RISK BASED METHODOLOGY FOR ASSESSING AVOIDED DEFORESTATION WITH APPLICATION IN ICF FOREST PROGRAMMES IN TERAI & CHURIA IN NEPAL

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Authors:

Veronique Morel, Ecometrica

Karin Viergever, Ecometrica

Richard Tipper, Ecometrica

Edward Mitchard, The University of Edinburgh

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Most data sources were helpfully provided by in-country experts. Ecometrica acquired the additional data sources and did the risk mapping analyses based on our interpretation of the expert input.

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CONTENTS

1 INTRODUCTION

The International Climate Fund (ICF) was set up by the UK government in 2011 with the aim of working in partnership with developing countries to reduce carbon emissions through promoting low carbon development, to help the world's poorest people adapt to climate change and reduce deforestation.

Forest activities funded under ICF should support developing country actions on Reducing Emissions from Deforestation and forest Degradation (REDD) and contribute to low carbon growth that reduces poverty. An improved understanding of forest areas at risk as well as historic and ongoing deforestation likely to occur in the absence of conservation interventions is important in deciding how to target interventions and how to evaluate the impact of conservation measures in terms of avoided deforestation.

The following risk-based method takes advantage of earth observation data and geospatial information products and has been devised to apply to large scale programmes in areas where broadly similar processes, legal and institutional constraints, play out across forest ecosystems.

The output of the method is an estimate of avoided deforestation derived from the amount of expected forest loss within an area over a 20 year period versus observed annual forest loss. Expected loss is estimated by applying an ACEU - type[1] risk model which assumes that land areas are at greater risk of deforestation and degradation if they are easily accessible, are suitable for cultivation, have an extractable value, and are unprotected. The methodology does not provide a prediction of future forest loss but assigns relative risk values, based on the ACEU criteria.

Each of the four ACEU parameters are defined and assigned a level of risk based on assessments of region-specific drivers of forest loss and land use change. The resulting risk map is intended to aid project developers and conservation organisations wishing to target efforts to areas where they are most needed.

The method was assessed for feasibility in 3 ICF project areas with markedly different forest types and drivers of land use change in southern Ghana, Terai and Churia in Nepal and Brazilian cerrado. This document describes the methodology used to produce a risk of deforestation map in each of these areas.

[1] The ACEU risk model determines an overall level of risk as the product of the risks associated with each of the four ACEU parameters: A = Accessible – local actors able to reach the area (RA); C = has Cultivable value – land can be used for subsistence or commercial crops (RC) E = Extractable Value – forest biomass has economic value (RE), U = Un/Protection Status – land tenure regime does not prevent extraction or conversion (RU). Risk is calculated as: RISK FACTOR = (RU)+(RC)+(RE)+(RA)

An important part of this work was in defining forest extents in each region, identifying drivers of forest loss in consultation with local experts and assessing the quality and availability of data. It is suggested that the risk maps may be updated in the future, to take account of new risks and changes to the understanding of drivers.

2 DESCRIPTION OF STUDY AREA

An area of 3 918 753ha covering the southern regions of Terai and Churia in Nepal was chosen for this risk analysis. This area was identified by the local stakeholders, the Multi-Stakeholder Forestry Programme, as at greatest risk of deforestation because of the relatively low slopes and high population densities.

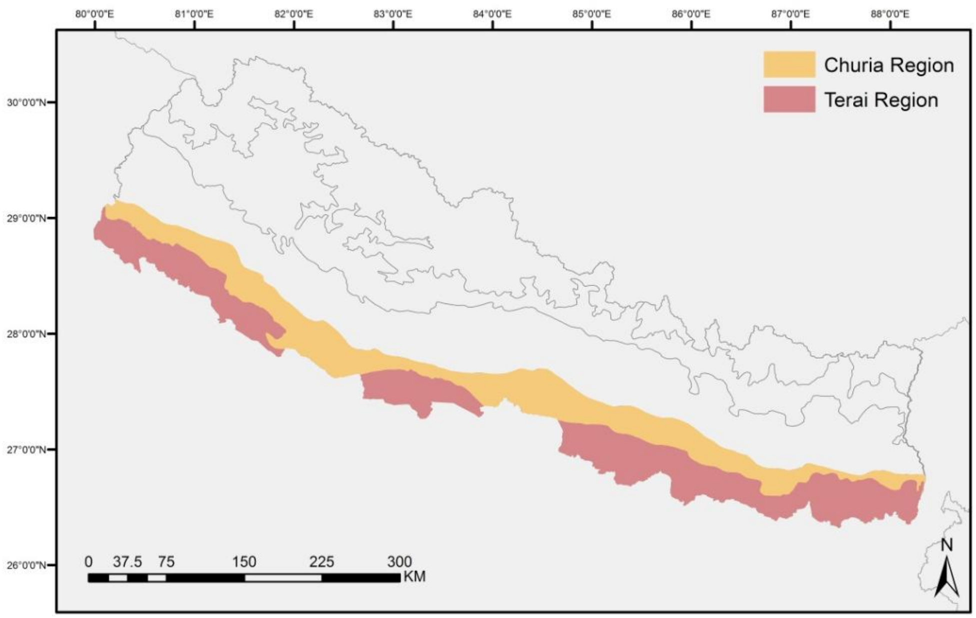

Figure 1: Southern regions of Terai and Churia in Nepal included in the risk analysis.

3 DEFINING FOREST EXTENTS

The first step for mapping risk of deforestation, is to identify the forest extent within the study area. To this end, several forest cover datasets were investigated, including the 2010 JAXA forest/non-forest 25m product[2] and the MODIS VCF percentage tree cover dataset[3]. We chose to produce the final risk map

[2] Masanobu Shimada, Takuya Itoh, Takeshi Motooka, Manabu Watanabe, Shiraishi Tomohiro, Rajesh Thapa, and Richard Lucas, "New Global Forest/Non-forest Maps from ALOS PALSAR Data (2007-2010)," Remote Sensing of Environment, accepted April 4, 2014 DOI=10.1016/j.rse.2014.04.014. http://www.eorc.jaxa.jp/ALOS/en/guide/forestmap_oct2010.htm

using the forest extent as represented by a locally produced forest map[4], i.e. ICIMOD land cover data for the year 2010[5] (shown in figure 2), based on object based image analysis using 30 m Landsat TM scenes.

