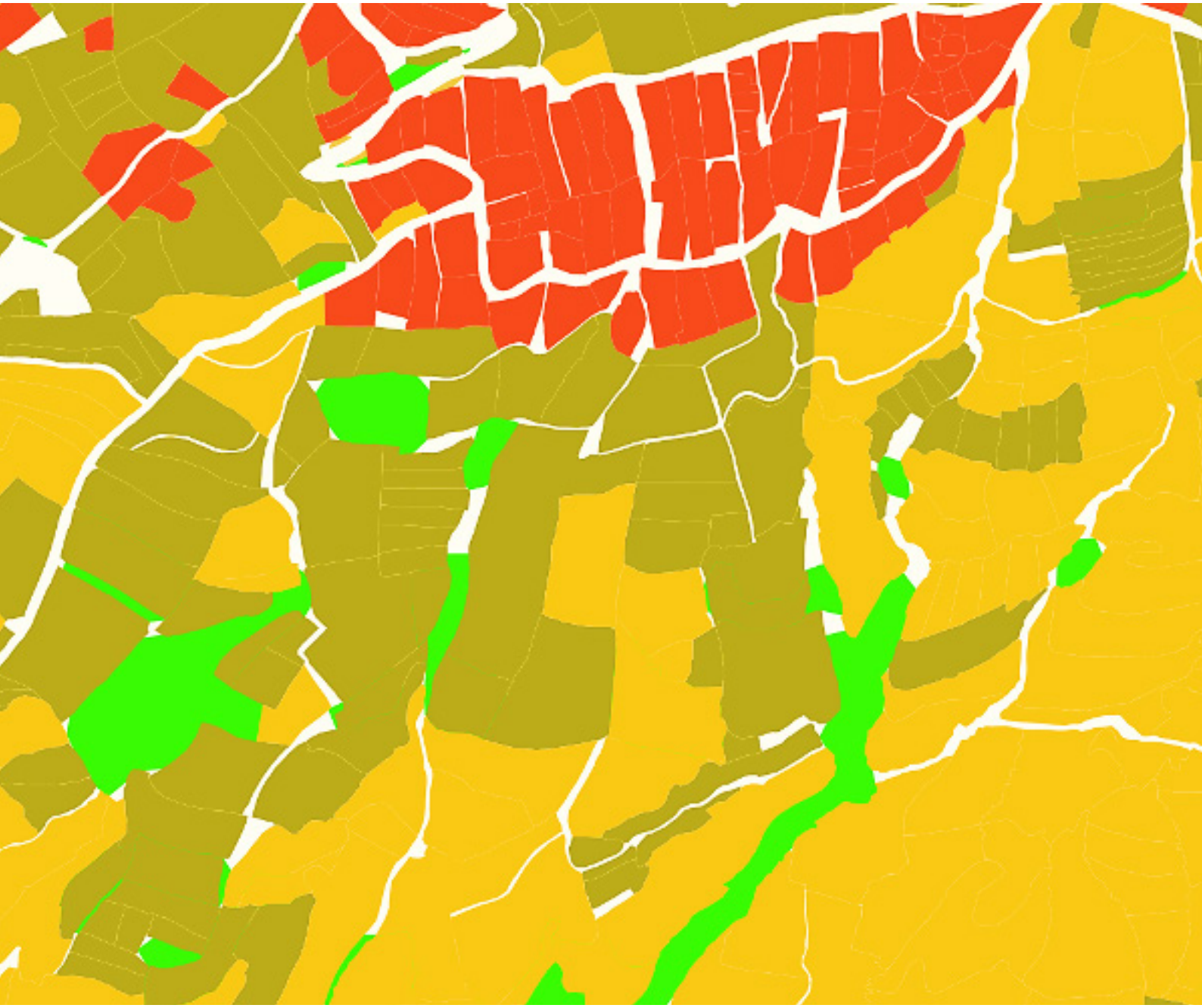
National Land Use Zoning Technical Framework

(NLUZ-TF 2021)



National Land Commission is working together with partners to secure High Conservation Values in south-western Bhutan

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‘This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag.’

