.05	1.13	1.20	1.24	1.32	
20	UN/STW	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	

		DTW															
21	Exp/STW	Amgachhi	26.44	87.52	2.50	2.82	2.97	3.11	3.20	3.30	1.80	1.50	1.18	1.45	1.79	2.28	
22	Exp/STW	Babiyabirta	26.52	87.42	2.13	2.24	2.40	2.58	2.62	2.72	1.36	1.05	1.15	1.42	1.60	2.01	
23	Exp/STW	Dangihaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	Exp/STW	Dharampur	26.43	87.40	3.60	3.69	3.82	3.97	4.05	4.15	2.90	2.50	2.55	2.75	2.87	3.18	
25	UN/STW	Haraicha	26.61	87.37	2.36	2.54	2.6	2.68	2.72	2.3	1.68	1.5	1.44	1.82	2.28	2.48	
26	Exp/STW	Rangeli	26.46	87.26	2.85	2.97	2.98	3	3.08	2.84	2.01	1.85	1.8	2.11	2.29	2.5	
27	Exp/STW	Takuwa	26.47	87.52	4.06	4.02	4.15	4.37	4.42	4.50	2.90	2.46	2.52	2.98	3.22	3.55	

District: Morang

Year: 2009

				Static Water Level Data												
S.No.	**Location**	**Lat**	**Long**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Remarks**
1	Rani Sikiyahi	26.42	87.27	3.71	3.75	4.03	4.16	4.35	1.55	1.82	1.67	2.38	2.95	3.3	3.8	
2	Daleli	26.55	87.49	2.24	2.85	3.50	3.65	3.82	1.90	2.00	1.68	2.1	2.32	2.5	2.87	
3	Darbesha	26.46	87.47	1.90	2.38	2.60	2.74	2.92	1.76	1.80	1.35	1.72	1.95	2.15	2.46	
4	Govindapur	26.48	87.58	1.99	2.35	2.51	2.65	2.82	1.65	0.68	1.4	1.77	1.95	2.58	2.86	
5	Haraicha	26.6	87.36	1.97	2.35	2.50	2.66	2.78	1.52	1.58	1.26	1.65	1.85	2.25	2.56	
6	Hasandaha	26.58	87.59	2.35	2.68	2.80	2.95	3.13	1.26	1.30	1.09	1.5	1.95	2.24	2.58	
7	JH/Baijanathpur	26.56	87.55	2.00	2.30	2.48	2.51	2.67	1.75	1.76	1.35	1.65	1.78	2.25	3.01	
8	Kadamaha	26.46	87.37	2.30	2.65	3.68	3.82	4.03	2.08	2.05	1.78	2.18	2.4	2.62	2.88	
9	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	Karshiya	26.46	87.4	1.22	1.85	3.05	3.20	3.39	1.37	1.45	1.12	1.59	1.82	2.05	2.28	
12	Kaseni	26.58	87.4	1.95	2.50	2.68	2.73	2.98	1.85	1.87	1.6	1.95	2.21	2.29	2.62	
13	Keroun	26.55	87.48	1.89	2.42	2.90	3.08	3.28	1.92	1.98	1.73	2.38	2.6	2.83	3.06	
14	Kureli	26.43	87.59	2.05	2.20	2.35	2.50	2.86	1.38	1.54	1.2	1.56	1.88	2.18	2.49	
15	Majhare	26.4	87.34	3.39	3.95	4.11	4.23	4.48	1.49	1.52	1.23	1.8	2	2.27	2.6	

