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Editorial

Welcome to the fifth volume of the annual Geo-ICT magazine of GES "**GeoSpace**". We are really proud and exuberant with all new hopes and hues to bring out the 5th issue, which will obviously unfold the link between students, professionals, researchers and Geospatial enthusiast. As the saying goes, mind like parachute works best when opened. GeoSpace has been delivering researches, exploratations, studies, works and accomplishments in the realm of Geomatics and Geoinformatics.

The enthusiastic write ups of our authors are indubitably sufficient to hold the interest and admiration of the readers. We believe that our success depends upon our power to perceive, the power to observe and the power to explore. We are sure that the positive attitude, hard work, sustained efforts and innovative ideas exhibited by our authors and contributors will surely stir the mind of the readers and take them to the surreal world of imagination and innovation. We have put in relentless efforts to bring excellence to this treasure trove. It gives us immense pleasure to launch this magazine on the occasion of "Nepal Geomatics Meet 2019". The reflection of the interdisciplinary collaboration and research of involvement of individuals, groups and organizations is the epitome of the magazine. The collection of research papers and articles is likely to provide insight and support the design of emerging geospatial domain and ripple them within the readers which could bring affirmative knock in an individual; the society, the nation and worldwide as a whole. Authors have put forth their researches and thoughts that are too deep to be expressed and too strong to be suppressed. I take the opportunity to thank all the contributors as their contribution is the reason that makes this magazine endearing with our readers.

I would like to express sincere appreciation to **Dr. Subash Ghimire** and **Dr. Reshma Shrestha** for their valuable guidance as Advisors. Furthermore I would also like to acknowledge my teacher **Assist. Prof. Uma Shankar Panday** and former editor-in chief **Er. Rohit Gautam** for their motivational support in every steps. Likewise, I am very much thankful to Marketing Head **Mr. Sudeep Kuikel** and his team who worked really hard to raise financial support for the magazine. I express my sincere gratitude to all the authors for their professional contribution.

Helen Keller rightly said that the world is moved along not only by the mighty shoves of its heroes, but also by the aggregate of the tiny pushes of each honest worker. This herculean task of editing this magazine would not have been possible without the sincere support of the members of the Editorial Board who sorted of the articles from the flood of articles we had got from our enthusiastic and inquisitive researchers, edited them and finally made a fair draft of them. I am thankful to all my colleagues who dipped their oars into the turbulent water of the magazine and have sailed it to the shore of publication. It is a fine thing to have ability but the ability to discover ability in others is the true test. I am really thankful to Department of Geomatics Engineering and Geomatics Engineering Society (GES) for entrusting us with the responsibility of publishing the volume V.

I take this opportunity to thank all the dignitaries for sparing their valuable time to send their best wishes for the magazine in the form of 'Messages'. I heartily wish all the readers my best wishes and hope this souvenir will enjoy your critical acclaim and prove itself to play a vital role in the all-round development of Geospatial knowledge.

Enjoy Reading!

Abinash Silwal
Editor-in-Chief
GeoSpace Vol-V

Kathmandu University
Office of the Vice Chancellor

Message from the Vice Chancellor

I am pleased to see the fifth issue of annual Geo- ICT magazine ***Geo-Space*** published by Geomatics Engineering Society (GES), Departmental club of Geomatics Engineering of Kathmandu University. This magazine adds to the literature of Geomatics Engineering in Nepal by creating and sharing new knowledge. Furthermore, it complements the initiatives of our University in advancing our institutional identity and in creating impact in the communities.

As our country moves in the era of decentralization that fuels development, the demand of expertise in Geomatics Engineering is increasing. I am hopeful that our team of Geomatics Engineering will help fulfill this by providing locally suitable, applied skill and knowledge. Together, we will open new avenues growth and progress in our society.

I congratulate GES, Department of Geomatics Engineering and the Geo Space team for this publication and extend my full support for your whole novel endeavors in coming days.

Prof.Dr. Ram Kantha Makaju Shrestha,MD
Vice Chancellor,
Kathmandu University
November 4, 2019

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Message from Head of Department

I am delighted to write a few words on the fifth issue of annual Geo- ICT magazine **"GeoSpace"** published by Departmental club, Geomatics Engineering Society (GES). First of all, I personally and on behalf of Department of Geomatics Engineering, would congratulate entire students, faculties and staff of the Department to bring out "GeoSpace -V". I am confident that this magazine is proficient not only to the surveying and mapping professionals, but also to other scientific community and researchers as well. I hope Geoinformation community will be benefitted at large by sharing scientific and professional articles.

It is my pleasure to mention that Department of Geomatics Engineering, youngest Department in School of Engineering, Kathmandu University, has been continuously contributing in the capacity building of Surveying, Mapping, Geoinformation Science and Earth Observation and Land Management. The Department has Diploma, Undergraduate, Graduate and PhD programs. It has Geospatial, Photogrammetry and Surveying lab and in the future Cartography lab will be established at the Department. The Department is working in line with Silver Jubilee initiatives such as Quality, Identity, Equity, Impact, Innovation and Global Engagement to achieve its vision. Finally, let me express my sincere appreciation to fellow colleagues, entire team of the editorial board for their invaluable contribution in "GeoSpace -V". I would expect such kind of support and professional contribution in the upcoming issues too. I believe that this effort will boost networking among the students, faculties and professionals.

Thanking you!

Dr. Subash Ghimire
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Department of Geomatics Engineering
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Message from Director General of Survey Department

It is my honor and privilege to express my view and convey my message to "GeoSpace" team. I would like to congratulate all the personnel involved in bringing the fifth issue to this stage. I hope this magazine is supporting in sharing the information in the field of geo science and wish for the continuity of the efforts. On behalf of the Survey Department, the National Mapping Organization of Nepal and myself, I would like to congratulate once again the Geomatics Engineering Society (GES) of Kathmandu University, members of the Editorial Board and the entire team to bring out this issue successfully. In the mean time I would also like to acknowledge the contributions of the authors for expressing their views and sharing their knowledge to the community.

Survey Department, the only National Mapping Organization of Nepal, has been continuously contributing in the sector of Surveying, Mapping, Geo-information Science and Earth Observation, which are very much crucial for the planned development of the country and understand that it is the organization directly concerned with the Geomatics profession. I have been observing the performance of the Geomatics professionals in Survey Department and other fields as well and I can see the much more scope is being developed for future endeavors.

I wish to see the performance of the young geomatics professionals maintained and further enhanced in future.

Enjoy reading.

Prakash Joshi
Director General
Survey Department
Kathmandu, Nepal
Website: www.dos.gov.np

Message from Executive Director of LMTC

It is indeed a matter of immense pleasure for me to have the privilege of conveying my message on GeoSpace. I thank the Geomatics Engineering Society and its Editorial Team for this opportunity and congratulate the team for being successful on bringing this issue which is equally brilliant like the earlier one. In fact, it is even more refined and one step ahead than the previous ones.

Being a regular follower of GeoSpace, I have an impression that GeoSpace is a magazine that reflects how innovative and professionally dedicated our 'Geomatics Engineers-to-be' are, and it gives me immense happiness to see the profession expanding with such an amazing pace.

Land Management Training Center (LMTC) is the only government training center that is responsible for producing human resources and developing capacity of the government officials working in the field of surveying, mapping and land management. LMTC's efforts and concern are always focused on the quality that has to be injected in the profession through new graduates. Therefore, the quality of new graduates always matters to LMTC and GeoSpace works as mirror to showcase the quality of the members of GES.

I am proud of the fact that LMTC played crucial role in laying the foundation of Geomatics Engineering (GE) courses at Kathmandu University (KU). LMTC-KU collaboration began in 2007 and this year the collaboration has been extended even further. Beauty of the collaboration is that only the courses in GE have proportional provincial representation. Personally, I am very much happy to see new intake for the year 2019 for GE course is represented by at least 30 districts from all the provinces. The line in our national anthem "we, as a garland of hundreds of flowers…" is fittingly reflected in the composition of GE classes. I firmly believe that such a "garland" will ultimately contribute to the national vision of "Prosperous Nepal: Happy Nepali". I wish to see GeoSpace continuing to fuel the meaningful strength of LMTC-KU collaboration in the days to come too.

Publishing a quality magazine in such scientific and technical domain is a commendable contribution in the professional development of students and practioners. With due respect, I thank the editorial team and entire GES community for their devotion, dedication and enthusiasm in this contribution.

Finally, let me reiterate my statement from the previous edition's message "GeoSpace is a digest for the beginners, informant for the professionals, and platform for the researchers. Reading GeoSpace is refreshing yourself. Enjoy reading GeoSpace!"

Thank you!

Ganesh Prasad Bhatta
Executive Director
Land Management Training Center
Ministry of Land Management, Cooperatives and Poverty Alleviation
Government of Nepal

Message from President of GES

Geomatics Engineering Society (GES) provides platform for the students of Geomatics Engineering to flourish their skills and talents. Since its establishment, it has been actively involved in providing opportunities to students to enhance their inner talents, knowledge and understanding regarding geomatics. Whether it be an orientation program to the freshers or Map literacy for school level, GES has always harvested the knowledge of geospatial technology and its applications among the youngsters. GES has also been associated in organizing various talk shows, lecture session, sports event to maintain the harmony, cooperation, understanding and teamwork capability among the students. Events organized by GES not only incorporate the teamwork among students in Geomatics Engineering, Kathmandu University but also involves the participants from various agencies, institutions and professionals relating to geoscience and surveying.

As a president of this club, I feel glad to have an efficient and hardworking team, contributing to the annual event **Nepal Geomatics Meet 2019** within the theme "Harvesting the knowledge of surveying and Geospatial Technology in Nepal". Managing and organizing such major event surely require an efficient teamwork and therefore, I am really thankful to the organizing team for their consistent effort to make this event a success. With major success in its past, GES is launching its annual magazine **"Annual Geo-ICT Magazine of GES, Volume V"** in the auspicious occasion of its annual event Nepal Geomatics Meet 2019 with a motive to encourage the students in researches and present their works to the wider audience. The magazine provides an opportunity to the students and individual to publish their research and studies related to the field of Geoscience and surveying.

I would like to thank the organizing team for their persistent hard work. As said by Helen Keller, "Alone we can do little, together we can do so much", this event is not an outcome of just the organizing team but also the support of helping hands. Therefore, I would like to express my gratitude to all the concerned authorities and helping hands to make this event a success. Such events and teamwork can be an example and foundation to the juniors where the future of GES can be built upon. Best wishes for the entire endeavor!

Enjoy Reading!

Saugat Pratap Singh Karki
President
Geomatics Engineering Society

Contents

Journal Articles

Magazine Articles

ANALYZING THE EFFECT OF CLIMATE CHANGE (RAINFALL AND TEMPERATURE) ON VEGETATION COVER OF NEPAL USING TIME SERIES MODIS IMAGES

Neha Joshi, Pradeep Gyawali, Sudha Sapkota, Dinesh Neupane, Sanjeevan Shrestha, Nawaraj Shrestha, Florencia Matina Tuladhar

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KEYWORDS: MODIS, NDVI, CHIRPS, Vegetation Change Pattern, Time Series

ABSTRACT:

Climate change and so its effect on terrestrial ecosystem has been a focus point for a while now. This paper aims to analyze the spatial-temporal distribution of vegetation cover, temperature and rainfall, and to examine the relationship of the latter two with vegetation for entire Nepal. Primary data used were vegetation and temperature data from Moderate Resolution Imaging Spectroradiometer (MODIS) and rainfall data from Climate Hazards Group Infrared Precipitation with Stations (CHIRPS) data product. The relationship analysis was carried out in three phases; first, the trend of vegetation with respect to rainfall and land surface temperature (LST) was inspected over entire study area by creating a time series of Normalized Difference Vegetation Index (NDVI) monthly means for six months, averaged over the whole study period. However, vegetation change pattern across various ecological regions of Nepal also needed to be considered, for the three different regions are profoundly different from each other in number of factors like altitude and soil type. Finally, the variation of vegetation with climatic parameters, i.e. rainfall and temperature, along the eleven-year study period was also portrayed, to depict how the vegetation cover has been fluctuating over the years. During the study period, the correlation coefficient between vegetation index and rainfall was the highest in October in Terai while that with temperature was in July in Hilly region. Overall, vegetation was influenced greater by the temperature than rainfall in all three ecological regions with highest correlation coefficient of vegetation with temperature and rainfall, being -0.937 and 0.556 respectively.

1. INTRODUCTION

Vegetation is sensitive to climate changes. Vegetation dynamics and the responses to climate changes have been recognized as one of the core issues of global change in terrestrial ecosystems (Fu & Li, 2010). Among them, rainfall and temperature happen to exert strong influence on the condition of vegetation cover (Li, Jianrong, & Yang, 2014). The monitoring of vegetation by remote sensing is an accepted technique of resource assessment. Due to high spatial and temporal resolutions and accuracy, remotely sensed data can provide technical support for monitoring vegetation dynamics at large scales. The NDVI was proposed by Rouse et al. based on red and near-infrared reflectance. NDVI has been frequently used for studying vegetation dynamics because it is highly correlated with the photosynthetic capacity, the leaf area index, biomass, and net primary productivity (Ning et al., 2015).

The monsoon precipitation and temperature is significantly known to affect the distribution of vegetation. Since vegetation requires moisture, rain and favorable temperatures, it may characterize the regional weather. For large areas comprising vegetation, NDVI method is better suitable where analysis is carried out using either past or present images with no ground truth data (AS et al., 2012). Vegetation and land use/land cover changes are closely correlated with precipitation and land temperature changes on a seasonal scale which, in turn, have feedback on the regional climate (Pandey et al., 2017).

Rainfall and temperature pattern are varying and, atmospheric CO_2 concentrations is increasing due to anthropogenic activities contributing to climate change. Therefore, study on effect of climate changes in vegetation is essential to identify the ecosystem functions for providing a scientific basis for corresponding policies. Therefore, this project attempts to study the spatial-temporal variation of vegetation, temperature and gridded satellite rainfall including the possible influence of climate, i.e. rainfall and temperature, on vegetation for eleven years in entire Nepal.

The project aims to determine the extent of changes occurred on vegetation cover of Nepal as an effect of rainfall and temperature over six months' period from 2000 to 2010 by using geospatial techniques.

2. STUDY AREA

The study covers whole Nepal (28.3949° N, 84.1240° E) with an area of 147,181 square kilometers. Nepal is landlocked by India on three sides and China's Tibet Autonomous Region to the north. Nepal measures about 800 kilometers along the Himalayan axis by 150 to 250 kilometers across. It rises from low of 59-meter elevation in tropical Terai to 8848 meters in the hill. Along south-to-north it can be divided into three belts: Lower Plains, Mountain and Hill. The Lower Plains, also called Terai, begins at the Indian border and includes some hill ranges. The southernmost part of Terai is flat and intensively farmed North-Indian River Plain and is called Outer Terai. The hilly area contains the region which generally doesn't contain snow. This area lies at an altitude of 1500-2700 meters. The Mountain Region or Parbat rises above 3000 meters that constitutes the subalpine and alpine zone which are mainly used for seasonal pasturage. The major altitude belts of Nepal are Tropical Zone (below 1000 meters), Subtropical Climate Zone (1,000 to 2,000 meters), Temperature Climate Zone (2,000 to 3,000 meters), Subalpine Zone (3,000 to 4,000 meters) and Alpine zone (4,000 to 5,000 meters).

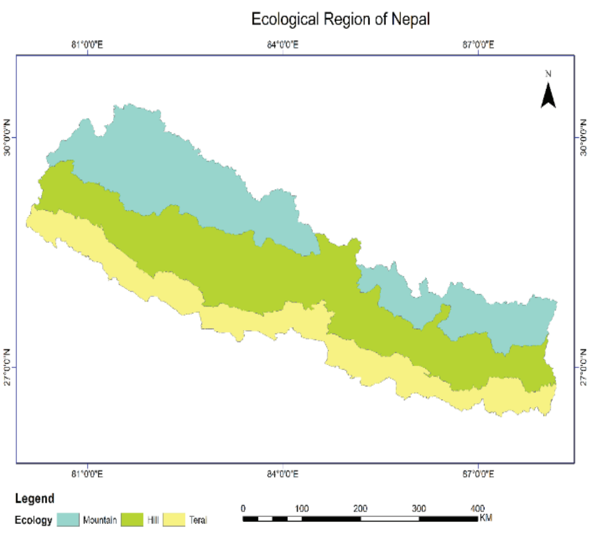


Figure 1. Study area

3. METHODOLOGY

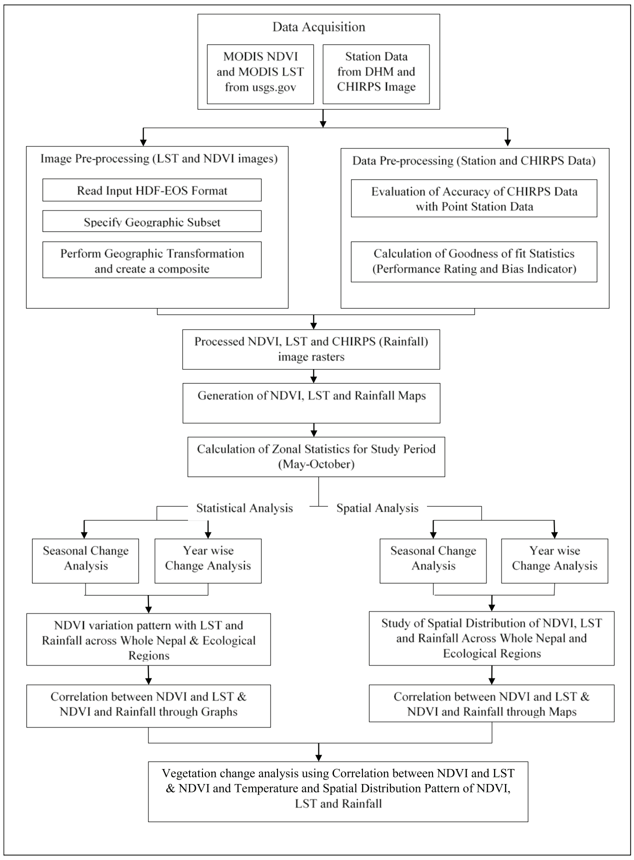


Figure 2. Workflow of the project

3.1 Data Acquisition

The primary datasets used were NDVI and LST from MODIS satellite product and monthly CHIRPS gridded precipitation datasets from the CHG archives. A monthly 1-kilometer spatial resolution in the Sinusoidal projection was downloaded to assess vegetation status while an average, 8-day, per-pixel LST in a 1200 x 1200 kilometer grid was downloaded where each pixel value in the MOD11A2 is a simple average of all the corresponding MOD11A1 LST pixels collected within that 8-day period. On the other hand, 0.05° resolution satellite imagery with in-situ station data was used so as to create gridded rainfall time series for rainfall trend analysis.

The validation of remote sensing products (RSPs) is fundamental work before the proper use of RSPs. Validation at pixel scale was carried out for this project which can be summarized into major three steps: sampling design for ground observation, data collection and estimation of the mean value at pixel scale. The data used for validation were Google Earth data for verifying the extent of vegetation cover for couple of years and the other one, Rain Gauge Station Precipitation data. Monthly Observed Precipitation data for 11 years obtained from Survey department of Nepal, from 2000-2010 were used for checking the quality of monthly CHIRPS precipitation dataset.

The rain gauge network was chosen such that it fairly covered Mountain, Terai, and Hilly regions uniformly.

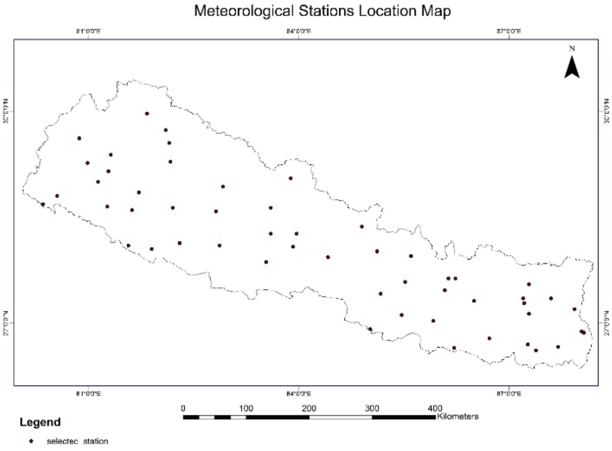


Figure 3. Map showing distribution of selected meteorological stations in Nepal

3.2 **Image Pre-processing**

The original MODIS products downloaded from USGS website, i.e. both LST and NDVI come in HDF-EOS format with sinusoidal coordinate system, therefore they were pre-processed in the software called MODIS Reprojection Tool. The functionalities of the tools that the software provides can be achieved both from the command-line and from the GUI. Considering the huge sets of data to be processed, batch processing via command- line was opted to avoid the repetition of the task.

MRT was used for two major reasons: create a mosaic, and project HDF format to tiff and reproject from sinusoidal to WGS84.

3.3 **Validation of Downloaded Data**

CHIRPS data has less spatial resolution as compared to other two data sets. Therefore, it was validated before use in order to ensure if it was credible enough to be used in the project.

