

# National Cadastral Datum Transformation

*Introducing Technical Concepts and approach to surveyors*

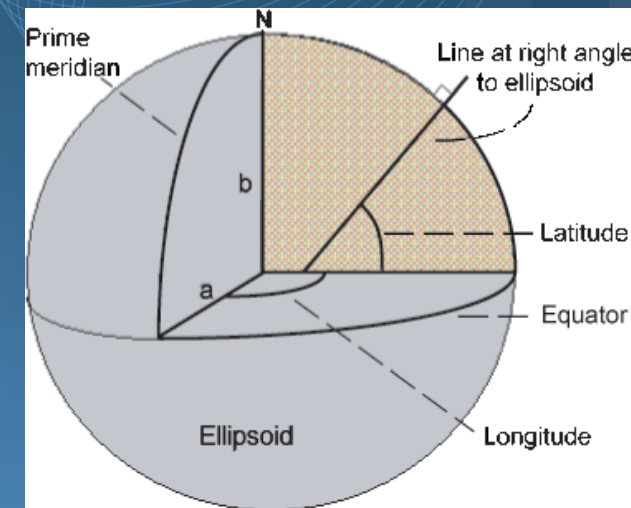
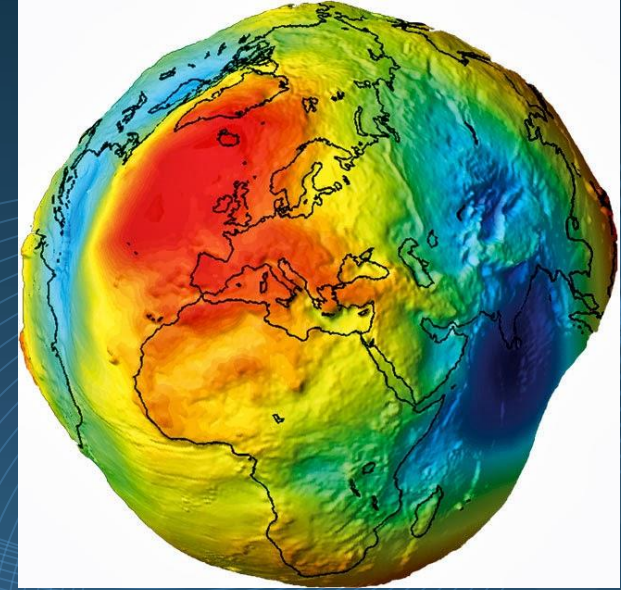
# Outlines:

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- What is geodetic datum?
- What is importance and types of geodetic datum?
- What is datum transformation?
- Why do we need the datum transformation?
- Effect of internal deformation
- Approach and Methodology for cadastral datum transformation
- Results of pilot Dzongkhag
- Strategy for control observation
- Program for national control observation
- Benefits of new datum

# What is geodetic datum?

- A **reference modal framework** used to define the **locations of points** on the Earth's surface in a consistent and standardized way.
- It consists of a set of parameters that define the origin, orientation, and scale of a coordinate system.
- Provides a basis for mapping and surveying activities, helping to ensure accurate and consistent spatial data interpretation.





# Importance of geodetic datum

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- **Accuracy and Consistency:** Ensure that spatial data collected at different times and by various organizations are compatible and can be integrated seamlessly.
- **Precision in Positioning:** Help achieve precise positioning by providing a common reference point.
- **Mapping and Navigation:** Essential for creating maps, navigation systems, and GIS.

