The Effects of Climate Change on Australia

Extracting Information from Various Visualizations

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ABSTRACT

A clear and well-documented LaTeX document is presented as an article formatted for publication by our team a way to increase awareness on climate change and to prove that it not only exists, but also has effects on the earth. This article presents and explains many of the common effects climate change has on Australia from agricultural effects to economic effects along with others.

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1 INTRODUCTION

Climate change has slowly become more and more noticed through data of temperature over the years. While it is one thing to notice a simple change in temperature over the years, what does this increase in temperature mean?

This is what this paper will explore. We will take a look at the data that was found along with breakdowns of how this may effect Australia. While climate change may not seem like a major problem, it can have a huge impact on a country in more ways than one. This includes agriculture and economics among others.

2 OVERVIEW OF AUSTRALIA'S CLIMATE

As noted in the introduction, the climate in Australia has shown fluctuation over the years. Looking at data dating back to the 1980s, it can be seen that from then till now, there is definitely an increase in temperature. While this is to be expected since the 1980s to current day has a gap of about 50 years, the evidence seems to show a much more drastic change at a certain time period. For more information of Australia's climate change you can find information from https://climateknowledgeportal.worldbank.org/download-data. Make sure to select "Australia" in the "Country" section and then click "download data".

2.1 The Trends in Australia's Climate

The range of the data that was observed spanned 4 decades. We looked at temperature data from 1980 to 2019. We split these years up into 4 different decades (1980s, 1990s, 2000s and 2010s) to see the differences from decade to decade. Based on the research this is what was found:

A common problem that is brought up in today's world is climate change. There have been many debates as to if climate change exists. If you look at the data provided, you can see that over time, climate change does exist. Now for this analysis, I will refer to the data that specifically references temperature change in December as it is easier to see and notice a trend. During the 1980s and 1990s, there seems does not seem to be a consistent increase in temperature. In those two decades, there were decreases in temperature from the beginning to the end of the respective decades. In the 2000s, however, there was a slight increase in temperature from the beginning to end of the decade, which lead up to the 2010s. In the 2010s there was a steady increase in temperature and a significant one as the decade started at 26.1 degrees Celsius and ended with 29.6 degrees Celsius. Many would wonder: why is this a problem? or what does this have to do with hunger? I had those same questions until I read Autumn G Hulllings article[5] on how climate change can actually affect hunger through agricultural means, thus inspiring the search for more information through visualizations. This point was also stressed by the food and agricultural organization (FAO)[4] and the world food programme.[8]

2.2 The Proof Through Visualizations

Now that we have talked about what the data is showing, let's take a look at the actual visualizations: Figure 1 shows that there is a clear decrease in temperature from the beginning of the decade to the end, with 1982 and 1989 being anomalies.

Figure 2 shows that there is a clear decrease in temperature from the beginning of the decade to the end and it's by nearly 2.5 degrees Celsius.

Figure 3 shows that there is an increase in temperature from the beginning of the decade to the end, with 2001, 2006 and 2008 being anomalies.

Visualization, Spring 2021, City College of New York

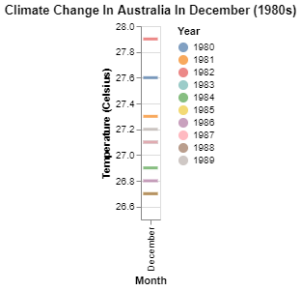

Figure 1: Vegalite visualization of climate change in December during the 1980s

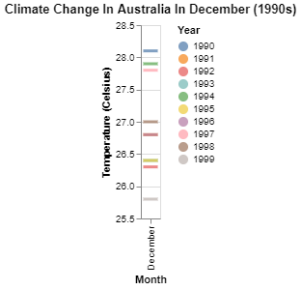

Figure 2: Vegalite visualization of climate change in December during the 1990s

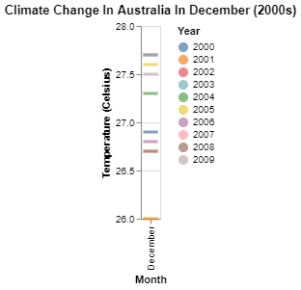

Figure 3: Vegalite visualization of climate change in December during the 2000s

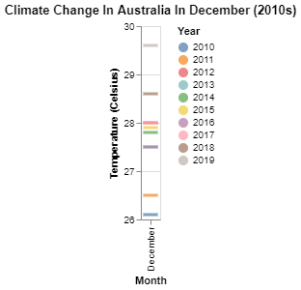

Figure 4: Vegalite visualization of climate change in December during the 2010s

Figure 4 shows that there is a clear increase in temperature from the beginning of the decade to the end and it's by nearly 3.5 degrees Celsius.