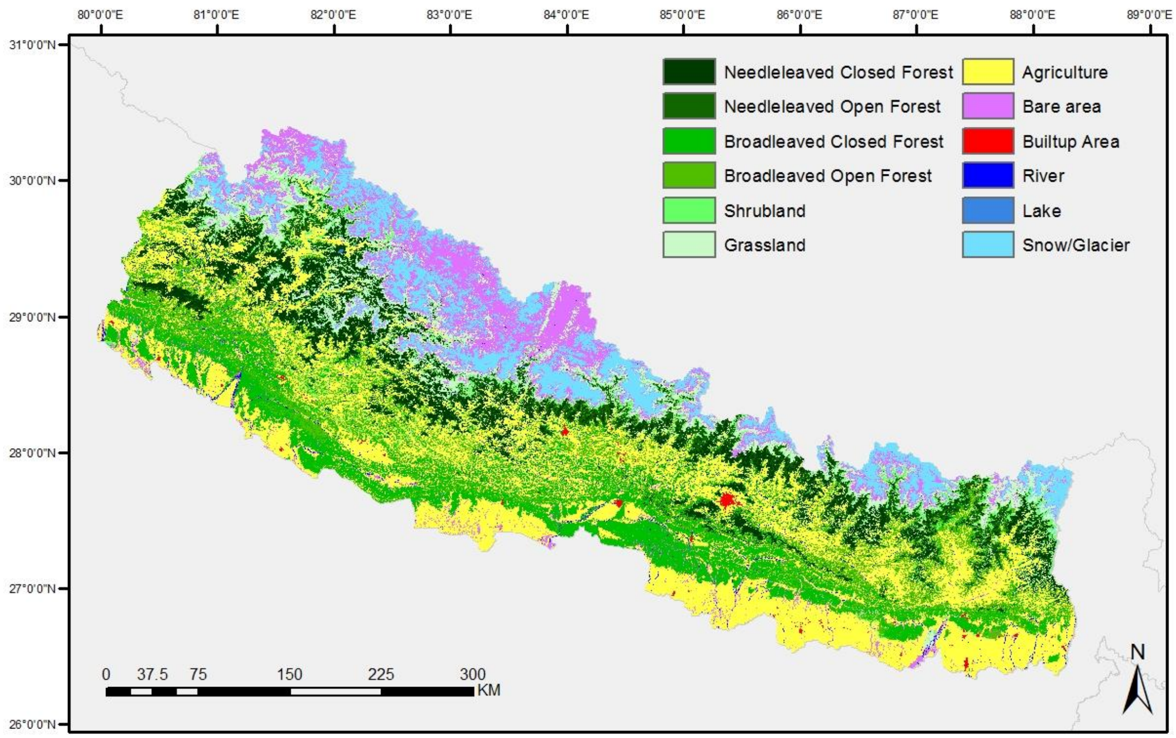

Figure 2: ICIMOD land cover map for 2010 created using object based image analysis with 30 m Landsat TM scenes.

The forest extent based on the ICIMOD 2010 land cover data was defined by 4 forest classes within the dataset; namely needle-leaved closed and open forest, and broad-leaved closed forest (see figure 3).

As this land cover analysis was undertaken across the across the Hindu Kush Himalayan region, it does not account for Nepal's forest definition of a minimum canopy cover of 10% and minimum area requirement of 0.5 ha. Smaller, isolated patches of forest vegetation of less than 0.5 ha can be found within the ICIMOD dataset that would not otherwise be defined as forest in Nepal. These forest

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[3] DiMiceli, C.M., M.L. Carroll, R.A. Sohlberg, C. Huang, M.C. Hansen, and J.R.G. Townshend (2011), Annual Global Automated MODIS Vegetation Continuous Fields (MOD44B) at 250 m Spatial Resolution for Data Years Beginning Day 65, 2000 - 2010, Collection 5 Percent Tree Cover, University of Maryland, College Park, MD, USA. http://glcf.umd.edu/data/vcf/

[4] It is regrettable that the recently produced forest cover maps for the Terai and Churia, from FRA Nepal study were not made available to the project team to include in the risk mapping.

[5] Uddin K., Shrestha H. M, Murthy M.S.R. , Bajracharya B., Shrestha B., Gilani H., Pradhan S., Dangol B. (2015) Development of 2010 national land cover database for the Nepal. *Journal of Environmental Management* 148, 82-90. http://rds.icimod.org/Home/DataDetail?metadataId=9224

vegetation patches were included in the risk analysis as they were assessed to be minimal and including the complete dataset was preferable to altering the data resolution to exclude them.

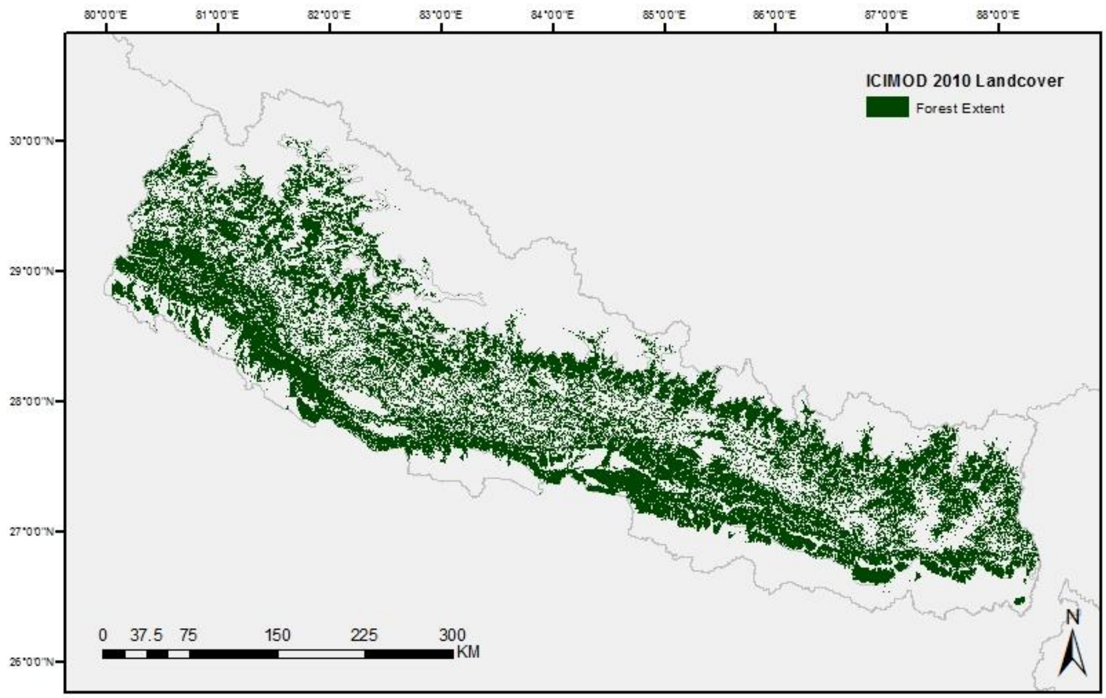

Figure 3: Forest extent derived the ICIMOD 2010 land cover dataset from needle-leaved closed and open forest, and broad-leaved closed forest classes.

The ICIMOD 2010 forest extent dataset was compared to 3 additional tree cover datasets: the 2010 JAXA forest/non-forest 25m product[6], global tree canopy cover percentage data for the year 2000 produced by Hansen et al[7] and the MODIS VCF percentage tree cover dataset[8].

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[6] Masanobu Shimada, Takuya Itoh, Takeshi Motooka, Manabu Watanabe, Shiraishi Tomohiro, Rajesh Thapa, and Richard Lucas, "New Global Forest/Non-forest Maps from ALOS PALSAR Data (2007-2010)," Remote Sensing of Environment, accepted April 4, 2014 DOI=10.1016/j.rse.2014.04.014. http://www.eorc.jaxa.jp/ALOS/en/guide/forestmap_oct2010.htm

[7] Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, & J. R. G. Townshend (2013) High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53 http://earthenginepartners.appspot.com/science-2013-global-forest.

[8] DiMiceli, C.M., M.L. Carroll, R.A. Sohlberg, C. Huang, M.C. Hansen, and J.R.G. Townshend (2011), Annual Global Automated MODIS Vegetation Continuous Fields (MOD44B) at 250 m Spatial Resolution for Data Years Beginning Day 65, 2000 - 2010, Collection 5 Percent Tree Cover, University of Maryland, College Park, MD, USA. http://glcf.umd.edu/data/vcf/

4 RISK FACTORS

This study applies the qualitative ACEU risk model, which is based on the hypothesis that forest areas are at greater risk of deforestation if they are accessible (A), located in areas suitable for cultivation of staple crops (C), contain timber resources that have an extractable value (E) and are unprotected (U). The sections below explain how each of these four parameters are defined and assigned a level of risk. Local knowledge was used as much as possible to assign values to the risk factors, but gaps were filled by literature study. It is important to note that these risk maps are early version first drafts and can be improved over time as newer data and information becomes available.

4.1 ACCESSIBILITY: RISK OF DEFORESTATION ASSOCIATED WITH ACCESS BY RIVERS

Proximity to major rivers are included as a risk factor for accessibility as transporting extracted timber via waterways to India is common in Nepal. Natural changes in river courses can also cause forest loss. Data for major rivers was sourced from the Survey Department, Ministry of Land Reform and Management[9].

Following consultation with local forestry experts, areas within the flatter Terai region up to 1 km from rivers were classed as very high risk, while areas up to 2 km were assigned a high risk status. Within Churia, areas up to 0.5 km were assigned the highest risk value and areas up to 1 km from rivers were classed as high risk.