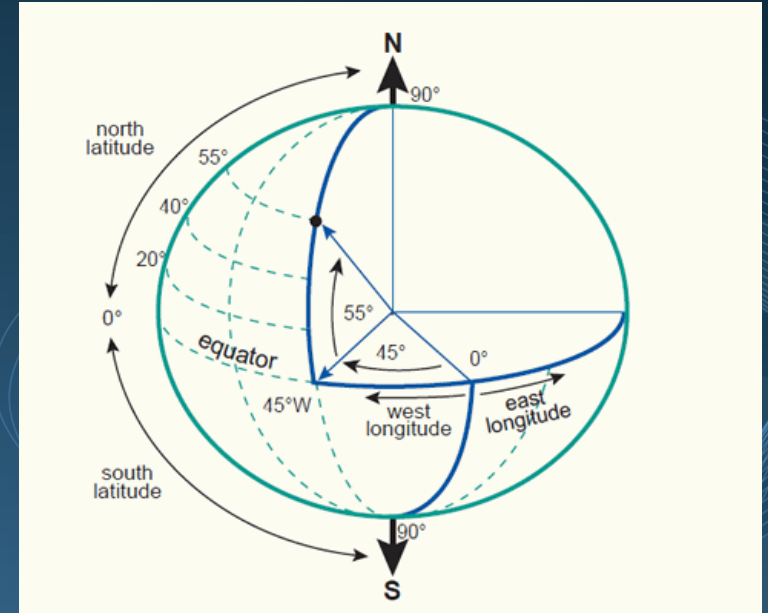
# Types of geodetic datum

- **Horizontal Datums:** Define positions

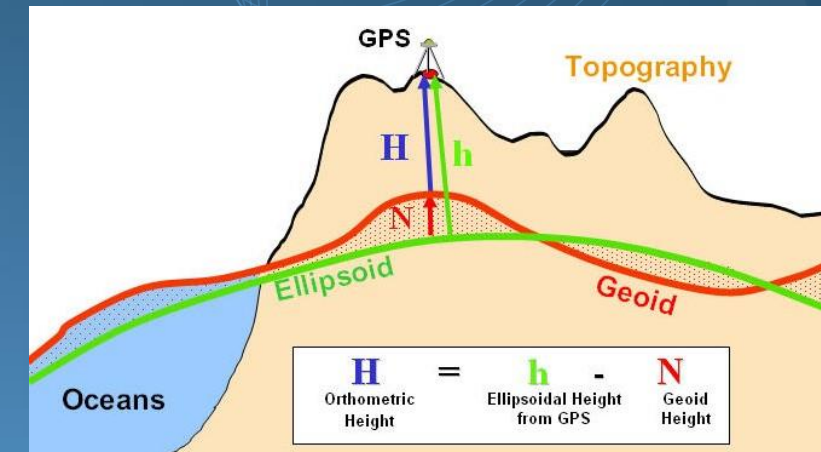
Ex. Geographic: latitude and longitude.

Projected: Easting, Northing

**Bhutan: DrukRef03** (*National Geodetic datum*)

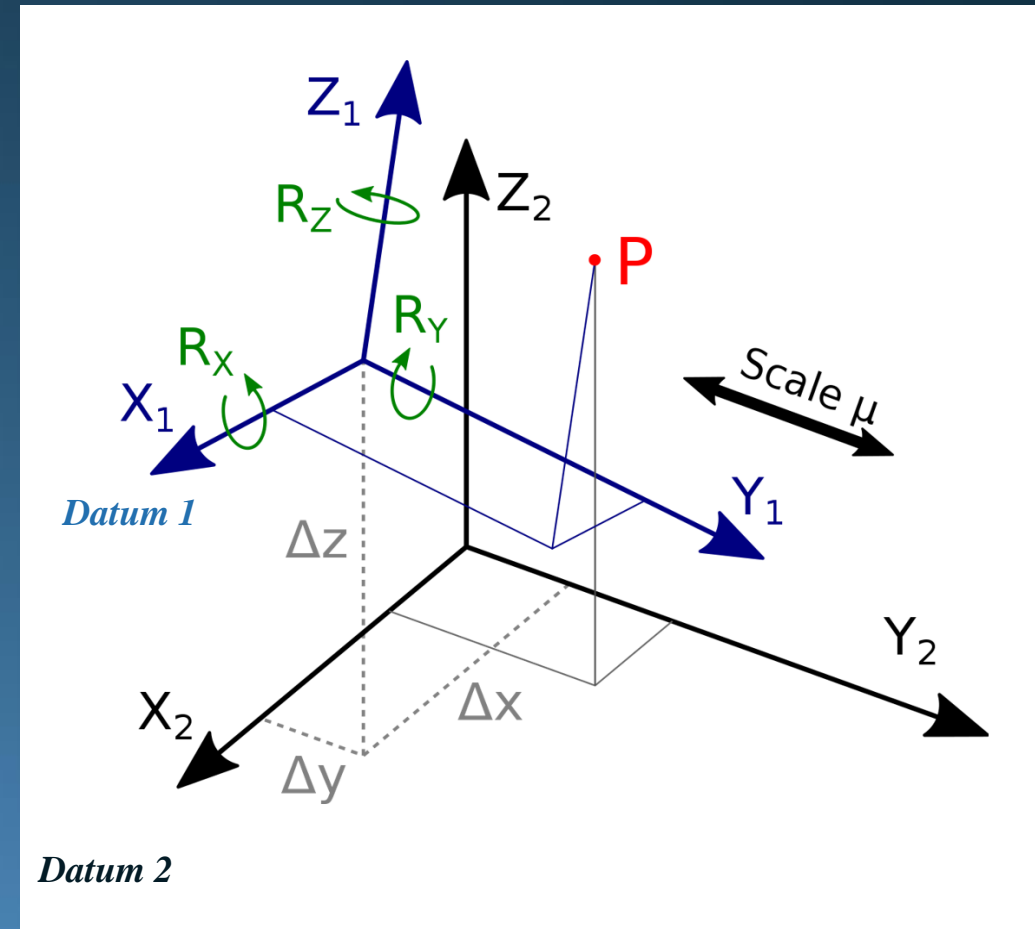


- **Vertical Datums:** Define elevations or depths relative to a specific reference point or surface.
- Ex. Mean Sea Level (MSL).
- **Bhutan: DrukGeoid2020**



