Czech University of Life Sciences Prague

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Bachelor Thesis

Climate Change’s Impact on Developing/Emerging Economies – A case study of Ethiopia

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BACHELOR THESIS ASSIGNMENT

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Economics and Management

Thesis title

Climate Change's Impact on Developing/Emerging Economies – Case study of Ethiopia

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Objectives of thesis

The aim of this thesis is to evaluate how certain climate change factors effect the economy of Ethiopia and also identify specific methods Ethiopia can employ to decrease the negative effects of climate change on its economy in the future.

Methodology

The theoretical part will provide a description of the current state of the Ethiopian economy in regards to climate change using secondary data. The practical part will be made up of data analysis methods and their interpretation.

The proposed extent of the thesis

30-40 pages

Keywords

Ethiopia, renewable energy, economy, climate change, fossil fuels, developing country

Recommended information sources

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Declaration

I declare that I have worked on my bachelor thesis titled " Climate Change’s Impact on Developing/Emerging Economies – A case study of Ethiopia" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 15th March 2023

Catalina Balan

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Climate Change's Impact on Developing/Emerging Economies – A case study of Ethiopia.

Abstract

This bachelor thesis focuses on how climate change affects the economy of developing countries, specifically the country selected for this work—Ethiopia. Climate change is an existing threat to our entire planet; it is not just an issue of the climate changing, but of everything around us changing. One slight change can lead to another change exasperating the issue and creating complications for the government and the people. When we think of what nations are doing to combat climate change, we picture the developed wealthy nations that tend to give special attention to this issue, however, developing countries are affected as well, most of the time with greater consequences.
In-depth research has been done on existing literature regarding climate change and developing countries, as well as on the impacts climate change factors have on these countries, with a specific emphasis placed on the economical and practical issues of Ethiopia that result from climate change.

In the practical part of the thesis, a statistical analysis has been done on chosen climate change factors to see if they somehow affect the GDP of Ethiopia. More specifically, the analysis looks at the share that agriculture has in the Ethiopian GDP. A correlation analysis examining both factors shows the exact relationship the variables have on the share of agriculture in GDP. The two mentioned climate change factors are Annual mean temperature and annual precipitation in Ethiopia. Through the use of the correlation analysis, it was found that there is no relationship between annual mean temperature and the share of agriculture in GDP, however, it was also discovered that there is a strong relationship between annual precipitation and the share of agriculture in GDP.

Keywords: Ethiopia, renewable energy, economy, climate change, fossil fuels, developing country

Vliv změny klimatu na rozvojové/rozvíjející se ekonomiky – případová studie Etiopie

Abstrakt

Tato bakalářská práce je zaměřena na to, jak změny klimatu ovlivňují ekonomiku rozvojových zemí, konkrétně země vybraná pro tuto práci – Etiopie. Změny klimatu jsou velkou hrozbou pro celou naši planetu, není to jen problém změny klimatu, ale změny všeho kolem nás. Jedna malá změna může vést k další, dokud se problém nezvětší a stane se záležitostí vlády a lidí. Když přemýšlíme o změnách klimatu, často myslíme na rozvinuté bohaté národy, které mají tendenci věnovat zvláštní pozornost této otázce, ale jsou dotčené i rozvojové země, většinou s většími důsledky.
Pro tuto prací byl proveden hloubkový výzkum existující literatury týkající se změny klimatu, nejméně rozvinutých zemí, také dopadů, které mají faktory změny klimatu na nejméně rozvinuté země, konkrétně na Etiopii, a na celkovou její ekonomiku. Byl proveden výzkum i na problémy, kterým Etiopie v současnosti čelí kvůli změně klimatu.

V praktické části práce byla provedena statistická analýza vybraných faktorů změny klimatu, zda nějak ovlivňují podíl zemědělství na HDP Etiopie. Korelační analýza zkoumající oba faktory ukazuje přesný vztah mezi proměnnými na podílu zemědělství na HDP. Dva zmíněné faktory změny klimatu jsou průměrná roční teplota a roční srážky v Etiopii. Pomocí korelační analýzy bylo zjištěno, že neexistuje žádný vztah mezi průměrnou roční teplotou a podílem zemědělství na HDP,ale existuje silný vztah mezi ročními srážkami a podílem zemědělství na HDP.

Klíčová slova: Etiopie, obnovitelná energie, ekonomika, změna klimatu, fosilní paliva, rozvojová země

Table of content

Introduction

Climate change has been a hot topic in recent years, it is a subject that sometimes slips into our day-to-day conversations. Nowadays, on a hot day, people tend to blame global warming for it being too unbearable outside. The matter of climate change will eventually, in one way or another, affect every one of us as some changes can already be observed. Most developed nations have targets to reach lower emissions by a certain date in time. People recycle and are mindful of their shopping choices, children are taught in school what climate change is and the small changes they can make to help with the matter.

Developed countries are praised when they meet climate change-reducing goals, but people often forget to also look at the poorer developing countries that struggle with climate change due to their economies. Instead of focusing on economic growth, developing countries have started to also divert attention to climate change which in many cases affects them more greatly than developed countries. It is a known fact that most developing countries have an agriculture-driven economy where other industries are not as invested in and a large share of their population works in agriculture. For these kinds of countries, climate change could have a devastating effect. Extreme weather like drought or excessive rainfall can damage the overall production of agricultural goods in the country. People are then left with less food and fewer working opportunities, which in turn makes them earn less money, making the government also suffers as the GDP falls below what it previously was.

Ethiopia is a developing country and just like many other countries, it primarily focuses on agriculture. Ethiopia was chosen for this work because it can represent more countries that are in a similar situation concerning the economy and climate change. In recent years, the country has been trying to tackle the effects that are already visible due to climate change, while simultaneously also trying to grow its economy. The budget spent on climate change is an opportunity cost that could have been used in other places to help its economy. However, this is the reality we live in today and the sooner we try to do something about it, the lesser the negative effects might be in the future.

Objectives and Methodology

1.1 Objectives

This thesis aims to evaluate how certain climate change factors affect the economy of Ethiopia. The theoretical part serves as a way to get a deeper understanding of the matter of climate change and also to introduce the country of Ethiopia. The subject of this research is weather phenomena like temperature and precipitation in Ethiopia and one important economical measure, which is the GDP of Ethiopia. All three variables are going to be used in the practical part of the thesis using statistical analysis. This is going to help explain how climate change affects the economy of Ethiopia.

1.2 Methodology

The theoretical part provides a description of the current state of the Ethiopian economy and climate change using secondary data. The practical part is made up of data analysis methods and their interpretation. A quantitative approach was chosen for the practical part of this thesis, as it provides a general understanding of what is currently happening in Ethiopia concerning climate change. All data used for the analysis are secondary data obtained through document study. Data about the share of agriculture in GDP can be found on the website of the World Bank and data about annual mean temperature and annual precipitation on the climate change portal of the World Bank. The data was used to show if there is a relationship between the chosen climate change factors and the share of agriculture in the GDP of Ethiopia.

The concrete statistical methods that are used in the practical part are as follows:

- Analysis of variables
- Time series analysis
- Autocorrelation testing
- Regression analysis focusing on correlation analysis

Literature Review

1.3 Climate change

1.3.1 Introduction

During the 20th century, scientists started to become worried about climate change and its impacts on our planet. Since the industrial revolution, we had been releasing dangerous, often poisonous gasses into the atmosphere, polluting our water sources with deadly chemicals, and cutting down all our forests to sell wood. It took people a long time to realize, that all these actions will come back with grave consequences, which can already be observed today. Scientists now know that the climate is getting hotter, primarily due to an increased release of greenhouse gases and other activities (Nesbitt, 2020).

The climate on Earth has always gone through changes. Scientists have proof that ice ages occurred which were then followed by periods of a warmer climate. The problem the climate is facing now is that due to the rapid release of dangerous elements into our atmosphere, these changes are occurring over a short period and at a greater speed. The effects of global warming can be clearly seen in the cooler places of our planet, like the North Pole or Antarctica, and even on glaciers (Valníček, 2015). The soil in the north that has been known to always be frozen, called permafrost, is beginning to melt, which causes microbes that were previously frozen to release methane into our atmosphere. The issue with that is that permafrost covers an area of around 23 million square kilometres, and some areas are already releasing more carbon into the atmosphere than they are absorbing (Smith, 2022). Because of the ice in the cold regions melting, the sea levels are beginning to rise, which may cause countries situated at a lower sea level to be flooded or islands to completely disappear. A very worrying example is the Marshall Islands. The World Bank has predicted that this country, which is located in the Pacific Ocean, might lose its status as a nation in the near future due to sea levels rising, causing 40% of the buildings located in the capital city Majuro to be permanently flooded (Mcdonald, 2021). The flooding of the Marshall Islands is not only a problem f0r the inhabitants of the islands, but soon it could be a problem for all humankind. During the Cold War, the United States used the islands as an atomic testing program, and between the years 1946 and 1958, it detonated 67 nuclear bombs in this area. After the testing was done, the US cleaned everything up and built the Runit Dome which now holds over 86 000 tonnes of radioactive waste. The US has left the dome on the islands and renounced all responsibility over it. Now with sea levels rising, it is at risk of collapsing (Rust, 2019).

1.3.2 Climate change in the past

From history, scientists already know that the phenomenon of climate change and global warming is not a new effect on our planet. In the last 2 million years, over 50 ice ages took place. During the last million years, the temperatures were changing in a cycle where ice ages occurred for 100 thousand years (Martin Branis, 2009). Of course, continents looked nothing like how we know them now, for example, Antarctica was ice-free until about 35 million years ago. The important factor in the climate changing in Antarctica was the continents shifting, which caused it to be isolated from other lands. This allowed ocean currents to cut off Antarctica from the warming effects of the tropical currents. Another factor in the cooling of Antarctica was the decrease in atmospheric carbon dioxide produced by the rise of the Himalayan mountains, even the tilt of our planet had an impact on Antarctica, as it triggered the formation of the ice sheets (Benjamin Lieberman, 2022). By looking at the example of Antarctica, we can observe how some factors can have a really big impact on the climate of a region or on our overall planet.

1.3.2.1 The Milankovitch cycles

The factors that greatly affected the temperature on Earth can be explained by the Milankovitch cycles. Milutin Milankovitch (Milankovic, 1998) came up with a hypothesis about how the Earth’s position relative to the sun strongly influences long-term climate changes, like the start and end of an Ice Age. His theory includes changes in the Earth’s eccentricity, obliquity, and precession (Buis, 2020). The first of Milankovitch’s cycles is the shape of Earth’s orbit around the sun (Eccentricity) which deals with the fact that Earth has an elliptical orbit around the sun and not a perfect circular orbit. If we had a perfect circle orbit, that would mean the Earth would be at the same distance from the sun the whole year, but because of greater eccentricity, which makes the orbit elliptical, we get seasons that are different in length. If the eccentricity were to decrease, all 4 seasons would have the same number of days. As of now, the eccentricity of Earth is the least elliptic (Benjamin

Lieberman, 2022). The second cycle, known as Obliquity, is the angle of Earth's rotation axis. The axis is tilted when it travels around the Sun, and this causes us to have seasons. The current angle that Earth is tilted right now is 23.5 degrees, which is approximately in the middle of the range of values that the obliquity has had over the last million years. These values are between 22.1 degrees and 24.5 degrees (Benjamin Lieberman, 2022). Finally, the last cycle named the Wobble is about how when the Earth rotates, it wobbles slightly on its axis, which is caused by gravitational influences of the Sun and Moon. The wobble creates climate variations in a cycle that spans approximately 25 700 years (Buis, 2020).

These 3 cycles are important because around 2.7 million years ago, they interacted to create the glacial and interglacial cycles, the cycles of the Ice Ages. (Buis, 2020)

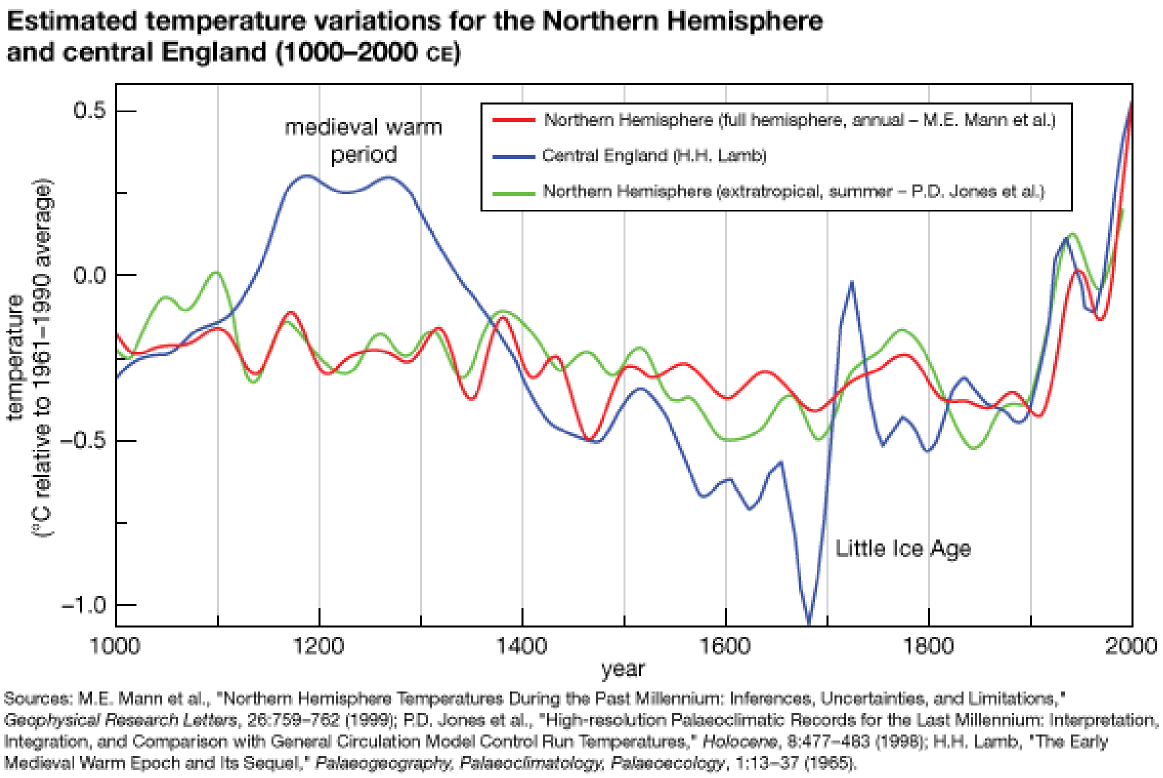


Table 1 Estimates of temperature variations for the Northern Hemisphere and central England from 1000 to 2000 Estimates of temperature variations for the Northern Hemisphere and central England from 1000 to 2000 ce source: https://www.britannica.com/science/m

By looking at the climate in the last 1000 years, it can be observed that during the Middle Ages, there was a period where the climate was hotter than usual. This period took place from approximately the 9th century until the 14th as can be seen in the graph above in Table 1. Warmer conditions were experienced all over the world, but mainly in the Northern Hemisphere, Europe, and Asia. Hubert Horace Lamb, a British climatologist, found that during this period, it was 1-2 degrees Celsius warmer than conditions in the early 20^{th} century (Rafferty, n.d.). The warmer weather might be the reason why the Vikings got to colonize the south coast of Greenland and why they could sail to the coast of North America (Martin Branis, 2009). Right after the medieval warm period came a colder period known as the Little Ice Age. This term is used for the colder period that occurred from the 16^{th} up until the 18^{th} century. During this time, the cold period was not constant, as can be seen on the graph above, but rather it jumped from cold to warm. The coldest period was in the years 1570 until 1730 and during the 19^{th} century (Martin Branis, 2009). The Ice Age was caused by mountain glaciers expanding in Europe, New Zealand, Alaska, and South America. The mean annual temperatures declined by 0.6 degrees Celsius across the Northern Hemisphere (Jackson, n.d.). This had disastrous effects on some countries, for example, in China in 1644 the Ming dynasty fell with one of the reasons for their fall being an erratic harvest. Rivers and harbours froze in Europe causing a disruption in harvest (Lanchester, 2019).