[9] *Ministry of Land Reform and Management* (MoLRM), Government of Nepal, Singhdurbur, Kathmandu, Nepal

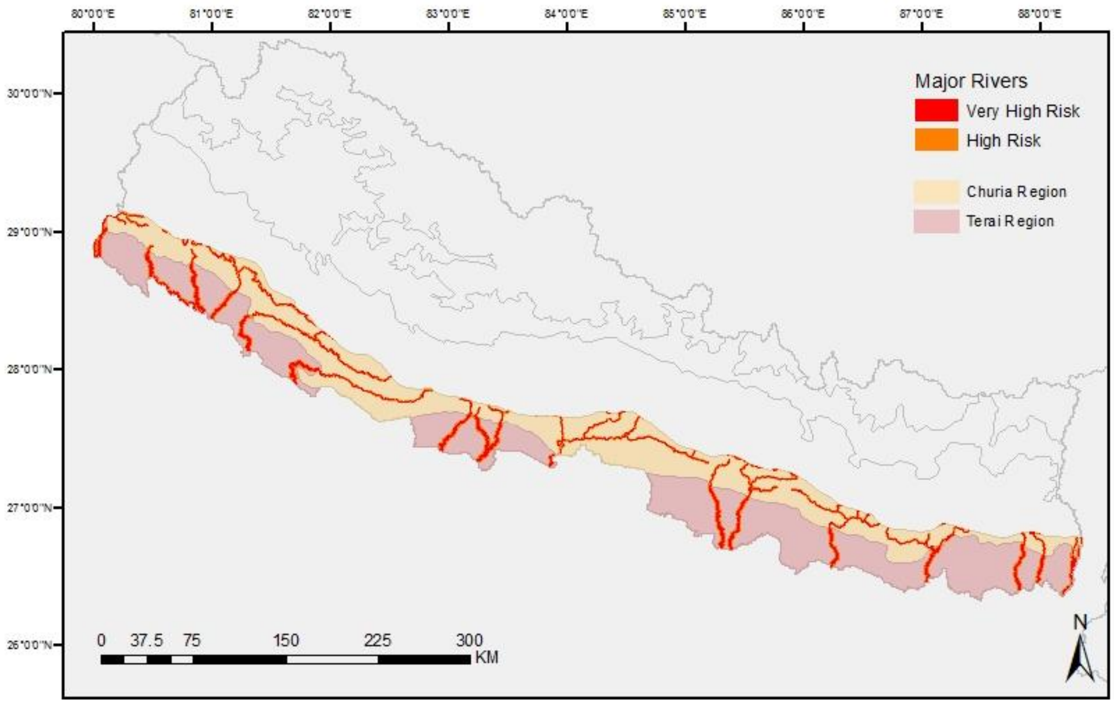

Figure 6: Risk of deforestation due to access by rivers to forested areas in Terai and Churia. Red shows very high risk (closer to roads), while orange shows one risk level lower (high risk). Risk is calculated for up to 2 km from a river in Terai and 1 km from a river in Churia.

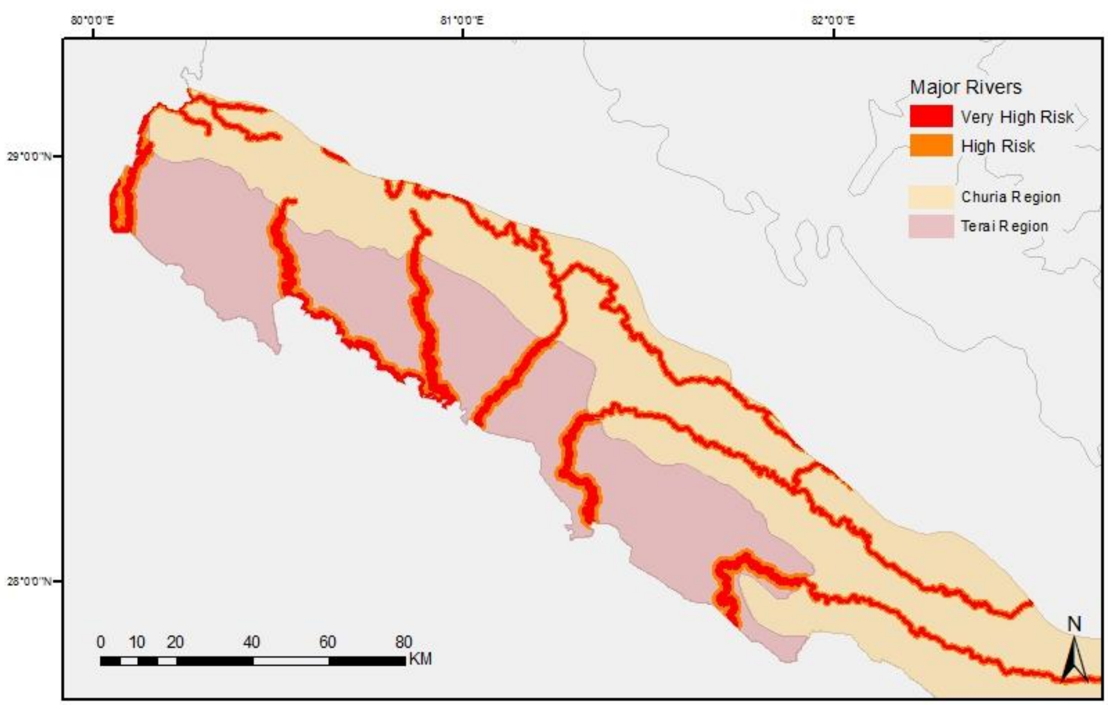

Figure 7: Zoomed in subset showing risk of deforestation due to access by rivers in Terai and Churia.

4.2 ACCESSIBILITY: RISK OF DEFORESTATION ASSOCIATED WITH ACCESS BY ROAD

Forested areas that are more easily accessible via roads and tracks were assigned higher risk values by defining 2 risk zones up to a distance of 2 km away from roads in Terai and up to 1 km from roads in Churia. Detailed roads and tracks data for Nepal was sourced from the Survey Department, Ministry of Land Reform and Management. Very high and high risk buffer zones of 1 km and 2 km respectively were created in the flatter Terai regions, with areas closest to the road given a high risk value while areas furthest away were given a lower risk value. Zones for very high and high risk in Churia were defined as 0.5 km and 1 km away from roads and tracks.

Risk of deforestation due to access by railways were not included in this analysis.

