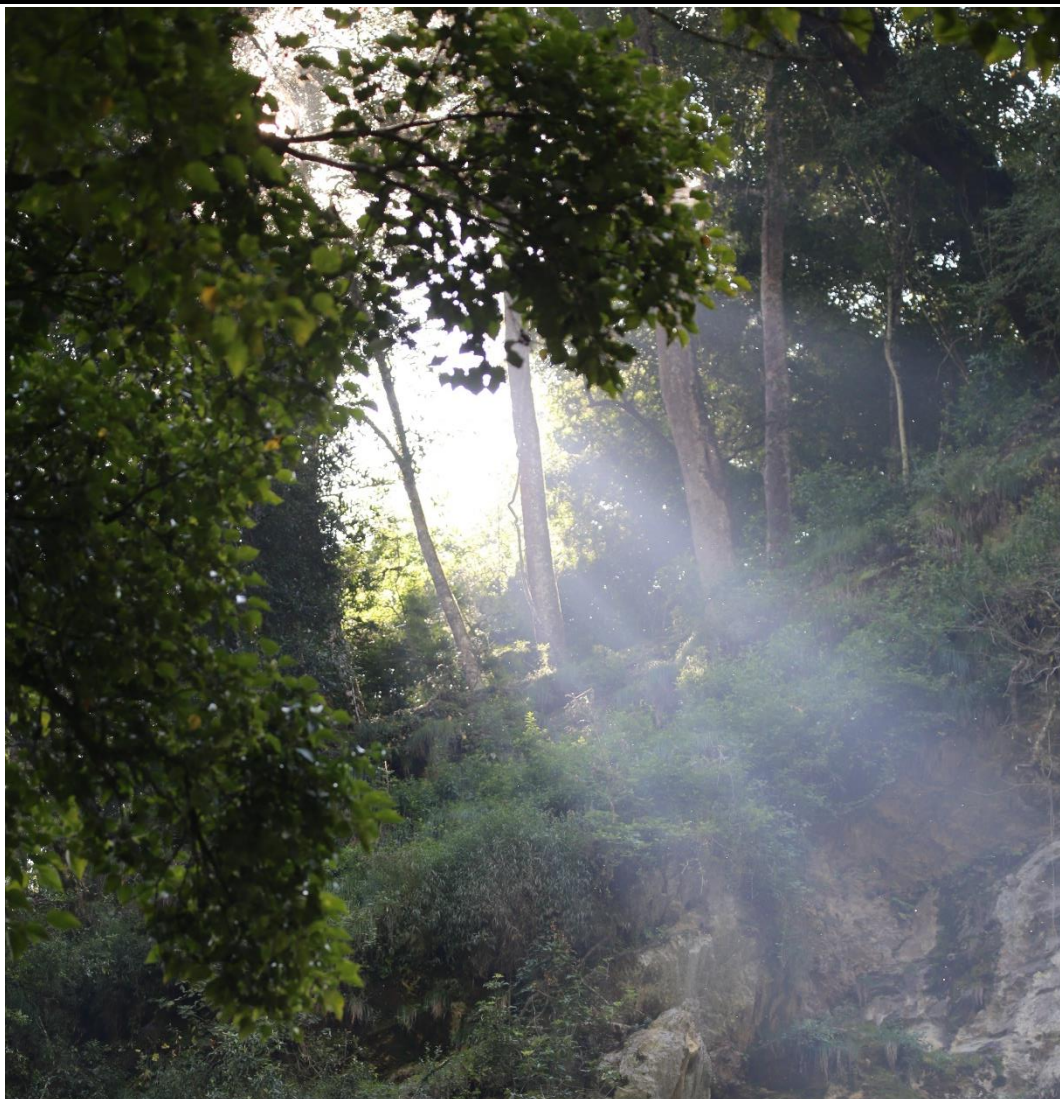# Forest Cover Loss Mapping

Name of Project: 118 MW Nikachhu Hydropower Project

Location: Tangsibji Gewog

Assessment Date: May 7- July 20, 2022

Prepared by:

Environment Unit, Tangsibji Hydro Energy Limited
for
118 MW Nikachhu Hydropower Project.

Table of Contents

List of Figures

Acronyms

ADB	Asian Development Bank
BPC	Bhutan Power Corporation Limited
DC	Direct Current
DoFPS	Department of Forest & Park Services
EIA	Environment Impact Assessment
FRL	Full Reservoir Level
Km	Kilometer
Ha	Hectare
LULC/LCMP	Land Use Land Cover Map
MW	Mega Watt
MHPA	Mangdechhu Hydro Power Authority
MoU	Memorandum of Understanding
NHPP	Nikachhu Hydropower Project
RoW	Right of Way
SPS	Safeguard Policy Statement
THyE	Tangsibji Hydro Energy Limited
TL	Transmission Line

Executive Summary

For the construction of the hydropower project, numerous project components are required to be established which involves development of access roads, contractor construction facility(colony, stock yards), muck yards and 33 kV TL. These pre-construction activities require felling of enormous number tress and clearing of vegetation. To offset the damaged area on the forest, afforestation for the project was initially proposed to carry out double the project disturbed area. As per the forest cover loss assessment carried out for the 132 kV TL of the project dated August 21, 2021, it was learned that the project falls in various land types areas such as forest land, shrub land, meadows and built up areas. The afforestation program to be taken up based on the actual impact area of forest. From the forestry aspect, the land use such as shrub, meadows, built up infrastructures should be excluded while determining the project impact area.