1.3.3 Climate change vs. Global warming

Firstly, there is a clear distinction between Climate change and Global warming that needs to be addressed, since many people use these two terms interchangeably, not knowing both have different meanings.

Climate change can be described as "*a long-term change in the average weather patterns that have come to define Earth's local, regional, and global climates"* (nasa.gov, Overview: Weather, Global Warming, and Climate Change, n.d.).
Whereas global warming is "*the long-term heating of Earth's climate system observed since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere"* (nasa.gov, Overview: Weather, Global Warming, and Climate Change, n.d.).

Climate change is connected to global warming. Due to the temperature rise caused by global warming, the climate is changing. Because the Earth is getting hotter, ice is melting, which in turn causes sea levels to rise or it also causes the weather to become more extreme (NOAA, 2021).

If we look at the previous year, there is clear evidence of global warming. In 2021, the average temperature across the global surface was recorded to be 0.84 degrees Celsius above the 20^{th} century average. This temperature was the sixth highest observed temperature from the year 1880 (NOAA, 2021).

For climate change, we can look at storms that occurred around the world in 2021. Last year had an above-average global tropical cyclone activity, there were a total of 94 identified storms. On the other hand, hurricanes were recorded to be lower than average with only 37 hurricane-strength tropical cyclones which is the lowest number of hurricanes on record (NOAA, 2021).

In Table 2 below, a clear example of global warming can be seen. The graph shows the annual mean temperature, from the first recorded data in 1880 to the last complete year 2020, with half of 2022 also recorded as the last year on the graph. Based on the data, it can be observed how the annual temperature is rising each year. For example, in the year 1880, in January the mean temperature was -2.59 degrees Celsius, in 1980 in January it was -2.12 degrees Celsius, and this year in 2022 in January, the temperature rose to -1.5 degrees Celsius (nasa.gov, Seasonal cycle from MERRA2 using base period 1980-2015, 2022). From the data presented, it can be seen just from one month as an example, that the temperature is rising each year with a difference of 1.09 degrees between the year 1880 and 2022. Since 1880, or the time of the industrial revolution, up until today, our planet has already got hotter, which can be proven with this graph, by looking at the individual temperatures. The observed rise in temperature on our planet has been linked to an increase in the concentration of greenhouse gases caused by human activity (Hunt Janin, 2012). In 2010, the United States National Academy of Sciences issued a statement regarding the rising temperatures, where they acknowledged that the Earth is in fact getting warmer and that the rise in temperature is very likely due to human activities (Hunt Janin, 2012).

Table 3 shows an example of climate change. The graph shows how the level of the seawater has got higher throughout the years, starting from 1993. The rise since 1993 up until May 2022 is 101 (± 4.0) mm (climate.nasa.gov, 2022). With the sea level rising at this rate, by the end of the century, 100 million people could be affected by it, some scientists believe even this estimate might be too low (climate.nasa.gov, 2022).

The problem with the sea levels rising is that even if we emit fewer greenhouse gases, there will still be additional sea level rise for a longer period due to ice melting at a different pace all around the globe based on location and temperature (Hunt Janin, 2012).

Table 2 Global warming 1880- Jun 2022 source: https://data.giss.nasa.gov/gistemp/graphs_v4/

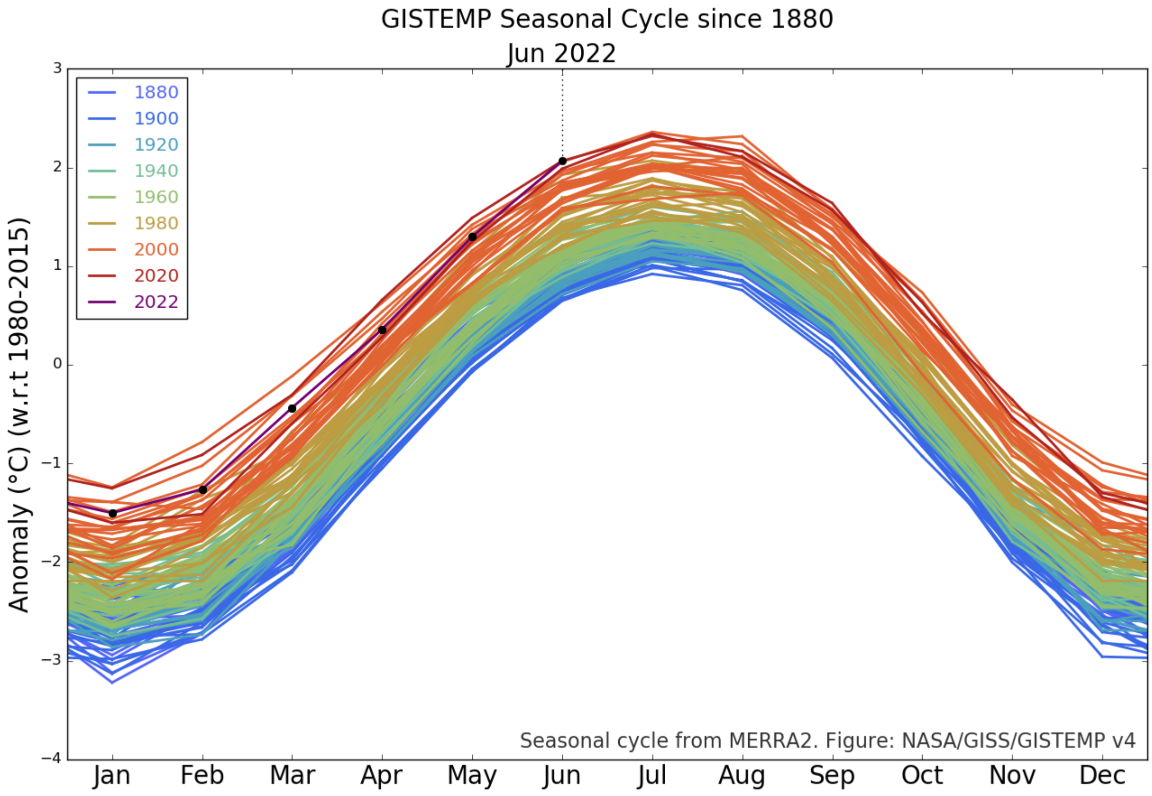
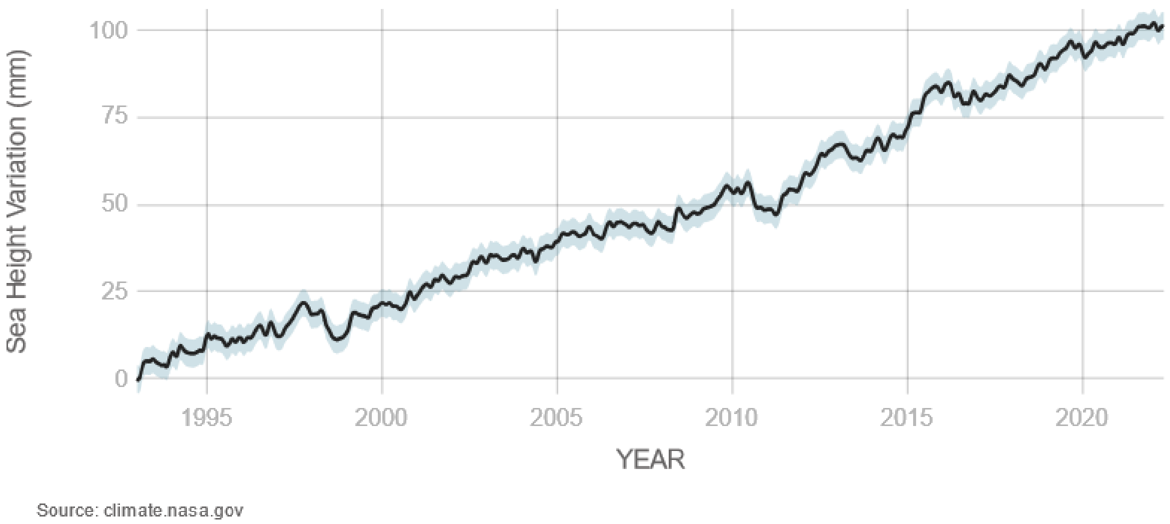


Table 3 Sea level 1995-2021 source: https://climate.nasa.gov/vital-signs/sea-level/



1.3.4 The Greenhouse Effect

A French mathematician and physicist, Joseph Fourier, came up with a theory in the 1820s, that said the energy coming from the sun onto our planet must be balanced out and returned to space since a heated surface emits radiation. He also proposed that some of this energy does not get out, making our planet warm. His theory was that our atmosphere acts like glass in a greenhouse, letting sunlight in and creating a hot temperature by trapping it in (Connolley, 2004). From the findings of his work, later in the 1850s, Eunice Newton Foote found out that in experiments with glass cylinders, there is a higher degree of heating in cylinders that contain carbon dioxide (History.com, 2022).

The greenhouse effect is a well-studied phenomenon that occurs when there is a difference between thermal infrared radiation that is emitted towards Earth from outer space and thermal infrared radiation emitted to space from Earth from our atmosphere. This effect is natural, and its purpose is to keep our planet warm, but because of emissions created by humans, the effect is enhanced (Edgerton, 1991). In the past 200 years, there has been a significant increase in atmospheric carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons, all due to various human activities, that have led to an increase in the greenhouse effect by approx. 1% (Schwartz, 2018).

An example of a significant increase of an important anthropogenic greenhouse gas is the already mentioned carbon dioxide, its global atmospheric concentration went from 280 ppm^3 (pre-industrial value) to 379 ppm^3 (in the year 2015) (Technology, 2007). Studies show that the annual growth rate of CO2 concentration was larger now in the past 10 years than ever before since measurements of CO2 started (Technology, 2007). The number one reason for this increase in the atmospheric concentration of CO2 is human activity, in this case, it is the use of fossil fuels (Technology, 2007).

In 2009, the U.S. Environmental Protection Agency officially concluded that greenhouse gases are dangerous and threaten the health and welfare of American citizens (Hunt Janin, 2012). The abundance of greenhouse gases in the 90s was greater than any other time in the last half-million years. After proper research done by scientists showing the increase of some greenhouse gases, measures were taken that resulted in the stabilisation of the abundance of some greenhouse gases in the atmosphere. Some of our past mistakes can be undone, for example in Greenland, the sulphate pollution was reversed in the 80s. Another example is where the concentration of chlorofluorocarbons is declining on a global level due to efforts to protect the ozone layer (Hervé Le Treut, 2018).

Because of these gases building up in our atmosphere, with the concentration of emissions of greenhouse gases caused by humans being higher than ever recorded, the planet is starting to heat up. From preindustrial times up until today, scientists have already recorded a 1-degree Celsius increase in temperature. As discussed in chapter 1.3.2, it is natural for the planet to go through cycles where the temperatures change, however, this change taking place now is caused solely by humans. Every summer, new reports of a place that broke its record for being the hottest that day, come in. If this continues, it is estimated that global warming will reach 1.5 degrees Celsius between 2030 and 2052. The planet getting hotter is altering the Earth's climate, wet regions are getting even more rain, but dry regions are getting less rain, making them even drier than before. Thanks to draughts affecting agriculture, the food supply will be reduced and insects that thrive in warmer conditions can more easily spread diseases. A study from 2011 found that for every degree the planet heats up, crop yields will be reduced by 5 to 15% (Cho, 2018). To curb the effects of greenhouse gases on the planet, greenhouse gas concentration must be decreased by 45% by the year 2030 and reach a net zero by 2050 (Denchak, 2016).

1.3.5 Impact on countries

As discussed in this thesis and seen in the multiple examples, climate change is unavoidable. The impact of rising temperatures and changes in weather that come with it will be widespread due to how a lot of today's economies are financially, politically, and economically integrated. It is predicted and, in some countries, already witnessed, that climate change will influence primarily the economic growth of countries, mostly through damage to property, infrastructure, a loss in productivity, and mass migration (Keith Wade).

Unfortunately, the poorer countries that often do not contribute to climate change as much as richer more developed countries are more affected by it. A study that looked at the health of the economies of 135 countries, found that lower-income countries will be faced in the future with a 3.6 times greater loss of GDP on average than richer countries. Economies that rely more on agriculture and are around the equator will be more at risk (Jones, 2022). As can be seen on the map in **Error! Reference source not found.** below, countries in west and north Europe plus Canada and the United States are the least vulnerable countries when it comes to global warming. On the other hand, countries with less stable economies, like Ethiopia, Egypt, India, the Philippines, etc. are very vulnerable. Even China, the country with one of the world's largest economies, is not safe from the impact of climate change and it is ranked in the vulnerable category. This summer China experienced very hot, above-average temperatures that led to the hottest August ever recorded. Due to the heat, the province of Sichuan ordered power cuts, which in turn interrupted the production of materials such as lithium and polysilicon but also disrupted the supply chain of Apple Inc. and Tesla Inc. (Bloomberg.com, 2022).

