CHAPTER 5: GEOGRAPHIC COORDINATES

OBJECTIVES OF THE UNIT

1. At the end of this unit, the reader must be able to:
2. Define coordinates,
3. Explain the difference between the Cartesian Coordinate System and the Geographic Coordinate System,
4. Differentiate latitudinal from longitudinal lines in geographic coordinates,
5. Read maps and locate properties using geographic coordinates,
6. Calculate coordinates using degrees, minutes, and seconds,
7. Identify a GPS receiver.

RATIONALE FOR THE UNIT

The rationale of this unit is to enhance the learners' knowledge and competencies of map reading using geographic coordinates. The Cartesian Coordinate System. The Cartesian coordinate system consists of a pair of lines on a flat surface, or plane that intersect at right angles. Each of the lines is called an axis and the point at that they intersect is called the origin. The axes are usually drawn horizontally and vertically and are usually referred to as the x and y axes, respectively. If the measurement is parallel with the x-axis, it is called the x-coordinate, and if the measurement is parallel with the y-axis, it is called the y-coordinate. For example, a point on the plane whose coordinates are 2;3) is 2 units to the right of the origin along the x axis and 3 units up from the origin along the y axis. As illustrated in Figure 38 it consists of two lines on a flat surface, or plane that intersect at right angles. Each of the lines is called an axis and the point at that they intersect is called the origin. The position of points (coordinates) in the plane is described in terms of distance from the origin of the axes (Van Sickle, 2004; Vlok, Harmse and de Jager, 2009).

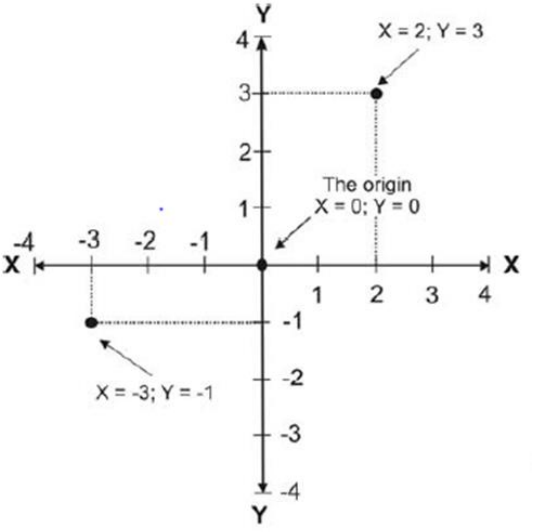

Figure 38: The Cartesian Plane (*Vlok, Harmse and de Jager, 2009:71).*

THE GEOGRAPHIC COORDINATE SYSTEMS

The principles of used to identify unknown points on a the Cartesian coordinate system is used when using the geographic coordinate system as discussed in the next paragraph as shown in Figure 39.

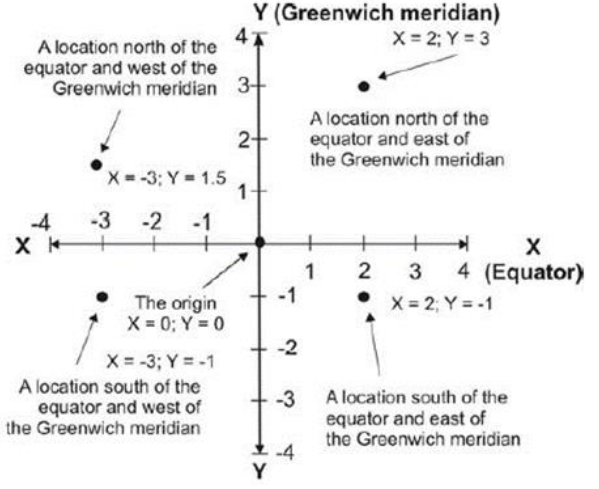

Figure 39: A simplified geographic coordinate system (Vlok, Harmse and de Jager, 2009:71).