16	Pothiyahi	26.41	87.32	2.18	2.36	2.55	2.68	2.85	1.65	1.70	1.43	1.85	2.05	2.26	2.57	
17	Salakpur	26.55	87.48	1.86	2.45	2.66	2.80	2.98	1.54	1.57	1.18	1.6	1.83	2.27	2.6	
18	Surat	26.51	87.55	2.32	2.69	3.05	3.20	3.40	2.00	2.02	1.8	2.08	2.25	2.45	2.9	
19	Thalaha	26.49	87.35	1.45	1.67	1.86	2.87	2.98	3.01	1.56	1.05	1.13	1.20	1.24	1.32	
20	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	
	DTWs															
21	Amgachhi	26.44	87.52	2.72	3	3.33	3.45	3.60	2.01	2.65	2.33	2.55	2.7	3	3.02	
22	Babiyabirta	26.52	87.42	2.25	2.52	2.68	2.80	2.94	1.90	1.98	1.76	2.05	2.24	2.55	2.85	
23	Dengihaat	26.61	87.44	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	Dharampur	26.43	87.40	3.35	3.85	4	4.14	4.32	2.52	2.60	2.28	2.61	2.85	3.05	3.35	
25	Haraicha	26.61	87.37	2.46	2.56	2.6	2.68	2.72	2.3	1.68	1.5	1.44	1.82	2.38	2.58	
26	Rangeli	26.46	87.26	3.2	3.29	3.4	3.44	3.51	3.2	3.1	3.07	3.05	3.18	3.25	3.41	
27	Takuwa	26.47	87.52	3.75	4.43	4.30	4.52	4.70	2.88	2.95	2.7	3.01	3.18	3.39	3.8	

District: Morang **Year: 2010**

					Static Water Level Data												
S.No.	**Well no.**	**Location**	**Lat**	**Long**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Remarks**
1	FM/STW	Rani Sikiyahi	26.42	87.27	4.25	4.45	4.57	4.65	4.85	4.5	4.4	3.05	2.65	2.76	2.85	3.48	
2	FM/STW	Daleli	26.55	87.49	3.08	3.2	3.38	3.52	3.63	3.50	3.28	2.8	2.66	2.77	2.85	3	
3	FM/STW	Darbesha	26.46	87.47	2.75	2.9	3.09	3.18	3.34	3.05	2.94	2.5	2.37	2.5	2.6	2.8	
4	FM/STW	Govindapur	26.48	87.58	3.03	3.2	3.4	3.56	3.72	3.5	3.38	2.9	2.63	2.75	2.8	2.95	
5	UN/STW	Haraicha	26.6	87.36	2.7	2.85	3.00	3.15	3.35	3.08	2.93	2.34	2.2	2.32	2.41	2.6	
6	UN/STW	Hasandaha	26.58	87.59	2.75	2.9	3.05	3.25	3.48	3.02	2.95	2.22	2.01	2.13	2.25	2.4	
7	UN/STW	JH/Baijanathpur	26.56	87.55	3.28	3.40	2.43	3.5	3.62	3.43	3.25	2.55	2.4	2.56	2.61	2.75	
8	UN/STW	Kadamaha	26.46	87.37	2.41	3.1	3.27	3.5	3.66	3.48	3.33	2.62	2.5	2.58	2.7	2.82	
9	UN/STW	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	UN/STW	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	UN/STW	Karshiya	26.46	87.4	3	2	2.75	2.92	3.02	2.85	2.72	2.2	2.05	2.35	2.45	2.65	
12	UN/STW	Kaseni	26.58	87.4	2.78	2.96	3.15	3.2	3.38	3.11	2.98	2.28	2.1	2.22	2.3	2.45	
13	UN/STW	Keroun	26.55	87.48	3.22	3.3	3.42	3.5	3.65	3.43	3.22	2.75	2.52	2.65	2.72	2.81	
14	UN/STW	Kureli	26.43	87.59	2.77	2.85	3.07	3.20	3.39	3.05	2.9	2.35	2.08	2.18	2.25	2.42	
15	FM/STW	Majhare	26.4	87.34	2.8	2.96	3.18	3.35	3.5	3.12	3.01	2.5	2.41	2.53	2.66	2.8	
16	UN/STW	Pothiyahi	26.41	87.32	2.73	2.85	2.78	3.07	3.2	3	2.92	2.38	2.1	2.23	2.45	2.65	
17	UN/STW	Salakpur	26.55	87.48	2.8	2.98	3.2	3.32	3.45	3.25	3	2.65	2.5	2.6	2.68	2.8	
18	UN/STW	Surat	26.51	87.55	3.05	3.25	3.42	3.60	3.72	3.38	3.22	2.8	2.65	2.76	2.8	3	
19	UN/STW	Thalaha	26.49	87.35	1.45	1.67	1.86	2.87	2.98	3.01	1.56	1.05	1.13	1.20	1.24	1.32	
20	UN/STW	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	
		DTWs															
21	Exp/STW	Amgachhi	26.44	87.52	3.05	3.60	3.72	3.85	3.97	3.5	3.12	2.85	2.5	2.58	2.63	2.8	
22	Exp/STW	Babiyabirta	26.52	87.42	3	3.15	3.26	3.35	3.5	3.05	2.97	2.66	2.15	2.26	2.32	2.5	

