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From Traditional Land Measurements to Coordinate-Based Valuation

Abstract:

The valuation profession is undergoing a major transformation due to technological advancements such as Artificial Intelligence, GIS, and digital land records. While AI simplifies many valuation processes, the foundation of valuation still rests on accurate land measurement. This article discusses the evolution of land measurement practices in India—from traditional units to metric systems and finally to coordinate-based measurements—and highlights the importance for valuers to understand coordinate conversions and distance calculations.

Introduction:

Valuation as a profession has witnessed significant changes in recent years. Earlier, land measurements were predominantly based on traditional units such as mulam, gajam, and ground. Today, with digitization of land records and integration of GIS-based systems, valuation relies increasingly on metric measurements and coordinate-based data. Understanding this evolution is essential for modern valuers.

Traditional Land Measurement Systems:

Historically, land measurements in India, particularly in Tamil Nadu, were carried out using traditional units. These units were practical for local use but lacked standardization.

Length Measurement Units:

Inch – 2.54 cm
Foot – 0.3048 m
Mulam (Muzham) – approximately 2 feet
Kadai – approximately 3 inches

Area Measurement Units:

Square Foot – 0.092903 sq.m
Gajam (Square Yard) – 9 sq.ft
Cent – 435.6 sq.ft Ground – 2400 sq.ft Acre – 43,560 sq.ft

While these systems served well in the past, they posed challenges in accuracy, scalability, and digital integration.

Shift to Metric Measurements:

The adoption of the metric system brought uniformity and scientific accuracy. Metric measurements are fundamentally based on physical constants. For example, one cubic meter of pure water equals 1000 liters and weighs 1000 kilograms. This universality made metric units ideal for engineering, planning, and valuation purposes.

Emergence of Coordinate-Based Land Measurement:

At present, land measurement has progressed further into coordinate-based systems. Survey maps, FMB sketches, GIS platforms, and valuation software now define land parcels using latitude–longitude or northing–easting coordinates. Even large extents such as one acre are represented through a series of coordinate points.

The Earth has a mean radius of approximately 6,371,000 meters and is divided into coordinate grids. Any location on Earth can be precisely identified using latitude and longitude. This system allows highly accurate calculation of distances, areas, and boundaries.

1. Distance Between Two Coordinates:

To compute the horizontal distance between two GPS coordinates, the Haversine formula is commonly used. This formula accounts for the curvature of the Earth and provides accurate surface distance.

Distance Calculation:

Haversine Distance Formula

Let:

- Latitude$_1$ = φ_1 , Longitude$_1$ = λ_1
- Latitude$_2$ = φ_2 , Longitude$_2$ = λ_2
- All angles must be in radians

$$a = \sin^2\left(\frac{\phi_2 - \phi_1}{2}\right) + \cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\lambda_2 - \lambda_1}{2}\right)$$
$$c = 2\tan^{-1}(\sqrt{a}, \sqrt{1-a})$$
$$d = R \times c$$

Where:

- ddd = horizontal distance (meters)
- RRR = Earth radius ≈ 6,371,000 m

Degree → Radian Conversion

Radians = Degrees×(π/180)

This method is widely used in GIS and valuation software.

2. Finding a New Coordinate from a Known Point:

If you know one GPS coordinate (Latitude–Longitude) and the distance, you can find the next point coordinate only if the direction (bearing) is also known.

Distance alone is NOT sufficient (infinite points lie on a circle). You must know **Bearing / Azimuth (θ).**

Required Inputs

- Known Point:
  - o Latitude$_1$ = φ_1
  - o Longitude$_1$ = λ_1
- Distance = d (meters)
- Bearing / Azimuth = θ (degrees, measured clockwise from North)

Forward Coordinate Formula (Direct Formula)

All angles must be in radians.

$$\phi_2 = \sin^{-1}\left(\sin\phi_1 \cos\frac{d}{R} + \cos\phi_1 \sin\frac{d}{R}\cos\theta\right)$$
$$\lambda_2 = \lambda_1 + \tan^{-1}\left(\frac{\sin\theta \sin\frac{d}{R}\cos\phi_1}{\cos\frac{d}{R} - \sin\phi_1 \sin\phi_2}\right)$$