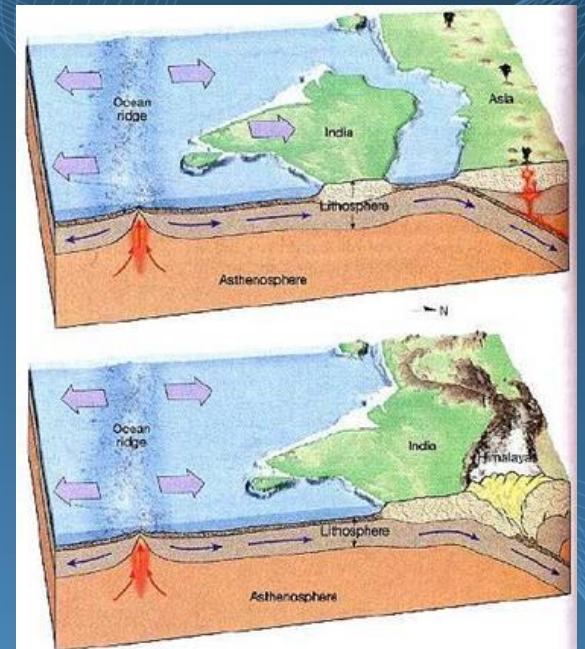
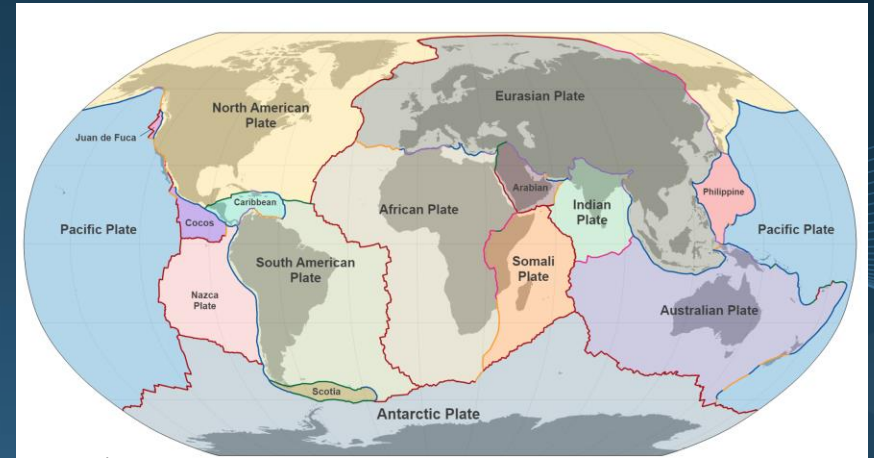
# What is datum transformation?

- Process of converting coordinates from one geodetic datum to another.
- This is necessary when working with spatial data collected using different datums.
- It ensures that the data is consistent and aligns accurately across different reference frameworks.



# Why do we need datum transformation?

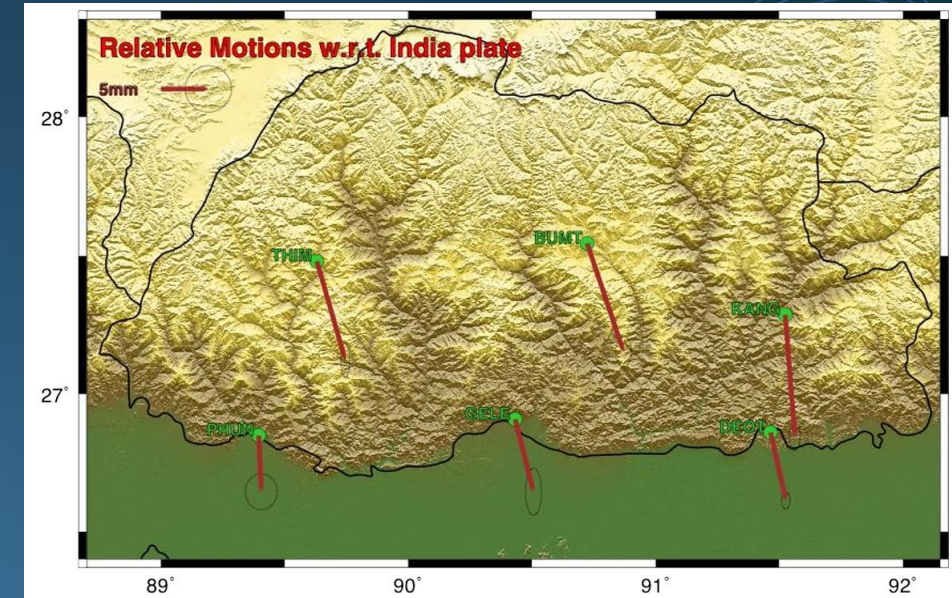
- DrukRef03 has been more the two decades
- The ongoing internal geological process (tectonic plate movements, earthquakes) have caused significant internal deformations, compromising the accuracy and consistency of DrukRef03.
- [..\Tectonic movement.mp4](#)
- The Himalayas are still rising by more than 1 cm per year