Supported by:

Federal Ministry
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REVISED TECHNICAL FRAMEWORK OF 2019

Department of Survey & Mapping
National Land Commission Secretariat

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Foreword

With the commencement of National Land Use Zoning (NLUZ) project since 2018 by National Land Commission Secretariat (NLCS), two main documents were produced upon thorough consultation, research and cross sectoral collaboration: National Land Use Zoning - Implementation Guidelines 2018 (NLUZ-IG 2018) and National Land Use Zoning - Technical Framework 2019 (NLUZ-TF 2019).

NLUZ-IG 2018 provides the guidance of management, policy interventions and the outcome of the project. However, NLUZ-TF 2019 specifies the technical process involved therein.

NLUZ-TF 2019 was prepared in view of the technical capability of the agencies as in 2018. However, the current technical team faced some setbacks in the project guidelines specifically the parameterization by the concerned agencies and lack of reliable spatial data.

The current NLUZ technical working team has come up with a pragmatic approach of result based data acquisition and processing techniques so as to deliver the output data anticipated as in NLUZ-IG 2018. Thus, the revised technical framework is approved in view of overall developments from 2018 through 2021.

This Revised Technical Framework (NLUZ-TF 2021) is adopted in view of current status and expected for further improvisation, should there be better inputs available in future. Nevertheless, the framework shall deliver the output as anticipated, if not, better.

The revision of the Technical framework and its subsequent guideline formulation was undertaken with financial support from WWF, Bhutan through the IKI: Living Landscape project.

(Director)

Department of Survey & Mapping

National Land Commission Secretariat

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Acronym and Abbreviation

NLUZ	:	National Land Use Zoning
GNHC	:	Gross National Land Happiness Commission
NLCS	:	National Land Commission Secretariat
MoAF	:	Ministry of Agriculture and Forest
MoWHS	:	Ministry of Works and Human Settlements
MoEA	:	Ministry of Economic Affairs
TF	:	Technical Framework
LULC	:	Land Use Land Cover
NEPA	:	National Environment Protection Act
FNCA	:	Forest and Nature Conservation Act
MCDA	:	Multi Criteria Decision Analysis
SRFL	:	State Reserve Forest Land
SNAP	:	Sentinel Application Platform
AHP	:	Analytical Hierarchy Process
CI	:	Consistency Index
GPS	:	Global Positioning System
GIS	:	Geographic Information System
ESA	:	European Space Agency
OBIA	:	Object Based Image Analysis
RF	:	Random Forest algorithm
LG	:	Local Government
WWF	:	World Wildlife Fund
HCV	:	High Conservation Value

1. INTRODUCTION

National Land Use Zoning (NLUZ) has been initiated as one of the major collaborative activities in the 11th FYP and spilled-over to the 12th FYP. National Land Commission (NLCS) in consultation with the Gross National Happiness Commission (GNHC) was supposed to lead the coordination of this particular program with an objective of realizing the effective management and sustainable use of limited land resources through sound national land-use planning complemented through the use of geo-information data.Following the adoption of the NLUZ project by the National Land Commission Secretariat, the National Land Use Zoning Implementation Guideline 2018 (NLUZ-IG 2018) and National Land Use Zoning Technical Framework 2019 (NLUZ-TF 2019) were published as reference documents for the project team.

NLUZ-IG 2018 details on overall project execution plan and the policy guidance. On the other hand NLUZ-TF 2019 describes the technical aspects of the project execution and technical outputs thereof. It also has a specific timeline for each output with responsibilities assigned to officials concerned.

In accordance with NLUZ-IG 2018, by the end of 2021, the project should have completed Phase 1 and Phase 2. However, some of the activities under these phases could not be achieved due to various reasons. Of several causes, one of the main reasons was due to the limitation in the technical framework (NLUZ-TF 2019).