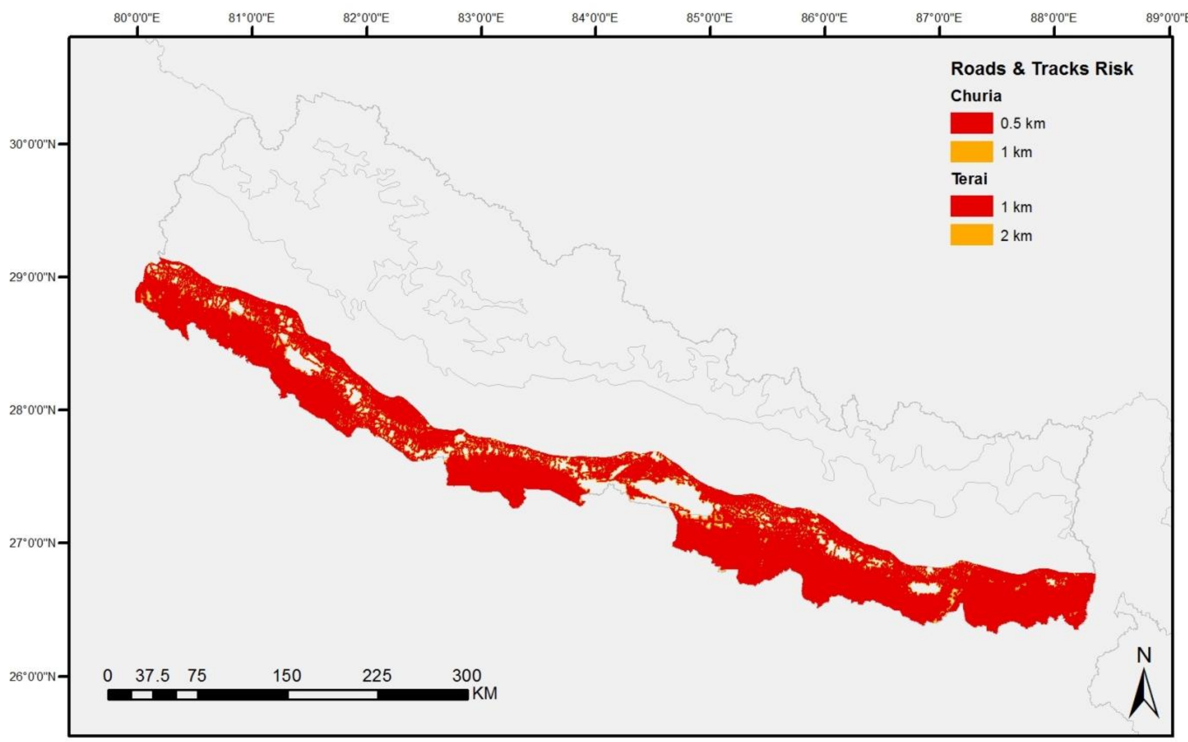

Figure 8: Risk of deforestation due to access by roads to forested areas in Terai and Churia. Red shows high risk (closer to roads), while orange shows one risk class lower (high risk). Risk is calculated for up to 2 km from a road in Terai and 1 km from a road in Churia.

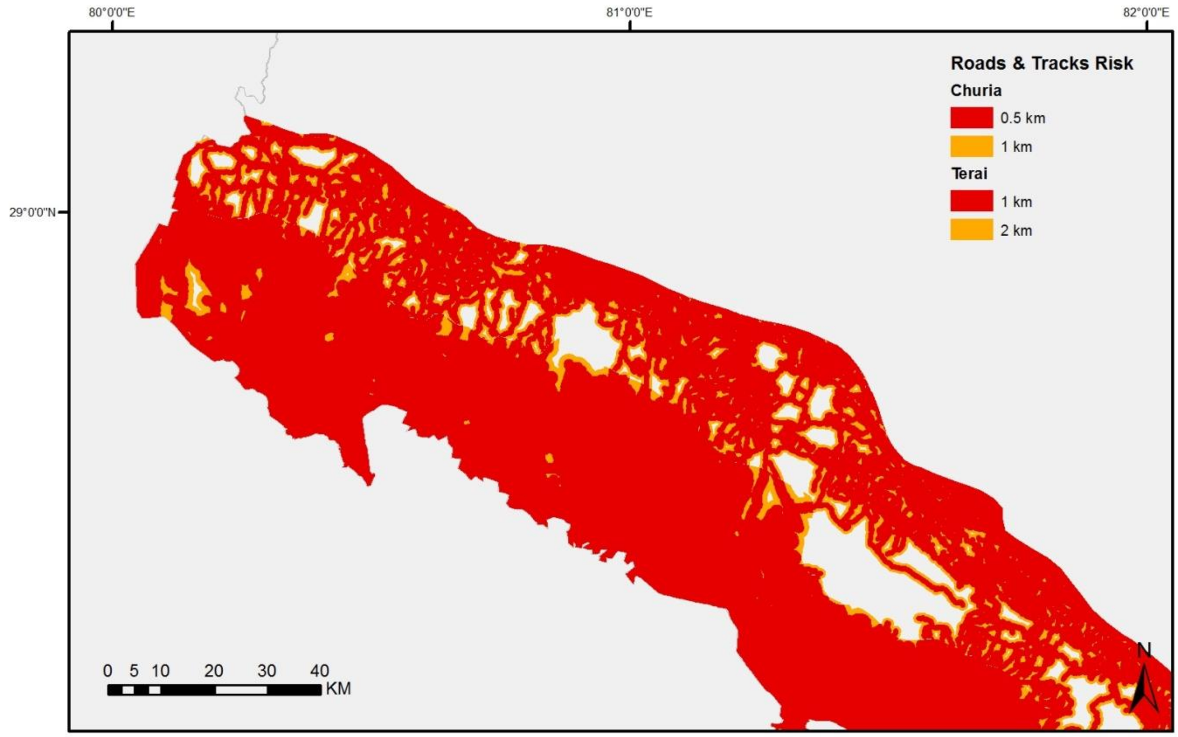

Figure 9: Subset showing a zoomed in area of the risk of deforestation map due to access by roads.

4.3 ACCESSIBILITY: RISK OF DEFORESTATION ASSOCIATED WITH DISTANCE FROM FOREST EDGES AND FRAGMENTED AREAS

As historic forest loss has been observed on forest edges, especially within Terai, these areas are at a higher risk of further deforestation. A forest fragmentation dataset created by ICIMOD for 2010 which defines edge, patch, perforated and core areas of forest within Nepal was used. Areas inside a 100 m buffer zone around exposed forest edges were assigned the highest risk value of 5.

Smaller areas of fragmented forest patches are also at high the risk of forest loss. As defined by the ICIMOD dataset, isolated patches of forest were assigned the second highest level of risk (high risk), and areas classed as perforated (an inner edge or gap with a forested area) were classed as medium risk (a value of 3). Core areas of forest of less than 100 ha were given a risk of 2 (low risk), while those larger than 100 ha were given a very low risk value.

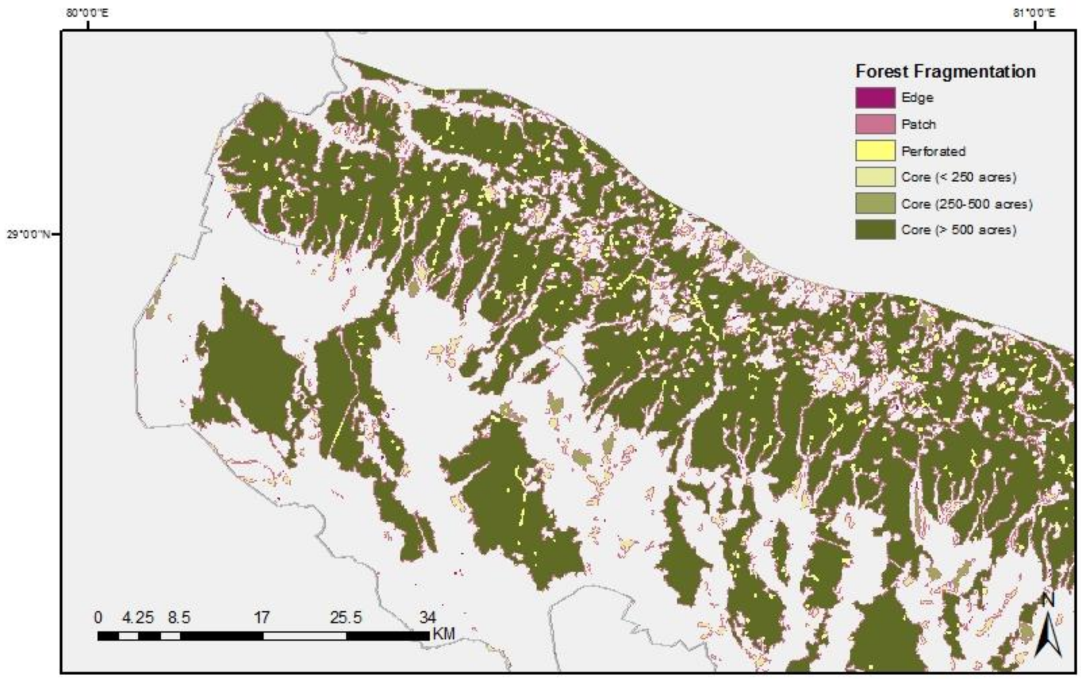

Figure 11: The forest fragmentation dataset created by ICIMOD for 2010 which defines edge, patch, perforated and core areas of forest within Nepal