# Effect of internal deformation

- The southern stations have minor residual motions with respect to India.
- The internal shortening of the baselines between two average parallel is about 5mm/yr.
- This implies the baselines between stations has already shortened by about 10cm by now.
- Cannot be ignored when different CORS are used as reference for georeferencing applications.



Horizontal velocities with respect to the India plate for the six stations installed in 2011/2012



# Effect of internal deformation

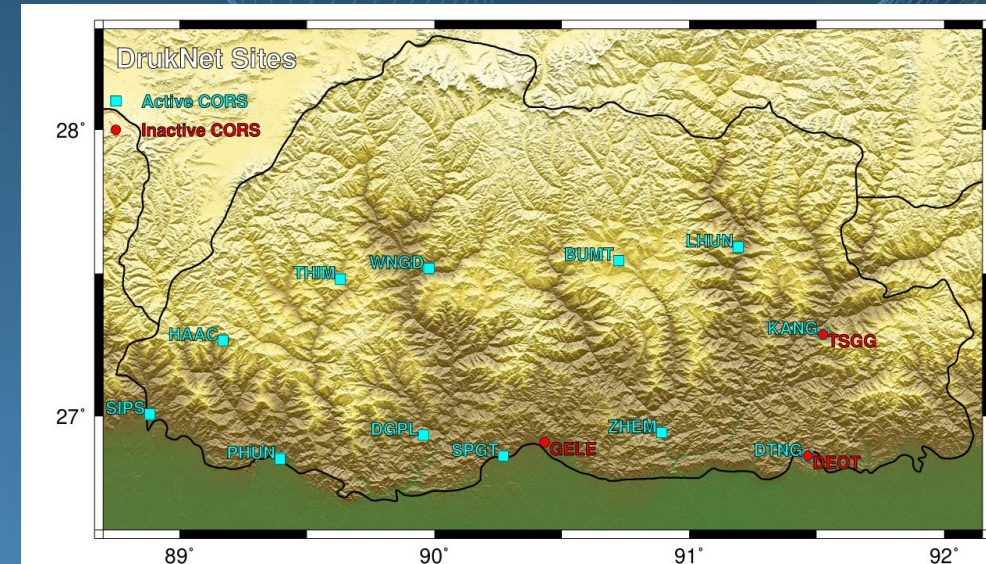
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- Internal deformation –
  - \* Velocity of about 5cm / year in NE direction
  - \* Southern region moves with faster velocity
  - \* Relative velocity of 5 mm / year – compression of ~10cm
  - \* Effect is about 1.4ppm (1.4mm / km) in the NS direction.
  - \* Progressive effect due to active tectonic movement
  - \* Degrades the accuracy of survey in long run.

# Approach to national datum transformation

## 1. Estimation of new datum: DrukRef2023:

- Materialized by the estimation of the coordinates of the 12 CORS stations of DrukNet w.r.t ITRF2020, the latest ITRF.
- The computation already done using data between June 20th and July 9th with the reference epoch selected to be **01-07-2023**.
- Need to officially adopt the new datum



# Approach to national datum transformation

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## 2. Implementation of new datum

Datum transformation of existing geospatial data

Priority: Cadastral datum transformation

## 3. Pilot work

- Completed pilot Paro and Thimphu chosen due to logistic convenience

## 3. National rollout

- Extension of pilot methodologies and techniques to all Dzongkhags



# Methodology for cadastral datum transformation

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- Existing control points suffers varying degrees of inconsistencies
- Control points with Less national integrity / localized
- Such error could be also due the physical disturbance
- This is compounded by active tectonic plate movement
- As a result, conventional 7 parameters (Helmert) transformation is not applicable
- **NTv2 techniques** is the recommended solution

