Research
Based
Curricula

How can mathematics help a farmer?

Key Stage 5 Maths/Business

2020

BROUGHT TO YOU BY RBC ACCESS ED

Contents

Part 1: Introduction

Part 2: Resources

Part 3: Advice and Guidance

For Students
Getting Started

RBC means Research-Based Curriculum,. Each RBC coursebook is written by a PhD student at a university about their cutting edge research.

Why complete an independent 'RBC' study pack?

RBC courses are challenge courses to sharpen your skills and resilience: finishing a RBC course is a major accomplishment to add to your academic CV. To get into the university, you must demonstrate that you are intellectually curious, and will make the most of the academic opportunities available to you. Completing a pack will allow you to gain invaluable experience to write about in your university application..

It allows you to:

- ✓ Build your subject experience to mention in your UCAS Personal Statement
- ✓ Sharpen your academic skills
- ✓ Experience what it's like to study beyond school and at university
- ✓ Better understand what you enjoy and don't
- ✓ Improve your overall subject understanding ahead of final exams

For Students
Getting Started

What's in this booklet?

Your RBC booklet is a pack of resources containing:

- ✓ More about how and why study this subject
- ✓ Six 'resources' each as a lesson with activities
- ✓ A final assignment to gauge learning
- ✓ Extra guidance throughout about the university skills you are building
- ✓ End notes on extra resources and where to find more information

Who should complete this pack?

Anyone interested in improving their academic skills or understanding what they should do at university. *This pack is especially great for anyone interested in studying* ***Maths*** **or Business Studies,** *and are interested in understanding the links between the two.*

Even if you are unsure of where your interest in these subjects can take you, by completing this pack you will have a clearer idea of the variety of subjects that link to one another.

If you have any questions while you are using the resources in this pack, you can contact your teacher or email us directly at schools@access-ed.ngo.

Good luck with your journey to higher education!

For Students
University Skills

To complete this resource, you will have to demonstrate impressive academic skills. When universities are looking for new students, they will want young people who can study independently and go above and beyond the curriculum. All of these skills that you will see here will demonstrate your abilities as a university student – while you're still at school!

Every time you have to look something up, or write up a reference you are showing that you can work independently.

Every time that you complete a challenging problem or write an answer to a difficult question, you might demonstrate your ability to think logically or build an argument.

Every time that you evaluate the sources or data that you are presented with, you are showing that you can "dive deep" into an unfamiliar topic and learn from it!

Skills you will build for university:

independent research	your ability to work on your own and find answers online or in other books
creativity	your ability to create something original and express your ideas
problem solving	your ability to apply what you know to new problems
building an argument	your ability to logically express yourself
providing evidence	your ability to refer to sources that back up your opinions/ ideas
academic referencing	your ability to refer to what others have said in your answer, and credit them for their ideas
Deep dive	your ability to go above and beyond the school curriculum to new areas of knowledge
source analysis	your ability to evaluate sources (e.g. for bias, origin, purpose)
Data interpretation	your ability to discuss the implications of what the numbers show
Active reading	your ability to engage with what you are reading by highlighting and annotating

Where can this subject take me?

Pathways

Studying Biology or Psychology can open the doors to many degrees and careers. It intersects with microbiology, chemistry, physiology, and sociology. Whatever interests you is likely to relate to biology in some way. See a snapshot of where studying Biology and Psychology can take you.

'Transferrable skills' from Maths to a career:

- Attention to detail
- Good at investigating, analysing and interpreting data, finding patterns and drawing conclusions
- information technology
- approaching problems in an analytical way
- dealing with abstract concepts
- Good at analysing large quantities of data
- Logical thinking

'Transferrable skills' from Business Studies to a career:

- Highly motivated
- Teamwork and leadership skills
- Good written communication
- Organisation and time management skills
- Numeracy (level depends on nature of the course)
- Ability to use initiative and can think creatively
- Proactive

What are some are the 'interdisciplinary' subjects in this course?

Interdisciplinary is a term you will hear used by higher education institutions. It's also how many professionals and academics in the real-world operate: they use multiple subjects, or disciplines, to achieve their work.

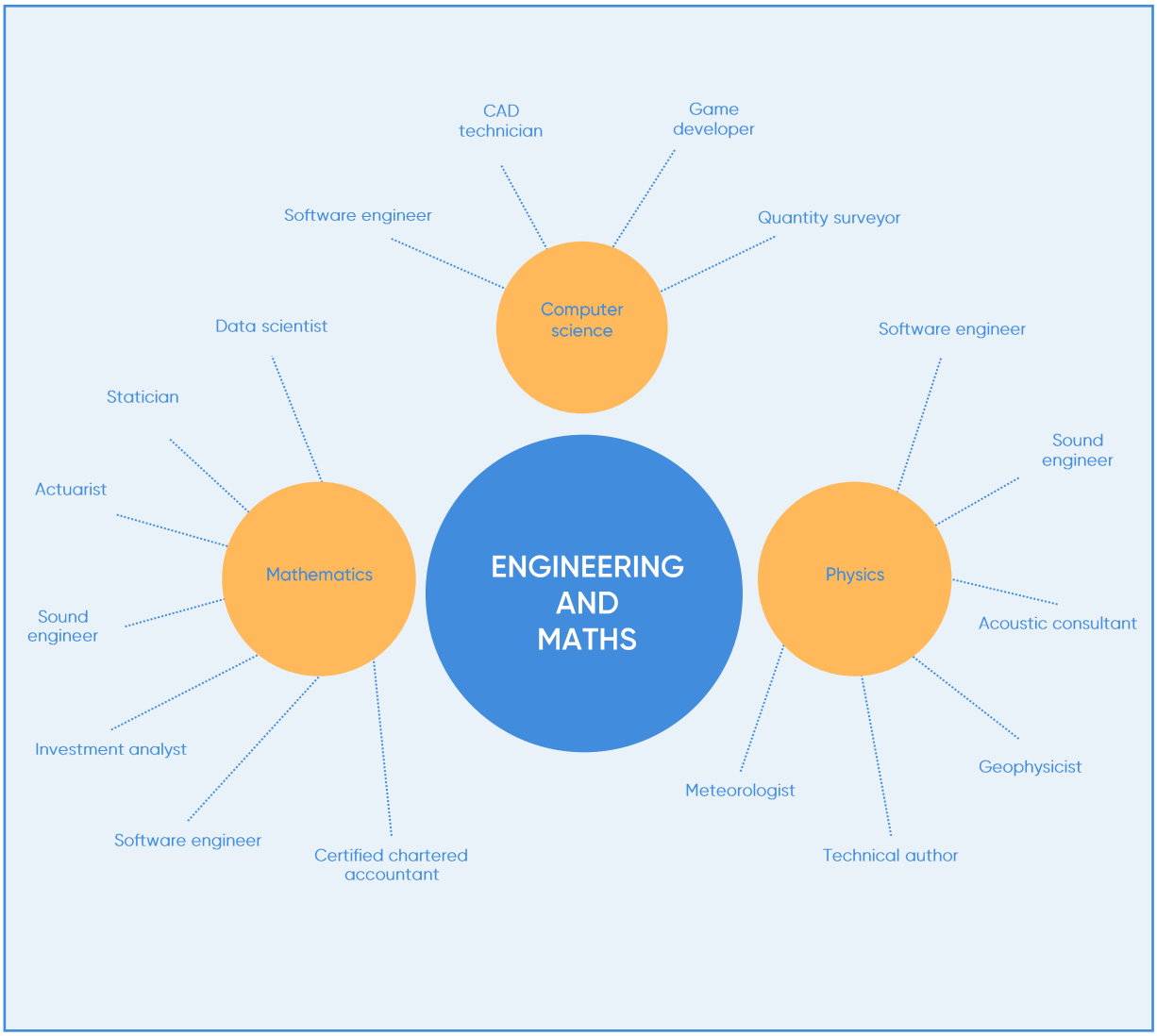
By thinking about which subjects you like, alongside maths, it can help you choose a career pathway later.

Read more about subject selection and careers pathways:

https://targetjobs.co.uk
https://www.prospects.ac.uk
https://thinkuni.org/

Subject map: Engineering and Maths

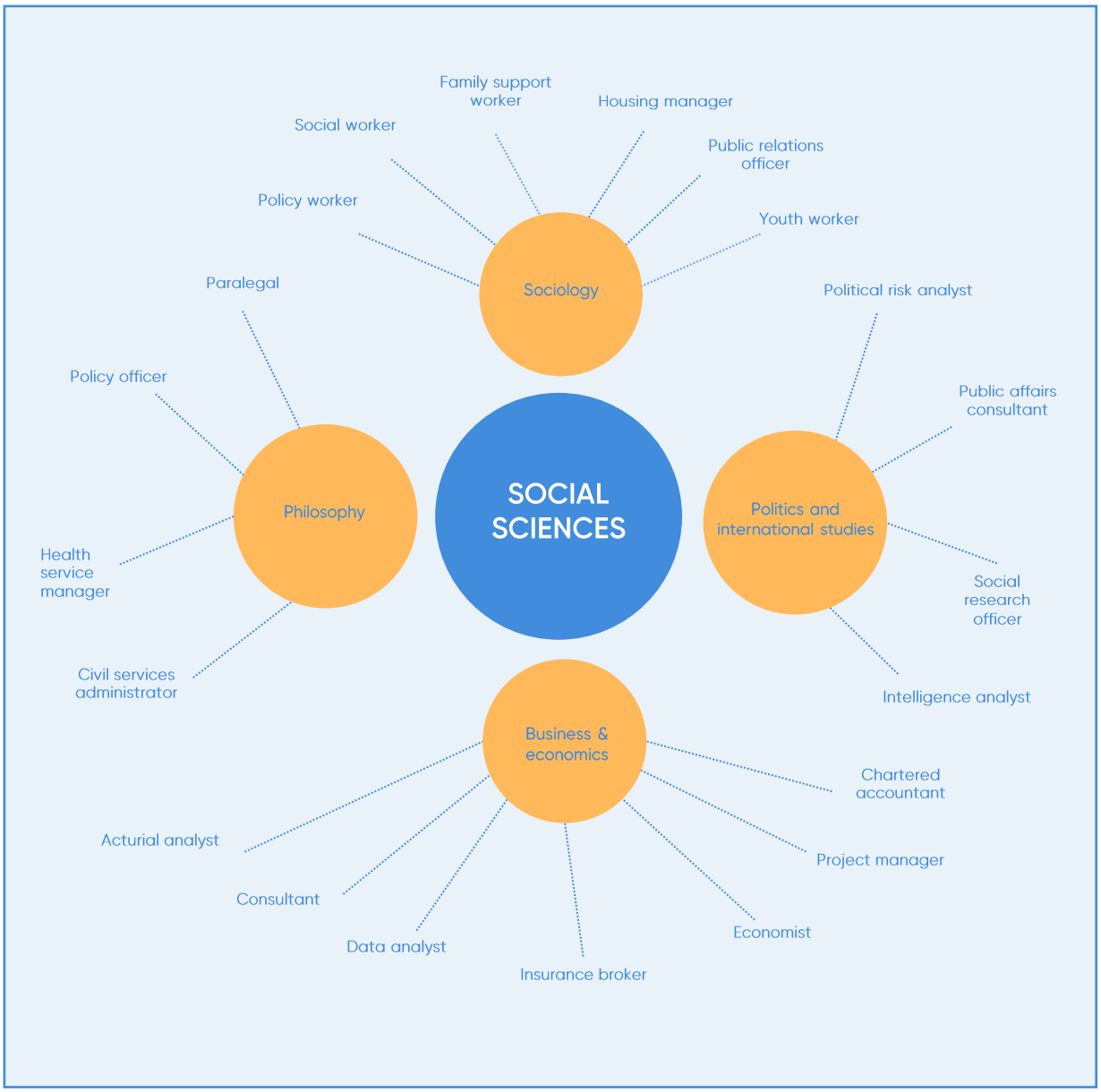
Students with an engineering degree are often seen with a background in mathematics and physics as this is essential in the principles of projects that they carry out. Students with a mathematics degree do into jobs in finance as well as IT services. Students studying mathematics and physics can also go into academia for further study in the subject.



Find our about Science-related careers here:
PROSPECTS: https://www.prospects.ac.uk
TARGET JOBS: https://targetjobs.co.uk

Subject map: Social sciences

Most students with a Social Sciences degree go on to work in public policy, financial services, civil services, and law. Approximately 25.4% of students doing a Bachelor's degree in Social Sciences choose to pursue a higher degree later on. A combination of the subjects in Social Sciences are very popular amongst students in their sixth form.



Find our about Science-related careers here:
PROSPECTS: https://www.prospects.ac.uk
TARGET JOBS: https://targetjobs.co.uk

For Teachers RBC Guide

Learner aims

The Research-Based Curriculum aims to support student attainment and university progression by providing classroom resources about cutting-edge research at local universities. The resources are designed to:

- ✓ promote intellectual curiosity through exposure to academic research
- ✓ stretch and challenge students to think deeply about content that may be beyond the confines of the curriculum
- ✓ develop core academic skills, including critical thinking, metacognition, and written and verbal communication
- ✓ inform students about how subjects are studied at university, and provide information, advice and guidance on pursuing subjects at undergraduate level

Content

The programme represents a unique collaboration between universities and schools. Trained by AccessEd, PhD Researchers use their subject expertise to create rich resources that help bring new discoveries and debates to students.

The Research-Based Curriculum offers ten modules suitable for either KS4 or KS5 study. The modules span a range of disciplines, including EBacc and A-level subjects, as well as degree subjects like biochemistry. Each module includes six hours of teaching content, supported by student packs, teacher notes and slides. All modules are available online and free of charge for teachers at select schools.

Using the RBC pack

These resources are designed to be used flexibly by teachers. The resources can be completed by students individually or in groups, in or out of the classroom.

For Teachers
Using the RBC packs

Extra-Curricular Subject Enrichment Clubs

Here are five examples of delivery options:

The resources can be completed in small groups (4-8 pupils) across a series of weekly lunch clubs or after-school clubs. Groups can reflect on their learning by presenting a talk or poster on the subject matter at the end of the course.

University Access Workshops

The resources can be used by students to explore subjects that they are interested in studying at university. This can inform their decision making with regards to university degree courses, and allow students to write more effective personal statements by including reflections on the Research-Based Curriculum.

Research Challenge

The resources can be used to ignite curiosity in new topics and encourage independent research. Schools could hold a research challenge across a class or year group to submit a piece of work based on the resources. Pupils could submit individually or in small groups, with a final celebration event.

Summer Project

Resource packs can function as 'transition' projects over the summer, serving as an introduction to the next level of study between KS3 and KS4, or KS4 and KS5. Students could present their reflections on the experience in a journal.

Why offer these?

The Research-Based Curricula programme builds on the University Learning in Schools programme (ULiS), which was successfully delivered and evaluated through the London Schools Excellence Fund in 2015. The project was designed in a collaboration between Achievement for All and The Brilliant Club, the latter of which is the sister organisation of AccessEd. ULiS resulted in the design and dissemination of 15 schemes of work based on PhD research for teachers and pupils at Key Stage 3. The project was evaluated by LKMCo. Overall, pupils made higher than expected progress and felt more engaged with the subject content. The full evaluation can be found here: ULiS Evaluation.

Questions

For more information contact hello@access-ed.ngo

Introduction to Topic
Maths and meteorology

As our world becomes more and more complex, there is an increased demand for people who do interdisciplinary work. Interdisciplinary simply means that you work in more than one field at the same time. Statistics can be studied on its own, by developing new hypothesis tests and proving their limiting behaviour. But it can also be used to better understand other areas, such as meteorology. Early meteorological studies mostly involved going out and observing the clouds or making measurements in your backyard and then drawing conclusions from that. But with today's supercomputers and enormous amount of data, mathematics and statistics is needed to make sense of all of this.

The topics within this pack will include:

What is my data telling me?

Can I know more about my data if I split it up?

Is the data the same everywhere?

How can satellites help African farmers?

It is cheap to be rich but expensive to be poor?

Why would I give you money so you can give it to me?

Because most of Africa does not have the financial means to collect large amounts of weather data and does not have the high-performing computers to process the data, European research centres are using satellites to monitor the weather. By using IR and microwave measurements taken on clouds and the ground, it is possible to estimate temperature, wind and rainfall using calibrated algorithms. It is these algorithms that still are being researched.