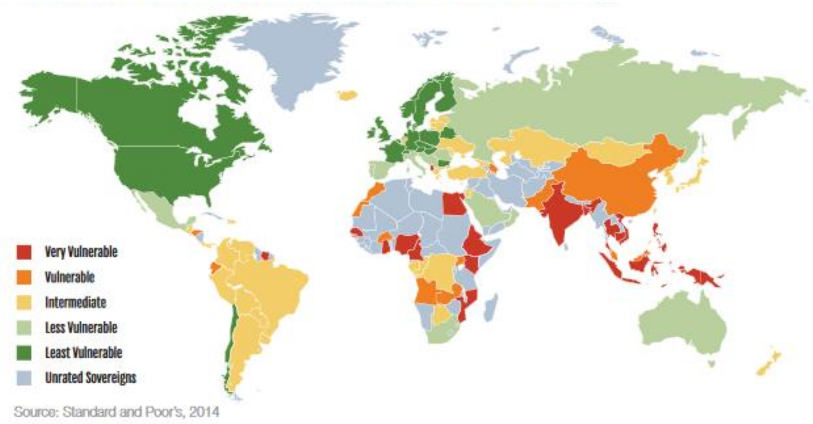


Figure 1 Impact of climate change on global economies. source: https://prod.schroders.com/en/sysglobalassets/digital/us/pdfs/the-impact-of-climate-change.pdf

If we look at it from a business standpoint, many businesses will most likely, due to extreme changes in weather, not want to replace their capital stock unless measures will be taken to prevent such damage in the future. This could mean that either the business will experience a period of disruption of normal activity or in a worst-case scenario, loss of capital stock and their output. Other changes that could occur are also lower labour productivity which could be caused by lower capital stock, but also by diseases, extreme weather, and food security. By using the basic economic theory of supply and demand, it would show that climate change affects supply, moving it to the left, thus increasing the prices and lowering the quantity of outputs (Keith Wade).

It depends greatly on how the climate will change, but in certain areas of the planet, temperatures will rise, making the conditions for agriculture worse, as yields of most crops are very sensitive to high temperatures and droughts. This change could reduce the size and area of yields, making food production more expensive (Keith Wade). For example, farmers from the United States supply nearly 25% of all grains to the global market. Changes in weather could have a devastating impact on the grain crops causing a reduction in yields which in turn will be reflected in the price of grains on the global market. The rise in temperatures will not only affect crops, but livestock as well, as is also a big part of agriculture. Heat waves have a negative effect on livestock, it increases the risk of diseases, heat-related stress and can reduce milk production (climatechange.chicago.gov, n.d.). It is predicted that the world economy could lose up to 10% of its total economic value by the year 2050, because of climate change. If nothing is done to slow down the effects of climate change, this percentage could reach 18% of GDP, if action is not taken and the temperatures rise by 3.2 degrees Celsius. According to forecasts, the area that will be hit hardest by the consequences of climate change will be the Asian economies (Marchant, 2021).

1.3.5.1 Effects on the developing world

As seen on the map in chapter 1.3.5, the effects of climate change will not be felt the same across the globe. Countries, that due to their economy, belong to the category of developing countries, will experience more negative effects of climate change. To begin with, most of these countries already have a hotter climate, since their location is closer to the equator. Most countries also heavily rely on their climate for agriculture, forestry, and tourism. The impacts climate change has on agriculture have already been discussed, but the problem in developing countries is that they, most of the time, lack the funds to create resources for drought-resistant harvests. This will also cause exports of some goods to fall in volume, with a majority of developing countries relying on the export of some goods to the developed countries. It should be also noted that more extreme weather will also have a strain on the domestic budget of these countries, forcing them to allocate funds to deal with the impacts of climate change instead of focusing on productive growth-enhancing projects. This may damage the growth prospects of the specific country (Keith Wade).

Wealthier countries, on the other hand, are the ones that produce most emissions. Recent data shows that from 1975 to 2020, five countries produced the most carbon dioxide. Those countries are USA, China, Russia, Germany, and the U. K (Blokhin, 2022). Developing countries contribute very little to the emissions in our atmosphere, yet they are the ones who take the biggest hits when it comes to climate change. Funding needs to be provided to these countries, but developed nations are reluctant in giving out funds, fearing it would make them legally liable for the consequences of climate change. A climate finance fund was promised in which developed countries would contribute $100 billion per year to help developing countries, but little has been done to settle the amount since each country decides on its own how much it will contribute (Sommer, 2021). This sum might not even be enough, in 2020 natural disasters caused damages worth $210 billion worldwide with this number possibly going even higher soon as extreme weather gets worse (Munichre.com, 2021).

1.4 Ethiopia

1.4.1 Introduction

The Federal Democratic Republic of Ethiopia is a country located in East Africa. It is a landlocked country that neighbours Eritrea, Djibouti, Somalia, Kenya, South Sudan, and Sudan. With a population of 120 million inhabitants (Ethiopia Population, 2022), it occupies an area of approx. 1 104 300 km^2 (Maps Of Ethiopia, 2021). It is the second most populous country in Africa and 12th in the world, the population is only expected to increase with a prediction of it reaching past 200 million inhabitants in 2050 (Ethiopia Population, 2022).
The capital and largest city of Ethiopia is Addis Ababa. Located in the central region of the country, the capital is an important cultural and financial centre (Addis-Ababa, n.d.). Major international organizations, for example, African Union and the United Nations Economic Commission of Africa, reside in the capital city (UNITED NATIONS CONFERENCE CENTRE IN ADDIS ABABA (UNCC-AA), n.d.).

1.4.2 History

Between the 8th and 6th millennia BC, agriculture started to develop in northern Africa and the population in this region started growing. From there, small cities started to form, then kingdoms took over the reign of the lands. A powerful kingdom named Aksum had trading power in the Red Sea by the 5th century AD. In the 300s, Christianity arrived on the territories of Ethiopia and the Ethiopian church was founded. Ethiopia as known today was created in 1855 by unifying various kingdoms (Marshall, 2021).

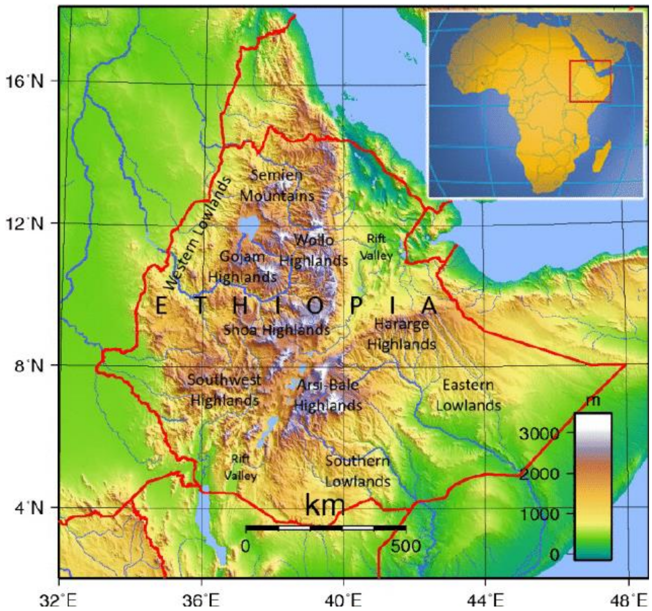
A lot of things changed in Ethiopia in the 20th century. Before the first world war, Italy claimed a protectorate over Ethiopia, which led the then-current emperor to fight against the Italians at the Battle of Adwa, where the Ethiopian troops won. By 1923, Ethiopia was trying to get access to a market economy by abolishing slavery and entering the League of Nations. In later years the economy had already started to boom, mainly due to the export of coffee. As the economy further grew, Italy once again took notice of Ethiopia. Benito Mussolini did not want Ethiopia to grow too strong and after a conflict, he declared war. The Italians, at a military advantage, used planes and poison gas on the army of Ethiopia and won. After that Ethiopia was joined to Eritrea and Italians dominated cities, towns, and routes. With help from the British, the Ethiopian emperor returned to the country and organized his own government. After that, coffee started to be sold on the world markets again and revenues were used to help the country. Trust in the monarchy began to fade and in 1974 the emperor was deposed, which led to the formation of Socialist Ethiopia. In 1975 there was a land reform that transformed ownership of land to the state and everything else like, industries, banking, insurance, etc. were nationalized. The new measures only created famine, people started to uprise and fight against the government. By 1991 rebels successfully overthrew the old government and a new one was formed which promised to democratize Ethiopia. Throughout the 90s, after an economic reform, the economy started to slowly improve but still did not attract many foreign investors into the country. After 2000 Ethiopia’s economy started rapidly growing, at one point reaching one of the fastest growing economies in the world, but political matters and worsening human rights brought the country into many problems. At the present day there are still a lot of conflicts going on in Ethiopia, in 2021 during elections, fights broke out and government officials had to be moved due to attacks in the capital (Britannica, Ethiopia, n.d.).

A new current conflict is starting to arise between Ethiopia and Egypt. Africa’s largest hydroelectric power plant known as the Grand Ethiopian Renaissance Dam was recently built on the Blue Nile River. This dam could make Ethiopia a main exporter of electricity. It should also allow over 65% of its population access to electricity (Tekle, 2022). The Egyptians see the dam as a threat as the Nile is very important for agriculture. Egypt fears that if Ethiopia decides to hold back even 10% of the water, over a period, 5 million farmers would be affected, in turn cutting down agricultural production. Ethiopia sees this as Egypt trying to prevent them from escaping poverty. Some speculate this conflict could lead to a “water war” in the future (Marshall, 2021).

1.4.3 Economy

To understand how agriculture and population density work in Ethiopia, the country must be divided into highlands and lowlands. The highlands occupy mostly the central territories. Lowlands can be found in the territories on the borders, as can be seen on the map below in Figure 2. The highlands are areas that are above 1500 m above sea level and have mild temperatures. Farmers in these areas use a farming method called sedentary agriculture, meaning they grow crops for their families, farm in one place, and do not rotate their fields (vedantu, n.d.). The population in the highlands is denser with a long history of settlement. Although the population is more concentrated in this area, the presence of malaria and other diseases is relatively low. The highlands make up only half of the area of Ethiopia, but they hold nearly 90% of the country's population, leading to this area being the economic centre of the country. The lowlands, on the other hand, are in areas below 1500 m above sea level and are the opposite of the highlands. The climate here is drier and rainfall is unreliable. They make up the second half of the country, however, only 10% of the population lives in this area, making it sparsely populated with a low contribution to the country's GDP (Yalew, 2020). The main farming type is pastoralism, a form of agriculture where pastors raise livestock on land and more according to where natural resources are located (wocatpedia, 2021).

Figure 2 Map of Ethiopia - Highlands, lowlands source: https://www.researchgate.net/figure/Topographic-map-of-the-Ethiopian-Highlands-and-major-lowlands-including-the-Great-East_fig1_281275875



Even with its location and agriculture, Ethiopia remains one of the poorest countries in Africa. Ethiopia qualified for debt relief in 2001 because it met the criteria for the Highly Indebted Poor Countries initiative (Britannica, Economy of Ethiopia, n.d.). The GDP per capita according to The World Bank is 944 US dollars. The GDP is predicted to grow in the upcoming years, in 2010 it was 324 US dollars and in 2001, the year the Ethiopian economy started to slowly take off, the GDP was merely 128 US dollars (statista, n.d.). By looking at the years 2021, where GDP per capita was 944 USD dollars, and 2001, where it was 128 USD, we can calculate that the annual growth rate, which is a perceptual change over a period of time, is 31.87%. This was calculated using the growth rate formula [(present value

– past value/ past value) *100]/period. This growth in GDP is mainly thanks to agriculture and services (Yalew, 2020). Up until the year 2019, the Ethiopian economy was among the fastest growing economies in the world, with an average growth of 9.5% per year. Due to the pandemic of COVID-19, the growth of the GDP fell to 6.3% with industry growth and services decreasing significantly. This fall in growth did not affect agriculture. The economy in Ethiopia is now experiencing changes from broad policy reforms made by the government. The new goal of the government is now to privatize the main state own businesses and have more flexibility (Administration, 2022).

Due to political instability, the rating that creditworthiness in Ethiopia got from Moody's is Caa2. Moody's Investors Service's rating system assigns ratings to securities that go from the best Aaa to the worst C (Emery, 2022). The inflation for 2022 rose to 37.7% in May due to the increase in prices of food and other goods. The country's currency, the birr, was devaluating by a rate of 25,6% in 2021. The government is trying to combat all these macroeconomic imbalances, in 2019 the Home-Grown Economic Reform Agenda was launched which aims to help the economy grow through reforms in the public sector (Administration, 2022).

1.4.3.1 Agriculture

In 2010, the share in GDP was overtaken by the service sector, but the main sector in terms of national income, employment, and export earnings still remains agriculture (Yalew, 2020). As of 2019, 67% of people are employed in agriculture. This number went down from when it was at its peak in 2005 when 78% of people were employed in agriculture (worldbank.org, 2019). The share of agriculture in GDP reached its lowest point in 2018 at 31.22%, industry contributed 27.31%, and services 36.41%. From 2018, the share of agriculture in GDP is once again starting to increase, and the share of services is on the decrease (O'Neill, 2022).

Agriculture production takes place mainly in the highlands, as stated in the previous chapter 1.4.3. The crops that grow in this region are the most commonly produced in Ethiopia. 5 major cereal crops take up about three quarters of total cultivated land and about 68% of production, making them a key part of the diets of most Ethiopians. These cereals are teff, maize, wheat, sorghum, and bailey (RASHID, 2012). Teff, which is indigenous to

Ethiopia, is grown in the highlands and used for bread. Barley, which is also grown in the highlands, is used for food but also for the production of a local beer named Tella. Maize production is also very important since Ethiopia is the 2nd largest producer of maize in Africa (agrifarming.in, n.d.). Another important crop that can be found only in Ethiopia is Enset, which is sometimes referred to as false banana, more than 20 million people depend on it for food and fibre (RASHID, 2012).

Since agriculture is such a big part of the Ethiopian economy, the government has taken necessary steps into improving the quality of the agriculture sector by launching several programs, which describe what the country has to do in order to achieve higher production. An important plan in regard to agriculture is the Growth and Transformation Plan II. The main objective of this program is to bring Ethiopia into the category of a low-middle-income country by the year 2025. The way in which this objective is to be reached is by enhancing the productivity of agriculture and manufacturing. The plan also focuses on improving the quality of production, bringing more competition into the economy, but also on industrial development, transportation, education, and tourism (ethiopia.un.org, 2019). A big goal concerning agriculture is increasing the productivity of crops, which is measured by looking at specific crops. The average productivity of cereals went from 2105 kg per hectare in the period 2014/2015 to 3092 kg per hectare in 2019/2020, which is an increase of 987 kg per hectare in 5 years. The biggest increase recorded in this 5-year period is in the production of maize which went up from 3429 kg per hectare in 2014/2015 to 5038 kg per hectare in 2019/2020 (Commission, 2016).