For comparing satellite- and ground-based rainfall products, pixel- to –pixel comparison was carried out in which, 53 region of interests(ROI) were generated in ENVI based on sample stations selected across Nepal. Afterwards, the monthly average for the whole study period, i.e. 2000 to 2010 for the pixels associated with the region of interest were generated. On the other hand, the daily precipitation data from Department of Hydrology and Meteorology (DHM) were processed and monthly average were generated for each station in MS Excel using pivot table.

After all the necessary data were generated to evaluate the accuracy of the satellite-based products when compared against the ground-based rainfall depths, a goodness of fit statistics was used, namely the percentage bias – PBIAS (Shrestha et al., 2017).

$$PBIAS = \frac{\sum(Rgauge - Rsatellite)}{\sum(Rgauge)} * 100 \qquad (1)$$

Where,
Rsatellite = rainfall estimates from the CHG product
Rgauge = rainfall recorded in a particular rain gauge.

Afterwards, monthly precipitation and difference of monthly precipitation of CHIRPS and rain gauge stations were generated, averaged for all sample stations for a given month to analyze the bias of the CHIRPS data.

3.4 **Generate Vegetation Cover Map, Temperature Map and Rainfall Map**

In order to analyze the seasonal evolution of vegetation, eleven images of NDVI monthly means for a given month were averaged over the whole study period, i.e. 2000 to 2010. It was carried out for all the months consecutively from May to October. The same was done for LST as well as CHIRPS as well, and hence vegetation, temperature and rainfall map were generated. As the analysis required the independent average value for each ecological region, 'zonal statistics' was used in order to derive the average value of each parameter for all the ecological regions.

3.5 **Establishment of Relationship of Vegetation with Temperature and Rainfall**

The analysis was carried out through two approaches, statistical and spatial. Under each type of analysis, further two approaches were opted to show the relationship, seasonal change and year-wise change. The variation in vegetation alongside the change in rainfall and temperature was analyzed month-wise in order to identify the impacts that the temperature and rainfall has on vegetation in each month through pre-monsoon to post-monsoon. Meanwhile, our analysis was guided by average data of eleven- years period. So to ensure if there are any abrupt changes in any given year that would deviate the final average, the analysis was made to inspect year-to-year impacts of these climatic parameters.

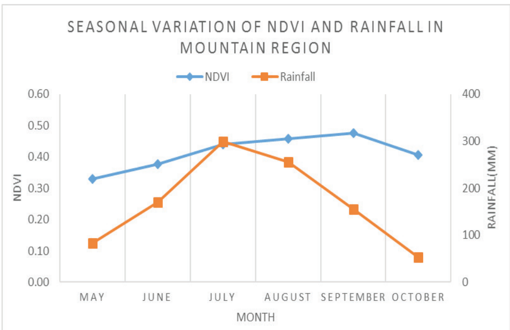
For statistical analysis, the data so generated were then represented in the graphs that supported the analysis while on the other hand, study of spatial distribution of the all three maps of NDVI, LST and rainfall was made for spatial analysis. Besides, the correlation maps indicating the relationship of NDVI with rainfall and temperature individually, were also generated using R script to help with the analysis. Afterwards, the analysis from both the approaches were brought together so as to condense the overall analysis to the final result.

4. RESULTS AND DISCUSSION

4.1 Relationship between NDVI and Climate Variables (Rainfall and Temperature) for Ecological Regions of Nepal

In first case, the analysis was guided by average data of eleven- years period, i.e. 2000 to 2010 to describe the variation of vegetation.

Relationship Between NDVI and Rainfall



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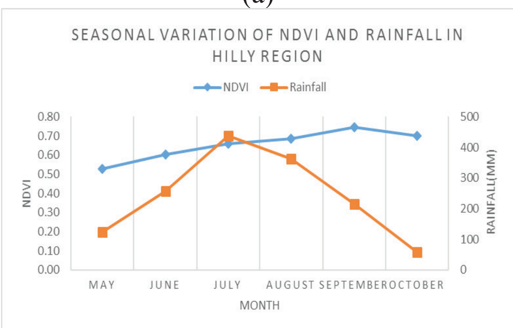

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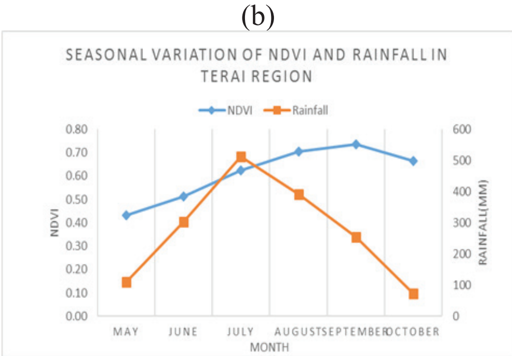
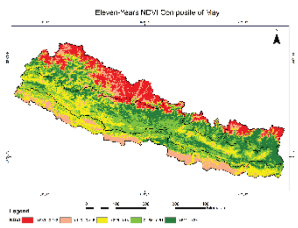


(c)

Figure 4 (a)-(c). Graph showing seasonal variation of NDVI with rainfall across (a).mountain, (b).hilly and (c).terai region

Although all three ecological regions depict similar trend, but the maximum NDVI and precipitation value attained in each region was different for a given particular month. In the beginning of study period, the value for both NDVI and rainfall was least for May as a result of comparatively limited amount of vegetation and so the precipitation. With the onset of monsoon, the precipitation increased vigorously however, the growth in vegetation could not be instantly seen. The water requirement of plants would then be sufficiently fulfilled due to monsoon rainfall as it helps to retain adequate moisture availability in soil so that the plant roots can easily extract water from soil for their growth. Accordingly, by the end of monsoon, NDVI tended to increase but by then, the rate of precipitation decreased deliberately.

The semi-arid land with minimal humidity and the fact that, the area is mostly covered by ice and glaciers, may have led to limited vegetation in mountain region (Baniya et al., 2018), as a result, very low response between the two variables was displayed. The hills had high NDVI values due to the presence of a large number of community forestry and agricultural practices while in Terai cultivated lands were high (Baniya et al., 2018) which supported the high NDVI values that the region had. Meanwhile, in some cases NDVI showed increase in its value even in those areas that did not receive adequate amount of rainfall, which can be due to the artificial irrigation carried out by people on their own.



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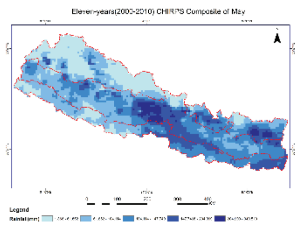

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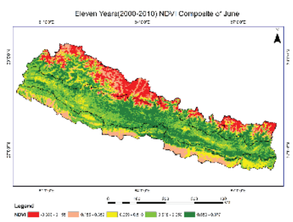

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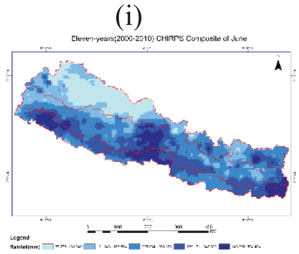

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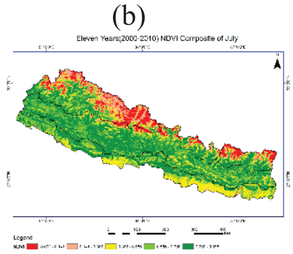

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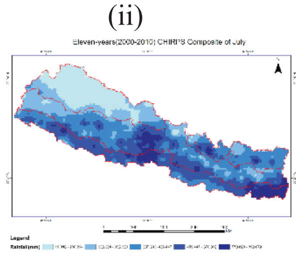

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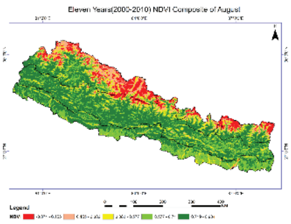

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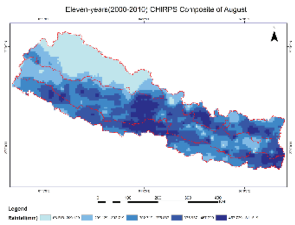

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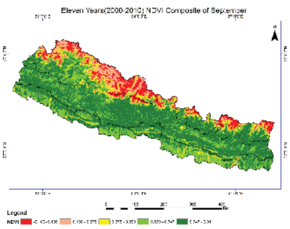

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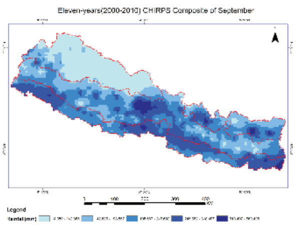

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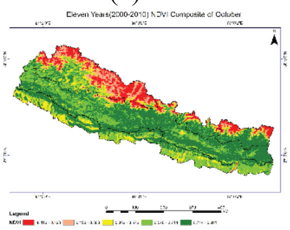

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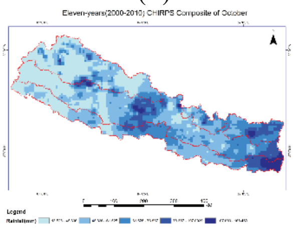
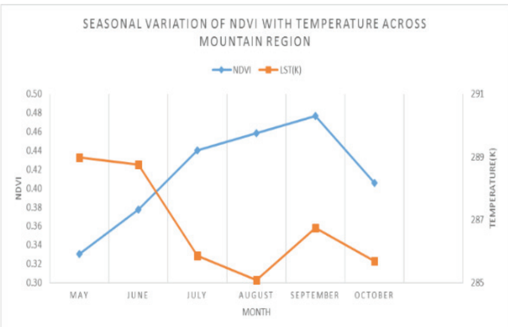


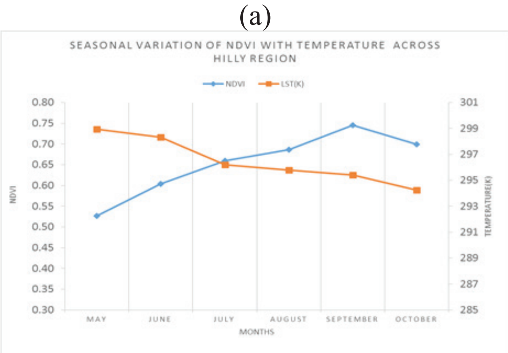
(vi)

Figure 5. Map showing NDVI eleven-years composite for (a).May, (b).June, (c).July, (d).August, (e). September and (f).October and map showing CHIRPS eleven-years composite for (i).May, (ii).June, (iii). July, (iv).August, (v).September and (vi).October

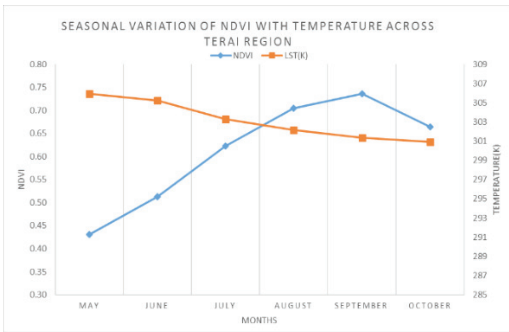
<u>Relationship Between NDVI and Temperature</u>



(a)



(b)

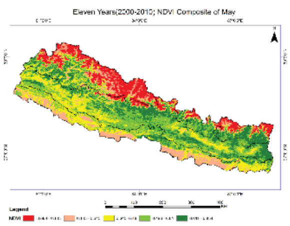


(c)

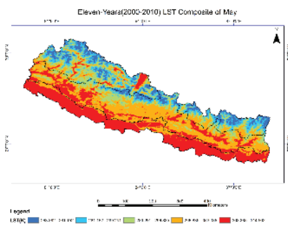
Figure 5 (a)-(c). Graph showing seasonal variation of NDVI with rainfall across (a).mountain, (b).hilly and (c).terai region

The LST value is greatly affected by altitude. The maps and graphs together depicted the fact that, unlike precipitation, the temperature showcased inverse relationship with vegetation. The temperature was the highest amongst all, in May while the vegetation was likely to be the least. As the month progressed, the temperature showed decreasing trend while the NDVI values showed the exact opposite. But this trend continued until the temperature was high. By the time it was October, both NDVI and temperature showed downward trend suggesting that, NDVI stayed inversely proportional to high temperature but once the temperature values started decreasing, NDVI almost became immune to its effect.

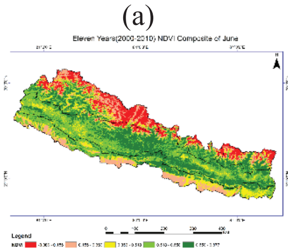
Apart from the negative pattern showcased by LST and NDVI in graphs, an additional fact was shown by the maps, i.e. the impact of temperature was seen to be least in the mountain region. This could be explained by the fact mentioned above that, as the temperature starts decreasing, its effect on vegetation too, subsides. Therefore, lesser the temperature, smaller its effect on vegetation. Also, the vegetation density in that region is way too low, which could also be one of the many reasons for it to not show the distinct impacts of temperature on its vegetation.



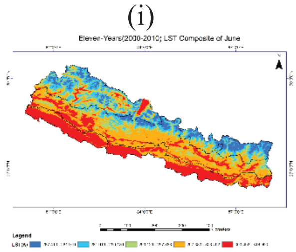
(a)



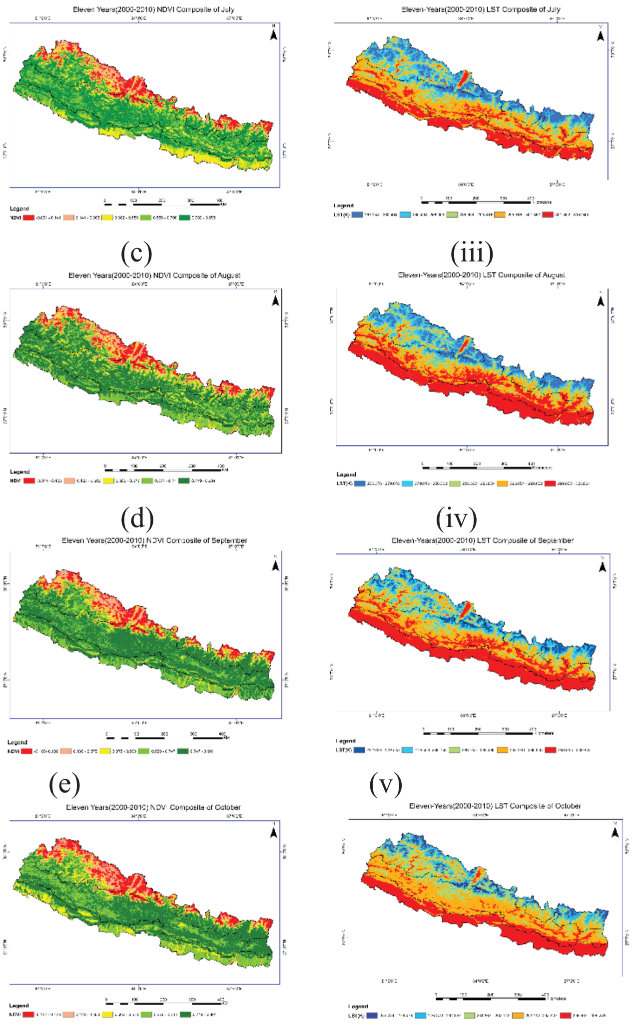
(i)



(b)



(ii)



(c) (iii) (d) (iv) (e) (v) (f) (vi)

Figure 6. Map showing NDVI eleven-years composite for (a).May, (b).June, (c).July, (d).August, (e).September and (f).October and map showing temperature eleven-years composite for (i).May, (ii).June, (iii).July, (iv).August, (v).September and (vi).October

4.2 Correlation Coefficient Values between Monthly NDVI and Monthly (a)Mean Rainfall and (b) Mean LST across three ecological regions

Month	Mountain	Hill	Terai
May	0.341	0.209	0.572
June	-0.426	0.288	0.611
July	-0.021	0.143	0.455
August	-0.426	-0.596	-0.177
September	-0.189	-0.014	0.292
October	-0.117	0.31	-0.793

Table 1. Correlation coefficient between NDVI and rainfall ((NDVI, Rainfall)) across different ecological regions during the period of study

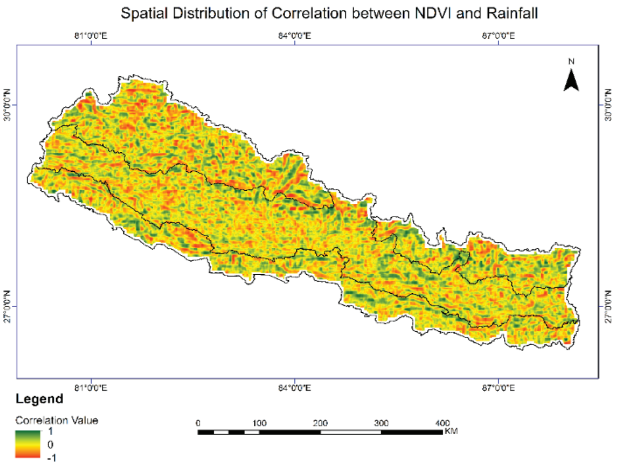
Month	Mountain	Hill	Terai
May	0.64	0.018	0.0175
June	0.357	-0.334	-0.728
July	0.011	0.76	-0.039
August	0.441	0.48	0.281
September	0.485	0.753	0.621
October	0.54	0.163	0.038

Table 2. Correlation coefficient between NDVI and temperature ((NDVI, LST)) across different ecological regions during the period of study

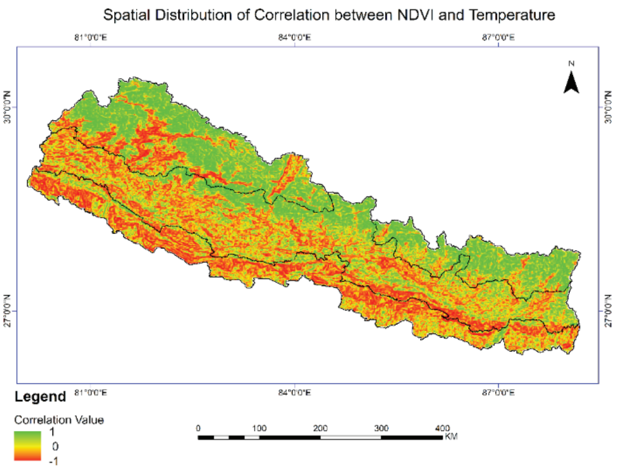
The correlation table indicating the relationship between the rainfall and NDVI well reflects the fact that NDVI and rainfall are positively correlated but the strength of correlation is really poor while the one with NDVI and temperature suggests, in each of the ecological region, the average value of LST and NDVI are negatively yet, highly correlated showing there is inverse relationship between them. Lower value of LST is characterized by the higher value of NDVI.

As precipitation does not immediately put an impact on vegetation, and requires a month or so to have its effect in action, the analysis of this delayed effect of seasonal rainfalls to NDVI showed vague correlation, as seen on the map. But on detailed inspection, the map tends to deliver poor relationship of NDVI to rainfall, closely limiting to 0 in most cases, throughout the study area.

On the other hand, the correlation map of NDVI relating to temperature shows befitting relationship as obtained from the statistical prospect. The statistical part claimed NDVI to have strong negative relationship with temperature which is why the hills and the Terai depict high negative correlation values, for the vegetation density is greater on that region while the mountains claim positive relationship which do not entirely justify the statistics because it is the aggregate for six whole months, which can be the reason for slight deviation in the results.



(a)



(b)

Figure 7. Spatial distribution of correlation between mean NDVI and climate factors (a. rainfall b. temperature) for six months' period

4.3 **Validation of CHIRPS Data**

While rainfall estimates based on satellite measurements are becoming a very attractive option, they are characterized by non-negligible biases (Shrestha, et al., 2017). As such, the accuracy of satellite product of the Climate Hazard Group (CHG) was assessed using ground-based measurements through the following graphs and plots.

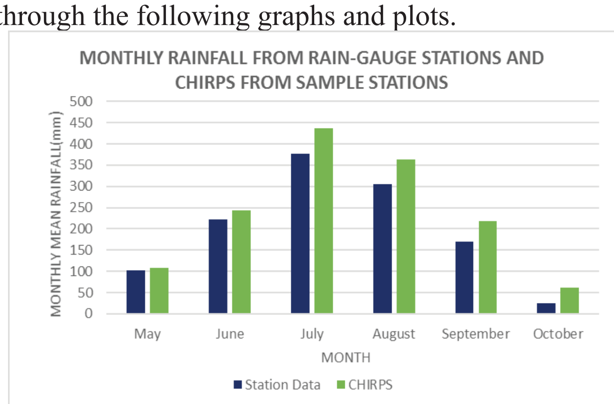


Figure 8. Monthly precipitation of CHIRPS and rain gauges, for all sample stations

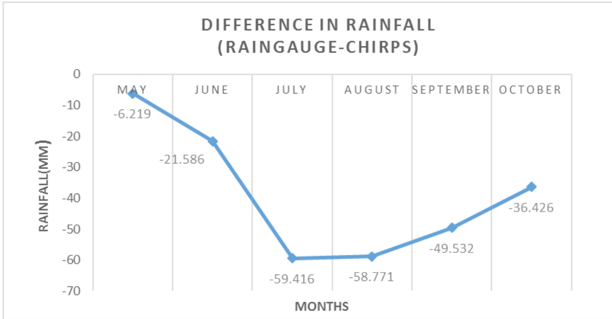


Figure 9. Difference in monthly precipitation, between CHIRPS and rain gauges, for all sample stations

From the graph above, the difference in rain gauge station data and CHIRPS data seem fairly comparable, given that the PBIAS value is also in range for good performance rating where, PBIAS was found to be -19.2763 % which considerably falls under good performance rating based on the following table:

Performance rating	PBIAS (%)
Very Good	< ± 15
Good	±15 – ±30
Satisfactory	±30 – ±55
Unsatisfactory	±55

Table 3. Performance rating of CHIRPS data (Shrestha et al., 2017)

As the (0.05° × 0.05°) resolution CHIRPS data was validated against the point station data, the grid data could be considered satisfactory on this regard.