How do we estimate rainfall even more accurately from satellite measurements? This involves estimating the correct rainfall distribution, both from the normal amounts but also the extreme rainfall events that maybe only happen every 5th or 50th year. My research is focused on estimating these things and how many kilometres rainclouds travel depending on how intense the rainfall is. This information can then be used to calibrate the satellite estimation algorithms to give better information to insurance companies and farming communities.

Introduction to Subject Maths at University

An undergraduate course in mathematics is probably one of the more diverse courses you can study. A typical Mathematics degree will span from pure mathematics such as real and complex analysis to applied modules such as discrete Mathematics and statistics. Because of this span of modules, studying Maths at university is quite different compared to studying in school. There is much less focus on solving straight up questions such as "What is x?" or "What is the volume of the can" and instead the main focus is to understand why the various mathematical models and methods work and where they come from. The more applied a module is the more question based and less proof focused will it be, but all areas have a bit of both.

Often the first two years of a Maths degree has mostly mandatory modules to give you a broad knowledge and understanding of the different areas of mathematics, and in the final year you can choose all or nearly all of your modules to fit around your mathematical interest. This can span all the way from proving how sequences of numbers behave to studying different models describing how viruses spread!

You can find application of mathematics everywhere, which makes it a great degree to study! Mathematicians create the theory for encryption keys so others cannot access your emails, derive equations describing how the atmosphere changes so we can get good weather forecasts and design medical trials to test if a new drug makes you better or not. Basically all industries need some input from a mathematician which means that more or less all doors are open with this degree.

Meet the PhD Researcher Jennifer Israelsson

My path to finding out what I wanted to study has been far from straight. I did all my education in Sweden before coming to the UK to study at University. While I studied science for A-levels, I also wanted to become a dancer, so I did a dance degree on the side. This meant that I did not have much spare time for anything else, but I became great at time management to fit in my assignments around all the dance. After A-levels, I was tired of studying and needed to find both motivation to study and decide what I really wanted to study at university. So I ended up taking 2 gap years, the first one working as a waitress at a hotel in the Caribbean, which still is one of the best experiences in my life. While working there, I started to realise how much I missed maths and studying. So during my second gap year, I went back to Sweden to work full time to save money for university while I was going through the UCAS application process. I did not know a single person that had studied at a UK university, so it was a bit of a challenge to understand the entire application process with a personal statement and references, because neither is required for studies in Sweden. Luckily the study advisor at my A-levels school was from the UK, so she gave me a massive amount of support, even though I had left the school more than a year ago.

I ended up studying a broad mathematics bachelor's degree at King's College of London. I did not really know what maths at university would be like, so I tried to go for the broadest course possible and assumed that it would be possible to narrow it down when I knew better what I found interesting. I was accepted to a MSci degree, a four year degree with the master directly following the bachelor. In the beginning of my third year however, I got interested in the PhD programme "Mathematics of Planet Earth", even though I never thought that I would do a PhD. This is a four year programme with the first year being a master in research and then three years of PhD. The theme of the programme is to apply mathematics

Meet the PhD Researcher Jennifer Israelsson

and physics to weather or climate to better explain how they behave. This was the perfect program for me because I wanted to continue to work with maths as a tool and I find the changes in our climate very interesting. Hence I decided to not do the fourth year at King's but just finish my bachelor's degree and move from London to Reading to do the MRes and PhD in this program, proving that nothing is set in stone.

A-Level Subjects	Mathematics, Physics, Chemistry, Biology
Undergraduate	Mathematics
Postgraduate	Master in Research in Mathematics of Planet Earth

Glossary

Term	Definition
Data analysis	Displaying data in graphs and plots to easier interpret data
Histogram	Graph with columns representing the number of data points within an interval
Box and whiskers	Graph showing the quartile values for a data set
Quartiles	0%, 25%, 50%, 100% values
Outlier	Data points that are very far away from the mean
Uniform distribution	All values are equally likely, i.e have the same probability
Time series	Graph with time on the x-axis and the measurements on the y-axis
Periodic	The same pattern is repeated
Sampling bias	Getting the wrong estimates because we only have data from one or a few groups in our population
CCD	Could cloud duration, the time that a cloud stays below a set temperature
Scatterplot	Graph with each data point plotted in the cartesian plane
Linear regression model	Best fit straight line to a scatterplot
Smallholder farmer	A farmer with a large enough land to feed the family but not more

Glossary

Term	Definition
Risk-reward trade-off	The common trade-off that a safe choice often gives less money than a risky choice
Discretionary income	The money that is left after all essential bills and food are payed
Bankruptcy	A company or person runs out of money and cannot pay their debts
Insurance	A contract that says how much you need to pay each month to get a predetermined amount of money in case of some emergencies.
Pay-out	Money from an insurance company if a covered accident happens
Weather-based insurance	Insurance scheme were some predetermined weather index, e.g if a certain amount of rain falls, decides if a pay-out will be made. This mostly exists in poorer countries with many small-holder farmers.
Reinsurance company	An insurance company that insures other insurance companies in case they need to make many pay-outs at the same time

Resource One Overview

Topic: What is my data telling me?

A-level Modules: Data representation/interpretation

Objectives: By the end of this resource, you will be able to:

- ✓ Understand what data analysis is and why it is necessary.
- ✓ Learn how to create and read histograms and Box and Whiskers plots.
- ✓ Understand the connection between a histogram and a Box and Whiskers plot.

Instructions:

1. Read the data source
2. Complete the activities
3. Explore the further reading

Resource One
Data Source

Section A

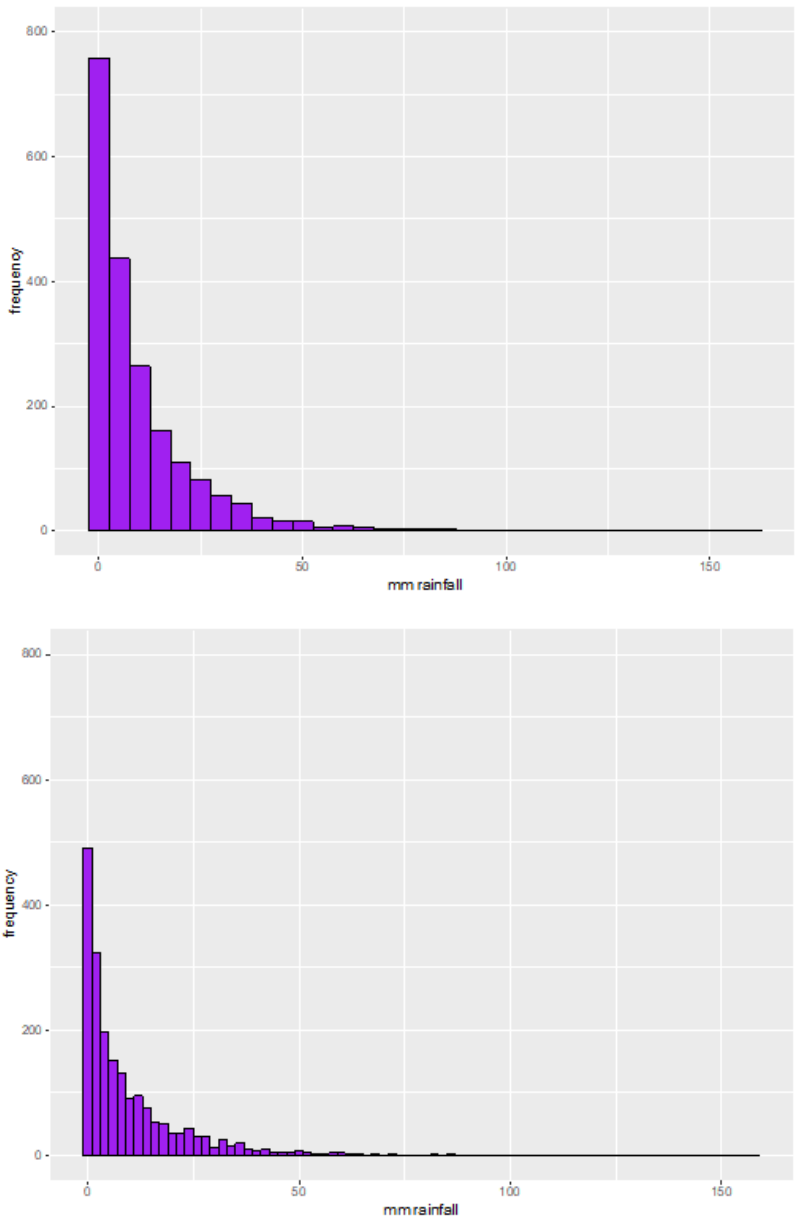
Histograms

Humans are generally not very good at understanding data by just looking at the numbers, which can be temperature measurements or weights of carrots for example. It is usually much easier to understand a dataset if we present some key numbers or graphs showing the shape of our data. This is usually called data analysis.

A good start to understand your data is to plot a histogram. A histogram is a graphical presentation of a frequency table which shows how many data points we have in each interval.

Figure 1

Two histograms with different bin width



Data interpretation

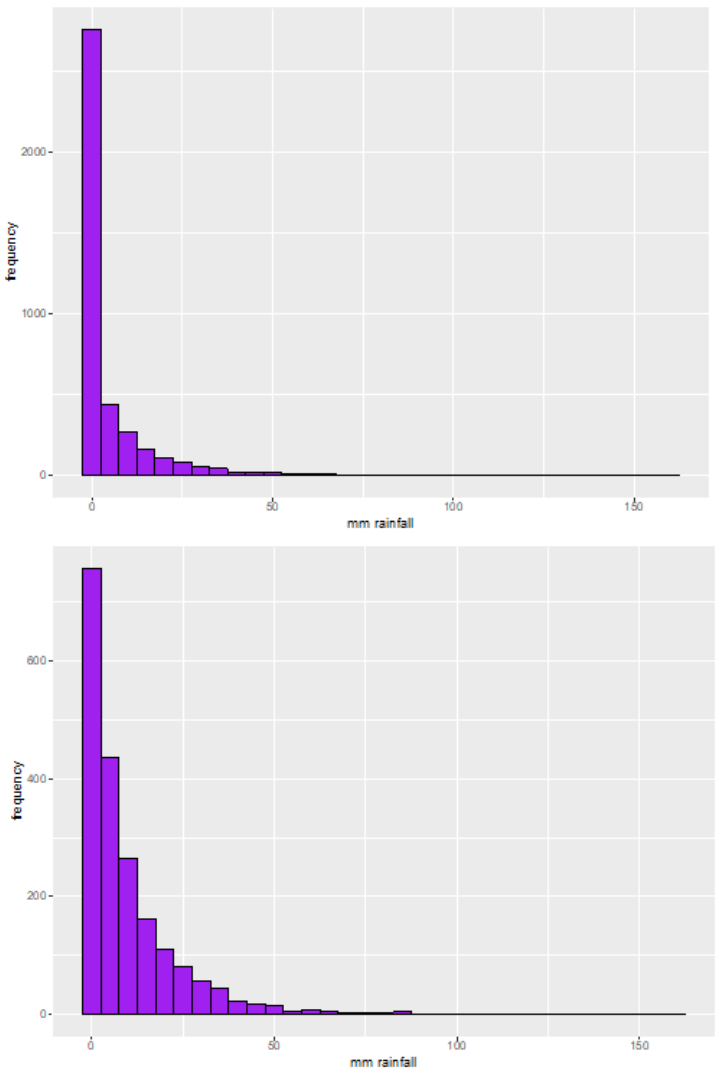
Resource One
Data Source

The histogram is a very simple tool, but we must be careful when choosing how wide each column should be. If we pick a very narrow columns, like the second histogram above, we will end up with one column for each value which can make the graph more noisy. In the above histogram, we can see a clear decreasing trend in the left graph but a much less smooth pattern in the right graph because we have split it up in such narrow columns.

Another thing that can make a histogram difficult to read is if we have a very high proportion of data points of one single value. If our data points are daily measurements of rainfall, then many of those data points will be zero since it does not rain every day. A histogram of this can look like

Figure 2

Histogram of rainfall including 0's and without



Resource One
Data Source

Since the first column is so much higher than the other, it can be better to remove the 0 values and only make a histogram of the non-zero rainfall values. If we remove all the 0's, we instead get the right histogram which tells us much more about the distribution of the data points. We can now describe our data as the combination of proportion of 0's and the distribution of the rest of the data points.

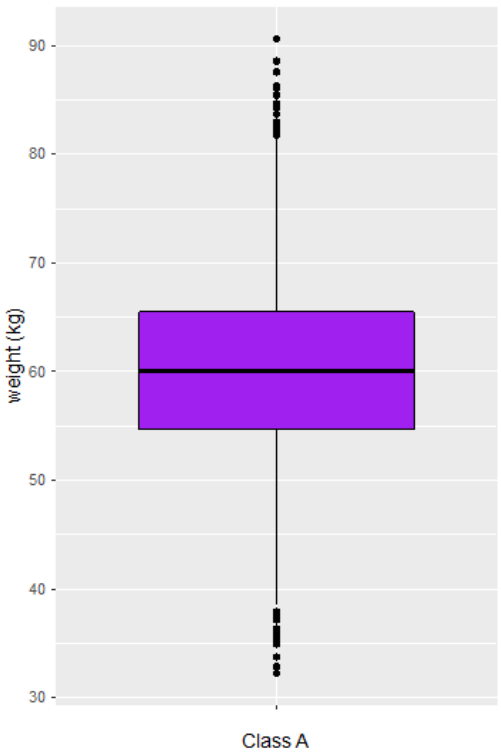
Section B

Box and whisker plots

Another great tool to describe our data is a Box and whiskers (BW) plot. These plots show where the minimum, 25% value, 50% value, 75% value and maximum of our data set is, also called the quartiles. This means that if we had 100 data points and ordered them in increasing order, we would mark out the 1st, 25th, 50th, 75th and 100th value. By marking out all these values, instead of just the mean and the minimum and maximum, we can better understand how our data points are distributed. If there are data points that are very far away from the middle point, usually more than 2.5*(50% value – 25% value), these are marked by a black dot instead and is called an outlier.

Figure 3

Box and whisker plot with outliers

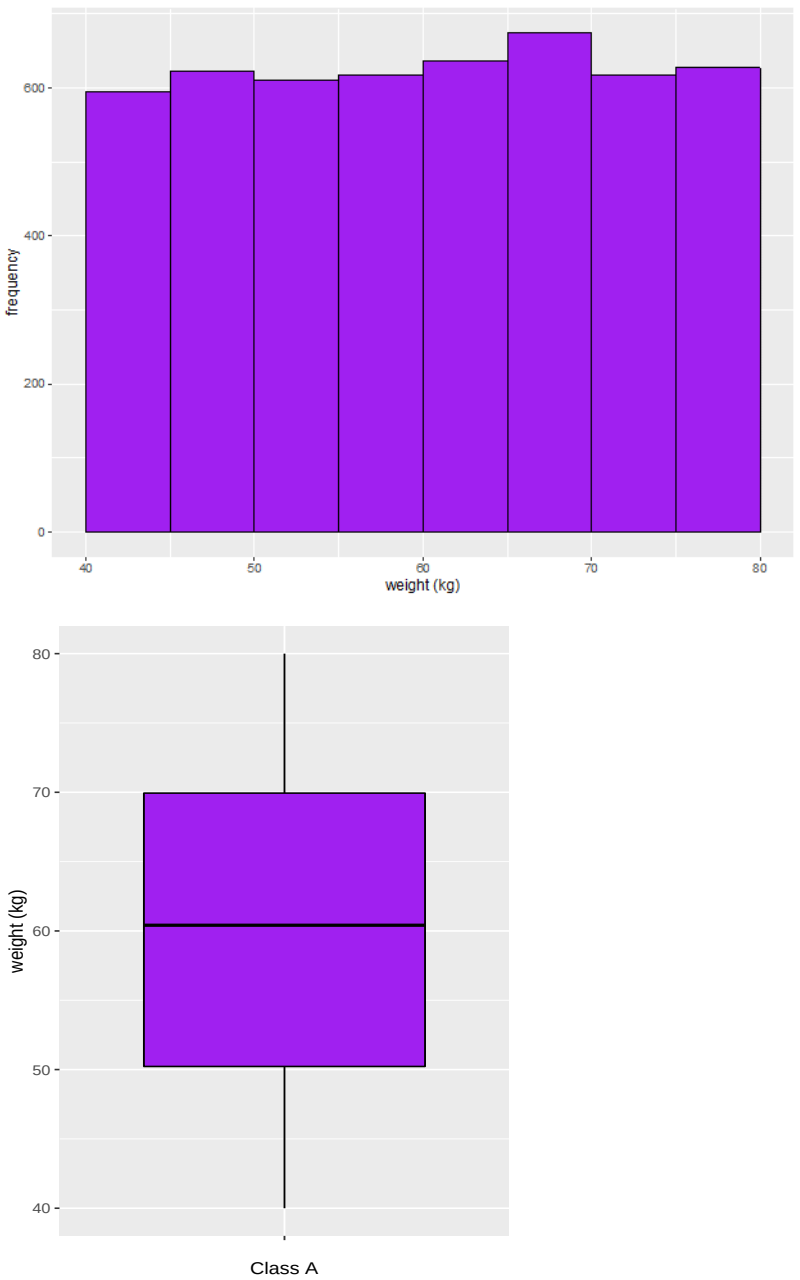


Resource One
Data Source

The BW plot and the histogram are two different ways of describing the same information. If all the columns in our histogram are of equal height, then the distance between the 0, 25%, 50%, 75% and 100% value will all be the same. A distribution like this is called uniform.