1.4.3.2 Exports and imports

The main exports of Ethiopia include coffee, worth $840M, other oily seeds, worth $384M, gas turbines ($328M), other vegetables ($261M), and gold worth $194M.
The 3 top countries that Ethiopia exports most to are the United States, Somalia, and Hong Kong.

Ethiopia imports refined petroleum worth $1.24B, gas turbines ($532M), planes, helicopters, spacecraft ($406), wheat ($320M), and medicaments worth $317M.
The countries it imports from most are China, India, United Arab Emirates also United States, and Kuwait. (oec.world, 2020)

Imports account for more than exports which causes Ethiopia to have a trade deficit. Total imports are increasing on average by 12,5% per year. During the peak of this trade deficit in 2015, imports got to $14.4B from $4.8B in 2010 (Administration, 2022).

1.5 Climate change in Ethiopia

Ethiopia, like many other countries, is at great risk of climate change related negative effects. This risk is further increased by the fact that Ethiopia heavily relies on sectors most likely to be affected by climate change, like agriculture. Another reason is the high level of poverty. Data shows that from the year 1980 until 2020, Ethiopia experienced many droughts and floods. Climate change is expected to increase the risk of flooding and draughts (climateknowledgeportal.worldbank.org, 2021). It is predicted that in the future the variability in rainfall will increase which will affect agriculture in turn affecting the GDP (Belay Simane, Hunachew Beyene, Wakgari Deressa, Abera Kumie, Kiros Berhane, and Jonathan Samet, 2016).

Due to the increase in annual GDP, greenhouse emissions that are related to agriculture and deforestation also increased (climatelinks.org, n.d.). With higher levels of emissions also comes higher heat, warming can cause more heat waves and also evaporate water more quickly, which leads to the loss of moisture from soil (Belay Simane, Hunachew Beyene, Wakgari Deressa, Abera Kumie, Kiros Berhane, and Jonathan Samet, 2016). The temperature in the last decade has already increased by about 0.2 degrees Celsius per decade (Keller, 2009).

The effects of climate change can already be seen in the number of people who do not have access to food or water, which as of 2021 was 5.9 million Ethiopians that needed food assistance. Furthermore, half a million people had to be displaced due to either drought or flooding (Giovetti, 2022).

Practical Part

The practical part of this thesis will focus on a statistical analysis of data. A correlation analysis will be done which will show if there is a correlation between temperature and other weather phenomena in Ethiopia and the share agriculture has in the GDP of Ethiopia in a chosen period of time. By doing a correlation analysis and examining the results of the analysis, the paper will reach a conclusion if climate change affects the economy of Ethiopia. Two hypotheses will be looked at, first one is whether there is any relationship between temperature in Ethiopia and the share of agriculture in the GDP of Ethiopia and the second one is whether there is a relationship between the amount of precipitation in Ethiopia and the share of agriculture in the GDP of Ethiopia.

1.6 Correlation analysis

The definition of a correlation analysis is the study of the relationships between variables. A correlation analysis also shows how strong a relationship between the variables is (James, n.d.). Correlation coefficient (r) is a statistical measure that shows the strength and direction of the relationship of the variables. The correlation coefficient ranges from -1.00 to + 1.00, values -1.00 or + 1.00 indicate a strong correlation while values that are close to 0 indicate a weak correlation. This range of the correlation coefficient is interpreted in the graph below.

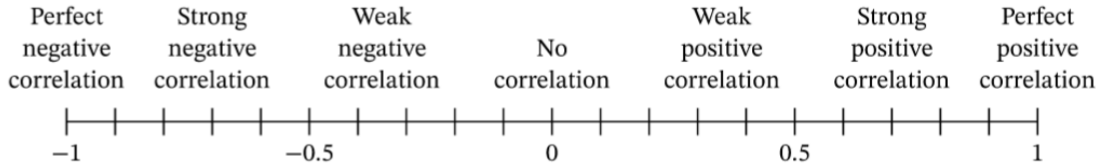


Figure 3 Strength of Linear Correlation source: https://www.nagwa.com/en/explainers/143190760373/

There are 3 types of correlation coefficient methods, Spearman, Kendall, and Pearson. For this analysis, Pearson Product-Moment Coefficient will be used. Pearson is the most widely used because it measures the strength of the linear relationship between two variables. The formula therefore is:

$$r = \frac{\Sigma(X - \overline{X})(Y - \overline{Y})}{(n - 1)s_x s_y}$$

Where x and y stand for variable x and variable y, n is the sample size, s is the standard deviation.

Next to the correlation coefficient, the coefficient of determination will also be used in this analysis. The coefficient of determination (r^2) is the proportion of variation in the dependent variable (y) that is explained by the variation in the independent variable (x). It is calculated by squaring the result given by the correlation coefficient (Bloomenthal, 2023). The range of the coefficient of determination goes only from 0 to 1, unlike the coefficient of correlation, it does not show the direction, only the variation.

1.7 Monitored variables

1.7.1 Share of agriculture in the GDP of Ethiopia

The first variable that will be part of the analysis is the share of agriculture in the GDP of Ethiopia. The data used is from the World Bank and it represents the GDP share of agriculture per year from the year 2007 to the year 2021 in US dollars. A representation of the GDP share of agriculture can be seen in the graph below. The share of agriculture in GDP was chosen because it has a big impact on the economy and the other two chosen variables might have a direct impact on it. Especially in Ethiopia, the share agriculture has in GDP is high, figures are in the range from approx. 30% to 45% share of the GDP. Both graphs shown below also include forestry and fishing in the numbers.

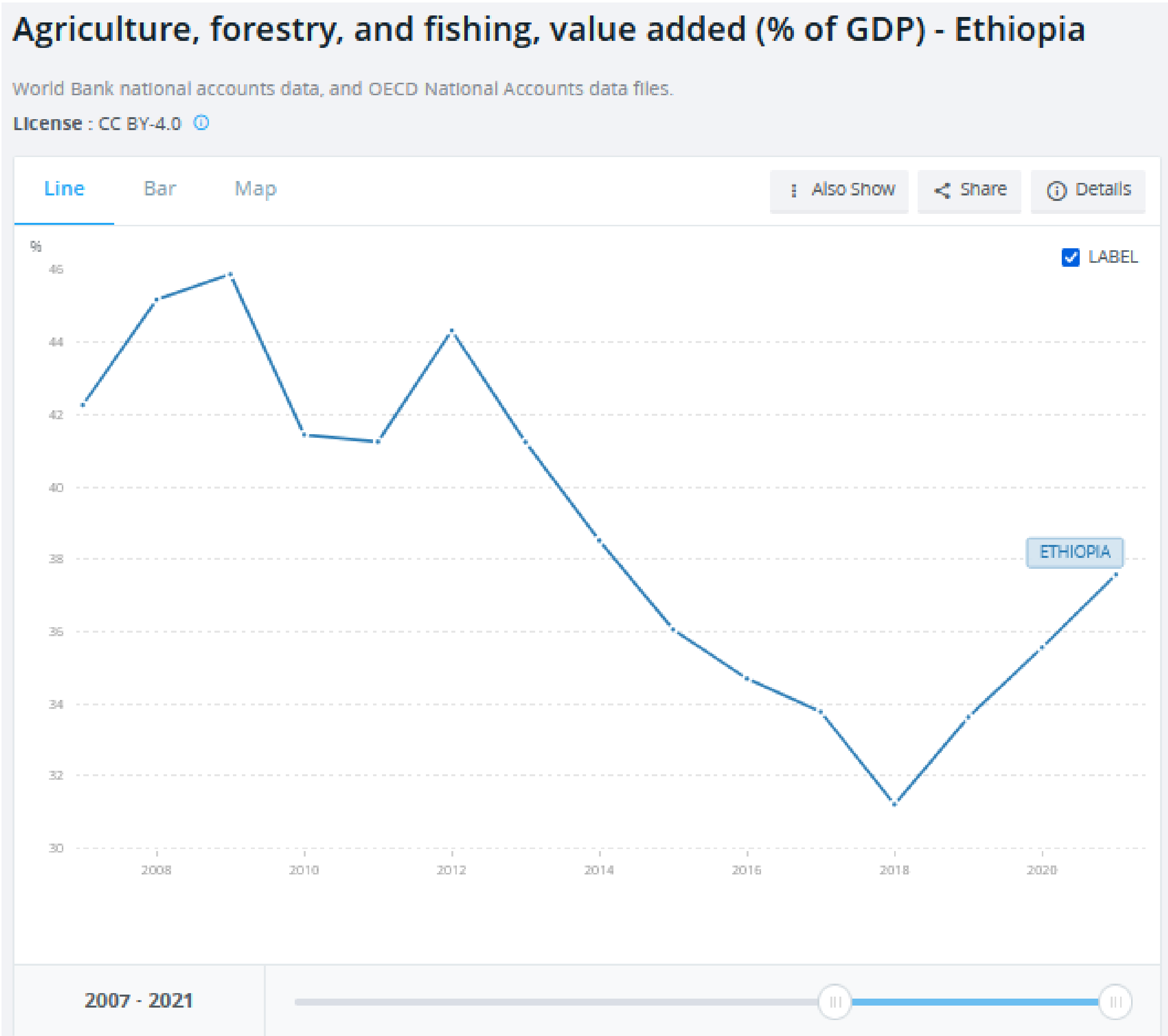


Table 4 Share of agriculture, forestry, and fishing in GDP in %. source: https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?end=2021&locations=ET&start=2007

Table 5 illustrates the share of agriculture in GDP in percentage. This way it is easier to understand the impact that agriculture, forestry, and fishing have on the GDP of Ethiopia. The country has been trying to lower the share of agriculture in GDP as can be seen by the decline in the graph. The highest the share has ever been was in the year 2009 when 45.9% of GDP was attributed to agriculture. The share has been the lowest in the year 2018 when it reached 31.22%. Since 2018, Ethiopia has seen a steady increase in the share agriculture has in GDP.

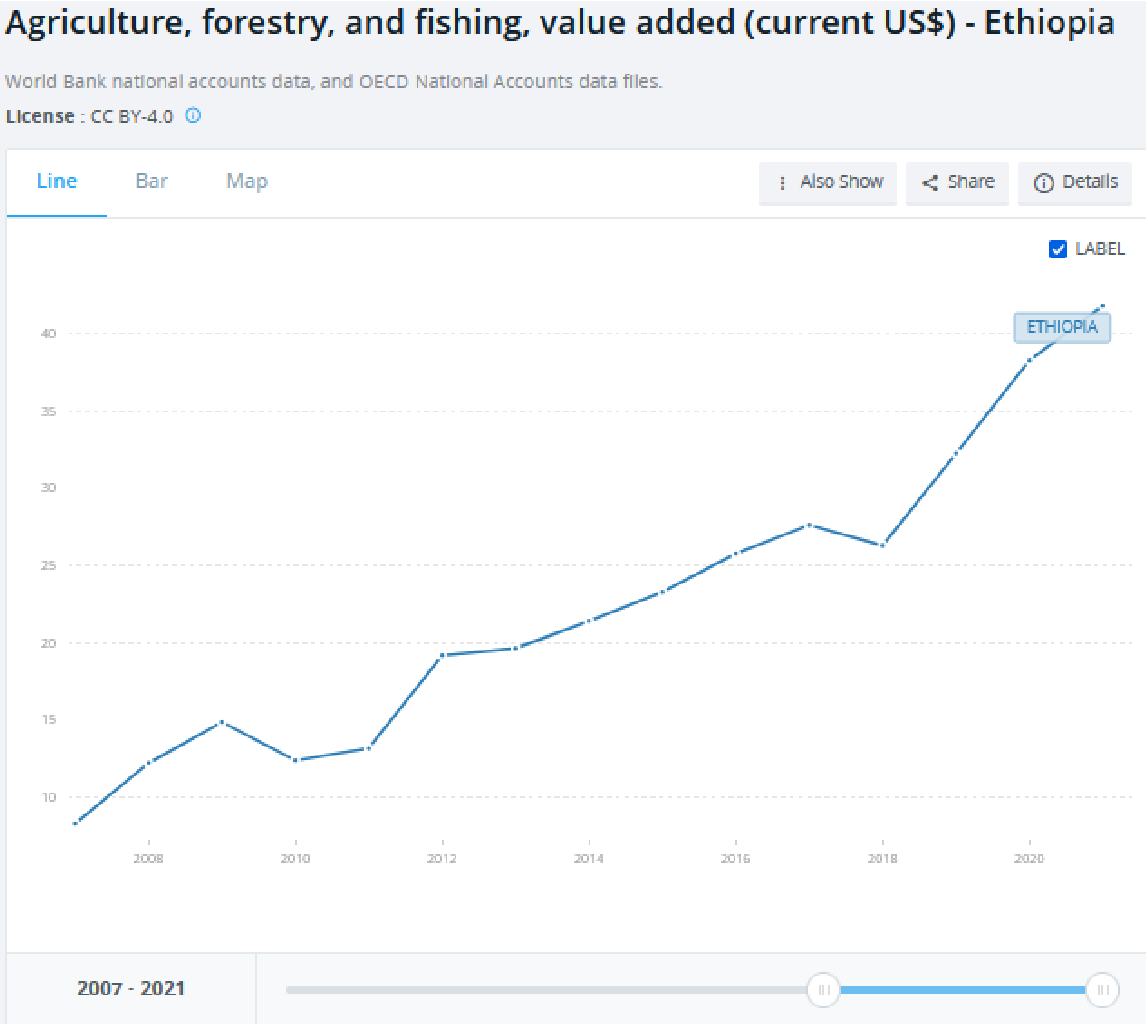


Table 5 Share of agriculture, forestry, and fishing in GDP in %. source: https://data.worldbank.org/indicator/NV.AGR.TOTL.CD?end=2021&locations=ET&start=2007

The graph in table 6 shows the share agriculture, forestry, and fishing have in the GDP in US dollars. As can be seen, Ethiopia is seeing an exponential increase in the share of agriculture in GDP. The rise in this graph coincides with the overall rise in GDP that Ethiopia has seen in the last decade. In the year 2021, the share agriculture had in the GDP was 41.81 US billion dollars which is a significant increase from the first year in the graph, 2007, when the share was only 8.33 billion US dollars. The data obtained from this graph will be later used for the correlation analysis.