Some of the challenges encountered during implementation of NLUZ-TF 2019 are as follows:

I. Inability to provide zone specific parameters by relevant sectors and agencies

II. Unreliability of available data / unavailability of data

III. Impractical methodology of parameterization and data acquisition

IV. Change in technical team composition

Compared to the 2019 Technical Framework, this revised framework is designed to enable the achievement of the NLUZ project objectives through a pragmatic process. It will provide an overarching strategic technical framework for the overall project implementation. Unlike the previous Technical Framework, the current TF will have three components as outputs: (1) Land Use Land Cover (LULC), (2) Alienable Land and (3) National Land Use Zone (NLUZ) map. This technical framework will be the basis for formulating subsequent guidelines to implement each component of the project output.

2. SCOPE OF THE DOCUMENT

This document will provide an overall framework based on which subsequent technical guidelines shall be formulated. The framework is strategically structured into three outcome-based components. It forms the basis for the formulation of the following technical guidance document, which describes the practical approach to enable robust implementation of the three components of the framework.

The document shall be referred to as the National Land Use Zoning Technical Framework 2021 (NLUZ-TF 2021).

3. OBJECTIVES

The main objectives of NLUZ TF 2021 are:

1. To provide a strategic roadmap for the NLUZ project
2. To succinctly define the technical deliverables and timeline
3. To serve as the basis of technical guidelines for robust implementatio

4. LEGISLATIVE COMPLIANCES

The outputs shall be produced in compliance with relevant existing laws and regulations:

- Forest and Nature Conservation Rules & Regulation 2017
- Forest and Nature Conservation Act of Bhutan (1995)
- Operation and Maintenance Manual for Transmission Lines
- Road Act of Bhutan 2013
- Land Act of Bhutan 2007
- Cultural Heritage Bill of Bhutan 2016
- Other relevant documents

5. ZONING FRAMEWORK

The overall technical framework for conducting national land use zoning is illustrated in the following figure no.1. It is organized into three main components with corresponding key outcomes, namely Land Use Land Cover (LULC) Map, Alienable Land and NLUZ map. This framework clearly describes the task components with corresponding methods for execution and end results. Each of the task components and their outcomes are described as follows

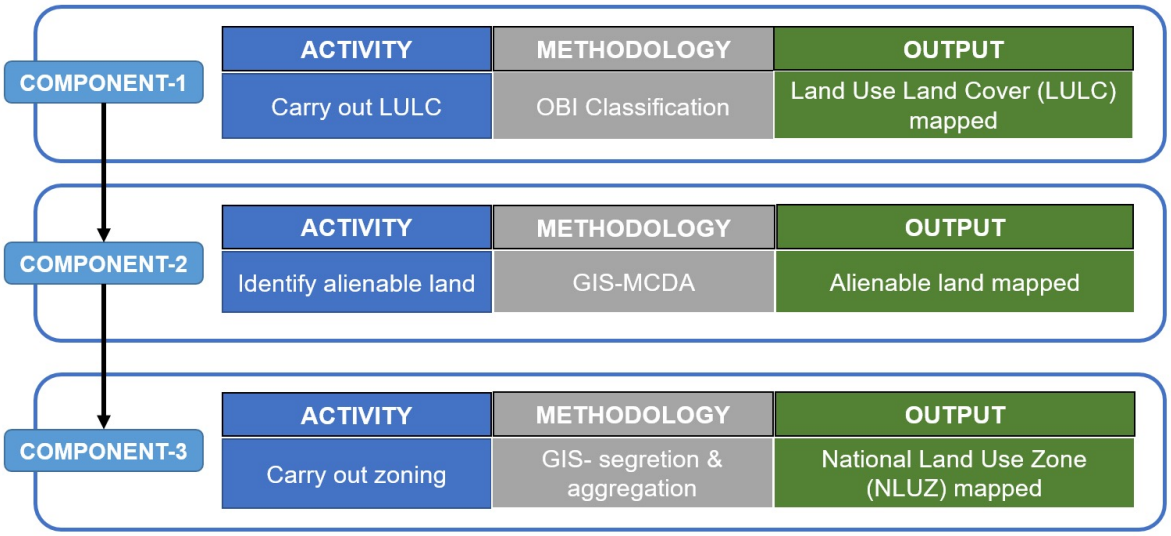


Figure 1: Overall technical NLUZ framework

Component-1 of the framework is to perform object-based image classification (OBI) of satellite imagery and produce the latest national LULC maps. This is necessary because it can be used as one of the primary inputs for identifying usable/alienable land.

