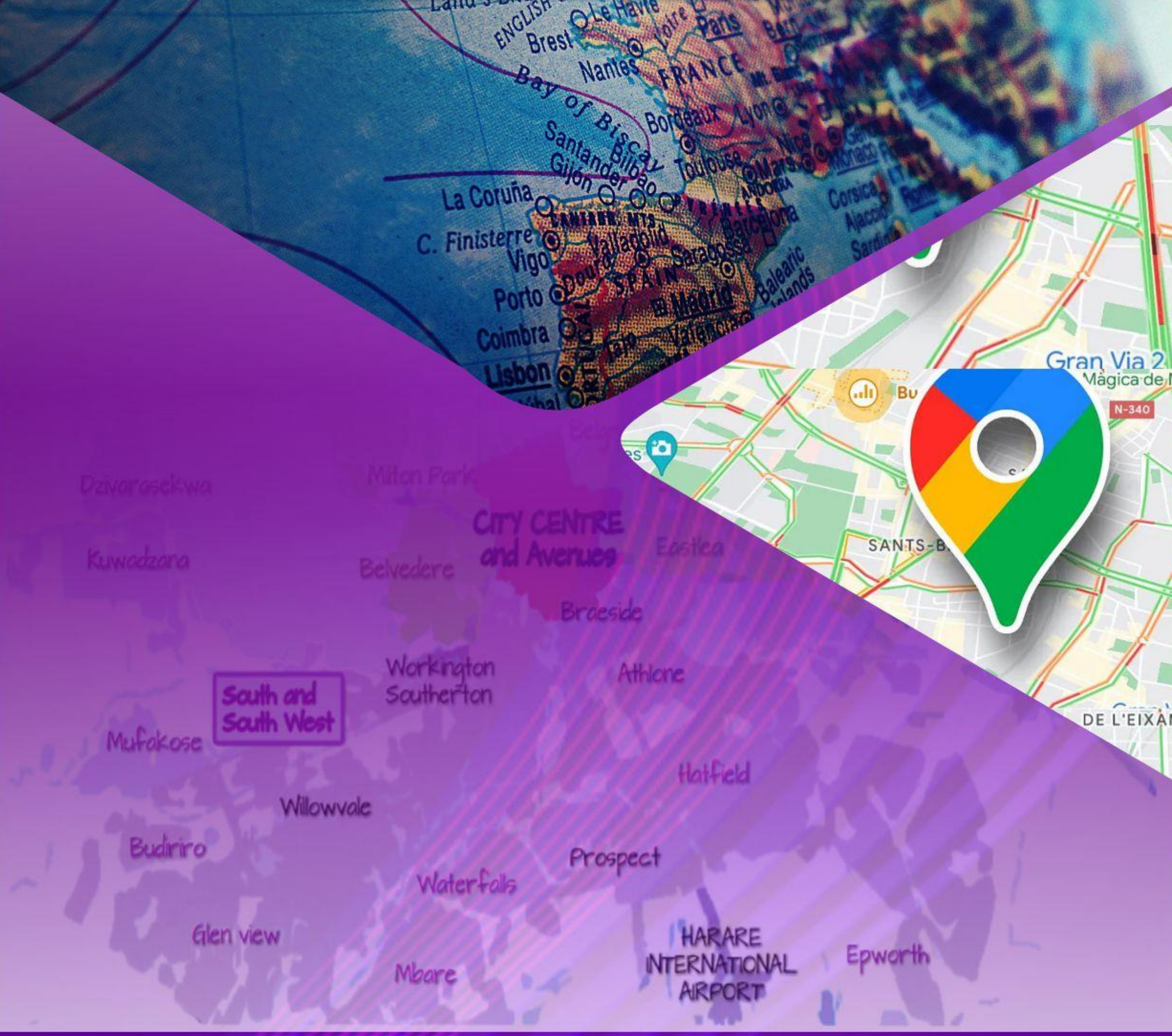
ANCHORS TO PLANNING AND REAL ESTATE ACCURACY in Location, Instrumentation and Measurement



Jairus T. Ndoma, Partson Paradza, Winnet K. Ngarakana, Tiisetso Dube and Innocent Chirisa

Anchors to Planning and Real Estate Accuracy in Location, Instrumentation and Measurement

Jairus T. Ndoma, Partson Paradza, Winnet K. Ngarakana, Tiisetso Dube and Innocent Chirisa

ISBN 978-1-77928-332-0
EAN 9781779283320

Published by the Zimbabwe Ezekiel Guti University (ZEGU) Press
Stand No. 1901 Barrassie Rd,
Off Shamva Road
P.O. Box 350
Bindura, Zimbabwe

SUBSCRIPTION AND RATES
Zimbabwe Ezekiel Guti University Press Office
Stand No. 1901 Barrassie Rd,
Off Shamva Road
P.O. Box 350
Bindura, Zimbabwe
Telephone: ++263 8 677 006 136 | +263 779 279 912
E-mail: zegupress@zegu.ac.zw
http://www.zegu.ac.zw/press

DEDICATION

To all location and built environment experts in the world.

ACKNOWLEDGMENT

We acknowledge the anonymus reviewers, the language and technical editing and production team that has helped our book to be stature it is.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF BOXES

SYNPOSIS

The aim of this monograph is to furnish a detailed and comprehensive explanation of the concept of location in a simplified and accessible fashion as well as basic description of surveying techniques and equipment through illustrations based on practical examples and photographs relevant to the planning and real estate fields. This work is designed for use by planning and real estate students for teaching/learning purposes. Location is one of the most used terms in built environment and its importance cannot be over emphasised, as it is used by land use planners, estate agents, property valuers, property managers and property developers - almost on daily basis. There is a common saying in real estate which runs as follows; the three most important things that determine property value and or property investment decisions are location, location and location (Kiel & Zabel, 2008). But what is this most important thing conceptualised as location? In other words, why does location matter? Or to put it in a way which reflects some levity, why the fuss with location? In as much as there exist vast literature explaining the concept of location in real estate and planning, existing texts do not explain in detail how relative and absolute location is applied in these two fields. These two terms are well explained in several geography textbooks but without relating them to the fields of real estate and planning.

Geography literature explains the concept of location without going further to discuss different methods used to capture data that is used in different components of relative and absolute location. These methods are explained in detail in land surveying literature that uses technical jargons. For a real estate or planning student to fully comprehend the concept of location, he/she is supposed to read several books from different fields that include real estate, planning, geography and land surveying. This work comes quite handy as it explains the concept of location using simple and accessible language, practical examples, as well as illustrations with the intention of simplifying the concept of location as it is applied in real estate, planning education and training. This monograph is divided into 8 units as follows: Firstly, Unit 1 focuses on the definition of location, Unit 2 critically discusses distance measurement in the field and Unit 3 focuses on distance measurement on maps. The fourth unit (Unit 4) discusses direction, whilst Unit 5 focuses on coordinates. Unit 6 discusses elevation and Unit 7 elaborates on Location as an aspect of public and business planning and management. The last Unit, Unit 8 focuses on revisiting

location as a philosophy. This monogram has been prepared to explain the concept of location using simple language, practical examples, as well as illustrations in an effort to simplify the concept of location as it is applied in real estate, planning education and training. By reading this monogram students in the built environment are expected to comprehend the concept of location as it is applied in the real world. It is recommended that this monogram should not be used in isolation from prescribed reference materials in land surveying and geomatics by students who are undertaking studies in these disciplines or would like to further their studies in these fields.

Keywords: accuracy, instrumentation, location, planning, real estate

CHAPTER 1: DEFINING LOCATION

OBJECTIVES OF THE UNIT

At the end of this unit, the reader must be able to:

- Define geographic location.
- Differentiate absolute from relative location.
- Locate properties from Google Earth or Google maps using absolute and relative location and
- Describe and communicate the location of a property using relative an absolute location.

RATIONALE FOR THE UNIT

The rationale of this unit is to develop the students' technical skills and competences required in property location by explaining the concept of geographic location in a simplified and accessible manner. Upon completion of this unit, students should be able to define geographic location and differentiate absolute from relative location.

ASPECTS AND ISSUES

Location provides an answer to the where question, that is where something is situated. For example, one can tell their friend about the folder where their favourite music is located in their computer, memory stick or phone. In real estate and planning, location refers to where a property is located on the earth surface, that can be absolute or relative. This is commonly referred to as spatial location. Figure 1 is a pictorial representation of how features are located on the earth surface (the globe).

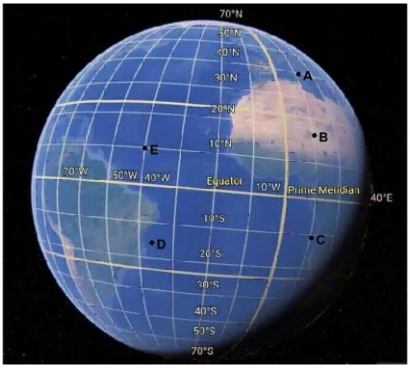


Figure 1: Location of geographic features on the earth's surface (Adapted and Modified from Vlok, Harmse and de Jager, 2009:55)

As depicted in Figure 1, points A to E are features that are found on the earth surface. In the built environment, a key notable spatial feature is real estate (land and buildings). One can describe the location of properties A to E in two ways, that is relative or absolute location as discussed in the next section. Before explaining the difference between absolute and relative location, it is important to briefly introduce and define the term 'datum to the rescue' which is key in location.

DATUM TO THE RESCUE

A datum, or starting point, provides a context to locations and heights on the Earth's surface (Ghilani and Wolf, 2012). Coordinates without a specified datum are vague. It means that questions like "Height above what?" "Where is the origin?" and "On what surface do they lie?" go unanswered. When that occurs, coordinates are of no real use. An origin, or a starting place, is a necessity for them to be meaningful. Not only must they have an origin, but they must also be on a clearly defined surface. These foundations constitute the datum. Datums have been in use for a very long time and are generally called Cartesian (Van Sickle, 2004).

RELATIVE LOCATION

With relative location, the subject property is located by relating it to other key features (landmarks) adjacent to that property. For example, with reference to Figure 2, one can describe the location of BA ISAGO University Gaborone Campus as: *BA ISAGO University Gaborone campus is located along Willie Seboni Road, approximately 3 kilometres, North-West of the Gaborone Central Business District.*

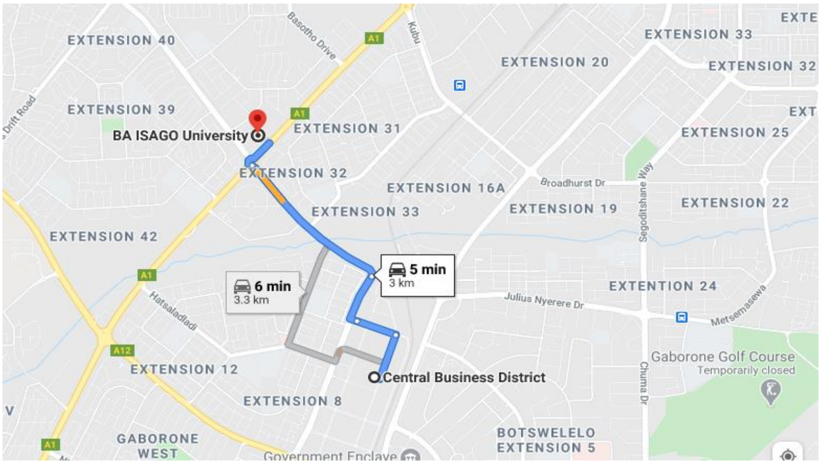


Figure 2: Location Map of BA ISAGO University from the CBD of Gaborone : Google Maps (Accessed: 30 August 2020)

The description above reflects the relationship of the BA ISAGO Gaborone campus to the CBD hence for one to locate the university, he/she must locate the CBD first. Equally important in this description are the distance and direction of the university from the CBD. Let us proceed to discuss absolute location.

ABSOLUTE LOCATION

Geographic coordinates provide an absolute location that is the identification of places by a precise and accepted system of coordinates (an address for the point). Absolute location provides us a definitive, measurable and fixed point in space. If one search BAISAGO University Gaborone Campus on Google Earth, one will get a map that is like the one in Figure 3.

Figure 3: BA ISAGO University Location Map Google Earth, 2020) Accessed 22 August 2020.

With reference to Figure 3, please pay attention to the numbers at the bottom of the map. There is the imagery date that is 2/3/2019 but our discussion is not going to dwell on this date discussion. What is important at this time are geographic coordinates that are 24°37'48.04"S 25°53'38.42"E elev 1016m. These are geographic coordinates or the exact address of BA ISAGO University on the earth surface. If one sends these geographic coordinates to anyone anywhere, he/she is supposed to be able to locate the university on Google Earth and use the map to locate the university physically. At this point one might not have an idea of what this information means but it is important to remember that this is the 'physical address' of BA ISAGO University Gaborone campus on the earth surface. Each spatial feature has its own unique physical address that shows where it is located.

HOW TO LOCATE A PROPERTY OF GOOGLE EARTH AND GOOGLE MAPS

Google Earth and Google Maps use the same satellite/aerial and street view imagery to give you some amazing data on our planet. Few aspects like searching and directions are also similar in both (Basu, 2020). There are however important differences between the two (ibid 2020);

- Google Earth is a 3D virtual globe while Google Maps is used more like a 2D map even though it has 3D features; Google Maps allows you to find and share directions and explore your locality with a fine-toothed comb. Google Earth and its satellite imagery may look the same when you compare it with Google Maps, but it offers a better set of Layers.
- In short, when you want to go from Point A to Point B, use Google Maps. When you want to explore the world in all its high-resolution 3D glory, use Google Earth.
- To locate a property on Google Earth, one must search for the property on the search bar on the top left corner of the interface shown in the Figure 4.

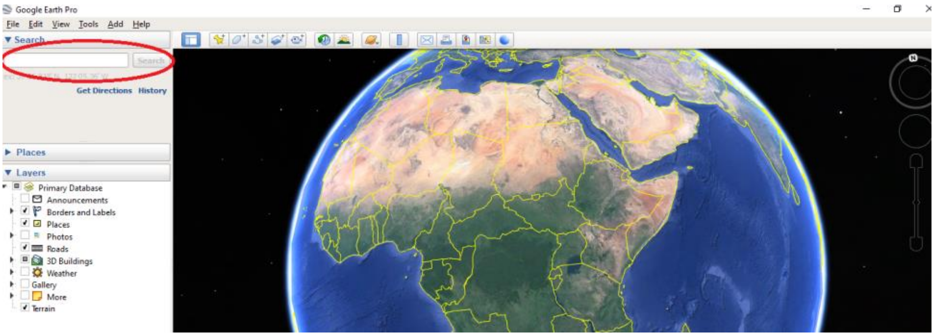


Figure 4: Example of locating property of Google Earth: Google Earth (2020) Accessed 22 August 2020

When searching, one can make use one of the options below, among others:

- City, Country: Gaborone, Botswana
- Street name: Koi Street, Gaborone, Botswana
- Specific address: plot number, street name, city, and country: 11 Koi Street, Gaborone, Botswana
- Property/Company name, city, and Country: BA ISAGO University, Gaborone, Botswana
- Longitude, Latitude: in DMS format, 24°37'45.57"S, 25°53'48.35"E or in decimal format, -24.629119, 25.896694
- General places: Universities in Gaborone, Botswana

The same search options can be employed in Google Maps. However, it is easier to obtain the coordinates from Google earth using the pin, then transfer the coordinates to Google Maps for greater details on directions and sharing with others.

SHARING A LOCATION

Location can be shared easily on Google Maps with others (colleagues, clients etc). However, as noted above, the exact location (coordinates) of a property, especially undeveloped property is easier to determine in Google Earth. Therefore, the process involves using both systems and the steps can be outlined below.

Step 1: Locate the property on Google Earth (Highlighted in blue in Figure 5).

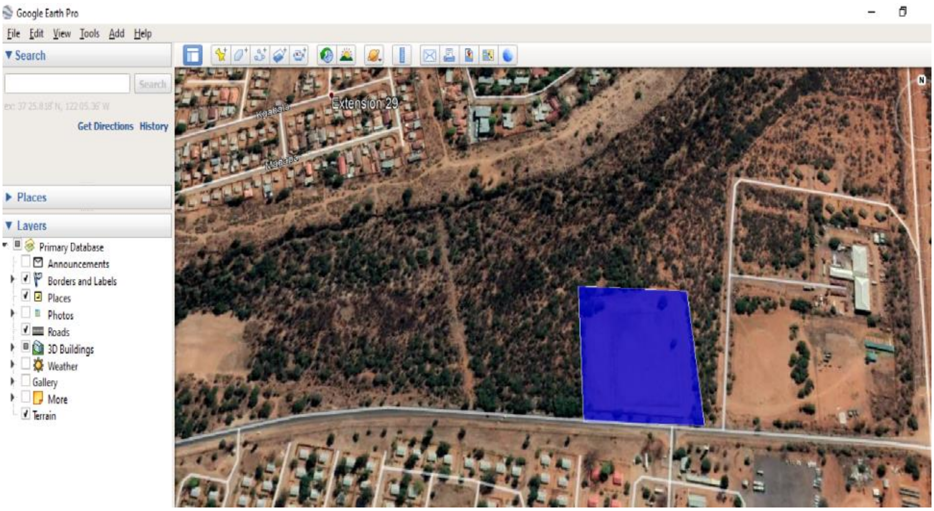


Figure 5: Step 1 of locating a property on Google Earth : Google Earth (2020) Accessed 22 August 2020

Step 2: Click the 'Add Placement' key (yellow pin) located on the ribbon at the top of the interface as shown in Figure 6.

Figure 6: Step 2 of locating a property on Google Earth (Google Earth (2020) Accessed 22 August 2020

A yellow pin will appear on the screen together with a pop-up window showing the coordinates of the point with the yellow pin.

Step 3: Drag the yellow pin on to the subject property, and the coordinates in the pop-up window will also change to reflect the new location of the pin (subject property) as shown below as shown in Figure 7.