To ascertain the forest cover loss by the project, an assessment was carried out from May 7 to June 20, 2022 consisting of repeated field visit with use of LULC/LCMP Maps, Google Earth imagery, print copy of the disturbed areas, SW Maps, GPS. As per the current findings, only 53.116 hectares (131.25 acres) of forest area was cleared for the development of the project components. The afforested area was equitable to the area impacted on the forest by the project.

1.0 Introduction

118 MW NHPP is located in Tangsibji Gewog under Trongsa Dzongkhag. The power generated from 118 MW NHPP will be evacuated through 18.6 km to pothead yard of MHPA. As per the requirement of the National Regulation and Asian Development Bank SPS, the EIA for the 132 kV DC transmission line was originally prepared in 2012 by the Bhutan Consultants and Research (BHUCORE). The EIA was later revised on May 2014 with inputs incorporated after stakeholder consultation. The EIA covers two parts: Part-I for the Main project and Part-II for the 132 kV DC TL. Tangsibji Hydro Energy Limited being a subsidiary company of Druk Green Power Corporation is an implementing agency to ensure that the project environmental and social measure fulfills the requirements of the national regulations and ADB SPS.

Aside from the alternative measures adopted during the EIA, development of the muck yards, colony's, worker camps, stockyards, storerooms was relocated to barren land and built up areas during the construction period with the intention to reduce impact on forest. To offset the bio-diversity loss especially with regard to loss of forest cover area in the project area, the **"Compensatory Afforestation Program"** was implemented by Department of Forest & Park Service. Under the fund support by the project, the program kick started in 2016 and ended in 2021. Total of **105 hectares** of area was brought under afforestation program. The plantation was carried out in barren land, community forest, degraded forest and watershed area in the catchment area. As part of meeting the national and ADB safeguard requirement, the project was required to initiate afforestation double the affected area. The project has leased 194.502 acres of state reserve forest land for the development of the project components listed in above line. Aligning with the afforestation program proposed during the EIA and EMP, the project will require to take up 389.006 acres (194.502 acres x 2) or **157.42 hectares** (78.71 hectares x 2).

2.0 Scope:

1) To ascertain the actual forest cover loss caused by the project;
2) Ensure compensatory afforestation program are implemented in a manner double the impact on forest area by the project.

3.0 Project location

The project is located in Tangsibji Gewog under Trongsa Dzongkhag where it stretches over 25 km from the Dam, Lorim to the Power House, Norbuodi with a 11.998 km Head Race Tunnel (HRT). The Environmental Clearance (EC) for development of 118 MW NHPP and 132 kV TL was obtained from National Environment Commission of Bhutan on July 01, 2014 and November 28, 2014 respectively. The clearance are renewed for pre-construction period which is valid till June 2023.