1.7.2 Temperature in Ethiopia

The next variable that will be looked at is the annual mean temperature. The data has been pulled also from the World Bank; it can be found in their Climate Change Knowledge Portal. It shows the observed annual mean temperature in Ethiopia between the years 1990 and 2021. Temperature was chosen as a variable because, due to climate change, the mean temperature is rising all over the world, including in Ethiopia. The World Bank also provides a graph that shows that it was not always this hot in Ethiopia. The trend of higher annual temperatures started around the 2000s. For example, according to their graph below, the annual mean temperature was 22.72 °C in the year 1981, which was only 40 years ago. In recent years the annual mean temperature has been around 23.5 °C.

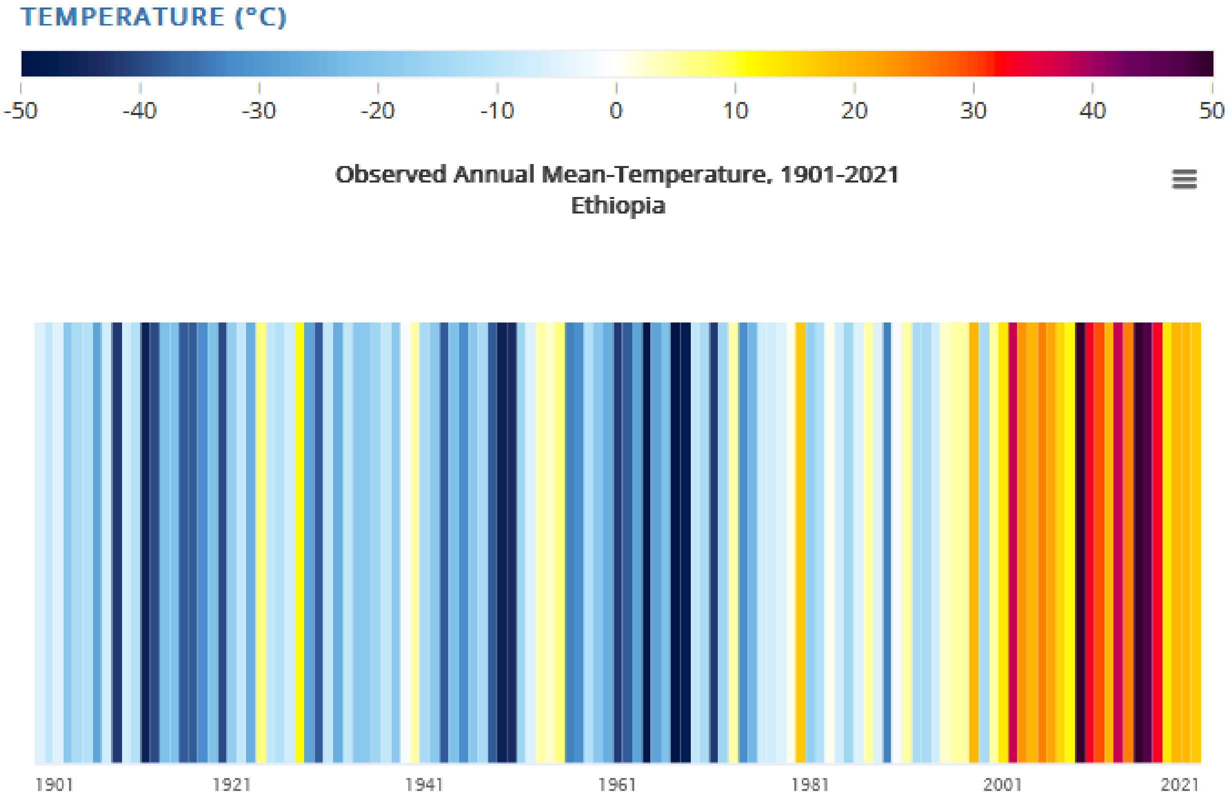


Table 6 Observed annual mean temperature 1901-2021 Ethiopia, source: https://climateknowledgeportal.worldbank.org/country/ethiopia/climate-data-historical.

The data that will be used for this analysis can be represented in a graph. The graph below shows the data on annual mean temperature only for the time period from the year 2007 until 2021. The temperature reached its peak in the year 2009 when it was recorded that the annual mean was 23.95°C. After 2009, the temperature began to decline and then reached another peak in the years 2015 and 2016. In the year 2021, the annual mean temperature was 23.35 °C.

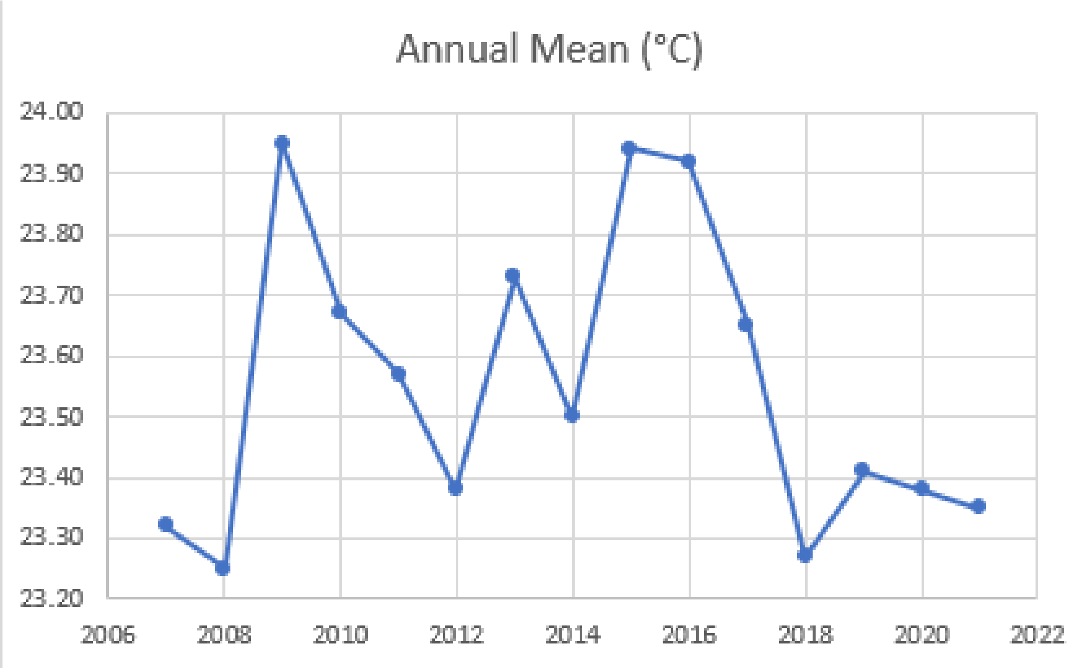


Table 7 Annual mean temperature Ethiopia 2007-2021, source: own work.

1.7.3 Precipitations in Ethiopia

The last variable that will be analysed is the precipitations that Ethiopia receives. The data was also found on the website of the World Bank, in the Climate Change Knowledge Portal. By looking at the annual precipitation from the year 2007 in the graph below, there is not such a drastic change in the amount of mm of rain each year as there was for temperature. In the last 15 years, the annual precipitations are around 770 mm to 850 mm. In recent years that number has increased, reaching 927.34 mm in 2021.

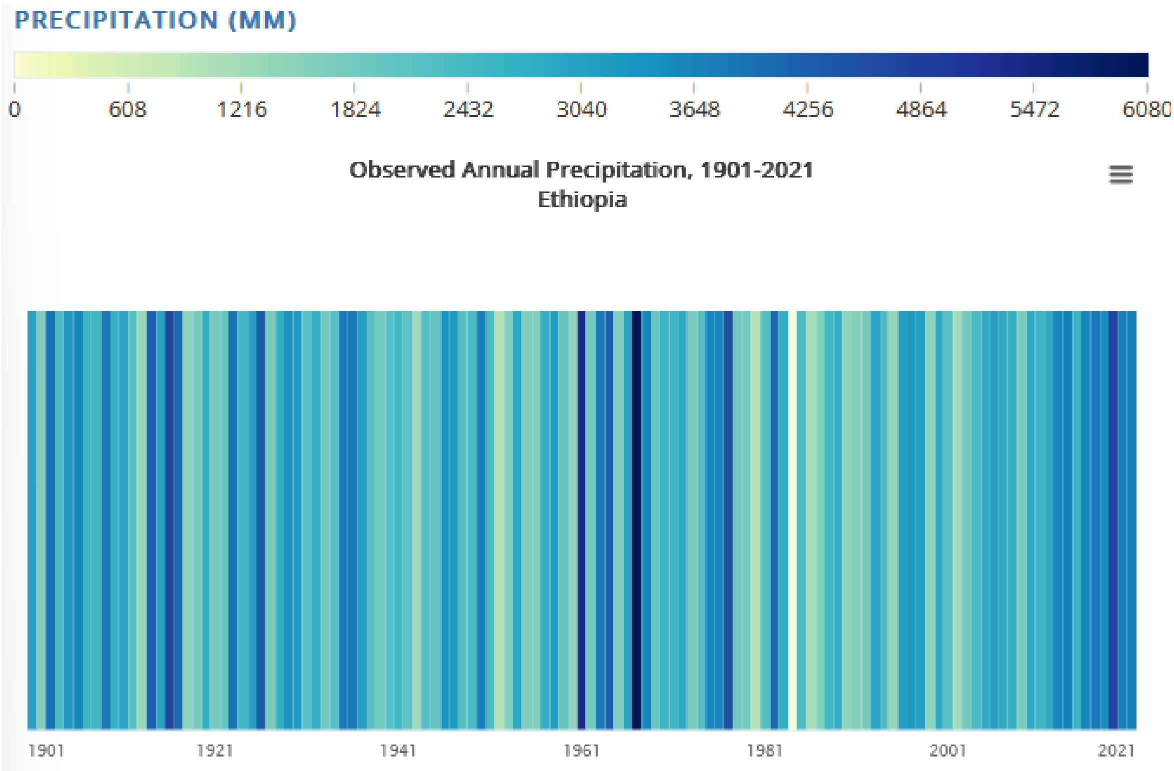


Table 8 Observed annual precipitation Ethiopia 1901-2021, source: https://climateknowledgeportal.worldbank.org/country/ethiopia/climate-data-historical.

For the data that will be used in the analysis, the time period from the year 2007 until the year 2021 was chosen again. The data is represented in the graph below. The year with the most precipitations is 2019, where annual precipitations reached 1001.38 mm.

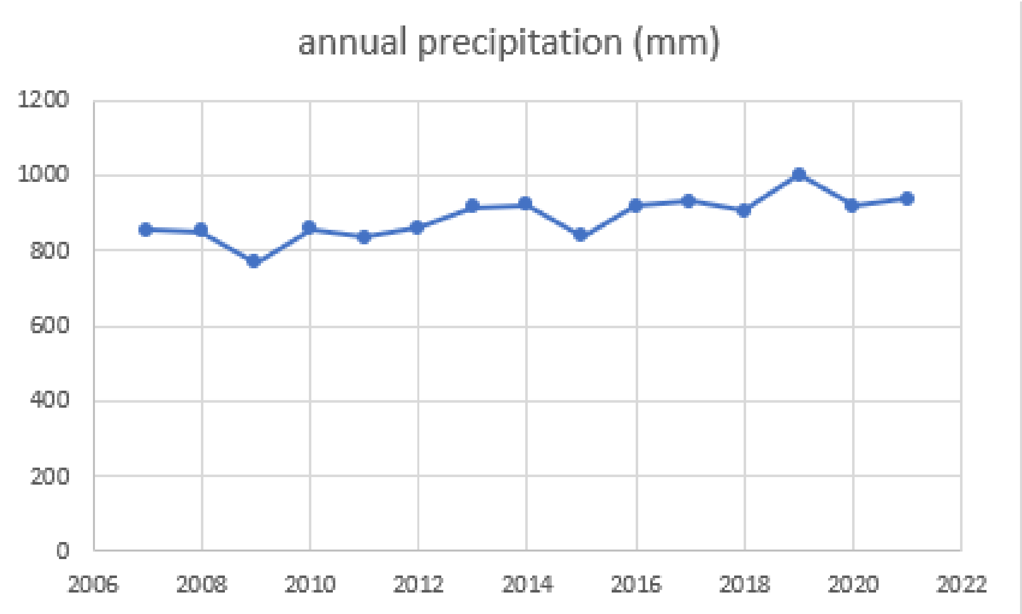


Table 9 Annual precipitation Ethiopia, 2007-2021, source: own work.

1.8 Time series

The trend functions for the 3 variables have been computed using Excel.

1.8.1 Share of agriculture in GDP

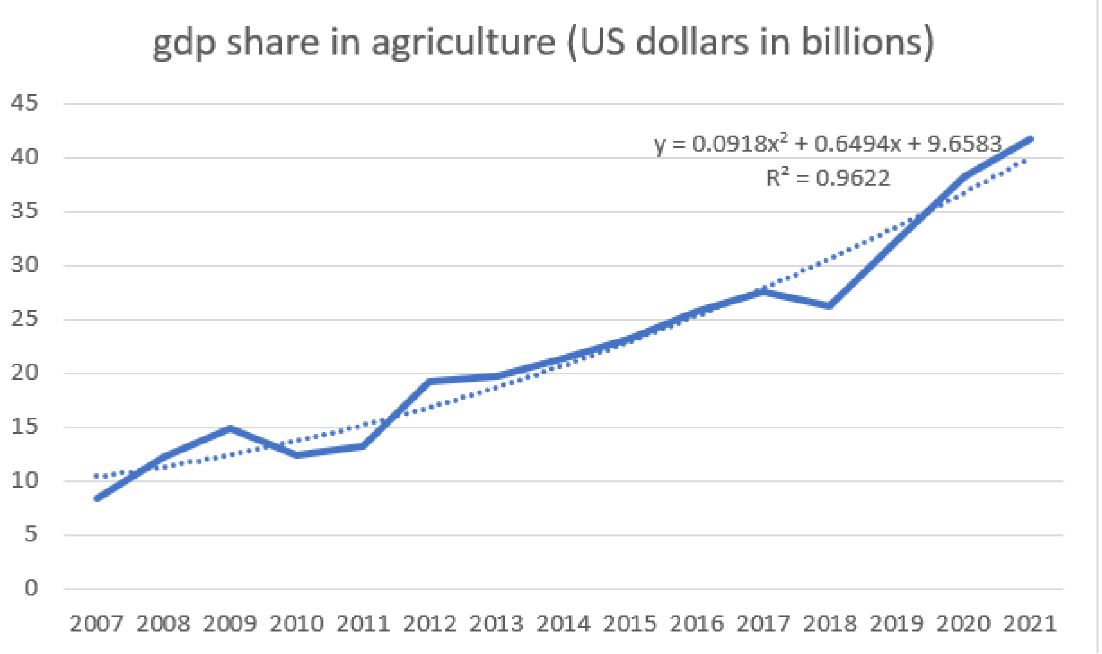


Table 10 Trend function GDP share in agriculture. source: own work.