Component-2 takes the output of Component-1 (LULC) in combination with the existing and available data such as topographic, thematic, environmental, social, economic and disaster data as input parameters and identifies alienable land using the GIS -based Multi Criteria Decision Analysis (MCDA) process.

In Component-3, the existing and relevant cadastral, environmental including High Conservation Value (HCV) data and information shall be used to generate the provisional zones through the GIS -based land type segregation. The final land use zone maps are then generated by inputting the provisional zones and net alienable land through the GIS -based aggregation process.

The following section describes, outlines and rationalizes each component of the frameworks.

5.1. COMPONENT-1: LAND USE LAND COVER

5.1.1. Definition

The term Land use and Land cover (LULC) although often used interchangeably have specific meaning. Land use refers to the purpose of land that is served for specific usage. e.g. recreation, agriculture, industry etc. Land cover refers to the surface cover on the ground like vegetation, urban infrastructure, water, bare soil etc. In general, LULC represents the spatial information on different types (classes) of physical coverage of Earth's surface.

The aim of the LULC mapping is to provide thematic information on different land use categories, which could be used in spatial planning development approaches.

5.1.2. Methodology

Image classification will be carried out based on the Object Based Image Analysis (OBIA) technique using the machine learning algorithm known as Random Forest (RF). This method has shown significant improvement in classification accuracy over other types of classification techniques such as Unsupervised and Supervised image classification techniques *(Robert C.Weih, 2008)*. RF is a supervised learning based algorithm that is operated by constructing a multitude of decision trees on training datasets.

The land cover classes defined in the LULC 2016 shall be adopted to carry out LULC mapping to maintain consistency in classes. The LULC maps shall be used as one of the primary inputs for identifying alienable land.

5.1.3. Data

Creating a land cover map using remote sensing technology requires high resolution satellite (HRS) images for better results of the land cover classes. In this project, the free Sentinel-2 satellite images available from the European Space Agency (ESA), Copernicus Open Access Hub will be used to carry out the LULC mapping.

In addition to the satellite images, ancillary data layers such as roads, rivers, cadastral map, Digital Elevation Model (DEM), Topographic base map, existing LULC map, vegetation indices maps and field data shall be used to improve the accuracy of LULC mapping.

5.1.4. Software and Hardware

The following software and hardware are necessary to process image classification.

a. eCognition v.9.5

b. ERDAS IMAGINE

c. SNAP

d. ArcGIS

e. QGIS

f. Workstation

5.1.5. Validation and Accuracy

For evaluating the accuracy of image classification, a common method for evaluating the accuracy of the classified image shall be analyzed by using an error matrix. Also, a random field validation will be carried out across the country to check the accuracy of the final classified image.

5.1.6. Results and Analysis

The technical report of LULC consisting of statistical analysis and map shall be generated after the validation.

5.2.1. Definition

Alienable land refers to state land (SL) that can delineated and demarcated for disposal area for development purposes - *Comprehensive Review of Land Act of Bhutan, 2007*

5.2.2. Rationale

One of the setbacks of the NLUZ IG 2018 and NLUZ TF 2019 is that it requires to carry out the objective based zoning directly using the GIS-MCDA process which is difficult to carry out due the lack of certain data and the inability of agencies/stakeholders to perform zone-specific parameterizations.

Therefore, it has become necessary to firstly identify alienable land which will be used as one of the inputs in addition to the existent cadastral data to generate the final NLUZ maps.