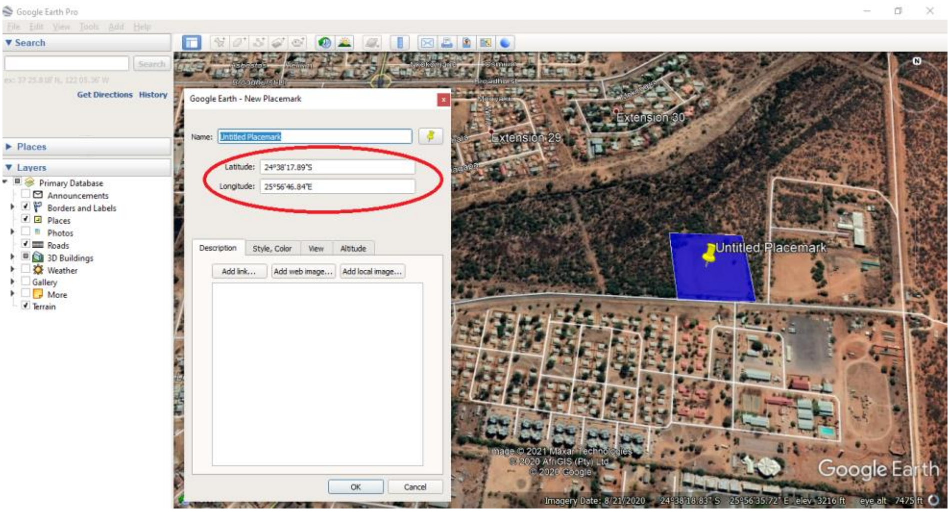


Figure 7: Step 3 of locating a property on Google Earth (Google Earth (2020) Accessed 22 August 2020

Step 4: Copy the coordinates (highlighted in red above), paste them in Google Maps search bar, and search the location. Alternatively, simply share the coordinates with the other user if he/she is using a GPS device, otherwise, use the processes to follow (see Figure 8).

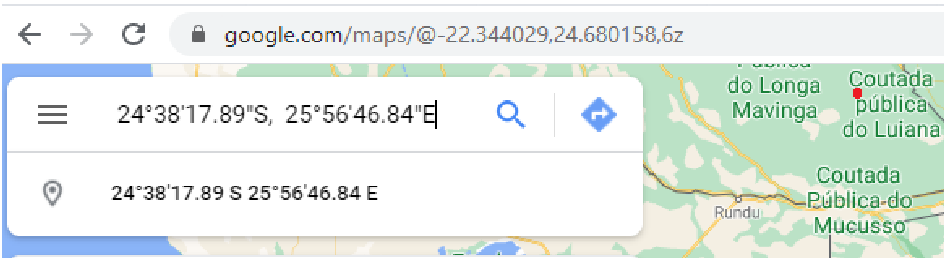


Figure 8: Step 4 of locating a property on Google Earth (Google Earth (2020) Accessed 22 August 2020.

Google Maps will navigate to the exact location which was shown on Google Earth as shown in Figure 9.

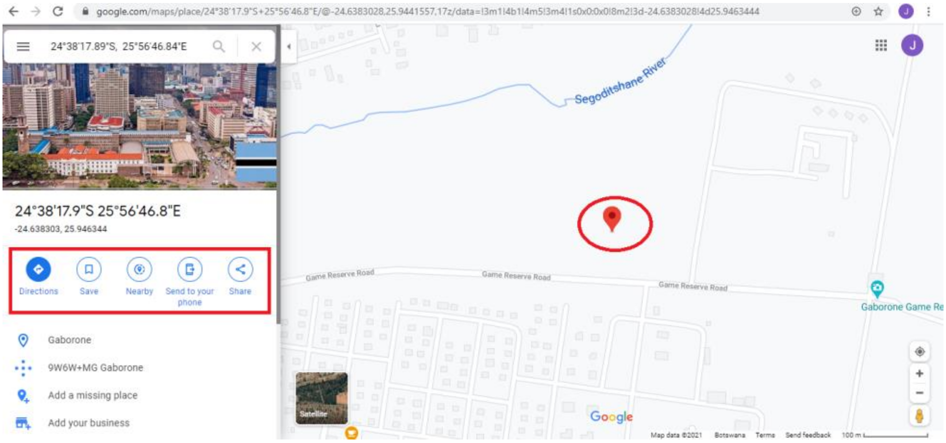


Figure 9: Step 4 of locating a property on Google Earth (Google Earth (2020) Accessed 22 August 2020

Step 5: The user can use the functions highlighted in the red box to get directions to the subject property, save the location, send to phone, or share the location with other users. To share, simply click the share option, copy the link (https://goo.gl/maps/RHSzvd698oZVAVSX6), and send to the other users.

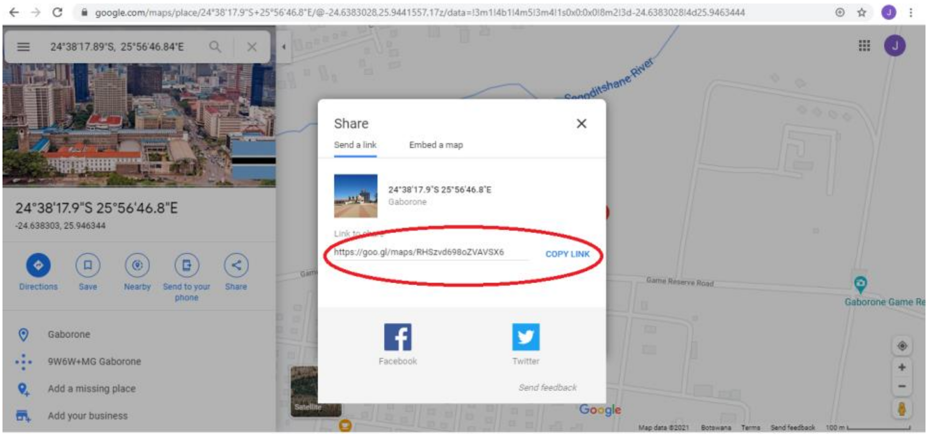


Figure 10: Step 5 of locating a property on Google Earth (Google Earth (2020) Accessed 22 August 2020

HOW TO PREPARE A LOCALITY/LOCATION MAP

Generating a locality map from Google Earth simply involves capturing images from the interface since it is already in aerial view. This involves capturing the images at different scales (resolutions) depending on the level of detail required on the map. To capture the images, one can use the inbuilt 'save image' functionality found on the top ribbon of the interface, highlighted in red below. To create the map:

- Click the same image icon as shown in Figure 11.

Figure 11: Click the image (Google Earth (2020) Accessed 22 August 2020

- Click on the 'untitled map' and edit the name of the map, then click on the 'save image' icon that appears below the ribbon, as indicated in Figure 12.

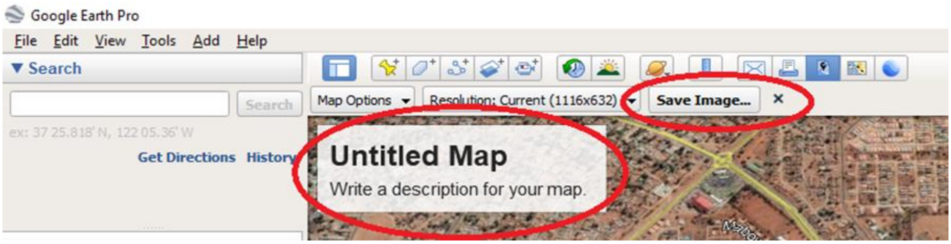


Figure 12: Click on the untitled map (Google Earth (2020) Accessed 22 August 2020.

- Browse the folder to save on, enter the name of the map and save. The map will save with a legend (key) showing any notable features captured on the map.

An example is shown in Figure 13, of the locality map of BA ISAGO University (Gaborone campus).

Figure 13: Locality Map of BA ISAGO University (Gaborone Campus) **(Google Earth (2020) Accessed 22 August 2020.**

User can play around with some labelling and the legend so that the map may communicate better, depending on the intention of the locality map. He/she can make use of the 'Add Polygon' and the 'Add Placement' keys to label the map and adjust the legend to show the desired information. An edited locality map is shown in Figure 14.

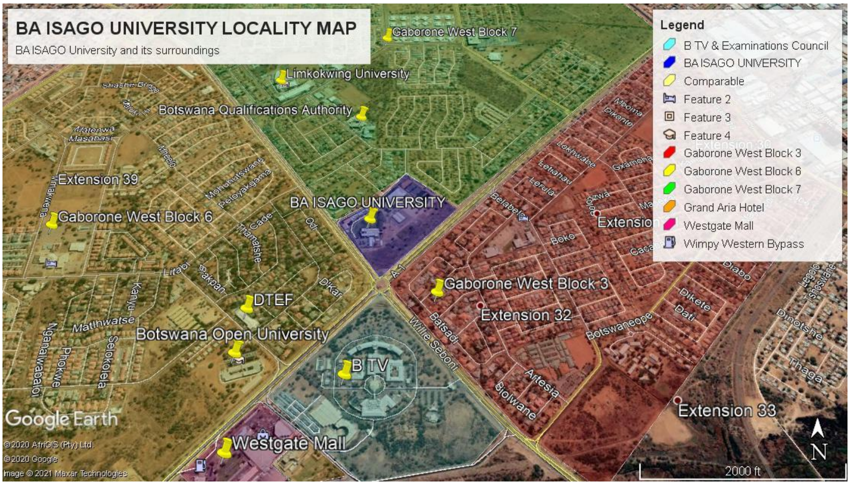


Figure 14: Edited Locality Map of BA ISAGO University (Gaborone Campus) Google Earth (2020) Accessed 22 August 2020

ACTIVITIES FOR THE READER

i. Define geographic location,
ii. With the aid of examples, differentiate relative from absolute location.
iii. Use Google Maps to locate your nearest shopping centre,
iv. Describe the location of your nearest shopping centre using relative location,
v. Use Google Earth to locate your learning institution,
vi. Describe the location of your learning institution using absolute location.
vii. Prepare 2 location maps of your house (1 from Google Earth and another one from Google Maps).

CONCLUSION

By now learners should be able to accurately locate properties online and describe the located properties with confidence. The knowledge, skills and competencies acquired will be used when designing location/locality maps which are used to communicate the location of subject properties with different stakeholders.

SUGGESTIONS FOR FURTHER READINGS

Anson, R., W. and Ormeling, F., J. (Eds.). 1991. Basic cartography for students and technicians: Exercise manual. London and New York, Elsevier applied science.

Basu, S. 2020. How to Get a Satellite View of Your House Using Google Earth. Online available from https://www.makeuseof.com/tag/globe-in-your-pc/ Accessed 25/01/2021.

Buckley, D., J. 1997. The GIS Primer: An introduction to GIS. Pacific Meridian Resources.

Kiel, K.A. and Zabel, J.E., 2008. Location, location, location: The 3L Approach to house price determination. Journal of Housing Economics, 17(2), pp.175-190.

Minchin, M. 2016. Introduction to Surveying, Second Edition. Australia. Government of Western Australia. Online available from www.dtwd.wa.gov.au Accessed 20/07/2018.

Van Sickle, J. 2004. Basic GIS coordinates. Florida, CRC Press.

Vlok, C., Harmse, A and de Jager, A. 2009. Geographical thinking and spatial perspectives: Study guide for EGIS01J. Pretoria, University of South Africa.

CHAPTER 2: DISTANCE MEASUREMENT (FIELD)

OBJECTIVES OF THE UNIT

At the end of this unit, the reader must be in good stead to:

- Use different distance measuring instruments like tapes, distance measuring wheel and laser range finder,
- Measure distance in the field using the pacing method,
- Calculate perimeter and area based on the measurements taken from different methods,
- Choose the most appropriate method and instrument when measuring distance for different purposes.

RATIONALE FOR THE UNIT

This unit is designed to develop students' knowledge and skills needed for one to competently measure the distance in real property using different methods and instruments. Students will work in groups to measure the distance of different properties and there after calculate area and perimeter of the same.

ASPECTS AND ISSUES

The dictionary definition of distance is the length of the space between two points. With reference to Figure 2, our two points are BA ISAGO University Gaborone Campus and the Central Business District that are 3km from each other. Vlok, Harmse and de Jager (2009) posit that distance can also be measure in terms of time. In this case, if we are to use the example of Figure 2, instead of describing BA ISAGO University as located 3km from the CBD, one can say the location of BA ISAGO University is a 5-minute drive from the CBD. How is distance measured by planning real estate professionals? Property measurement (distance) is done either in the field (on the ground) and/or in the office (on maps). Let us proceed to discuss the common distance measurement techniques and instruments that are used in the real estate industry. In the field, distance measurements can be obtained by many different methods but the commonly used are pacing, taping, digital measuring wheel (odometer) and electronic distance measurement (EDM). The choice of measurement technique and tools to be used depend on the accuracy of the result needed, cost, required skills, availability of equipment and characteristics of the subject property.

THE PACING METHOD

One can measure distances roughly by pacing. This means one count the number of normal steps that will cover the distance between two points along a straight line. Pacing is particularly useful in reconnaissance surveys, for contouring using the grid method and for quickly checking chaining measurements. To be accurate, one should know the average length of their step when one walk normally. This length is called their normal pace. Always measure their pace from the toes of the foot behind to the toes of the foot in front. Refer to Figure 15 below for a diagrammatic illustration.

Figure 15: Example of pacing measurement (Primary Data, 2024)

PACE FACTOR (PF)

The first thing one is supposed to do when using the pacing method is to calculate their pace factor. To measure the average length of their normal pace (the pace factor):

- Take 100 normal steps on horizontal ground, starting with the toes of their back foot from a well-marked point, A, and walking along a straight line.

- Mark the end of their last step with peg B, at the toes of their front foot.
- Measure the distance AB (in metres) with, for example, a tape and calculate their pace factor PF (in metres) as follows:

Example
If for 100 paces, one measure 75 m, then their pace factor is calculated like this:
PF = 75 m /100 = 0.75 m.
Now that one knows how to calculate the pace factor, let us proceed to discuss how one uses the same in calculating distance. Please refer to Figure 16.

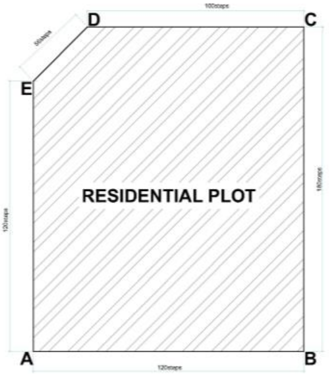


Figure 16: Pacing Example. (Designed by Authors)

To calculate the distance from A to D, one is supposed to do the following:
Add steps AB, BC and CD to get the total number of steps (N)
Multiply the N by their pace factor PF (in metres) to get a rough estimate of the distance in metres, as follows: Distance (m) = N x PF.
To measure ABCD, pace distances AB = 120 steps; BC = 180 steps; CD = 100 steps and DE = 55. ABCDE = 120 + 180 + 100 + 56 = 456 steps.
If PF = 0.75 m,
therefore, ABCDE = 456 x 0.75 m = 342m

ADVANTAGES OF THE PACING METHOD
It is simple hence there is no need for specialised skills;
It is cheap since there is no need of specialized equipment.

DISADVANTAGES OF THE PACING METHOD
Error increases as the terrain becomes more difficult (slope, vegetation, obstacles).

- Requires practice to take a consistent pace.
- It can be time consuming when measuring large properties.
- It only measures distances that is you cannot measure distance and angles at the same time.
- It requires being able to walk the route hence it is not very useful for measuring distance in rough terrain, across swamps, or in any other terrains where an individual could not walk the distance or walk in a straight line (Field & Long, 2018).

THE TAPING METHOD

This is a traditional method of measuring distance between two points. Taping is carried out by two persons. Tapes are popular for making rough measurements or when the accuracy of a chain is not needed. The tapes are classified based on the materials of which they are made of, such as Cloth or linen tape, Fibre Tape, Metallic Tape, Steel tape and Invar Tape. Figure 17 shows an example of a fibre tape.

Figure 17: Fibre tape (Image taken by Authors)

ADVANTAGES OF THE TAPING METHOD

1. Non-metallic tapes are usually lighter and easier to use,
2. They require less maintenance and are not as easily damaged by moisture,
3. Inexpensive.

DISADVANTAGES OF THE TAPING METHOD

1. Tapes will stretch under tension and therefore are not very accurate.
2. Need multiple people,

3. Must have a clear, travelable route,
4. High precision requires temperature and tension correction.

THE DIGITAL MEASURING WHEEL/ ODOMETER

It is a wheel fitted with a fork and handle. The wheel is graduated and shows a distance per revolution. There is a dial that records the number of revolutions. Thus, the distance can be computed. The distance is calculated by multiplying the number of revolutions by the wheel's circumference. The smoother the path the wheel travels, the more accurate the measurement. This method is particularly useful for curved lines. Odometer wheels can also be used to verify other measurements. Figure 18 shows a digital measuring wheel.

Figure 18: Measuring wheel (Image taken by Authors)

ADVANTAGES OF A MEASURING WHEEL

1. Easy to use;
2. Do not need exercise or experience;
3. Fast to give an estimate of the distance.

DISADVANTAGES OF A MEASURING WHEEL

1. Error increases as the terrain becomes more difficult (slope, vegetation, obstacles),
2. It only measures distances that is you cannot measure distance and angles at the same time,
3. Accuracy might be compromised due to technical faults like when the power is low,
4. It requires being able to walk the route hence it is not very useful for measuring distance in rough terrain, across swamps, or in any other terrains where an individual could not walk the distance or walk in a straight line (Field & Long, 2018).

LASER DISTANCE METER RANGEFINDER

A laser distance meter uses the focusing of lenses on a distant object to estimate the distance to the object. This technique is the same as single-reflex lens cameras. A laser rangefinder is a handheld device that projects a beam of light and measures the time of reflection to calculate the distance to the object off that the beam reflects. Lasers have a maximum range of 500 m. And there is another type a laser rangefinder is a device that uses a laser beam to determine the distance to an object. The most common form of laser rangefinder operates on the time-of-flight principle by sending a laser pulse in a narrow beam towards the object and measuring the time taken by the pulse to be reflected off the target and returned to the sender. Due to the high speed of light, this technique is not appropriate for high precision sub-millimetre measurements, where triangulation and other techniques are often used. The precision of the instrument is determined by the rise or fall time of the laser pulse and the speed of the receiver. One that uses very sharp laser pulses and has a very fast detector can range an object to within a few millimetres. An example of a Laser distance meter is shown in Figure 19.

Figure 19: Handheld laser distance meter ([online] Available at: **https://www.autobuild.co.za/products/fm880/** (Accessed: 11/09/2020).

ADVANTAGES OF RANGEFINDERS

1. They are not heavy hence they are easy to use in the field;
2. High level of accuracy in the results recorded;
3. The laser distance meter can accumulate independently to calculate surfaces and volumes;
4. Capable of determination of very large distances hence not time consuming;
5. No need of many people to operate it.

DISADVANTAGES OF RANGEFINDERS

1. Only measures on flat surface;
2. Source of power battery always charging;
3. Instruments used are expensive;
4. Requires training;
5. Accuracy might be compromised due to technical faults like when the power is low.

ACTIVITIES FOR THE READER

- Point out any two (2) instruments used to measure the distance of property in the field.

- Explain any two (2) advantages of taking distance measurements using each of the following: the pacing method, the taping method, the digital measuring wheel, and the laser distance meter.
- Explain any two (2) disadvantages of measuring distance using each of the following: the pacing method, the taping method, the digital measuring wheel and the laser distance meter.

You measured the length and width of a property on the ground using the pacing and your measurements were as follows:

Length	1 000 steps
Width	750 steps
Distance covered by 200 steps	150m

a) Calculate the pacing factor,
b) Calculate the perimeter of the property,
c) Calculate the area of the property.