5. CONCLUSION

The project discussed the spatial-temporal patterns and relationships of NDVI with LST and gridded satellite rainfall throughout the study period. Both precipitation and temperature are dominant climate factors contributing to the vegetation growth in the study area. The correlation analysis with significant NDVI, LST and CHIRPS trends indicated that precipitation showed strong and positive impact on vegetation at most places while temperature had a significant negative impact. NDVI was more susceptible to the variations of rainfall and temperature in Hilly and Terai while the impact appeared to be least in Himalayan region, for it has low vegetation density as compared to prior two, as an effect of topography and altitude. Overall, the impact of temperature was seen to be greater than rainfall as a whole.

Meanwhile, there are other factors that need to be considered on the influence of terrestrial vegetation growth, such as relative humidity, nutrients, light intensity and mechanical factors including wind and occurrence of fire, and so on (Breckle, 2002). So, incorporating other climatic factors for better analysis on climate impact is highly recommended.

6. ACKNOWLEDGEMENT

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भूमि व्यवस्थापन प्रशिक्षण केन्द्र

धुलिखेल, काभ्रेपलाञ्चोक ।

टेलिफोन नं. ०११-४१५०५५

वि.सं. २०२५ सालमा नापी तालीम केन्द्रको रुपमा स्थापना भै वि.सं. २०५७ सालमा भूमि व्यवस्थापन प्रशिक्षण केन्द्रको रुपमा स्तरोन्नति भएको यो केन्द्र नापनक्सा र जग्गा प्रशासनको क्षेत्रमा शैक्षिक वा कार्यक्रमहरू संचालन गर्ने एक मात्र सरकारी निकाय हो। वि.सं. नाप नक्साको क्षेत्रमा हाल सम्म करीव ७५,०० भन्दा बढी जनशक्ति उत्पादन गरेको यस केन्द्रले विभिन्न लामो तथा छोटो अवधिका तालीमहरु संचालन गरी नाप नक्सा र जग्गा प्रशासनको क्षेत्रमा दक्ष जनशक्ति उत्पादन गर्दै आएको छ। वि.सं. २०६४ देखि यस केन्द्र र काठमाण्डौं विश्वविद्यालयको सहकार्यमा Bachelor in Geomatics Engineering तथा वि.सं. २०७० देखि Master in Land Administration विषयमा स्नातकोत्तर तहको कार्यक्रम संचालन गर्दै आएको छ भने, वि.सं. २०७६ मा गरिएको चौथो MOU अनुसार विगतका कार्यक्रमको निरन्तरताका साथै M.Sc./M.E. in Geoinformatics कार्यक्रम पनि थप संचालन हुने क्रममा छ । साथै वि.सं. २०७२ देखि यस केन्द्र, काठमाण्डौं विश्वविद्यालय र प्राविधिक शिक्षा तथा व्यवसायिक तालीम परिषद्को त्रिपक्षीय सहकार्यमा Diploma in Geomatics Engineering कार्यक्रम संचालन गरिरहेको छ।

<u>यस केन्द्रबाट संचालन भइरहेका प्राज्ञिक कोर्ष तथा तालीम कार्यक्रमहरू</u>

१) केन्द्र र काठमाण्डौं विश्वविद्यालयको सहकार्यमा संचालन भइरहेका प्राज्ञिक कोर्षहरु

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२) केन्द्र , काठमाण्डौं विश्वविद्यालयको र प्राविधिक शिक्षा तथा व्यवसावयक तालीम परिषदको सहकार्यमा संचालन भईरहेको कार्यक्रम

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ङ) स्थानीयतहको भूमिव्यवस्थापन सम्बन्धी स्थानीय तहका जनप्रतिनिधि एवम प्राविधिक कर्मचारीहरूको लागि अभिमुखीकरण तालीम (एक हप्ता)

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INFLUENCE OF IONOSPHERE IN GNSS SOLUTION

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KEYWORDS: Ionosphere, TECU, linear combination, GNSS solution

ABSTRACT

The radio signals coming from satellites to the user's receiver passes through different layers of atmosphere. Ionosphere is a layer in the atmosphere which contains freely charged particles ions. These ions are charged by solar activity and these ions are can bend low frequency radio signals and bring irregularities in the observation. Therefore, the influence of the ionosphere is to be monitored and modelled. Dual frequency GNSS measurements can effectively provide integral information on the electron density along the ray path that assists in modelling of ionospheric effects.

1. INTRODUCTION

Ionosphere is the layer of upper atmosphere ranging from approx. 70km – 1200km. Ionosphere consists of sufficient amount of ions which are ionized from the radiation from sun. This ion has adverse effect in low frequency radio signals. Frequencies below, the ionosphere bends path traveled by the radio wave with the frequencies less than 30MHz toward earth. Therefore, the radio signals are propagated with larger frequencies in order to pass ionosphere. However, the speed of the signal propagated is affected by ionosphere and is dependent on the density of electrons. The density of electron in the signal path is termed as Total Electron Content (TEC). The TEC is the number of free electrons in a column extending from the receiver to the antenna and with a cross-section of 1 m^2. Usually the TEC is given in TEC units (TECU): 1 TECU = 1016 free electrons per m^2

The following figure is the Chapman profile showing the number of ions produced in ionosphere along the altitude or solar zenith angle.

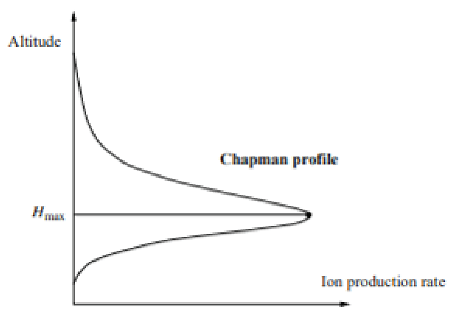


Fig 1: Chapman Profile of ion production rate

Due to variability of the ion production in ionosphere the true estimation of electron concentration is difficult. It is because variability in ion production is not only the function of altitude but other several factors like solar activity, degree of exposure to sun and observer's location.

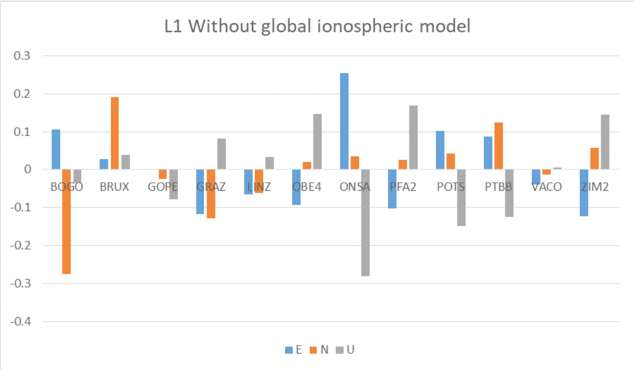
1.1 Data and Software used

For this study, the observation data from 13 ground stations are processed to calculate station's coordinates. Comparison between single frequency and dual frequency for analyzing impacts of ionosphere on GNSS solution along with the study of impact due to use of regional and global ionospheric model is also done in this paper. The data used in this study are from Regional European GNSS Network and processing of data was done using Bernese Software.

1.2 Choice of linear combination

Ionospheric refraction is frequency dependent since different frequency behave differently with the freely charged ions. That is why the choice of frequency or their combination is to be done carefully. In case of shorter baseline basic frequency L1/L2 can give good performance but for the longer baseline we must certainly use their combination. The following graphs shows the impact of using single frequency (L1) and the ionosphere free linear combination (L3) on the station coordinates.

The graphs below show the comparison between the residues in station coordinates while using L1 or L3 frequency. The analysis for the study was done using the observations of stations locating in Europe and residue are calculated with reference to IGS08 station.



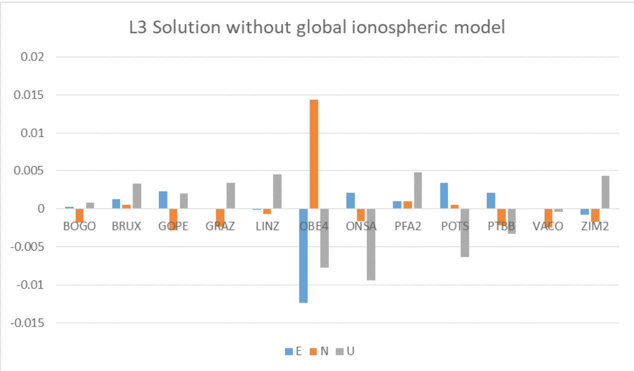


Fig 2: Residue in station coordinate while using L1 and frequency and no ionospheric model Fig 3: Residue in station coordinate while using L3 and frequency and no ionospheric model

The comparison shows that the residue using L3 (ionosphere free linear combination) provides much fine results in estimating the station coordinates. Refraction is dependent on the frequency and lower frequencies are easily deviated when travelling from satellite to receiver. The impact of ionospheric effect is seen on the solution of station coordinates.

Parameters	L1 frequency	L3 frequency
Translation in x(mm)	1314.24 +-311.38	0.60 +- 0.11
Translation in y(mm)	293.11 +- 75.06	0.14 +- 0.03
Translation in z(mm)	1625.62 +-378.90	0.67 +- 0.13
Scale factor(mm/km)	**-0.31892 +- 0.07760**	**-0.00014 +- 0.00003**

The main effect of neglecting ionospheric refraction is seen in the scaling of the baselines. The following table is derived to compare the scale factor of the solution using single frequency or the combined one.

The above data suggests that there is significant variation that causes the scale factor of the solutions to change when neglecting ionospheric refraction or using single frequency L1. It is because the scale bias is proportional to the Total Electron Content (TEC), the total number of electrons in the path of line of sight between receiver and satellite with a cross section of one square meter. TEC bends the radio signal travelling along to the receiver. This causes the length of the baseline calculated to be longer than the actual. So, we see the higher impact on scale factor using L1 frequency.

2. IONOSPHERIC EFFECT ON GNSS SIGNALS

The major ionospheric effect on GNSS signal is range error. This error is caused due to variation in electron content in ionosphere layer which causes the variation in the speed of signal. The concentration of electron on ionosphere layer is not uniform and is varied due to local time, solar and magnetic activity, geographic latitude, seasons etc. Thus, ionospheric effect is seen different for different seasons and for different parts of the earth.

On the other hand, the irregularities of the ionosphere also give rise to short term signal variation. The short term signals and fading periods are not well handled by GNSS receiver which cause the large number of cycle slips. This effect is known as Scintillation effect. This effect mainly occurs in geomagnetic equatorial belt and on the poles.

2.1 Ionospheric Models

Ionosphere Models is prepared taking in account the total electron contents. The model determines the total electron content as the function of geographic latitude and sun fixed longitude. Local ionospheric model or TEC model are generally based on 2 dimensional Taylor series expansion whereas the regional or global model are based on spherical harmonic expansion.

For this study a regional ionospheric model using L4 (geometry free linear combination) was prepared using 24 hours sampling rate.
The regional model is given by (Dach, R.,Hugentobler, U.,Fridez, P. & Meindl , M., 2007)

$$E_v(\beta_m, s) = \sum_{n=0}^{n_{max}} \sum_{m=0}^{n} \bar{P}_{nm}(\sin \beta_m)(a_{nm} \cos ms + b_{nm} \sin ms)$$

Where,

- P_{nm} are the normalized associated Legendre functions of degree n and order m, based on normalization function Λ(n, m) and Legendre functions Pnm

- a_{nm} b_{nm} are are the (unknown) TEC coefficients of the spherical harmonics, i.e., the global ionosphere model parameters to be estimated.

- n_{max} is the maximum degrees of the two–dimensional Taylor series expansion in latitude β and in longitude s,

- β is the geographical latitude and s is the sun fixed longitude.

The s is related to Local time which then can be written as the following form including Universal Time and λ which is geographical longitude as $s = LT - \pi \approx UT + \lambda - \pi$. The geographic longitude and temporal factor is to be considered because of the variation in the ionosphere with respect to time and solar activity.

The RMS of Total electron Content is calculated from ionospheric model for single frequency L1 and combination of frequencies L4 (geometry free combination).

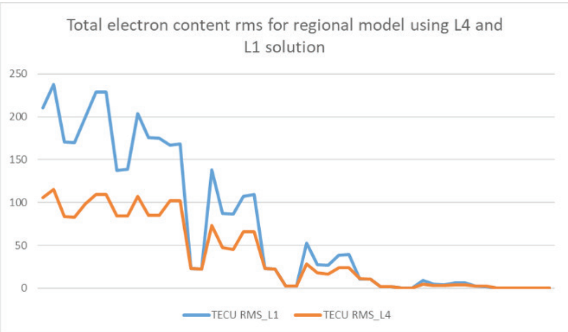


Fig 4: Comparison between RMS of TEC using L1 and L4

As a result we can see that there is significant improvement in the RMS calculation while using L4. The ionospheric model provides improved solution for TEC as its RMS gets lower while using L4 frequency. The performance of ionospheric model is better with low TEC RMS.

3. COMPARISON BETWEEN REGIONAL AND GLOBAL MODEL

Here are the few comparisons between regional and global ionospheric model using different frequencies.

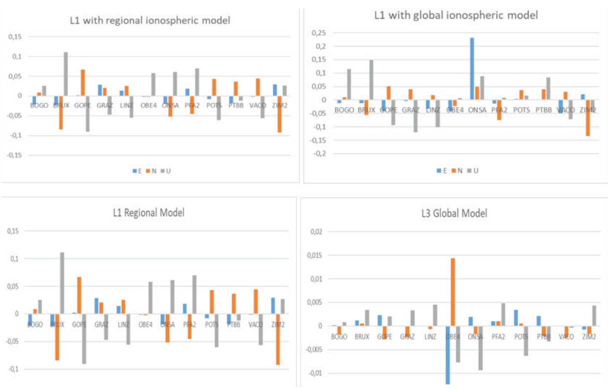


Fig 5: Comparison between regional and global ionospheric model with different frequency

The first two figure shows that the use of L1 frequency with regional ionospheric model could provide a better solution to station coordinates than with the use of global ionospheric model. It can be due to the impact of station variables impacts of ionosphere with L1 frequency. There is variation in behavior of station solution.

On the other hand when the station solution of L1 frequency with regional model is compared with the station solution using L3 solution with global ionospheric model, the solution got improved nearly about ten times for these stations.

4. CONCLUSION

The radio signals coming from satellites to the user's receiver passes through different layers of atmosphere. Ionosphere is the layer in the atmosphere which contains freely charged particles ions. These ions are charged by solar activity and these ions are can bend low frequency radio signals and bring irregularities in the observation. Therefore, the influence of the ionosphere is to be monitored and modelled.

Dual frequency GNSS measurements can effectively provide integral information on the electron density along the ray path. This is done by computation of differential phases of code and carrier phase measurements while neglecting higher order terms in the refractive index. These higher order terms has negligible impacts on the solution when we use dual frequency. The differential phase is proportional to the integral of the electron density along the ray path i.e. TEC between the transmitting GNSS satellite and the receiver. This is used in generating model for reducing the impact of ionospheric impacts on the GNSS Solution.

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PROBLEMS AND ITS POSSIBLE SOLUTIONS FOR CONVERSION OF 2D CADASTRE TO 3D CADASTRE IN CONTEXT OF NEPAL

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KEYWORDS: Cadastre, 3D Cadastre, Land Administration

ABSTRACT

The concept of three-dimensional (3D) real property has been the subject of increased interests in land use management and research during the last decade. The history of land recording in Nepal was started from one dimension (i.e. keeping the record only) and now the registration of two dimensions (i.e. measuring the length and breadth of the parcel and calculating area) is in practice. Due to the high population growth and growing interest in using space under and above the surface for infrastructure development, there is a need of registration of vertical dimension of the legal status of real estate objects. Lack of proper implementation of plans and policies regarding the 3D cadastre from authorized organization is major legal problem for conversion of 2D cadastre to 3D cadastre. Also, Lack of sufficient creation of 3D database, 3D model, Visualization of 3D real estate objects, Human Resources, sophisticated equipment's are major technical problems regarding conversion of 2D to 3D cadastre. Lack of initial capital investment cost is also considered as a major financial problem for building 3D cadastre. This paper aims to figure out problems and its possible solutions for conversion of 2D cadastre to 3D cadastre in context of Nepal. It includes legal, institutional and technical aspects. Smart Institutional and Strong Legal Framework, Advancement on Computer Technology, Implementation of Core Cadastre Domain Model (CCDM), Production of qualified human resources, Public and private sector working together, Implementation of Hybrid cadastre etc. might be the possible solutions for transferring 2D cadastre to 3D cadastre in context of Nepal.

1. INTRODUCTION

The concept of three-dimensional (3D) real property has been the subject of increased interests in land use management and research during the last decade. The traditional cadastre focused on land parcel but modern cadastre focused on land object. (Paudyal, 2005). 2D cadastre cannot effectively represent the complexities of reality. The 2D cadastral systems are not able to manage and represent land ownership rights, restrictions and responsibilities in 3D context (Aien, A., Rajabifard, A., Kalantari, M. & Williamson, I. , 2011).

However, until today most of the countries around the world use 2D land parcels as the base for their land administration systems, regardless of the 3D characteristics implied by the relative real property legislation (Oosterom, P.V., 2018). Thus, representation of Right, Restriction and Responsibility (i.e. RRRs) through 2D projection of land parcels cannot accommodate issues such as: complex, overlapping real property and many more.

In addition, an increasing number of tunnels, underground networks and infrastructure objects (e.g. water, gas, electricity, telephone, Internet and other pipe networks) under or above land are not owned by the owner of the land which are the issues that cannot deal only through 2D cadastre (Roić, 2012). So, conversion of 2D cadastre into 3D cadastre becomes necessity in cadastral system of any country for infrastructure development and urban planning.

2. OBJECTIVES

The objective of this article are as follows:

- To show the problems and its possible solutions related for conversion of 2D Cadastre to 3D cadastre system in context of Nepal.
- To study different aspects and needs of 3D Cadastre in Nepal.

3. ASPECTS OF 3D CADASTRE

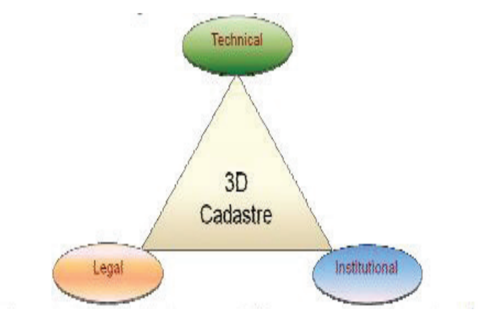

Figure 1: Relationship between different aspects of 3D Cadastre (Aien A., Rajabifard, A., kalantari, M. & Williamson, I., 2011).

The 3D cadastre includes legal, institutional and technical aspects which are mainly essential for the effective and efficient progress in 3D cadastre system of a country.. (Aien, A., Rajabifard, A., Kalantari, M. & Williamson, I. , 2011). The three aspects of 3D Cadastre are discussed below:

3.1 Legal aspect

"Legal cadastral domain" is used as a common term for laws and regulations regulating the content of traditional cadastre, multipurpose cadastre and land registers storing legal real property information, regardless of any national differentiation between these registers (Paasch, 2004). The legal aspect includes 3D property legislations (i.e. rules, rights and responsibilities) related to the land registration and ownership. The legal aspect is also considered as the foundational aspect in cadastre system.

According to (Paudyal, 2005), following laws are related to land administration and real estate ownership currently govern the 3D real estate's registration in Nepal.

- Muluki Ain (Common Law Codes) is equivalent to a common law and this law prevails where there is no any specific law in any specific subject.
- Land (Survey and Measurement) Act, 1962 (8th amendment), there is the provision of measurement and registration of separate ownership for a floor or room in a building.
- In land Administration Act, 1967 and Land Revenue Act 1977, there is a lack of description about the 3D registration of real estate objects.
- Joint Residence Ownership Act, 1997, there is a provision of registration of flat/apartment in a multi storey building. Still there is need of linking of this Act with other land registration Act and clear description about the right, restriction and responsibilities about joint residential area.
- Housing Act, 2000 and Town Development Act, 1989 describes about the housing development and urban development.