5.2.3. Methodology

The alienable land shall be identified using GIS -MCDA, whereby the land is assessed for capability or suitability through evaluating multiple criteria or parameters. GIS-based MCDA is spatial decision-making process that involves a set of alternatives, conflicting and incommensurate multi-criteria evaluation. It involves the following process:

- Use of specific hardware and software
- Input parameters
- Data collection and preparation
- Processing and Analysis
- Result generation and validation

5.2.4. Software and Hardware

- High specification GIS Workstation
- ArcGIS and QGIS
- Handheld GNSS/Garmin

5.2.5. Input parameters

Parameters can either be a factor or constraint. A factor is a criterion that increases or decreases the suitability of alternatives under consideration while a constraint is a criterion that limits or restricts the consideration of alternatives (legal restriction or natural land capacity).

Based on the availability of relevant spatial data, the input parameters such as topographic, thematic, environmental, social, economic, disaster, etc. are considered to derive the required factors and constraints for identifying alienable land. To be more pragmatic, the input parameters shall be identified based on the availability and reliability of the existing spatial data.

5.2.6. Data collection and preparation

Once the input parameters are identified, the corresponding spatial data shall be collected from relevant sources. The data currency, relevancy and quality of the data shall be assessed and validated to the extent possible and categorized/segregated into factors and constraints, and converted into raster format of 10 m spatial resolution. The data and information shall be processed and entered into the geodatabase.

5.2.7. Result and analysis

The end-result of the component-2 will be a spatial and statistical report for the alienable land.

5.2.8. Validation and evaluation

The alienable land produced by GIS-MCDA method shall be subjected to field validation as well as desktop validation using the satellite images or images captured using drones where appropriate. The sites for field validation shall be selected or preferred based on high number of land use and development. Any issues detected shall be reported and appropriate measures shall be taken to rectify the issues.

5.3. COMPONENT 3: NATIONAL LAND USE ZONE MAP

The third component of the framework is to generate national land use zone maps, which is the ultimate outcome of the zoning project envisaged in the NLUZ implementation guideline.

5.3.1. Definition

Land use zoning is defined as a process of identifying and designating land for different uses based on the suitability and capability of the land within a given geographical location.

5.3.2. Methodology

Identification, classification, and definition of the National Land Use Zones shall be carried out in consultation with the concerned stakeholders.

The cadastral map with the land type information and environmental data shall be used to generate the provisional zones using the GIS-based segregation method. The provisional zones and alienable land shall be used as inputs to generate the final zones by GIS-based aggregation methods.

5.3.3. Data collection and preparation

Alienable, cadastral, and environmental data among others shall be the primary inputs for producing the final zone maps. Alienable land and updated cadastral data and information shall be obtained from the NLCS and all environmental data from the MoAF. Accurate land type information shall be obtained by linking the map and Thram record and conforming with ground reality through field verification using drone technologies and image processing.

5.3.4. Result

The output of this component shall be a National Land Use Zone map.

5.3.5. Validation

The final zones shall be evaluated through GIS processing systems and ground validation. Ground Validation shall be carried out in collaboration with the LG. Any problems detected shall be reported and appropriate measures shall be taken to rectify the problems.