23	Exp/STW	Dengihaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	Exp/STW	Dharampur	26.43	87.40	3.45	3.08	3.20	3.3	3.43	3.02	2.90	2.6	2.53	2.6	1.65	2	
25	UN/STW	Haraicha	26.61	87.37	2.48	2.56	2.6	2.68	2.72	2.3	1.68	1.5	1.44	1.82	2.32	2.45	
26	Exp/STW	Rangeli	26.46	87.26	2.8	2.87	2.91	2.97	3.08	2.74	1.96	1.7	1.64	1.95	2.28	2.47	
27	Exp/STW	Takuwa	26.47	87.52	4	4.18	4.25	4.38	4.55	4.06	3.9	3.6	3.5	3.55	3.65	3.84	

District: Morang

Year: 2011

					Static Water Level Data												
S.No.	Well no.	Location	Lat	Long	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Remarks
1	FM/STW	Rani Sikiyahi	26.42	87.27	3.87	3.94	4	4.05	4.12	4.05	3.85	3	1.6	1.62	3.2	3.35	
2	FM/STW	Daleli	26.55	87.49	3.09	3.12	3.18	3.24	3.28	3.25	3.00	2.82	2.7	2.8	3	2.95	
3	FM/STW	Darbesha	26.46	87.47	2.96	3	3.10	3.15	3.2	3.23	3.05	2.76	2.73	2.76	2.8	2.7	
4	FM/STW	Govindapur	26.48	87.58	3	3.2	3.28	3.32	3.4	3.38	3.3	2.9	2	2.1	2.15	2.3	
5	FM/STW	Haraicha	26.6	87.36	2.72	2.8	3.00	3.02	3.1	3	2.8	2.2	2.2	2.23	2.4	2.42	
6	UN/STW	Hasandaha	26.58	87.59	2.5	2.62	2.65	2.85	2.9	2.82	2.75	2.5	2.48	2.55	2.65	2.8	
7	UN/STW	JH/Baijanathpur	26.56	87.55	2.83	2.90	3	3.05	3.12	3.1	3.01	2.55	2.51	2.5	2.6	2.9	
8	UN/STW	Kadamaha	26.46	87.37	2.95	3.01	3.08	3.1	3.15	3.11	3.03	2.78	2.71	2.7	2.78	2.85	
9	UN/STW	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	UN/STW	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	UN/STW	Karshiya	26.46	87.4	2.9	3	3.12	3.20	3.25	3.15	3.01	2.8	2.58	2.6	2.8	3	
12	UN/STW	Kaseni	26.58	87.4	2.57	2.61	2.67	2.72	2.75	2.74	2.6	2.1	2.05	2.1	2.25	2.33	
13	UN/STW	Keroun	26.55	87.48	3	3.1	3.15	3.2	3.26	3.21	3.04	2.84	2.56	2.6	2.75	2.52	
14	UN/STW	Kureli	26.43	87.59	2.5	2.65	2.7	2.75	2.85	2.8	2.5	2	1.45	1.45	1.6	1.78	
15	UN/STW	Majhare	26.4	87.34	2.95	3.05	3.1	3.15	3.25	3.14	3	2.8	2.5	2.05	2.15	2.31	
16	UN/STW	Pothiyahi	26.41	87.32	2.82	2.9	3.01	3.07	3.1	3.07	3.00	2.5	2.45	2.4	2.45	2.36	
17	UN/STW	Salakpur	26.55	87.48	2.92	2.97	3.05	3.10	3.12	3.1	3	2.8	2.5	2.55	2.62	2.82	
18	UN/STW	Surat	26.51	87.55	3.1	3.15	3.3	3.35	3.50	3.40	3.2	2.85	2.82	2.9	3	3.16	
19	UN/STW	Thalaha	26.49	87.35	1.45	1.67	1.86	2.87	2.98	3.01	1.56	1.05	1.13	1.20	1.24	1.32	
20	UN/STW	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	
		DTWs															
21	Exp/STW	Amgachhi	26.44	87.52	2.91	2.97	3.04	3.1	3.15	3.1	3	2.5	1.5	1.05	1.72	1.9	
22	Exp/STW	Babiyabirta	26.52	87.42	2.65	2.75	2.82	2.90	2.97	2.95	2.8	2.62	2.6	2.7	2.8	3	