One can see that this simplified geographic coordinate system if like the Cartesian coordinate system in Figure 33, the only major difference being the introduction of two important terms that are the Greenwich meridian as the Y axis and the Equator as the X axis. From now on we do not talk about X axis and Y axis this this module, we talk of the Greenwich meridian and the Equator. The Greenwich Meridian (or prime meridian) is a zero line of longitude from that we measure east and west and end at the north and south poles. In fact, the zero line passes through the Royal Observatory in Greenwich, England, that is why we call it what it is today. In a geographical coordinate system, the prime meridian is the line that has 0° longitude as summarised in Box 5.1.

Box 5.1: A summary of the geographic coordinate system

A great circle (one that divides the earth into two equal hemispheres) drawn midway between the poles and at right angles to them is called the equator and serves as the starting line for the reference system. Distances from the equator are measured in degrees north or south to the poles. The angular distance north or south of the equator is called latitude and is measured from 0° at the equator to 90° north and 90° south at the respective poles. This allows us to locate any place on earth precisely with respect to the equator. The system of parallels is only one-half of the earth's reference system.

Unfortunately, there is no fixed point or line on the earth comparable to the poles or the equator that can be used as a convenient origin for measurement along the parallels. For many years each country used a true north–south line passing through its capital or some other significant location. Distances were measured from this line in degrees and called longitude. When maps of only one country were used there were few problems; but with faster travel around the earth and the use of a variety of maps, this system became cumbersome. In 1884, the International Meridian Conference established the line through the transit instrument at the Royal Observatory at Greenwich, England, as the starting line for east–west measurement; this line is called the prime meridian. The angular distance east or west of the prime meridian to some other point, measured from 0° to 180°, is the longitude.
Source: Tyner (2010)

The equator is where we measure north and south. For example, everything north of the equator has positive latitude values. Whereas everything south of the equator has negative latitude values. Most horizontal datums assign the equator as a zero line of latitude. The equator is where we measure north and south. Whereas the Greenwich Meridian (or prime meridian) is a zero line of longitude from that we measure east and west as shown in Figures 40 and 41. Together, these lines provide a reference for latitude and longitude that always

zig-zag into each other. This geographic grid provides unique latitude and longitude for every position on Earth.

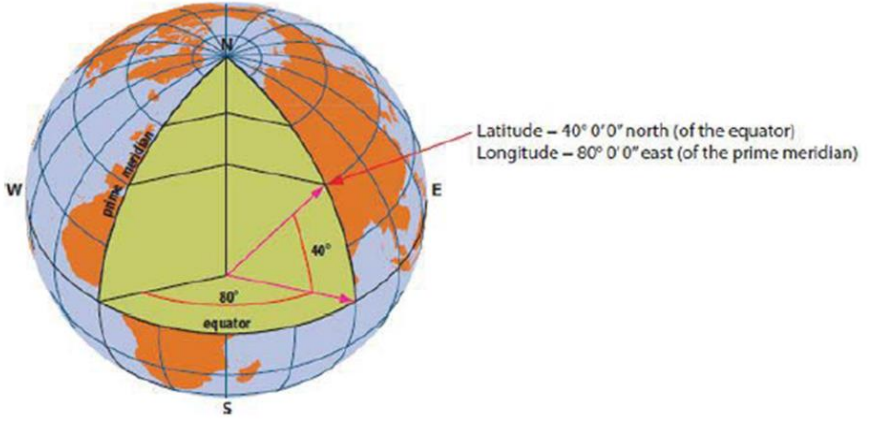

Figure 4040: The Greenwich meridian and the equator (Law and Collins, 2015:125).

LATITUDE AND LONGITUDE

The geographic coordinate system consists of an imaginary graticule or grid of lines called latitudes and longitudes (also called meridians). The origin of this reference system is where the equator (0° latitude) intersects with a line (referred to as 0° longitude or the Greenwich meridian) running straight over the globe's (earth's) surface through the old Royal Astronomical Observatory in Greenwich (England) connecting the North and the South Poles (Vlok, Harmse and de Jager, 2009).