You measured the length and width of a property on the ground using the pacing and your measurements were as follows:

Length	1 000 steps
Width	600 steps
Distance covered by 200 steps	175m

a) Calculate the pacing factor,
b) Calculate the perimeter of the property,
c) Calculate the area of the property.

vi. You measured the length and width of a property on the ground using the pacing and your measurements were as follows:

Length	**1 000 steps**
Width	500 steps
Distance covered by 200 steps	180m

a. Calculate the pacing factor,
b. Calculate the perimeter of the property,
c. Calculate the area of the property.

You measured the length of a footpath using the pacing method and you counted 2000 steps. If your 100 steps are equivalent to 65m, Calculate:

- The Pace Factor.
- The length of the footpath in metres.

CONCLUSION

Having completed this unit, learners should be able to competently measure land and buildings using different methods and instruments as well as calculate perimeter and area with accuracy. The knowledge and skills gained will be used when designing location/locality maps which are used to measure different properties for various purposes and effectively communicate the area of the subject properties with different stakeholders.

SUGGESTIONS FOR FURTHER READINGS

dela Cruz, C., R. 1983. Fishpond engineering: A technical manual for small-and medium-scale coastal fish farms in Southeast Asia. Metro Manila, the Food and Agriculture Organization of the United Nations.

Field, H., L. and Long, J., M. 2018. Introduction to agricultural engineering technology: A problem solving approach (Fourth Edition). Springer: ISBN 978-3-319-69678-2; ISBN 978-3-319-69679-9 (eBook). https://doi.org/10.1007/978-3-319-69679-9.

Ghilani, C., D. and Wolf, P., R. 2012. Elementary Surveying: An Introduction to Geomatics (Thirteenth Edition). New Jersey, Prentice Hall.

Gomarasca, M, A. 2010. Basics of geomatics. Springer, ISBN 978-1-4020-9013-4).

Kavanagh, B., F. 2010. Surveying with construction applications (Seventh Edition). New Jersey, Prentice Hall.

Kavanagh, B., F. and Mastin, T., B. 2014. Surveying Principles and Applications (Ninth edition). New Jersey, Prentice Hall.

Minchin, M. 2016. Introduction to Surveying, Second Edition. Australia. Government of Western Australia. Online available from www.dtwd.wa.gov.au Accessed 20/07/2018.

Vlok, C., Harmse, A and de Jager, A. 2009. Geographical thinking and spatial perspectives: Study guide for EGIS01J. Pretoria, University of South Africa.

CHAPTER 3: DISTANCE MEASUREMENT ON MAPS

OBJECTIVES OF THE UNIT

At the end of this unit, the reader must be able to:

1. Differentiate different types of map scale;
2. Correctly read different scale on a scale ruler;
3. Measure distance on a printed map using the correct scale on a scale ruler;
4. Calculate the scale on a map given the distance on the map and corresponding distance on the ground;
5. Calculate distance on the ground given the map scale and distance on the map;
6. Calculate distance on the map given the map scale and distance on the ground.

RATIONALE FOR THE UNIT

The rationale of this unit is to improve the learners' knowledge and competencies in property measurement on a printed map using a scale ruler. Each student will work independently to measure properties using different scale on a scale ruler and calculate area as well as the perimeter of the measured properties. Also, students will calculate scale given the measurement on the ground and on the map as well as convert distance on the map to its corresponding distance on the ground or the other way round.

ASPECTS AND ISSUES

Generally, two methods are used to measure distance on a map depending on the type of the map. Manual measurements are done on printed maps using a scale ruler and electronic measurements are done on electronic maps like CAD and Google Earth. Before we start discussing about these two types of measurement, it is important to introduce a subject of scale. If one do not understand how scale works then understanding property measurement on a map can be challenging.

MAP SCALE

Maps are a graphical representation of the world or a section of the world. The relationship between the real-world size of a geographic feature and its representative feature on a map is known as scale (Vlok, Harmse and de Jager, 2009; Tyner, 2010). Scale is important because it enables us to recognize the relationship between a drawing or physical model and the reality of its real-world size. As a representation of the world, maps are compressed versions of the real world meaning that a large piece of land is recreated onto a smaller piece of paper or digital file.

Scale can be described in three ways: as a ratio, in words, or graphically/line. For example, with a word scale will be like: Word scale: 10 cm on the map represents 100 m in reality or 1 cm on the map represents 10 m in reality and a graphic scale (Vlok, Harmse and de Jager, 2009). A line scale must always specify the unit of measurement as shown by Figure 20.

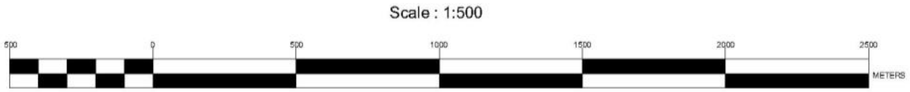


Figure 20: A graphical scale (*Authors*)

A ratio is simply a comparison of map size to real-world size as in 1:1,000,000 or 1:24,000. This means one unit on the map represents 1,000,000 of the same units in the world; thus 1 inch represents 1,000,000 inches or 1 centimetre represents 1,000,000 centimetres. It is the same as saying the map is 1/1,000,000 the size of the earth. Expressing scale in this way is called the representative fraction (RF), the natural scale, or the scale of the map. No units (inches, centimetres, miles, kilometres) are attached to the RF since it is a ratio. Please note that a map scale is independent of the unit of measurement. If the plan of a house has been drawn at a scale of 1:100 one can say that 1 mm on the plan is equivalent to 100 mm in reality or one can say 1 cm on the plan is equivalent to 100 cm in reality. It means the same! (Vlok, Harmse and de Jager, 2009; Tyner, 2010).

Scale operates along a continuum from large scale to small scale as shown in Figure 21. Large-scale maps show small portions of the Earth's surface; detailed information may therefore be shown. Small-scale maps show large areas, so only limited detail or generalized situations can be carried on the map (Dent, Torguson, and Hodler, 2009; Vlok, Harmse and de Jager, 2009). The terms "large scale" and "small scale" are often used and frequently confused. A large-scale map shows a small area in detail; a small-scale map shows a large area but with little detail. Thus, a world map shown on an atlas page is a small-scale map and a city map appearing in the same atlas is a large-scale map. The larger the denominator of the RF, the smaller the scale. The scale 1:1,000,000 is smaller than the scale 1:500,000 (Tyner, 2010). Dent, Torguson, and Hodler (2009) stress that:

It is important to note that the definition of scale as discussed here and in other textbooks is specific to cartography and maps. The cartographer's approach to scale is somewhat different from that used by people in defining the scope of what they do or events that occur. For example, the newscaster may report that the disaster was contained to a small scale (meaning held to a limited area) or that the cure for polio was implemented on a large scale (meaning great breadth). Since a cartographer's view is the "opposite" of these popular connotations of scale, it may be helpful to remember the often-used pneumonic for many cartographers: large scale, large in detail, but small in area—small scale, small in detail, but large in area.

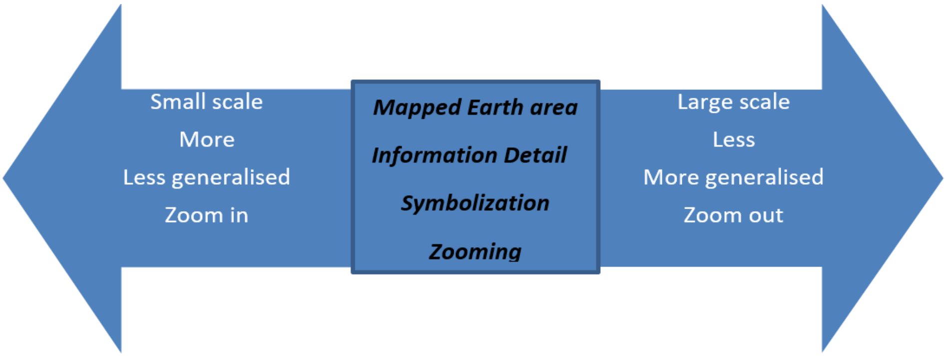


Figure 21: Differences between small and large scales (Adapted and Modified from Dent, Torguson, and Hodler, 2009).

MAP SCALE CALCULATIONS

If one has a map scale, one can calculate the distance of their property in the real world. To calculate the real distance, one multiply the measured map distance by the denominator (Vlok, Harmse and de Jager, 2009). If their scale is 1:100 then their denominator is 100. Remember we said 1:100 is the same as 1/100. For example, if the scale of a house plan is 1:250 then if the measurement on the plan is say 5cm then the real distance will be 5 X 250 = **1250cm**. Please remember that, when applying the map scale, one is supposed to use the same unit of measurement like in this example I used cm that meaning to say 1cm on the map represents 250cm on the ground. Never use different units of measurement. Usually, real distance is presented in metres of kilometres hence one need to convert the 1250cm into metres as follows: 1cm = 100cm hence 1250cm= **125m**.

One can also calculate the distance on the map if one has the real distance and the scale. Using the above example, if their real distance is 125m and their scale is 1:250, to calculate the distance on the map one dived the value of their real distance by the denominator. Our distance on the ground is 125m and we want to calculate the distance on the map, remember that we cannot draw a line that is 125m on the map so what it means is their answer should be either in cm or mm. In this example I am going to use cm. So, the first thing before diving their ground distance by their denominator is to convert the real-world distance (125m) into cm that is 1250cm (see the example above if one is still having a challenge with the conversion). Now that one has converted their real distance into cm one can now go ahead to calculate the distance of the same as represented on a map by dividing 1250/250 = **5cm**.

There are cases where one can have a map/plan without a scale that becomes difficult if not impossible to use. In this case one can calculate the map scale. For one to be able to calculate the map scale, one need to identity at least points on the map/plan say property boundaries or sides of a property and measure them on the ground. The map distance between the points is measured and using the formula RF = Map Distance/Ground Distance the scale can be determined. Remember that RF is a fraction expressed as 1/x (Tyner, 2010). For example, if the length of a property on the map is 10cm and the actual distance on the ground is 10m one can calculate the map scale as follows: (1) convert 10m into cm that is 100cm and (2) use the formula above (Map distance/ground distance) 10/100 = 1:10. More than one sides are used to validate their answer. Let us conclude this topic by discussing an important instrument that is used to measure distance on a map, it is called the Architect's Scale Ruler.

THE ARCHITECT'S SCALE RULER

A scale ruler is the three-sided ruler used by architects, engineers, planners, and real estate professionals to convert between scaled drawings and the actual dimensions without having to resort to any mathematical calculations. An architect uses the scale ruler to convert dimensions into a smaller drawing of a building plan. The reader of maps will then use a scale ruler to translate the drawing into the real sizes for construction. If reading a blueprint, the appropriate scale will be written on the plans. If drafting a plan, choosing an appropriate scale will depend on the size of the drawing compared to the actual dimensions described. Scales were traditionally made of wood, but today they are usually made of rigid plastic or aluminium. The plastic scale rulers are more affordable but are more prone to chipping and wear compared with the aluminium rulers. Architect's scales may be flat, with 4 scales, or have a symmetric three-lobed cross-section, with 6 scales. If one chooses one side, one will notice one has a scale running left to right, and another running right to left. Figure 22 shows an example of a scale ruler.

Figure 22: Plastic Scale ruler (Images taken by the Authors)

DISTANCE MEASUREMENT CALCULATION OF AREA USING GOOGLE MAPS AND GOOGLE EARTH

It is also possible to measure the distance of real properties and even calculate area online using tools which are available in Google Maps and Google Earth (Ellis, 2019). The first part of this section is going to focus on how distance is measured and the section to follow dwells on calculation of area online.

ONLINE DISTANCE MEASUREMENT

This section is divided into two parts, the first part explains how distance is measured on Google Maps and followed by measurement of distance on Google Earth.

GOOGLE MAPS

To measure distance on Google Maps, follow the steps to follow:
First, right-click on the starting point, and select Measure distance on the menu that pops up (Ellis, 2019). Let us use an example of measuring the distance

between Gaborone and Harare. Our starting point in this case is Gaborone as shown with a red mark in Figures 23 and 24.

Figure 23: Locating Gaborone on Google Maps (Google Maps - Accessed 09/02/2021)

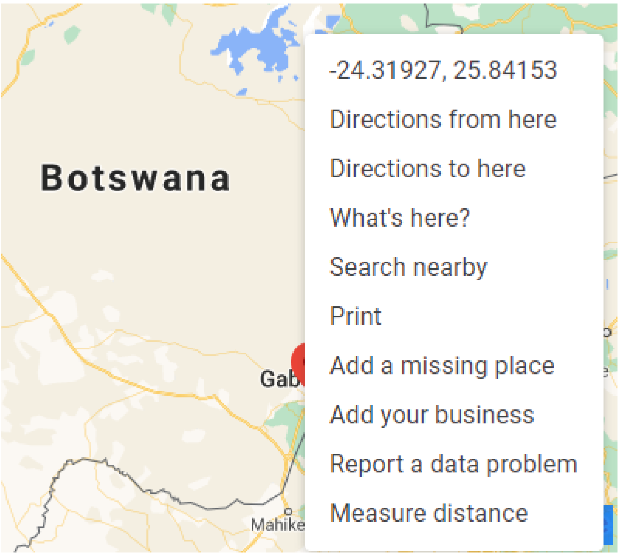


Figure 24: Measure distance on the menu that pops up (Google Maps - Accessed 09/02/2021)

Click on the second point (the destination that you want to measure to from your starting point) on the map. Once this point is selected, Maps will automatically show the distance between both points (Ellis, 2019).

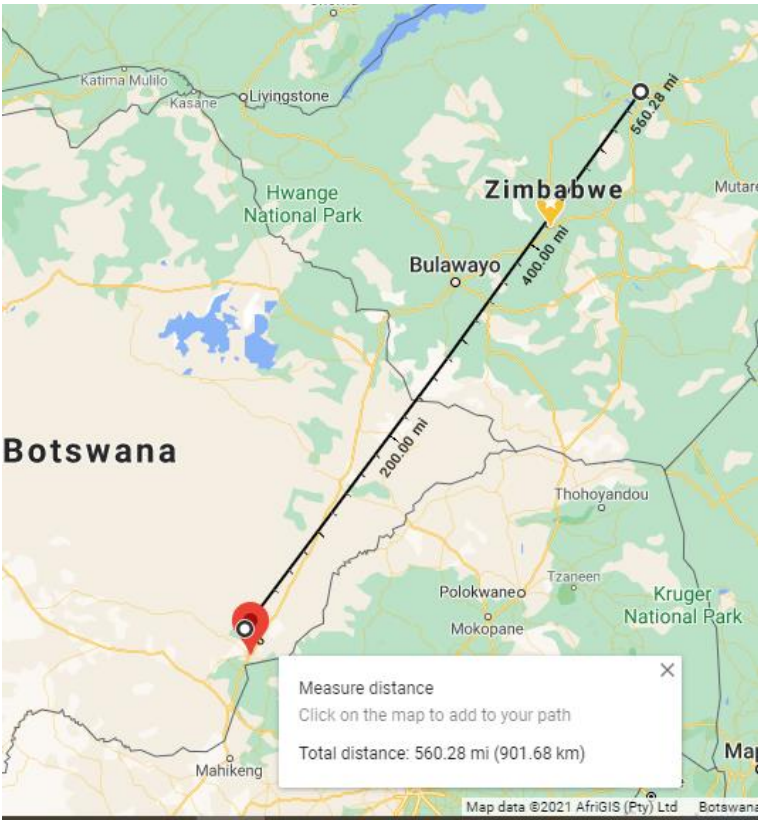


Figure 25: Measuring distance between Gaborone and Harare on Google Maps (Google Maps - Accessed 09/02/2021)

As shown in Figure 25 the distance between Gaborone and Harare is 901.68 km.

GOOGLE EARTH

To measure distance between Gaborone and Pretoria on Google Earth please do the following:

Open Google Earth Pro (https://support.google.com/earth/answer/148134?hl%3Den) as shown in Figure 26.

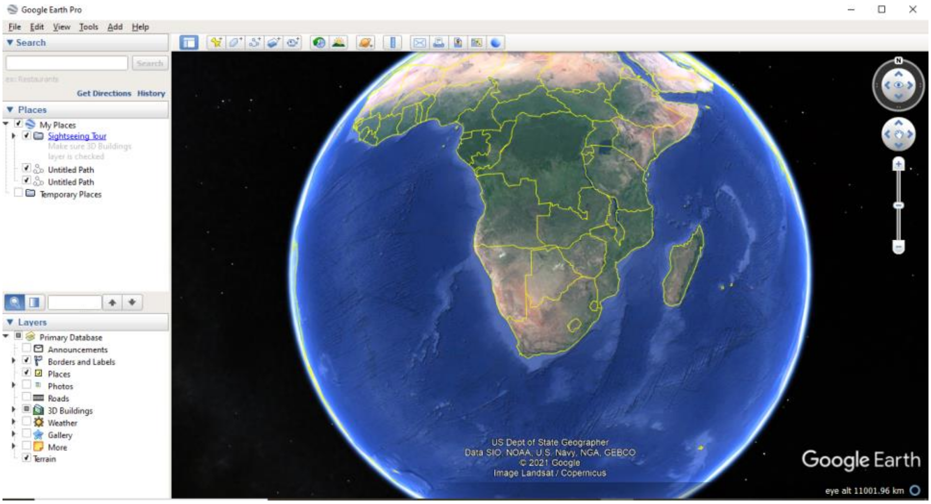


Figure 26: Google Earth Pro: (Google Earth, 2021) (Accessed 09/02/2021)

To start measuring distance in Google Earth, select the ruler icon at the bottom of the left-hand sidebar or in the menu bar, click Tools and then Ruler. A new "Ruler" window with options appears (https://support.google.com/earth/answer/148134?hl%3Den; Ellis, 2019) as shown in Figure 27.

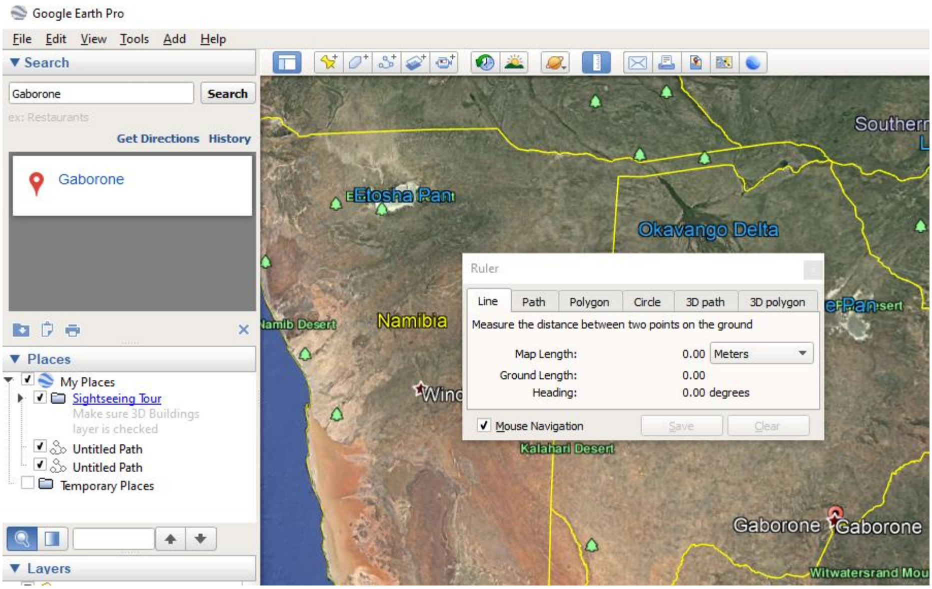


Figure 27: Selecting a ruler : (Google Earth, 2020) (Accessed 09/02/2021)

On the map, hover over a spot and click a starting point for your measurement.