23	Exp/STW	Dengihaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	Exp/STW	Dharampur	26.43	87.40	2.11	2.2	2.28	2.32	2.35	2.3	2.00	1.6	2.5	2.3	2.35	2.5	
25	UN/STW	Haraicha	26.61	87.37	2.38	2.46	2.6	2.68	2.72	2.3	1.68	1.5	1.44	1.82	2.22	2.41	
26	Exp/STW	Rangeli	26.46	87.26	2.68	2.87	2.91	2.97	3.08	2.74	1.96	1.7	1.64	1.95	2.28	2.51	
27	Exp/STW	Takuwa	26.47	87.52	3.9	4	4.05	4.1	4.15	4.1	4	3.8	3.58	3.6	3.75	3.89	

District: Morang **Year: 2012**

					Static Water Level Data												
S.No.	Well no.	Location	Lat	Long	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Remarks
1	UN/STW	Rani Sikiyahi	26.42	87.27	3.47	3.58	3.68	4.95	4.53	4.11	2.20	2.95	3.05	3.12	3.18	3.24	
2	FM/STW	Daleli	26.55	87.49	3.27	3.40	3.58	3.65	3.72	3.80	1.60	1.80	1.96	2.00	2.08	2.10	
3	UN/STW	Darbesha	26.46	87.47	3.05	3.19	3.38	3.45	3.50	3.55	1.95	2.02	2.08	2.12	2.15	2.65	
4	FM/STW	Govindapur	26.48	87.58	2.42	2.55	2.70	2.76	2.80	2.86	1.15	1.00	1.60	1.68	1.74	1.80	
5	UN/STW	Haraicha	26.6	87.36	2.50	2.85	3.00	3.08	3.18	3.22	2.00	2.08	2.10	2.08	2.12	2.21	
6	UN/STW	Hasandaha	26.58	87.59	2.90	3.05	3.16	3.30	3.40	3.45	0.10	2.25	2.34	2.40	2.46	2.52	
7	UN/STW	JH/Baijanathpur	26.56	87.55	2.85	3.02	3.18	3.25	3.40	3.43	2.00	2.06	2.13	2.18	2.25	2.36	
8	UN/STW	Kadamaha	26.46	87.37	2.96	3.07	3.18	3.25	3.32	3.40	0.30	2.39	2.60	2.66	2.70	2.95	
9	UN/STW	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	UN/STW	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	UN/STW	Karshiya	26.46	87.4	3.08	3.18	3.37	3.46	3.50	3.58	5.00	4.38	4.50	4.57	4.63	4.70	
12	UN/STW	Kaseni	26.58	87.4	2.39	2.65	2.85	2.92	3.02	3.07	1.07	1.25	1.38	1.45	1.51	1.60	
13	UN/STW	Keroun	26.55	87.48	2.90	3.12	3.25	3.48	3.55	3.62	2.17	2.28	2.35	2.42	2.47	2.58	
14	UN/STW	Kureli	26.43	87.59	1.90	2.06	2.19	2.25	2.31	2.35	1.10	1.25	0.95	1.02	1.08	1.18	
15	UN/STW	Majhare	26.4	87.34	2.35	2.65	2.72	3.44	3.55	3.63	0.00	1.10	2.10	2.15	2.20	2.30	
16	FM/STW	Pothiyahi	26.41	87.32	2.55	2.73	2.85	3.00	3.15	3.21	1.85	2.00	2.03	2.12	2.18	2.25	
17	UN/STW	Salakpur	26.55	87.48	2.80	3.95	4.10	4.25	4.36	4.40	2.05	2.15	2.22	2.25	2.30	2.50	
18	UN/STW	Surat	26.51	87.55	3.25	3.50	3.72	3.80	3.90	4.00	2.05	2.11	2.14	2.13	2.20	2.30	
19	FM/STW	Thalaha	26.49	87.35	1.45	1.67	1.86	2.87	2.98	3.01	1.56	1.05	1.13	1.20	1.24	1.32	
20	FM/STW	Urlabari	26.66	87.6	1.34	1.4	1.59	1.76	1.8	1.85	0.25	0.1	0.21	0.6	1.09	1.35	
		DTWs															