Latitude and longitude are coordinates that represent a position with angles instead of distances. Lines of latitude and longitude always cross each other at right angles, just like the lines of a Cartesian grid, but latitude and longitude exist on a curved rather than a flat surface. There is imagined to be an infinite number of these lines on the ellipsoidal model of the Earth. In other word every place has a line of latitude and a line of longitude passing through it, and it takes both to fully define a place. Latitude is an angular measurement of the distance a point lies north or south of the plane through the equator measured in degrees, minutes, seconds, and usually decimals of a second. Longitude is also an angle measured in degrees, minutes, seconds, and decimals of a second east and west of the plane through the chosen prime, or zero, position (Van Sickle, 2004).

LATITUDE

Angles of latitude most often originate at the plane of the equator. The values for latitude range from a minimum of 0° to a maximum of 90°. The latitudes north of the equator are positive, and those to the south are negative. Lines of latitude, circles, are called parallels because they are always parallel to each other as they proceed around the globe. They do not converge as meridian do or cross each other (Van Sickle, 2004).

LONGITUDE

Angles of longitude originate at the plane through an arbitrarily chosen place, now Greenwich, England. The east longitude is labelled E or given a positive (+) value and the west longitude is labelled W or given a negative (−) value. Longitudes range from + 0° to +180° E longitude and − 0° to −180° W longitude (Van Sickle, 2004). Figure 41 shows lines of longitude and latitude.

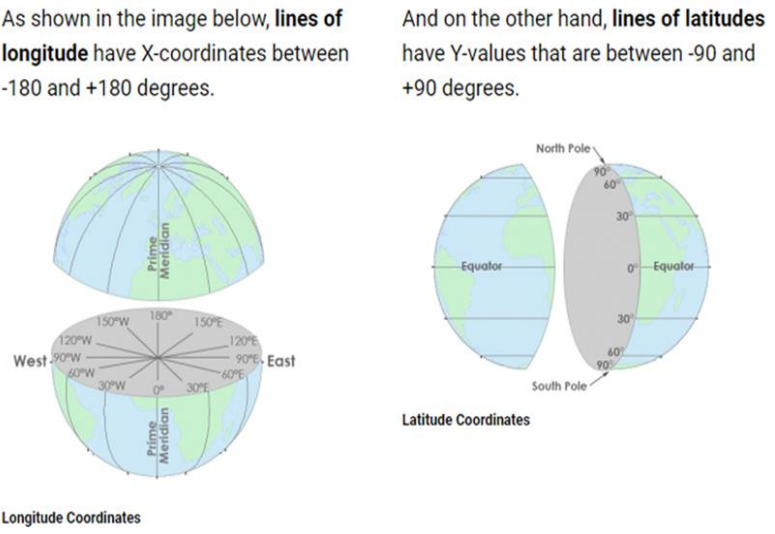

Figure 41: Lines of longitude and latitude (GIS Geography (2020) Available online: https://gisgeography.com/latitude-longitudecoordinates/#:~:text=As%20shown%20in%20the%20image,%2D180%20and%20%2B180%20degrees.&text=And%20on%20the%20other%20hand,%2D90%20and%20%2B90%20degrees.&text=The%20equator%20is%20where%20we,equator%20has%20positive%20latitude%20values. (Accessed: 27 December 2020).

We have now established that the earth's grid (graticule) or reference system consists of imaginary lines of latitude extending over the entire "breadth" of the globe and imaginary lines of longitude extending over the entire "length" of the globe. Except for the North Pole and the South Pole that are points situated at 90° N and 90° S respectively, all locations on the earth's grid must be described by a latitudinal and a longitudinal reading. The "reading" refers to the point where a parallel cross a meridian. These crosses are called geographical coordinates. When answering the "Where is" question in terms of geographical coordinates it is convention to first refer to the latitude position. Remember to use "N" or "S" to distinguish between latitudes in the Northern and Southern Hemispheres. To distinguish between longitudes in the Eastern and Western Hemispheres one should use the abbreviations "E" and "W". The coordinate situated at the intersection of the 20° E meridian and the 15° South parallel must therefore be referred to as 15° S; 20° E.