Then, hover over another spot and click an end point as illustrated in Figure 28.

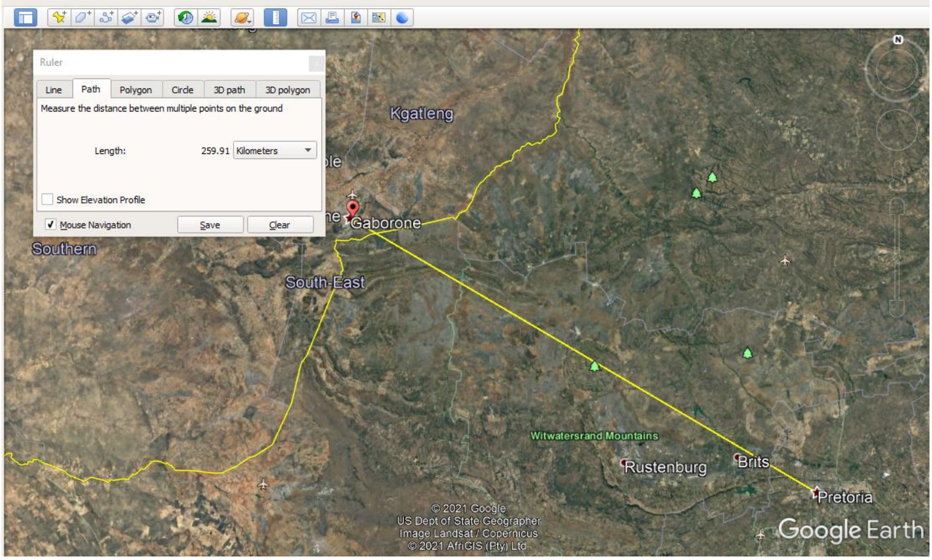


Figure 28: Distance between Gaborone and Pretoria on Google Earth
Source: Google Earth (2020) (Accessed 09/02/2021)

- The measurement will show up in the "Ruler" window. To save your measurement, click Save.
- In the "Name" field, type a name for your measurement.
- In the bottom right, click OK. Google Earth Pro will add your measurement under "Places" in the left-hand panel.
- With reference to Figure 29 note that the distance between Gaborone and Pretoria is 259.91 km. Also note that you can also change the measurement units, converting them to kilometers, yards, nautical miles, or other units.
- To change measurement systems on a Windows computer, select Tools and then Options. Then, under "Units of measurement," choose feet or meters.
- To change measurement systems on a Mac, select Google Earth and then Preferences. Then, under "Units of measurement," choose feet or meters.

If you want to measure the distance for something like a mountain trail, you can switch to 3D view after selecting the ruler icon. This lets you measure large objects such as mountains, or accurately trace a path along an incline (https://support.google.com/earth/answer/148134?hl%3Den).

CALCULATION OF AREA ONLINE

This section is divided into two parts, the first part explains how distance is measured on Google Maps and followed by measurement of distance on Google Earth.

GOOGLE MAPS

Box 3.1 is a summary of how area of properties is calculated using Google Maps.

Box 3.1: Area calculation on Google Maps

To measure any area in Google Maps, you just need to start with the same process as for measuring distance. First, right-click on the map at your starting point and choose the Measure distance option. Add points around the location's boundary. Once you close the shape by clicking on the starting point, Google will automatically calculate the area of your shape. Source: Ellis (2019).

GOOGLE EARTH

Box 3.2 is a summary of how area of properties is calculated using Google Maps.

Box 3.2: Area calculation on Google Earth

You will start off the same way as when measuring distance, with the ruler icon. NB select Polygon not line or path. Once you select multiple points and close the outline by selecting your starting point again, Google Earth will automatically calculate area. Again, you can drag points to change the outline or switch between units of measurement. Source: Ellis (2019).

ACTIVITIES FOR THE READER

Measure all **five (5)** lines using the given scales.

ITEM NO.	LINE	SCALE	YOUR ANSWER	CORRECT ANSWER
i.		1:100		
ii.		1:200		
iii.		1:300		
iv.		1:400		
v.		1:500		
vi.		1:600		

With reference to Figure 29 and using a scale of 1:200, measure the sides of the following shapes. Your answer must be in metres.

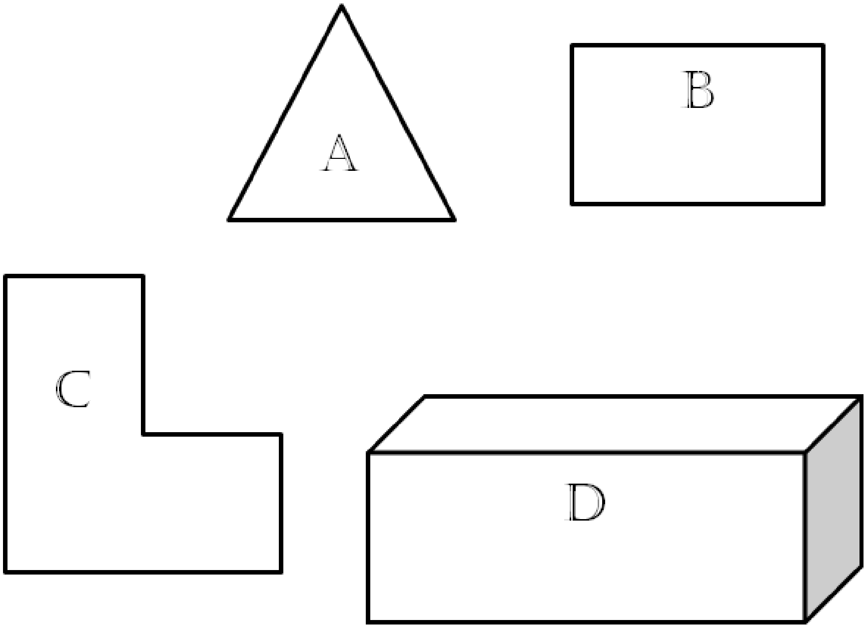


Figure 29: Shapes to be measured by students (Designed by authors)

You measured the length of a footpath using the pacing method and you counted 2000 steps. If your 100 steps are equivalent to 65m, calculate the length of the footpath in cm on a map using a scale of 1:2500.

1. Draw a line which represents 60m on the ground, using a scale of 1: 200.
2. Explain the difference between a large and a small map scale.

3. Calculate the scale if the length of a footpath on the ground are 60m and its length on the map is 30cm.
4. If you measured 500m on the ground, what would be its corresponding distance on a map, if the map scale is 1: 50 000.

You measured 20cm on a map of scale 1: 500, calculate the actual distance on the ground.

Calculate the area of a property on a map of scale 1: 2 500 if your measurements on the ground using the pacing were as follows:

Length	**1 000 steps**
Width	750 steps
Distance covered by 200 steps	150m

CONCLUSION

By now learners should be able to accurately measure distance on a printed map using a scale ruler and calculate scale on a map where distance on the ground and on the map is furnished.

SUGGESTIONS FOR FURTHER READINGS

dela Cruz, C.R. 1983. Fishpond engineering: A technical manual for small-and medium-scale coastal fish farms in Southeast Asia. Metro Manila, the Food and Agriculture Organization of the United Nations.

Dent, B., D. Torguson, J., S. and Hodler, T.W. 2009. Cartography: Thematic map design (sixth edition). New York, McGraw-Hill.

Ellis, M. 2019. How to Measure Area and Distance in Google Maps and Google Earth.

Field, H.L. and Long, J.M. 2018. Introduction to agricultural engineering technology: A problem solving approach (Fourth Edition). Springer: ISBN 978-3-319-69678-2; ISBN 978-3-319-69679-9 (eBook). https://doi.org/10.1007/978-3-319-69679-9.

Ghilani, C.D. and Wolf, P., R. 2012. Elementary Surveying: An Introduction to Geomatics (Thirteenth Edition). New Jersey, Prentice Hall.

Kavanagh, B.F. and Mastin, T.B. 2014. Surveying Principles and Applications (Ninth edition). New Jersey, Prentice Hall.

Minchin, M. 2016. Introduction to Surveying, Second Edition. Australia. Government of Western Australia. Online available from www.dtwd.wa.gov.au Accessed 20/07/2018.

Shekar, S. and Xiong, H. (Eds.) 2018. Encyclopedia of GIS. New York, Springer.

Tyner, J.A. 2010. Principles of map design. New York, The Guilford Press.

Vlok, C., Harmse, A and de Jager, A. 2009. Geographical thinking and spatial perspectives: Study guide for EGIS01J. Pretoria, University of South Africa.

CHAPTER 4: DIRECTION

OBJECTIVES OF THE UNIT

At the end of this unit, the reader must be able to:
Define direction as it is applied in real property;
Explain the difference between true north and magnetic north;
Differentiate azimuth from bearing;
Identify surveying instruments which are used to measure angles.

RATIONALE FOR THE UNIT

This unit is designed to improve the learners' understanding of direction and identify surveying instruments used to measure angles.

ASPECTS AND ISSUES

When locating properties, distance without direction is useless. Just imagine if one just says BA ISAGO University is 3km from the CBD, there are many places that are 3km from the CBD and BA ISAGO University is just one of them. For the message to be complete there is need for one to give direction that was given as North-West of the CBD in the first example.

Direction is the position of one point on the earth relative to another point or a course along that someone or something moves, that must be taken to reach a destination. Compass directions, such as north, south, east, west, southwest, and so on are commonly used when speaking of direction. Note that the international convention is to place north and south before east and west. With reference to Figure 30, we can describe the location of points B and C relative to our position at A as:

- Point B: west south-west,
- Point C: north north-west.

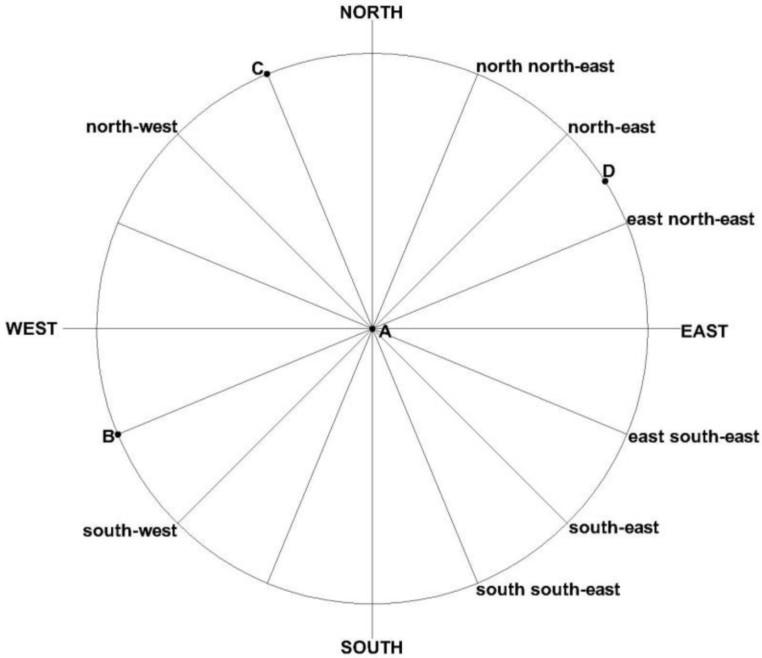


Figure 30: Sixteen campus direction (Adopted and Modified from Vlok, Harmse and de Jager, 2009:51).

NORTH

We need to point out that there are two types of north namely true north (geographic north) and magnetic north. True north points to what we know as the North Pole. Maps indicate true north. However, when using a compass, the needle does not point to polar north but to magnetic north. A further complication is that the magnetic north is a floating point – its position constantly changes (Vlok, Harmse and de Jager, 2009).

In fact, the magnetic North Pole has moved more than 600 miles since the early 19th century and it is still at it, moving at a rate of about 15 miles per year, just a bit faster than it used to be. The Earth's magnetic field is variable. For example, if the needle of a compass at a place points 15° west of geodetic north, there is said to be a west declination of 15°. At the same place 20 years later, that declination may have grown to 16° west of geodetic north. This kind of movement is called secular variation. Also known as declination, it is a change that occurs over long periods and is probably caused by convection in the material at the Earth's core (Van Sickle, 2004). The position of magnetic north is governed by natural forces, but grid north is entirely artificial. The direction to north is established by choosing one meridian of longitude. Thereafter, throughout the system, at all points, north is along a line parallel with that chosen meridian. This arrangement purposely ignores the fact that a meridian pass through each of the points and that all the meridians inevitably converge with one another (Van Sickle, 2004).

So what? The point is that if one is using a compass in the field to get to from point A to B and the direction was given to in terms of true north one will walk in the wrong direction. The problem is easy to solve. On the 1:50 000 maps of South Africa the angular difference (referred to as the magnetic declination) between true north and magnetic north is given as a diagram that also indicates how the magnetic declination changes over time. As illustrated in Figure 31 we can infer that the magnetic declination measured at the place is 20° west of True North (Vlok, Harmse and de Jager, 2009).

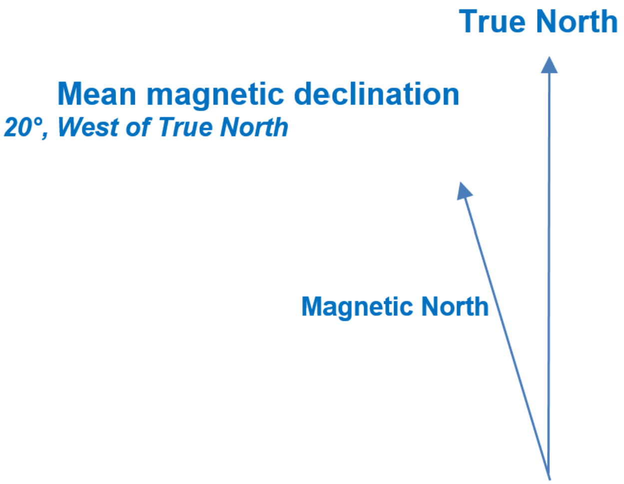


Figure 31: The true north, magnetic North, and magnetic decline (Adapted from Vlok, Harmse and de Jager, 2009:52).

DETERMINING DIRECTION IN THE FIELD

Just saying North, East, West South is not enough, to be accurate about the actual location of a property there is need state the angle at that one is supposed to take moving toward the stated direction. This angle is determined in two way that are azimuth and bearing as discussed in the sections to follow.

AZIMUTH

One can surely agree that the cardinal directions are convenient but that it is still rather vague. A much more accurate way of describing direction is to divide the circle into 360°. Azimuth is the angle measured clockwise from the reference line and has a value between 0° and 360° (Van Sickle, 2004; Vlok, Harmse and de Jager, 2009; Tyner, 2010). By placing a protractor on Figure 32 (or on a map) in such a way that 0° coincides with north, angles of azimuth varying between 0° and 360° can be read off the protractor in a clockwise direction. We can now describe the location of points B, C and D relative to our position at A as:

Point B: 250°
Point C: 340°
Point D: 50°

Figures 32 and 33 illustrate how direction is expressed in terms of azimuth.

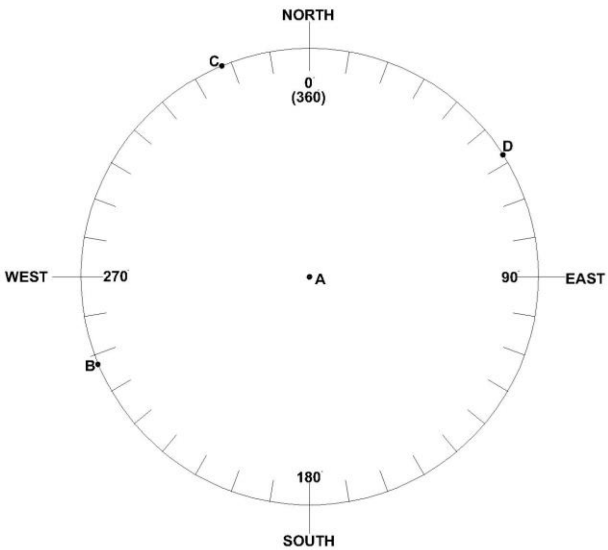


Figure 32: Expressing direction in terms of Azimuth (Adapted from Vlok, Harmse and de Jager, 2009:51).

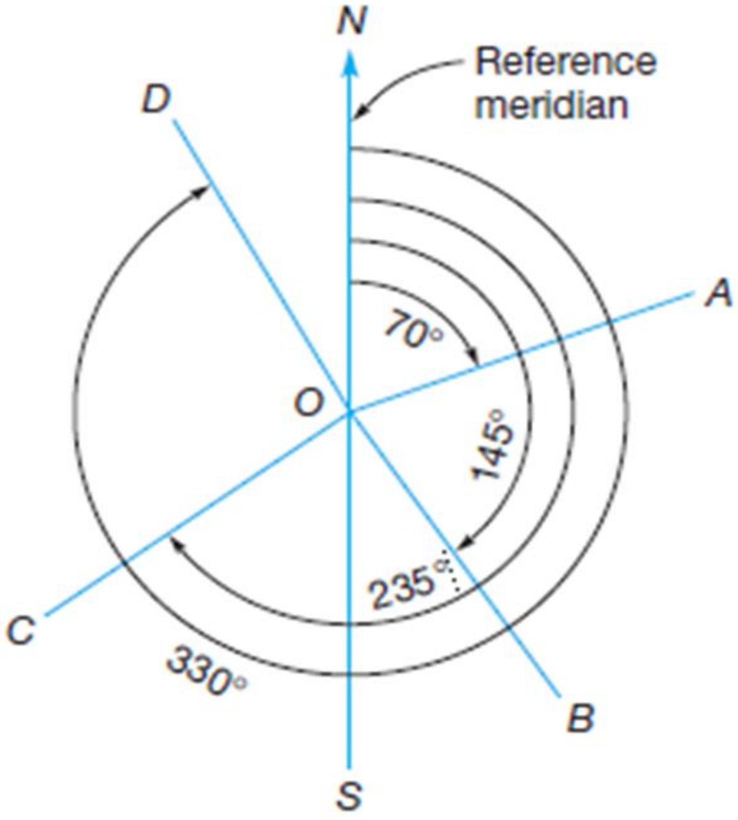


Figure 33: Azimuth (Ghilani and Wolf, 2012)

As illustrated in Figure 33, the azimuth of OA is 70°; of OB, 145°; of OC, 235°; and of OD, 330°.