With an estimated energy generation of 491.52 MU, 85 % shall be exported which will not only enable revenue generation for Bhutan but also reduce Green House Gas emission in the neighboring countries by replacement of fuel by clean and renewable energy, hydropower. Further, the outflow from the project into Mangdechhu reservoir will provide additional energy generation of 323.77 MU to Mangdechhu Hydropower Authority.
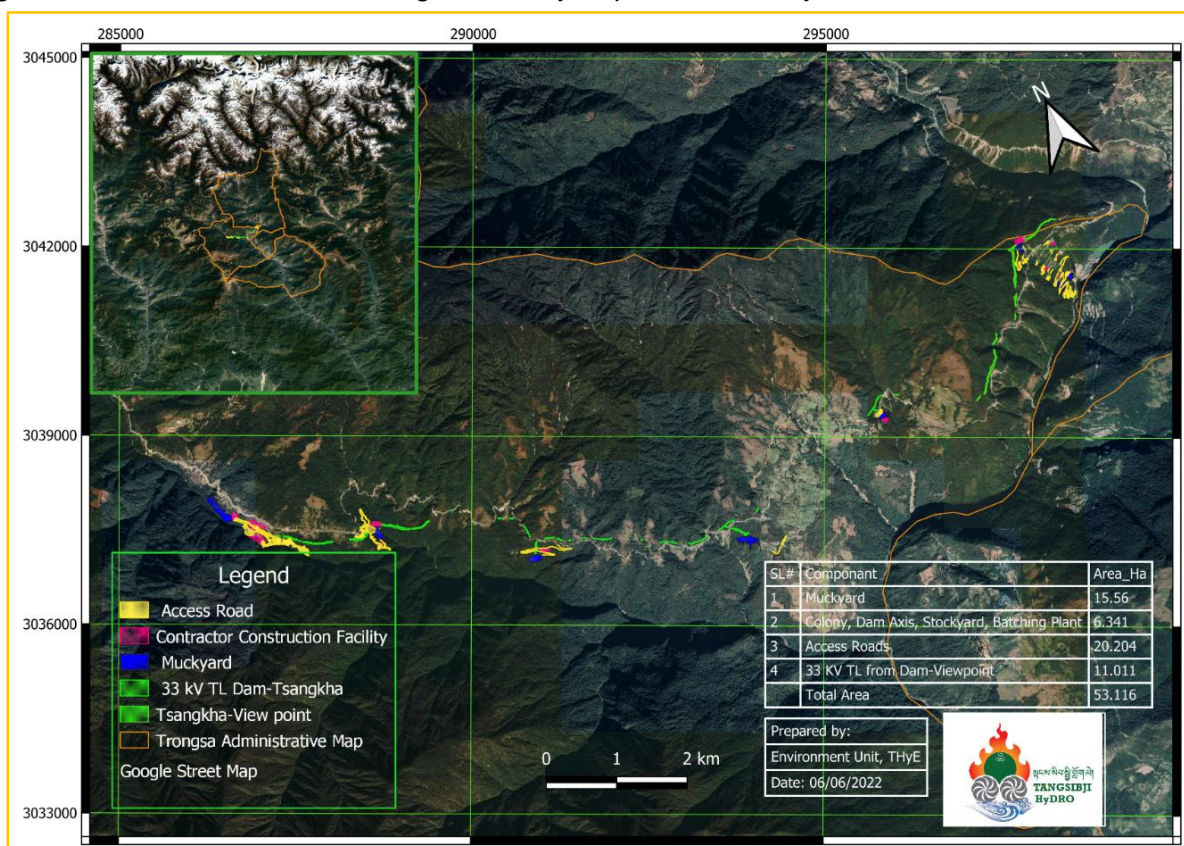

Figure 1: Location map showing project component developed in Tangsibji Gewog, Trongsa Dzongkhag.

4.0 Materials

The forest cover loss mapping for the project was carried out with reference to the definition of the forest given below:

1. Forest and Nature Conservation Rule, Bhutan (2017), forest is a land with tree spanning more than 0.5 ha with tree higher than 5 meter and a canopy more than 10 percent.
2. Forest Resource Assessment (2010), Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.
3. Forest cover loss due to hydropower projects and transmission lines, DoFPS (2019).

4.1 Data & Software

The main data and software used in this study are:
- Coordinates of the Muck yards, contractor construction facility's, tower footings, colony's and coordinate of the access roads was picked up by surveyor using Differential Global Positioning System (DGPS).
- Bhutan Land Use Land Cover Map (LCMP) 2010.
- Historical Imagery of Google earth 2003, 2006, 2010, 2014, 2017, 2020, 2022.
- SW Maps, GPS, Total Station Survey, DGPS.
- Software: QGIS & Google Earth Pro.

5.0 Methodology

Remote sensing plays a crucial role for the management of forest resources, habitat assessment and land degradation over a period of time. For the project, Google Earth has been used as it is widely used by many sectors as it is free and open source. As per the Forest cover loss due to hydropower projects and transmission lines, (DoFPS, 2019), the Google Earth have spatial resolution ranging from 15 m to 15 cm (FRMD, 2019). In addition to this, the Google Earth provides satellite imagery taken at different interval of time which enable to detect changes.

Initial coordinates of the project components such as access roads, muck yards, workshops, colony, stock & store yards, 33 kV TL picked by total station and Differential Global Positioning System were imported in Google earth and then Bhutan LCMP (2010) prepared by the MoAF with resolution of 10 m was overlaid to visualize the Google Earth Imagery and classification of the land use. Accordingly, the disturbed areas are manually delineated and classified as muck yards, access roads, contractor construction facilities such as colony's, Dam axis, stockyards, Batching Plants. The coordinates of the 33 kV TL poles was also imported to Google Earth to simulate disturbed area along the 12 meter right of ways from Dam to View point. Refer figure 2, 3, 4, 5 & 6.

During the initial desk assessment, it was observed that some of the classified project components falls in hill side or shade area where manual delineation was not possible. For this, drone images was used wherein slide caused by the construction of the access roads was also delineated. Refer figure 7, 8, 9,10,11,12. Followed by this, the initial field verification

was carried out using numbers of plotted coordinates in SW Maps and also in hard copy. This was also done to manually validate the accuracy achieved by SW Maps and Google Earth image. Refer figure 13 & 14.

