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.

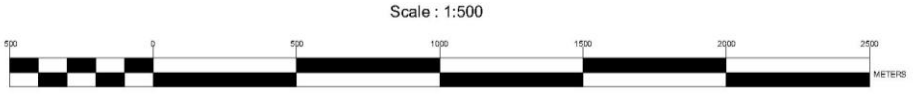

Figure 20: A graphical scale (*Authors)*

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.

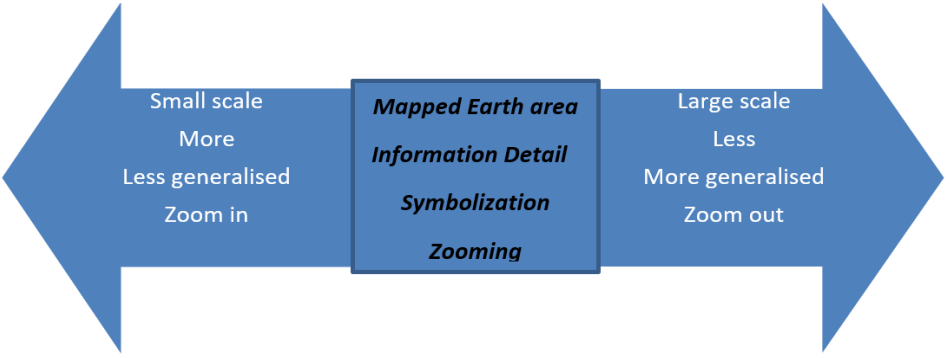

Figure 21: Differences between small and large scales (Adapted and Modified from Dent, Torguson, and Hodler, 2009).

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)

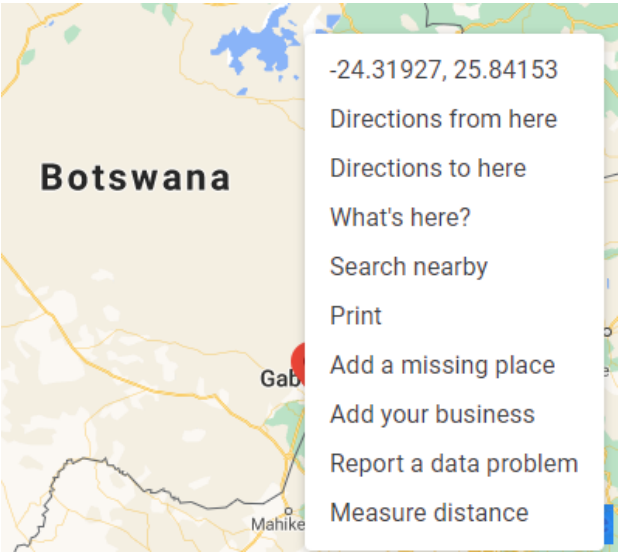

Figure 24: Measure distance on the menu that pops up (Google Maps - Accessed 09/02/2021)

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).