Bearing

Another way of describing direction is to take a bearing. A bearing is also expressed as an angular measurement but there are two differences:

a. bearings can be measured clockwise or anti-clockwise.

b. bearing may not be larger than 90° as illustrated in Figure 28 (Van Sickle, 2004; Vlok, Harmse and de Jager, 2009).

Figures 34 and 35 illustrates how direction is expressed in terms of bearing.

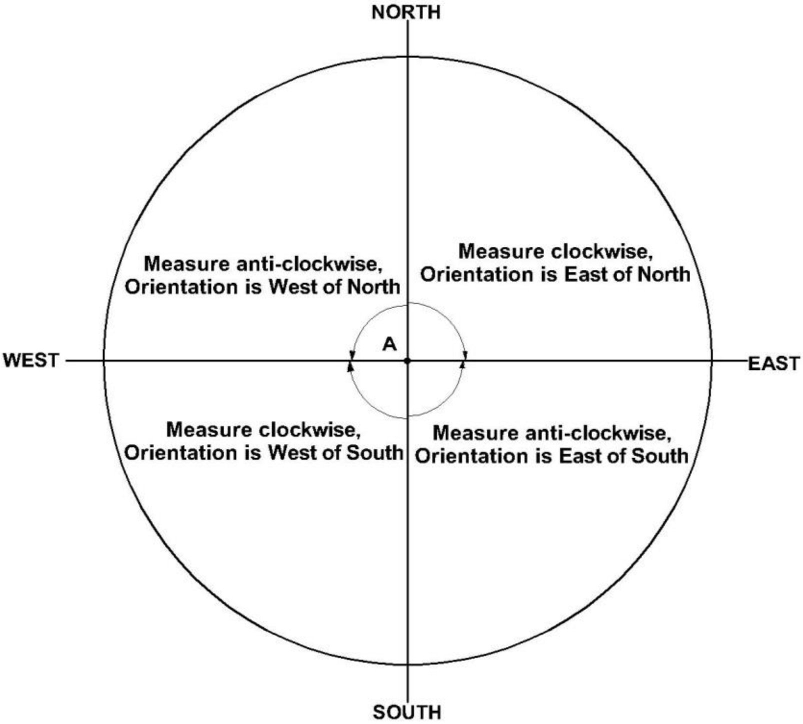


Figure 34: Bearings (Adapted from Vlok, Harmse and de Jager (2009:52).

A bearing is used to represent the direction of one-point relative to another point. Bearings are another system for designating directions of lines. The bearing of a line is defined as the acute horizontal angle between a reference meridian and the line. The angle is observed from either the north or south toward the east or west, to give a reading smaller than 90°.The letter N or S preceding the angle, and E or W following it shows the proper quadrant. Thus, a properly expressed bearing includes quadrant letters and an angular value. An example is N80°E. In Figure 36, all bearings in quadrant NOE are measured clockwise from the meridian. Thus, the bearing of line OA is N70°E. All bearings in quadrant SOE are anticlockwise from the meridian, so OB is S35°E. Similarly, the bearing of OC is S55°W and that of OD, N30°W (Ghilani and Wolf, 2012).

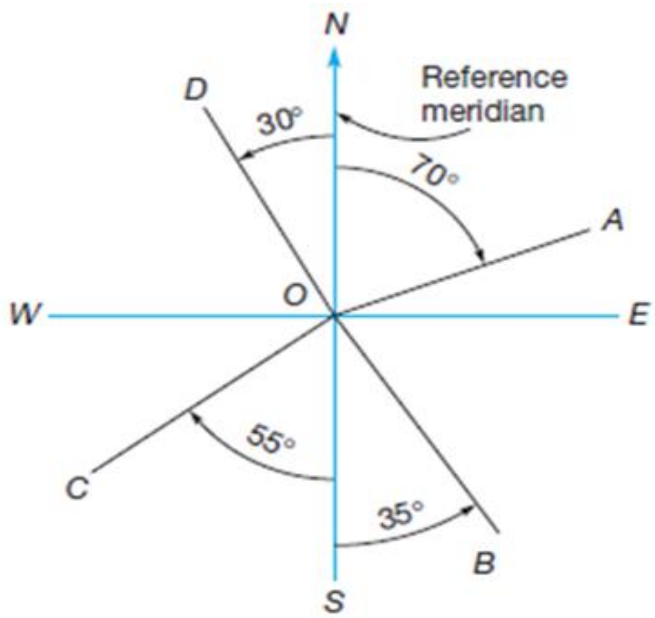


Figure 35: Bearings (Ghilani and Wolf (2012).

In this section we have discussed that the direction of property is best illustrated by use of angles that are either bearing or azimuth. Let us discuss how these angles are measured and or calculated. Please note that measurement and calculation of bearing or azimuth are not a considered to be core competencies of real estate professionals. That is the job of Land Surveyors and where one should get professional assistance when there is need for measurement of angles the same way one is supposed to get a Bill of Quantities from a Quantity Surveyor. However, one need to have an appreciation of how Land Surveyors measure and calculate angles. Let us start by learning about traversing.

INSTRUMENTS FOR FIELD MEASUREMENT OF ANGLES

Horizontal angles (azimuth and bearings) are usually measured with a theodolite or total station.

THEODOLITES

A theodolite is a precision instrument for measuring angles in the horizontal and vertical planes. It is capable of measuring angles and, when used in conjunction with graduated reference objects, distances with a high degree of accuracy (Ghilani and Wolf, 2012). There are two different kinds of theodolites: digital and non-digital. Non digital theodolites are rarely used anymore. Digital theodolites consist of a telescope that is mounted on a base, as well as an electronic readout screen that is used to display horizontal and vertical angles. Digital theodolites are convenient because the digital readouts take the place of traditional graduated circles and this creates more accurate readings (Ghilani and Wolf, 2012). It also works with a rod that is used to determine the relative heights of the different points Figure 36 shows a theodolite.

Figure 366: Theodolite (Image taken by the Authors)

TOTAL STATIONS

A total station consists of a theodolite with a built-in distance meter (EDM), and so it can measure angles and distances at the same time (Ghilani and Wolf, 2012). The coded scales of the horizontal and vertical circles are scanned electronically, and then the angles and distances are displayed digitally. The horizontal distance, the height difference and the coordinates are calculated automatically, and all measurements and additional information can be recorded. Total stations are used wherever the positions and heights of points, or merely their positions, need to be determined (Ghilani and Wolf, 2012). A total station is shown in Figure 37.

Figure 37: Total Station (Image taken by the Authors)

ACTIVITIES FOR THE READER

Define direction as it is applied in real property;

1. Explain the difference between true north and magnetic north;
2. Differentiate azimuth from bearing;
3. Point out any 2 surveying instruments which are used to measure angles.

CONCLUSION

Now that we have come to the close of this unit, learners should be able to define direction, explain the difference between true and magnetic north as well as azimuth and bearing. Lastly learners should be able to point out surveying instruments used to measure angles.

SUGGESTIONS FOR FURTHER READINGS

Field, H., L. and Long, J., M. 2018. Introduction to agricultural engineering technology: A problem solving approach (Fourth Edition). Springer: ISBN 978-3-319-69678-2;ISBN 978-3-319-69679-9 (eBook). https://doi.org/10.1007/978-3-319-69679-9.

Ghilani, C., D. and Wolf, P., R. 2012. Elementary Surveying: An Introduction to Geomatics (Thirteenth Edition). New Jersey, Prentice Hall.

Gomarasca, M, A. 2010. Basics of geomatics. Springer, ISBN 978-1-4020-9013-4).

Kavanagh, B., F. 2010. Surveying with construction applications (Seventh Edition). New Jersey, Prentice Hall.

Kavanagh, B., F. and Mastin, T., B. 2014. Surveying Principles and Applications (Ninth edition). New Jersey, Prentice Hall.

Minchin, M. 2016. Introduction to Surveying, Second Edition. Australia. Government of Western Australia. Online available from www.dtwd.wa.gov.au Accessed 20/07/2018.

Shekar, S. and Xiong, H. (Eds.) 2018. Encyclopedia of GIS. New York, Springer.

Van Sickle, J. 2004. Basic GIS coordinates. Florida, CRC Press.

Vlok, C., Harmse, A and de Jager, A. 2009. Geographical thinking and spatial perspectives: Study guide for EGIS01J. Pretoria, University of South Africa.

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).

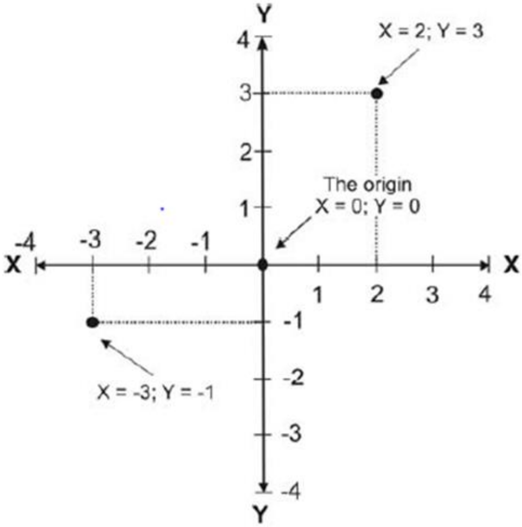


Figure 38: The Cartesian Plane (*Vlok, Harmse and de Jager, 2009:71*).

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.

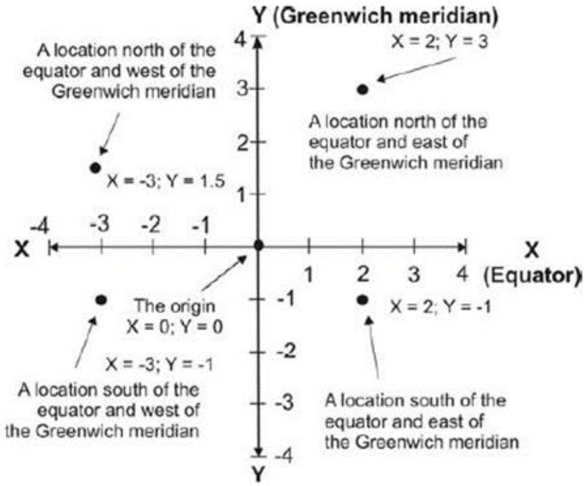


Figure 39: A simplified geographic coordinate system (Vlok, Harmse and de Jager, 2009:71).

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.

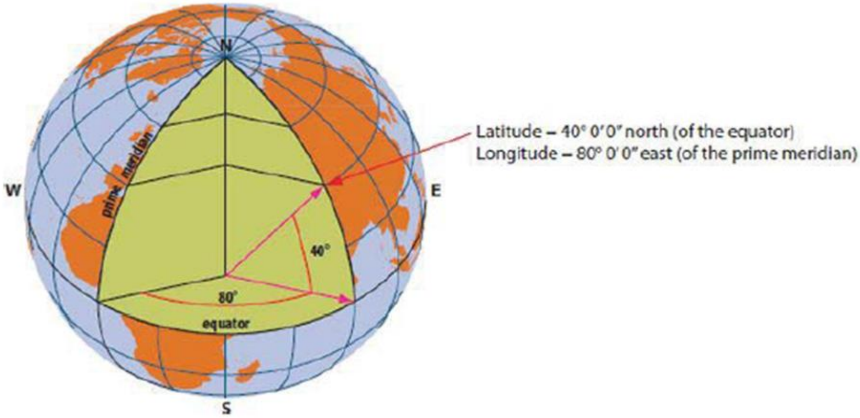


Figure 4040: The Greenwich meridian and the equator (Law and Collins, 2015:125).

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.

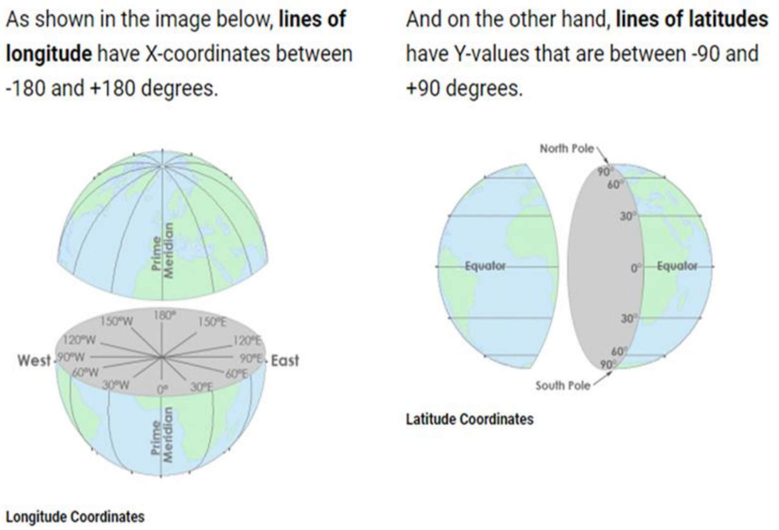


Figure 41: Lines of longitude and latitude (GIS Geography (2020) Available online: https://gisgeography.com/latitude-longitudecoordinates/#:~:text=As%20shown %20in%20the%20image,%2D180%20and%20%2B180%20degrees.&text=And %20on%20the%20other%20hand,%2D90%20and%20%2B90%20degrees.&tex t=The%20equator%20is%20where%20we,equator%20has%20positive%20latit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

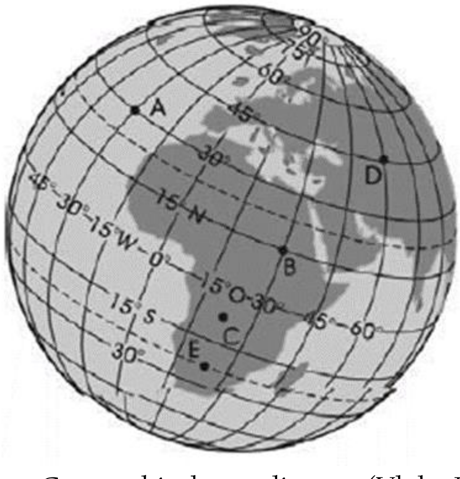


Figure 42: Reading Geographical coordinates (Vlok, Harmse and de Jager, 2009:55.

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.

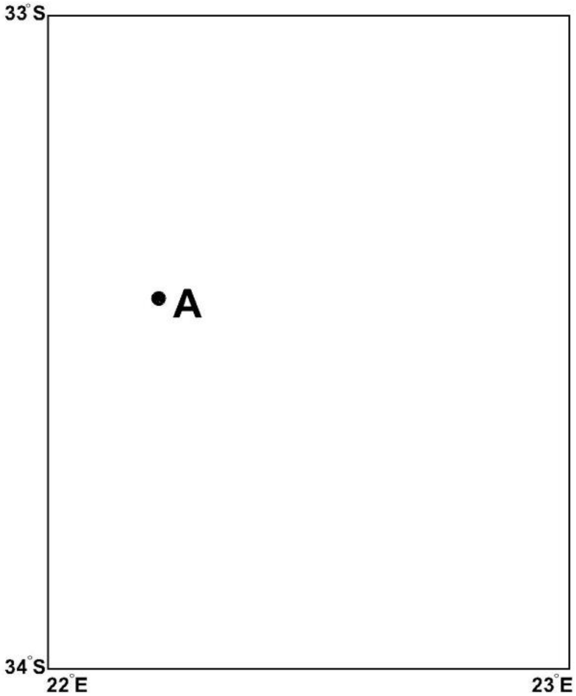


Figure 43: Map Location Example 1 (Adapted from Vlok, Harmse and de Jage (2009).

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).

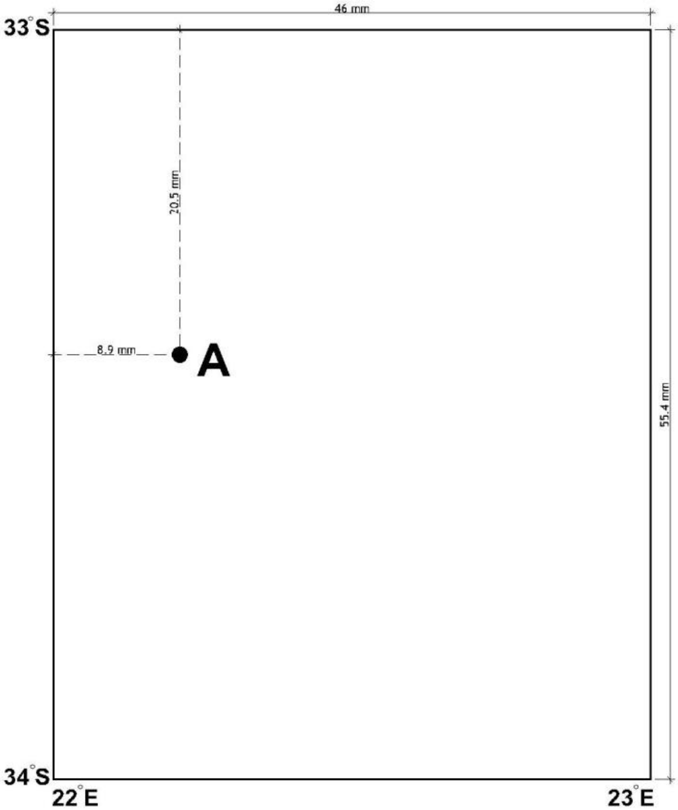


Figure 444: Map Location Example 2 (Adapted and modified from Vlok, Harmse and de Jage (2009).