Figure 4

Histogram and box and whisker plot of uniform data

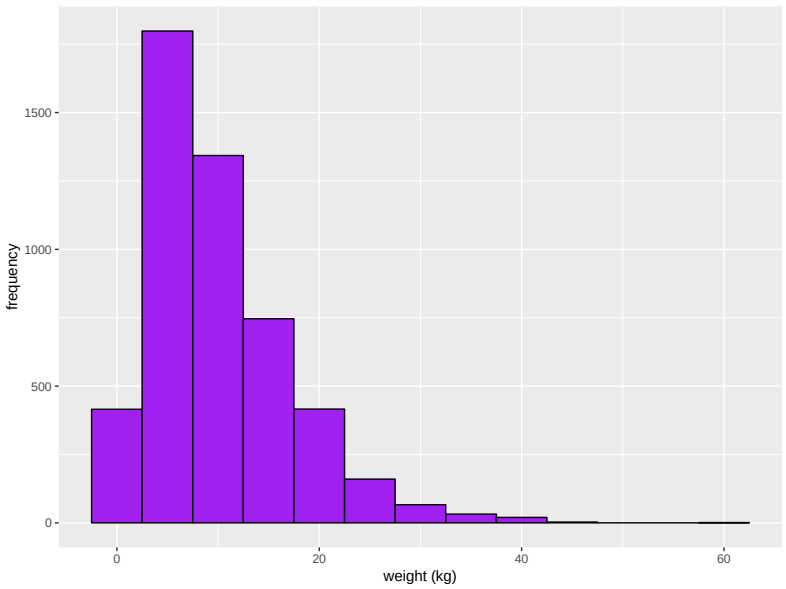


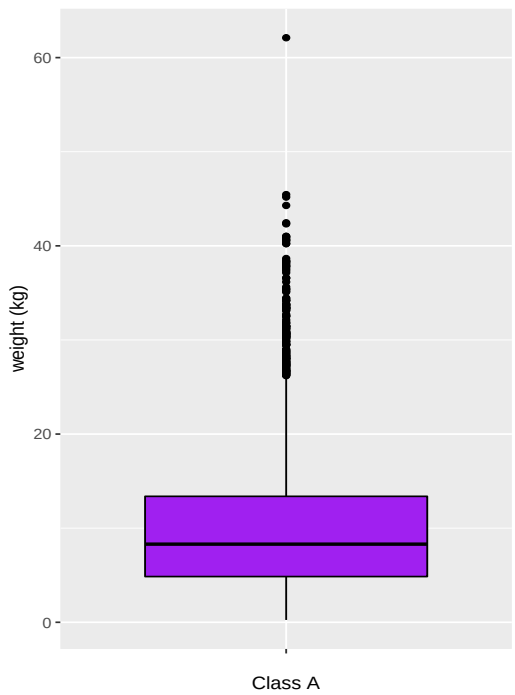
Resource One Data Source

If we instead have a skewed histogram, like the first ones in this resource, then the difference between the middle value and the 25% will be different than the difference between the 50% and the 75%.

Figure 5

Histogram and bx and whisker plot of uniform data





Resource One Activities

Activities

1. Use the table below to create a histogram.

Rain (mm)	[0,10)	[10,20)	[20,30)	[30,40)	[40,50)	[50,60)
Freq	53	40	32	61	11	26

2. Below is another table with the same data but with different intervals. What do you think will be the difference between the 2 histograms? Draw the histogram and see if you were correct.

Rain (mm)	[0,5)	[5,10)	[10,15)	[15,20)	[20,25)	[25,30)	[30,35)	[35,40)	[40,45)	[45,50)	[50,55)	[55,60)
Freq	20	33	22	18	20	12	22	39	10	1	5	21

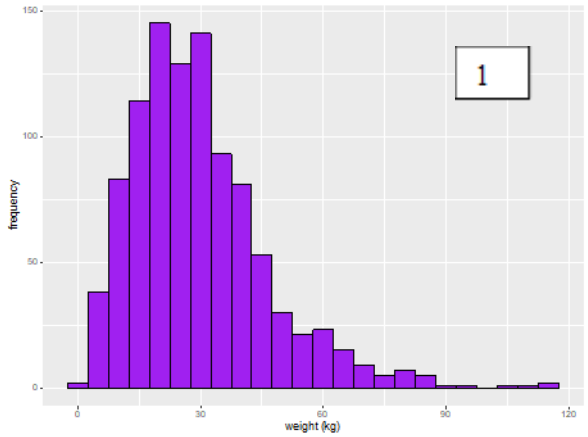
3. Below are the quartile values from the data in the table. Draw the Box and whiskers plot.

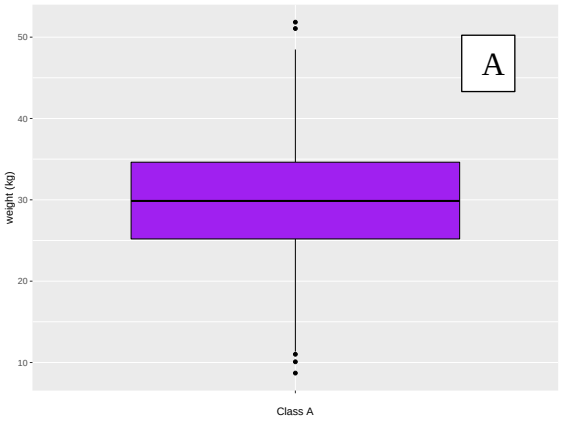
Quantile	0	25%	50%	75%	100%
Rain (mm)	0	9	27	38	60

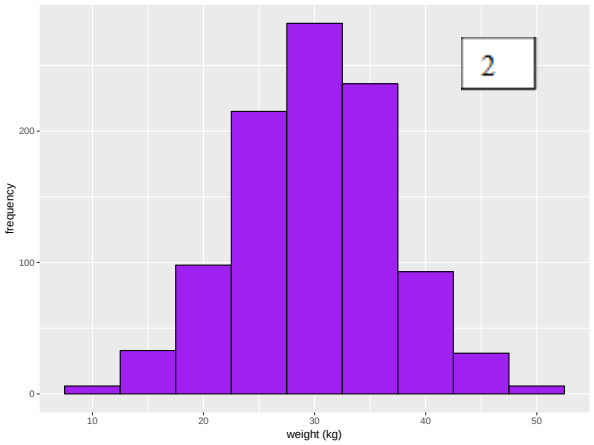
4. Match the correct histogram with each Box and Whiskers plot on the next page.
5. When do think you want to use a histogram and when is a Box and whiskers plot better?

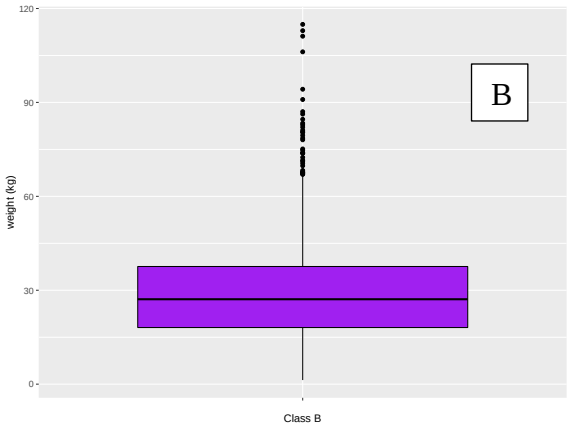
Resource One Activities

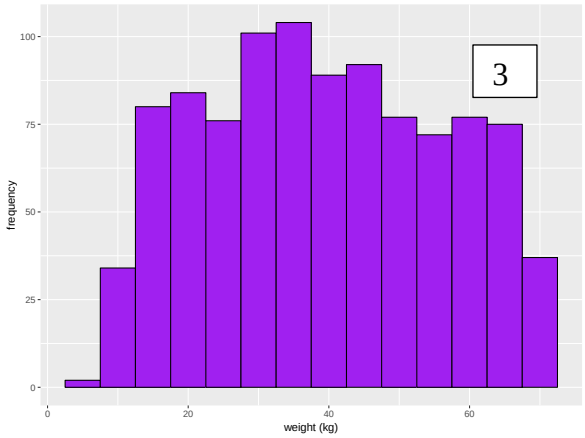
Activities

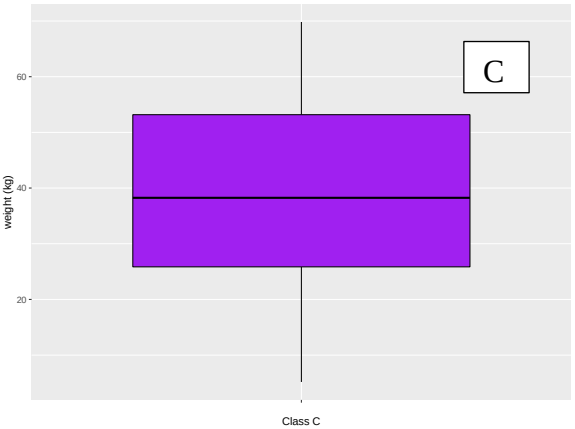












Resource One
Further Reading

Explore

- Join the free online course in how to do data analysis in Excel: https://www.coursera.org/learn/excel-data-analysis
- Find a report from a survey (from your school, in the news,..) and see what kind of data analysis they have done on the survey data. Do you agree with it, or would you have done it differently?

Resource Two Overview

Topic	Can I know more about my data if I split it up?
A-level Modules	Data presentation/interpretation

Objectives

By the end of this resource, you will be able to:

- ✓ Know what a time series is and when it should be used
- ✓ Know different patterns that can be present in a timeseries and how to detect them.
- ✓ Understand why it sometimes is better to make separate Box and Whiskers plots for different subsets of a data set.

Instructions

1. Read the data source
2. Complete the activities
3. Explore the further reading

Resource Two
Data Source

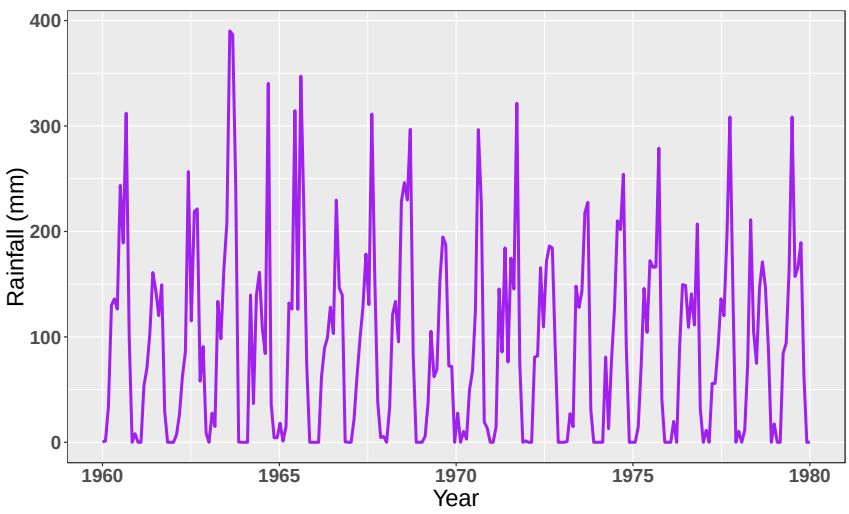
Section A

Time series

Many types of data set contain measurements that are not all measured at once, but they are often measured over time. This is nearly always true in weather and climate science, but is also true for many other areas. We measure temperature, rainfall and wind speed every hour, day or maybe month depending on what we want to use the data for. The important thing is that each measurement comes with a time stamp. If we want to understand how this variable changes with time, we can plot a timeseries. A timeseries has the time on the x-axis and the value of our variable, for example rainfall, on the y-axis.

Figure 1

Time series of monthly rainfall values for 20 years



Data interpretation

A time series can exhibit different types of patterns. The time series above has a periodic pattern which means that the same pattern repeats itself, in this case 0 rainfall for a couple of months of the year and a peak of around 200-300mm. Other periodic measurements can for example be daily temperature which is higher during the summer and lower during the winter and happens every year. This is also true for rainfall if you live near the equator and only have rain during the monsoon season, such as the data in the timeseries above.

Another pattern is if the timeseries has a trend. A trend means that the values are either getting larger or smaller as

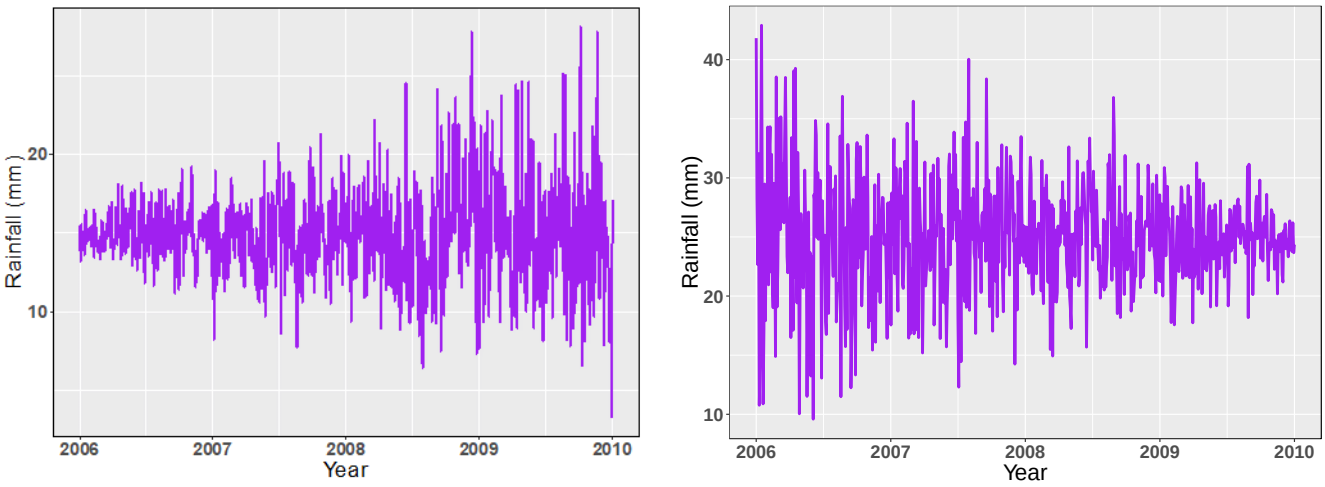
Resource Two
Data Source

we move forward in time. There can be an increasing trend in the temperature in a room if you put the heating on and a decreasing trend in the size of an ice cube if you leave it outside the freezer.

Figure 2. Time series of increasing and decreasing trends

One last type of pattern is changes in the variability, also called volatility. Variability is the difference between the maximum value and minimum value. If there is a large variability, then there is more difficult to guess what the future value will be since there is a larger spread in the range of possible values.