# Methodology for cadastral datum transformation

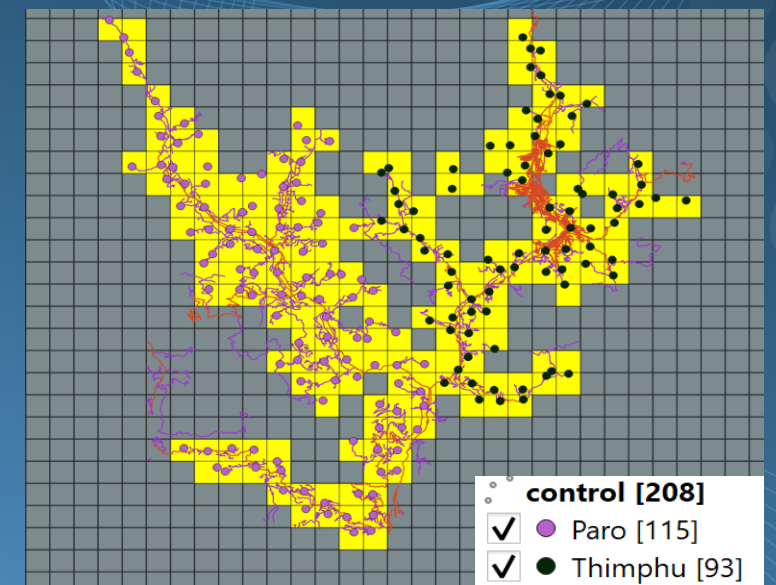
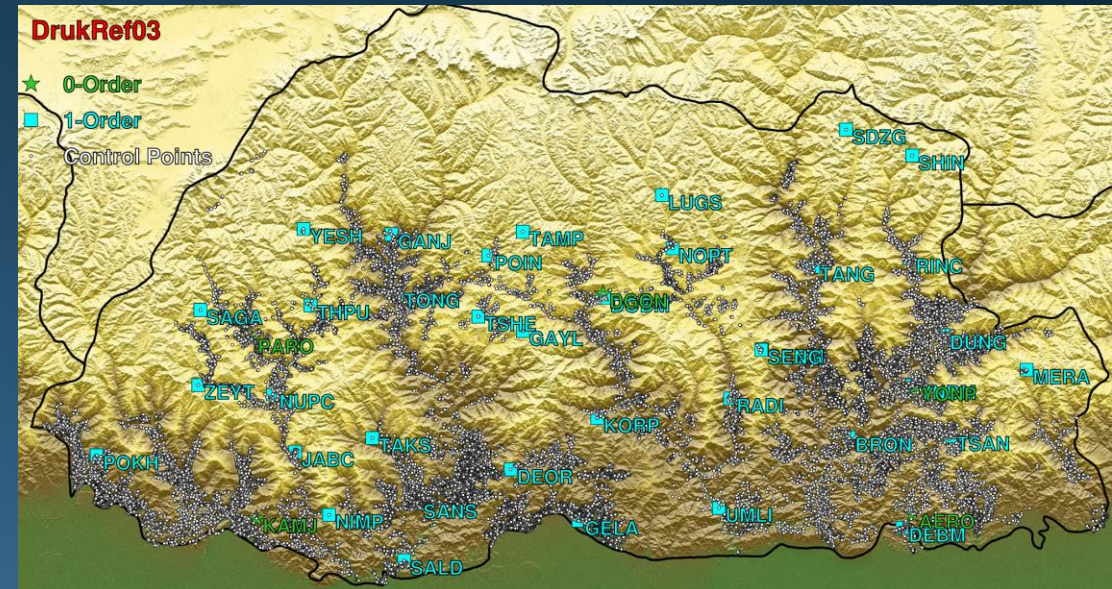
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## NTv2 (National Transformation Version2)

- Account for variations due to internal deformations and/or observational errors.
- Customized for specific regions, capturing local geodetic anomalies and irregularities.
- Use for both horizontal and vertical transformations.
- Can regularly updated to reflect the latest geodetic measurements and models.

# Methodology for cadastral datum transformation

- Control observation
  - Consist of 27200 control points
- Optimizing for efficiency:
  - Grid based observation
  - 2x2km grid
  - RTK solutions
- Generate NTV2 files for every Dzongkhag
- Perform the transformation on cadastral maps
- Conduct field Validations