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)

Adapted and Modified from official 1: 50 000 Naledi Map Extract K6NE

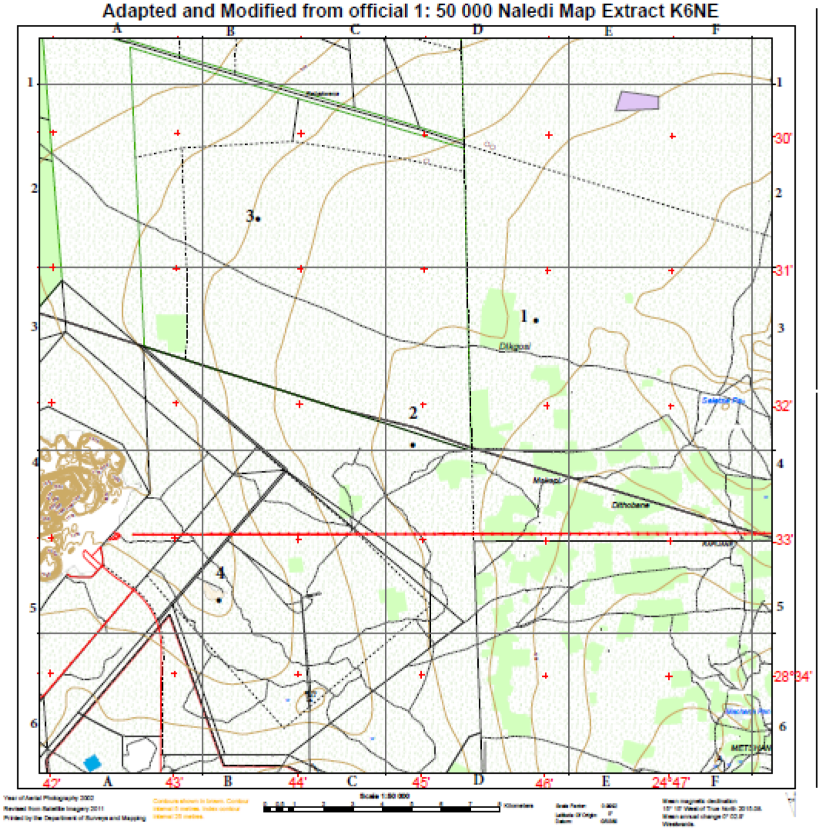


Figure 47: Extract from the official 1:50 000 map of Naledi (map K6NE NALEDI). (Modified Map from Department of Surveys and Mapping, Botswana)

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

Anson, R., W. and Ormeling, F., J. (eds.). 1991. Basic cartography for students and technicians: Exercise manual. London and New York, Elsevier applied science.

Buckley, D., J. 1997. The GIS Primer: An introduction to GIS. Pacific Meridian Resources.

Cartwright, W., Gartner. G., Meng, L., and Peterson, M., P. (eds.) 2009. Cartography and Art. Berlin, Springer.

Ghilani, C., D. and Wolf, P., R. 2012. Elementary Surveying: An Introduction to Geomatics (Thirteenth Edition). New Jersey, Prentice Hall.

Gomarasca, M, A. 2010. Basics of geomatics. Springer, ISBN 978-1-4020-9013-4).

Kavanagh, B., F. 2010. Surveying with construction applications (Seventh Edition). New Jersey, Prentice Hall.

Kraak, M.J. and Ormeling, F., 2010. Cartography: visualization of geospatial data (Third edition). London, Pearson Education Limited.

Minchin, M. 2016. Introduction to Surveying, Second Edition. Australia. Government of Western Australia. Online available from www.dtwd.wa.gov.au Accessed 20/07/2018.

Shekar, S. and Xiong, H. (Eds.) 2018. Encyclopedia of GIS. New York, Springer.

Tyner, J. A. 2010. Principles of map design. New York, The Guilford Press.

Van Sickle, J. 2004. Basic GIS coordinates. Florida, CRC Press.

Vlok, C., Harmse, A and de Jager, A. 2009. Geographical thinking and spatial perspectives: Study guide for EGIS01J. Pretoria, University of South Africa.

CHAPTER 6: ELEVATION

OBJECTIVES OF THE UNIT

1. At the end of this unit, the reader must be able to:
2. Define elevation,
3. Explain the difference between elevation and slope,
4. Calculate elevation using the differential levelling method,
5. Identify different surveying instruments used in levelling.

RATIONALE FOR THE UNIT

This unit is designed to develop the learners' understanding of elevation, instruments used to measure elevation as well as basic principles of calculation of elevation using differential levelling.

ASPECTS AND ISSUES

Our coordinates in Figure 2 (refer to Unit 1) have a third aspect (elev 1016m) that we have not covered so far. This represents the elevation or height of BA ISAGO University. According to Van Sickle (2004: 65):

> Coordinates for latitude and longitude, northing and easting often come in pairs, but that is not the whole story. For a coordinate pair to be entirely accurate, the elevation it represents must well-defined that might be may be above or below the surface of the Earth at a particular place.
>
> Elevations are usually measured in meters or feet. They can be shown on maps by contour lines, which connect points with the same elevation; by bands of colour; or by numbers giving the exact elevations of particular points on the Earth's surface. Maps that show elevations are called topographic maps (Available online: https://www.nationalgeographic.org/encyclopedia/elevation/ (Accessed: 21 January 2021).

Besides contour lines, elevation is also shown by means of spot heights and trigonometrical stations. It is important for one be able to read the map and understand the elevation and slope of properties before starting the development. The elevation and slope of the site have the cost implications during and after the development phase.

Ghilani and Wolf (2012) defined elevation as the distance measured along a vertical line from a vertical datum (reference point) to a point or object (point of unknown height). A vertical datum is any level surface to that elevations are referenced. This is the surface that is arbitrarily assigned an elevation of zero. This level surface is also known as a reference datum since points using this datum have heights relative to this surface. A geoid is defined as a level surface that serves as a datum for all elevations and astronomical observations as shown in Figure 48.

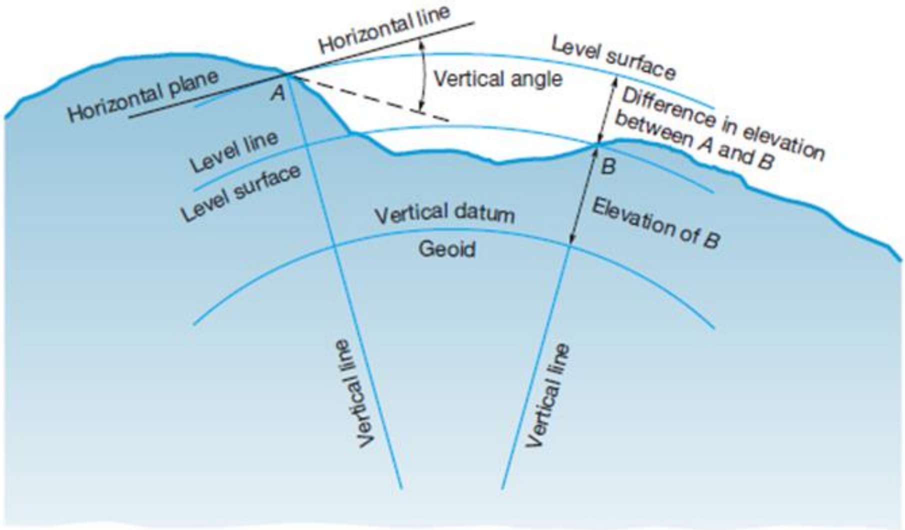


Figure 48: Levelling terms (Ghilani and Wolf, 2012:74).

If the elevation of point A is 802.46m, what it means is A is 802.46m above the reference datum. The elevation of a point is also called its height above the datum.

MEASURING ELEVATION (FIELD)

Real estate and planning practitioners are not expected to be highly skilled in levelling since this is the job of Land Surveyors. When part of the property practitioner requires levelling, then he/she must seek the services of a qualified Land Surveyor, the same way he/she is supposed to get BOQs from Quantity Surveyors when doing the cost approach to valuation or doing development appraisal. However, it is important to have an appreciation of how Levelling is done, so this section will discuss basic principles of levelling so that students will appreciate how it is done.

Levelling is the general term applied to any of the various processes by that elevations of points or differences in elevation are determined. A Benchmark (BM) is a relatively permanent object, natural or artificial, having a marked point whose elevation above or below a reference datum is known or assumed. Common examples are metal disks set in concrete, reference marks chiselled on large rocks, non-movable parts of fire hydrants, curbs, *et cetera* (Ghilani and Wolf, 2012).

The vertical distance between two points is called the difference in elevation. The process of measuring differences in elevation is called levelling. So, levelling refers to height measurements for representing the relative difference in height (altitude) between various points on the earth's surface. One could simply say it is the process of measuring heights. According to Ghilani and Wolf (2012), several techniques are used when determining elevation and these include but not limited to differential levelling, barometric levelling, and indirectly by trigonometric levelling. Let us just focus on differential levelling to give one a general picture of how it is done.

DIFFERENTIAL LEVELLING

Differential levelling most employed method and it is simple in principle. An instrument called a level is used to establish a line of sight that is perpendicular to gravity in other words, a level line. With reference to Figure 49, please take note of the Datum elevation that is 0.00. This is the starting point for all elevation measurements. Do not worry about measurements that are shown in ft in the illustration, we will explain using metres. Also, take note of the Benchmark that is labelled as BM in Figure 49. Ghilani and Wolf (2012) defined a Benchmark (BM) as a relatively permanent object, natural or artificial, having a marked point whose elevation above or below a reference datum is known or assumed. Common examples are metal disks set in concrete, reference marks chiselled on large rocks, non-movable parts of fire hydrants, curbs, etc. In simpler terms, this is a point of known height, that is used as a starting point whenever one is measuring elevation for unknown points. In this example our known elevation is 820.00. What it simply means is that BM rock is 820m from the Datum elevation and remember that this distance is measured vertically.

Now that we have our benchmark (BM) and our point of unknown height that is X (to the right side of Figure 49), let us now discuss how we can determine the elevation of point X. With the benchmark and the point X it is now possible to measure the unknown elevation and the instrument used to do this is known as a level that works with level rods. With reference to Figure 49, level is midway between BM and X. The illustration also shows two rods, are held vertically resting on two solid points in this case the solid points are the BM and the point X. Rods marked with the same graduations, like rulers (see Figure 49). We can now proceed to discuss how the measurements are taken.

THE PROCESS OF DIFFERENTIAL LEVELLING

The first step is to look at the rod to the rear (BM) through the telescope of the level, there is a graduation at the point at that the horizontal level line of sight of the level intersects the vertical rod. That reading is taken and noted. This is known as the backsight (BS) and it tells the height, or elevation, that the line of sight of the level is above the mark on that the rod is resting. In the case of Figure 49 the BS is 8.42m (remember we are using m the ft illustrated on the diagram. Back-sights are also called plus sights (+ S), because one must always add them to a known elevation to find the height of the instrument (HI). With reference to Figure 49 the HI is calculated by adding the BS (8.42m) to the BM (820m) that is 828.42m. What it simply means is that the line of sight of the level is **828.42m** above the Datum level.

The HI is not the end of the process, we need it to calculate the final elevation but for us to do so we need to rotate the level to observe the vertical rod ahead (at point X) and a value is read there. This is known as the foresight (FS). Said in other words, FS is the reading taken towards the point of unknown height (in this case point X). Foresights are also called minus sights (-S), because they are always subtracted from HI to obtain the elevation E of the point. The FS on Figure 49 is 1.20m. To determine the elevation of point X, one subtract the FS (1.20) from the HI (828.42): 828.42m – 1.20m = **827.22m**. If this procedure is repeated, then, the height of points along the route of survey can determined (Van Sickle, 2004).

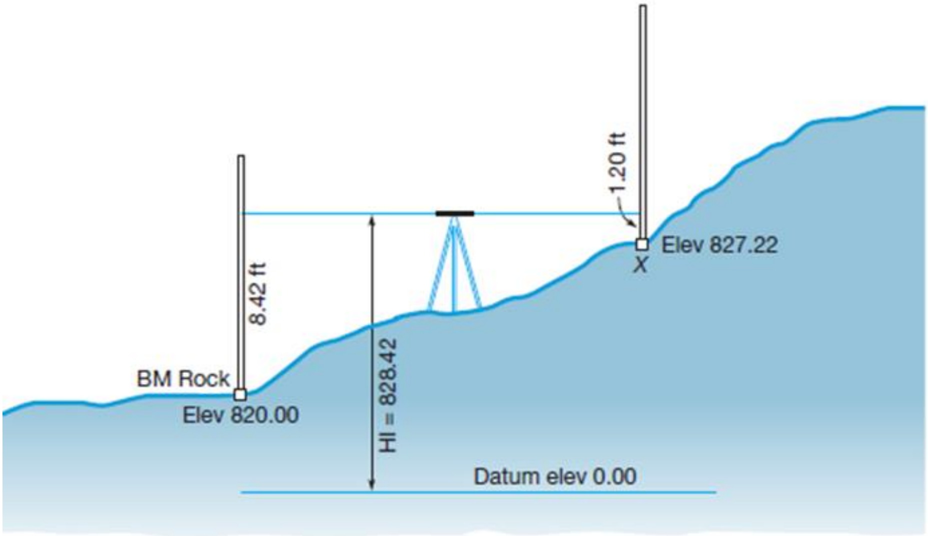


Figure 49: The process of differential levelling (Ghilani and Wolf, 2012:79).

EXAMPLE

Let us use Figure 50 to calculate the unknown elevation.

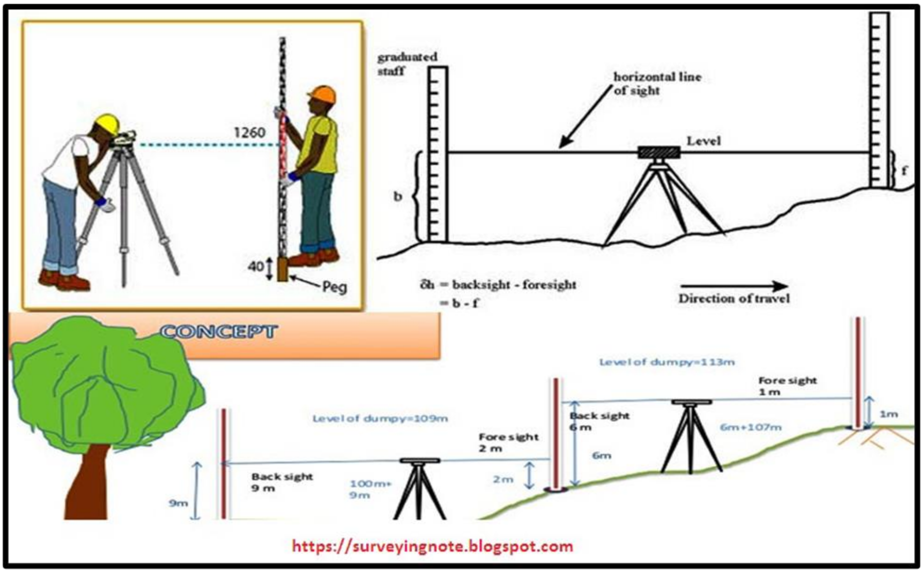


Figure 50: Levelling example (*Available online: https://surveyingnote.blogspot.com/2019/0/4/lavelling-lavelling-surveying.html (Accessed: 27 December 2020)*.

Example

a) The unknown elevation on Figure 50 will be calculated as follows:

1. The surveyor sets up between the benchmark (BM) and Point1.
2. A back sight (9m) is taken to the BM.
3. This lets one calculate the height of instrument (HI) as 100m + 9m = **109m**.
4. The surveyor then turns and takes a foresight reading on of 2m.This permit calculating the elevation of Point1 as 109m − 2m = **107m.**
5. The surveyor then moves forward to a location between Point1 and Point2. A back sight reading on Point1 is 6m. This allows a calculation of the new HI as follows: 107m + 6m = **113m**
6. The surveyor then turns and takes a foresight reading on Point 2 of 1m. This allows the calculation of the elevation of Point 2 as 113m − 1m = **112m**.
7. The height difference between A and B is equal to the sum of the back sight and the foresight.

Table 6.1: Calculation of Elevations (Adopted from Ghilani and Wolf, 2012:79).

Point	Backsight (B.S) +	Height of Instrument (H.I)	Foresight (F.S.) -	Elevation (Elev.)
BM				100m
	+9m	109m		
Point 1			-2m	107m
	+6m	113m		
Point 2			-1m	112m

Therefore, the elevation for point 2 is **112m.**
Height difference between BM and Point 2:
Sum of B.S.: 9+6 =**15m**
Sum of F.S.: -2m + -1m = **-3m**
B.S. − F.S.: 15m − 3m = **12m**
Or simply 112m − 100m = **12m.**

LEVELLING EQUIPMENT

LEVEL

The level, its tripod, the staff, and the staff bubble are all precision items of equipment upon that the accuracy of the work is highly dependent. A surveyor's level also known as the optical level is basically a telescope, fitted with cross wires for sighting, and attached to a levelling device that is mounted on a tripod (a support with three legs) so that it can rotate horizontally through 360 degrees (Ghilani and Wolf, 2012). In older instruments, the horizontality of the sighting line was adjusted with a sensitive spirit level and fine-threaded adjusting screws. In more recently made instruments (known as self-levelling or automatic levels), the line of sight is automatically brought to the horizontal, that makes surveying operations much easier. The telescope magnifies far-away objects that means one can observe the graduation on a levelling staff at a much greater distance than one could with their ordinary eyesight. There are three basic types of level that are dumpy levels, tilting levels and Automatic levels. Figure 51 shows an example of a level.

Figure 51: Optical Level (Image taken by authors)

Tripod Stands

A tripod stand, as shown in Figure 52 below, is a device used to support any one of several surveying instruments, such as theodolites, total stations, and levels. There are two different kinds of tripods, such as adjustable-leg tripods and fixed tripods. Adjustable-leg tripods are the more common of the two in the construction world, especially outdoors because of generally uneven terrain. A tripod is made up of three legs, each with metal points called shoes; and a head that the theodolite or other levelling device attached (Ghilani and Wolf, 2012).

Figure 52: Tripod Stand (Image taken by Authors)

ROD / STAFF

A rod also known as a staff is a rectangular cross section and is used to determine the relative heights of the different points. A variety of level rods are available, some of which are made of wood, fiberglass, or metal. The most common engineer's rod is called the Philadelphia Rod. The lower part of the rod with metal is used to protect from spoil while using. The instrument is sectional, and it can be shortened for storage and lengthened for use (Ghilani and Wolf, 2012). Figure 53 is an example of a level rod.

Figure 53: Rod / Staff (Image taken by authors)

ACTIVITIES FOR THE READER

1. Define elevation.
2. Explain the difference between elevation and slope.
3. Write brief notes on the following surveying instruments:
4. Level,
5. Tripod stand,
6. Level rods.
7. Refer to Figure 54 and answer questions which follows. Calculate elevation using the differential levelling method,

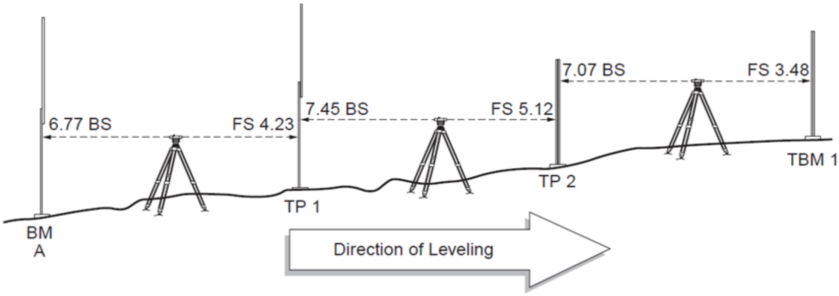


Figure 54: Levelling

Calculate the level of TBM1 using differential levelling.
Calculate the height difference between BMA and TBM 1.

CONCLUSION

Having completed this unit, learners are expected to be able to define elevation and confidently point out instruments used to measure elevation as well as to calculate of elevation using differential levelling.