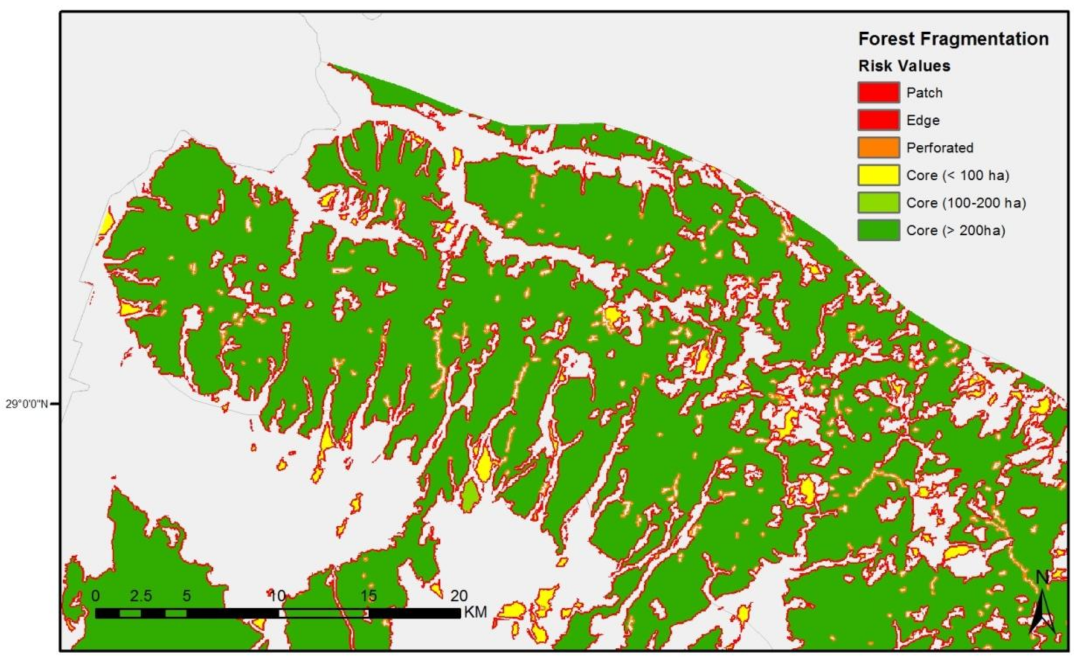

Figure 12: Risk classes assigned to forest edges, isolated patches, perforated and core areas according to the forest fragmentation dataset created by ICIMOD

4.4 ACCESSIBILITY: RISK OF DEFORESTATION ASSOCIATED WITH PROXIMITY TO POPULATED AREAS

Local forestry experts unanimously agreed that forests in close proximity of settlements were at a higher risk of deforestation. Due to the lack of availability of data on population numbers for specific settlements, population data at the administrative level was used. Data from the National Population and Housing Census 2011 (CBS) was combined with 2001 Village Development Committee (VDC) boundaries sourced from the Survey Department, Ministry of Land Reform and Management.

Population census data was available at ward level and aggregated to Village Development Committee (VDC) level, shown in figure 13, as local experts in Nepal confirmed data for some wards may be switched between VDC level areas and is more reliable at ward level. Total population numbers per ward were added for each VDC area. Population densities per hectare were then derived by dividing the total population by the VDC area. Risk levels were assigned according to higher levels of population density, shown in figure 13.

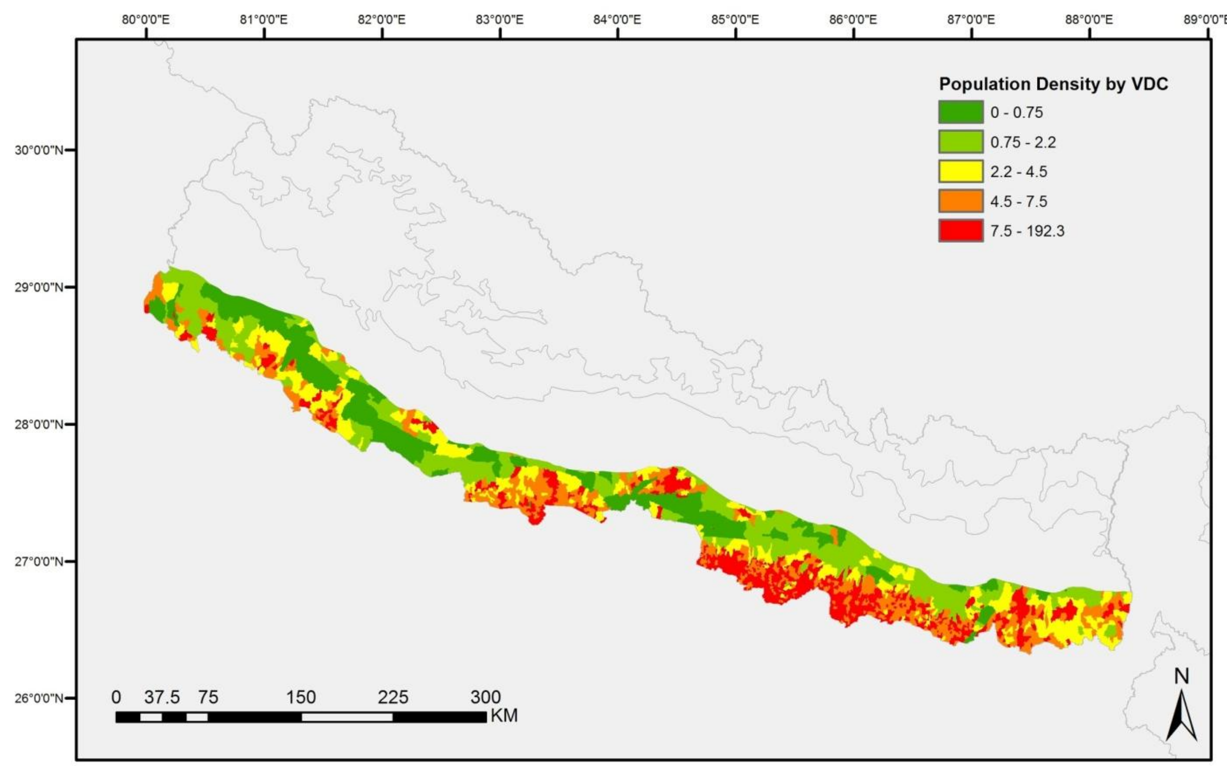

Figure 13: Map of population densities at VDC level that fall partially or completely within the Terai or Churia regions classified using a quantile classification.

4.5 ACCESSIBILITY/CULTIVABILITY: RISK DUE TO PROXIMITY TO PREVIOUS SITES OF DEFORESTATION

Forest areas close to previously deforested areas are expected to be at greater risk of future forest loss. A density map of historical deforestation events (2001-2013) with an area of 0.5 ha was created based on the Hansen et al forest loss data (Hansen et al, 2013). The density map was then divided into 5 classes based on the density values – i.e. group of highest density values were given highest risk value (5) and the group of lowest density values were given lowest risk value (1). The density map was created using a radius of 10 km, where higher than average densities were classed in high and very high risk categories, and lower than average densities are classed as very low and low risk, shown in Figure 10.