6. CAPACITY DEVELOPMENT

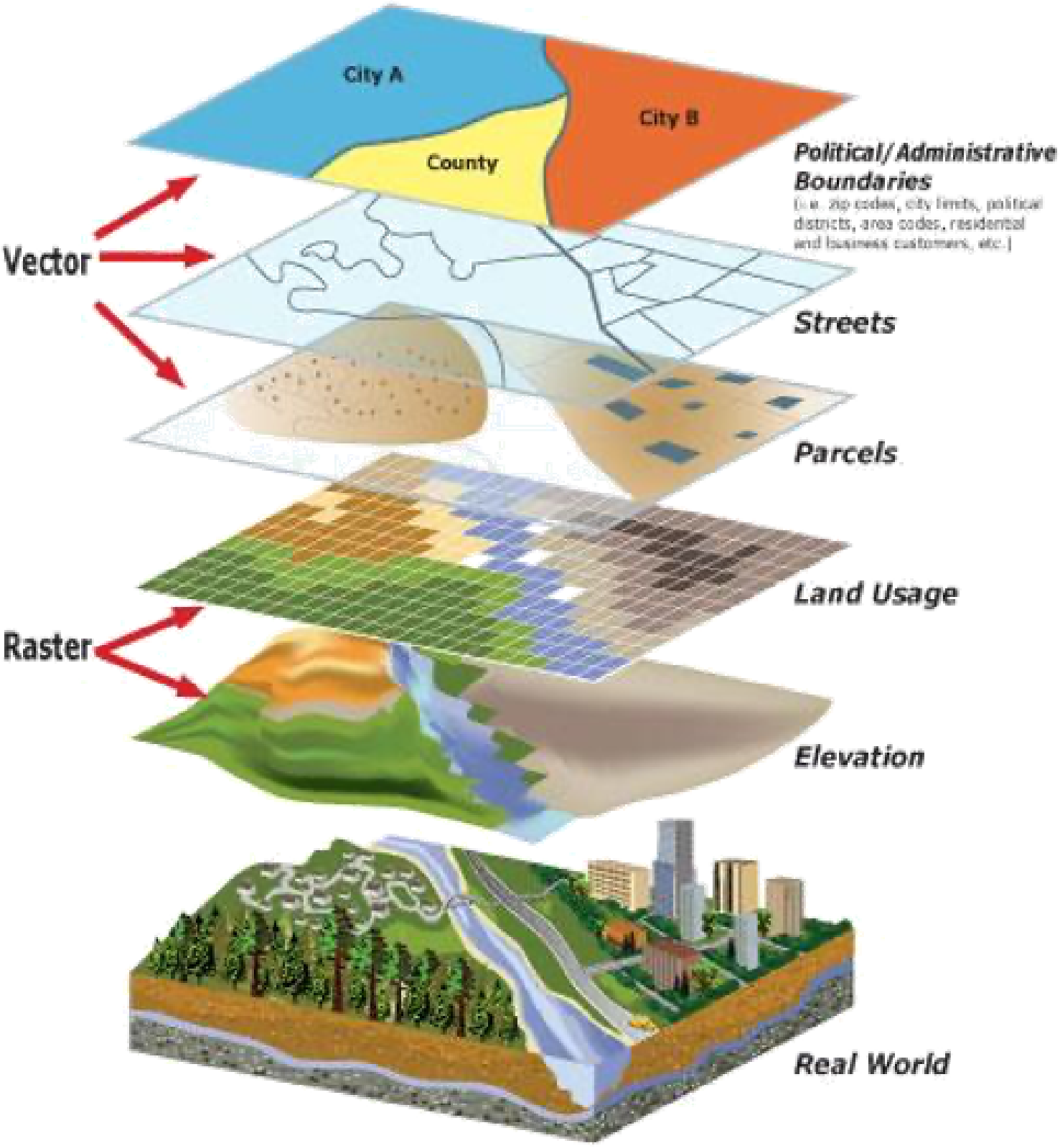
Officials involved in the NLUZ project shall be provided Ex-country tour/training/online to inculcate international best practices and expertise on zoning, land use planning.

Most of the Capacity development component has already been carried out according to the NLUZ IG 2018. However, with the change in the working team and implementation strategy, technical training in the following field has become crucial:

- Machine learning/AI for image classification
- Earth Observation technologies for land resource planning/zoning/management

7. IMPLEMENTATION PLAN

Activity	Timeline	Indicator	Lead Agency	Collaborating Agency	Human Resource	Budget (Nu. in M)
Revise Technical Framework appro	September 2021	Final draft submitted	NLCS	_	SE-6, LR-1, PO-1	0.50
Revise Technical Guideline	September 2021	Final draft submitted	NLCS	_		
Review & Status Report	September 2021	Status Report submitted	NLCS	_		
Capacity development	2021-2023	Required capacity developed for core team	NLCS	_		4.00
Prepare LULC Map & Report (component I)	June 2022	LULC Map & report produced	NLCS	MoAF		2.00
Mapping of Alienable Land (Component -2)	June 2023	Alienable land mapped	NLCS	_		4.7
Prepare Zone map (Component 3	April 2022-June 2023	Zone map prepared	NLCS	MoWHS, MoAF, MoEA, WWF		4.5



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