21	UN/DTW	Amgachhi	26.44	87.52	2.30	2.85	3.20	3.50	3.60	3.63	2.08	2.13	2.17	2.22	2.26	2.50	
22	Exp/DTW	Babiyabirta	26.52	87.42	2.88	3.02	3.15	3.35	3.42	3.45	2.35	2.41	2.45	2.50	2.52	2.60	
23	Exp/DTW	Dengihaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	Exp/DTW	Dharampur	26.43	87.40	2.90	3.05	3.24	3.35	3.45	3.50	2.00	1.97	2.04	2.20	2.25	2.30	
25	Exp/DTW	Haraicha	26.61	87.37	2.33	2.44	2.6	2.68	2.72	2.3	1.68	1.5	1.44	1.82	2.29	2.39	
26	Exp/DTW	Rangeli	26.46	87.26	2.88	2.9	2.91	2.97	3.08	2.74	1.96	1.7	1.64	1.95	2.28	2.48	
27	Exp/DTW	Takuwa	26.47	87.52	3.90	4.05	4.19	4.32	4.45	4.56	3.15	3.22	3.28	3.35	3.40	3.42	

District: Morang **Year: 2013**

					Static Water Level Data												
S.No.	**Well no.**	**Location**	**Lat**	**Long**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Remarks**
1	UN/STW	Rani Sikiyahi	26.42	87.27	3.30	4.05	4.40	4.50	4.60	2.35	1.70	1.02	2.27	2.57	3.60	3.65	
2	FM/STW	Daleli	26.55	87.49	2.22	2.35	2.50	2.70	2.80	2.20	1.70	1.25	1.30	1.46	1.65	1.88	
3	UN/STW	Darbesha	26.46	87.47	3.65	4.80	4.89	4.96	5.00	3.00	1.60	0.82	0.90	1.01	2.43	2.65	
4	FM/STW	Govindapur	26.48	87.58	2.66	2.85	2.72	2.40	2.58	2.30	1.75	1.05	1.08	1.15	1.45	1.68	
5	UN/STW	Haraicha	26.6	87.36	3.80	2.05	3.97	4.25	4.55	3.80	2.80	1.08	1.11	1.20	1.55	1.80	
6	UN/STW	Hasandaha	26.58	87.59	2.65	2.78	2.85	2.98	3.05	2.60	2.05	1.30	1.33	1.42	1.85	2.10	
7	UN/STW	JH/Baijanathpur	26.56	87.55	2.49	2.61	2.72	2.80	3.00	2.65	2.00	1.00	1.20	1.25	1.48	1.62	
8	UN/STW	Kadamaha	26.46	87.37	3.05	2.60	2.73	2.80	2.95	2.50	1.72	1.05	2.09	1.40	1.47	2.05	
9	UN/STW	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	UN/STW	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	UN/STW	Karshiya	26.46	87.4	4.78	3.62	3.70	3.82	3.90	3.00	2.60	2.25	2.24	2.26	2.30	3.20	
12	UN/STW	Kaseni	26.58	87.4	1.75	4.42	2.95	3.08	3.18	2.50	1.90	1.00	1.10	1.18	1.35	1.59	
13	UN/STW	Keroun	26.55	87.48	2.65	2.76	2.80	2.90	3.00	2.77	1.60	0.43	0.55	1.00	1.36	1.60	
14	UN/STW	Kureli	26.43	87.59	1.30	3.92	3.05	3.20	3.33	2.90	2.15	1.38	1.42	1.50	2.03	2.15	