Where:

R=6,371,000 m (Earth radius)

Result → **Latitude$_2$ (φ_2), Longitude$_2$ (λ_2)**

Degree → Radian Conversion

Radians=Degrees×π/180

3. Finding an Unknown Point Coordinate

(Given TWO known points + distance from ONE point)

Finding Point C Coordinate

C does NOT lie on AB line)

This problem is solved by **intersection of two circles.**

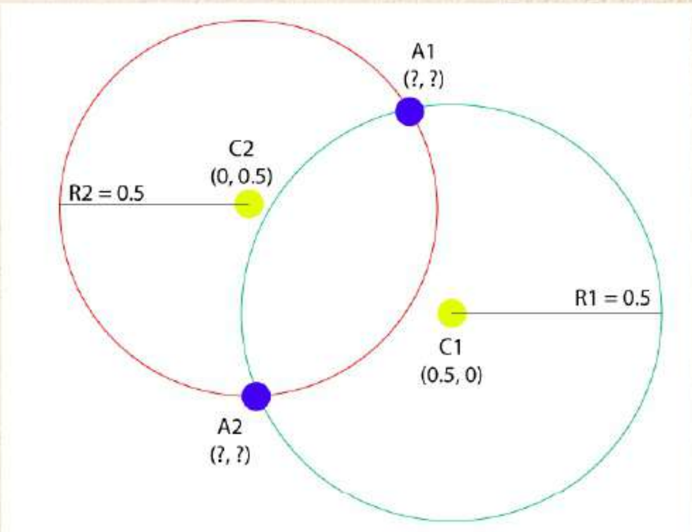
Given Data

- Point A = (x1,y1)
- Point B = (x2,y2)
- Distance AC = r1
- Distance BC = r2

* Point C is the intersection of:

- Circle centered at A, radius r1
- Circle centered at B, radius r2

* There will be **TWO possible solutions** (left side / right side of AB).



Step-1: Distance Between A and B

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Step-2: Check Feasibility (Very Important)

A solution exists only if:
$|r1 - r2| \le d \le (r1+r2)$
Otherwise ✗ no real solution.

Step-3: Distance from A to Foot Point (along AB)

$$a = \frac{r_1^2 - r_2^2 + d^2}{2d}$$

Step-4: Height from AB Line

$$h = \sqrt{r_1^2 - a^2}$$

Step-5: Base Point on AB Line

$$x_3 = x_1 + a\frac{x_2 - x_1}{d}$$
$$y_3 = y_1 + a\frac{y_2 - y_1}{d}$$

Step-6: Final C Point Coordinates (Two Solutions)

Solution-1

$$x_{C1} = x_3 + h\frac{y_2 - y_1}{d}$$
$$y_{C1} = y_3 - h\frac{x_2 - x_1}{d}$$

Solution-2

$$x_{C2} = x_3 - h\frac{y_2 - y_1}{d}$$
$$y_{C2} = y_3 + h\frac{x_2 - x_1}{d}$$

One point lies on **left side of AB,**
the other on **right side of AB.**

Which One is Correct?

You must know one extra condition:

- Orientation (left/right)
- Field sketch
- Bearing / site layout
- Third reference point

Applicability

✔ NE coordinates
✔ AutoCAD
✔ Total Station
✔ FMB / subdivision
✔ Valuation boundary fixing
✗ Long-distance GPS ____ use geodesic trilateration

Importance for Valuers:

With increasing reliance on digital land records, every valuer must be proficient in: Understanding traditional and metric units Converting coordinates to distances Calculating intermediate points Interpreting GIS and FMB data

Conclusion:

The valuation profession is transitioning from traditional measurement practices to advanced coordinate-based systems. While technology continues to evolve, the valuer's fundamental responsibility remains unchanged—ensuring accuracy and reliability in land measurement. Mastery of coordinate systems and metric conversions is no longer optional but essential for future-ready valuers.