Figure 42 is a representation of the spherical earth with the graticule imposed on it, as it would appear if seen from a distance. Note the coordinates we have indicated with point symbols. The geographical locations of coordinates A, B and C are:
Coordinate A: 30°N;30°W
Coordinate B: 15°N;30°E
Coordinate C: 7°30´S;22°30´E

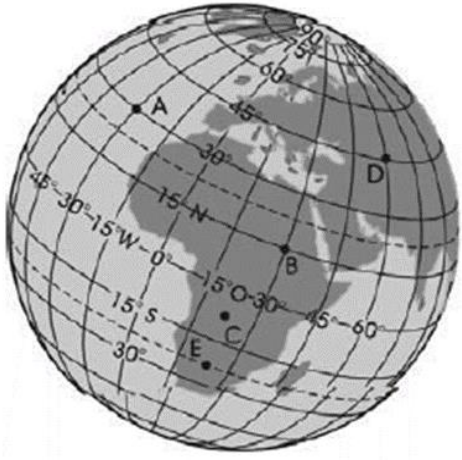

Figure 42: Reading Geographical coordinates (Vlok, Harmse and de Jager, 2009:55.

EXAMPLE

Let us now go back to our geographic coordinates for BA ISAGO University as highlighted earlier. Remember the lesson is about finding location using geographic coordinates. With reference to Figure 2 (See Unit 1), our geographic coordinates are 24°37'48.04"S 25°53'38.42"E elev 1016m and from what we have covered so far we know that geographic coordinates are saved on maps (Geographical Information Systems (GIS), web mapping applications, such as Google Maps, and GPS) as degrees (°), minutes (′), and seconds (″). Hence the geographic coordinates of BA ISAGO University can be interpreted as follows:

LATITUDE

The University if located 24 degrees (°) 37 minutes (′) 48.04 seconds (″) South of the Equator or in simply the Southern Hemisphere.

LONGITUDE

The University if located 25 degrees (°) 53 minutes (′) 38.42 seconds (″) East of the Greenwich meridian line or simply in the Eastern hemisphere.

PRINCIPLES OF GEOGRAPHIC COORDINATES

One degree (°) is normally divided into 60 minutes (′) or decimals.
One minute (′) is normally divided into 60 seconds (″) or decimals.
One second (″) is normally divided into decimals (when divided).

HENCE

1° (degree) = 3600″ (seconds).
90° (degrees) = 5400′ (minutes) (Vlok, Harmse and de Jager, 2009:55).

Let us use these principles to illustrate how they are applied when calculating calculate coordinates on a paper map. However, note that as real estate professionals one rarely calculate geographic coordinates, one use them to locate and communicate the location of properties with others. But it is necessary to have an appreciation of how the calculations are done.

CALCULATION OF GEOGRAPHICAL COORDINATES FROM A PRINTED MAP

One must understand the following terminology and underlying principles:

1 degree (°) is equivalent to 60 minutes (') or decimals.
1 minute (') is equivalent to 60 seconds (") or decimals.
Hence
1° (degree) = 3600" (seconds).
90° (degrees) = 5400' (minutes).

EXAMPLE
We are going to use an example from Vlok, Harmse and de Jager (2009). With reference to the diagram below, Point A is located between points 22° and 23° East as well as 33° and 34° South as shown in Figure 43.

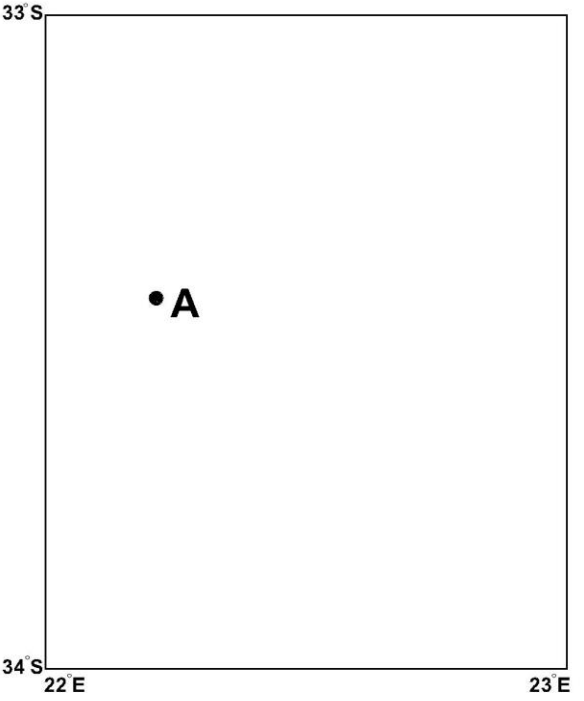

Figure 43: Map Location Example 1 (Adapted from Vlok, Harmse and de Jage (2009).