15	UN/STW	Majhare	26.4	87.34	3.50	3.65	3.80	3.95	4.10	2.12	1.05	0.35	1.14	1.35	1.80	2.20	
16	FM/STW	Pothiyahi	26.41	87.32	2.47	2,51	2.85	2.97	3.08	3.00	2.10	1.08	1.15	1.22	1.45	1.65	
17	UN/STW	Salakpur	26.55	87.48	2.63	2.70	2.77	2.85	3.05	2.60	1.30	0.55	0.65	0.85	1.13	1.45	
18	UN/STW	Surat	26.51	87.55	2.40	2.57	2.68	3.30	3.48	3.00	1.80	1.00	1.50	1.60	1.75	1.95	
19	FM/STW	Thalaha	26.49	87.35	1.45	1.67	1.86	2.87	2.98	3.01	1.56	1.05	1.13	1.20	1.24	1.32	
20	FM/STW	Urlabari	26.66	87.6	4.35	4.42	4.52	4.60	4.67	4.00	3.00	1.80	1.88	2.00	2.38	2.75	
		DTWs															
21	UN/DTW	Amgachhi	26.44	87.52	3.20	3.45	3.05	3.20	3.28	2.20	1.60	0.82	0.85	1.72	1.90	2.05	
22	UN/DTW	Babiyabirta	26.52	87.42	2.75	2.88	2.95	3.08	3.15	2.85	2.30	1.65	1.70	2.00	2.39	2.58	
23	UN/DTW	Dangihhaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
24	UN/DTW	Dharampur	26.43	87.40	2.42	2.50	4.50	4.72	4.80	4.00	2.35	1.15	1.20	1.35	1.65	1.82	
25	UN/DTW	Haraicha	26.61	87.37	2.4	2.5	2.6	2.68	2.72	2.3	1.68	1.5	1.44	1.82	2.34	2.54	
26	UN/DTW	Rangeli	26.46	87.26	2.77	2.87	2.91	2.97	3.08	2.74	1.96	1.7	1.64	1.95	2.28	2.42	
27	UN/DTW	Takuwa	26.47	87.52	3.35	3.95	4.15	4.25	4.35	3.00	2.60	2.05	2.18	2.50	3.01	3.33	