Table 10 shows the trend function of the share of agriculture in GDP in US dollars from 2007 until 2021. The function has a positive slope and the R squared, which is used to measure the quality of the trend function, is 0.96. This means there exists a long-term tendency.

1.8.2 Annual mean temperature in Celsius

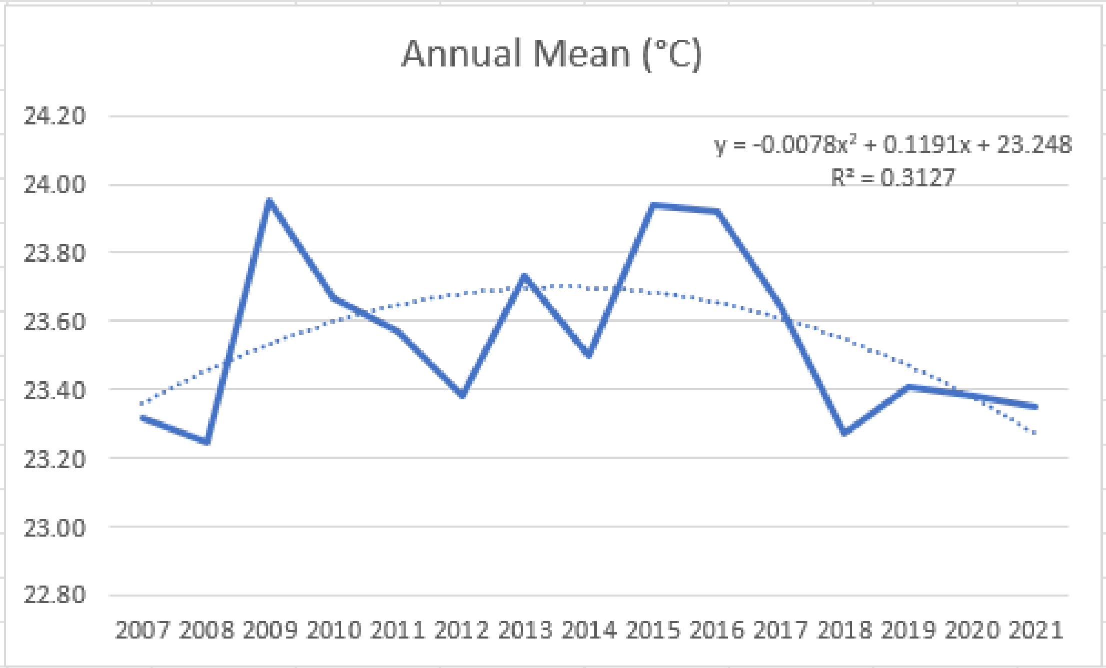


Table 11 Trend function of annual mean temperature. source: own work.

Table 11 shows the trend function of the annual mean temperature in degrees Celsius from 2007 until 2021. The R squared is 0.31 which indicates a worse model with less long-term tendency. The function contains seasonal variations that can be observed as the temperature goes up and down in the graph.

For that reason, a new graph was made using the Moving Average method. This method is used for seasonal and cyclical data that is not stationary. The goal of the method is to smooth the data using the average value of 3 observations. The data obtained is the following:

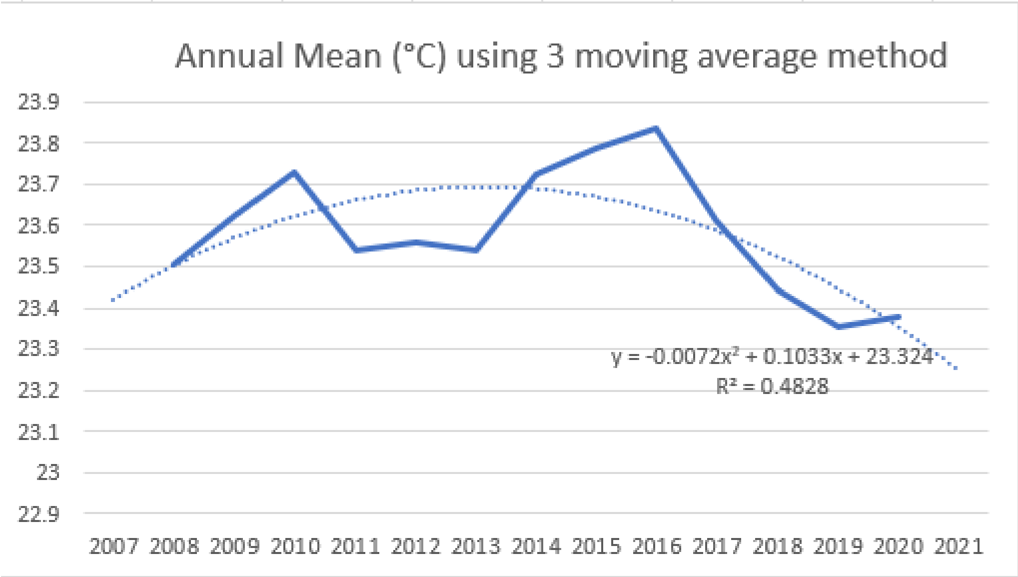


Table 12 Annual mean temperature using Moving average method, source: own work.

The data of the annual mean temperature still fluctuates even after using the Moving average method. A higher R squared has been reached than from the previous data set. Further smoothing of the data will be done using the 5-moving average. This method works on the same basis as the 3 moving average method used before, but instead of 3 observations, it looks at the average of 5 observations.

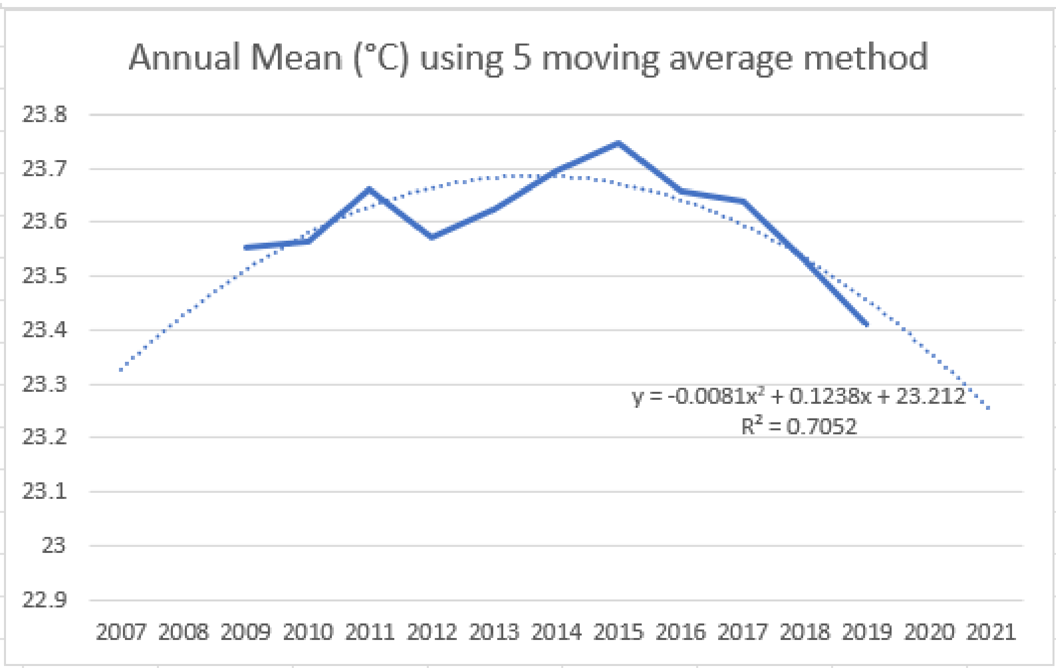


Table 13 Annual mean temperature using 5 Moving average. source: own work.

There still exist fluctuations in the data. Further smoothing will not be done because it will result in the loss of more data. Using the 5 moving average method the R squared of the model went up to 0.70 which now makes it a good quality model.

1.8.3 Annual precipitation in mm

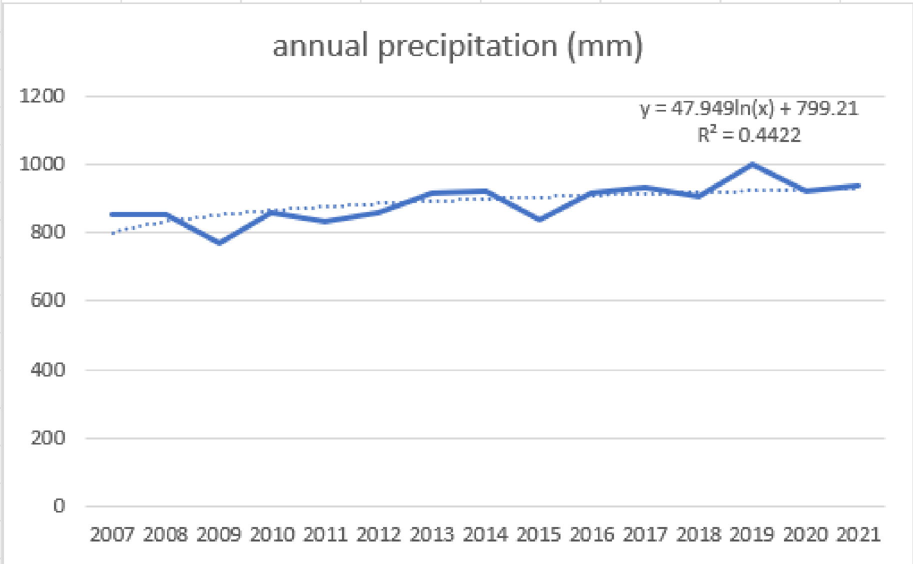


Table 14 Trend function of annual precipitation. Source: own work

Table 14 shows the trend function of annual precipitation in mm from 2007 until 2021. The slope is slightly increasing, it is showing a positive slope. R squared is 0.44 which could mean there is a long-term tendency.

1.9 Autocorrelation testing

Autocorrelation is a term used in statistics that describes the degree to which a time series is similar to itself (Dondurur, 2018). There are two types of autocorrelations, positive and negative. Autocorrelation can be spotted using the Durbin-Watson test, if the test finds that there is autocorrelation in the model, it might affect the standard error and p-values (Bock, n.d.).

Both models used in this work will be tested using the Durbin-Watson test. The formula of the test is the following:

$$DW = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2}$$

The test works with two assumptions, first H0 = there is no autocorrelation, and alternative H1= autocorrelation exists. The possible range of the test is from 0 up to 4. The rejection area is from 0 to the lower bound of the Durbin-Watson value from the statistical table and the acceptance area is from the upper bound of the Durbin-Watson value from the statistical table to 2. Results in between are inconclusive.

1.9.1 Annual mean temperature and share of agriculture in GDP

```
gretl: model 1
File  Edit  Tests  Save  Graphs  Analysis  LaTeX
Model 1: OLS, using observations 2009-2019 (T = 11)
Dependent variable: gdpshareinagricultureUSdo

                       coefficient   std. error   t-ratio   p-value
  -----------------------------------------------------------------
  const                  429.855      524.087      0.8202    0.4333
  AnnualMeanACusin~      -17.3025      22.2031    -0.7793    0.4558

Mean dependent var    21.44818   S.D. dependent var    6.331439
Sum squared resid     375.5321   S.E. of regression    6.459550
R-squared             0.063210   Adjusted R-squared   -0.040878
F(1, 9)               0.607277   P-value(F)            0.455817
Log-likelihood       -35.02579   Akaike criterion      74.05158
Schwarz criterion     74.84737   Hannan-Quinn          73.54995
rho                   0.876122   Durbin-Watson         0.209822
```

The Durbin-Watson test value was computed using the econometric software Gretl, the Durbin-Watson test value was computed. The value is 0.20 which indicates a positive autocorrelation as this number is close to 0. To find the lower and upper bound, the statistical table Appendix Durbin-Watson Significance table was used. The model uses the smoothed version of the annual mean temperature, here the sample size is 11. By looking at the mentioned table at n=11 and k=1 and a significance level of 0.05, the bounds are 0.927 and 1.324. The Durbin-Watson value of 0.20 lies outside the lower bound, meaning we reject the null hypothesis stating there is no autocorrelation.

1.9.2 Annual precipitation and share of agriculture in GDP

gretl: model 1

File Edit Tests Save Graphs Analysis LaTeX

```
Model 1: OLS, using observations 2007-2021 (T = 15)
Dependent variable: gdpshareinagricultureUSdo

                       coefficient   std. error   t-ratio   p-value
  ------------------------------------------------------------------
  const                -85.2411      30.6649      -2.780    0.0156   **
  annualprecipitat~      0.121206     0.0344525    3.518    0.0038   ***

Mean dependent var   22.43800   S.D. dependent var   9.786081
Sum squared resid    686.8328   S.E. of regression   7.268651
R-squared            0.487722   Adjusted R-squared   0.448316
F(1, 13)             12.37686   P-value(F)           0.003781
Log-likelihood      -49.96438   Akaike criterion     103.9288
Schwarz criterion    105.3449   Hannan-Quinn         103.9137
rho                  0.187401   Durbin-Watson        1.314239

LM test for autocorrelation up to order 1 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 0.420051
  with p-value = P(F(1, 12) > 0.420051) = 0.529118
```

The same test using the same null and alternative hypothesis and conditions will be done for this model as well using the same software. Here, the lower and upper bound for n=15, k=1, alpha= 0.05 are 1.077 and 1.361. The Durbin-Watson value of 1.31 lies in the middle of these bounds, meaning the result is inconclusive.

1.10 Findings

Firstly, a scatter plot diagram was computed for the analysis of the relationship between the share of agriculture in GDP and annual mean temperature and the share of agriculture in GDP and precipitations. The diagrams were done in the statistical software SAS Studio.