With help of the LCMP 2010, comparative Google Earth imagery of 2003, 2006, 2010, 2014, 2017, 2021 and 2022, determining the forest area was convenient for delineation. Refer figure 16.1 to 22.2. The delineated forest area was imported in Qgis to calculate the forest cover loss.
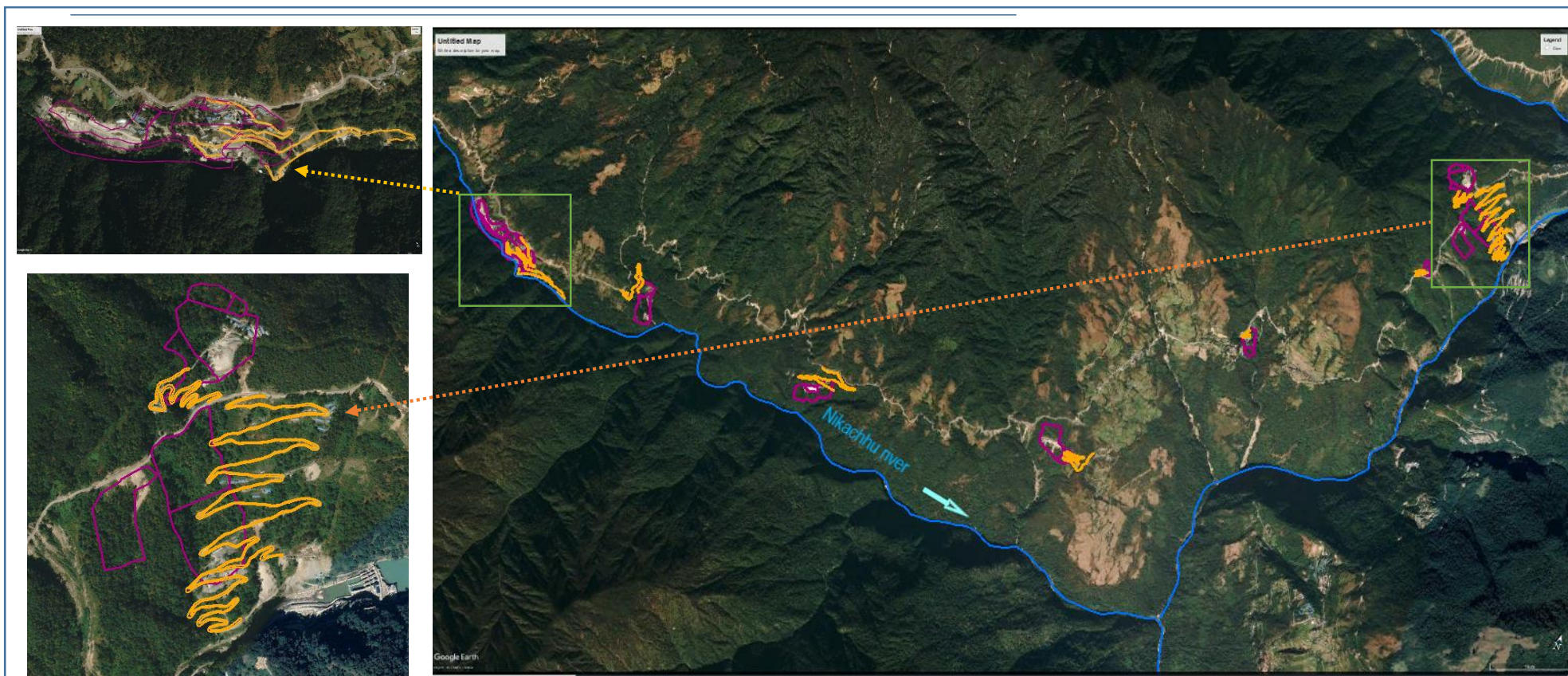
Figure 2: Cadastral Map of project componant of Head work, HRT & Power House & 33 kV TL
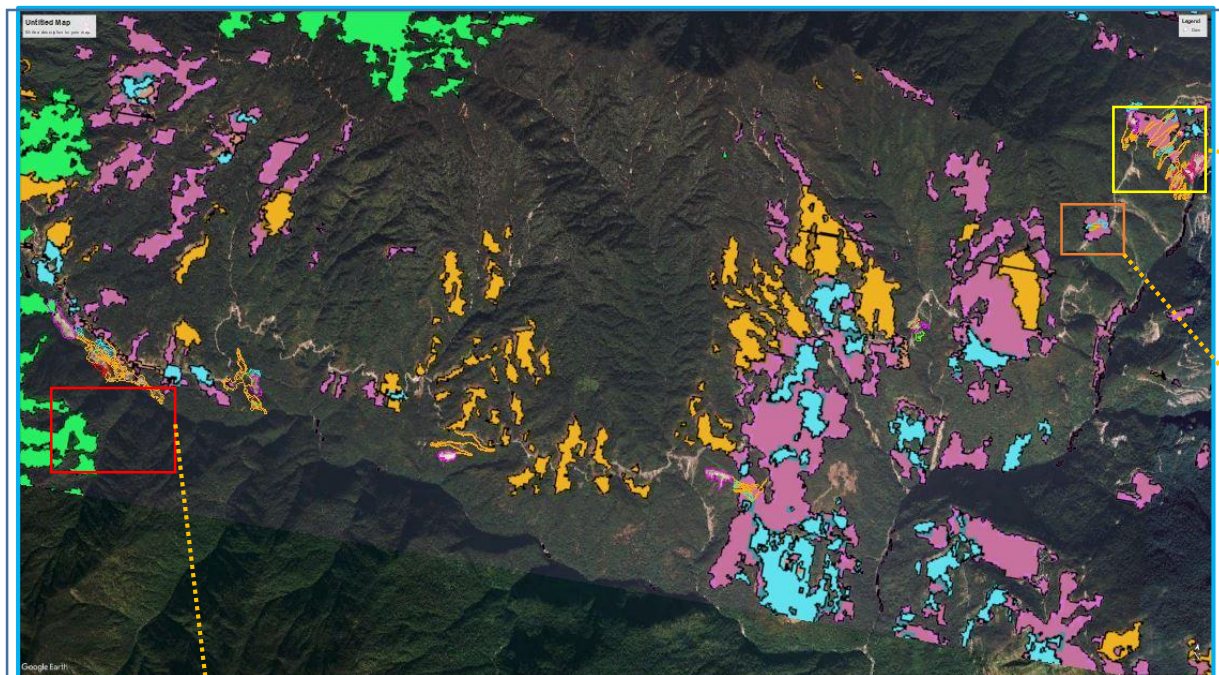
Figure 3: LCMP 2010 overlaid over project cadastral map