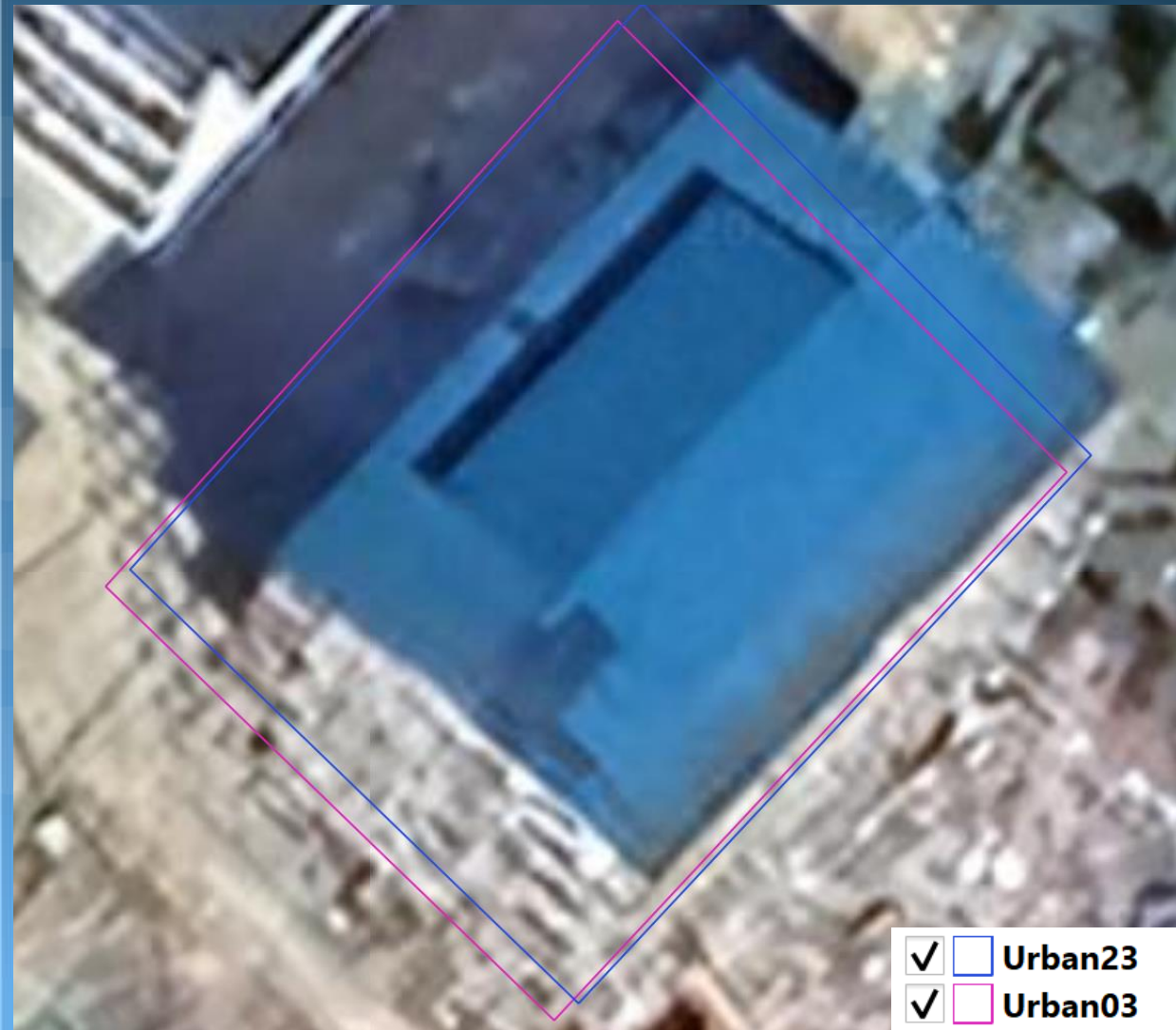


# Results of piloted Dzongkhag : Transformed parcel