Figure 3. Time series of increasing and decreasing volatility



Resource Two
Data Source

Section B

Splitting up the data

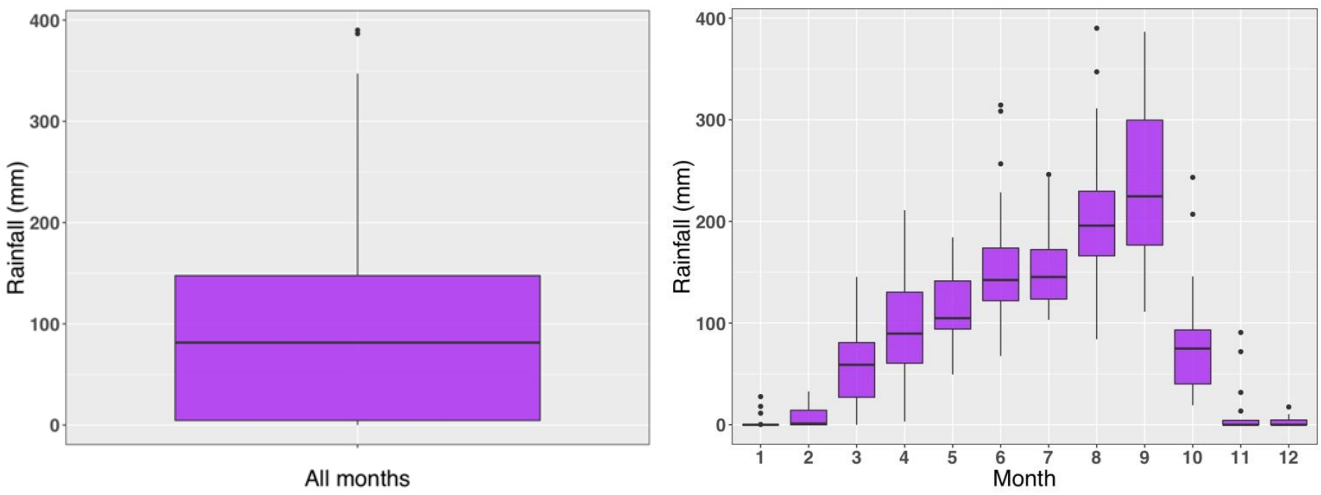
A timeseries can of course have one or more of these 3 patterns, and the pattern might only happen during some part of the time series. Going back to the temperature in the room, we might have the heating on for 3 hours and then turn it off. Then we will have an increase in the temperature for 3 hours and then no trend or a decreasing trend depending on how much heat is leaving the room.

Another way to analyse our data in time is to split it up into hours of the day, days of the week or months. Which split that is the best depends on what kind of data we are working with. If we want to analyse how many people are taking the bus, then we probably want to split up the data into hours since most people take the bus when they go to work in the morning and from work in the afternoon. If we instead analyse the average daily temperature, we can split our data into months since we have warmer temperatures in June than February.

Looking at the time series over rainfall, it is clear that we have more rainfall during the summer months compared to the winter months. If we put all the data points in a Box and Whiskers plot, this information would be lost. If we instead split up the data into months, we can easily see that it rains more during the summer months. Splitting up the data into months/days/hours is especially useful if we have a periodic pattern in our time series.

Figure 4

BW with all the data points and BW split into months



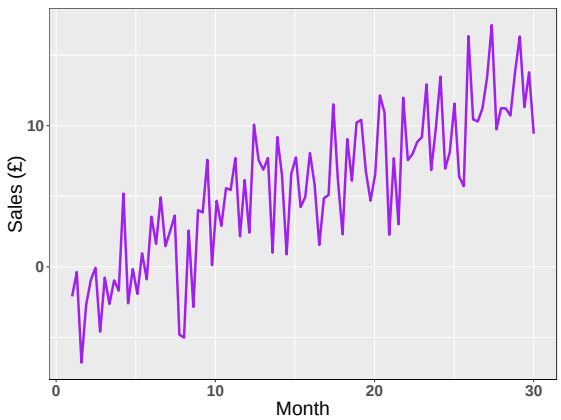
Resource Two Activities

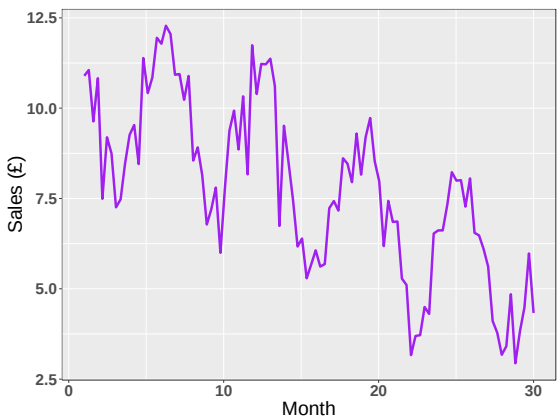
Activities

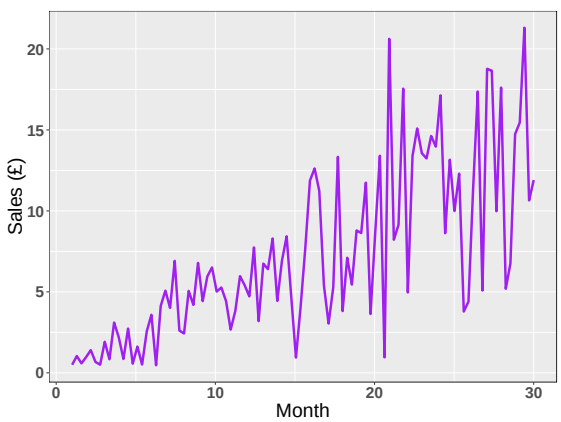
1. For the data on the average daily windspeed below, plot the time series and describe what pattern it has

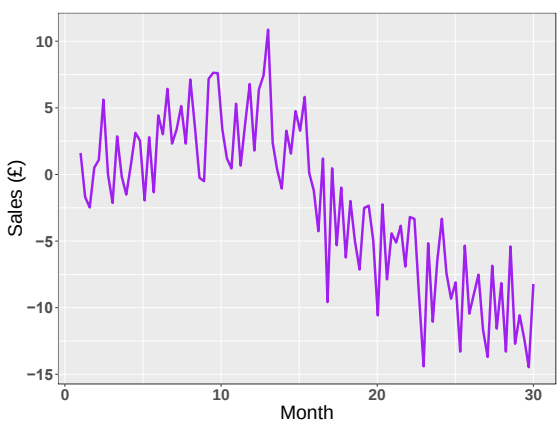
Day	1	2	3	4	5	6	7	8	9	10	11	12
wind (m/s)	7.6	7.7	5.3	2.7	2.4	4.3	7	7.9	6.1	3.4	1.7	3.6

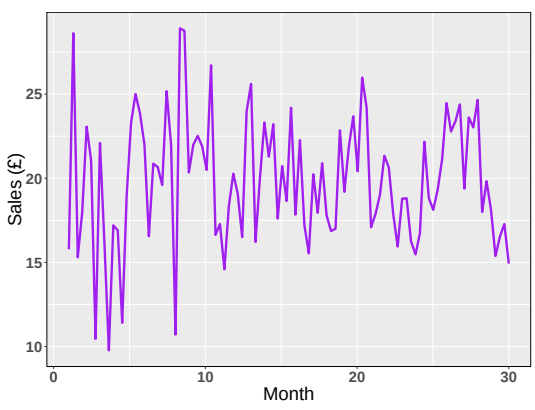
2. For each time series describe the type of pattern. Remember that it can be more than one. (5 ts)











Problem solving

Resource Two Activities

Activities

3. If we get a data set with the number of gloves sold in UK for each day during 5 years, what could be a good way to group our data to get a better understanding (day of the week/week of the year/month of the year/year etc.). Explain why you have chosen to split your data in that way.
4. You are getting data on the width of a tree measured on the 2nd of each month. What kind of pattern can we expect this data to have? Explain why.
5. Come up with your own example of a data set that has a periodic pattern, either during a year or during the day. Explain why this is.
6. Come up with your own example of a data set that has an increasing or decreasing pattern. Explain why this data is increasing or decreasing.

Resource Two
Further Reading

Explore

- Do the online course https://www.futurelearn.com/courses/data-science-environmental-modelling
- Look at the different variables and time periods in the MetOffice tool and see what time series patterns you can find https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-temperature-rainfall-and-sunshine-time-series

Resource Three Overview

Topic	Is it the same everywhere?"
A-level module	Data presentation/interpretation

Objectives

After completing this resource, you should be able to:

- ✓ Know that data can come with a spatial distribution.
- ✓ Understand the problems we can get if we do not have data everywhere.
- ✓ Understand how various variables can lead to unequal behaviour at different locations.

Instructions

1. Read the data source
2. Complete the activities
3. Explore the further reading

Resource Three Data Source

Just as we sometimes need to split up our data depending on when during the day or the year they are measured, we sometimes want to model where it has been measured. We can for example have rainfall measurements from different locations all over UK. The map below shows the measured annual rainfall during 2008.

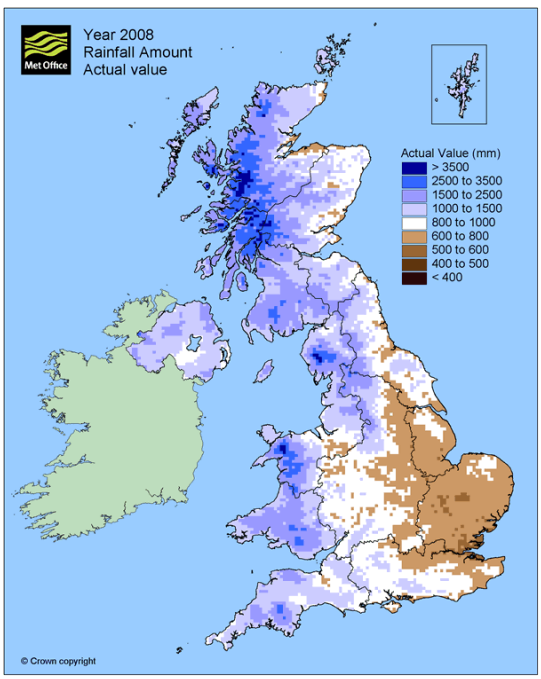


Figure 1

Map over UK with colour representing the annual rainfall amount. Source: Map from the MetOffice website, obtained on 1/11/2019.

Data interpretation

In the map above, we can clearly see that there was much more rainfall along the west coast and in the north compared to London. This is because most rain clouds in the UK are created over the Atlantic Ocean and then carried over land from the west. Having a different distribution of environmental variables at different places is very common. Why we have different values at different locations can be explained by many different variables. If we have measurements of temperature over Europe, then we will have more days with a temperature over 20°C in Southern Europe compared to Norther Europe because they are closer to the equator. If our data instead is on average windspeeds, then we will have higher values from a large open field compared

Resource Three
Data Source

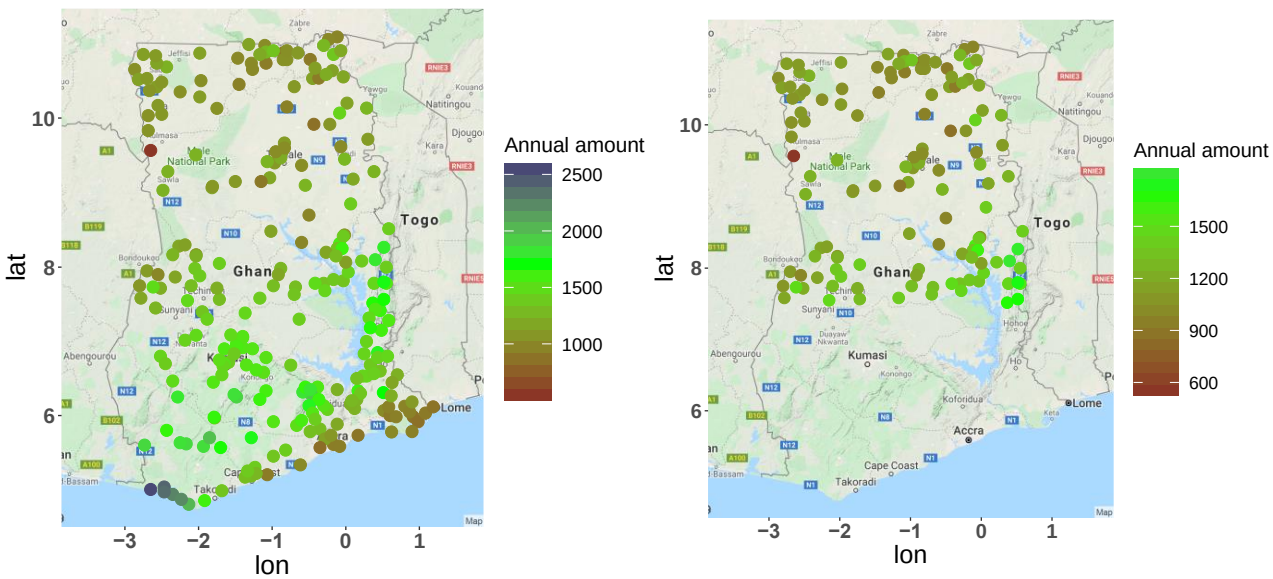
to a forest since the trees in the forest slows the wind down. Differences in rainfall depends on many things. It usually rains more next to a mountain because the clouds need to drop water to get over the mountains. This is called the orographic effect. There is also usually more rainfall along the coast because raincloud are created over the ocean and then release the rain as they come over land, exactly the pattern we see in the UK map above.

Because of all of these different variables that can affect our data, it is important to understand the nature from where we get our data. This is also why we like to have datapoints from all places in the country or region that we want to analyse. The left hand map in Figure 2 shows the average annual rainfall for locations over Ghana. But say that we only have data from the northern part of the country. Then the map would instead look like the right hand map in Figure 2.

Figure 2

Left: Map over Ghana with dots of annual average rainfall

Right: Map over Ghana with dots only in the northern half

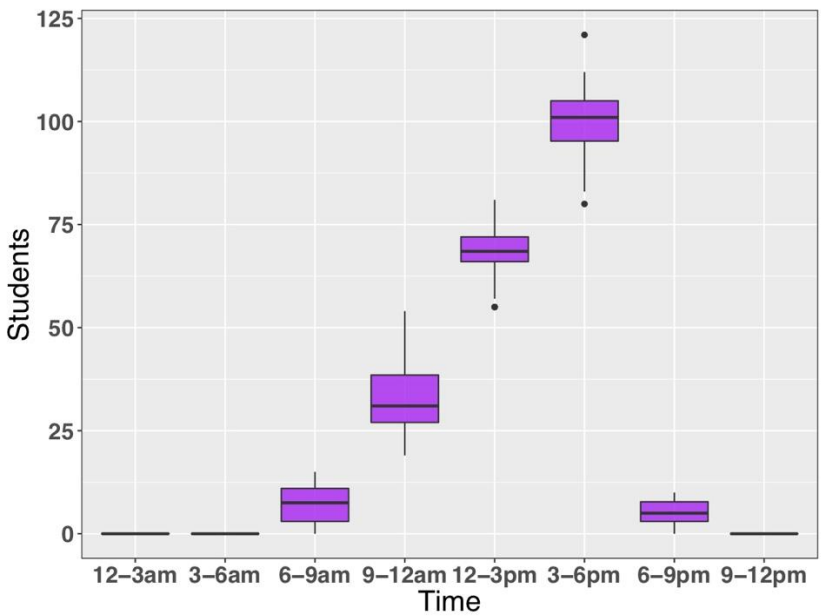


Resource Three Data Source

If this is the only information we have, we would wrongly assume that it rains less in the southern half than it really does. This can also happen if we want to know the average daily temperature but only have weather stations in towns and cities, where it is usually a few degrees warmer than the true temperature. Only having information about some of our data is called sampling bias. This can happen in any data where we have different groups or locations of data. If we for example want to know what the most popular TV program in the UK is, but only asked people over 60, we would probably have a sampling bias. Sampling bias does not have to be spatial, but can also be in time. Say that we wanted to know how many students use the library but only counted between 6-9am.