3.2 Institutional aspect

According to (North 1990), institutional are defined as 'the humanly devised constraints that shape human interactions'; the rule of the games and organizations are the players of the games (North, 1990). Ministry of Land Management, Cooperatives and Poverty Alleviation, Ministry of Federal Affairs and General Administration and Ministry of Urban Development are the main three Ministries responsible for implementation of 3D cadastre in Nepal. These Ministries are mandated to formulate and implement the policies and programme for implementing 3D cadastre. The Department of Land Management and Archives, Survey Department (SD) under Ministry of Land Management, Cooperatives and Poverty Alleviation are responsible for registration and maintenance of 3D cadastre. The Department of Urban Development & Building Construction (DUDBC) under Ministry of Urban Development is responsible for regulating and monitoring of 3D real estates like buildings and other overhead/underneath structure of public utilities. Likewise, the Local Authorities (Municipalities and *GauPalika*) are responsible for the valuation, taxation, permitting, as well as right, restriction and appeal about 3D real estate objects.

3.3 Technical aspect

The technical aspect consists of 3D cadastral mapping, 3D real estate objects registration, creation of 3D cadastral database etc. In Nepal, 2D parcels are surveyed in the field thus there is a lack of 3D cadastral mapping at the time of adjudication and boundary survey the description of 3D real estate objects had recorded on the field book. In Nepal, the 3D real estate objects like the room in a building can be registered at the land registry office. But the identification of real estate objects and their spatial parts recording system is not sufficient in present context. Nowadays, GIS and other spatial analytical systems put more applications on cadastral systems and it is possible to analyse and query cadastral data. Although all efforts on cadastral system were previously 2D, new initiatives such as Google Earth, Google SketchUp, Autodesk Map 3D, Bentely's City GIS, and ESRI's ArcGIS are promoting researchers to consider the practical possibilities of 3D cadastre.

4. **NEED OF 3D CADASTRE IN NEPAL**

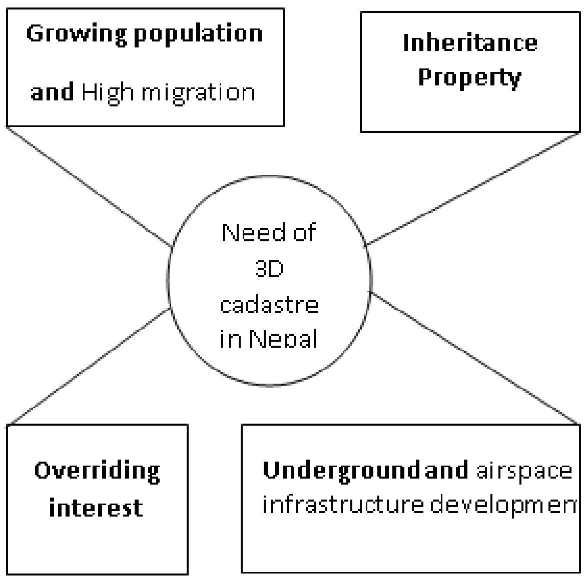

Figure 2: Need of 3D cadastre in Nepal

The reasons for necessity of 3D Cadastre in Nepal are described below:

4.1 Growing population and High migration towards urban areas

According to (UNFPA, 2017), population of Nepal is increasing day by day with an average growth rate of 2.5 %. In urban areas, there is no other solution than going to high rise residential buildings. In the last decade, the urban centers have witnessed huge investment in the construction of such buildings. Existing legal provisions do not clearly mention about the right of owner of each unit of a multi-storey building over the common space areas. Therefore, there is a strong need of clear legal provision for proper record of conflicting ownership rights.

4.2 Inheritance Property

Inheritance of property in Nepal is a very sensitive issue. In some cases, especially in Kathmandu Metropolitan areas, there are some places where ground floor of a building is used by a community whereas the upper floors are owned by different owners. In some districts, especially in remote hilly districts like Jumla, the houses are built in such a way that the roof of a house owned by a family is used as courtyard by the owner of the house built in the upper terrace of the ground (Bhatta, G.P., Khanal, G.R., & Sharma, R.K., 2005). These are some issues that have not been well addressed by the existing registration system.

4.3 Underground and airspace infrastructure development

Urban centers in Nepal are getting densely populated day by day. As a result, there is no adequate space available for building, transportation and utility infrastructures. To meet the need of growing population, such infrastructures are necessary to get expanded, for which, there is no other solution than going below or above the land surface. The space below and above the earth surface will be needed to acquire from the owners of the belonging parcels. Without proper system of registering such cases, it will not work efficiently and hence 3D cadastre is required.

4.4 Overriding interest

To register the overriding interests of different entities over a single piece of land, current legal framework does not seem supportive. This can be possible only in the presence of 3D cadastre system.

5. PROBLEMS

The concept of 3D cadastre is itself a complex with respect to implementation. The major problem regarding the implementation of the 3D cadastre in context of Nepal are described below:

5.1 Legal Problems

Legal is used to describe things that relate to the law. Legal issue refers to lack of implementation of proper plans and polices regarding 3D cadastre in Nepal from the authorized organization. Government itself is failed to initiate the 3D cadastre plans and polices due to various issues. Few laws were made in past decade but those are insufficient for the implementation of 3D. There are more than 60 acts and regulations concerned to land but the most prominent ones are: Civil Code, Land Revenue Act and Rule, Trust Corporation Act, Land and Building Act and Rule, Forest Act and Rule, Ownership of Joint Residence Related Act and Rules, Local Governance Act and Rules, etc. These many acts and rules have created overlapping and evading accountability and responsibility making cadastre more complicated. (Acharya B. R., 2011)

5.2 Technical Problems

The major technical problem regarding implementation of 3D cadastre in Nepal are discussed below:

- Due to lack of sufficient creation of database for recording all the information (i.e. 3D maps, 3D model and attributes), 3D cadastre is not yet implemented in Nepal.
- Due to lack of sufficient creation of 3D model, it would be difficult to analyze information. Since, 3D cadastral model make it possible to move around selected places.

According to the cadastre 2014 document, the cadastral mapping will be changed to cadastral modeling. The 3D real estate objects will be visualized in term of 3D model. With the help of new ICT and GIS/CAD tools the 3D real estate objects will be visualized . (Paudyal, 2005). But, still cadastre 2014 document hasn't been implemented completely in Nepal.

- At present, large number of employee are working for parcel boundary mapping in different districts of Nepal and are familiar to 2D cadastre only but do not have relevant knowledge, skills regarding 3D cadastre.
- For implementing the 3D cadastre, sophisticated equipment and technology are required such as Real-time Sampling (RTS) technology, Ground Penetrating Radar (GPR), 3D Laser Scanner, Building Model Information (BIM), 3D Geographic Information Systems (GIS) etc. But, Nepal lacks these sufficient sophisticated equipment and technology.

5.3 Financial Problems

In addition to the more legal and technical problems, financial problem also became reason for conversion of 2D cadastre boundary plans to 3D cadastre in Nepal. It is developing country which lies in the poverty margin and have very weak economic growth compare to other developed nation such as Netherlands, Denmark, United States of America(USA), Australia etc. Since, for implementing 3D cadastre over all parts of country, Nepal government have to spend large amount of initial investment cost which is difficult for it. So, due to lack of initial budget, government itself can't implement 3D cadastral system. Meanwhile, the number of 3D real property units has been increasing day by day which became mandate for implementation of 3D cadastre. Thus, new and more efficient ways of registration should be introduced by government.

6. POSSIBLE SOLUTIONS

In order to introduce modern concept of 3D cadastre, adequate capacity is needed. In this context, smart institutional and organizational strengthening is required. Recruitment of technically qualified human resources and continuing professional development is very crucial. The public sector should closely work together with private sector so that private sector can also be encouraged to support 3D cadastre through Public Private Partnership model.

Some possible solutions for the Implementation of 3D cadastre in context of Nepal is given below:

- **Advancement on Computer Technology and Equipment**

To overcome lack of sufficient sophisticated Equipment and technology, there should be advancement on computer technology and equipment's. As 3D cadastre is itself the world of digital environment, it required the expensive and advance computing system and equipment's for processing images and making maps. If Nepal could develop in the field of computer technology and could have advance equipment then, this would help for better implementation of 3D cadastre.

- **Smart and Strength Institutional and Legal frame work**

To deal legal problems, current legal provision does not seem sufficient. Therefore, there is a need of legal reform. Basically, the rights on common properties, security of ownership, sustainability issues of the property among others should be well addressed in the reformed legal provisions. The legal reform should be made such that it focuses on establishing strong legal base for 3D cadastre addressing.

- **Public and private sector working together**

To overcome financial issue, government should collaborate and work with private sector. Statement-4 of Cadastre Vision 2014 state "public and private sector working together". It implies that if government can collaborate and work with private sector, then it will be helpful for overcoming financial issues as there are large number of private housing investors who can spend for 3D cadastre concept since its necessity is increasing day by day.

- **Implementation of Hybrid Cadastre System**

Hybrid cadastre proposed by Stoter, 2004 is a good start towards implementation of 3D cadastre in Nepal. The concept of hybrid cadastre is to preserve the current 2D registration and add the 3D component in the registration system. There are two approaches to register 3D object namely registration of right-volume and registration of 3D physical object. The 3D representation of each approach is embedded in the CCDM base model.

- **Implementation of Core Cadastre Domain Model (CCDM)**

A standardized CCDM, covering land registration and cadastre in a broad sense will serve two important goals:

1. Avoid reinventing and re-implementing the same functionality over and over again, but provide an extensible basis for efficient and effective cadastral system development based on a model driven architecture, and

2. Enable involved parties, both within one country and between different countries, to communicate based on the shared ontology implied by the model. (Oosterom, P.V., Stoter, J. & Lemmen, C., 2014). Thus, implementing the CCDM concept also helps to implement the 3D cadastre.

- **Production of qualified and sufficient human resources for 3D cadastre**

One of the major problem for implementation of 3D cadastre in Nepal is lack of qualified and sufficient human resources. For resolving this issue proper training, workshops, seminar and other required skills related to 3D cadastre should be given to employee. Similarly, concerned authority should pay attention for producing the qualified and sufficient human resources by making collaboration with different national and international universities, organizations etc.

- **Detailed 3D Tags in the current 2D cadastral registration**

This means preservation of the 2D cadastre with references to representations of 3D situations. Complex 3D situations are registered using adhoc solutions in current situation. The reference can be made in various ways. The simplest solution is to tag 3D situations in the registration where upon the user then has to consult the public registers to find the detailed information. (Stoter, J. & Salzmann, M. , 2001)

7. CONCLUSIONS

This paper analyzed problems and possible solutions for conversion of 2D cadastre to 3D cadastre in context of Nepal. The major problems for conversion are divided into three categories i.e. are legal, technical and financial problems. Legal problems described about lack of effective plans and policies regarding the implementation of 3D cadastre. In addition, technical problems such as lack of sufficient creation of 3D database, 3D model, visualization of 3D real estate objects, Human Resources, sophisticated equipment's are the reasons for not implementing 3D cadastre. Also, lack of initial investment is one of the major financial problem for not implementing 3D cadastre in Nepal.

To overcome the problem of legal issues, smart and strength institutional and legal frame work should be established. Likewise, to overcome the technical problem advancement on computer technology, implementation of CCDM, production of qualified human resources is crucial. Finally, to overcome the financial issues, the public and private sector should work together.3D cadastre is emerging concept in context of Nepal since number of 3D property are increasing day by day. Thus, concerned authority should pay attention and tries to resolve all the issues and problems for implementing the 3D cadastre in Nepal.

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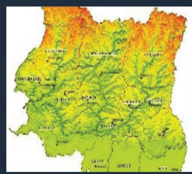
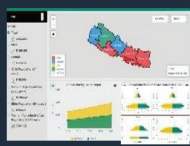


Municipal profile
Resource allocation
Planning tools

Demographic Projection

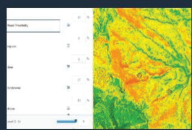


Demographic profile at national & subnational level

Agriculture, Energy & Watershed

Identify pocket areas for development and Geotargetting

Health Coverage



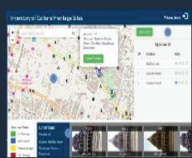
Health target setting & access to health facility

Cultural Heritage

Dashboard

Inventory of heritage & structural analysis

Monitoring & Evaluation



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FOREST COVER CHANGE AND ITS IMPACT ON ECOSYSTEM SERVICE VALUE OF CHURE AND TERAI REGION

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KEYWORDS: Object-Based Image Analysis, Ecosystem Service Value, Community Based Forest, Land use cover change

ABSTRACT

Proper information on forest cover change and its spatio-temporal characteristics are essential for natural resource management and sustainable development. It is one of the major factor that affect the ecosystem and the services it provides. In this study, we used remote sensing techniques and a geographical information system to extract the forest cover categories based on the Object-Based Image Analysis (OBIA) techniques from Landsat TM/ETM/OLI satellite in the Chure and Terai region from 1994-2018. In addition, ecosystem service value coefficient per unit area contributed by forest cover was taken from the previous studies and adjusted by taking accounts of yearly inflation or buying power to bring about the proper estimation of the ESV in terms of money impacting forest cover area. In 1994(40.02%), forest covered the highest area and found decreased quite faster till 2004(28.87%), and afterwards a gradual decrease arriving to 2018(26.52%). The highest ESV in 1994 was found to be 78.7 billion and lowest in 2018 was found to be 43.2 billion in current fiscal year. The spatial distribution of the Ecosystem Service Value is shown by the map where immediate action can be taken. The findings of this study could facilitate the strong forest conservation policy formulation further and development management intervention.

1. INTRODUCTION

Forest cover change significantly affect the major functioning aspects of the ecosystem and are easily detectable indicators of changes in global ecology. The changes of biodiversity affects ecosystem services (the benefits of nature to households, communities and economies). Although Nepal has significantly improved on biodiversity and ecosystem conservation, implementation of ecosystem services concept is still limited (e.g., only independent project-based PES schemes that focus mainly on water-related services). In recent years, the Government of Nepal has taken several steps towards broader application of ES concept. Nepal has been at the forefront of CBF (Community Based Forest) for over four decades, with almost 40% of the total population directly involved in protecting and managing more than 32% of the country's forested land (Paudyal, 2017). However, in the past, the focus of CBF in Nepal was the provision of goods for local subsistence, and there has been limited analysis of the role of CBF in providing ecosystem services value (ESV) from restored forest landscapes. The values of ecosystem services based on LUCC have recently been assessed for the transboundary Koshi river basin and Gandaki river basin of central Himalayas (Bhaskar Shrestha, 2019). However, to date, similar studies have not been conducted in the Chure and Terai taking accounts of forest cover dynamics and its analysis. states that the 2010 global datasets of land cover are far from the reality and 2010 national datasets published by ICIMOD in 2015 [34] are closer to ground truth in Nepal. The quantification of ESV from forest cover analytics is done as forest is most contributing factor of ESV in Chure and Terai. Chure is a belt of hilly region stretching from East to West in the entire length of Southern Nepal. This region is ecologically diverse, and as it provides several ecosystem services to the areas downstream, it has direct influence on the quality of the environment. According to the latest forest resource assessment (2010–2014) results of eastern Chure of Nepal, this region has 73.0% (1,384,445 ha) of the total area under forests; majority of the forest area (76%) falling outside the protected areas with the annual rate of forest cover change of –0.21% between the period 2001–2010.

2. OBJECTIVES

The main objective of the project is to assess the ecosystem service value (ESV) changes corresponding to the forest cover changes of the Terai and Chure belt of Nepal in the period of 1994-2018 using time series Landsat imageries.

The sub objectives are:

- To prepare time series Forest cover map in the period of 1994-2018 at interval of 5 years.

- To prepare and calculate the forest cover changes in the period of 1994-2018 at interval of 5 years.

- To calculate the District Wise forest cover area.

- To assess the ecosystem service value (ESV) changes corresponding to the forest cover changes. The concern of the project is to find out the transition of ecosystem services value due to forest transition in Chure to Terai regions of Nepal. The ecosystem service value transition study is useful in analyzing the spatio-temporal changes of ecosystem services and linking socio-economic services demand at different scales.

3. STUDY AREA

The study area covers the Chure and Terai belt of Nepal about 849 km in length and 24 to 72 km in breadth and has an area of 39, 236 sq.km between 26.36º to 29.17º North latitude and 80.05º to 88.20º East longitudes. It runs east to west in 33 administrative districts of Nepal. It shares an international boundary with India in the east, west and south.

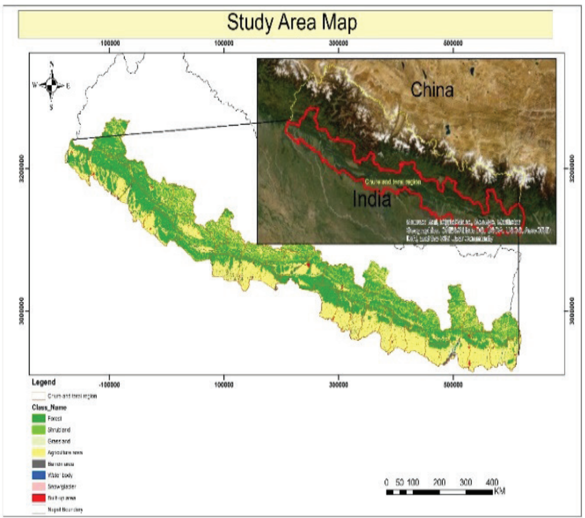


Figure 1: Study Area

4. METHODOLOGY

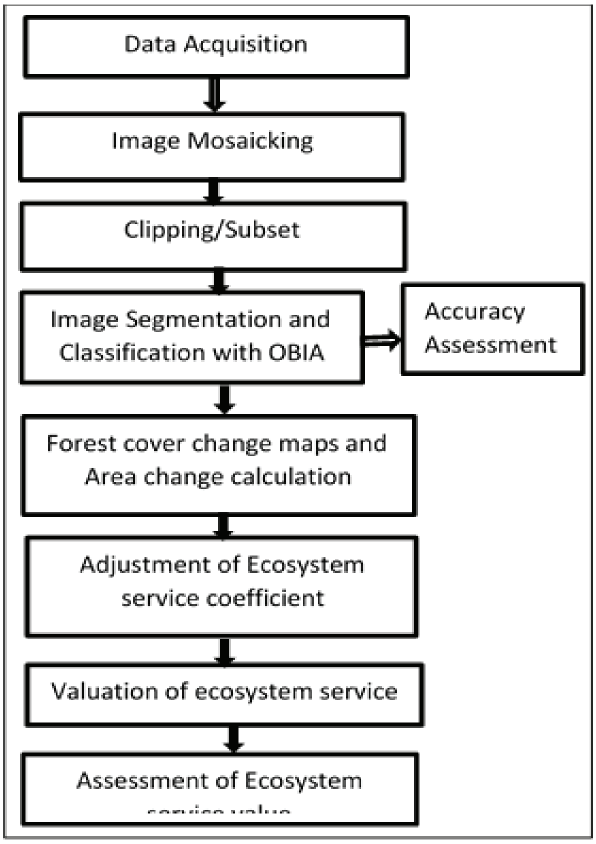


Figure 2: The Framework of the study

4.1 Data Collection

For this study, the Landsat images of 1994 to 2018 each with 5 years' interval were downloaded from the USGS (https://earthexplorer.usgs.gov).

Year	Satellite	Sensor	Data acquisition date
1994	Landsat 4-5	TM	30 December, 1993 1 January, 1995
1999	Landsat 4-5	TM	30 December, 1998 1 January, 2001
2004	Landsat 4-5	TM	30 December, 2003 1 January,2005
2009	Landsat 4-5	TM	30 December,2008 1 January,2010
2014	Landsat 7	EMT+	30 December, 2013 1 January, 2015
2018	Landsat 8	OLI/ TIRS	30 December, 2017 1 January, 2019

4.2 Object based image classification

4.2.1. Multi resolution segmentation

A multi-resolution algorithm was used for segmentation of the satellite image, which locally minimized the average heterogeneity of image objects for a given resolution. A multiresolution segmentation used to identify the individual object within the image using a combination of spatial and spectral characteristics. Segmentation was performed by the combination of various parameter i.e. scale, shape and compactness. The scale 32, shape 0.1, and compactness 0.5 used in segmentation of the Landsat images satisfied the distinct identification of two adjacent features.

4.2.2 Indices

Basic spectral information and remote sensing indices derived from satellite imagery were computed on previously segmented image objects. In our project, we selected a Normalized difference vegetation index (NDVI) to distinguish forest and non-forest cover area. The threshold that were used during forest and non-forest classification ranges from 0.2-0.3 based image data properties. The threshold of NDVI value is as follows:

Forest cover Non Forest Cover

NDVI>0.25 NDVI<=0.25 (Hammad Gilani, 2014)

4.2.3 Classification

Assign class algorithm was used for image classification. By calculation of NDVI, two classes were assigned to the pixels of NDVI calculated images in order to distinguish Forest and non-forest based on threshold value i.e. NDVI value of forest and non-forest. False color composites were used to improve visual interpretation of satellite images and facilitate identification of forest cover features.