# Transformed parcel



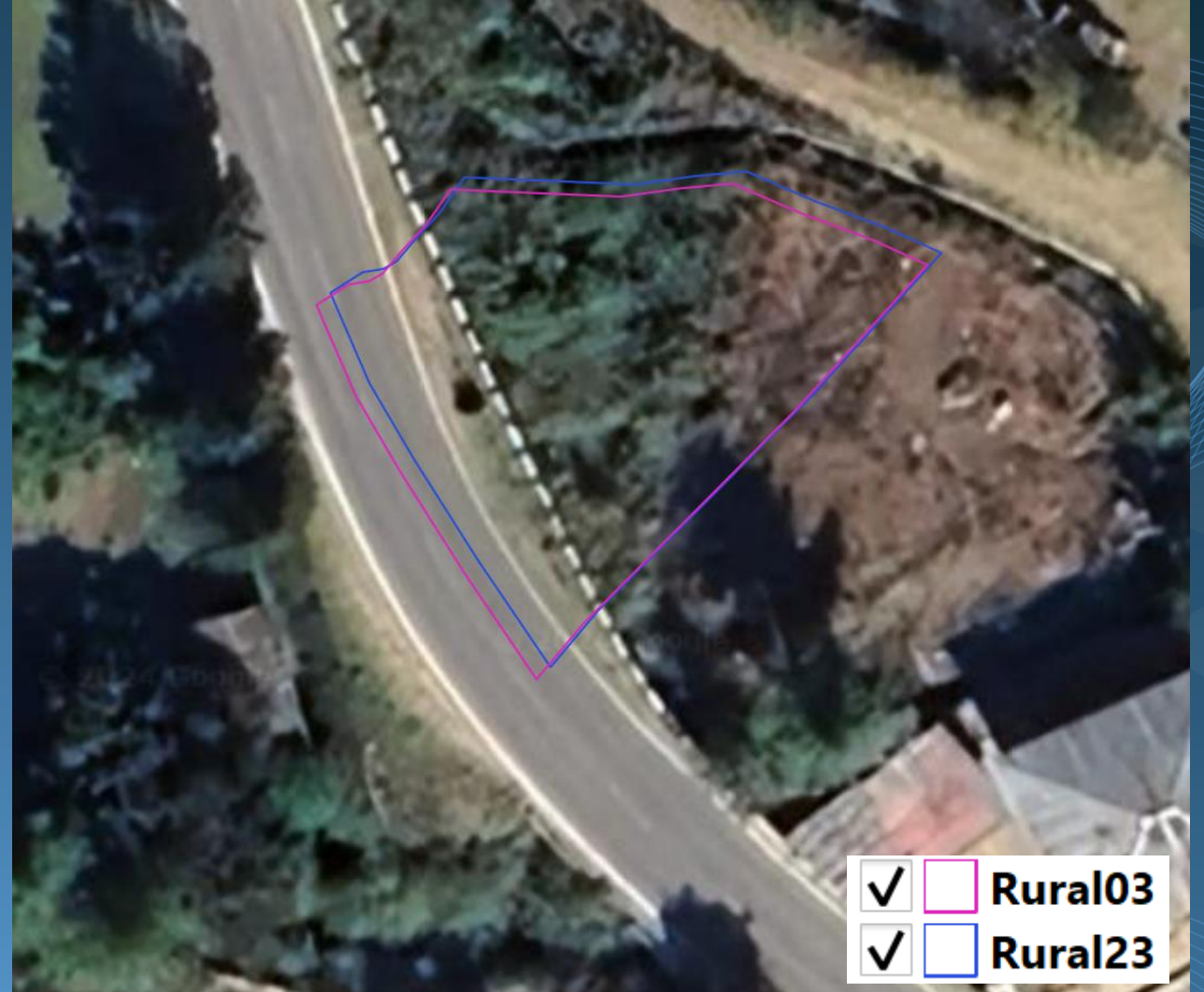
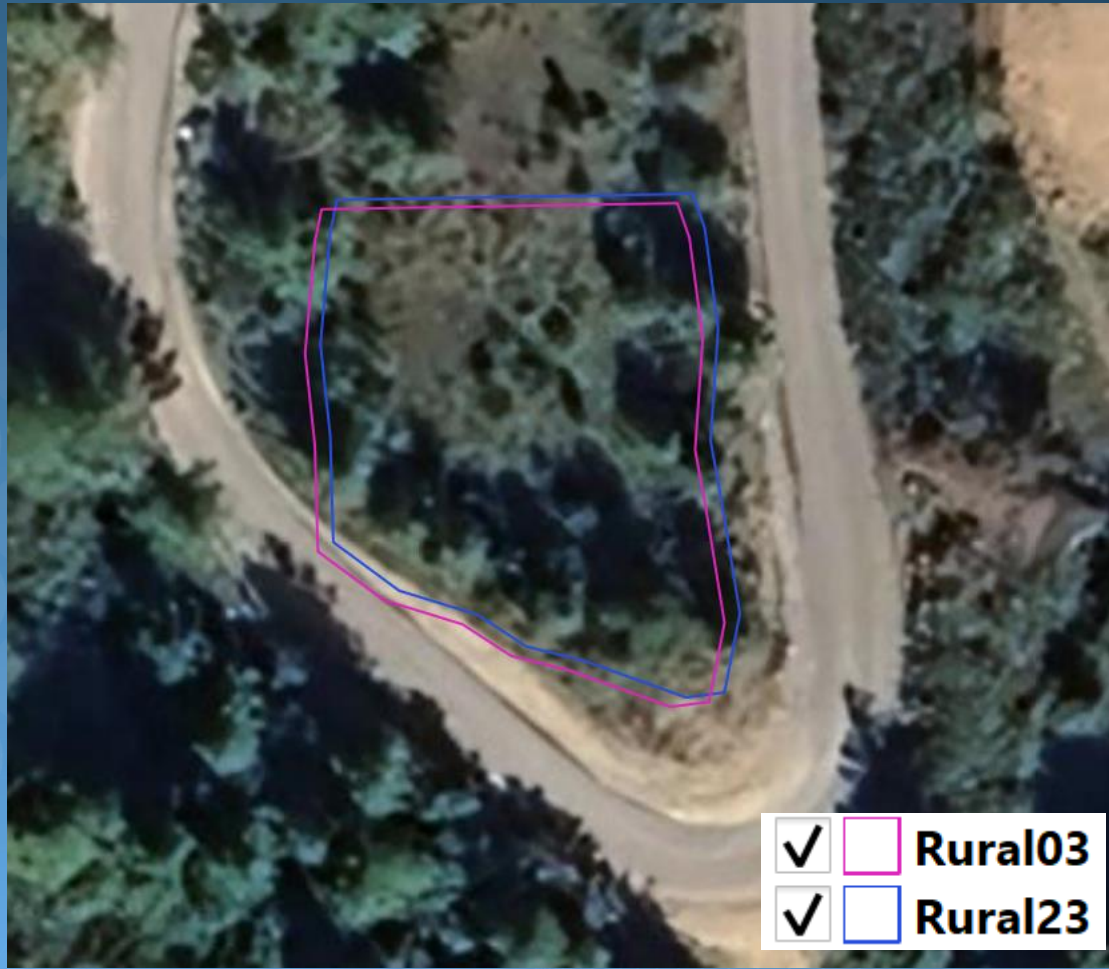