Figure 3

Time series and BW of the number of students using the library during the day

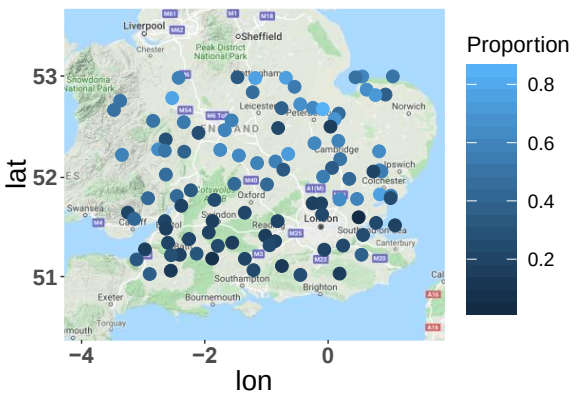


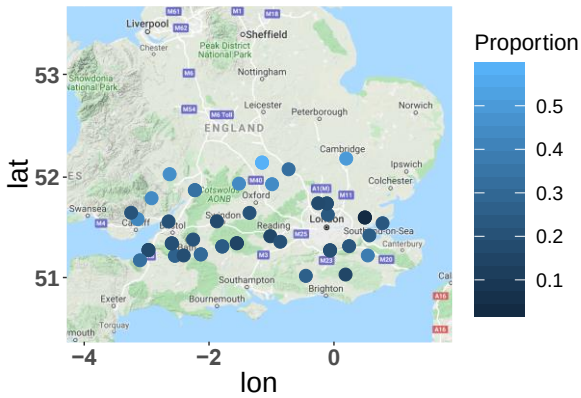
Clearly we would think that very few students used the library if we only had data from 8 am and might decide to close it even if it is very popular at other times of the day. Because of the sampling bias, whenever we want to analyse some data, we must think about if there could be some difference between ages/locations or time of the day or year and make sure that we have data from all of these different times and groups.

Resource Three Activities

Activities

1. 1Using the map over UK, which regions should we remove the data from to assume that it rains more over UK than it does?
2. If we want to know how much air pollution there is in a city but we only have measurements from 2 parks and a relatively calm street, what sampling bias might we have then? Where should we take some measurements to reduce our sampling bias?
3. The left map shows the proportion of people taking the bus to work for different locations. The right map shows the same data, but only for some of the locations. What wrong conclusion might we make if we only have the right map.





Problem solving

4. You are given data on how much money households spend on food each week. What different types of sampling bias can this data set contain? Try and come up with at least 2 examples.
5. Come up with an example where there can be a sampling bias depending on when we measure the data. Explain how and why our results will differ depending on when we measure our data.

Resource Three
Further Reading

Explore

- Link to MetOffice website to explore how more weather measurements are distributed over the year https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-actual-and-anomaly-maps
- Article about sampling bias: http://www.scholarpedia.org/article/Sampling_bias

Resource Four Overview

Topic	How can satellites help African farmers?
A-level Modules	Linear regression

Objectives

After completing this resource, you should be able to:

- ✓ Understand what linear regression is and how it relates to scatter plots.
- ✓ Understand how satellite data can be used to estimate rainfall amounts.
- ✓ Understand why satellites are used to estimate rainfall instead of rain gauges in Africa.

Instructions

1. Read the data source
2. Complete the activities
3. Explore the further reading

Resource Four
Data Source

Section A

Rainfall

UK is one of the countries in the world with the longest rainfall records, with the first measurements recorded in 1841, and rainfall measurements are today taken everywhere. Thanks to all of these measurements, we know exactly how much rainfall has fallen in any location. Even if most people do not care exactly how much rain has fallen, for farmers this information is vital because crops need a certain amount of rainfall during different phases of the growing period not to dry away. The summer of 2018 clearly demonstrated how important a good amount of rainfall is for our food production.

Figure 1

Map over UK with all rainfall measurements locations. Source: gaugemap.co.uk

Data interpretation

In most countries in Africa, very few rain gauges exist and most of them have only collected data for a few decades. This lack of data means that we do not know how much rain has fallen in many places, and it is not possible to do time series over rainfall amounts for long periods of time to see if it rains more or less because of climate change and warmer temperatures. Without this knowledge, it is very hard to recommend farmers on what to grow or when to sow their

Resource Four
Data Source

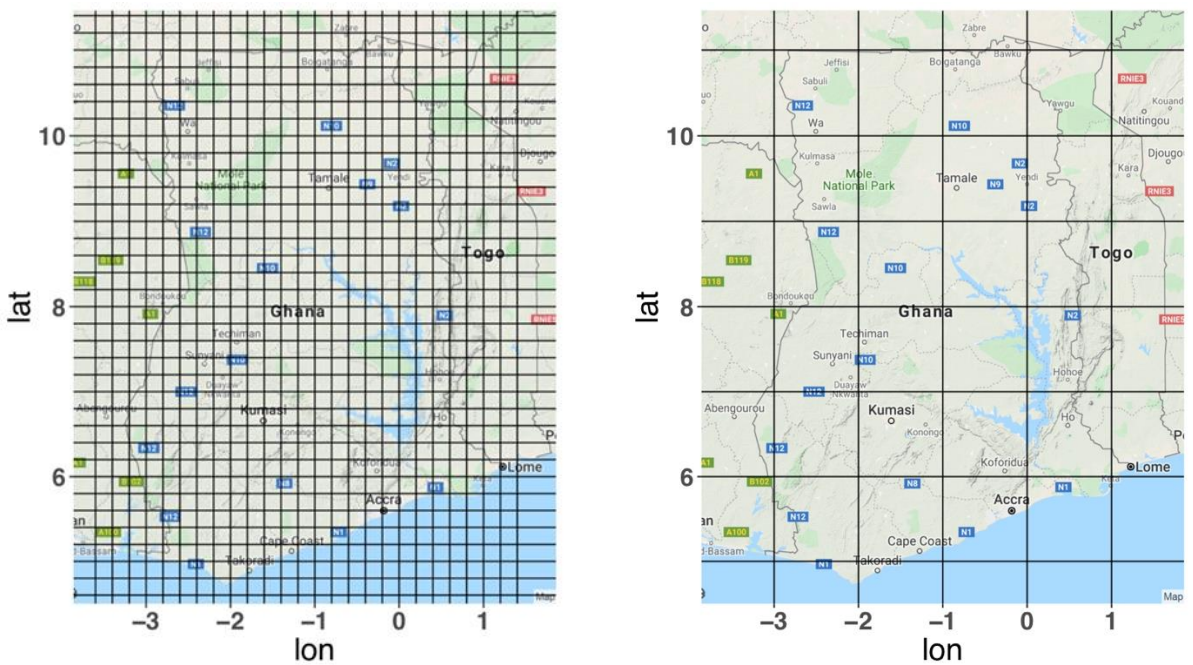
crops to secure a good supply of food. The reason for the lack of rain gauges are many. Collecting and storing data is expensive, which means that most African farmers cannot afford it. There is also limited knowledge on how this data can help them to better understand the changes they might experience, much because of limited access to education and news. Because of these different barriers, satellites are used today to estimate rainfall amounts over Africa.

Section B

Satellite measurement

Satellite measurements are taken in a grid, with the length of each grid square depending on how big or small area we are measuring and how much money we have. The finer the grid and the larger the area, the more expensive it is, since it means that we need to store more data. The best satellite products over Africa have a grid size of 4km, but several have a grid size of 50-100km. The maps below show the difference between a 20km and a 100km grid.

Figure 2. Map with a square grid

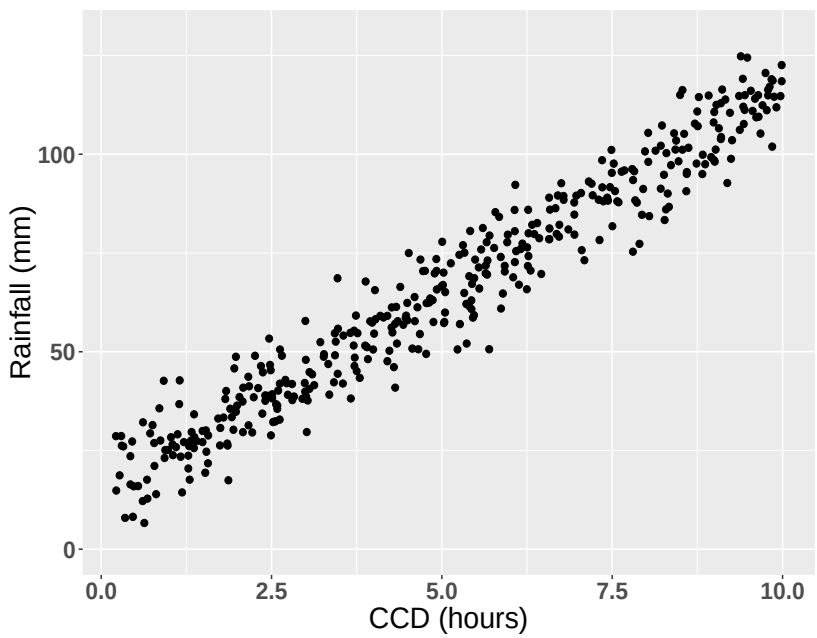


Resource Four
Data Source

Satellites do not measure the temperature directly, but it measures radiation of different wave lengths from the clouds, which then are converted to temperature. These conversion equations have been used since the 90's and are therefore a well-established and calibrated method. There are different methods to estimate rainfall from these converted satellite measurements, but one of the simpler method is fitting a linear regression equation on the Cold Cloud Duration or CCD. CCD is how many hours the top of a cloud is colder than some pre decided temperature. This temperature varies with location and time of the year, but is usually somewhere between -50°C and -70°C. So for each of the squares in our grid, we measure for how many hours each day the clouds are colder than -50°C for example. This must then be compared to how much rainfall that has been measured within the same grid point. If there is more than one rain gauge within the square, we take an average of these amounts, else we just use the one value we have. Once we have the satellite CCD value and the rainfall amount from the rain gauges, we can plot this in a scatter plot.

Figure 3

Scatter plot CCD on the x-axis rainfall amount on the y-axis



Resource Four
Data Source

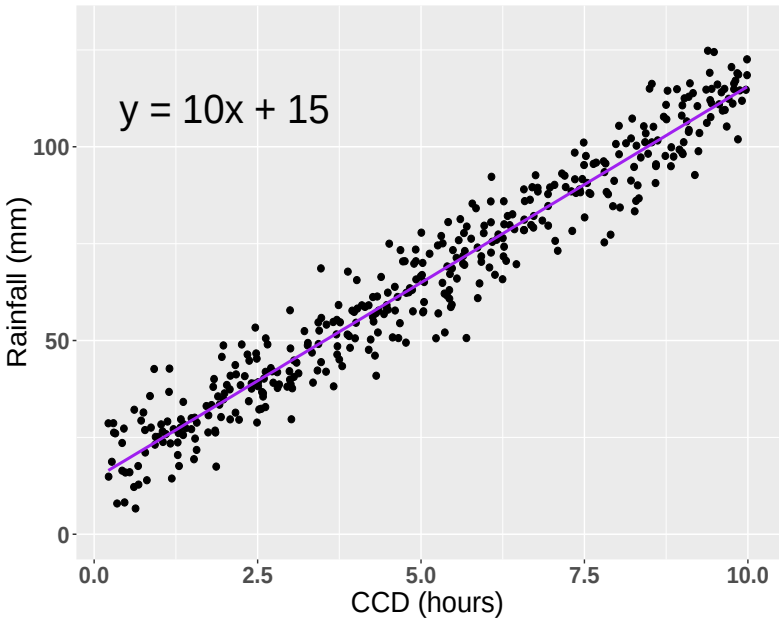
Section C

Linear regression

From the plot above, we can see that there is a general pattern of more rain if we have more hours of cold clouds. We can find a relationship between these 2 values by fitting a linear regression model. A linear regression model is an equation that describes how much rainfall we can expect if we know the CCD value. Below is the plot if we fit a linear model to our scatter plot and a snippet of the data table.

Figure 4

Linear regression model to scatter plot with equation



Sample	x = CCD	y = Rain
1	1.3	27.5
2	2.1	40.9
3	6.3	71.7
4	6.1	72.7
5	0.8	13.9
6	7.1	75.7
7	7.4	89.0
8	0.4	16.4
9	7.6	95.6
10	3.7	45.1
11	0.5	15.9

To find this linear model, we need to solve two sets of equations. If we have our table as above with rainfall measurements (y) and CCD measurements (x), we want to find the best a and b such that the difference between our measured rain and the estimated $\hat{y}$ values from the equation $\hat{y} = a^*x + b$ is as small as possible. In order to find these a and b, we have to solve the two equations

$$b = \frac{\sum_{i=1}^{n} x_i * y_i - n * \bar{x} * \bar{y}}{\sum_{i=1}^{n} x_i^2 - n * \bar{x}^2}$$

$$a = \bar{y} - b * \bar{x}$$

Resource Four
Data Source

This looks a lot more complicated that it is in reality. $\sum_{i=1}^{n} x_i$ means that we sum the x (CCD) values with sample number 1,2,…,n or simply 1.3+2.1+6.3+…+0.5. For the scatter plot above, we have 400 measurements so n=400 but in our table we only have 11 hence n=11 for the table. $\bar{x}, \bar{y}$ means the *mean* or *average* of x and y. We get this by summing all x and y values separately and then dividing by n, which was how many samples we have. This can be written with the symbols above as

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

To calculate this a bit easier, we can expand the table above with each value we need for the equations.

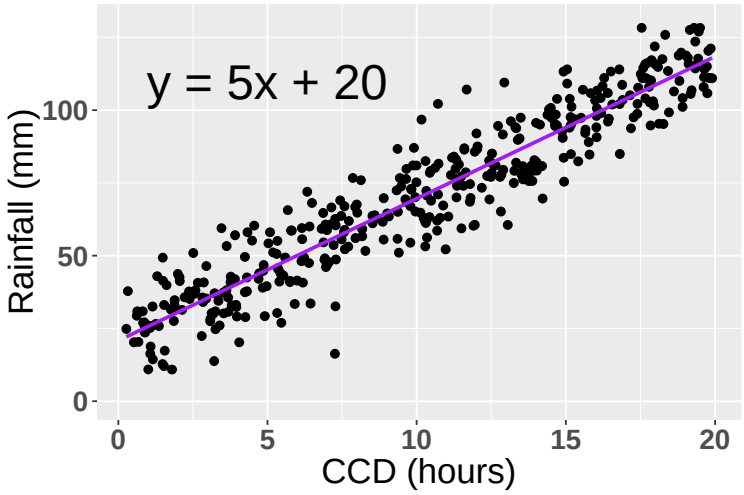
Sample	x = CCD	y = Rain	$x_i * y_i$	x^2
1	1.3	27.5	36.2	1.7
2	2.1	40.9	85.3	4.3
3	6.3	71.7	449.0	39.2
4	6.1	72.7	441.3	36.9
5	0.8	13.9	11.2	0.7
6	7.1	75.7	534.1	49.7
7	7.4	89.0	661.0	55.2
8	0.4	16.4	7.0	0.2
9	7.6	95.6	730.1	58.3
10	3.7	45.1	169.1	14.1
11	0.5	15.9	7.6	0.2
n = 11	$\sum_{i=1}^{11} x_i$ =43.3	$\sum_{i=1}^{11} y_i$ =564.5	$\sum_{i=1}^{11} x_i y_i$ =24450.3	$\sum_{i=1}^{11} x_i^2$ =260.5
	$\bar{x}$ =3.9	$\bar{y}$ =51.3		

The derivation of these equations is beyond the scope of this resource (see further reading). Once we have the linear relationship, we can estimate how much rainfall that fall in a region without any rain gauges by only measuring the CCD. For example, we can see that if we measure the CCD to be 3 hours, we can expect there to be 3*10+15=45mm of rainfall and for each hour of CCD we expect there to rain 10mm more. In this way, we can get data without the need of a person going out everyday and reading of a rain gauge and recording the value in some register.

Resource Four Activities

Activities

1. Using the linear regression plot and equation below, how much rainfall do we expect if the measured CCD is 5?



2. Using the table below make your own scatter plot. Only using the first 10 measurements, calculate the optimal a and b for the linear model. Continue to fill in the table below and use your numbers in the equations in the resource. The first line is given as a start. What kind or trend do you find (increasing/decreasing)?

CCD (hours)	13	23	17	28	24	26	21	26
Rain (mm)	52.5	98.2	82.9	128.9	108.5	106.3	72.4	114.6
CCD (hours)	6	11	2	12	4	23	20	16
Rain (mm)	20.2	65.1	42.6	58.3	22.2	100.1	92.1	71.6
CCD (hours)	15	15	29	20	18	15	19	27
Rain (mm)	74.9	64	125.7	73.7	88.8	54	78.2	128.9

Resource Four Activities

Activities

Sample	x = CCD	y = Rain	$x_i * y_i$	x^2
1	13	52.5	682.5	169
2	23	98.2		
3	17	82.9		
4	28	128.9		
5	24	108.5		
6	26	106.3		
7	21	72.4		
8	26	114.6		
9	6	20.2		
10	11	65.1		
n=	$\sum_{i=1}^{10} x_i =$	$\sum_{i=1}^{10} y_i =$	$\sum_{i=1}^{10} x_i y_i =$	$\sum_{i=1}^{10} x_i^2 =$
	$\bar{x} =$	$\bar{y} =$		

Problem solving

3. Do you think we have a bigger or smaller grid size if we take satellite measurements over all of Africa compared to just one country? Why?
4. What issues do you think we get when using a very large grid size?
5. If there is a very large spread around our fitted linear regression line, is it still a good idea to use it? What could be a better way to describe it? Explain your answer.