4.3 Accuracy assessment

Accuracy assessment of data is the process of checking the accuracy and quality of data before using/processing the data source. For the accuracy assessment of this project Google Earth Pro was carried out. Google earth high-resolution imagery is important for accuracy assessment by comparing point by point basis. About 120 number of random sample points for both forest and not forest has been collected from the Google Earth using stratified random sampling. By counting matching points and non-matching points i.e. forest-forest, forest-non-forest, non-forest-non-forest and non-forest-forest confusion matrix was prepared in Excel. Finally, we calculated the Kappa coefficient and Overall accuracy which was intended to examine the accuracy of Land Use Land Cover Classification.

4.4. Determination of forest cover area

The forest cover area within different time series was analyzed in terms of total forest and non-forest cover of the study area. After the classification of image from 1994 BS-2018 BS within the five years' interval, the classified raster image was converted to vector format where every single class represents individual polygon. Finally, the area of polygon containing pixel of forest was calculated by using ArcGIS 10.4 software.

4.5. Adjustment of Ecosystem service coefficient

The economic valuation of biodiversity ecosystem services can be a tool to express the multiple societal benefits ecosystems and their ecological functions. So, by using the coefficient of ESV from previous studies (Bhaskar Shrestha, 2019)the inflation of the coefficient was calculated at different time periods from 1994 to 2018AD. Here, we adjusted ESV coefficients of 1994, 1999, 2004, 2009, 2014 and 2018 using the Consumer Price Index (CPI) using Inflation Calculator from the Website of Bureau of Labor Statistics, United States Department of Labor (States, n.d.).

4.6. Valuation of Ecosystem Service

Here, in our study ecosystem service value was computed by using the adjusted ecosystem service coefficient and the area of the forest cover obtained at different time periods.

4. RESULT AND DISCUSSION

year(AD)	Forest cover (hectare)	Total land cover area(hectare)	Percent Forest cover(%)
1994	2683357.92	5829970.10	40.02
1999	1904320.50	5829970.10	32.66
2004	1683498.52	5829970.10	28.87
2009	1651903.38	5829970.10	28.33
2014	1569459.96	5829970.10	26.92
2018	1545579.19	5829970.10	26.52

The table above shows the resulted temporal statistics of forest cover obtained after the classification of Landsat Imageries. The highest forest cover was found in 1994 and lowest in 2018.

The map below shows the spatio-temporal pattern of forest cover in the year of 1994.

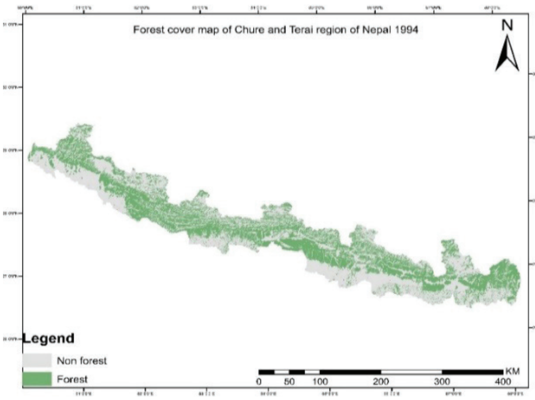


Figure 1 Map of Forest Cover 1994

The results showed forest cover from 1994AD to 1999AD drastically decreased by 13.36%, from 1999AD to 2004AD forest cover decreased by 3.78%, 2004AD to 2009AD forest cover was slightly decreased by 0.54%, from 2009AD to 2014AD decreased by 1.41%, and finally from 2014 to 2018AD forest cover was found to be decreased by 0.40%.

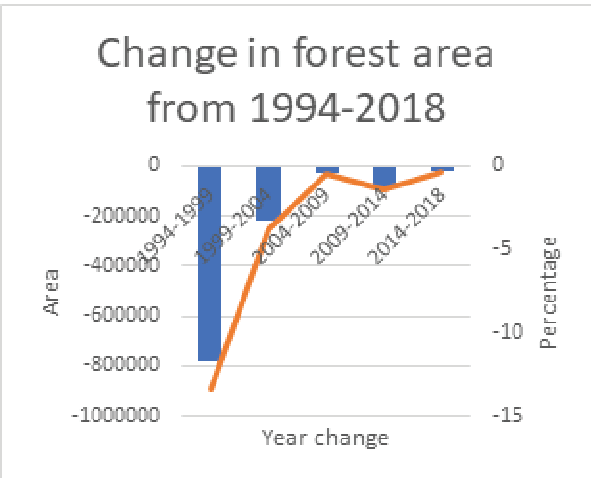


Figure 2 Stats of Forest Cover change

The map below shows the pattern of forest cover change from 1994 to 1999.

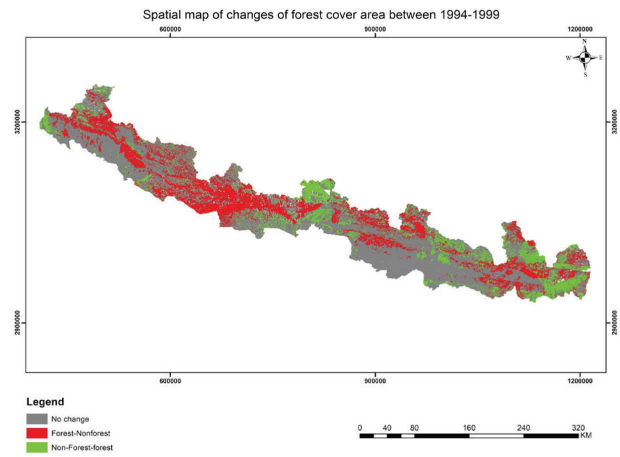


Figure 3 Spatial distribution of forest cover change 1994-1999

We analyzed the resulted forest cover to determine spatial forest cover pattern in terms of each district that falls under the study area. District-wise forest cover status shows that highest forest cover by Dang district and lowest forest cover by the Mahottari district.

Here, we adjusted ESV coefficients of 1994, 1999, 2004, 2009, 2014 and 2018 using the Consumer Price Index (CPI) using Inflation Calculator from the Website of Bureau of Labor Statistics, United States Department of Labor (States, n.d.). The ESV coefficient in the year of 2003 AD was taken be 2168.84 USD per hectare. The ESV coefficients for the corresponding years computed from the online inflation calculator.

Year(AD)	ESV coefficient ($ per ha)
Xie et al.(2003)	2168.84
1994	1745.1
1999	1961.15
2004	2210.62
2009	2520.28
2014	2792.11
2019	2958.63

Table 1 Adjusted ESV coefficient

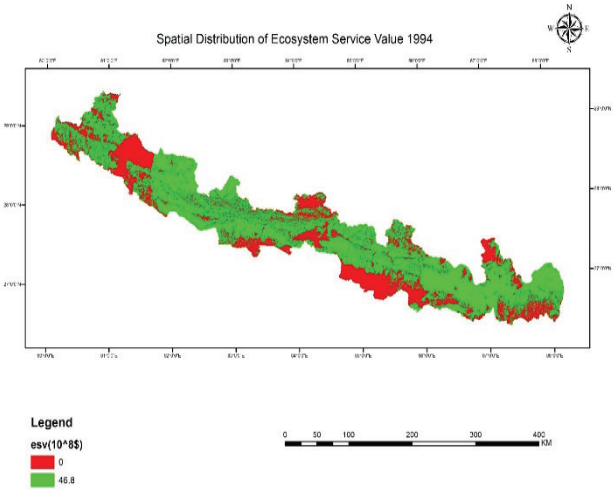
Year(AD)	Total Forest Cover(ha)	ESV coeffcient ($/ha)	Total ESV (10^8$)
1994	2683357.9	1745.10	46.8
1999	1904320.5	1961.15	37.3
2004	1683498.5	2210.62	37.2
2009	1651903.4	2520.28	41.6
2014	1569460	2792.11	43.82
2018	1545579.2	2958.63	45.7

Table 2 Total estimated ESV

Year (AD)	ESV Value(10^8) at 2019	Year from-to(AD)	ESV Change (10^8$)
1994	78.7	1994-1999	22.8
1999	55.8	1999-2004	6.6
2004	49.2	2004-2009	0.7
2009	48.5	2009-2014	1.5
2014	46.9	2014-2018	3.7
2018	43.2		

Table 3 ESV values change

The map below shows the spatial distribution of estimated ESV values in the years of 1994.



The ESV in Chure and Terai has decreased by 35.5*10^8 from 1994 to 2018. This change in ESV is also in accordance with the change in ESV in Karnali River Basin which is adjacent to Chure and Terai. The loss of ESV in Chure and Terai is due to decline of forest cover, conversion of forest to agricultural land, deforestation etc. The decrease in ESV implies weaker ecosystem activities and thus its services

5. CONCLUSION

In our study, we discussed the spatio-temporal pattern of forest cover and its dynamics over the past two decades in the Chure and Terai regions of Nepal using Landsat imageries from 1994 to 2018AD. Furthermore, we have evaluated and analyzed the ESV contributed by forest cover. Forest covered the highest area in Chure areas, there are both faster and slower decrease of forest cover in last two decades in Chure and Terai. Due to this forest cover change, ESV for Chure and Terai decreased by 35.5*10^8$ in last 25 years, and this loss mainly occurred in Chure regions where forest cover is more abundant. The decrease in ESV shows declining Ecosystem services and forest cover is one of the driving factors of changes of ESV in the Chure and Terai. The spatio-temporal integrated geo-information of Chure and Terai had a major advantage over the common method as it shows the spatial distribution and change characteristics of the forest cover as well as ESV of the area, which is an important contribution to forest cover, and ESV related studies. The spatial distribution of forest and changes in ESV extracted by using spatio-temporal integrated forest information facilitates in better understanding the spatio-temporal dynamics of forest cover and changes in ESV.

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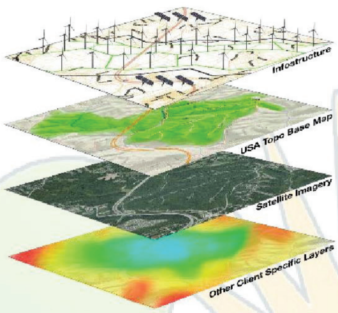

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IONOSPHERIC MODELLING USING CORS DATA OF NEPAL

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KEYWORDS: TEC maps, Ionosphere, GPS, CORS, IONEX

ABSTRACT

Monitoring and modelling the ionosphere is one of the important aspect in GNSS (Global Navigation Satellite System). Among various factors that affect GNSS signals, ionosphere is one of the most influencing factors. Ionosphere keeps on varying with respect to time, day, location and seasons due to various forces from both top and bottom sides of ionosphere. Although dual frequency GNSS receivers can minimize the ionospheric error to greater extent, single frequency receivers fail to mitigate these errors and depends on different techniques or model estimations. The present study investigates the interplanetary space-dependent drifts in the ionospheric irregularities which cause predominant ranging errors in the GPS signals for the region of Nepal. The development of GNSS, especially of GPS, has led to the operation of CORS (Continuous Operating Reference Stations) that acquire GPS signals without any interruption. Despite the availability of more than 60 CORS in Nepal our country still lacks its own regional ionospheric model. So, this study has incorporated these CORS data from various stations in Nepal to make a tool that can generate the TEC maps. For, the corrections of GPS data, the tool developed generates IONEX file. Also from the developed dynamic map showing variation of TEC over a day. Based upon our analysis, it was found that the ionospheric activity is varying with solar activity and changing constantly over a period of time. However, distinct pattern of the ionospheric activity was hard to estimate perhaps. Nepal is in a need of its own regional ionospheric model and this tool and the result of this project will be helpful

1. INTRODUCTION

The ionosphere is the layer of the Earth's upper atmosphere containing high concentration of electrons and ions, mostly caused by solar radiation producing free electrons from the existing atoms of Earth's atmospheric gases (Panda, Gedam, & Rajaram, 2015). This layer of ionosphere extends from 50 km to more than 1000 km altitude above the earth's surface. The free electrons in the ionosphere is quantified in terms of Total Electron Content (TEC) which is the total number of free electrons contained in a column with cross-sectional area of 1 square meter and its unit is TECU, where 1 TECU is 10^{16} electrons/m^2 (Schaer, 1999; Dach et. al., 2015). A change in TEC value of about 1 TECU can create a delay of about approximately 0.16 meters (Takahashi et al. 2016). The spatial and temporal behavior of TEC has a great coverage in regional and global level.

Monitoring the ionosphere is one of the challenges for GNSS (Global Navigation Satellite System). Among various factors that affect GNSS signals, ionosphere is one of the influencing factors. GPS mainly uses two frequencies L1 and L2 where L1= 1575.42 MHz and L2= 1227.60 MHz. Each of these frequencies is altered by the ionosphere on its way to the surface of the earth. Also, in recent developments a new L5 frequency where L5= 1176.45 MHz was introduced. For a GPS (Global Positioning System) signal, the ionosphere has a significant effect particularly for the single frequency users as they are affected to a greater extent. However, the varying nature of error with respect to time, day, location and seasons due to various forces from both top and bottom sides of ionosphere makes it more challenging to estimate (Sharma, Ansari, and Panda 2018). As for dual frequency GNSS receivers, these observations can be used to eliminate almost all of the ionosphere's effect.

The development of GNSS, especially of GPS, has led to the operation of continuous operating reference stations (CORS) that acquire GPS signals without any interruption (Volker SCHWIEGER, 2009). CORS are receiver stations established that can continuously receive GNSS data that can be useful for number of applications. In the context of Nepal, 60 CORS distributed all over Nepal can be found at UNAVCO DAI ("Data Archive Interface v2") and data of these stations are available to use for free.

2. THEORETICAL FRAMEWORK

- Temperature and electron density profile of layers of atmosphere:

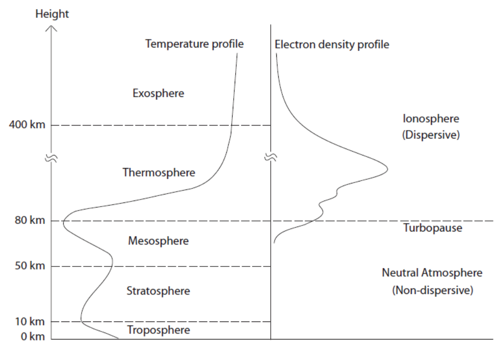
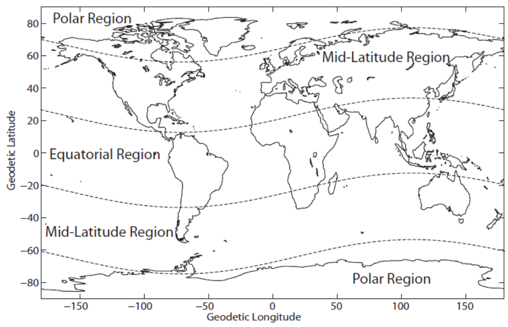


Figure 1: Temperature and Electron density profile of various layers of atmosphere

Source: (Memarzadeh 2009)

Different parts of atmosphere have different characteristics based on their temperature and electron content. However, while dealing with signal propagation to layers are significant which are troposphere and ionosphere (Memarzadeh 2009).

- Major Geographic regions of Ionosphere



- Figure 2: Geographic regions of ionosphere according to geodetic latitudes

Source: (Memarzadeh 2009)

Ionosphere can further be divided into several regions according to the latitude regions of the earth. They are equatorial, mid-latitude and high-latitude regions.

- Ionospheric Total Electron Content (TEC)

Total electron content is a derived parameter from electron density and it is defined as the line integral of electron density on a ray path.

$$TEC = \int n_e d\rho \qquad (1)$$

where n_e is the electron density or number density of electron and ρ is mass density of Earth's atmosphere.

TEC corresponds to the total number of electrons in a cylindrical tube with 1 m^2 cross section. It is expressed in terms of TECu where 1 TECu refers to 10^{16} electrons/m^2 (Psiaki, Bust, and Mitchell 2015).

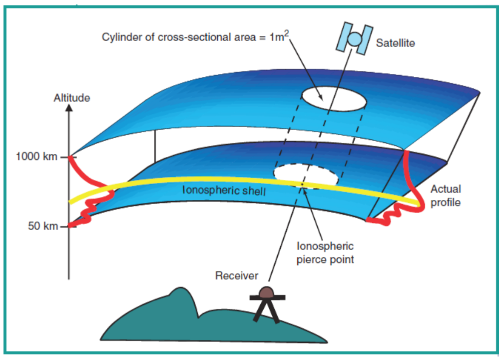


Figure 3: Visual representation of TEC values

Source: (Fedrizzi et al. 2001)

3. STUDY REGION

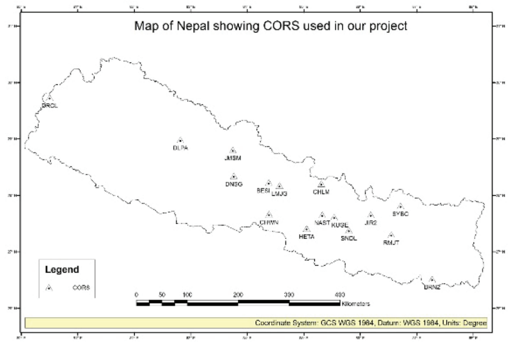


Figure 4: Project Study Area

For monitoring the ionospheric activity, whole region of Nepal (28.3949º N, 84.1240º E) was taken as study area. According to the regions of ionosphere, it lies in the equatorial region (0 to 20 degrees' geomagnetic latitude) which has the highest value of peak-electron density.

Below map shows the positions of the stations whose data we will be using in order to get our result. For this purpose, the ground based dual-frequency CORS situated along the different parts of Nepal were considered as a data source.

4. METHODOLOGY

The methodological flow diagram of the steps performed is shown in the figure below:

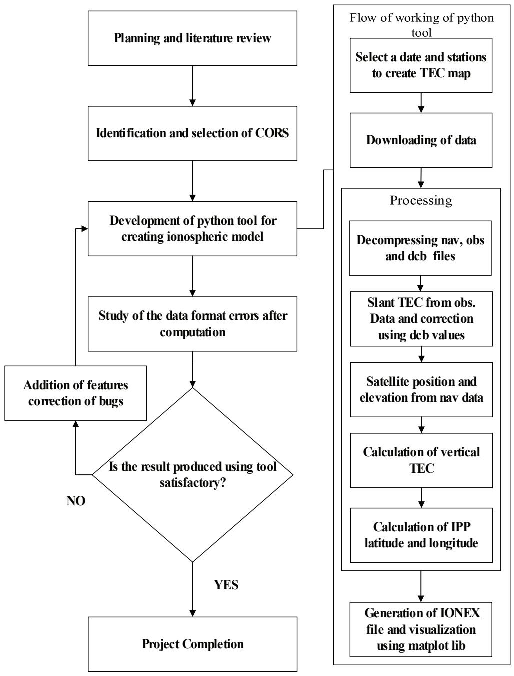


Figure 5: Flow diagram of project

While looking practically the overall completion of our project was dependent on four major steps that are described as follows:

- Data Acquisition

Hatanaka Files: These are the files written and maintained by Yuki Hatanaka. These files contain GPS data in a lossless compression format. The “compact” RINEX files, which are generated by a two-step procedure (actual Hatanaka compression plus standard UNIX compression), are nearly 8 times smaller than the original ASCII RINEX files, yielding a gain of about 2.5 in disk space and transmission times compared to standard compressed files (Gurtner, 1998). These files were downloaded from the UNAVCO website. UNAVCO has been using this compression strategy for all of its RINEX observation files.

Navigation Files: These files contain satellite ephemeris, to calculate the elevation & azimuth angles of satellite; required in the conversion of slant to vertical TEC.

DCB Files: These files contain monthly satellite bias values for each satellite. These files can be downloaded from the CODE’s website using the FTP login

- Data Preparation

The downloaded and zipped files are then decompressed using the python library unlzw into the hatanaka and navigation files. Nav files are easily readable in python script using the georinex library however hatanaka files are needed at first to convert obs files to be able to load using python script and use its data in the python file. For the DCB files same library is used to unzip.

- Data Processing

The obs and nav files are then read using georinex python library which converts the files into the pandas data frame and makes it easy for data accessing and manipulating. At first the computation is done for the STEC values using the observations of the obs file.

$$STEC = \frac{1}{40.3}\left({}^{1}/_{f_1^2} - {}^{1}/_{f_2^2}\right)(P_2 - P_1) \qquad (2)$$

Where, P1 and P2 are pseudorange values for frequency f1 and f2 respectively. Values for f1 and f2 are known for a satellite system which in our case is GPS.

The obtained STEC value is not from DCB error thus it needs to be corrected using the monthly DCB values

$$STEC_{corrected} = STEC_{computed} + Bias * 2 \qquad (3)$$

Here, STEC computed is the value obtained from equation 2 and the Bias values are obtained from the DCB files, 2.85 is the factor to convert the DCB values in NS to TECU (Mylnikova, Yasyukevich, Kunitsyn, & Padokhin, 2015) in order to add that to the STEC.