Figure 4: Muck yard of SS, access road, colony developed in shrub land

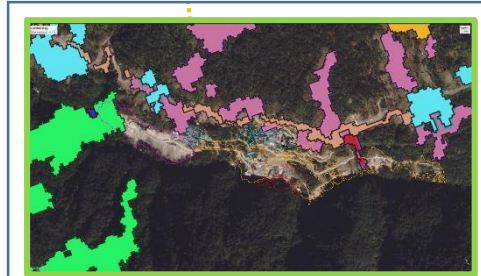Figure 5: Workshop developed in shrub land as per LCMP 2010

Figure 6: Dam component such as muck yard, access roads, dam axis and colony's developed on mix conifer forest, broadleaved forest, shrub land, agricultural & landslide area
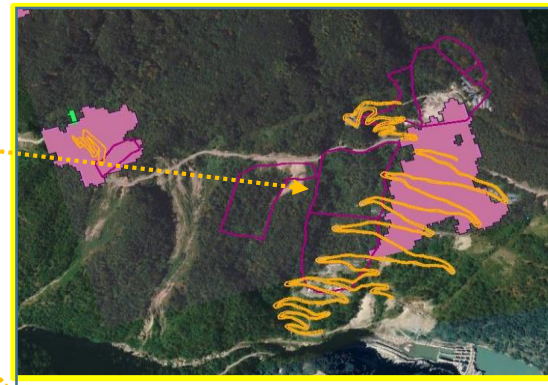
Figure 7: Left bank of Dam not visible in the Google Earth image

Figure 8: Left bank of Dam visible using drone image & delineated for land use classification

Figure 9: Left bank of access road to Dam no visible in Google Earth image

Figure 10: Left bank of the access road to dam visible & delineated for classification of land use using drone image
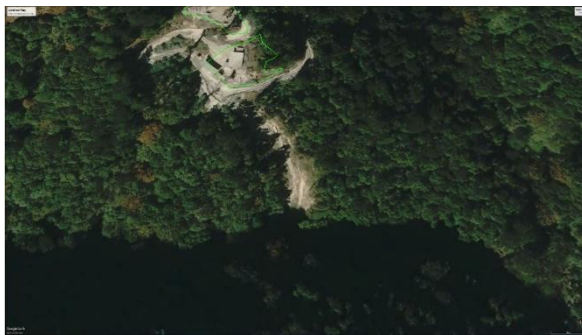