To locate the absolute location of point A, measure the distance between 22° and 23° (longitude) as well as 33° and 34° (latitude) (see Figure 44).

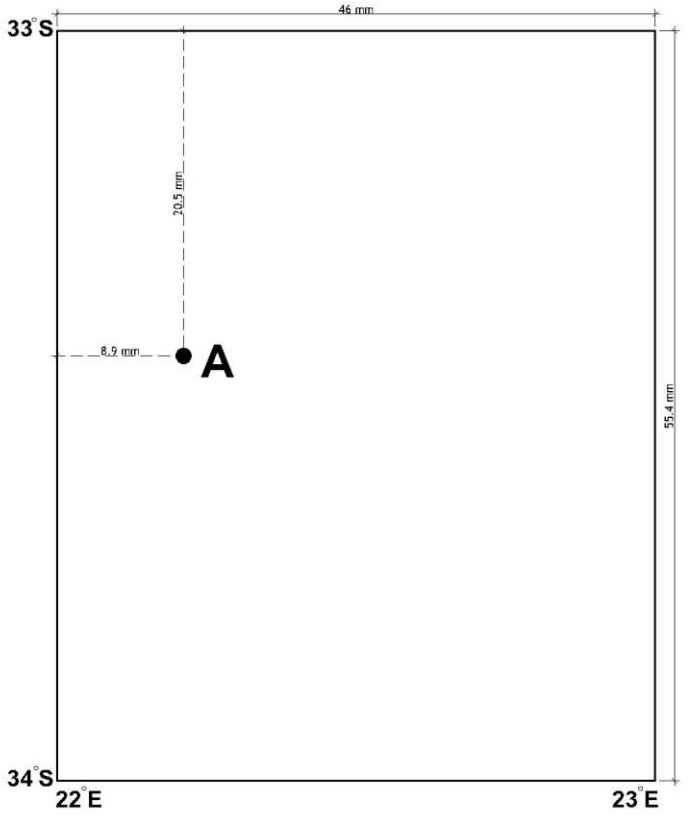

Figure 444: Map Location Example 2 (Adapted and modified from Vlok, Harmse and de Jage (2009).

CALCULATIONS

1. The phenomenon is between 22° and 23° east.
2. On the map the distance between 22° and 23° is 46 mm. One degree (or 60 minutes) is therefore represented by 46 mm.
3. On the map the phenomenon is located 8.9 mm east of the 22° E line of longitude.
4. Because we know that 1° is equal to 60 minutes and that in this instance 60 minutes are equal to 46 mm, we can now apply the follow arithmetic:
5. 46 mm on map = 60 minutes ∴ 8.9 mm on map = 60 × (8.9 ÷ 46) = 11.6087' or 11.6087 minutes.

6. The decimal portion that we calculated in step 5 means 0.6087 of a minute. Remember there are 60 seconds in a minute. The 0.6087 therefore actually means 0.6087 of 60 seconds.
7. ∴ 0.6087 × 60 seconds = 36.522 seconds
8. The longitude of the phenomenon entrance is therefore: 22 degrees + 11 minutes + 36.522 seconds East.
9. We write it as 22°11′36.522″ E (Vlok, Harmse and de Jage, 2009).

Let us now discuss the instrument that is used to capture geographic coordinates in the field.

INSTRUMENT USED TO CAPTURE COORDINATES

Geographic coordinates are captured in the field using a Global positioning sensor (GPS). A GPS receiver takes data from 24 satellites to determine location. These satellites are arranged so that at least four are always visible in the sky from anywhere on Earth. A GPS receiver attempts to locate signals from at least three satellites, but preferably four or more. With these signals, their latitude and longitude, altitude, speed, and direction can be determined anywhere on Earth and in any weather. Figure 45 is a pictorial representation of a GPS receiver.