District: Morang **Year: 2014**

					Static Water Level Data												
S.No.	Well no.	Location	Lat	Long	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Remarks
1	UN/STW	Rani Sikiyahi	26.42	87.27	4.03	4.06	4.25	4.42	4.50	3.85	3.28	2.42	1.70	2.05	3.17	3.38	
2	FM/STW	Daleli	26.55	87.49	1.96	2.10	2.22	2.43	2.58	2.70	2.85	1.50	1.11	1.32	1.99	2.25	
3	UN/STW	Darbesha	26.46	87.47	2.43	2.44	2.45	2.50	2.61	2.00	1.65	1.02	0.48	0.70	1.00	1.23	
4	FM/STW	Govindapur	26.48	87.58	2.54	2.59	2.72	2.83	2.50	2.70	2.78	2.08	1.73	2.00	2.27	2.38	
5	UN/STW	Haraicha	26.6	87.36	2.00	2.12	2.20	2.38	2.48	2.10	2.17	1.65	1.50	1.90	3.15	1.80	
6	UN/STW	Hasandaha	26.58	87.59	3.25	3.40	3.48	3.55	3.68	3.09	3.18	1.80	0.98	1.15	1.38	1.98	
7	UN/STW	JH/Baijanathpur	26.56	87.55	3.87	3.90	3.98	4.08	4.15	3.90	4.08	2.27	1.77	1.95	2.05	2.20	
8	UN/STW	Kadamaha	26.46	87.37	2.03	2.10	2.16	2.31	2.42	2.00	2.15	1.45	0.65	0.78	1.70	1.82	
9	UN/STW	Kanchanbari	26.98	87.27	1.92	1.95	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.38	1.40	
10	UN/STW	Kanepokhari	26.65	87.44	2.22	2.21	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.45	2.51	
11	UN/STW	Karshiya	26.46	87.4	3.33	3.41	3.58	3.80	3.92	3.18	3.35	2.00	0.50	0.95	2.55	2.80	
12	UN/STW	Kaseni	26.58	87.4	2.10	2.23	2.35	2.50	2.57	2.40	2.52	1.85	1.00	1.25	3.39	1.85	
13	UN/STW	Keroun	26.55	87.48	3.05	3.11	3.15	3.21	3.28	3.30	3.48	2.15	1.86	2.00	1.85	1.56	
14	UN/STW	Kureli	26.43	87.59	1.77	1.82	1.95	2.08	2.21	2.00	2.00	1.55	0.50	0.65	1.65	2.30	
15	UN/STW	Majhare	26.4	87.34	3.17	3.21	3.24	3.42	3.67	2.95	3.08	1.05	0.85	0.98	1.66	1.88	
16	FM/STW	Pothiyahi	26.41	87.32	1.85	2.00	2.11	2.25	2.36	2.40	2.45	2.05	1.45	1.58	1.65	1.73	
17	UN/STW	Salakpur	26.55	87.48	1.95	2.00	2.09	2.19	2.25	2.25	2.36	1.35	1.00	1.22	4.60	4.68	
18	UN/STW	Surat	26.51	87.55	2.29	2.35	2.45	2.60	3.30	2.10	2.13	1.10	0.88	2.46	2.50	2.58	
19	FM/STW	Thalaha	26.49	87.35	1.45	1.67	1.86	2.87	2.98	3.01	1.56	1.05	1.13	1.20	1.24	1.32	
20	FM/STW	Urlabari	26.66	87.6	2.96	3.08	3.20	3.41	3.50	3.00	3.32	2.38	1.85	2.01	2.08	2.12	
		DTWs															
21	UN/DTW	Amgachhi	26.44	87.52	2.61	2.70	2.86	3.05	3.11	2.52	1.75	2.50	1.10	2.18	1.95	2.20	
22	UN/DTW	Babiyabirta	26.52	87.42	2.88	2.91	3.00	3.09	3.13	2.80	2.47	2.55	2.05	1.95	2.45	2.68	

23	UN/DTW	Dangihhaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	UN/DTW	Dharampur	26.43	87.40	2.49	2.50	4.50	4.72	4.80	4.00	2.35	1.15	1.20	1.35	1.75	1.90	
25	UN/DTW	Haraicha	26.61	87.37	2.28	2.48	2.6	2.68	2.72	2.3	1.68	1.5	1.44	1.82	2.43	2.56	
26	UN/DTW	Rangeli	26.46	87.26	2.65	2.79	2.91	2.97	3.08	2.74	1.96	1.7	1.64	1.95	2.32	2.46	
27	UN/DTW	Takuwa	26.47	87.52	4.10	4.12	4.15	4.28	4.36	3.85	3.47	2.38	1.75	2.00	2.56	3.65	