Figure 11: Landslide area along access road of Adit-I in Google Earth image

Figure 12: Landslide area delineated using drone image

Figure 13: Delineated polygon at site by plotting points in SW Maps

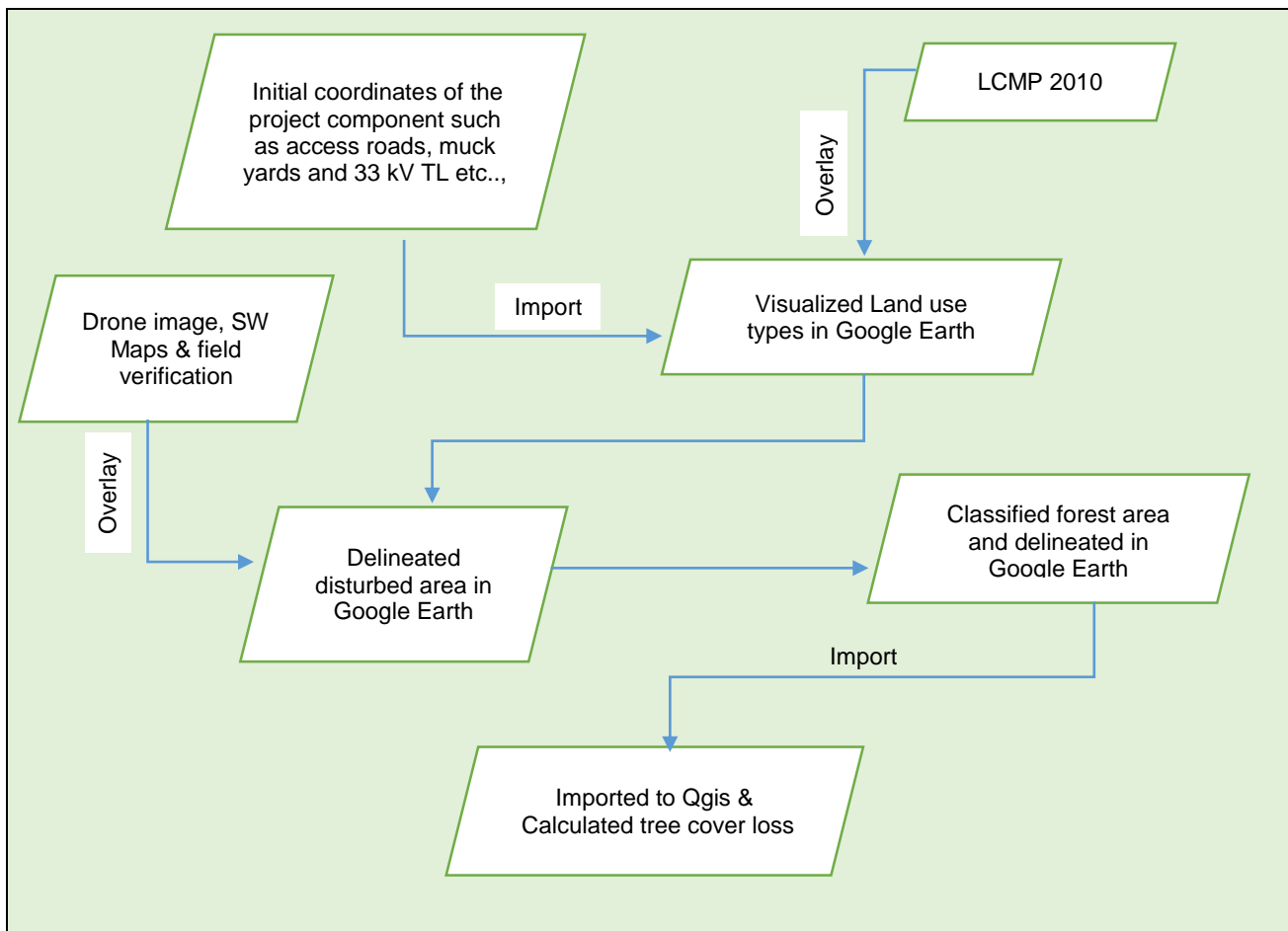Figure 14: Coordinates from SW Maps are imported in Google Earth

Figure 15: Flow chart for forest cover loss analysis for project component

Figure 16.1: Forest area cleared by Dam component as of 2022

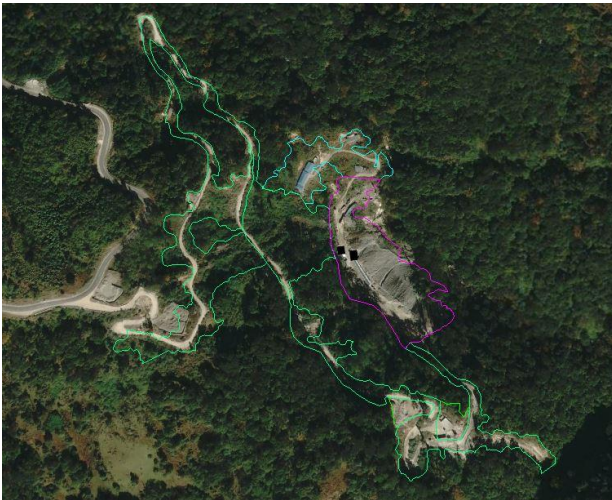Figure 16.2: Forest cover at the dam site in 2014