SUGGESTIONS FOR FURTHER READINGS

dela Cruz, C., R. 1983. Fishpond engineering: A technical manual for small-and medium-scale coastal fish farms in Southeast Asia. Metro Manila, the Food and Agriculture Organization of the United Nations.

Field, H., L. and Long, J., M. 2018. Introduction to agricultural engineering technology: A problem solving approach (Fourth Edition). Springer: ISBN 978-3-319-69678-2; ISBN 978-3-319-69679-9 (eBook). https://doi.org/10.1007/978-3-319-69679-9.

Ghilani, C., D. and Wolf, P., R. 2012. Elementary Surveying: An Introduction to Geomatics (Thirteenth Edition). New Jersey, Prentice Hall.

Gomarasca, M, A. 2010. Basics of geomatics. Springer, ISBN 978-1-4020-9013-4).

Kavanagh, B., F. 2010. Surveying with construction applications (Seventh Edition). New Jersey, Prentice Hall.

Kavanagh, B., F. and Mastin, T., B. 2014. Surveying Principles and Applications (Ninth edition). New Jersey, Prentice Hall.

Minchin, M. 2016. Introduction to Surveying, Second Edition. Australia. Government of Western Australia. Online available from www.dtwd.wa.gov.au Accessed 20/07/2018.

Van Sickle, J. 2004. Basic GIS coordinates. Florida, CRC Press.

CHAPTER 7: LOCATION AS AN ASPECT OF PUBLIC AND BUSINESS PLANNING AND MANAGEMENT

OBJECTIVES OF THE UNIT

1. At the end of this unit the reader must be able to;
2. Define Location; and
3. Explain Location as an aspect of Public Planning and Management,
4. Explain Location as an aspect of Business Planning and Management.

RATIONALE FOR THE UNIT

This unit is designed to improve a learners' understanding of location as an aspect of Public and Business Planning and Management. Upon completion of this unit, students should be able to explain how the aspect of location influences public and business planning, management, decision making and actions.

ASPECTS AND ISSUES

Location, location, location is a worn-out cliché, but often true in the literature (Dixit *et al*, 2019). Business site selection is a complex strategic decision that may affect a company's future in the long run. When considering location as an aspect of public and business planning, it is important to factor in different factors such as choosing the right business location as this determine the success or failure of the business. Beyond these business factors, place image factors such as sense of place as this also influence the final decisions regarding public planning and business locations.

LOCATION AS ASPECT OF PUBLIC PLANNING.

In this unit, an examination of how location influences public planning is critically examined simultaneously looking at how public planning choices influence location decisions. In this unit reference is made to location theorists such as Isard,1956) who argued that time and space are the basic factors in location decision. This is because locating a facility say a clinic at a certain location entails that people take time to travel the distance to reach the clinic. This involves distance which needs to be travelled hence incurring transport cost. Public planners in their practice seek to put facilities in areas accessible to many people. Blair (1995) explains that access is the principal determinant of the highest and best use in an urban environment. Location is thus an aspect of public planning because it promotes accessibility to public facilities including shopping malls, public offices, bus termini, schools, clinics, parks and gardens within built up areas. Planners and developers recognise that the higher the accessibility of a given location the higher the profit potential (Assink and Groenedijk, 2009).

Accessibility is a function of transport infrastructure, availability of public transport for commuters for instance in Harare, it is easier for people to access Parirenyatwa Group of Hospitals due to the presence of King George Street which is busy with commuter omnibuses from various locations including Malborough, Greencroft and Westgate. On the other hand, travellers using own transport can use Mazowe Street to enter into the hospital. Further taking the example of Harare's public facilities as example as to how the location aspect is related to public planning, many schools and shopping centres are situated closed to major to roads. Blakiston Primary school in Milton Park is accessed through Blakiston Street. Prince Edward High School is at the corner of Prince Edward and Josiah Tongogara Avenue. The location of these public facilities is highly accessible and learners get easily get there either by own transport or public transport. In the high density suburbs of the city shopping centres, clinics and schools have been allocated through local development plans for respective areas. In the western suburbs of Kuwadzana, shopping centres for Kuwadzana were allocated along the main roads traversing the residential area. These include Kuwadzana 2 shops, Kuwadzana 3, 4 and 5. The unit thus borrows the idea from Mills and Hamiliton (1994) who argues that public land uses are directed at serving the greater public through enhanced accessibility.

LOCATION AS AN ASPECT OF BUSINESS MANAGEMENT

In this section, we examine the location of business firm within a defined space. Capello (2007) pointed out that the higher the accessibility of a given location to positive amenities the higher its productivity and value. A profit oriented firm seek to locate its economic activities where there agglomeration economies, transport economies as well as availability of labour. Firms in the fast food sector tend to locate in central business districts (CBDs) of cities and towns because of the availability of market, hence their sales can sustain higher rents in these areas. In this regard, relative location is a strong factor affecting the business decision to locate in busy areas. Fast food outlets are located close to large office apartments, for example in CBD of Harare, the location of Chicken Inn at the Construction House enjoys a large customer base from nearby offices and shops. Others are located closer to inner city bus termini, Chicken Slice is closer to Copacabana Rank. On the contrary, some have been developed along major highways. For instance Harare-Masvingo highway, there is Mutangadura Truck Inn targeting mainly truck drivers and other travellers. In Chivhu there is the Chicken Inn, Tilly Food Market, serving travellers either public transported or privately. The principle emphasised here is that the food outlets have been located close to the highway for accessing travelling customers.

Firms also locate their business in areas close to transport networks, large pools of labour and closer to auxiliary facilities such as banks. The issue of location of firms has been outlined in the works of Weber, a German economist (Shaffer,Deller and Marcouiller, 2004). Weber argued that, firms locate where profits are maximised through cost minimisation. Holding other things constant, a rationale business would seek to cut transport cost on in-bound material supplies and outbound goods meant for the market, simultaneously seeking alternative sources of labour that keep the wage bill minimised. The decision to locate a firm within certain area is based on several economic factors, chief among them transport cost of shipping raw materials for processing and ferrying finished products into the market, availability of supply firms within a locality, labour and space as defined the cost of rentals. This unit however borrows largely from the arguments of Shaffer, Deller and Marcouiller (2004) that the decision to locate in an area is not uniform to all firms because of variations in structures, technology and rent levels. For instance a technologically intensive firm might not consider labour as a significant factor because most of its processes are automated. On the contrary, an agro-processing firm might locate closer to the railway line or highway for easy of shipping products from farmlands. In some instances, it is pretty costly for firms in the logistics business to locate in central areas where rent is high (as explained in the theoretical underpinnings of Von Thunen and Alonso). Consequently such firms locate their warehouses and fleet parking in outer zones because of availability of large tracts of land and cheaper rent.

The location theory by Alfred Weber (1929) justifies the location of firms on economic grounds of cost minimisation and profit maximisation. In this view location is an aspect that can be used to determine a firm's location by looking at the business climate. Assink and Groenejik, (2009) outlines business climate elements including cheap labour, limited regulation and lower taxes. These define the cost minimisation concept. On the other hand, firms may look for communities that offer high quality infrastructure, skilled labour, building locations and high quality of life. As an aspect of business management, location is important because firms seek to locate and operate in areas that offer comparative advantages over others.

ACTIVITIES FOR THE READER

i. Define location as an aspect of public planning.

ii. As a planning officer of an urban local authority, outline the factors you would consider when locating:

a). A school

b). A clinic

c). A shopping centre

d). A community centre

i. iii). What is the importance of location in business management?

ii. iv). Which factors determine the location of business firms?

CONCLUSION

Upon completing this unit, the student must be able to explain location as an aspect of public planning and business management. The knowledge gained from this unit is expected to improve learners' understanding of how and why economic activities and public facilities are located where they are. Furthermore after reading this unit, learners should be able to apply theoretical ideas to real life location issues as they apply in different public planning and business management contexts.

SUGGESTIONS FOR FURTHER READING

Alonso, W. (1960). "A theory of urban land market ", Papers and Proceedings of the regional Science Association, 6.

Assink, M., and Groenendijk, N. (2009). Spatial quality, Location Theory and Spatial Planning. Paper presented at Regional Studies Association Annual Conference. Understanding and shaping regions: Spatial, social and economic futures. Leuven, Belgium.

Blair, J.P. (1995). Local Economic Development-Analysis and Practice. SAGE Publications, California.

Capello, R. (2007). Regional Economics. Routledge, London.

Dixit, A., Clause, C,. and Turken, N,. (2019). Strategic Business Location Decisions: Importance of Economic Factors and Place Image. Rutgers Business Review. Spring Publications. USA. Vol 4, No. 1. Page 73.

Isard, W. (1956). Location and Space Economy. MIT, Massachusetts.

Shaffer, R., Deller, S.C and Marcouiller, D.W. (2004). Community Economics: Linking Theory and Practice. Blackwell, Oxford, England.

Mills, E.S., and Hamilton, B.W. (1994). Urban Economics (5th ed). Harper and Collins,

CHAPTER 8: A REVISIT OF LOCATION AS A PHILOSOPHY

OBJECTIVES OF THE UNIT

1. At the end of this unit, the reader must be able to:
2. Define Location;
3. Understand location as a philosophy;
4. Analyse different location theories;
5. Critique the applicability location theory

RATIONALE FOR THE UNIT

The rationale of this unit is to enhance the learners' knowledge and competencies on various location theories that inform location of different establishments in physical planning and real estate. Each student should appreciate and comprehend different location theories. Also, students will critique the applicability of different theories and understand that despite the existence of these theories, they might not be applied as they are in different countries.

ASPECTS AND ISSUES

There are many locational theories that are used in developing the value of a particular property, and during the zoning process in physical planning. From ancient Greek philosophers to contemporary thinkers, the concept of location has been examined from various angles, including its impact on identity, knowledge, and perception. Some of the theories have lost relevance in the contemporary world and therefore, there is need to revisit this philosophy of location and critique its relevance and applicability.

WHAT IS LOCATION?

A location is the place where a particular point or object exists. Location is an important term in geography and is usually considered more precise than "place."(https://education.nationalgeographic.org/resource/location/ (accessed 16.01.2024). Location as an aspect of public planning and management aims at improving spatial planning of public services to ensure ease of access to public facilities e.g. schools, clinics etc. The whole purpose would be looking at ease to which services may be reached from a given location. Figure 56 shows some examples of locations of facilities.

Figure 55: Illustration of different Locations (*[online] Available from: https://education.nationalgeographic.org/resource/location/ [accessed: 01/03/2023]*

A Location can be absolute or relative. A place's absolute location refers to the exact place on earth, which is often given in terms longitude or latitude.

For example, the National University of Science and Technology (NUST) is located on a latitude of – 20.1612 and longitude of 28.6355. It is located at the corner of Cecil Avenue and Gwanda road, in Bulawayo, Zimbabwe. This is NUST's absolute location. Absolute location assists in establishing the exact location of a particular place.

Location can also be expressed in relative terms. Relative location is a description of how the place is related to other places. For example, NUST is located 433 km from Harare, opposite Harry Allen golf club. It is about 10km from the main post office. These are the relative locations of NUST to other locations. Relative location can assist to analyse how two places are connected. Directions such as north, south, east and west help describe the location of one place in relation to another.

Longitudinal and latitudinal coordinates help pinpoint the exact location of a place. Knowing that a location is 0 degrees west (longitude) and 30 degrees north (latitude) informs one that the place is near the City of Bulawayo. Being advised that the location is 0 degrees south and 41 degrees, 10 minutes and 10 seconds north informs one that the location is Zonkizizwe, a shopping complex in Bulawayo. To get to the shopping complex, directions like left, right, proceed for 1km then turn right give people a more precise location.

LOCATION AS A PHILOSOPHY

The physical location in which an individual is situated can shape his or her experiences, values, and worldview. For example, someone growing up in a rural area may have a different perspective on life compared to someone raised in an urban environment. The cultural, social, and environmental factors associated with a particular location can influence an individual's sense of self and their place in the world. Different locations offer unique opportunities for learning and understanding, and our knowledge is influenced by the particularities of the places we inhabit.

Moreover, location is intimately connected to perception and our understanding of reality. The philosophical concept of phenomenology explores how our experiences are shaped by our situatedness in the geo-political world. Pursuant to the philosophical conception of phenomenology (a philosophy of experience), our perception of the world is always mediated by our bodily presence and the context in which we find ourselves. Our location influences how we perceive and interpret the world around us, highlighting the subjectivity and contextuality of human experience.

In contemporary discussions, the concept of location has taken on new dimensions. With the advent of globalization and digital technologies, our understanding of location has expanded beyond the physical realm. Virtual spaces and online communities have challenged traditional notions of location and have created new opportunities for connection and engagement. The emergence of social media platforms and digital communication tools has enabled individuals to interact across vast distances, transcending the limitations of physical location.

Furthermore, debates around environmental philosophy and ethics have emphasized the importance of our location within the natural world. The impact of human activities on the environment has highlighted the interconnectedness of all locations on Earth. Our actions in one location can have far-reaching consequences for other places and ecosystems, emphasizing the need for a more holistic and environmentally conscious approach to location and our relationship with the Earth.

LOCATION THEORIES

Location theories explain in a consistent and logical way the distribution and location of economic activities in space in a manner in which various facets of economic activity are interrelated. The theories are derived from David Ricardo; the Ricardian rent theory which suggests that productivity of land determines rent and given that rent diminishes in unison with productivity as distance from the optimum location increases, rent diminishes (Capello, 2011). A rent gradient would emerge consisting of a series of 'bid rents' which would compensate for falling revenue and higher operating costs. Different land uses would have different rent gradients.

THE VON THUNEN THEORY

Von Thunen (1783-1850) was a German scholar and farmer who got interested in the relationship of land use and rent in villages surrounding a central market place (Shaffer, Deller and Marcouiller, 2004). In his study he explored the economic forces that affect agricultural prices, land rent and the relationship of these forces to the pattern of land use. Von Thunen observed that rents tended to be higher in the centre of the village and constantly declined as one moves away from the village centre (Glatte, 2015).

a. ASSUMPTIONS OF THE THEORY

- Von Thunen based his land use model on a number of assumptions. These were adapted from Dube, Brunelle and Legros (2016):
- Economic activities are distributed around a single market centre
- Prices of products are identical for each product in the market.
- Rent is homogenous within the same economic establishments
- The sum of the individual establishments' location decisions will give concentric spatial distribution of economic activity around a centre.
- Differences in transport routes and topography are ignored.

Von Thunen's analysis was based on the assumption that the geographical pattern of agricultural production was directly related to the competition among alternative uses (timber, crops, and livestock) for a single plot of land and the use that earned the highest "rent" determined land use at that location. He assumed that a single, central city located on a homogeneous plane purchased all agricultural produce and that labour and capital were not mobile. Distance from the central market place was the prime determinant of land use. Land near the city would be used for the most intensive agricultural production such as dairying and horticulture. As distance increased from the centre, transportation costs increased and land prices declined because only less intensive uses could be supported.

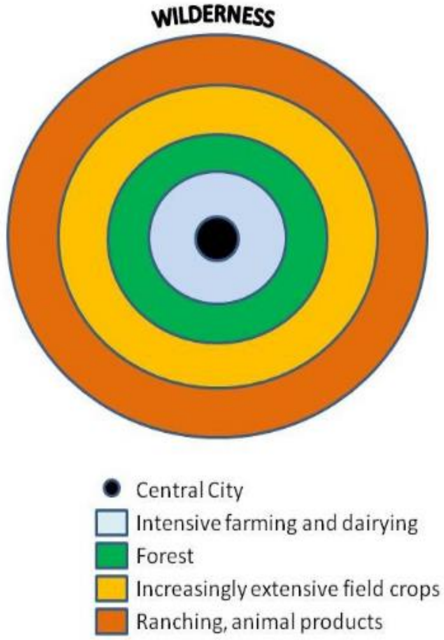
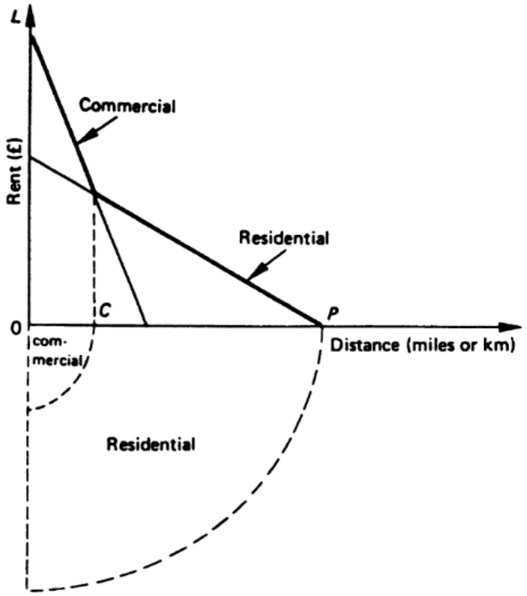


Figure 56: Von Thunen Land-use concentric rings (Adapted from Henry *et al.*, 1997:490)

APPLICATION OF THE VON THUNEN THEORY

The von Thunen theory of location is based on transport cost from the central market producing a pattern of concentric zones, each zone specialising in a particular type of agricultural produce. By substituting general accessibility with transport cost, we can apply the von Thunen model to urban areas.



- ☐ The outcome will be a commercial zone of radius OC surrounded by residential zone.
- ☐ Similarly, land values will fall from the city centre to the periphery by the thick line LP which shows the highest bid at any point.

Figure 57: Application of the von Thunen model to urban areas (Shaffer *et al*, 2004)

Allowing for its simplified assumptions, therefore von Thünen model explains: The pattern of land use of the urban area;

- The fall in land values from the centre towards the periphery;
- How the urban area grows, since each zone tends to expand into the next as population and economic growth; and

The basic pattern eventually results – a separation between workplace and residence. The broad pattern of land uses which depict in a highly simplified form, certain broad, but irregular concentric zones as follows.

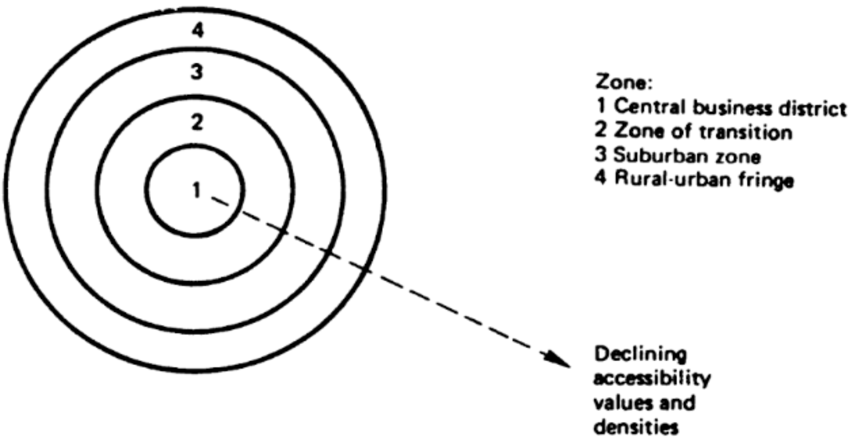


Figure 58: Application of the von Thunen model to urban areas (Henry *et al.*, 1997:491)

CRITICISM OF VON THUNEN LAND USE MODEL

The theory has been criticised for oversimplifying land-use and economic activities location in space.