# Transformed parcel





# Transformed parcel



# Strategy for geodetic control observation

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- Entails massive resources (manpower, machines, time)
- Collaborative approach by involving respective Dzongkhags and Thromdee
- Denser observation in Thromdee
- Provide prior capacity building to surveyors
- Expenses to be met from the project
- Projected timeline for completion is 6 months (Sept 2024 – Feb 2025)
- Works of the surveyors to be accounted in their IWP

# Strategy for geodetic control observation

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- Take up three Dzongkhags at a time
- Five teams from NLCS and at least one surveyor from Dzongkhag
- Total of 8 teams (5 from NLCS + 3 from Dzongkhag)
- 3 teams for two Dzongkhags with higher number of observation
- 2 teams for a Dzongkhag with lowest number of observation
- Expected progress of minimum of 6 control per surveyor per day
- Thromdee surveyors to cover their respective Thromdee area
- ***Surveyors to share observations while visiting for their own field works.***



# Principles for geodetic control observation

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- **Mode of Observation:** Use RTK (Real-Time Kinematic) with CORS as the primary mode of observation.
- **Establish Your Own Base:** In the absence of CORS, establish your own base station.
- **Minimum Control Point Requirement:** Ensure that at least one control point per grid is observed by any available means.
- **Priority Control Points:** Make effort to observe control points marked as Priority 1. If a Priority 1 control point is not available, proceed to observe a control point marked as Priority 2.
- **Alternative Observations:** If neither Priority 1 nor Priority 2 points are available, make an observation using other available options.

# Principles for geodetic control observation...

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- **More Control Points, Better Results:** The more control points you observe, the better the results, aiming for up to 5 points per grid. This approach also helps avoid the need for reobservations.
- **Reobservation:** Reobserve the same points at different times to improve accuracy and reliability of the data.
- **Reobservation Strategy:** if you observe a point near a road while starting your travel, observe the same point again when returning. At least one reobservation in a day.
- **Efficient Fieldwork:** Avoid walking long distances unless necessary, particularly in the absence of nearby control points.



# Program for control observation

SI No	Dzongkhag	Field work sequence	Survey Team		Tentative Duration (up to)
			NLCS	Dzongkhag / Dungkhag	
1	Gasa	1	1	1	1 month
2	Punakha		1	1	
3	Wangdue Phodrang		2	1	
4	Trongsa		2	1	
5	Bumthang	2	1	1	1 month
6	Lhuentse		2	1	
7	Monggar		2	1	
8	Trashigang	3	2	1	1 month
9	Trashigang Yangtse		1	1	
10	Pema Gatshel		2	1	
11	Samdrup Jongkhar	4	3	1	1 month
12	Zhemgang		2	1	
13	Tsirang	5	1	1	1 month
14	Dagana		2	1	
15	Sarpang		2	1	
16	Chhukha	6	2	1	1 month
17	Samtse		2	1	
18	Haa		1	1	



# Benefits of new datum

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- Strengthened and improved the geodetic reference in term of Drukref2023 in the country.
- Improved accuracy and reliability of all geospatial data in Bhutan.
- Enhanced efficiency in all land survey and mapping
- Strengthened national geospatial infrastructure for integration and applications.
- Compliance with national and international geodetic standards and seamless data exchange.
- Realized the efficiency of CORS system in the latest ITRF2020 reference system.

Questions....???



THANK YOU

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