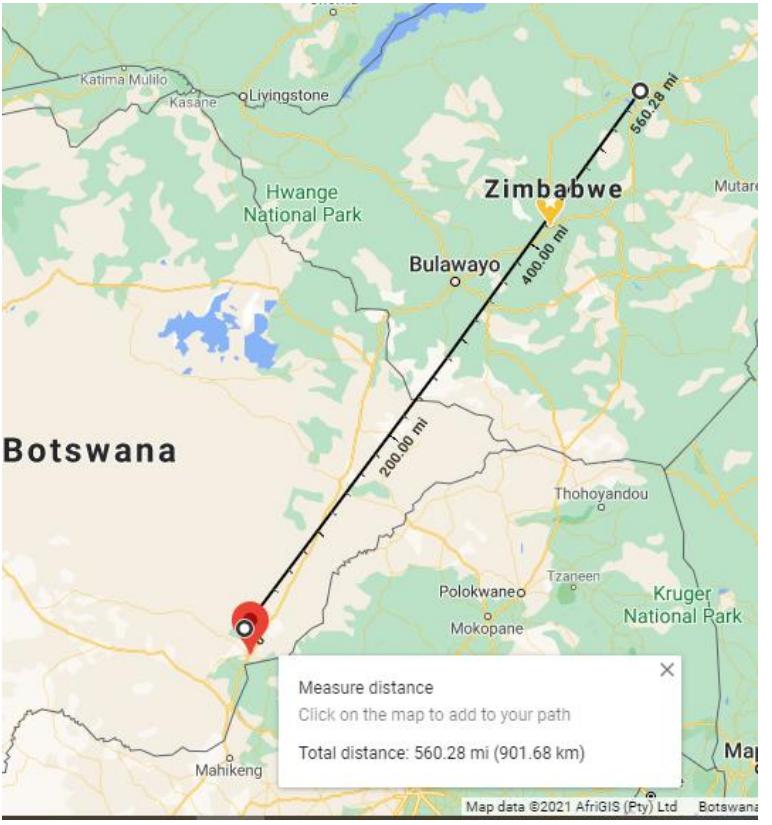

Figure 25: Measuring distance between Gaborone and Harare on Google Maps (Google Maps - Accessed 09/02/2021)

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.

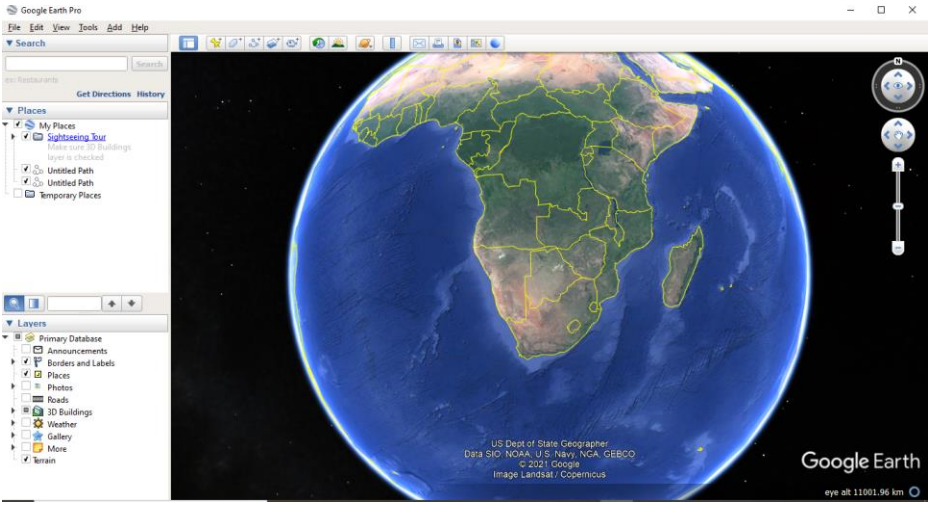

Figure 26: Google Earth Pro: (Google Earth, 2021) (Accessed 09/02/2021)

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.

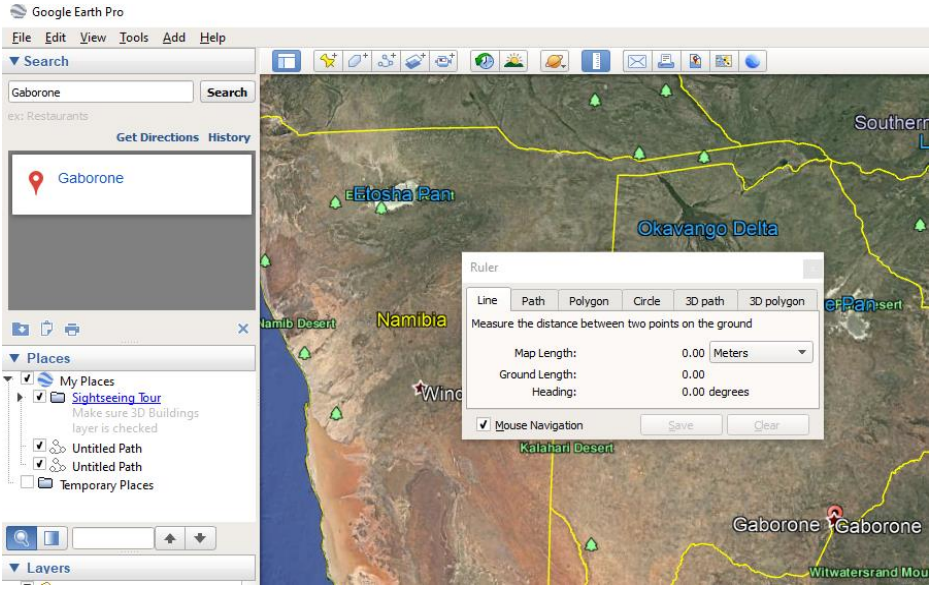

Figure 27: Selecting a ruler : (Google Earth, 2020) (Accessed 09/02/2021)

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.