Figure 45: GPS Receiver (Images taken by Authors)

ACTIVITIES FOR THE READER

a) Define coordinates.
   i. Explain the difference between the Cartesian Coordinate System and the Geographic Coordinate System.
   ii. Point out the instrument which is used to capture geographic coordinates.
   iii. Differentiate latitudinal from longitudinal lines with reference to geographic coordinates.

b) With reference to **Figure 46**:
   i. Identify the geographic coordinates of BA ISAGO University Gaborone campus.
   ii. Explain in simpler terms what is meant by the geographic coordinates you identified in (a).

c) **i.** With reference to **Figure 47**, calculate coordinates for points 1, 2 and 3. Your answer must show degrees, minutes, and seconds.

d) Analyse the pattern of geographic coordinates of the map in **Figure 42** and identify:
   i. The location of the places shown on the map with reference to the equator.
   ii. The location of the places shown on the map with reference to the prime meridian line.
   iii. State the longitudinal line which is just before 31°00′.

Figure 46: Location Map of BA ISAGO University (Google Maps)

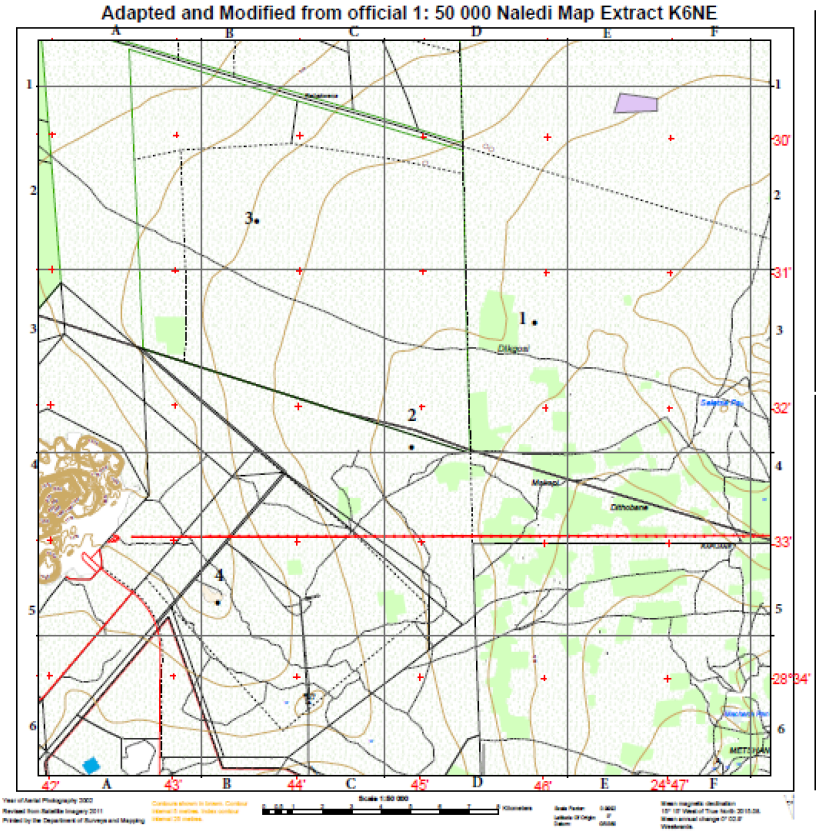

Figure 47: Extract from the official 1:50 000 map of Naledi (map K6NE NALEDI). (Modified Map from Department of Surveys and Mapping, Botswana)

CONCLUSION

At this point learners should be competently able locate properties on a map using coordinates as well as calculate geographic coordinates from a map. Also, they should be in a position to explain the difference between the Cartesian Coordinate System and the Geographic Coordinate System as well as to identify latitudinal from longitudinal lines with reference to geographic coordinates.

SUGGESTIONS FOR FURTHER READINGS

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