Resource Four
Further Reading

Explore

- Explore the distribution of different measuring stations over UK. Find where your closest rain gauge is https://www.gaugemap.co.uk/#
- Play around with the maps in TAMSAT to see rainfall over Africa derived from 4km satellite data https://www.tamsat.org.uk/data/rfe/index.cgi
- Youtube videos about the proof of the linear regression equations. This video is the introduction and the following 4 is the actual proof https://www.youtube.com/watch?v=6OvhLPS7rj4&list=PLU5aQXLWR3_wuWOWMA-8aPLhp4p3sZdK2&index=9
- Read the paper listing different satellite products and a description how the calibration is done: Maidment, R. I., Grimes, D., Allan, R. P., Tarnavsky, E., Stringer, M., Hewison, T., Roebeling, R., and Black, E. (2014), The 30 year TAMSAT African Rainfall Climatology And Time series (TARCAT) data set, J. Geophys. Res. Atmos., 119, 10,619– 10,644 doi:10.1002/2014JD021927.

Resource Five Overview

Topic	It is cheap to be rich but expensive to be poor?
A-level Modules	Economic resources, Allocation of resources, Effects of poverty

Objectives

After completing this resource, you should be able to:

- ✓ Understand the economic situation for an African smallholder-farmer
- ✓ Understand the financial implications of choosing a cheap seed or an expensive high-quality seed
- ✓ Know what discretionary incomes means and how it affects your ability to take risks

Instructions

1. Read the data source
2. Complete the activities
3. Explore the further reading

Resource Five
Data Source

Section A

Is it cheap to be rich and expensive to be poor?

"It is cheap to be rich and expensive to be poor" can seem a bit counterintuitive but is in many cases true. The reason behind this is that you can usually choose the better of two options if you can afford it in the first place. It is usually cheaper to live in a house you own than one you rent, but it requires that you have the deposit and are able to get a mortgage to begin with. The issue of not being able to make the best choice and the fact that you need to choose between several things that you might need, is the reality for anyone with limited funds.

Price 12 month train ticket: £5468
Price per month: £455.6

Price 1 month train ticket: £525

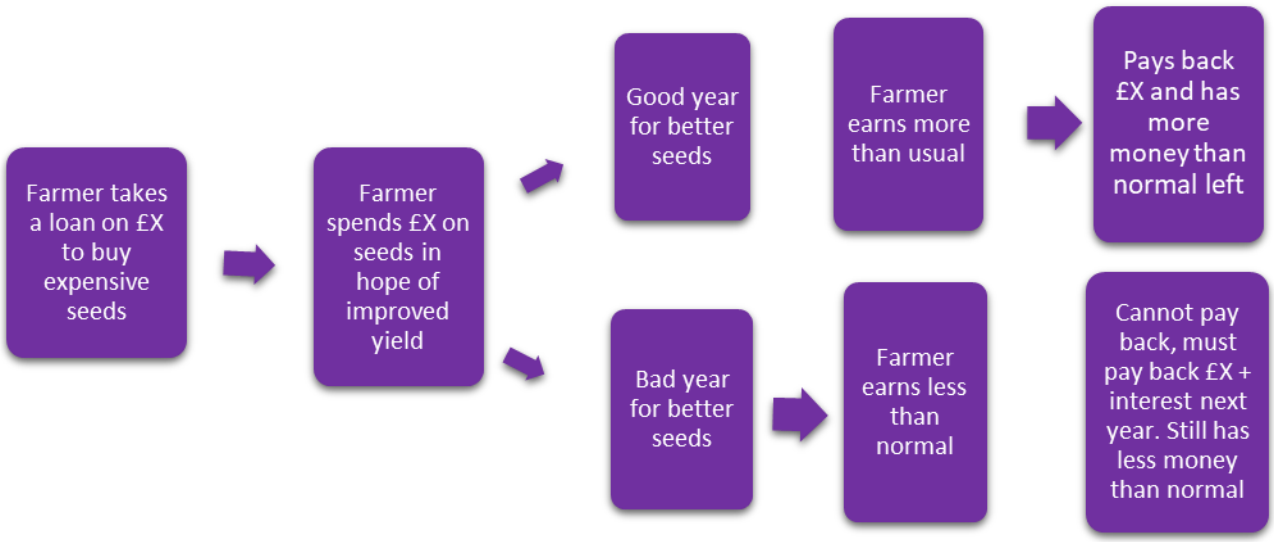
One group with really limited amounts of money are African smallholder farmers. A smallholder farmer is someone who has got enough land to feed his or her own family and make a little bit of money, but not much more than that. The size of this farm can vary a lot between countries but is usually somewhere between 0.7-2.2 hectares. The difference in size dependence on the general quality of the land, which determines how high yield it can produce, and the economic situation in the country. Because of this limited farming area, even a really good harvest year means that they will only make enough money to pay for one expensive thing, like improving the roof, buying some new equipment or sending a child to school. But it will not be enough to put away and save in case of a bad harvest year. If this sounds strange to you, keep in mind that 50% of all Brits between 20-29 have no savings at all and 15% of all adult Brits have no savings, even if we have a much better financial situation.

Active reading

To increase their income, farmers can choose to buy more expensive seeds that are of a higher quality. Higher quality can mean that the seeds give a higher yield or that they are

Resource Five
Data Source

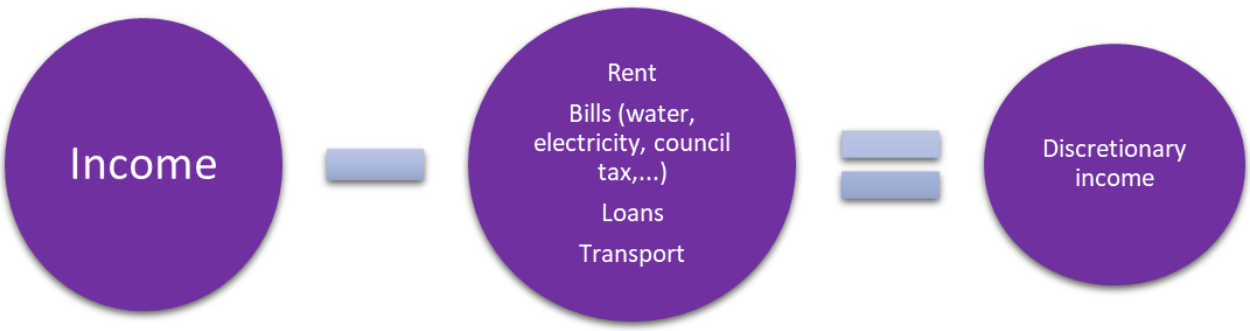
more resistant to drought or insects. But the price for these seeds are much higher than the normal seeds which means that they quite often need to take a loan from the seed company to buy them. The loan should then be payed off after the harvest. If for some reason the better seeds did not increase their income, if for example the seeds were better at resisting drought but it rained a lot, then they cannot pay back the loan and they could loose some of their land or get a huge fine. This is a similar situation to if you do not pay back your credit card on time, which will occur a large fine. Choosing which seed to use has the same risk-reward reasoning as when deciding what stocks to invest in. Either you pick a stock that can bring you a lot of money but there is also a high risk that you loose your money, or you pick a low risk stock that will never give you a large amount of money either.



The amount of money you have left after paying the essentials, such as food or rent, is called your discretionary income. Big discretionary income means that you can experiment and take risks but if you have small margins then there is not a lot you can do. With very small margins, you are usually quite limited to what changes you can make in your

Resource Five
Data Source

life. Researchers can tell farmers that it is going to be a dry year, but unless the farmers have money to pay for or access to irrigation, that information will be irrelevant because they are unable to make adjustments. The economic ability of a person or company is something that always must be considered when suggesting changes that will incur a cost.



Section B

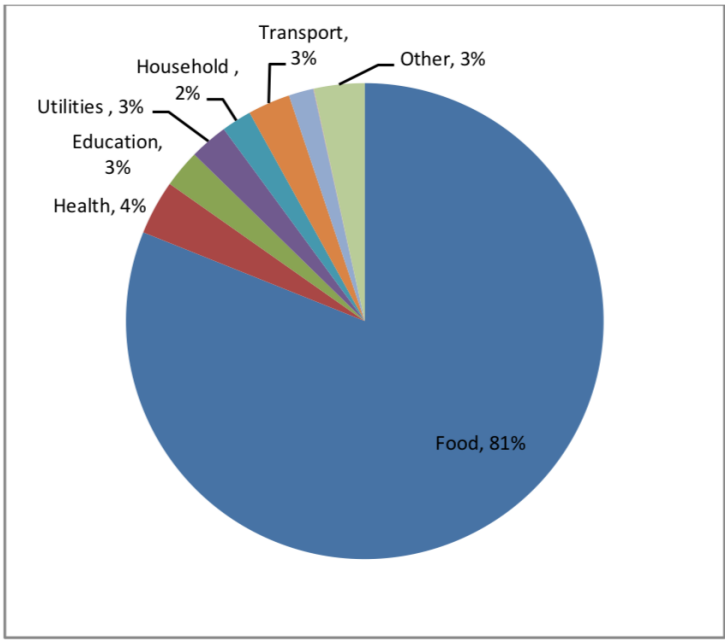
Case study

The biggest "capital" a small holder farmer has is the labour that family members can do. In Ethiopia, a family of more than 5 members will have on average 4 family members working at the farm and the rest seeking work outside the farm to diversify the income a bit. This is to reduce the risk of bankruptcy in case of a very low yield. Off-farm work often involves working at larger farms, fishing or construction. The production in an average small holder farm in Kenya will produce 58% maize, a crop that is sold very cheap but makes up a large portion of their food, 17% is beans and other crops make up the rest. Only about 20% of the food produced is sold, the rest is consumed by the family. One of the reasons for this is that many farmers live far away from a proper road which makes it very difficult to get to a market to sell their products. The income from the farm and off-farm work sums up to around $2'527USD, which with a family of 5 means $1.4 USD per day and person. In Ethiopia the average is instead $0.8USD per person. This need to cover the cost of food that they cannot produce, clothes, education and health services. How a small holder farmer in Tanzania spends their money is displayed in the circle diagram below.

Resource Five
Data Source

Figure 1

Source: Smallholder Farmers' DataPortrait



We can see that a huge majority, 81%, of the money is spent on food and only 3% on education. We can also see that the discretionary income, the section "other", only makes up 3%, so a tiny portion of their entire income. This is the portion of money that can be used to buy new equipment, clothes or other necessary things. Since the majority of their food comes from their own farm, in case of a bad production year, the food cost will be even higher. This means that they cannot spend any money on some of the other things, such as education and health.

Resource Five Activities

Activities

1) What proportion of UK adults do not have any savings?
2) Why is it easier to make cheap options if you are rich compared to if you are poor?
3) Come up with another example where it is cheaper if you have a lot of money and pay it all at once compared to if you need to spread out the cost.
4) Can you think of another example where there is a higher risk but more reward compared to the safe choice?
5) What could the seed companies do to reduce the financial risk of smallholder farmers without going bankrupt?
6) If you have access to Internet, look up how much an average UK family spends on rent (Household), food and utilities. Compare the numbers with the ones found in the circle diagram.

Resource Five
Further Reading

Explore

- Article from the UN about farmers economy: http://www.fao.org/3/a-i5251e.pdf

Resource Six Overview

Topic: Why would I give you money so you can give it to me?

GCSE Modules: Understanding that businesses operate within an external environment, Consumer behaviour

Objectives: After completing this resource, you should be able to:

- ✓ Know what an insurance is and what the common features of them are.
- ✓ Understand how an insurance needs to be constructed for it to be profitable for the company and attractive to buy.
- ✓ Understand how satellite weather data is used in insurance schemes for African farmers.

Instructions:

1. Read the data source
2. Complete the activities
3. Explore the further reading

Resource Six
Data Source

Section A

Insurance

Home, car and travel insurance. Most people in the UK hold multiple insurances to protect against financial loss in various situations, for example in case of a fire in your home or accidents when you are abroad. Even if the insurances protect you in different kind of situations, they are all constructed in a similar way. The basic principal behind an insurance is that many people pay in money to get protected against a future accident, but only a few people need to get money, a pay-out, because of an accident. For example, nearly everyone has a home insurance to protect against fire, water leaks and theft but only a small proportion of all households will experience any of these accidents. By having many people paying a small amount but only a few who need to use them, the people who use the insurance can get enough money to repair the house, even if they have payed in a much smaller amount than what it will cost.

This is the great thing about an insurance. A small investment protects you in very expensive situations, where you most likely would not be able to pay it yourself. This of course only works if only a few people need to use the money in the insurance scheme. If half of the people paying into the scheme also needed money from it, then they would only get twice the amount that they payed in and the purpose of an insurance would disappear. One other thing that most insurances have in common is the need to prove the loss that you want to get money for. If you get ill or injured when abroad then a medical certificate verifying this is needed and if something happens to your house, you will have to present pictures and other documents proving the damage.

Resource Six Data Source

Section B

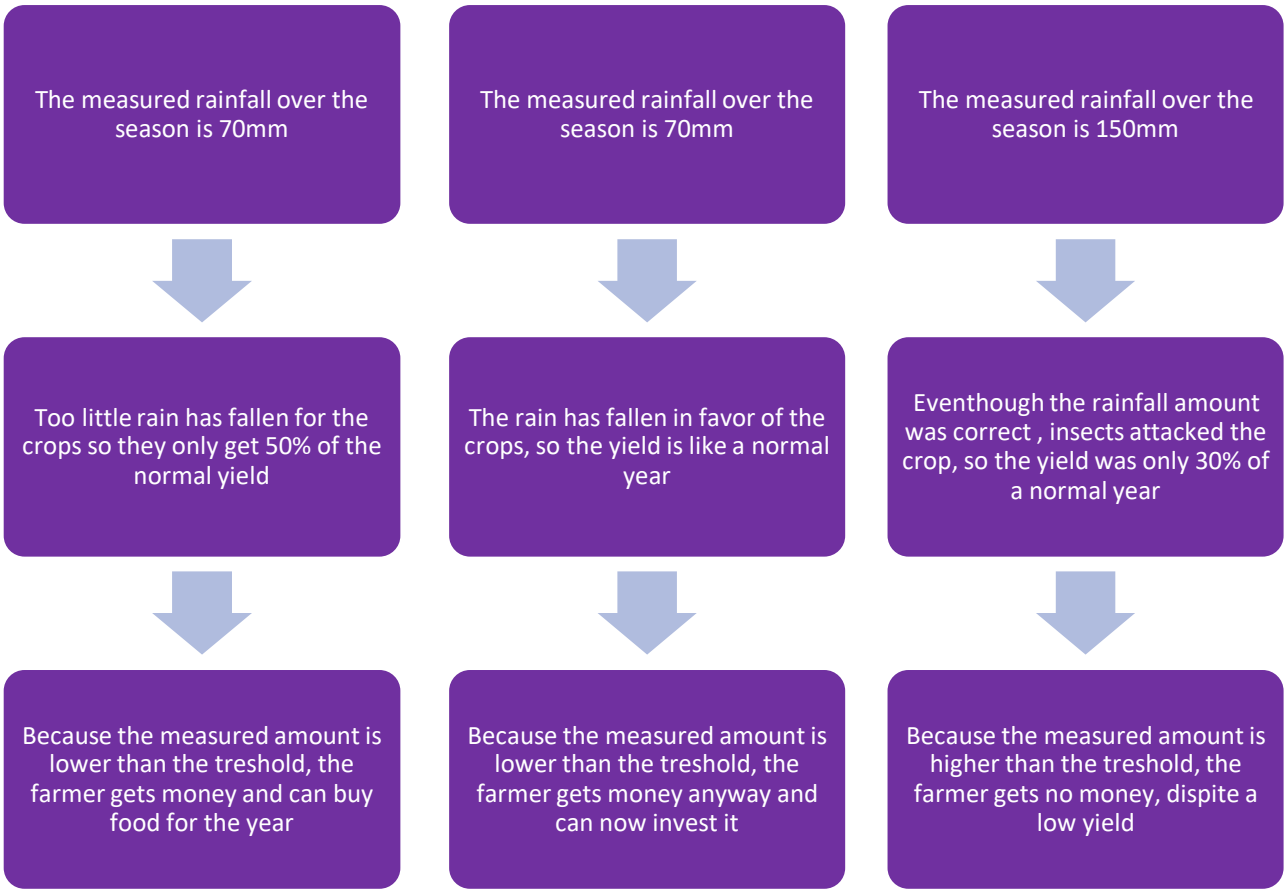
Insurance for an African farmer

For an African farmer, the most valuable and thereby the thing they want to insure, is their crops. Since all their food and money comes from the annual harvest, this determines their entire economy. But proving a loss of income due to a very bad crop year is difficult, since it would require someone from the insurance company to visit every single farmer and weigh their crops to determine if the harvest is much smaller than a normal year. This would be very expensive, which would lead to the insurance policy be so expensive that no one could afford it. The very small discretionary income also makes these farmers more sensitive to the cost of an insurance policy and simply will not buy it if they do not think it will give back more than it costs. That is why weather based insurance has been introduced. Instead of measuring how much crop that has been produced, the insurance companies measured how much rainfall has fallen during the growing season or how high the average temperature has been and from that calculates if the harvest should have been good or bad. If the seasonal rainfall amount has been very low, the insurance scheme pays out, even if the harvest might have been good anyway. The opposite can of course also happen. To estimate how much rain has fallen in a region in a cheap way, and because there are very few rain gauges in most African countries, satellite data is used to determine the rainfall. It is therefore very important that the rainfall estimate models are accurate, so correct rainfall amounts are estimated from the satellite pictures.