Figure 17.1: Forest area cleared by Adit-I component as of 2022
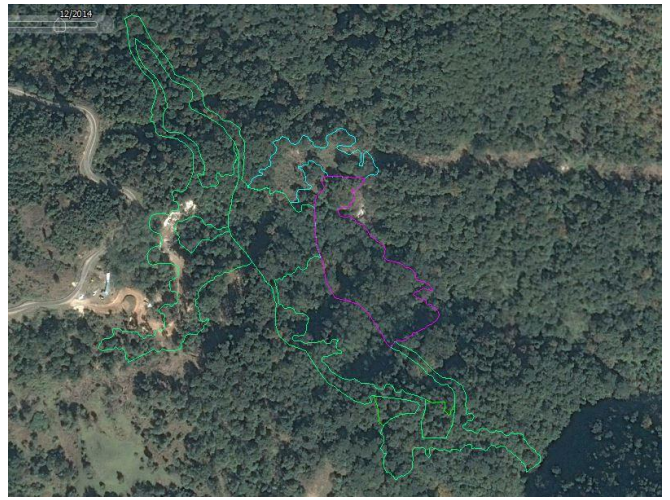

Figure 17.2: Forest cover at Adit-I in 2014

Figure 18.1: Forest area cleared by Adit-II component as of 2022

Figure 18.2: Forest cover at Adit-II in 2014

Figure 19.1: Forest area cleared by SS, IPS & PH component as of 2022

Figure 19.2: Forest cover at SS, IPS & PH in 2014

Figure 20.1: Forest area cleared by muckyard at Adit-II as of 2022

Figure 20.2: Forest area cleared in patches during development of muckyard at Adit-II

Figure 21.1: Forest are cleared by access road & Muck yard at Power House as of 2022

Figure 21.2: Status of the Forest cover at Power House in 2014
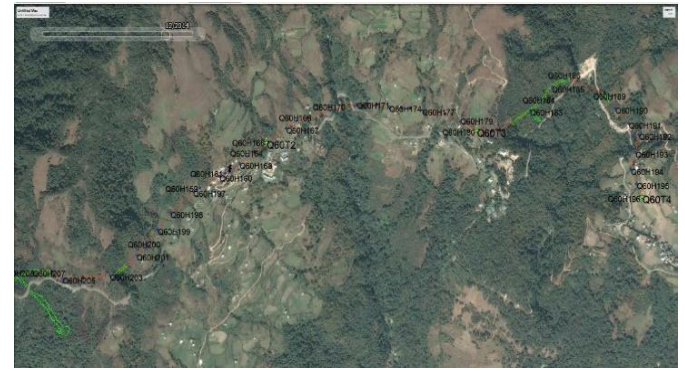
Figure 22.1: Forest area cleared by 33 kV TL as of 2022

Figure 2.2: Forest cover along the 33 kV TL from Adit-III to Tsangkha in 2014

6.0 Results

With manual digitization of the disturbed area and forest area through use of Google Earth images, SW Maps and with repeated field visit, the delineated forest cover area was converted to shape file and imported in Qgis to calculate the area. The forest cover loss measured 53.116 hectares.

Figure 23: Forest area cleared by project component

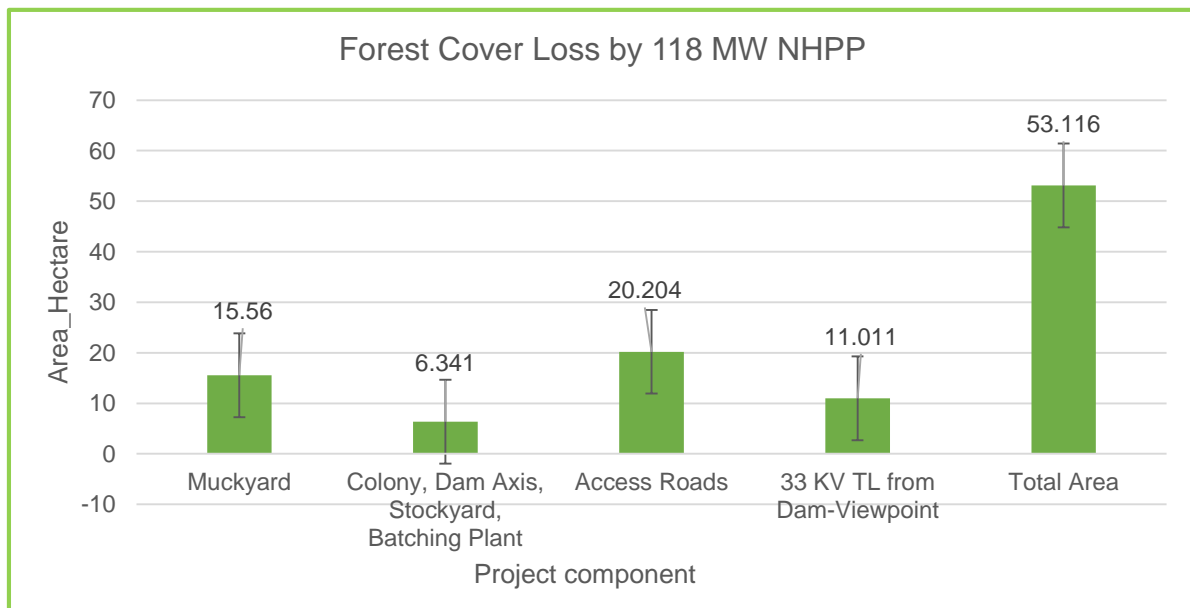## 7.0 Findings;

The current assessment excludes submergence area as the tree removal program is yet to be initiated by the Natural Resources Development Corporation Ltd in July 2022. The submergence area measured 3.008 Hectares (7.413 acres) as per total station survey data provided by the M/s HCC. The forest area cleared by the submergence area will be offset while rejuvenating the muck yards, existing colony's, office and stockyards by the M/s HCC during the project commission phase.