After the computation of the STEC values we need to calculate the satellite elevation. Following is the algorithm derived from (ESA, 2011) used to calculate the satellite position from the nav data.

Compute the time tk from the ephemerides reference epoch toe (t and toe are expressed in seconds in the GPS week):

$$t_k = t - t_{oe} \qquad (4)$$

Compute the mean anomaly for tk,

$$M_k = M_0 + \left({}^{\sqrt{\mu}}/_{\sqrt{a^3}} + \Delta n\right)t_k \qquad (5)$$

Solve (iteratively) the Kepler equation for the eccentricity anomaly Ek:

$$M_k = E_k - e \sin E_k \qquad (6)$$

Compute the true anomaly vk:

$$v_k = \arctan\left(\frac{\sqrt{1-e^2}\sin E_k}{\cos E_k - e}\right) \qquad (7)$$

Compute the argument of latitude uk from the argument of perigee ω, true anomaly vk and corrections cuc and cus:

$$u_k = \omega + v_k + c_{uc}cos2(\omega + v_k) + c_{us}sin2(\omega + v_k)$$

Compute the radial distance rk, considering corrections crc and crs:

$$r_k = a(1 - ecosE_k) + C_{rc}cos2(\omega + v_k) + C_{rs}sin2(\omega + v_k) \quad (9)$$

Compute the inclination ik of the orbital plane from the inclination io at reference time toe, and corrections cic and cis:

$$i_k = i_0 + i.t_k + c_{ic}cos2(\omega + v_k) + c_{is}sin2(\omega + v_k)$$

Compute the longitude of the ascending node λk (with respect to Greenwich):

$$\lambda_k = \Omega_0 + (\Omega - \omega_E)t_k - \omega_E t_{oe} \quad (11)$$

Compute the coordinates in TRS frame, applying three rotations (around uk, ik and λk):

$$\begin{matrix} X_k \\ Y_k \\ Z_k \end{matrix} = R_3(-\lambda_k)R_1(-i_k)R_2(-u_k)\begin{matrix} r_k \\ 0 \\ 0 \end{matrix} \quad (12)$$

where R1 and R3 are the rotation matrices defined in Transformation between Terrestrial Frames. Now after having the Position of satellite and receiver we need to have elevation angle and azimuth of the satellite with respect to the receiver. Now the conversion of STEC to VTEC is carried out by the use of mapping function given as:

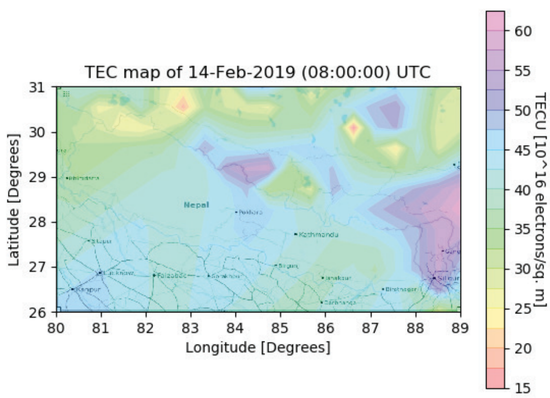
$$VTEC = STEC * \sqrt{1 - (\frac{R\cos(e)}{R+h})^2} \quad (13)$$

Here, R is the radius of earth, h is the height of IPP and e is the elevation angle.

- Visualization and Output

The VTEC value is represented in the form of colored contour map with position of IPP being the positional value. The IONEX file is generated alongside the visualization which can then be used to apply the corrections to the GPS data.

5. RESULT AND CONCLUSION



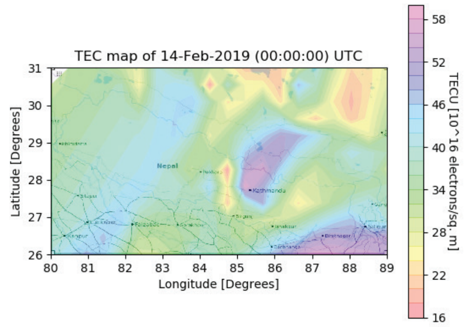


Figure 6: Generated TEC maps

Above are the sample maps generated using the python tool that we developed.

Also the tool developed is free and open source to use and can be found at GitHub at repository:

https://github.com/Binabh/TEC-Maps-of-Nepal

In conclusion, looking at the map we find that the ionospheric activity is varying with solar activity and changing constantly over a period of time. However, distinct pattern of the ionospheric activity was hard to estimate perhaps due to limitation in data points over the study area and very simplistic approach of TEC estimation.

The project is freely available for anyone to add features and use for their own use. So, we encourage the interested students/researchers to have a look at our work and add new features to the tool like model fitting with global models, correction formulas, inclusion of observables from other satellite systems.

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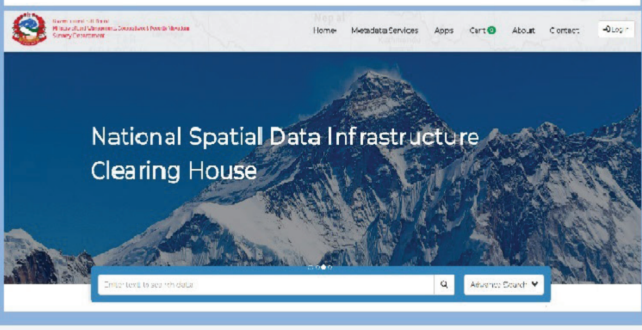
Available Maps and Data



- ✓ Geodetic Control data
- ✓ Aerial Photographs
- ✓ Topographic Base Maps
  - > Terai and middle mountain at the scale of 1:25,000
  - > High hills and Himalayas at the scale of 1:50,000
- ✓ Land Resources Maps
- ✓ Administrative and Physiographic Maps of Nepal
- ✓ Digital Topographic Data at scales 1:25,000 & 1:50,000
- ✓ Cadastral Maps & Data
- ✓ Orthophoto Maps
- ✓ Orthophoto Digital Data
- ✓ SOTER Data
- ✓ Administrative Boundary Data
- ✓ Topographic Digital Data at scales 1:100,000 1:250,000 1:500,000 1:1,000,000
- ✓ Socio Economic Atlas of Nepal
- ✓ ZY-3 image (for non-commercial purpose)

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INLAND WATERWAYS PLANNING AND SURVEYS

Punya P. Oli and Yasoda Oli

KEYWORDS: Inland waterway, orthometric height, aqueduct, dredging, bathymetry, land pooling.

1. SUMMARY

The fossil and other fuel are being replaced or reduced drastically in ten years' time to reduce the effect of climate change by greenhouse gases. Inland waterway is five to twenty times cheaper than road transport and twice cheaper than railways. Nepal has problems of heavy transportation cost, underground water recharge, wildlife transmigration route, flood and draught problems. If East West canal could be built mostly along the Bhabar zone connecting Mechi to Mahakali Rivers, economical transportation would be developed and above problems will be solved. The width of canal will be about 60-100m and 5m depth, able to transport passengers, 1000-3000 tons cargos and will have natural surface with road and wild life passages. The problems of collection of construction materials, flooding and siltation will also be solved. Koshi, Gandaki and Karnali Rivers along with East West Canal will be used for inland water transportation. They will also be used in hill areas as inland waterways as and when the planned reservoirs will be constructed.

Experts agreed to prepare preliminary plans of inland canal connecting east to west Nepal connecting main rivers specially Koshi, Gandak i and Karnali Rivers with or without connecting Indian side and pursue the government to construct navigable canal along the Bhabar. It is also required to prepare the surveyors to conduct such surveys.

As surveyors need to survey all details including height as orthometric elevations of the planned canal area and measured the depth or carry out bathymetric works to calculate the depth for dredging work. The preliminary planning will be carried out using existing digital database. Existing bathymetric data of Koshi, Gandaki and Karnali Rivers will also be used for preliminary planning. Fresh bathymetric survey will be needed for inland waterway feasibility study. It is assumed that canal projects will be implemented by land pooling technique.

In this article, it is briefly describe the survey techniques used in planning and including connection to national control network, DGNSS, satellite imagery, LiDAR survey or field survey, EIA and land acquisition to design the inland waterways. This article will assist surveyors and planners during the detail project report preparation of inland canals.

2. BACKGROUND

There are heavy cost of transportation, the use of fossil fuel needed to reduce for environmental protection, ground water table is also receding and needed to recharge, and construction material for development projects. The distribution of rain or surface water is not uniform, some areas will have heavy flooding and some area will have water deficient. Therefore, canals are needed to transfer the excess water to deficient areas. Inland waterways are also needed to connect seaport and harbor. It will also provide regular water for fishery, canal and other environment purposes.

On 7th April 2018, an Indo-Nepal joint statement of prime ministers of Nepal and India on inland waterways development was agreed and press released during the visit of the Prime Minister of Nepal to India. The follow up first meeting Inland Waterways Connectivity between Nepal and India held at Kathmandu on 15th to 16th July 2018.

Nepal has total estimated 237 km^3/year renewable water resource including surface sources 225 km^3/year and groundwater sources 12 km^3/year) and capacity water availability 9600 m^3/capita/year in 2001. There are about 3,252 glaciers with total coverage of 5,323 km^2 in Nepal and similarly, there are about 2323 glacial lakes located in this region with total coverage area of 75.70 km^2.

There are 1000 rivers longer than 10 km and about 24 of them are more than 100 km. The cumulative length of rivers is 45,000 km. Nepal also has abundant groundwater resources. The estimated renewable groundwater potential of the country is 12 km^3. They are major source of domestic uses and irrigated agriculture in Terai and valley regions. The water table is also declining and hence it is needed to recharge ground water.

The Fig.1 and Fig.2 will show the situation of terrain in Nepal and The Fig.3, Fig.4 and Fig.5 will show the location of main E-W canal.

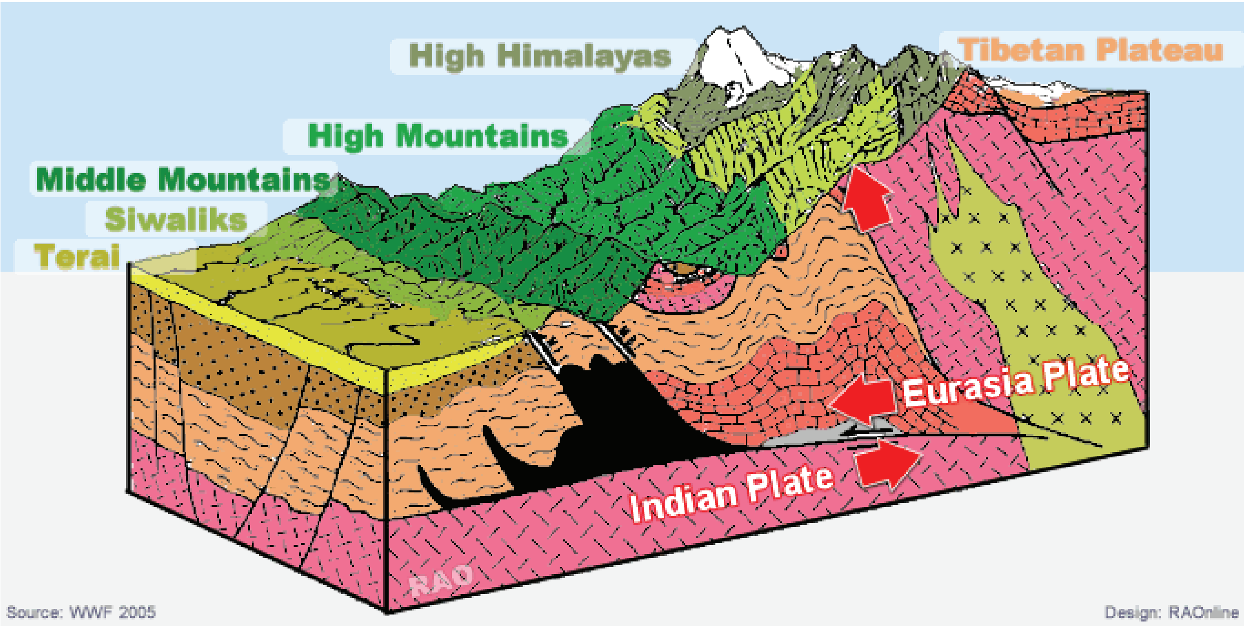

Fig.1: Typical Topographical Features of Nepal from North to South

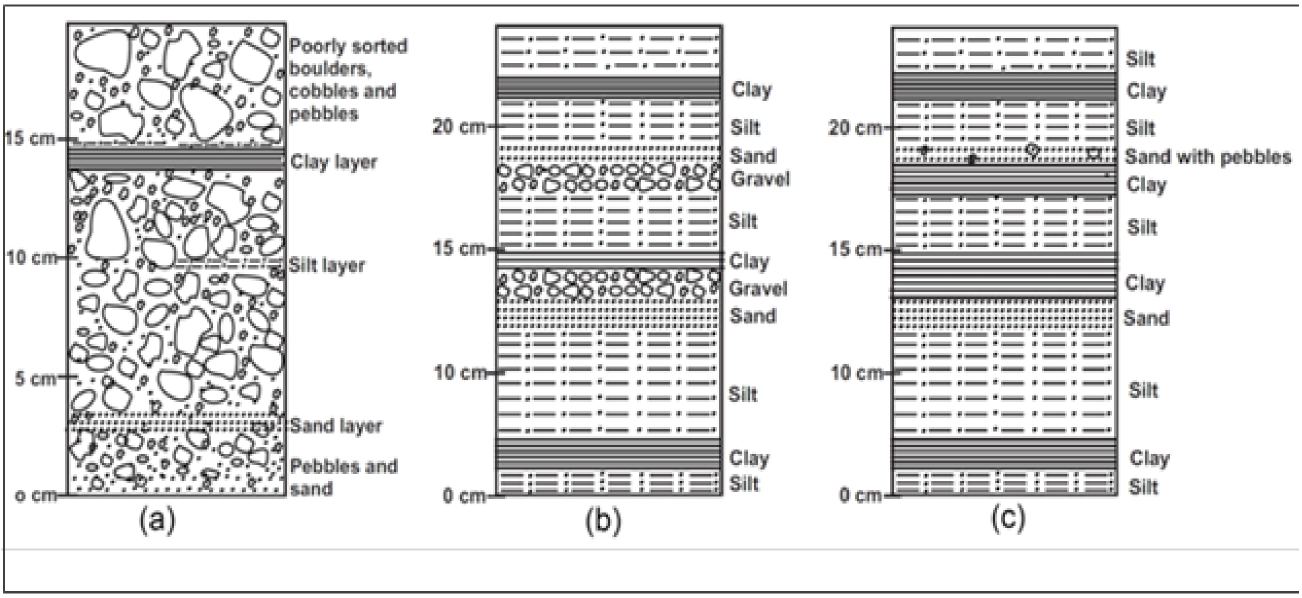

Fig.2: Typical Lithological Logs of (a) Bhabar Zone, (b) Middle Terai, and (c) Southern Terai

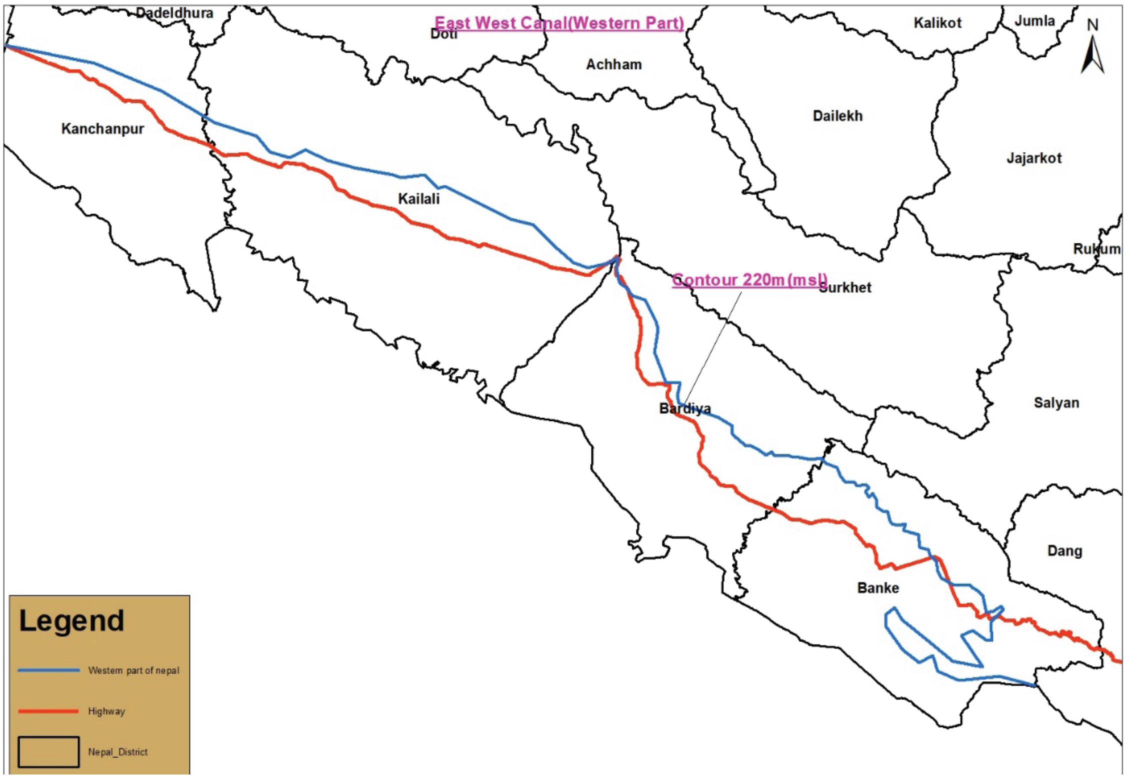

Fig.3:Conceptual Zone for West Tarai (Karnali Basin)

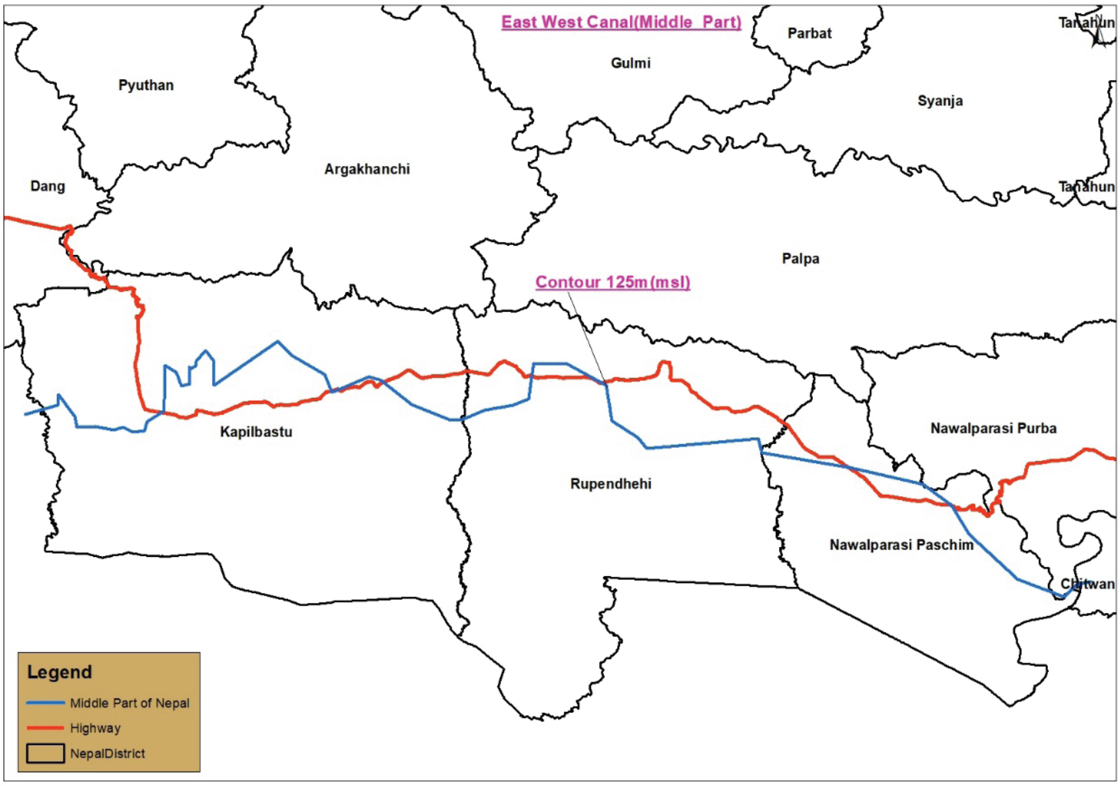

Fig.4: Conceptual Zone for Middle Terai (Gandaki Basin)

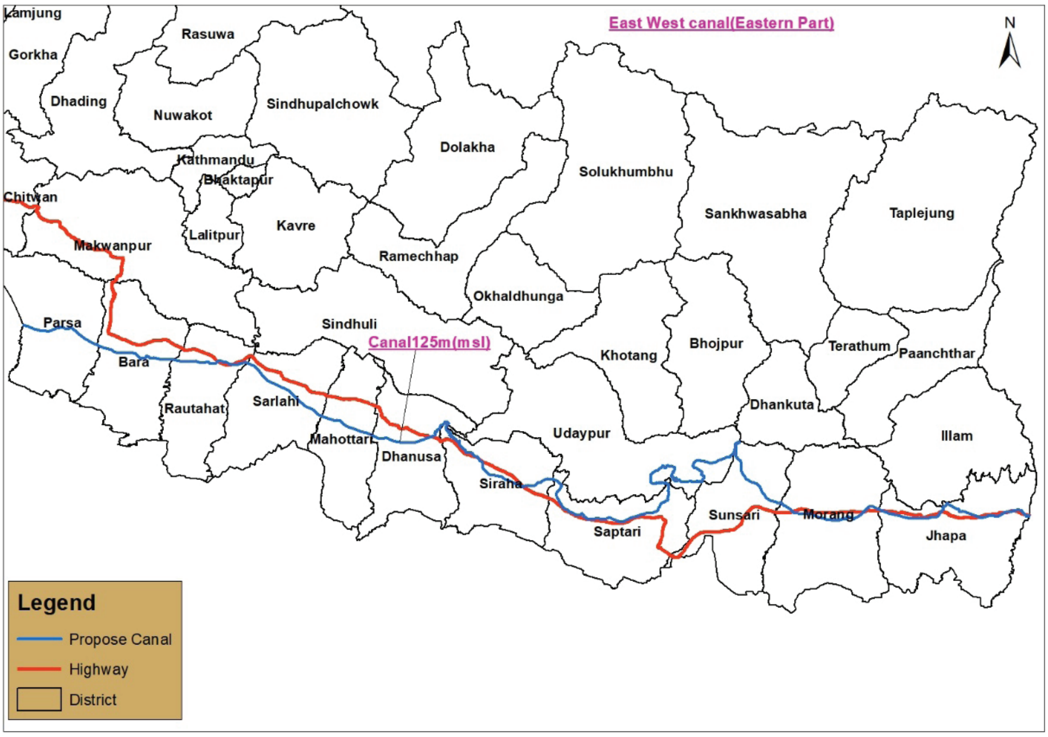

Fig.5: Conceptual Zone for East Tarai (Koshi Basin)

3. REQUIREMENT OF CANAL

The east west canal is required to connect north south inland waterways, recharge ground water, economic transport of goods, and supply of drinking and irrigation water in deficient area. As the canal will be constructed on Bhabar area without concrete surface and covered by vegetation and road.