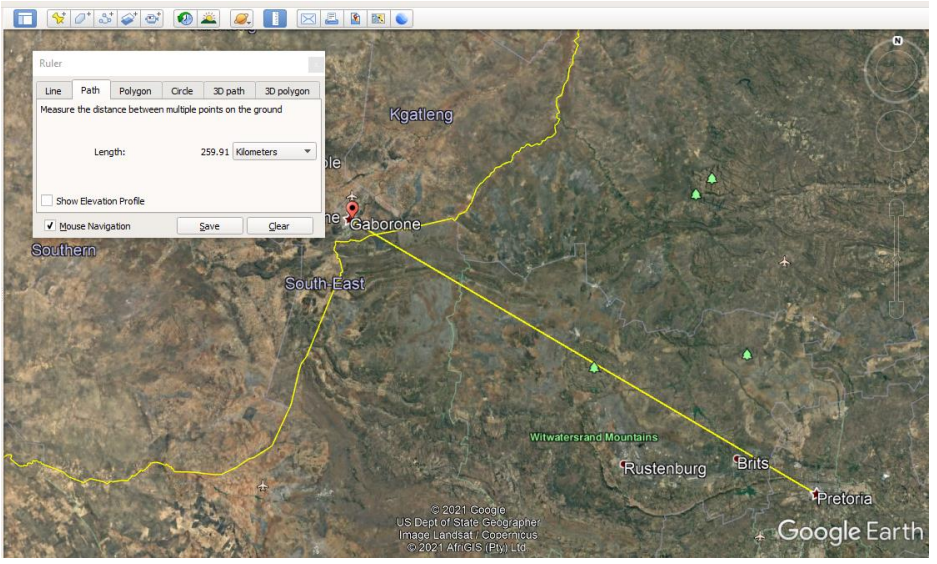

Figure 28: Distance between Gaborone and Pretoria on Google Earth
Source: Google Earth (2020) (Accessed 09/02/2021)

- 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.

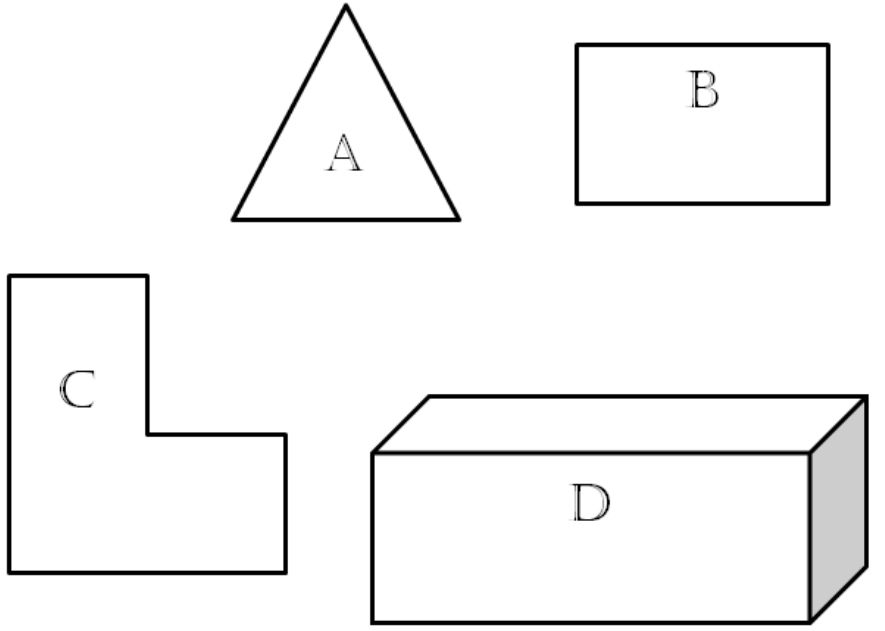

Figure 29: Shapes to be measured by students (Designed by authors)

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.