It was also observed that the right bank of the submergence area falls in shade area and not accessible considering its steep gradient and out crop cliff. Refer figure 16.1, picture 1.5 & 1.6. Based on these findings, it is being recommend to carry out a drone survey once before and after removal of the trees in submergence area. .

Conclusion:

The current assessment is an attempt to demonstrate only the actual forest area cleared by the existing project component such as access roads, muck yards, contractor construction facility and 33 kV transmission line.

DoFPS has initiated implementation of the compensatory afforestation program for the project in 2016 and with completion of the program in 2021, 105 hectares of area was brought under the afforestation program. As the program was initiated during the pre-construction phase, ascertaining the actual impact on forest area by the project was required. As per the current assessment, 53.116 hectares of forest area was cleared by the project. The total afforestation required by the project would be 106.232 hectares (53.116 *2).

During June 5th 2021, THyE has brought 2.1 hectare (5.12 acres) under plantation area. Considering the plantation created by the DoFPS and THyE, the compensatory afforestation stands equal to the forest area cleared or impacted by the project.

For the future hydropower, a drone survey is recommended for the pre and post impact assessment considering its high resolution and accuracy attainment use in remote sensing.

Acknowledgements

On behalf of THyE management, the Environment Unit would like to extend our gratitude to DoFPS and GBCL for successfully implementing the compensatory afforestation program of the project. The project also would like to thank Chariman & members of the TCBEM for giving directives and also conveys sincere gratitude to BFTD; Ranger Tashi Gis Focal, Trongsa Range Office; Ranger Jigme Tshering and DGPC; Sr. Environment Officer Tandin Tshering, THyE; Safety officer Lungten Jamtsho for sharing your knowledge, advices and support.

Appendix
Supporting pictures

Picture 1.0: Ongoing construction of Dam

Picture 1.1: Tree removed for development of worker colony

Picture 1.2: Gabion wall constructed at the base of the upstream muck yard of Dam

Picture 1.3:Trees falling under FRL 2292 m in reserviour area

Picture 1.4:Trees removed for development of muckyard

Picture 1.5:Left & right bank slope upstream view from Dam

Picture 1.6:Right bank & left bank slope downstream view from upstream muck yard

Picture 1.7:Trees & vegetation cleared along the access road connecting ADC- Dam axis

Picture 1.8:Trees removed from muckyard of Adit-II

Picture 1.9:Observed vegetation at right bank RD 35 m upstream of existing Diversion tunnel.

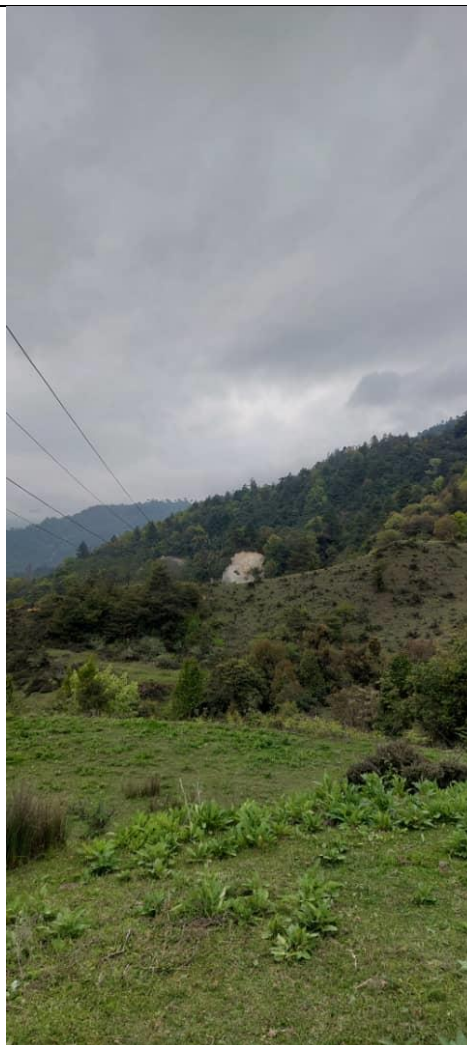Picture 2.0:Field validation using SW Maps to draw polygon using plotted points

Picture 2.1:Using printed copy of the delineated disturbed areas and tools

Picture 3.0:Vegetation not cleared for line stringing of 33 kV TL at Banglapokto subject to meeting the clearance height

Picture 3.1: Vegetation cleared along 33 kV TL row at Nyelamchhu area

Picture 3.2: Shrub land along 33 kV TL row at Bagnlapokto