The preliminary data for east west canal length is 938.2 km out of which 178.2 falls in India and N-S canals length is about 96 km which is shown in the following Table No. 1:

Table No 1. Preliminary Data for East West Canal.

S.N.	Description	Length/ No (in km/ No.)	Quantity million Cum/No.	Remarks
a A-1	Mahadevpatti - Mechi			
i	EW/excavation/embankment/bio-engineering, all complete. (Length)	384	268.8	
ii,	Aqueduct construction all complete in Small Rivers (No.)	50	50	
iii	Barrage construction all complete in medium Rivers (No.)	3	3	
iv	Barrage construction all comp in large Rivers (No.)	1	1	
b A-2	Gandaki - Mahadevpatti (INDIA)	89.6 -	62.72	
c A-3	Kapilvastu, Arra Nala -Gandaki			
i	EW/excavation/embankment/bio-engineering, all complete. (Length)	129	90.3	
ii	Aqueduct construction all comp. in Small Rivers (No.)	20	20	
iii	Barrage construction all complete in medium Rivers (No.) -	0	0	

iv	Barrage construction all comp in large Rivers (No.)	1	1	
d A-4	Tal Baghauda –Arra (INDIA)	88.9		
e A-5	Mahakali -Tal Bagauda			
i	EW/excavation/embankment/bio-engineering, all complete. (Length)	247	172.9	
ii	Aqueduct construction all complete in Small Rivers (No.)	30	30	
iii	Barrage construction all comp in medium Rivers (No	2	2	
iv	Barrage construction all comp in large Rivers (No.)	1	1	
	N-S Canal	96		
	Koshi River to India	46	32.2	
	Gandaki River to India	17	11.9	
	Karnali River to India	33	23.1	

China's National Standard of Inland Waterway specifies the waterway classification in corresponding to vessel tonnage and water depth which is fairly same as the as follows:

Table No 2. Waterway Classification for Canal

Canal Classification	I	II	III	IV	V	VI	VII
Vessel tonnage(t)	3000	2000	1000	500	300	100	50
Water depth(m)	3.5-4.0	2.6-3.0	2.0-2.4	1.6- 1.9	1.3-1.6	1.0-1.2	0.6-0.9

The width of main canal is 42-63m at the bottom and 100m at the top, the depth will be of 2-5m depending open the tonnage of the ship. The minimum width of canal at aqueduct is 40m and minimum curvature of the canal will be more than the 500m radius. In general, width of large ship will be 6.6m and 9-11.4 long and an engine may tow 3-4 vessels at a time. Port or terminal area may be of 1-10 ha wit jetty or station on middle. Locks, raising or lowering ships. Containers will be moved by crane on rail.

The canal surface will be earthen with grass coverage on sloping areas and high bond in south side road and tree plantation with road especially on south side. The deposited dredge or silt will be removed regularly. The slope of the canal will be maintained so that the speed of water on canal is 0.5m/s at main canal and 1-1.5m/s on north south river canal.

A navigation lock is a kind of hydraulic structure used by vessels to overcome the falls in a river, canal or at the place where the inland waterway connects with other canals and the sea. The locks provide the means by which vessels are raised or lowered from one pool to the next. There are also some medium and large size locks: up to 10 locks of a size of 230x20x (4-5) m were built on the canal.

An Inland waterway Terminal (IWT) normally includes facilities for mooring, cargo loading and unloading, dispatch and control, and repair and service of all craft that can navigate the waterway. Terminals either exist or are established at the origin and terminus of the inland water route. Intermediate terminals are located along the way, wherever a change in transportation mode is required.

Terminals on an IWT can be classified as general cargo, container, and liquid, or dry bulk commodity shipping points. Terminals of the three latter types usually include special loading and discharge equipment that permits rapid handling of great volumes of cargo.

The study of surface by bathymetry is required regularly at least once after rainy season.

4. PLANNING

As usual preliminary planning will be carried out using available digital topographical data like 1:25,000 topographical (contour v i 5m), geological, land system /soil maps, river discharge data and climatic data. Feasibility and detail project report studies need detail topographical mapping at the scale of 1:500 or LiDAR survey data with orthometric heights. Geological, land system /soil maps and river discharge data and climatic data of at least 5 years observations are needed.

Location of terminals, docks, locks, aqueduct and ship building and maintenance, offices of 1-10 ha area is surveyed at the scale of 1:500.

5. SURVEY AND INVESTIGATIONS

Like other water resources project, topographical, geological, geophysical, metrological and other surveys and investigation is necessary to carry out.

Topographical survey involves permanent monumentation of control points, DGNSS observations connecting to national control network points and benchmark (orthometric elevation) points with new monumented control points for the survey of the project. It is usually conducted by DGNSS of high accuracy (better than 12mm/km). The detail survey is carried out using either ground survey by total station with point cloud of 5m interval or LiDAR survey with 10 - 15 cm ground resolution color imagery. Required details will be depicted either during field survey or photo interpretation and ground truething.

Digital data base will be prepared annotating or all the required information including with their name, class, and quantity. The symbolization will be carried out from data base as per the national standards. Bathymetric survey of river, reservoir or canal will be carried out using single beam eco sounder or other techniques and total station.

Geological maps will be prepared on the topographical base map along with imagery and field investigations. They are also added to data base. Similarly, bore hole, geophysical point, climatic station, hydrological station, and other field investigation points will also be located, annotated and added to data base.

Location of and depiction of construction material sites, office, settlement area and dumping sites will also be carried out. The survey area will be 250-500 m on either side of central line of canal. The imagery will be at the scale of 1:10,000.

Hydrological/climatological river discharge and siltation data will be observed at least 5 years period.

6. LAND ACQUISITION AND ENVIRONMENTAL STUDIES

Land Acquisition is usually carried out getting accurate information about land parcel with area and owners name. It is usually carried out superimposition of design on cadastral data. The land owner names and official area will be checked at local survey and land revenue offices. It is planned carried out land acquisition by land pooling technique of 1000m width area. A 1000m width area including 100m canal will be developed.

Land Pooling process involves consolidation, infrastructures development and distribution of developed parcels to land owners with reduced size. It is managed by Users Committee and Management Committee.

The prior Environmental Impact Assessment (EIA) or Initial Environment Assessment (EIA) is compulsory to implement the development programs in Nepal. Environmental protection Act and Rules of Nepal and guidelines of major multinational financial institution like ADB, WB guidelines will provide guidelines on assessment and mitigation on environment effects. The projects will be delayed in developing countries due unpreparedness and unawareness of project managers of technicality of environmental studies.

It involves preparation of terms of reference (TOR), scoping documents, Environment Management Plan (EMP), resettlement action plan (RAP) and carry out base line surrey, qualitative and quantitative analysis, social impact assistant (SIA) and preparation of monitoring framework to effective monitoring at the implementation phase. The major task is also land acquisition for the projects.

Digital topographical maps are proposed for the project areas at 1:500 – 1:10,000 (point clouds for 5m to 100 m interval), cadastral map at the scale of 1:500 – 1:2500 and present land use maps at prepared using aerial/satellite imageries of about 0.5 or better resolution. Base line surrey is carried using questionnaires of all affected land owners along with FGD surrey method. Extensive field visit was carried out by experts and their environmental and social impact assessments described in the reports. Various experts present their finding in verbal texts but they could be easily presented in GIS formats/spatial data base, which are easier to understand the situations.

7. CONCLUSION

Inland waterway was developed since ancient time. It is more efficient and energy saving transport system. We are planning to developed multipurpose inland waterways along with irrigation, ground water recharge, fishery, recreation, environmental enhancement and other uses. It will be associated with lock, aqueduct and ports. It will also develop along with hydropower development project with reservoir. As we are planning to reduce drastically use of the fossil fuel, it is necessary to develop inland waterways and electric vehicles.

Surveyor needs to know technique of surveys of for planning, construction and maintenance of navigable canals including DGNSS, orthometric heighting, eco-sounding, Lidar survey, bathymetry, and preparation of Navigation charts.

8. CONTACT ADDRESS

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GIS: IT'S NOT ABOUT THE TOOLS, IT'S ALL ABOUT DATA AND PROCESS

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KEYWORDS: GIS, FOSS, Big Data, Cloud Computing

Geotechnology has been stated as one of the three "megatechnologies" of the 21st century, along with biotechnology and nanotechnology (Gewin, 2004). The rapid growth in the number and variety of geographical datasets, newly evolved ways to process these datasets and a whole new level of data visualization and statistical/mathematical modeling are some of the most important development in GIS recently. Recent surge of interest in Free and Open Source Software (FOSS) among the online community is considered as one of the major spin-offs of advancement in internet technology and there's no way geospatial community remain outside of that circle. It has now become evident that overwhelming development in internet technology have seen GIS move forward from a static, closed, often single application environment to one that reaps the benefits of networked environment. It's global reach and real-time accessibility has made it even more interesting.

1. Tool vs science debate

For many GIS can be a tool but it's a "science/art" when it comes to refining, map making and performing complex analysis. The utility industry regards GIS as a very important tool whereas the software/algorithm development side of GIS is a pure science. The science in GIS is the math, statistics and data structure it uses in the back-end. Another part of science in GIS is the discovery of spatial pattern in data that otherwise demonstrate other relationship. All scientific disciplines are inherently derivative of other sciences and Math and GIS is one of those.

All sciences have their own collection of commonly used techniques and tools: as for example astronomers use telescopes to view stars and planetary bodies, biologists use electron microscopes to envision the structure of cell organelles and supercomputers to simulate ecological systems, and computer scientists develop new computer architectures and algorithm using computer-aided design software. Geographic information science (GI Science) is concerned with the fundamental principles that creates a base for GIS: the basic functions and data models, data pre-processing and processing methods, and generally held principles of geography and geographic information. GI Science allows to consider the philosophical, epistemological and ontological contexts of geographic information and GI Systems provide the infrastructure, tools and methods for tackling real world problems within acceptable timeframes (Maguire, 2010). In the early years of GIS, the geospatial community was focused on the development methods for key information handling, tools and technologies (Waters, 1998). As the result of that today's GI system are fully capable to deal with vast amount of geographic information and have a quite sophisticated rules, relationships and processes encoded in the logic of the software used in the system. Nowadays, GI systems are considered more efficient and effective. The type of information to use, methodology to process that information and the insights obtained as a result were unclear and that's where the concept of GI Science came into play. GI Science provided an overarching framework for using information theory, spatial analysis and statistics, cognitive understanding, and cartographic principles (Mark (2003) and Longley et al (2005)). So, there is a consensus about the value of both Geographic Information Science and Geographic Information Systems.

2. Tool vs Data and Methods

There's a long running debate going on among GIS community that which GIS software tool is the best either Quantum GIS or ESRI's ArcGIS. If you are into GIS field for some time, it's not that uncommon to hear this kind of debate going on. It's obvious that both are software tools; one made by an enterprise company and another one is the work of awesome open source contributors. QGIS uses the GDAL/OGR python bindings to read and write GIS data formats and it supports more than 70 vector data formats. Whereas, ESRI's ArcGIS is still considered as the industry standard. So, most of the professional work require expertise in it. The general movement towards open source tools is increasing and the use of QGIS is gaining momentum and it will continue to gain more of the desktop GIS market share. But neither ArcGIS nor QGIS will eliminate the other. ArcGIS and QGIS are just tools, both do essentially the same thing with various quirks. Spending a brief amount of time on either one will translate to the other. That means GIS methods can be applied to any tool. The basic understanding of python and spatially enabled databases is more of a requirement for better understanding of GIS functionalities.

The next big thing that comes into play is data. The science of "Where" is almost incomplete without spatial datasets. With the increase in the number of mobile and web application using geospatial there is a significant increase in the number of people who come into contact with geospatial data. GIS stores data collected from heterogeneous sources in different formats in the form of geodatabases representing spatial features. The size of geodatabases is growing day by day generating huge volume of data from remote satellite images providing details related to physical structure of the Earth and from other sources for representing natural resources like water bodies, desert, snow cover, forest covers, soil quality monitoring etc. The quality of these datasets plays a major role on whether the end product you are expecting is a valuable piece of information or just a result with a lot of biases an inaccuracy that does not solve any real-world problem. The completeness, accuracy and consistency in data is required to produce better results. So, it's not about the tools, it's all about data and process. Being a data-wizard is awesome but being a tool-wizard is just being a tool. The methods and tools mean nothing if you are playing with the faulty data.

3. Big Data and GIS in the Cloud

The trend of big data has impacted every industry recently and so it is a little surprise that big data in GIS has significant implications for how we acquire and leverage spatial information. The convergence of GIS with big data means the potential applications of the two will become limitless. The cost of hardware which was considered as one of the major challenges about ten years ago is no more among the toughest challenges. The reason is that the cost of hardware along with processing capability and memory is in decreasing trend. Middle scale organizations can now afford robust hardware for housing data and analytics tool that precisely meet their needs. The presence of highly scalable cloud-based solutions has been boon for small organizations. Cloud services, in the form of centralized web-based applications, where applications and files are hosted on a "cloud" consisting of thousands of computers and servers, all linked together and accessible via the Internet (Michael, 2009, John, 2009). So, that basically means cloud-based GIS platforms are hosted on a vendor's servers and accessed through a browser. There are many advantages of cloud GIS system over legacy server systems. It is more reliable, requires less-maintenance than in-house systems, cheaper and more accessible to the end-users. So, the major challenge of big-data in GIS is less about hardware and memory and more about finding skilled people who can manage the huge volume of datasets and transform it into value and insights.

GIS and big data are empowering a lot of humanitarian projects across the globe. Advancement in technologies like Internet of Things, open data platforms, crowd sourced spatial data and the evolution of big data technology has helped countries around the globe to acquire incredibly vast amount of information that can help them achieve UN's Sustainable Development Goals which represents a framework for achieving a "better and more sustainable future for all". The evolution and use of big data and its increasing value to GIS is both exciting and challenging at the same time. There are newer challenges of maintaining geospatial data security. Web-based applications have long been exposed to certain security risks. So, protecting our infrastructure should be a top priority.

To conclude, spatial big data is still in nascent stage, however GIS industry as whole is preparing itself for next big band in spatial big data. The future of spatial big data and GIS cloud computing will be shaped by how well big data will be used for geospatial analytics and how well analytics as service grow in coming years.

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"GIS IN AVIATION INDUSTRY"

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The first International GIS for Airport Management was recently held within the airport at Orly Airport in Paris, France. The ESRI sponsored event brought together leading airport personnel from many airports and associated operating agencies to learn from each and to exchange ideas about how GIS is being used to operate and manage airports. Aviation or Air transport refers to the activities surrounding mechanical flight and the aircraft industry. According to ICAO (International Civil Aviation Organization) define Aerodrome (Airport) as an area on land or water including any building, installation, and equipment's intended to be used either wholly or in part for arrival, departure and surface movement of aircrafts. Aerodrome Reference Point is the designated geographical location of an aerodrome. The aerodrome reference point shall be located near the initial or planned geometric center of the aerodrome and shall normally remain where the first establish the position of the aerodrome reference points shall be measured and given to the nearest second latitude and longitude. Airport engineering involves design and construction of a wide variety of facilities for the landing, takeoff movement on the ground, and parking of aircraft, maintenance and repair of aircraft, fuel storage, and handling of passengers, baggage and freight.

Following are the application of satellite imagery and GIS in Aviation Industry:

1. Facilities Management
2. Capital Planning
3. Property/ Lease Management
4. Land Acquisition
5. Security and Risk Assessment
6. Flight Path Management
7. Airport Layout Planning
8. Pavement Management
9. Parking Management
10. Courtesy Vehicle Management
11. Utility Maintenance
12. Lighting Management
13. Noise Monitoring and Modeling
14. Disaster Management
15. Environmental Assessment.

1. Facilities Management:

Geographic information system (GIS) technology manages infrastructure both outside and inside buildings to provide full operational awareness. Use it to optimize existing space, move staff efficiently and map asset conditions. Throughout the facility life cycle, GIS supports from site selection to space planning and maintenance, lease management and usage, safety issues, and continuity planning. GIS gives organizations a look at their facilities across all scales using the same data and software, allowing them to analyze dependencies, decrease costs, make better decisions, and improve performance management. GIS is a robust information system that supports a diverse set of analytic capabilities, workflows, and applications.

ArcGIS improves all areas of facilities-focused business functions including:

- Planning Move management
- Estate/Portfolio management
- Asset management

- Safety and security
- Environmental health Work order management
- Transportation planning
- Emergency planning and Response
- Way finding (routing across campus and through buildings)
- IT infrastructure management
- Energy management

2. Capital Planning:

A surface condition index is assigned to each roadway segment. When a SCI threshold is met a project is entered in the capital program. Once in the Capital Plan, a project is reviewed whether it needs to be advanced or deferred based on additional surveys or resourcing and funding available. When scheduled work is completed project is removed from plan. Benefits of integration with GIS Visualize physical location of assets Show current condition of each asset Visualize scheduled capital projects for any asset. Capital Project are tied to the linear road network. Individual or overall picture showing current condition and proposed capital projects spatially tie with other assets and conduct current or historical spatial analysis.

For example:

- Give all Reconstruction projects on a given area that affect Traffic Modernization projects.
- Give all expansion projects where land needs to be purchased etc .
- By utilizing the power of mapping technology in the asset management world we add a new dimension to our data that allows spatially referencing assets, capital projects and conducting complex spatial analysis.

3. Property/ lease Management

Whether for a commercial real estate agency, multiple listing service (MLS), home builder, or property management department in a corporation, ESRI brings the geographic advantage. Location drives the real estate industry. It's not just about finding any site but finding the best site. Real estate companies count on GIS technology to deliver the results they need. By analyzing data around locations—demographics, aerial photographs, traffic counts, shopping center usage, merchandise potential data, and competitive influences—they can find properties to match exacting specifications. GIS helps the real estate industry to analyze, report, map, and model the merits of one site or location over another. From identifying the bestfit for new commercial development or matching a homebuyer's decision criteria to managing a property portfolio, ESRI GIS delivers the answers needed to make the best choice in real estate.

4. Security and Risk Management:

A GIS based risk analysis procedure can be synthesized by the following steps:

• Planning:

Security programs begin with understanding the problem. This involves strategic and tactical planning to locate and identify potential emergency management problems and, using GIS, identifying these hazards and evaluating the consequences of potential attacks, emergencies, or disasters. The plan should identify obvious hazards such as nuclear plants, infrastructure hot spots (such as the intersection of gas mains and high-voltage assets), and other potential hazards or targets. The hazard data can be viewed with other maps data (population density, streets, pipelines, power lines) to develop a risk assessment.