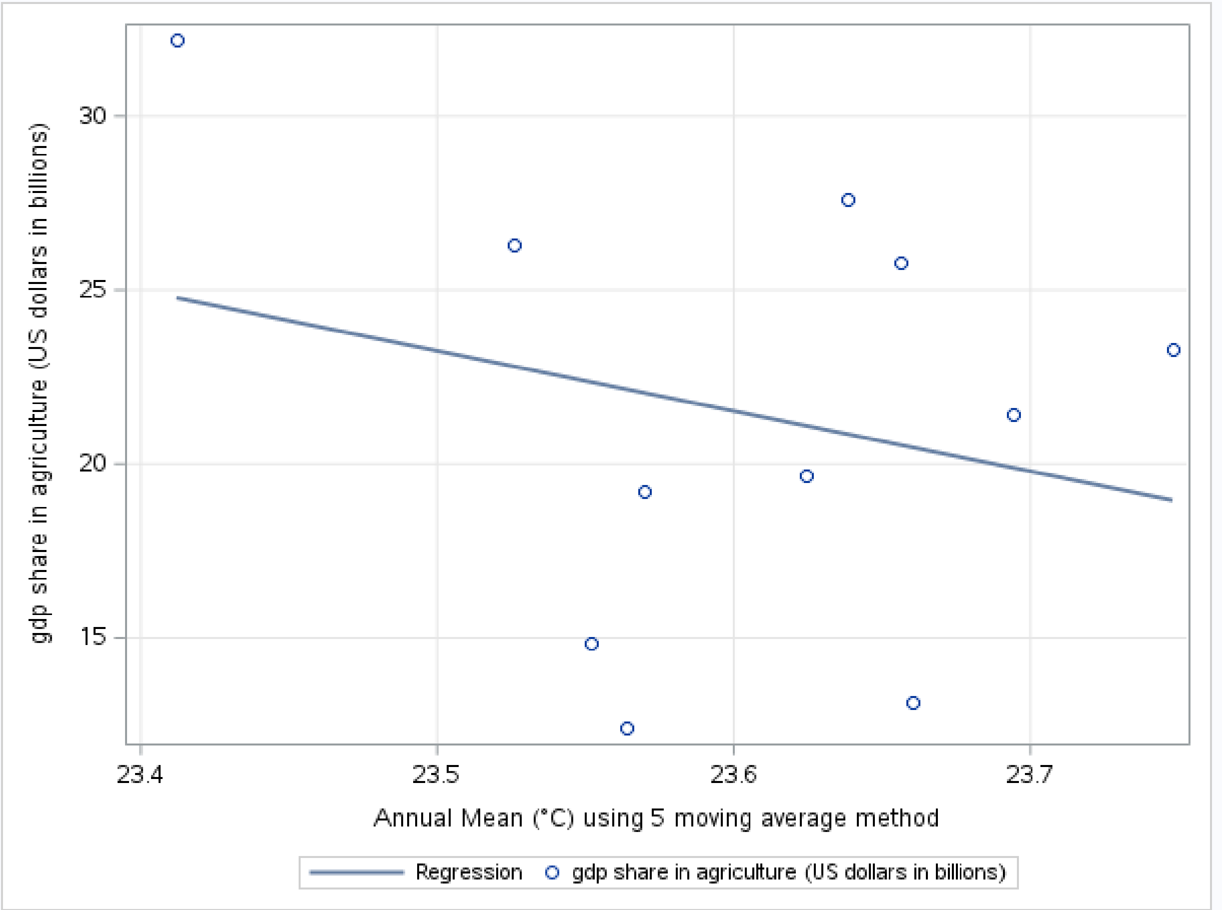


Table 15 Scatter plot diagram of GDP and annual mean temperature, source: own work in SAS Studio.

The scatterplot in Table 15 shows the relationship between the share of agriculture in GDP in US dollars measured in billions and the annual mean temperature in Celsius during the years 2007 until 2021. Data using the 5 moving average was used for the Annual mean temperature. There are many outliers, and the relationship is not strong or linear. There is also no direction in the relationship between GDP share from agriculture and temperature and the data does not follow the regression line, meaning it is not a good fit. There is no correlation in this scatter plot showing the relationship of GDP share from agriculture and temperature because all the points on the diagram are scattered with no visible direction, form, or strength.

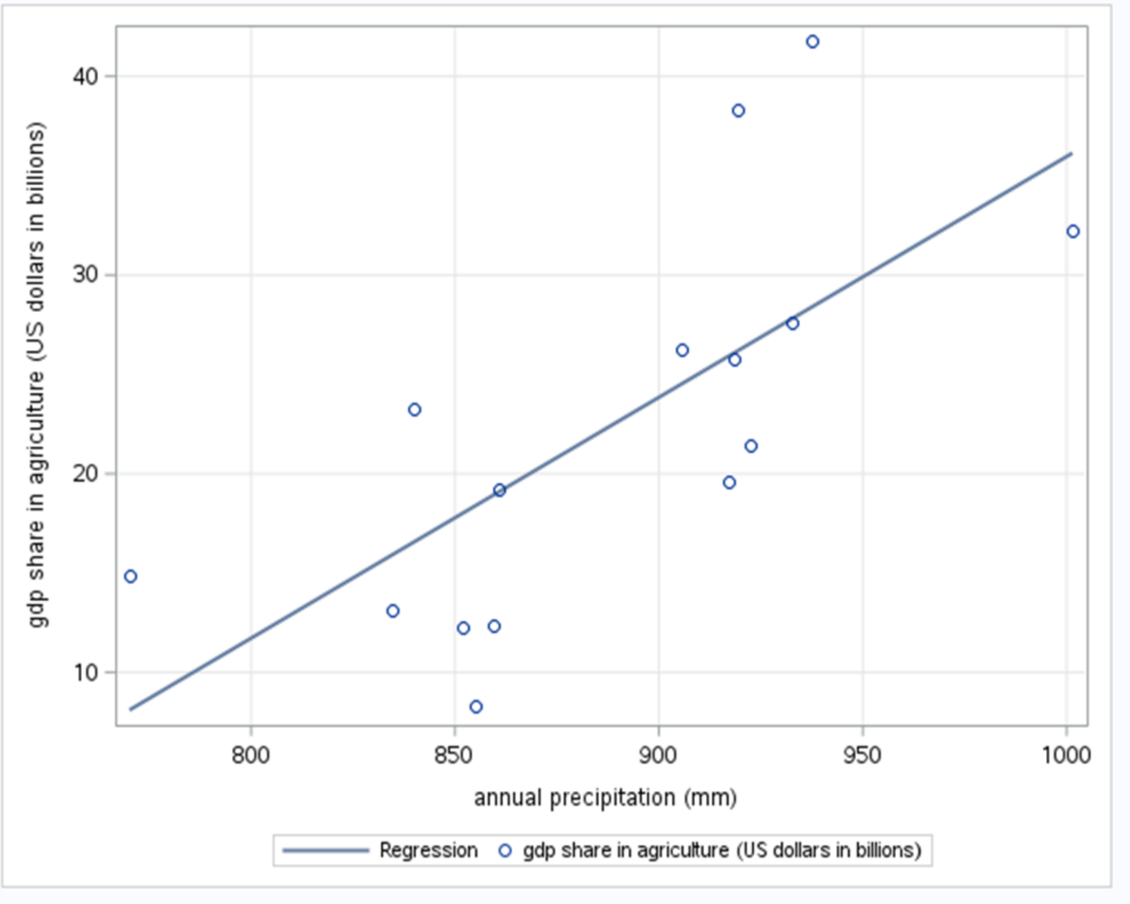


Table 16 Scatter plot diagram of GDP and annual precipitation, source: own work in SAS Studio.

The scatterplot in Table 16 shows the relationship between the share of agriculture in GDP in US dollars measured in billions and the annual precipitation in mm during the years 2007 until 2021. Unlike the previous scatterplot, this one has a direction. The direction is positive as all of the plots appear to be following the regression curve going upwards. There do appear to be 2 outliers in the data. A moderately strong relationship can be seen in the scatterplot. The data follows the regression line, which indicates a good fit of the model. As precipitation increases, the share of agriculture in GDP also tends to increase.

A scatter plot is a way to assess if there is a relationship before starting the analysis that shows the bigger picture. It only gives an idea about the nature and extent of correlation but does not show anything about causation. Further tests must be done and SAS Studio was used again to get the following data.

1.10.1 Correlation analysis between share of agriculture in GDP and Annual Mean Temperature

Model: MODEL1
Dependent Variable: gdp share in agriculture (US dol gdp share in agriculture (US dollars in billions)

Number of Observations Read	11
Number of Observations Used	11

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	25.33910	25.33910	0.61	0.4558
Error	9	375.53206	41.72578		
Corrected Total	10	400.87116			

Root MSE	6.45955	R-Square	0.0632
Dependent Mean	21.44818	Adj R-Sq	-0.0409
Coeff Var	30.11700		

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	429.85539	524.08657	0.82	0.4333
Annual Mean (°C) using 5 moving	Annual Mean (°C) using 5 moving average method	1	-17.30246	22.20314	-0.78	0.4558

Table 17 Analysis between share of agriculture in GDP and Annual mean temperature, source: own work

These tables show statistical data on the first relationship, the relationship between GDP share of agriculture in US dollars in billions and the smoothed-out data of the annual mean temperature in Celsius.

In this analysis, the values from the tables that are highlighted in yellow will be explained as they are the most important.

First, the null and alternative hypotheses need to be set. The null hypothesis states that there is no relationship between the target variable and the explanatory variable, H0: $\beta = 0$. The alternative hypothesis states that there is a significant relationship between the variables, H1: $\beta \neq 0$.

In the table Parameter Estimates, 3 results can be found. The parameter estimate of intercept and annual mean temperature gives information about the constant and the regression coefficient. For that the general form of linear regression equation will be needed which is:

$$\hat{Y} = a + bX$$

In the example provided above, a is the y-intercept, and b is the slope of the line. If put into the general form, this result is reached:

$\hat{y} = 429.85 - 17.30\ x$

b shows that there is a negative relationship between the share of agriculture in GDP and the annual mean temperature. It indicates the slope of change; if annual mean temperatures change by one degree Celsius then the GDP decreases on average by 17 billion US dollars.

In the same table, there can also be found the p-value and t-test.

The p-value for the GDP share of agriculture and annual mean temperature is estimated to be 0.4558. P value will be compared with an alpha level of 0.05. P value 0.4558 is more than alpha 0.05, meaning we ***accept the null hypothesis***. There is no relationship between the GDP share of agriculture and annual mean temperature.

The t-test will be used in hypothesis testing. Hypothesis testing will support the findings of the p-value. The null and alternative hypotheses will remain the same as stated above and the alpha level will still be 0.05. Degrees of freedom must be chosen, for this example 10 degrees of freedom will be used because t-test works with n-1 degrees of freedom, n being the sample size. This analysis has the sample size of 11 observations. By looking at the statistical tables that can be found in Appendix Statistical table, the critical value of 2.228 can be found. The value from the statistical table and that of the t-test from above can be compared to reach a conclusion. T-test value of -0.78 is smaller than the value from statistical tables of 2.228, which means the null hypothesis can be accepted. The t-test proves that there is no significant relationship between the share of agriculture in GDP and annual mean temperature.

The last analysis to be looked at is the goodness of fit which will be analysed from the middle table from the SAS Studio result. R-Square is 0.06 which means that 6% of the variation in GDP share in agriculture was explained by the regression model. The residual is very high, 94% of the variation was not explained by the model. The coefficient of correlation can be obtained by doing a square root of R-Square. The result is 0.2. According to Figure 3 where the strength of correlation was stated, the result indicates a weak positive correlation.

1.10.2 Correlation analysis between share of agriculture in GDP and Annual Precipitation

Model: MODEL1
Dependent Variable: gdp share in agriculture (US dol gdp share in agriculture (US dollars in billions)

Number of Observations Read	15
Number of Observations Used	15

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	653.91046	653.91046	12.38	0.0038
Error	13	686.83278	52.83329		
Corrected Total	14	1340.74324			

Root MSE	7.26865	R-Square	0.4877
Dependent Mean	22.43800	Adj R-Sq	0.4483
Coeff Var	32.39438		

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	-85.24107	30.66485	-2.78	0.0156
annual precipitation (mm)	annual precipitation (mm)	1	0.12121	0.03445	3.52	0.0038

Table 18 Correlation analysis between share of agriculture in GDP and annual precipitations, source: own work.

The second analysis is between the variables share of agriculture in GDP in billions in US dollars and the annual precipitation in mm. This analysis will follow the same steps as the previous one concerning annual mean temperature.

The important values that will be looked at are again highlighted in yellow for easier orientation.

The null hypothesis and alternative hypothesis need to be set first. The null hypothesis for this analysis states that there is no relationship between the target and the explanatory variable, H0: $\beta = 0$. The alternative, on the other hand, states that there is a relationship between these two variables, H1: $\beta \neq 0$. The alpha level used for testing will also remain the same 0.05 as used in the previous analysis.

Continuing with the interpretation of the results, the first table to be looked at will be table Parameter Estimates, where there can be found information about 3 results, the intercept, p-value, and the t-test.

The first to be analyzed will be the intercept. As stated above, the intercept follows the general linear regression equation which is:

$$\hat{Y} = a + bX$$

In this model, the intercept is the following:

$\hat{y} = -85.24 + 0.121x$

this time b shows that there is a positive relationship between the share of agriculture in GDP and the annual precipitation. It indicates the slope of change, in this case, if the annual precipitation changes by one mm, then the share of agriculture in GDP changes on average by 121 million US dollars.

From the same table, the p-value can be analysed to prove or disprove the null hypothesis. The p-value for the GDP share of agriculture and annual precipitation is estimated to be 0.0038. This p-value will be compared to the alpha level of 0.05. The p-value is smaller than the alpha level meaning we ***reject the null hypothesis***. There is a relationship between the share of agriculture in GDP and annual precipitation.

To further prove this conclusion of the null hypothesis that was reached with the p-value, hypothesis testing will be done using the t-test. The null and alternative hypothesis will remain the same as stated above and alpha level of 0.05 will still be used. The degrees of freedom will change, because this model has the sample size of 15, meaning 14 degrees of freedom will be used. The critical value that can be found in Appendix Statistical table is 2.145. This critical value will be compared to that of the t-test from Parameter Estimates which is 3.52. The t-value is larger than the critical value from the statistical tables, meaning the null hypothesis can be rejected. The t-test proves that there is a relationship between the share of agriculture in GDP and annual precipitation.

The last to be looked at that is an important value for the correlation analysis is the goodness of fit of the model, which can be found in the middle table. In this case, the R-Square is 0.4877, which indicates a better result than the previous model. It means that about 48% of the variation in the GDP share of agriculture was explained by this regression model. The residual is the remaining other half, about 52%, meaning 52% of the variation was not explained by the model. The coefficient of correlation is the square root of the R-Square, for this model it is 0.6983. This number indicates that there is a strong positive correlation between the share of agriculture in GDP and the annual precipitation.