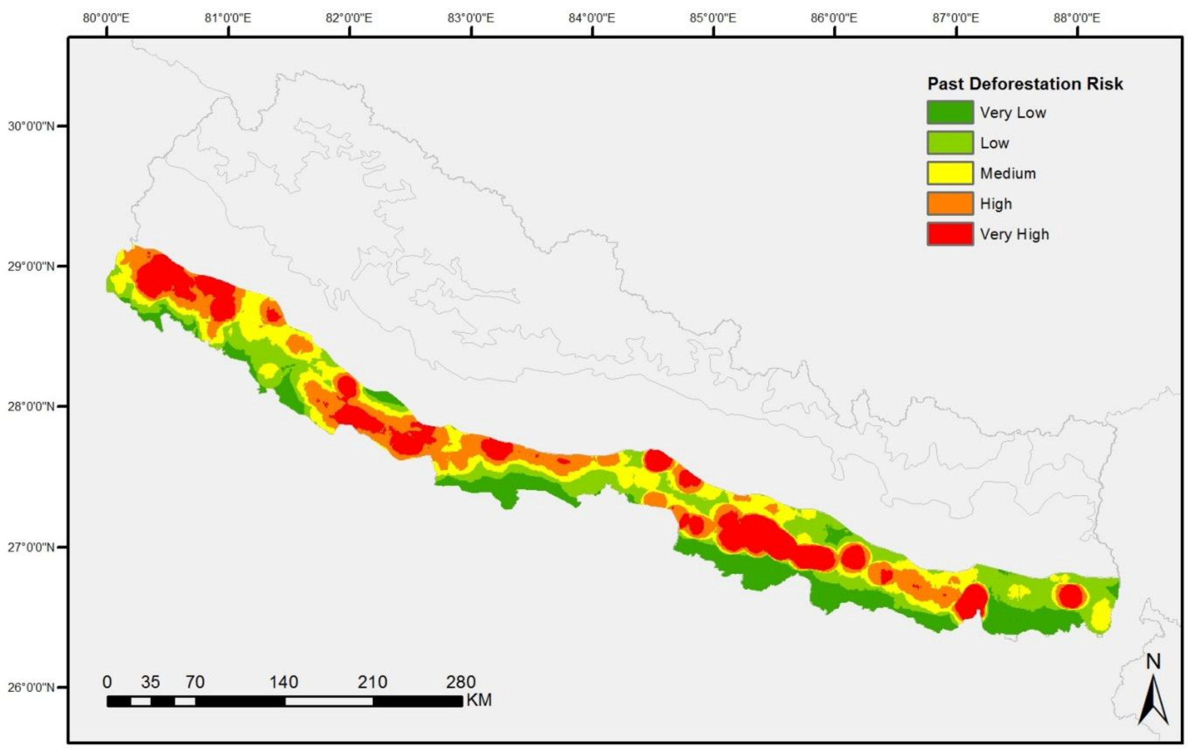

Figure 10: Density map of past deforestation in the Terai & Churia regions of Nepal. Red areas indicate a high number of deforestation events, while green shows low density of deforestation events. The density values shown here were classed using a quantile classification, where areas in red show densities of deforestation above the mean, and green values are below the mean deforestation event densities across the study area.

4.6 EXTRACTABILITY: RISK OF DEFORESTATION ASSOCIATED WITH ACCESS DUE TO SLOPE

Degrees of slope within the Terai and Churia regions was used to identify areas where timber would be difficult to extract. Slopes of over 45° were deemed to be mostly avoided for extracting timber from the forest and were assigned the lowest risk value of 1. Slopes of between 31 and 45° were assigned a medium risk value of 3, while slopes of between 0 and 30° given the highest risk value of 5.

Shuttle Radar Topography Mission (SRTM) elevation data (figure 17) acquired at 90 meter (3 arc-second) resolution was used to derive degrees of slope in the study area. The risk classes based on slope are shown in figure 18. While the majority of land area within Terai fell within the highest risk slope range of between 0 and 30°, mountainous areas along the south-west and north-east borders of Churia were classed as medium and low risk areas.

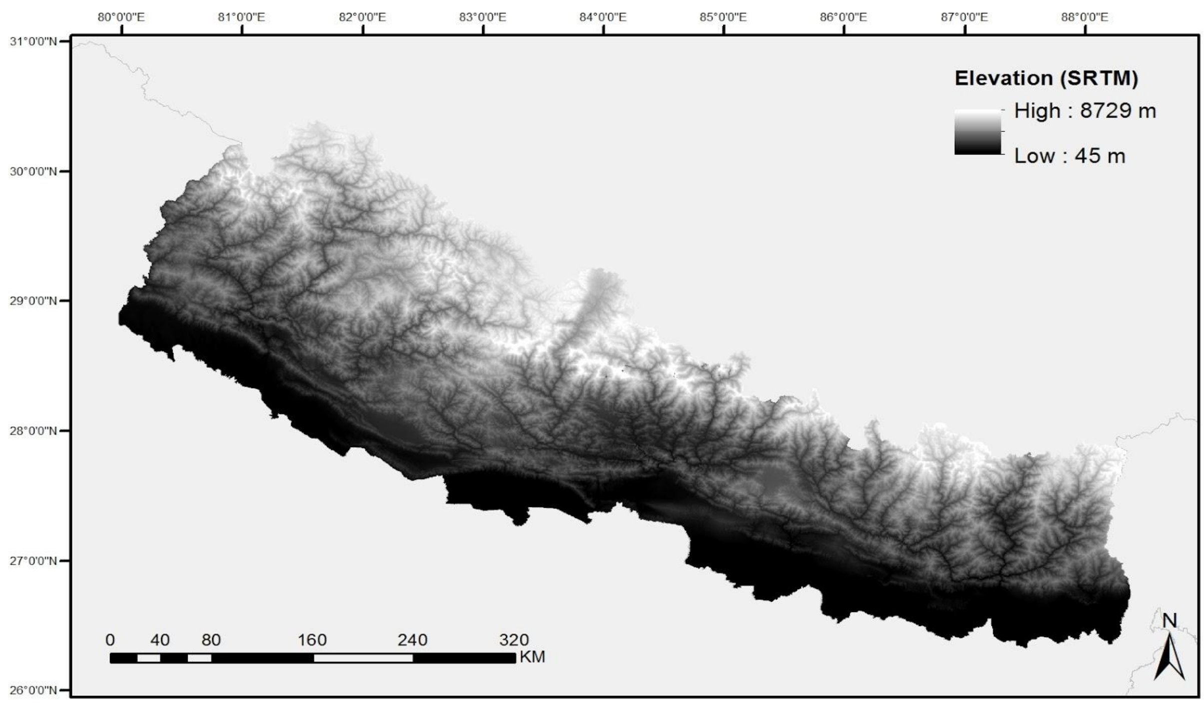

Figure 17: Elevation data from Shuttle Radar Topography Mission (SRTM) 3 Arc-Second data used derive degrees of slope.

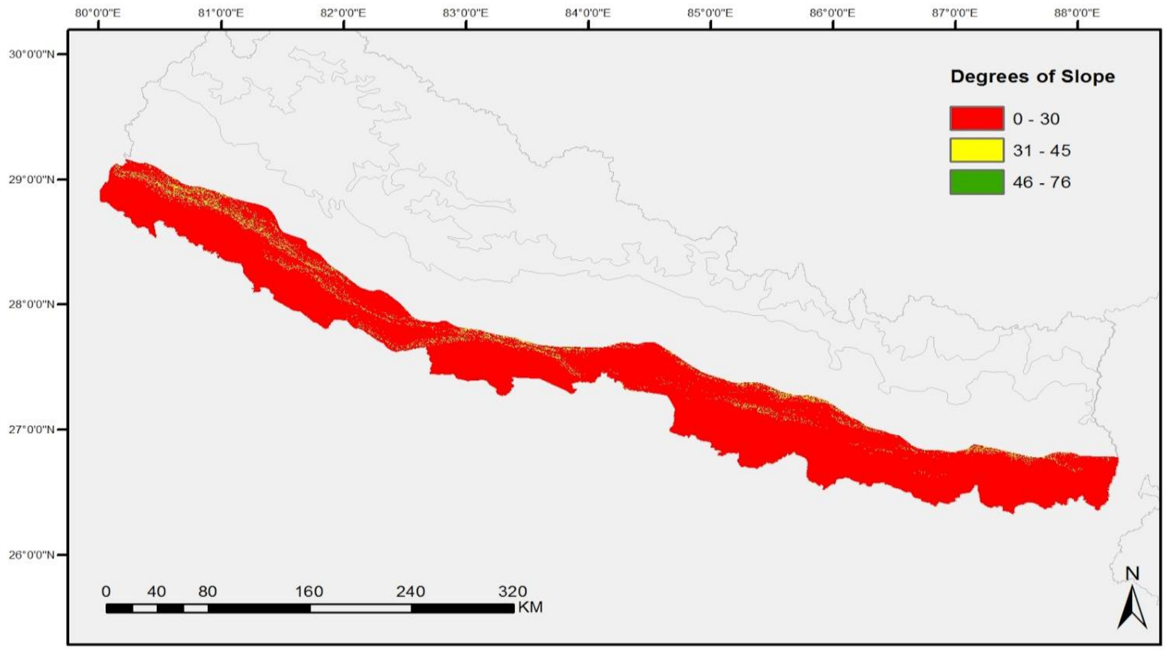

Figure 18a: Degrees of slope with the lowest risk value, shown in green, assigned to steeply sloped areas within the study site.