• Mitigation:

Once the risk assessment has been completed, GIS analysis can easily determine adjoining structures, utilities, and affected population areas to the hazard. It can identify the potential impact of outages. Other mitigation efforts may target hazardous leaks and establish security buffers around high-risk structures or environmental health monitoring. Mitigation involves understanding potential hazards at risk from these emergencies and targeting them for protective and/or preventive action.

• Preparedness:

Preparedness includes those activities that prepare for actual emergencies. These activities include contingency planning, model building, and training. In an emergency, GIS can be used to answer questions such as "Where should first responder teams be staged to improve response time and capability?" or "What critical assets have been lost?"

• **Response**:

The first priority in responding to a disaster is the safekeeping of people and the management of life-threatening situations such as fire, explosions, loose wires, or collapse of structures. Managers seek to stabilize the situation and reduce the probability of secondary damage (for example, shutting off contaminated water supply sources or cordoning off affected areas to prevent further injury) as well as to speed up other emergency operations for victims.

• **Recovery:**

Recovery efforts begin when the immediate threat to life, property, and critical infrastructure is over. Recovery efforts are often in two phases—short term and long term. As a consequence, the Geographic Information Systems (GIS) could be employed by industry and at all levels of government for risk management and in all stages of emergency management – preparation and planning, response, recovery and mitigation – Geographic Information Systems have become the most significant basic tool for mapping and modelling in disasters. Short-term recovery efforts can be visually displayed and quickly updated. A visual status map can be accessed and viewed from remote locations by critical decision makers. This is particularly helpful for large emergencies or disasters where multiple efforts are ongoing at different locations. GIS is critical to understanding the scope, complexity, and severity of the emergency as well as distinguishing available assets from those lost or no longer available. In addition, laptop computers and handheld wireless devices can update the primary database from the field. Long-term recovery means restoring all services to normal or better. Long-term recovery, such as replacement of buildings, facilities, power systems, and streets, can take several years. GIS can be used during this period to identify facilities, assess damage, and establish prioritization for major restoration projects. As funds are allocated for repairs, accounting information can be recorded and linked to each location.

5. Flight Path Management:

Within the field of aviation, GIS applications can be utilized to present geographic data so that safety is reinforced through an enhanced threat and error management (TEM) decision making process. Using GIS aviation applications, a pilot is able to see or "fly" a specific arrival or departure at an airport. Textual descriptions or 2D maps can be compiled into an interactive virtual model that can be reviewed from all angles. Threats such as controlled flight into terrain (CFIT) or other unrecognized hazards are more easily identified and mitigated before the flight ever operates. The growth of GIS compatible data has created an environment where off-the-shelf programs can be utilized to present the information in a meaningful way for flight crew members. Through the use of layered information, a pilot would be able to "see" an approach or departure by reviewing previous flights. This can be enhanced by overlaying navigation information against the terrain and/or highlighting specific areas of concern. This synthetic experience allows a pilot to more fully understand the arrival or departure challenges associated with an airport even if he/she has never flown there before.

6. Courtesy Vehicle Management

GIS integrates multiple sources of information, displays results on a map or satellite image, and delivers the resulting situational awareness on a secure network. we can combine real-time tracking of vessels and port-based vehicles with sources such as live CCTV cameras to deliver a real-time security view of your port facilities. These capabilities make GIS an essential technology for managing a port's security framework.

7. Utility Maintenance

The primary goal of any utility is to plan and manage the use of facilities to deliver a commodity such as water, natural gas, or electricity to its customers. The utility industry has always relied on hardcopy maps to manage facilities, so it was natural that electric, gas, and water companies should be among the first users of digital mapping software.

8. Noise Monitoring and Modeling

Noise pollution of urban areas is one of serious factors that the local agencies and state authorities have to consider in decision making processes. The spatial analysis and geostaticstical methods of GIS can play an important role to control noise pollution. GIS provide framework to integrate noise calculation models with spatial data that can be used for building noise maps. Noise maps can be used to assess and monitor the influence of noise effects. Noise maps within GIS have been developed in most of the European Countries. European Commission has approved the Directive called ‘Environmental Noise Directive 2002/49/EC’ for noise mapping. Most of the noise maps that are available today and also that suggested by EU are in two dimensional (2D) in which noise effect is presented in x,y plane. 2D noise maps are built with the noise levels of one particular height. In the reality, noise travels in all direction. Residents living in high rise buildings are also severely affected by traffic noise. It is therefore important to develop 3D noise maps that can show influence of noise in all direction. 3D city model can be used to build 3D noise maps.

9. Disaster Management

GIS can also provide onsite technical personnel to assist with emergency GIS operations. Some of the common requests for assistance include:

- Data Support—either in finding, managing or operationalizing data sets to support organizations
- Situational Awareness—building viewers and sites to support both internal and external (public maps showing road closures for example) situational awareness
- Damage Assessment—taking a paper based process and spatially enabling that with GIS to support the damage assessment needs in the field
- Help with ArcGIS Online—setting up an AGOL Organizations account and best practices around making and using maps for public websites, coordination, etc.

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ड्रोन डारिज : किन जरुरी छ नेपालमा ड्रोनको ?

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भौगोलिक क्षेत्रफलमा निकै नै सानो भएपनि विभिन्न प्राकृतिक सम्पदाको धनी नेपालका यस्ता कयौं कुराहरू र विशेषताहरू छन् जसले नेपाललाई विश्व सामु आफ्नो बेग्लै पहिचान दिएको छ। ती कयौं विशेषताहरू मध्ये नेपालको एक महत्वपूर्ण विशेषता हो यसको भौगोलिक बनौट। समुद्री सतह देखी करिव ७० मिटरको होचाई देखी ८८४८ मिटरको संसारकै सबैभन्दा ठूलो उचाईसम्म यही सानो क्षेत्रफलमा ओगटेको नेपाल पृथ्विको स्वर्ग नै भन्न सकिन्छ। तर जति राम्रा यसका पक्षहरु भएपनि यही विविधताले गर्दा यहाँको जनजिवन कठिन भएको छ। करिव ७२% यहाँको जमिन भौगोलिक रूपमा अनियमित र कठिन छ जसका कारण आजसम्म पनि थुप्रै ठाउँहरुमा सहज बाटोहरू पुग्न सकेका छैनन्, जसको कमीले गर्दा शिक्षा, स्वास्थ्य र नेपाली जीवनशैलीमा ठूलो कठिनाई निम्त्याईदिएको छ।

जबसम्म नेपालका हरेक कुनाकाप्चामा सहज बाटाहरु र यातायातको सुविधा पुग्न सक्दैन, तवसम्म सबै अरू आवश्यकताहरु सबै ठाऊँमा पुर्याउन र नेपाली जीवनशैली उकास्न सम्भव छैन भन्दा कुनै अत्युक्ती नहोला। अहिलेको हाम्रो विकाशको गति, प्राकृतिक प्रकोपले निम्त्याएका विनाश र जथाहाभावी निर्माणलाई मध्यनजर गर्ने हो भने यो सपना पूर्ण हुन केही वर्ष नभएर थुप्रै दशकहरु बित्ने देखिन्छ। के यसको मतलव संसार चन्द्रमा र मङ्गल ग्रहमा जीवन विस्तार गर्ने प्रयासमा लागीरहेको वेलामा अझै धेरै नेपाली पिडीहरु सास्तीको जिवनमै सकिने हुन् त? आज संसारमा विज्ञानले यति ठूलो फड्को मारीसकेको छ की यसको सही प्रयोग गर्न सक्ने हो भने यहाँको जीवनलाई उकास्न दशकौं पर्खिरहन पर्दैन। नेपाली भूगोल, नेपाली जीवनको कठिनता र विज्ञानको एउटा सानो तर शक्तिशाली उपजको चर्चा गरौं, नेपालमा किन ड्रोन आवश्यक छ भन्ने चर्चा गरौं।

1. औषधी, रगत जस्ता अति आवश्यक स्वास्थ्यका आधारभूत कुरासम्म पनि यहाँका दुर्गम भेगका जनताहरूको पहुँच निकै न्यून छ। बजारमा पाईने औषधीको कमिमा कसैले ज्यान गुमाउनु भनेको निकै निन्दनीय हो। यस्ता घटनालाई न्यून पार्नु तथा सबै भेगका जनतालाई उचित स्वास्थ्य सेवा दिनुमा ड्रोनले निकै ठूलो भूमिका निर्वाह गर्न सक्छ। कम समयमा र कम खर्चमा जस्तो सुकै भेगमा पनि औषधी, रगत जस्ता कुराहरूलाई सजिलै ओसारपसार गर्न सक्ने ड्रोन नेपाल जस्तो राष्ट्रको लागी वरदान साबित हुन सक्छ।

2. प्राकृतिक प्रकोपको दृष्टिकोणले निकै जोखिममा रहेको नेपालमा कुन वेला के विपत्ति आउन सक्छ भन्ने आधार नै छैन। यस्ता घटनाहरू घटेका क्रममा निकै मानिसले खानपान, औषधी तथा सुरक्षा समेत पाउन मुस्किल छ। साथै यस्ता अवस्थामा मानिसको खोजी कार्य पनि निकै नै महतपूर्ण तर कठिन हुन्छ। यसका लागी रोबोट, र विशेष गरि ड्रोन, को प्रयोगले खोजी कार्य, खानेकुरा तथा औषधी वितरण जस्ता कार्यहरुमा निकै नै सजहता पुर्याउँछ।

3. खराव भूगोलका कारण यहाँ गरिने सर्वेक्षणका कार्यहरूवाट एकदम सही डाटा निकाल्न निकै मुस्किल छ र प्राय डाटाहरु अनुमानित हुन्छन् जसका कारण यहाँका निर्माण तथा विकासका कार्यहरू दिगो रहँदैनन्। यदी ड्रोनको प्रयोग गरेर सर्वेक्षण गर्ने हो भने निकै नै सही तथा ठेट डाटा पाईन सकिन्छ जसले गर्दा निर्माण कार्यहरूको योजना राम्रोसँग गर्न सकिन्छ। साथै ड्रोनको प्रयोगले पूर्वाधारहरुको नियमित जाँच गर्न, 3▯ मोडलहरु सहजै बनाएर बिश्लेषण गर्न, ईत्यादी कार्यहरुमा पनि निकै सहज हुन्छ।

4. पर्यावरणका लागी निकै नै उचित भएपनि नेपालले यस क्षेत्रलाई सही उपयोग गर्न सकेको छैन्। यदी नयाँ प्रविधिहरूको उचित प्रयोग गरेर यस क्षेत्रका पूर्वाधारमा लगानी गर्ने हो भने यहाँ पर्यावरणबाट अकल्पनीय आर्जन गर्न सकिन्छ। ड्रोनको प्रयोगले एक त पर्यटकका लागी औषधी लगायतका वस्तु जुनसुकै ठाउँमा चाहेको बेला पुर्याउन सकिन्छ भने, अर्को त ड्रोन फोटोग्राफी, भिडियोग्राफी बाट यहाँका सुन्दर तथा मनोरम स्थानको चर्चा विश्वसामु पुर्याउन सकिन्छ र भर्चुवल टुरिजममा पनि यसलाई प्रयोग गर्न सकिन्छ।

5. कृषि मूलक देशका रूपमा चिनिने नेपालमा प्रविधिको प्रयोगबाट थुप्रै कुराहरुमा देश आत्मनिर्भर रही आयातसमेत गर्न सकिने गरी उब्जनी गर्न सम्भव छ। ड्रोन र विभिन्न सेन्सरको प्रयोगले ठूलो क्षेत्रफलमा कम समय तथा लगानीमा निरिक्षण, बिउ रोप्ने, रोग लागेका बोट बिरुवाको पहिचान, सहजै औषधी हाल्ने काम जस्ता थुप्रै कामहरु गर्न सकिन्छ।

6. अझैपनि सबै सरकारी निकायहरूले प्रविधि नअँगाल्नुले चिठीपत्रको संजालबाट चलेको छ नेपाल। यसले जनताको जीवन त कष्टकर त बनेको नै छ, तर नेपाली सरकारी कामलाई कछुवाको गतिमा पनि सीमित गरेको छ। ड्रोनको विशेष प्रयोग गरेर संवेदनशिल तर अत्यावश्यक चिठीपत्रहरु तथा जनताले टाढा धाएर लिनुपर्ने काजजातहरु हरेक स्थानिय तहको कार्यालयहरुमा पुर्याउन सक्ने व्यवस्था गर्न सक्ने हो भने पनि निकै सहज र सुलभ रुपमा जनताले सरकारी सुविधा पाउन सक्छन्।

7. उचित सुरक्षा नीति तथा गतिविधिहरूको कमीमा राजधानी लगायत कुनै पनि कुनामा यहाँका सुरक्षाको सही प्रचलन अझैपनि हुन सकेको छैन। यस्तीमा, दुर्घटना भएका स्थानमा, ट्राफिक निरिक्षण आदिमा ड्रोनको प्रयोग गर्ने हो भने सबै ठाउँमा जनतालाई सुरक्षा दिन सजिलो हुन्छ। साथै हाईवेहरुमा गस्ति तथा अनुगमन ड्रोनबाट नियमित रूपमा गर्दा, वनजङ्गलको निरिक्षण गर्दा तस्करीका कार्यहरु नियन्त्रण गर्न निकै नै सहज हुन्छ।

यी त कयौं मध्येका केही महत्वपूर्ण विधाहरुमात्र भए जसमा ड्रोनको प्रयोगले आमूल परिवर्तन नै ल्याउन सम्भव छ। संसारले विज्ञानलाई चुनौती दिँदै अगाडी बढीरहेको बेलामा भएका प्रविधीलाई पनि सही रूपमा अँगाल्न छोडेर र सही नीति नियम तथा योजनाका बलमा यस्ता नयाँ प्रविधीको बढी भन्दा बढी प्रयोग गरेर देशलाई कसरी द्रुत गतिमा अघि बढाउने चिन्तन छोडेर उँडेका ड्रोन समाउँदै हिँडेको सरकारले ड्रोन प्रतिको आफ्ना नीति तथा व्यवस्थामा संशोधन गर्नुपर्ने बेला भइसकेको छ। साथै जिम्मेवार मिडियाहरुले पनि कहाँ कस्तो ड्रोन समातियो भन्ने खवरलाई मात्र छापेर प्रविधीका सबै विधामा हातहालेको जस्तो देखावट गर्न छोडी यसका विषयमा खोज गर्न, संसारमा भइरहेका ड्रोनका सही उपयोगहरूलाई सबै सामु प्रस्तुत गर्न तथा सरकारलाई यस विषयमा सजग तथा जिम्मेवार हुन पहल गर्नमा अगाडी बढ्नैपर्ने समय आएको छ।

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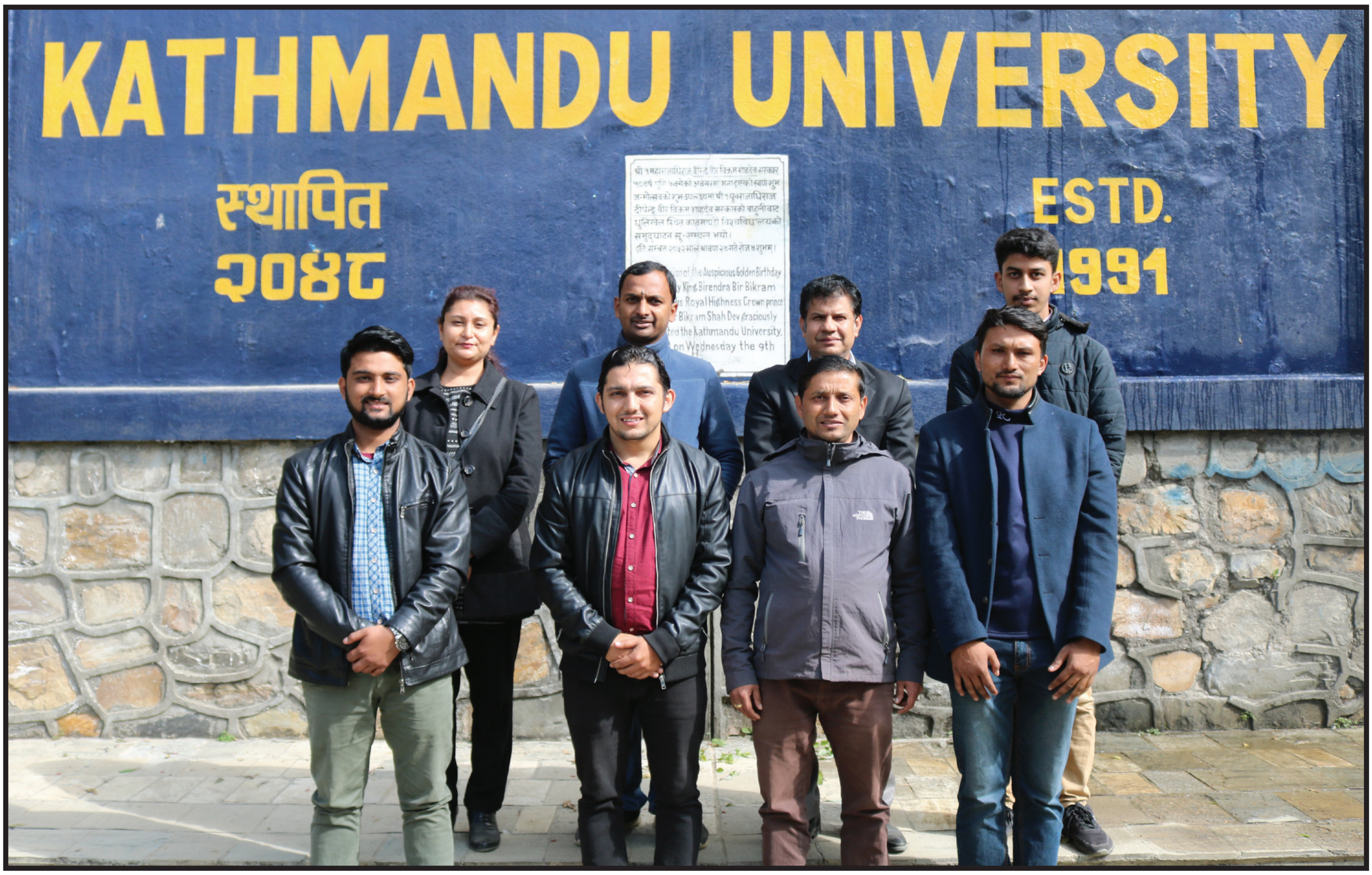

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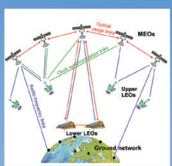

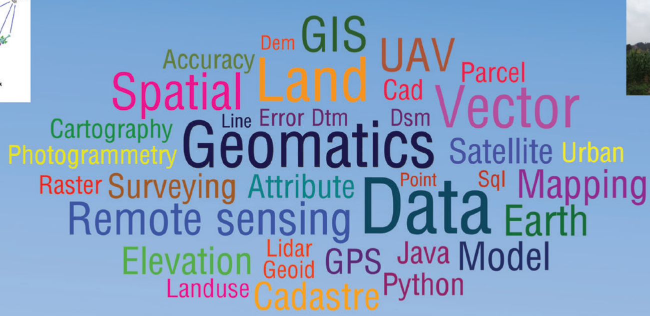

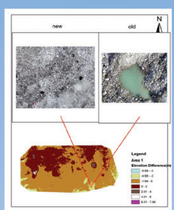

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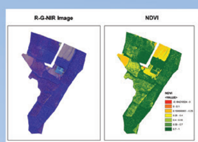

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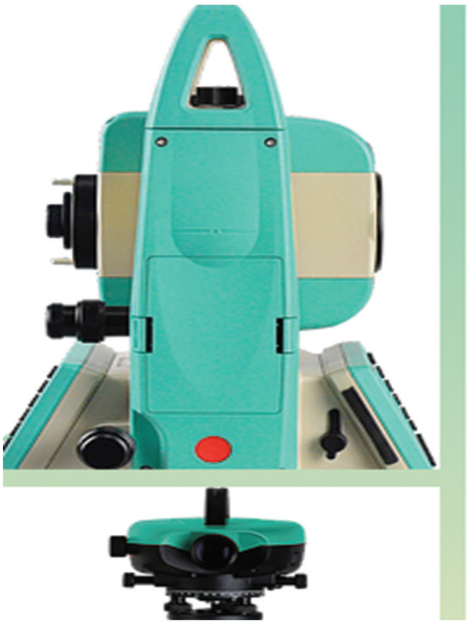

GeoSAT Solutions P. Ltd.

Founded by the team of expert in the field of Geo-Positioning/Survey, Geo Sat Solution P.Ltd, is truely an emerging solution provider for Surveying Equipment Portfolio (TS, Theodolite, Level, and Accessories) and Software Solutions (web design, processing software, photogrammetric software) in Nepal. As an authorized dealer for Ruide Brand, we provide the pre sales and after sales assistance to the portfolio we offer.

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