1.11 Results and Discussion

The results of the correlation analysis are as follows:

Share of agriculture in GDP in billions in US dollars and annual mean temperature = no relationship, no correlation.

Share of agriculture in GDP in billions in US dollars and annual precipitation = relationship, positive strong correlation.

In the case of the mean temperature, the result of the analysis shows that at present time, the rise in the average temperature that Ethiopia has experienced in the last 15 years, has no direct impact on the share of agriculture in the GDP of the country. This result contradicts research that has been done in the theoretical part that stated that countries all over the world are already being negatively affected by the rise in temperature. This could mean that Ethiopia has not yet got the chance to see the effects of global warming on its economy and it might be bound to happen in the near future. The result of the analysis does not mean that Ethiopia has not experienced climate change related negative effects, but they are not reflected in the GDP. For now, the higher temperatures do not seem to disrupt the life of people and the government in a way that will lower the GDP by a significant amount. Moreover, further research with better models needs to be done on this matter, the model used in this paper that used annual mean temperature proved to not be of good quality.

As for the result of the second analysis which looked at the share of agriculture in GDP and annual precipitation and found both a relationship and a correlation, this means that the increase in precipitation that Ethiopia has been experiencing in the last 15 years is beneficial to the GDP of the country. According to the 2 graphs provided in the part Precipitations in Ethiopia, there have not been that many drastic changes in the amount of precipitations, unlike how temperature has significantly increased in the last couple of years. The amount of precipitation is increasing steadily. Ethiopia heavily relies on agriculture for food and jobs, and in the last year, has seen rises in the production of some crops. The result of this analysis shows that one factor that might have influenced that is the annual precipitation. Since most of the crops are grown in the highlands, where temperatures are colder, the rise in temperature might not have affected the crops yet, but the increase in precipitations has in a positive way affected the yields of crops. From 2018, the share that agriculture had on

GDP started to increase and the higher yields can be seen in the increase in GDP that Ethiopia has seen in recent years.

Conclusion

The main goal of this thesis was to better understand climate change and its impacts on the economy of a developing country, that country being Ethiopia. In conclusion, it can be said that for now, the temperature does not affect the share of agriculture in the GDP on a significant level as the correlation analysis found no relationship between the mean annual temperature and the share of agriculture in the GDP of Ethiopia. This fact may change in the future when the changes in temperatures may increase drastically and worsen crop production, but for now, the temperature is not causing that much trouble to the economy. The quality of the model must also be taken into consideration. The variable that is causing changes already is the annual precipitation that rose in the past couple of years. The result of the correlation analysis states that there is a relationship between the share of agriculture in GDP and the annual precipitation and there was found to be a positive correlation. In regard to GDP, this means that the GDP rises with the rise of annual precipitation. The reason for that was stated to be mainly because of agriculture, which makes up a big share of the GDP since Ethiopia heavily relies on agriculture.

The research was done to show that we are facing a big problem that will lead to bigger problems in the future. The practical part was meant to show this in a specific example of Ethiopia. Although the findings are positive for annual precipitation, that might also change in the future if Ethiopia is to get more and more rainfall each year. If this trend continues, the soil could get waterlogged which will have a devastatingly negative effect on agriculture.

Climate change should not be taken lightly and more must be done by developed countries to combat the negative impacts it has on the planet.

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List of pictures, tables, graphs, and abbreviations

1.12 List of pictures

1.13 List of tables

Appendix

Table A-2

Models with an intercept (from Savin and White)

Durbin-Watson Statistic: 5 Per Cent Significance Points of dL and dU

	k'*=1		k'=2		k'=3		k'=4		k'=5		k'=6		k'=7		k'=8		k'=9		k'=10	
n	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU
6	0.610	1.400	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	0.700	1.356	0.467	1.896	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	0.763	1.332	0.559	1.777	0.367	2.287	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
9	0.824	1.320	0.629	1.699	0.455	2.128	0.296	2.588	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10	0.879	1.320	0.697	1.641	0.525	2.016	0.376	2.414	0.243	2.822	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
11	0.927	1.324	0.758	1.604	0.595	1.928	0.444	2.283	0.315	2.645	0.203	3.004	-----	-----	-----	-----	-----	-----	-----	-----
12	0.971	1.331	0.812	1.579	0.658	1.864	0.512	2.177	0.380	2.506	0.268	2.832	0.171	3.149	-----	-----	-----	-----	-----	-----
13	1.010	1.340	0.861	1.562	0.715	1.816	0.574	2.094	0.444	2.390	0.328	2.692	0.230	2.985	0.147	3.266	-----	-----	-----	-----
14	1.045	1.350	0.905	1.551	0.767	1.779	0.632	2.030	0.505	2.296	0.389	2.572	0.286	2.848	0.200	3.111	0.127	3.360	-----	-----
15	1.077	1.361	0.946	1.543	0.814	1.750	0.685	1.977	0.562	2.220	0.447	2.471	0.343	2.727	0.251	2.979	0.175	3.216	0.111	3.438
16	1.106	1.371	0.982	1.539	0.857	1.728	0.734	1.935	0.615	2.157	0.502	2.388	0.398	2.624	0.304	2.860	0.222	3.090	0.155	3.304
17	1.133	1.381	1.015	1.536	0.897	1.710	0.779	1.900	0.664	2.104	0.554	2.318	0.451	2.537	0.356	2.757	0.272	2.975	0.198	3.184
18	1.158	1.391	1.046	1.535	0.933	1.696	0.820	1.872	0.710	2.060	0.603	2.258	0.502	2.461	0.407	2.668	0.321	2.873	0.244	3.073
19	1.180	1.401	1.074	1.536	0.967	1.685	0.859	1.848	0.752	2.023	0.649	2.206	0.549	2.396	0.456	2.589	0.369	2.783	0.290	2.974
20	1.201	1.411	1.100	1.537	0.998	1.676	0.894	1.828	0.792	1.991	0.691	2.162	0.595	2.339	0.502	2.521	0.416	2.704	0.336	2.885
21	1.221	1.420	1.125	1.538	1.026	1.669	0.927	1.812	0.829	1.964	0.731	2.124	0.637	2.290	0.546	2.461	0.461	2.633	0.380	2.806
22	1.239	1.429	1.147	1.541	1.053	1.664	0.958	1.797	0.863	1.940	0.769	2.090	0.677	2.246	0.588	2.407	0.504	2.571	0.424	2.735
23	1.257	1.437	1.168	1.543	1.078	1.660	0.986	1.785	0.895	1.920	0.804	2.061	0.715	2.208	0.628	2.360	0.545	2.514	0.465	2.670
24	1.273	1.446	1.188	1.546	1.101	1.656	1.013	1.775	0.925	1.902	0.837	2.035	0.750	2.174	0.666	2.318	0.584	2.464	0.506	2.613
25	1.288	1.454	1.206	1.550	1.123	1.654	1.038	1.767	0.953	1.886	0.868	2.013	0.784	2.144	0.702	2.280	0.621	2.419	0.544	2.560
26	1.302	1.461	1.224	1.553	1.143	1.652	1.062	1.759	0.979	1.873	0.897	1.992	0.816	2.117	0.735	2.246	0.657	2.379	0.581	2.513
27	1.316	1.469	1.240	1.556	1.162	1.651	1.084	1.753	1.004	1.861	0.925	1.974	0.845	2.093	0.767	2.216	0.691	2.342	0.616	2.470
28	1.328	1.476	1.255	1.560	1.181	1.650	1.104	1.747	1.028	1.850	0.951	1.959	0.874	2.071	0.798	2.188	0.723	2.309	0.649	2.431
29	1.341	1.483	1.270	1.563	1.198	1.650	1.124	1.743	1.050	1.841	0.975	1.944	0.900	2.052	0.826	2.164	0.753	2.278	0.681	2.396
30	1.352	1.489	1.284	1.567	1.214	1.650	1.143	1.739	1.071	1.833	0.998	1.931	0.926	2.034	0.854	2.141	0.782	2.251	0.712	2.363
31	1.363	1.496	1.297	1.570	1.229	1.650	1.160	1.735	1.090	1.825	1.020	1.920	0.950	2.018	0.879	2.120	0.810	2.226	0.741	2.333
32	1.373	1.502	1.309	1.574	1.244	1.650	1.177	1.732	1.109	1.819	1.041	1.909	0.972	2.004	0.904	2.102	0.836	2.203	0.769	2.306
33	1.383	1.508	1.321	1.577	1.258	1.651	1.193	1.730	1.127	1.813	1.061	1.900	0.994	1.991	0.927	2.085	0.861	2.181	0.796	2.281
34	1.393	1.514	1.333	1.580	1.271	1.652	1.208	1.728	1.144	1.808	1.079	1.891	1.015	1.978	0.950	2.069	0.885	2.162	0.821	2.257
35	1.402	1.519	1.343	1.584	1.283	1.653	1.222	1.726	1.160	1.803	1.097	1.884	1.034	1.967	0.971	2.054	0.908	2.144	0.845	2.236
36	1.411	1.525	1.354	1.587	1.295	1.654	1.236	1.724	1.175	1.799	1.114	1.876	1.053	1.957	0.991	2.041	0.930	2.127	0.868	2.216
37	1.419	1.530	1.364	1.590	1.307	1.655	1.249	1.723	1.190	1.795	1.131	1.870	1.071	1.948	1.011	2.029	0.951	2.112	0.891	2.197
38	1.427	1.535	1.373	1.594	1.318	1.656	1.261	1.722	1.204	1.792	1.146	1.864	1.088	1.939	1.029	2.017	0.970	2.098	0.912	2.180
39	1.435	1.540	1.382	1.597	1.328	1.658	1.273	1.722	1.218	1.789	1.161	1.859	1.104	1.932	1.047	2.007	0.990	2.085	0.932	2.164
40	1.442	1.544	1.391	1.600	1.338	1.659	1.285	1.721	1.230	1.786	1.175	1.854	1.120	1.924	1.064	1.997	1.008	2.072	0.952	2.149
45	1.475	1.566	1.430	1.615	1.383	1.666	1.336	1.720	1.287	1.776	1.238	1.835	1.189	1.895	1.139	1.958	1.089	2.022	1.038	2.088
50	1.503	1.585	1.462	1.628	1.421	1.674	1.378	1.721	1.335	1.771	1.291	1.822	1.246	1.875	1.201	1.930	1.156	1.986	1.110	2.044
55	1.528	1.601	1.490	1.641	1.452	1.681	1.414	1.724	1.374	1.768	1.334	1.814	1.294	1.861	1.253	1.909	1.212	1.959	1.170	2.010
60	1.549	1.616	1.514	1.652	1.480	1.689	1.444	1.727	1.408	1.767	1.372	1.808	1.335	1.850	1.298	1.894	1.260	1.939	1.222	1.984
65	1.567	1.629	1.536	1.662	1.503	1.696	1.471	1.731	1.438	1.767	1.404	1.805	1.370	1.843	1.336	1.882	1.301	1.923	1.266	1.964
70	1.583	1.641	1.554	1.672	1.525	1.703	1.494	1.735	1.464	1.768	1.433	1.802	1.401	1.838	1.369	1.874	1.337	1.910	1.305	1.948
75	1.598	1.652	1.571	1.680	1.543	1.709	1.515	1.739	1.487	1.770	1.458	1.801	1.428	1.834	1.399	1.867	1.369	1.901	1.339	1.935
80	1.611	1.662	1.586	1.688	1.560	1.715	1.534	1.743	1.507	1.772	1.480	1.801	1.453	1.831	1.425	1.861	1.397	1.893	1.369	1.925
85	1.624	1.671	1.600	1.696	1.575	1.721	1.550	1.747	1.525	1.774	1.500	1.801	1.474	1.829	1.448	1.857	1.422	1.886	1.396	1.916
90	1.635	1.679	1.612	1.703	1.589	1.726	1.566	1.751	1.542	1.776	1.518	1.801	1.494	1.827	1.469	1.854	1.445	1.881	1.420	1.909
95	1.645	1.687	1.623	1.709	1.602	1.732	1.579	1.755	1.557	1.778	1.535	1.802	1.512	1.827	1.489	1.852	1.465	1.877	1.442	1.903
100	1.654	1.694	1.634	1.715	1.613	1.736	1.592	1.758	1.571	1.780	1.550	1.803	1.528	1.826	1.506	1.850	1.484	1.874	1.462	1.898
150	1.720	1.747	1.706	1.760	1.693	1.774	1.679	1.788	1.665	1.802	1.651	1.817	1.637	1.832	1.622	1.846	1.608	1.862	1.593	1.877
200	1.758	1.779	1.748	1.789	1.738	1.799	1.728	1.809	1.718	1.820	1.707	1.831	1.697	1.841	1.686	1.852	1.675	1.863	1.665	1.874

*k' is the number of regressors excluding the intercept

Table 19 Appendix Durbin-Watson Significance table

Critical values of the Student's t-distribution

f	Significance level α (two sided)			
	0,10	0,05	0,02	0,01
1	6,314	12,706	31,821	63,657
2	2,920	4,303	6,965	6,925
3	2,353	3,182	4,541	5,841
4	2,132	2,776	3,747	4,604
5	2,015	2,571	3,365	4,032
6	1,943	2,447	3,143	3,707
7	1,895	2,365	2,998	3,499
8	1,860	2,306	2,896	3,355
9	1,833	2,262	2,821	3,250
10	1,812	2,228	2,764	3,1169
11	1,796	2,201	2,718	3,106
12	1,782	2,179	2,681	3,055
13	1,771	2,160	2,650	3,012
14	1,761	2,145	2,624	2,977
15	1,753	2,131	2,602	2,947
16	1,746	2,120	2,583	2,921
17	1,740	2,110	2,567	2,898
18	1,734	2,101	2,552	2,878
19	1,729	2,093	2,539	2,861
20	1,725	2,086	2,528	2,845
21	1,721	2,080	2,518	2,831
22	1,717	2,074	2,508	2,819
23	1,714	2,069	2,500	2,807
24	1,711	2,064	2,492	2,797
25	1,708	2,060	2,485	2,787
26	1,706	2,056	2,479	2,779
27	1,703	2,052	2,473	2,771
28	1,701	2,048	2,467	2,763
29	1,699	2,045	2,462	2,756
30	1,697	2,042	2,457	2,750
40	1,684	2,021	2,423	2,704
60	1,671	2,000	2,390	2,660
120	1,658	1,980	2,358	2,617
	1,645	1,960	2,326	2,576
	0,05	0,025	0,01	0,005
	Significance level α (one sided)			

Table 20 Appendix Statistical table Student t-distribution