Active reading

For a certain crop and country, 100mm of rain is determined to be the minimum amount to generate a normal yield. Below are some different scenarios that can happen with a weather insurance that only uses rain as an index

Resource Six
Data Source



Another important aspect when designing an insurance scheme, is to set the correct levels for when the insurance pays out. If the insurance company sets very high levels to make a pay out, then farmers might not find it worth the money and leave the insurance company. If they instead set a too low level and pay out money often, then the insurance company will go bankrupt. In case of weather insurance, there is the additional problem that if one farmer is affected by drought, then most likely all farmers in that region will be affect and should get a pay-out. If a company sells home insurance, then it is quite unlikely that a majority of the houses will be flooded or catch fire at the same time, which spreads out the cost. There is therefore something called a Reinsurance company, which is an insurance company that insures other insurance companies in case a high proportion of their clients need a pay-out at the same time.

Resource Six
Data Source

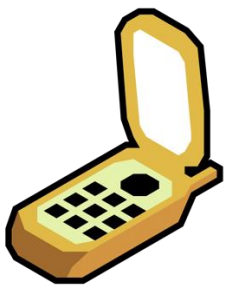
Section C

Case study

One of the larger insurance schemes is the "Agriculture and Climate Risk Enterprise" (ACRE) that runs over East Africa and now insures over 1.7m farmers in Kenya, Tanzania and Rwanda. One of the things that makes this scheme so successful is the use of sending money between mobile phones, which means that pay-outs can quickly be made without someone having to visit each farmer to deliver the money. They offer different products depending on the size of the farm. For smallholder farmers, the insurance meant that they could invest in a new type of seed and fertiliser for a minimum value of $100USD. Without the insurance, most farmers would not have dared to take the risk with such a big investment. For larger farms (>20 acres), the insurance company teamed up with the seed company. Each acre is insured for about $650USD, which is a lot more money than most farmers have. The seed company payed for the insurance policy at the start of the season, and the farmers payed it back after the harvest. A third method was to include the insurance cost with the bag of seeds for smallholder farmers and if there was not enough rain during the initial growing period, a pay-out was made to cover the cost of buying new seeds to not lose that year's harvest.

Farmer buys an insurance so they can take the risk of buying more expensive, but better seeds.

In case the satellites estimate that too little rainfall has fallen, the farmer gets a pay-out so the farmer won't be put in debt.



The farmer gets the money instantly because it is sent to their mobile.

Resource Six
Data Source

Some of the observed positive effects of providing insurance to poor farmers are:

- Fast payouts means that farmers do not have to sell of land or tools, which would reduce their harvest the following year.
- Farmers with insurance are more likely to make investments that will lead to higher yield in the future.
- By helping the community to recover quickly from a bad year, the circle of increased poverty after a bad year is broken.

Resource Six Activities

Activities

1) Why is it good to have an insurance?
2) Detail one accident that each of the three UK insurances mentioned in the text can cover.
3) Your home insurance covers the loss of items in your home as well as the home itself. How might you prove the loss of items in the accident of for example theft?
4) Weather based insurance usually only covers the risk of drought. What other accidents/risks can there be for a farmer where the insurance will not pay out? Try and list at least 3.
5) What will happen to the insurance company if our model estimating rainfall from satellite data constantly estimates more rain that what is actually measured? What happens in the opposite case, i.e the model estimates less rain than the true value?

Resource Six
Further Reading

Explore

- Paper describing weather insurance in different countries: Greatrex H, Hansen J, Garvin S, Diro R, Blakeley S, Le Guen M, Rao K, Osgood D. 2015. Scaling up index insurance for smallholder farmers: Recent evidence and insights. CCAFS Report No. 14. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).
- Ask your parents about what insurances you have and look up what they cover and not. If there is something you think it should cover but does not, think about why that might be.
- Paper discussing the price farmers are willing to pay for an insurance scheme: Fonta, W.M., Sanfo, S., Kedir, A.M. et al. Agric Econ (2018) 6: 11. https://doi.org/10.1186/s40100-018-0104-6

Final Reflection

Deep Dive

You have decided to open a chocolate factory in Ghana, a country you know very little about. You managed to get hold of 5 years of daily rainfall data which you want to use to determine the crop cycle. You want to do a data analysis of the data to understand the distribution of the rainfall. Think about good ways to split the data to find this information.

The time series is very short, think about how this might affect your conclusions about the rainfall distribution (example if those 5 years were unusually dry or very long rainy season etc...).

With the limitations described about weather based insurance, what different situations would you like to be protected against? How would you prove your losses to the insurance company for the difference scenarios that you want to be protected against? Are these things likely to make the insurance policy too expensive for anyone to want to buy it?

Present your work in a report. A good way to structure your report and work could be:

• A short description of the problem (just a reformulation of the problem given above)

• Data analysis on an annual scale (e.g amount, number of rainy days, number of days of very heavy rainfall...)

• Data analysis on a monthly scale (e.g same as above or other things you can think about)

• Write a section about what kind of bias you might have due to the very short sample and only from 3 stations.

• Write about what other types of data you would like access to, to make a well researched decision about your crops.

• If you could design your own insurance policy, what would you like to include in it? How would you prove these types of damages?

• With the policy you have designed, discuss if each individual bit is likely to make the insurance much more expensive. Think about how common that problem is (common as often or that it affects many people at the same time) and how expensive it will be to replace what you have lost (e.g it is more expensive to give a pay out if the accident leads to your entire crop being lost compared to getting a lower than normal yield).

• Write a summary of your work, highlighting interesting things from your data analysis, potential sampling biases and what your insurance policy will cover.

Part 3 – Study Skills, Tips & Guidance

This section includes helpful tips to help you complete this pack, as well as improve your study skills for any courses you take next year.

It also includes a few fantastic easy-to-use resources to know what to do next if you are hoping to go to university in the next few years, like UCAS advice and web links to more academic opportunities.

In this section:

University Study Skills:

- ✓ Cornell Notes
- ✓ Key Instruction Words
- ✓ Academic Writing
- ✓ Referencing
- ✓ Evaluating Your Sources

University Guidance:

- ✓ What next?

Subject Guidance:

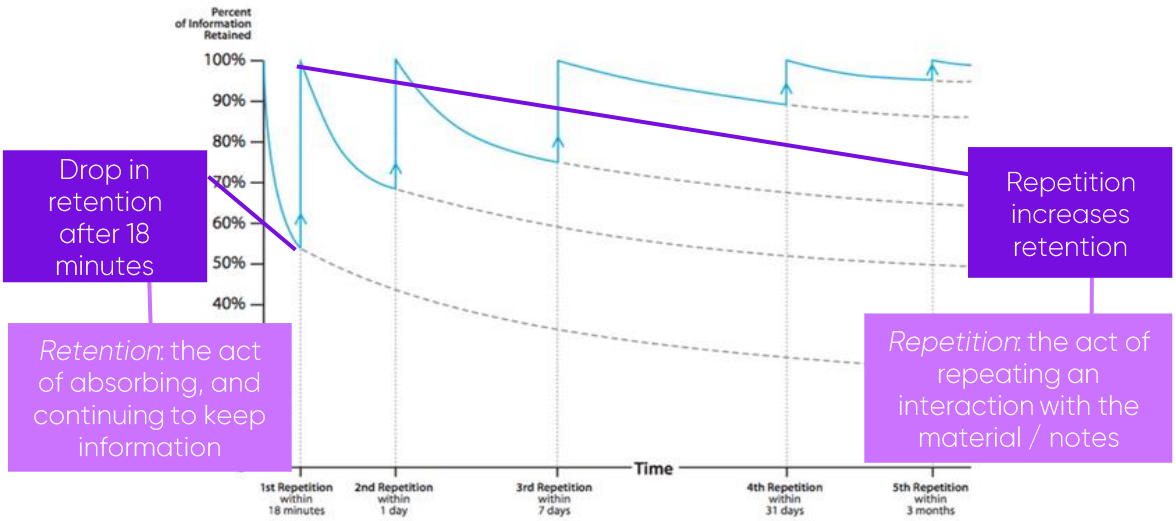
- ✓ More on studying your subject

University Study Skills
Cornell Notes

Why is good note taking important?

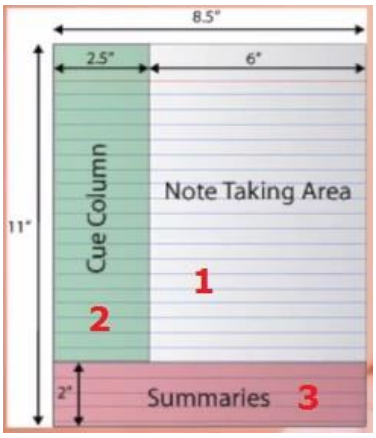
If it feels like you forget new information almost as quickly as you hear it, even if you write it down, that's because we tend to lose almost 40% of new information within the first 24 hours of first reading or hearing it.

If we take notes effectively, however, we can retain and retrieve almost 100% of the information we receive. Consider this graph on the rate of forgetting with study/repetition:



Learning a new system

The Cornell Note System was developed in the 1950s at the University of Cornell in the USA. The system includes interacting with your notes and is suitable for all subjects. There are three steps to the Cornell Note System.



Step 1: Note-Taking

1. Create Format: Notes are set up in the Cornell Way. This means creating 3 boxes like the ones on the left. You should put your name, date, and topic at the top of the page.

2. Write and Organise: You then take your notes in the 'note taking' area on the right side of the page. You should organise these notes by keeping a line or a space between 'chunks' /main ideas of information. You can also use bullet points for lists of information to help organise your notes.

University Study Skills
Cornell Notes

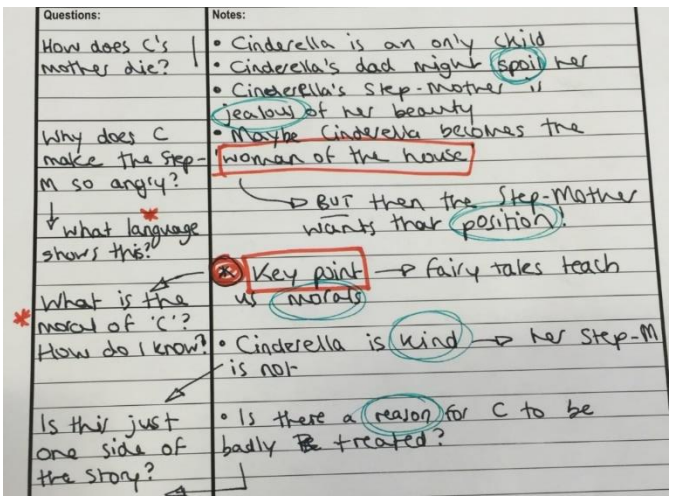
Step 2 Note-Making

1. Revise and Edit Notes: Go back to box 1, the note taking area and spend some time revising and editing. You can do this by: highlighting 'chunks' of information with a number or a colour; circling all key words in a different colour; highlighting main ideas; adding new information in another colour

2. Note Key Idea: Go to box 2 on the left hand side of the page and develop some questions about the main ideas in your notes. The questions should be 'high level'. This means they should encourage you to think deeper about the ideas. Example 'high level' questions would be:

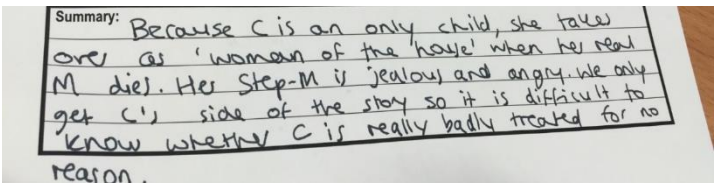
- Which is most important / significant reason for...
- To what extent...
- How does the (data / text / ideas) support the viewpoint?
- How do we know that...

Here is an example of step 1 and step 2 for notes on the story of Cinderella:



Step 3 Note-Interacting

1. Summary: Go to box 3 at the bottom of the page and summarise the main ideas in box 1 and answer the essential questions in box 2.



Give the Cornell Note Taking System a try and see if it works for you!

University Study Skills
Key Instruction Words

These words will often be used when university tutors set you essay questions - it is a good idea to carefully read instruction words before attempting to answer the question.

Analyse – When you analyse something you consider it carefully and in detail in order to understand and explain it. To analyse, identify the main parts or ideas of a subject and examine or interpret the connections between them.

Comment on – When you comment on a subject or the ideas in a subject, you say something that gives your opinion about it or an explanation for it.

Compare – To compare things means to point out the differences or similarities between them. A comparison essay would involve examining qualities/characteristics of a subject and emphasising the similarities and differences.

Contrast – When you contrast two subjects you show how they differ when compared with each other. A contrast essay should emphasise striking differences between two elements.

Compare and contrast – To write a compare and contrast essay you would examine the similarities and differences of two subjects.

Criticise – When you criticise you make judgments about a subject after thinking about it carefully and deeply. Express your judgement with respect to the correctness or merit of the factors under consideration. Give the results of your own analysis and discuss the limitations and contributions of the factors in question. Support your judgement with evidence.

Define – When you define something you show, describe, or state clearly what it is and what it is like, you can also say what its limits are. Do not include details but do include what distinguishes it from the other related things, sometimes by giving examples.

Describe – To describe in an essay requires you to give a detailed account of characteristics, properties or qualities of a subject.

Discuss – To discuss in an essay consider your subject from different points of view. Examine, analyse and present considerations for and against the problem or statement.

University Study Skills
Key Instruction Words

Con't

Evaluate – When you evaluate in an essay, decide on your subject's significance, value, or quality after carefully studying its good and bad features. Use authoritative (e.g. from established authors or theorists in the field) and, to some extent, personal appraisal of both contributions and limitations of the subject. Similar to **assess**.

Illustrate – If asked to illustrate in an essay, explain the points that you are making clearly by using examples, diagrams, statistics etc.

Interpret – In an essay that requires you to interpret, you should translate, solve, give examples, or comment upon the subject and evaluate it in terms of your judgement or reaction. Basically, give an explanation of what your subject means. Similar to **explain**.

Justify – When asked to justify a statement in an essay you should provide the reasons and grounds for the conclusions you draw from the statement. Present your evidence in a form that will convince your reader.

Outline – Outlining requires that you explain ideas, plans, or theories in a general way, without giving all the details. Organise and systematically describe the main points or general principles. Use essential supplementary material, but omit minor details.

Prove – When proving a statement, experiment or theory in an essay, you must confirm or verify it. You are expected to evaluate the material and present experimental evidence and/or logical argument.

Relate – To relate two things, you should state or claim the connection or link between them. Show the relationship by emphasising these connections and associations.

Review – When you review, critically examine, analyse and comment on the major points of a subject in an organised manner

University Study Skills
Academic Writing

What is academic writing?