It is not always true that land-uses are located in an isolated geographical plane. Some areas have rugged terrain hence the impact on how land is utilised an economic value emanating thereof.

Today's settlements reveal multiple centres where people can access goods and services. In this regard the theory is ancient and outdated because it was developed when villages relied on single market centres for trade (Dube et al, 2016).

The theory suffers from inadequate coverage on the impact of labour, entrepreneurship and capital on location decision. Its main emphasis is on land and transport cost of produce to the market. Modern locational decisions are no longer based on transport but several factors including technology, proximity to supplies of raw materials for manufacturing firms.

Von Thunen's theoretical underpinnings have been overtaken by developments in technology such as automobile invention where people can commute from far-away places with relative easiness. The advent of information communication technology has altered location decisions to a greater extent. Merchants, firms and their clients are able to trade online while deliveries can be made through contracting third parties.

BID RENT THEORY

The bid rent theory was conceived by William Alonso in the 1960s. It attempted to explain the variations in urban land values. The theory was inspired by Von Thunen land use model and it is based on the principle that rents tend to diminish outward from the city centre (Jordaan *et al*, 2004). The theory is based on micro-economic theory and was mainly developed in the context of urban land uses and urban land values. In this theory, patterns of land use are determined by land values that are, in turn, related to transportation costs. Each type of urban activity will have its own bid rent function & the combination of several bid rent function will define the rent gradient

a. *ASSUMPTIONS OF THE BID RENT THEORY*

- Cities exist on a featureless plain, without rivers, hills or other geographical obstacles that might affect commutes & prices
- Transportation costs are a linear function of distance from the city centre
- CBD contains the vast majority of employment, and all other employment is distributed evenly throughout the metropolitan area
- The city's population is evenly distributed and households have uniform taste of housing
- All land is privately owned
- The market place for all goods and services is located in the CBD – so all goods have to be transported to CBD for sale

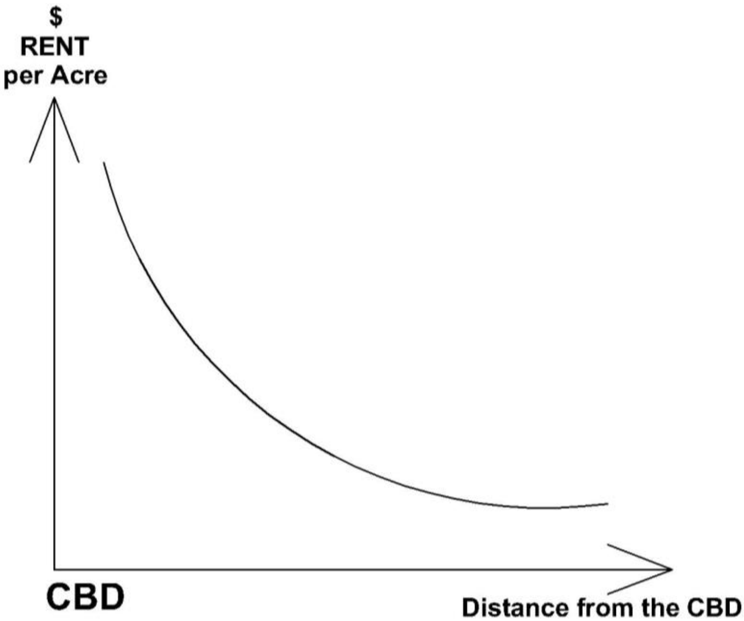


Figure 59: Bid rent curve showing relationship between rent and distance from CBD (Adapted from Capello, 2004)

The bid rent function in the theory explains the relation between land uses and urban land values.

In a very simplified way, households and firms make trade-offs between the land price, transportation costs and the amount of land they use (Alonso, 1960). This results in a convex land price curve with the highest land values near the city centre

The bid rent theory states that rents increase upwards close to the city centre as households seek to minimize transportation costs (Balchin et al, 1995). Rents are a negative function of distance from the city. Conversely rents are lower away from the city centre because transport costs are higher. Transportation costs are low near CBD, firms locating near the CBD are willing to pay more for centrally located parcels of land in order minimise their transportation costs. According to Blair (1995), this feature of the bid rent theory causes land values to fall with increasing distance from the city centre. Transportation costs on the rent gradient are not limited to bus fares or fuel consumption but also include the opportunity cost of commuting for example time spent on commuting could be spent on leisure or work. The intensity use of land in the CBD results in the development of high rise buildings to accommodate a hype of activities.

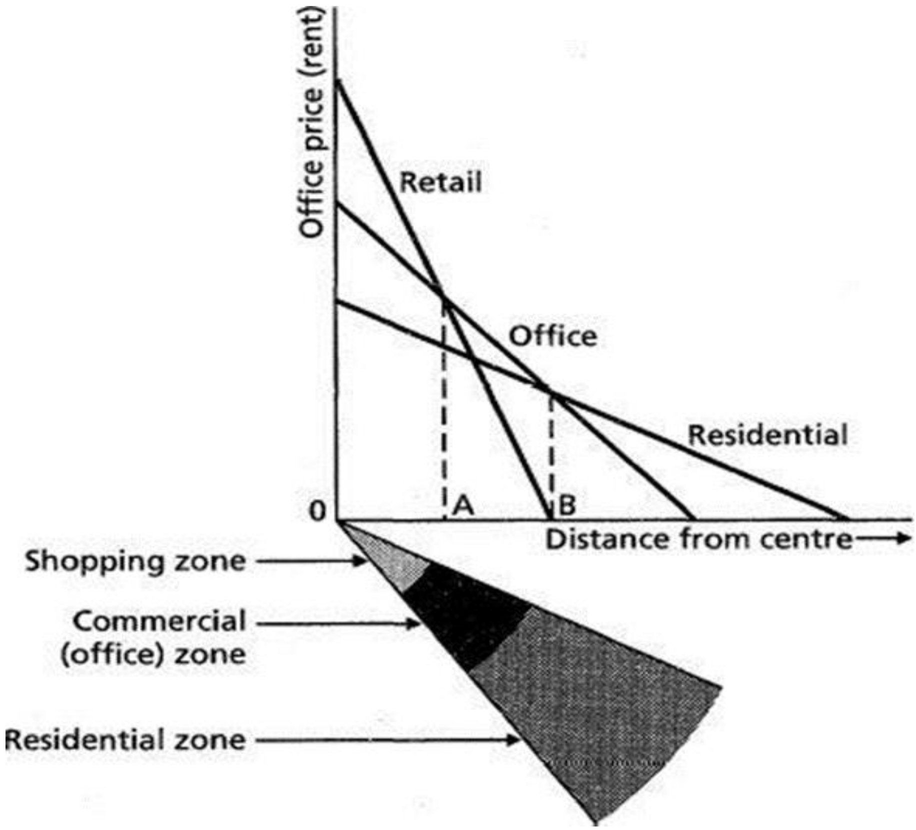


Figure 60: Land uses according to the bid rent theory (Blair, 1995)

The intersection of two bid-rent functions (point A) defines the point at which land use changes from retail activities to Office activities. Retailers would occupy land from CBD to A – up to this point the retail bid-rent line is above the bid rent line for office. While households would value access to CBD to minimize transport costs, many households also value open space and low density lifestyles (Alonso, 1960). As a result households would have a bid rent function for land that is flatter than that for manufacturing.

b. Bid rent functions

This section summarizes the functions and factors affecting land uses of different land use zones in a city.

The location of shops in the CBD depends on the flow and character of pedestrian traffic, nature of adjacent development and availability of vacant sites.

Manufacturing sector location is determined by factors such as nature of the product, stage of development of a firm (Balchin et al, 1995).

Heavy industry location tend to favor the outer urban zones closers to major roads for transportation of materials and larger spaces to promote flow method of production (Assink and Groenedijk, 2009).

c. Applicability of the Bid Rent Theory

Despite being an ancient theory, the bid rent remains relevant in modern day location and land use planning practices in cities across the world. The traditional function of the CBD as a commercial zone remains prevalent for example upmarket supermarkets and fashion boutiques are found in city centers such Harare. Retail companies take advantage of increased flow of pedestrian traffic and hence thrive in city centers. Rentals are high given the obtained high level of economic returns from sale of products. The high level of competition amongst companies promotes decentralization of some activities that were traditionally found in the CBD. Industries and manufacturing companies locate in zones outside the CBD to access main transport corridors for instance the Southerton and Workington industrial zones in the city of Harare. The residential land use especially low income are located far from the CBD as people trade-off transport cost with low rent. However the high income seek low density residential zones where they enjoy open spaces and luxurious accommodation.

d. Criticism of Bid Rent Theory

The bid rent theory has many limitation in reality. This unit presents some of the main criticisms outlined by Dube and Legros (2015).

The theory is based on the operations of the market in terms of prices and rent bids. It heavily ignores the operations of the 'visible hand' that characterize land use planning in public planning spheres.

Just like the Von Thunen land use model, the bid rent model assumes a single city centre where all commercial activities are carried out. In today's cities there are more than suburban centres that compete with the main city centres in terms of retail functions.

The theory is outdated and has been overtaken by advances in technology because some firms have traded off the comparative advantage of CBD with suburban locations. Development in online and web based commercial transactions has promoted the location of firms in outlying zones.

WEBER'S NEOCLASSICAL LOCATION THEORY

It was propounded by a German economist Alfred Weber who argued that the economy was characterized by and constant returns to scale. The theory is an attempt to explain why firm locate in a particular place.

a. ASSUMPTIONS

1. The theory is based on a number of assumptions. This unit presents some of the assumptions outlined by Glatte (2015).
2. The economy is characterized by perfect competition
3. Firms in the economy seek to maximize profit
4. Firms maximize profits by minimizing the transportation costs of shipping input supplies to the firm and maximizing the potential market demand for their good or service.
5. There exist a featureless surface that is not complicated by natural or institutional barriers such as mountains, rivers and valleys that create transportation bottlenecks and political boundaries.

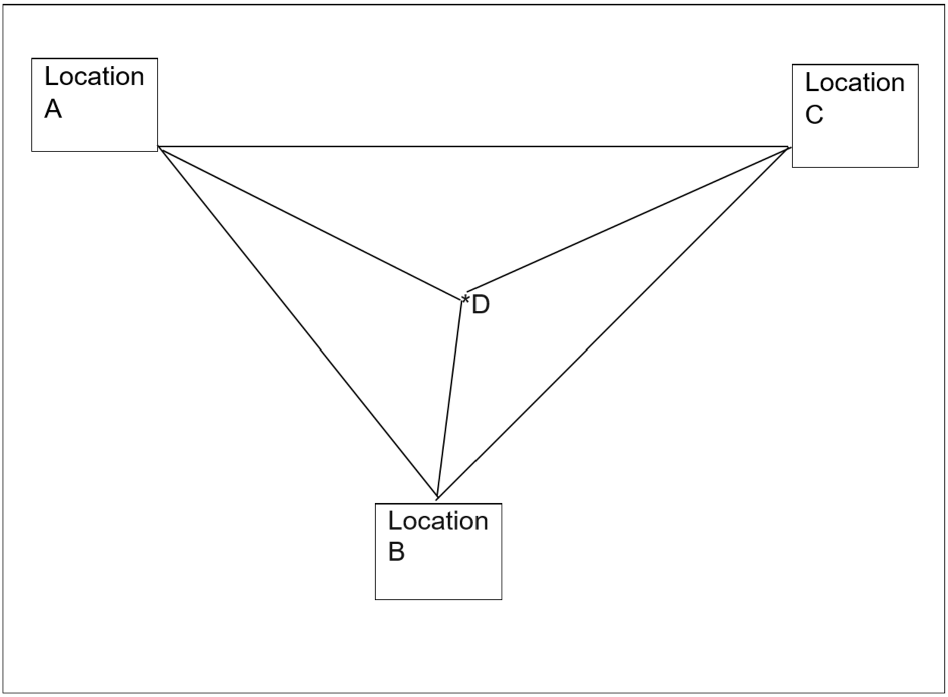


Figure 61: Weber's Location theory in diagrammatic presentation (Adapted from Shaffer et al., 2004)

The firm is purchasing its inputs from three markets A, B and C and selling its output in all three markets. As way to minimize transport costs and maximize demand in all the three markets. The optimum location would at point D which is equidistant from all the three markets. Transport costs would be minimized on distances AD, BD and CD. At the same time, the firm should aim to maximize the demand for its products in the three markets. This model assumes that location decisions are primarily based transport cost of ferrying input and products to the market. According to Shaffer et al (2004), the diagram in figure 52 is known as the Weber problem.

b. Applicability of Weber's Neoclassical Location Theory

- This unit focuses on the applicability of the theory in reality by looking at Zimbabwean examples.
- Industrial locations in Harare indicate the influence of transport factors costs included.

- Location of firms within an economic region is linked to the supply of raw materials which are shipped through either road or rail transport, for example ZimGold Cooking Oil processing industries along Lytton Road in Harare's Workington industrial area ship soya beans and sunflower from farms around Harare and other areas

c. CRITICISM OF WEBER'S NEOCLASSICAL LOCATION THEORY

- A number of criticisms have been levelled against Weber's Neoclassical Location Theory. This unit presents criticisms outlined by Glatte (2015).
- The existence of an economic plane is an oversimplification because in reality the earth's surface is characterized by various topographical and geomorphological features which affect transport routes and hence costs.
- The assumption of perfect market conditions is an abstract from reality because in some circumstances markets are characterized by monopoly and oligopolies that band together to control market operations.
- Location decisions are sometimes based on local authority and central government policies and regulations as opposed to market operations as assumed in the Weber Theory.

ACTIVITIES FOR THE READER

i) Write short notes on location as a philosophy

ii) Briefly explain three location theories outlined in this unit

iii) With the aid of diagrams explain the applicability of location theories in practice

iv) Outline the limitations of each of the theories explained in (ii).

CONCLUSION

We have not come to the end of this unit, and now, therefre, it is expected that the reader must be able to explain location as a philosophy. Further students are expected to understand location theories, their underlying assumptions, and diagrammatic presentation while appreciation how these apply in real world situations. On the other hand, students should be able to critique location theories.

SUGGESTIONS FOR FURTHER READING

Alonso, W. (1960). “A Theory of Urban Land Market”. MIT Press, Massachusetts.

Assink, M., and Groenedijk, N. (2009). Spatial quality, Location Theory and Spatial Planning. Paper presented at Regional Studies Association Annual Conference. Understanding and shaping: Spatial Social and Economic futures. Leuven Belgium.

Balchin, P.N., Bull,G.H and Kieve, J.L. (1995). Urban Land Economics (2nd edition).Macmillan Press Limited, London.

Blair, J.P. (1995). Local Economic Development: Analysis and Practice. SAGE Publications, Carlifornia.

Capello, R. (2011). Location, Regional Growth and Local Development Theories. AESTIMUM 58, 1-25.

Dube, J., and Legros, D. (2015). Spatial temporal for the simultaneous and time on the market. Problem Real Estate Economics DOI: 10.111/154-6229.12121.

Dube,J., Brunelle, C., and Legros, (2016). Location Theories and Business Location Decision: A Micro-Spatial Investigation of a Nonmetropolitan in Canada. Regional Science Association 46(2), 143-170.

Glatte, T. (2015). Location strategies: Methods and their methodological limitations. Journal of Engineering, Design and Technology 13(3), 435-462.

Henry, M.S., Barkely, D.L., and Bau, S. (1997). The Hinterland’s Stake in Metropolitan Growth: Evidence from Selected Southern Regions. Journal of Regional Science 37 (3), 479-501.

https://education.nationalgeographic.org/resource/location/. Accessed on 24.04.2024

Shaffer, R., Deller, S.C and Marcouiller, D.W. (2004). Community Economics: Linking Theory and Practice. Blackwell, Oxford England.

Synopsis

The aim of this monograph is to furnish a detailed and comprehensive explanation of the concept of location in a simplified and accessible fashion as well as basic description of surveying techniques and equipment through illustrations based on practical examples and photographs relevant to the planning and real estate fields. This work is designed for use by planning and real estate students for teaching/learning purposes. Location is one of the most used terms in built environment and its importance cannot be over emphasised, as it is used by land use planners, estate agents, property valuers, property managers and property developers - almost on daily basis. There is a common saying in real estate which runs as follows; the three most important things that determine property value and or property investment decisions are location, location and location (Kiel & Zabel, 2008). These two terms are well explained in several geography textbooks but without relating them to the fields of real estate and planning.

About the Authors

Jairus Ndoma is a trained urban planner and real estate professional. He holds a Bachelor of Science Honors Degree in Rural and Urban Planning from the University of Zimbabwe. He has a Master of Science in Real Estate from the University of Pretoria in South Africa. He is a Registered Valuer and Registered Estate Agent in terms of the Laws of Zimbabwe. Jairus Ndoma is also a Chartered Valuation Surveyor (MRICS) with the Royal Institution of Chartered Surveyors.

Partson Paradza is a Senior Lecturer in the School of Construction Economics and Management at the University of the Witwatersrand, Johannesburg - focusing on land expropriation, compensation, sustainability and planning education. He holds a PhD and MSc in Real Estate from the University of Pretoria, an MBA from the University College of Estate Management and a BSc Honors in Rural and Urban Planning from the University of Zimbabwe.

Winnet K. Ngarakana is Lecturer in the Real Estate department at BA ISAGO University in Botswana. She holds a Bachelor of Science Honors Degree in Rural and Urban Planning from the University of Zimbabwe (2010) and a Masters of Arts in Urban and Regional Planning from the University of Botswana (2017). Recently, she obtained a Certificate in Vocational Education and Training (2024) and aims to explore innovative urban solutions.

Tiisetso Dube is the Head of Department at BA ISAGO University, Gaborone, in the Department of Real Estate. He holds a BSc Rural and Urban Planning, MSc in Rural and Urban Planning from the University of Zimbabwe and a PhD in Urban and Regional Planning from the University of Free State, South Africa. His research interests include Urban Governance and Planning and urban informality, Housing and Land related issues.

Innocent Chirisa is the Vice Chancellor of the Zimbabwe Ezekiel Guti University (ZEGU), a Full Professor in Urban and Regional Planning with a keen interest in urban and peri-urban dynamics. Currently focusing on environmental systems dynamics with respect to land use, ecology, water and energy. Holds a DPhil in Social Sciences. Professor Chirisa is also a Research Fellow with the Department of Urban and Regional Planning, University of the Free State, South Africa.