District: Morang

Year: 2015

					Static Water Level Data												
S.No.	**Well no.**	**Location**	**Lat**	**Long**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Remarks**
1	UN/STW	Rani Sikiyahi	26.42	87.27	3.88	4.35	4.62	4.3	4.4	3.85	3.28	2.42	1.70	2.05	3.17	3.35	
2	FM/STW	Daleli	26.55	87.49	2.00	2.10	2.22	2.43	2.58	2.70	2.85	1.50	1.11	1.32	1.99	2.25	
3	UN/STW	Darbesha	26.46	87.47	1.9	5.15	3.49	3.52	3.55	3.57	3.68	2.9	2.49	2.61	2.85	2.98	
4	FM/STW	Govindapur	26.48	87.58	2.58	2.77	2.95	3.06	3.2	3.24	3.5	3.6	2.78	2.97	3.13	3.35	
5	UN/STW	Haraicha	26.6	87.36	2.52	3.65	4.25	4.36	4.52	4.6	4.82	2.5	2.76	3.11	3.4	3.52	
6	UN/STW	Hasandaha	26.58	87.59	2.55	2.73	2.88	2.94	3	3.12	3.38	3.4	3	3.21	2.89	2.98	
7	UN/STW	JH/Baijanathpur	26.56	87.55	2.66	2.7	2.75	2.88	2.95	3	3.23	3.28	3.42	3.5	3.72	3.85	
8	UN/STW	Kadamaha	26.46	87.37	2.2	2.26	2.69	2.8	3.3	3.7	3.96	4	1.42	2.41	2.6	2.84	
9	UN/STW	Kanchanbari	26.98	87.27	1.90	1.98	2.03	2.16	2.23	2	1.06	1.02	1	1.22	1.33	1.43	
10	UN/STW	Kanepokhari	26.65	87.44	2.20	2.26	2.28	2.31	2.38	2.41	2.30	2.24	2.30	2.36	2.40	2.56	
11	UN/STW	Karshiya	26.46	87.4	4	3.51	3.59	3.7	2.9	2.98	3.26	3.02	1.76	1.96	3.25	3.45	
12	UN/STW	Kaseni	26.58	87.4	2.3	2.98	3.75	3.82	3.9	3.97	4.1	4.12	4.18	4.25	4.42	4.5	
13	UN/STW	Keroun	26.55	87.48	2	2.1	2.65	2.65	2.78	2.83	3.08	3.13	3.2	3.3	3.52	3.65	
14	UN/STW	Kureli	26.43	87.59	2.63	1.68	2.78	2.85	2.92	3.02	3.22	3.25	0.5	0.91	1.45	1.58	

15	UN/STW	Majhare	26.4	87.34	2.86	3.15	3.35	3.42	3.55	3.24	3.62	0.65	0.85	1.08	2.45	3.4	
16	FM/STW	Pothiyahi	26.41	87.32	1.80	2.09	2.11	2.25	2.36	2.40	2.45	2.05	1.45	1.58	1.76	1.86	
17	UN/STW	Salakpur	26.55	87.48	5	5.17	5.32	5.4	5.45	5.54	5.63	5.65	5.71	5.73	5.78	5.82	
18	UN/STW	Surat	26.51	87.55	2.85	2.9	2.99	3.05	3.18	2.98	3.35	3.4	1.95	2.13	2.5	2.85	
19	FM/STW	Thalaha	26.49	87.35	1.38	1.69	1.86	2.87	2.98	3.01	1.56	1.05	1.13	1.20	1.30	1.44	
20	FM/STW	Urlabari	26.66	87.6	2.96	3.08	3.20	3.41	3.50	3.00	3.32	2.38	1.85	2.01	2.12	2.23	
		DTWs															
21	UN/DTW	Amgachhi	26.44	87.52	2.65	2.85	3.10	3.16	2.98	2.60	2.81	2.65	1.40	1.51	2.08	2.40	
22	UN/DTW	Babiyabirta	26.52	87.42	2.90	3.08	3.16	3.25	3.33	3.38	3.46	3.36	3.00	3.05	3.20	3.40	
23	UN/DTW	Dangihhaat	26.61	87.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Artesian
24	UN/DTW	Dharampur	26.43	87.40	2.44	2.50	4.50	4.72	4.80	4.00	2.35	1.15	1.20	1.35	1.75	2.00	
25	UN/DTW	Haraicha	26.61	87.37	2.38	2.48	2.6	2.68	2.72	2.3	1.68	1.5	1.44	1.82	2.43	2.66	
26	UN/DTW	Rangeli	26.46	87.26	2.55	2.79	2.91	2.97	3.08	2.74	1.96	1.7	1.64	1.95	2.32	2.56	
27	UN/DTW	Takuwa	26.47	87.52	3.92	4.05	4.29	4.35	4.30	3.85	3.47	2.38	1.75	2.00	2.30	2.75	