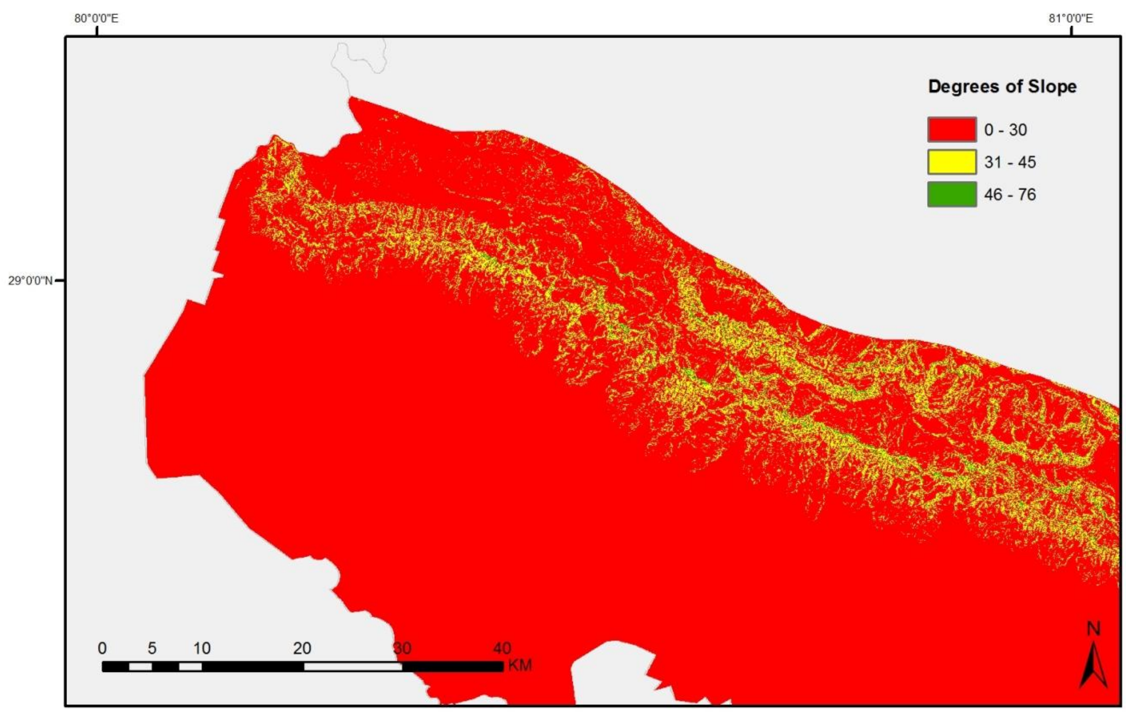

Figure 18b: Zoomed in subset of the degrees of slope map with the lowest risk value, shown in green, assigned to steeply sloped areas within the study site.

4.7 PROTECTED AREAS

The effect of Protected areas was added as a final step, after all risk parameters discussed above were combined into 1 risk map. For the purposes of this mapping exercise, it is assumed that protected areas have a very low risk of forest loss, while buffer areas within a buffer zone in a protected area have a slightly higher risk of forest loss.

Data for protected areas was sourced from the International Centre for Integrated Mountain Development (ICIMOD), shown in Figure 15. Buffer zones around the edges of protected areas were defined by ICIMOD.

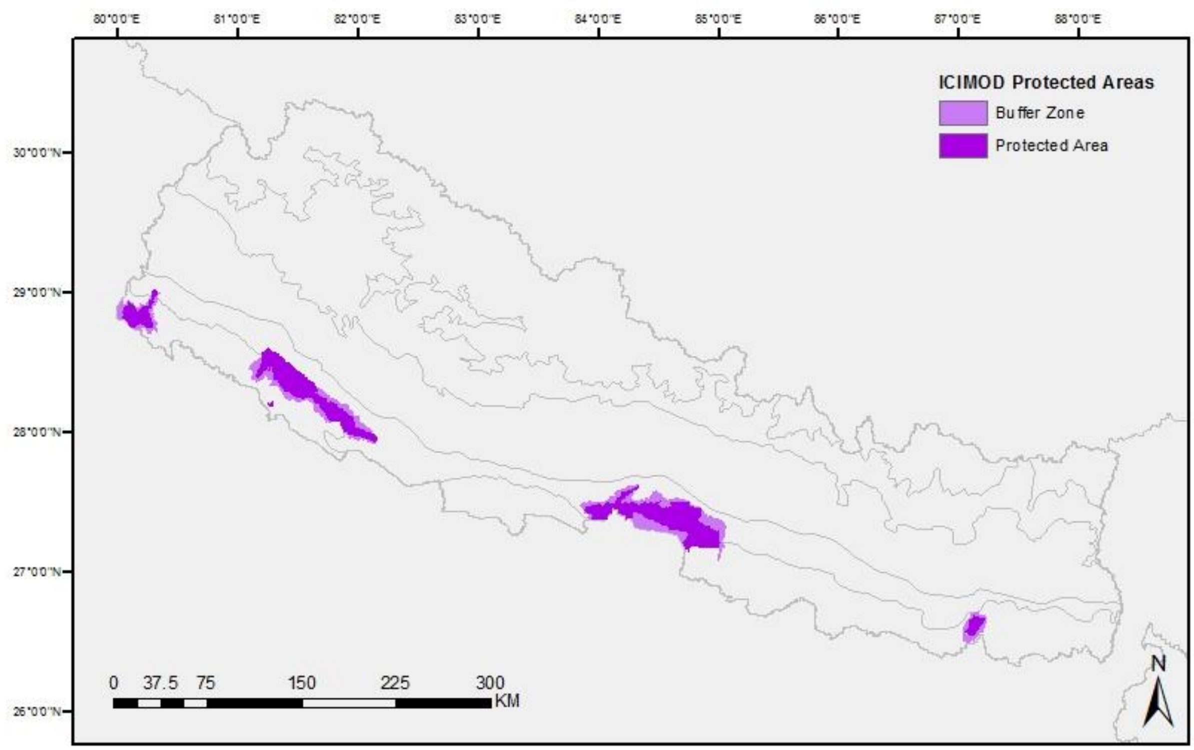

Figure 15: Map of Protected Areas within Terai & Churia sourced from ICIMOD, with buffer areas as defined by ICIMOD shown in light purple.

The following protected areas and buffer zones as allocated by ICIMOD were included in this analysis:

Shuklaphanta Wildlife Reserve, Bardiya National Park, Bank National Park, Krishnasar Conservation area, Chitwan National Park, Parsa Wildlife Reserve and Koshi Tappu Wildlife Reserve

All protected areas were reclassified as very low risk, while areas within a buffer zone in a protected area were assigned one risk value lower than previously assigned due to risk from proximity to roads and past deforestation, shown in figure 16.