'Academic writing' is a specific way of writing when communicating research or discussing an argument/point of view. It has a logical structure, and it uses formal language. There is a particular tone, 'voice' and style to the language. Unlike creative or narrative writing, academic writing will also use different sources of information to support what is being said.

The language of academic writing: do's and don'ts

- Do use words you know the meaning of and are confident using, it doesn't have to be complicated to be clear!
- Do not use contractions; don't, can't, doesn't, it'd. Do write out fully; do not, cannot, does not, it would.
- Do not use colloquialisms- this is 'writing as you speak'. Examples include misuse of the words 'literally' or 'basically', common phrases, such 'like chalk and cheese'.
- Do not use slang or jargon. For example, 'awks', 'lit', 'woke'.

Expressing your opinion in academic writing

In academic writing, it is best practice to express an opinion without writing in the first person, which can often be challenging. Always bear in mind that your work should read like a voice that is guided by the evidence and not basic personal intuition.

Therefore, rather than saying 'In my opinion, this proves that', you can express the outcome of your reasoning in other ways:

- 'This indicates that…';
- 'The aforementioned problems in Smith's argument reveal that…';
- 'Such weaknesses ultimately mean that…', and so on.

Signposting

Signposting guides your reader through different sections of your writing. It lets those who read your writing know what is being discussed and why, and when your piece is shifting from one part to another. This is crucial to for clear communication with your audience.

Signposting stems for a paragraph which expands upon a previous idea	Signposting stems for a paragraph which offers a contrasting view
Building on from the idea that … (mention previous idea), this section illustrates that … (introduce your new idea).	However, another angle on this debate suggests that … (introduce your contrasting idea)
To further understand the role of …(your topic or your previous idea) this section explores the idea that … (introduce your new idea)	In contrast to evidence which presents the view that … (mention your previous idea) an alternative perspective illustrates that …
Another line of thought on … (your topic or your previous idea) demonstrates that …	However, not all research shows that … (mention your previous idea). Some evidence agrees that …

University Study Skills
Referencing

What is a reference or referencing?

A reference is just a note in your assignment that tells your reader where particular ideas, information or opinions that you have used from another source has come from. It can be done through 'citations' or a 'bibliography'.

When you get to university, you will need to include references in the assignments that you write. As well as being academic good practice, referencing is very important, because it will help you to avoid plagiarism.

Plagiarism is when you take someone else's work or ideas and pass them off as your own. **Whether plagiarism is deliberate or accidental, the consequences can be severe.** You must be careful to reference your sources correctly.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should I use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

University Study Skills
Referencing

Is it a source worth citing?

Question your sources before referencing using these tips:

Currency: the timelines of the information

- When was it published or posted? Has it been revised or updated? Does your topic require current information, or will older sources work as well?

Relevancy: the importance of the information for your needs

- Does the information relate to your topic or answer your question? Who is the intended audience? Have you looked at a variety of sources?

Authority: the source of the information

- Who is the author/publisher/source/sponsor? What are the author's credentials? Is the author qualified to write on the topic?

Accuracy: the reliability and correctness of the source

- Is the information supported by evidence? Has the information been reviewed or refereed? Can you verify whether it is a personal or professional source? Are there errors?

Purpose: the reason the information exists

- Does the author make the intensions/ purpose clear? Is the information fact opinion or propaganda? Are there are biases? Does the viewpoint appear objective?

University Study Skills
Referencing

How do I reference?

- There are a number of different ways of referencing, but most universities use what is called the Harvard Referencing Style. Speak with your tutor about which style they want you to use, because the most important thing is you remain consistent!

- The two main aspects of referencing you need to be aware of are:

1. In-text citations

- These are used when directly quoting a source. They are located in the body of the work, after you have referred to your source in your writing. They contain the surname of the author of the source and the year it was published in brackets.
    - E.g. *Daisy describes her hopes for her infant daughter, stating "I hope she'll be a fool—that's the best thing a girl can be in this world, a beautiful little fool."* ***(Fitzgerald, 2004)****.*

2. Bibliography

- This is a list of all the sources you have referenced in your assignment. In the bibliography, you list your references by the numbers you have used and include as much information as you have about the reference. The list below gives what should be included for different sources.

- Websites – Author (if possible), *title of the web page*, 'Available at:' website address, [Accessed: date you accessed it].
    - E.g. *'How did so many soldiers survive the trenches?'*, Available at: http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [Accessed: 11 July 2019].

- Books – Author surname, author first initial, (year published), *title of book*, publisher
    - E.g. Dubner S. and Levitt, S., (2007) *Freakonomics: A Rogue Economist Explores the Hidden Side of Everything,* Penguin Books

- Articles – Author, *'title of the article'*, where the article comes from (newspaper, journal etc.), date of the article.
    - E.g. Maev Kennedy, *'The lights to go out across the UK to mark First World War's centenary'*, The Guardian Newspaper, 10 July 2014.

University Study Skills
Evaluating your sources

Knowing about the different types of sources and what makes them worth using is important for academic work.

When doing research you will come across a lot of information from different types of sources. How do you decide which source to use? From newspaper articles to books to tweets, this provides a brief description of each type of source, and breaks down the factors to consider when selecting a source.

A platform for millions of very short messages on a variety of topics.

Blogs (e.g. Tumbler) are an avenue for sharing both developed and unpublished ideas and interests with a niche community.

A collection of millions of educational, inspirational, eye-opening and entertaining videos.

A reporting and recording of cultural and political happenings that keeps the general public informed. Opinions and public commentaries can also be included.

A collection of analytics reports that outline the objectives, background, methods, results and limitations of new research written for and by scholars in a niche field.

The information presented is supported by clearly identified sources. Sometimes each chapter has a different author.

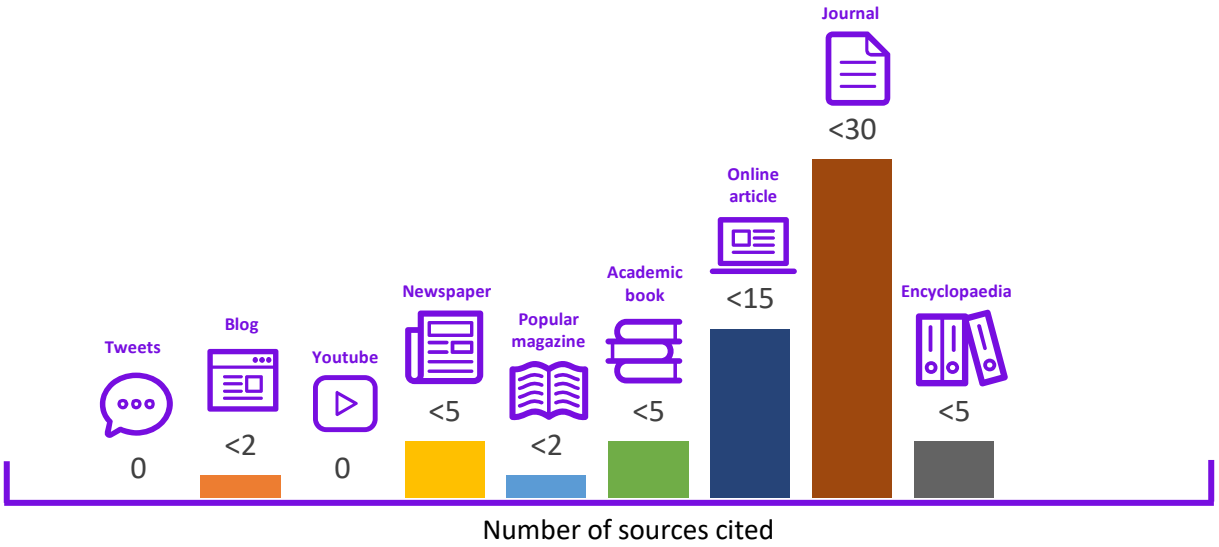
Books or online – giving information on many different subjects. Some are intended as an entry point into research, some provide detailed information and onwards references.

A glossy compilation of stories with unique themes intended for specific interests.

University Study Skills
Evaluating your sources

Number of outside sources

When an author used many outside sources into their writing, they demonstrate familiarity with ideas beyond their own. As more unique viewpoints are pulled into a source, it becomes more comprehensive and reliable. This shows the typical number of outside sources used in each publication.



Degree of review before a source is published

Two factors contribute to the amount of inspection that a source receives before it might be published: the number of reviewers fact-checking the written ideas, and the total time spent by reviewers as they fact-check. The more people involved in the review process and the longer the review process takes, the more credible the source is likely to be.

Number of reviewers	0 reviewers		
Time in review	seconds	minutes	minutes
	1-2 reviewers		
	hours	days	days
	3-4 reviewers		
	2-3 months	6-2 months	3-5 years

University Guidance
What next?

University Guidance

Different people go to university for different reasons. You might have a particular job in mind or just want to study a subject you are passionate about. Whatever your motivations, going to university can help improve your career prospects, as well as develop your confidence, independence and academic skills.

Choosing a course and university

Choosing the right course to study is an important decision so make sure you take time to research the different options available to you. Here are some top tips:

- ✓ You don't have to choose a course which you have already studied, there are lots of courses which don't require prior knowledge of the subject. You can apply skills gained from school studies to a new field.
- ✓ The same subject can be taught very differently depending on the course and university you choose. Take a look at university websites to find out more about the course content, teaching styles and assessment types.
- ✓ When choosing a university, think about what other factors are important to you. Do you want to study at a campus university or be based in a city centre? What accommodation options are there? Does the university have facilities for any extracurricular activities you're involved in?
- ✓ To research your options, have a look at university prospectuses and websites, as well as seeing if there are opportunities to speak to current students who can give you a real insight in to what life is like there.

Insight into: University of Reading

The author of this coursebook attends the University of Reading.

The University of Reading runs a large number of sessions to help find out more about the process of applying to university as well as taster sessions and Open Online Courses in a number of different subjects. To find out more, visit: www.reading.ac.uk/virtual-events.

Chat to current University of Reading students via Unibuddy and get their views on what university life is like!

University Guidance
What next?

Exploring Careers and Subject Options

- ✓ Find job descriptions, salaries and hours, routes into different careers, and more at https://www.startprofile.com/
- ✓ Research career and study choices, and see videos of those who have pursued various routes at http://www.careerpilot.org.uk/
- ✓ See videos about what it's like to work in different jobs and for different organisations at https://www.careersbox.co.uk/
- ✓ Find out what different degrees could lead to, how to choose the right course for you, and how to apply for courses and student finance at https://www.prospects.ac.uk/
- ✓ Explore job descriptions and career options, and contact careers advisers at https://nationalcareersservice.direct.gov.uk/
- ✓ Discover which subjects and qualifications (not just A levels) lead to different degrees, and what careers these degrees can lead to, at http://www.russellgroup.ac.uk/media/5457/informed-choices-2016.pdf

Comparing Universities

Use our platform ThinkUni.org to take a short quiz about your preferences and interests to find out which universities might be a great fit for you.

Other popular resources:

- ✓ https://www.ucas.com/
- ✓ https://www.whatuni.com/
- ✓ http://unistats.direct.gov.uk/
- ✓ https://www.thecompleteuniversityguide.co.uk/
- ✓ https://www.opendays.com/

University Guidance
What next?

UCAS and the university application process

All applications for UK degree programmes are made through UCAS. There is lots of information on the UCAS website to guide you through the process and what you need to do at each stage.

Apply

- Applications **open in September** the year before you plan to start university.
- You can apply for up to **five courses.**
- The deadline for most courses is **15 January**, though there is an earlier deadline of **15 October** for Oxford and Cambridge, medicine, veterinary medicine/science and dentistry.

Decisions

- Some courses may require an interview, portfolio or admissions test in addition to UCAS application. Check individual university websites details.
- Check UCAS Track which will be updated with decisions from the universities you have applied for and to see your deadline for replying to any offers.
- You should choose a firm (or first) choice university and an insurance choice. If you already have your exam results or a university thinks your application is particularly strong, you might receive an **unconditional offer**.

Results

- If you're holding a conditional offer then you will need to wait until you receive your exam results to have your place confirmed.
- Clearing & Adjustment allows you to apply to courses which still have vacancies if you didn't meet the conditions of your offer, have changed your mind about what or where you want to study, or have met and exceeded the conditions of your offer and would like to look at alternate options.

Personal statements

A really important part of your application is the personal statement. The personal statement gives you the opportunity to tell universities why they should offer you a place.

Here a few top tips for making your personal statement stand out:

- You can only submit one personal statement so it's important that you are consistent in your course choices. Make sure you have done your research to show your understanding of the subject area and passion for it.
- Start by brainstorming all your skills, experience and attributes. Once you have everything written down, you can begin to be selective – you only have 47 lines so won't be able to include everything.
- The ABC method: action, benefit and course can be a useful way to help demonstrate your relevant experience and how it applies to the course you're applying for.

University Guidance
What next?

Personal Statement do's and don'ts

Read the tips below from real life professors and admissions staff in university Biology and Psychology departments, on the 'do's' and 'don'ts' of what to include in your personal statement:

Maths

- Passion for Mathematics – why you love it, what aspects do you enjoy and what motivates you to pursue Maths at University. Can you demonstrate this through your academic studies or extra-curricular activities?
- Which areas of Mathematics are you most interested in?
- Demonstrate skills such as problem solving , clear writing and attention to detail
- What aspects of studying mathematics at university are you looking forward to?
- Have you read any books about mathematics beyond those you use at school?

Business Studies

- Why have you chosen to study Business – what has inspired you?
- Have you studied Business at school or has work experience encouraged you to explore this area?
- Be specific about the areas that interest you. Is there anything you've recently read that motivates you to learn more?
- How have you developed your understanding of Business – through work experience, current affairs, professional journals. What have you learnt and what skills have you developed?
- What are your future plans and how do they link to your chosen area for undergraduate study?

Further useful resources

Be sure you know what you'll need to do to apply to university in the UK:

- ✓ Key dates and deadlines: www.access-ed.ngo/timelines-for-applying-to-university
- ✓ Get tutor advice on writing a UCAS personal statement at www.access-ed.ngo/writing-your-ucas-personal-statement
- ✓ An easy template to start practising your personal statement: https://www.ucas.com/sites/default/files/ucas-personal-statement-worksheet.pdf
- ✓ Untangle UCAS terminology at https://www.ucas.com/corporate/about-us/who-we-are/ucas-terms-explained
- ✓ Discover more about the application process including when to apply and how to fill in your application on the UCAS website.
- ✓ Read more useful advice about what to include in your personal statement on UCAS, the Complete University Guide and The Student Room.
- ✓ Attend one of our virtual sessions to find out more about applying and personal statements.

Subject Guidance

Maths at University

- ✓ Mathematical Sciences are the study of number, quantity, and space, either as abstract ideas (pure maths) or as applied concepts (statistics or mechanics).
- ✓ You will use technology to apply mathematical techniques, and develop your analysis skills to find solutions.
- ✓ You can find out more about different courses and entry requirements by exploring the UCAS Mathematical Sciences Guide online: https://www.ucas.com/ucas/subject-guide-list/mathematical-sciences/
- ✓ You can find out more about the different careers by exploring the UCAS Maths Careers online: https://www.ucas.com/job-subjects/maths

A Deeper Look Into Maths and Meteorology

- ✓ **Read:** The paper listing different satellite products and a description how the calibration is done Maidment, R. I., Grimes, D., Allan, R. P., Tarnavsky, E., Stringer, M., Hewison, T., Roebeling, R., and Black, E. (2014), The 30 year TAMSAT African Rainfall Climatology And Time series (TARCAT) data set, J. Geophys. Res. Atmos., 119, 10,619– 10,644 doi:10.1002/2014JD021927.
- ✓ **Watch:** Watch the 10min TED talk about weather insurance. https://youtu.be/RPjqPHCMJHU
- ✓ **Listen**: To the podcast "Linear digression" which is available on all platforms. 20 min episodes where they talk about different data science/analysis projects each time.
- ✓ **Do:** Put up a bucket somewhere outside and read of the rain amount around the same time very day for 3 months (or longer if you like). Analyse your data and compare your results with the Met Office estimates for your location.

www.researchbasedcurricula.com

ACCESS ED

www.access-ed.ngo

@_AccessEd

hello@access-ed.ngo

100 Black Prince Road
London, SE1 7SJ

AccessEd is a non-profit company registered in England (#10383890)