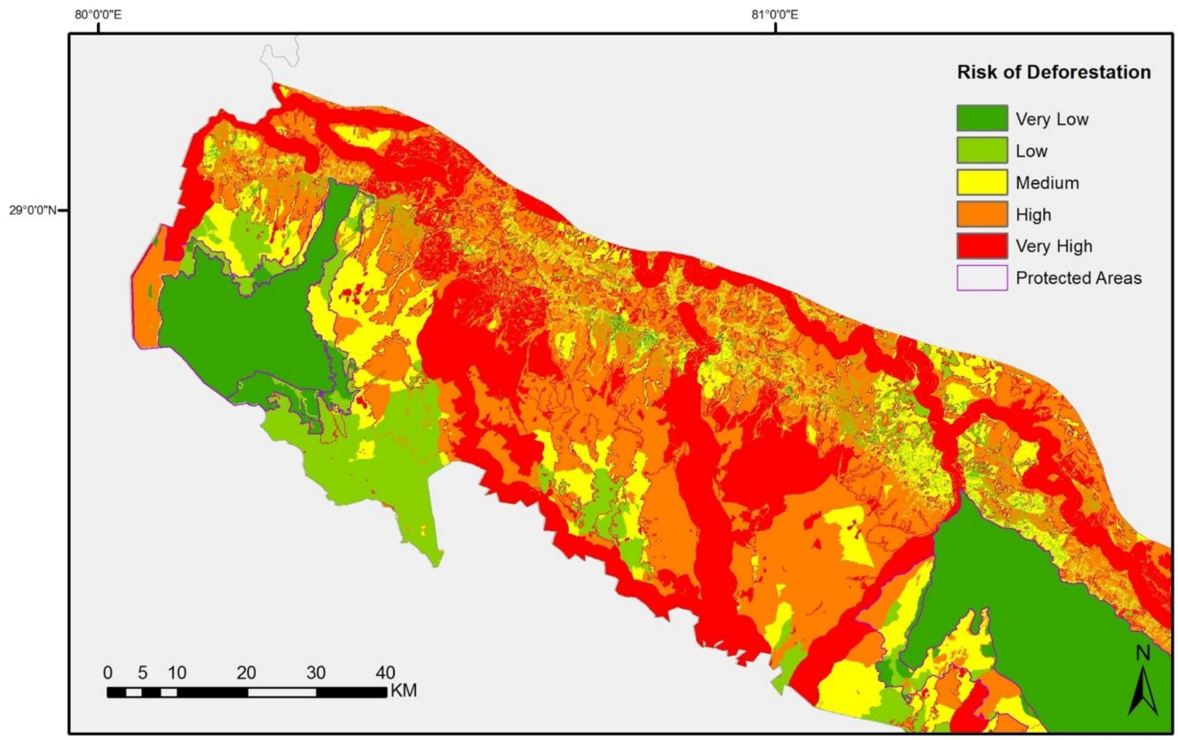

Figure 16: Suklaphanta Wildlife Reserve and Bardia National Park shown with buffer zones, with areas falling within a buffer zone in a protected area were assigned one risk value lower than as previously assigned without protection status

5 METHODS AND CALCULATIONS

The total risk of deforestation for the Terai and Churia regions of Nepal was calculated using the risk parameters described above. First, risk values from 1 to 5 were assigned as follows:

- Areas in close proximity to rivers were assigned risk values of 4 and 5.
- Areas in close proximity to roads were assigned risk values of 4 and 5.
- Forest edges, small isolated forest patches, inner forest edges and core areas < 100ha in size were assigned values of 5, 4, 3 and 2 respectively, while all other areas were assigned the lowest risk value of 1.

- The population density map at VDC level was assigned values 1 to 5 according to a quantile classification.
- Areas denoting risk based on proximity to past deforestation (derived from the density map) were assigned values 1 to 5. .
- Areas with low slopes (0 to 30°) were assigned the highest risk of 5. Slopes between 31 and 45° were assigned risk values of 3, slopes of over 45° given the lowest risk 1.

These layers were added to obtain a map of combined risk values for risk due to accessibility, cultivability and extractability. The resulting map contained risk values of between 12 and 30. The values were then classified into 5 classes using a quantile classification. This combined risk map was then adjusted to take into account the effect of protected areas: risk values in areas under protection were reclassified to the lowest risk (i.e. risk value 1), while buffer zones within protected areas were assigned one risk value lower than their combined risk. As a last step, the final risk map was overlain by the forest extent map to show the risk categories for forest areas (see Fig. 20).

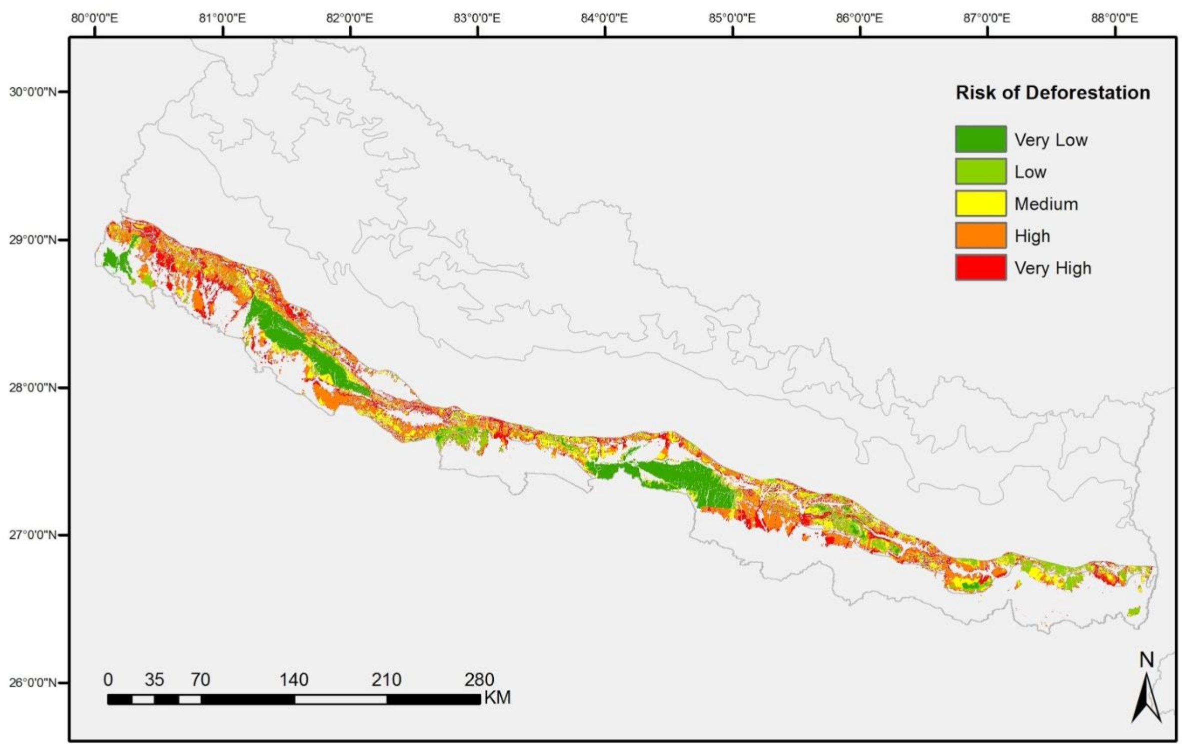

Figure 20: Map showing final risk of deforestation for forested areas in the Terai and Churia regions of Nepal, based on proximity to roads, rivers and forest edges, past deforestation, population density, slope and protection status of lands. High risk areas are represented in red, while low risk areas are in green. All protected areas were assigned the lowest risk value of 1

6 NOTE ON FURTHER WORK

Risk assessment is an inexact science as the drivers of land use change can vary according to economic trends, new policy developments and environmental changes (droughts, floods, etc).

The ACEU method of risk classification could incorporate finer scale data as this becomes available for the area as a whole, and further refined with local inputs and weightings for existing or additional deforestation drivers. However, there is a danger of attempting to create fine scale risk assessments in situations that are inherently unpredictable. Several potential current and future datasets were identified through collaboration with local organisations, institutions and government departments which could help improve the accuracy and detail of the risk map outputs in time. These include data on the percentage of the population reliant on wood fuel sources at Village Development Committee (VDC) level and a spatial cost-distance analysis used to calculate travel distances and barriers.