Many would wonder: why is this a problem? or what does this have to do with hunger?

3 CLIMATE CHANGE'S EFFECT ON POTENTIAL HUNGER IN AUSTRALIA

If you look at the agricultural productivity visuals, you can see that the previously highlighted trend in climate correlates with the productivity of growing agriculture.

Note: The data refers a to TFP, which is total factor productivity. TFP is essentially the measure of productivity given total production (Output) divided by average input. When the TFP is high, it means that the productivity is strong and that more is being grown, but a lower TFP means less productivity and therefore less growth. The TFP is also calculated using the total-factor productivity and labor input, but those are not shown in the data. The given input and output had a direct relationship to the TFP, so it is enough to notice a trend in it.

In the climate change data, we saw that in the 1980s and 1990s, the climate decreased in temperature when looking at the change throughout the decades during the month of December. The TFP data of the 80s and 90s, with respect to cows (beef) as the agriculture, show and upward trend in productivity, which shows a relationship with the change in climate. A slight decrease in temperature shows an increase in the productivity of beef. You can see the TFP data below:

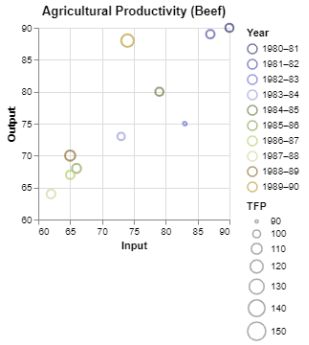

Figure 5: Vegalite visualization of total factor productivity during the 1980s

This is further proven when looking at the 2000s and 2010s decades as 2000s has a slight increase in temperature and the TFP still increased but not by much, but in the 2010s, when the temperature was drastically increased, the TFP significantly decrease. You can see this trend below:

As the temperature change increases, the productivity of agriculture like beef decreases, which means if the temperature continues to increase, the production can continue to decrease. While this

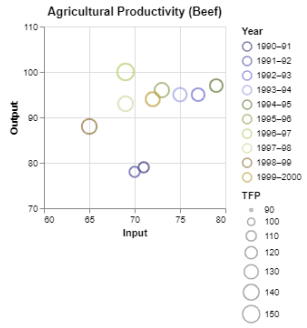

Figure 6: Vegalite visualization of total factor productivity during the 1990s

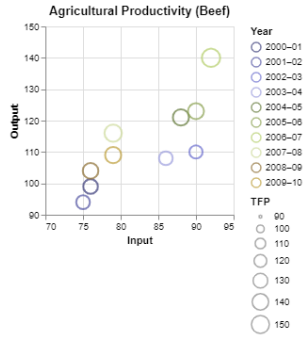

Figure 7: Vegalite visualization of total factor productivity during the 2000s

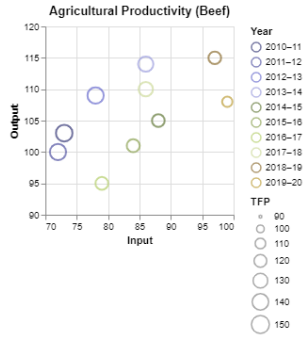

Figure 8: Vegalite visualization of total factor productivity during the 2010s

decrease is not enough to cause hunger in the present, if this continues to be a trend for the decades to come, there could be less agriculture/livestock for people to eat.

4 HOW HAS CLIMATE CHANGE AFFECTED WHEAT YIELDS IN DIFFERENT REGIONS OF AUSTRALIA?

Australia is one of the largest producers and exporters of wheat in the world. According to ABARES, wheat production in Australia accounts for 55% of the total agricultural land, wheat is grown on more than half of Australia's cropland making it one of the most important crops produced in Australia [2]. This means that changes in wheat production can have a big impact on global food security, including the lives of farmers [9]. Global food security requires that grain yields continue to increase for the next 30 years, but many yields have stalled in many developed countries [11]. There are many factors contributing this challenge and climate change can be one of them. For this reason, it is important to investigate how climate change has been affecting the yearly production of wheat in different regions of Australia. In the map we can see the effects of climate change on wheat production from 1978-2015.

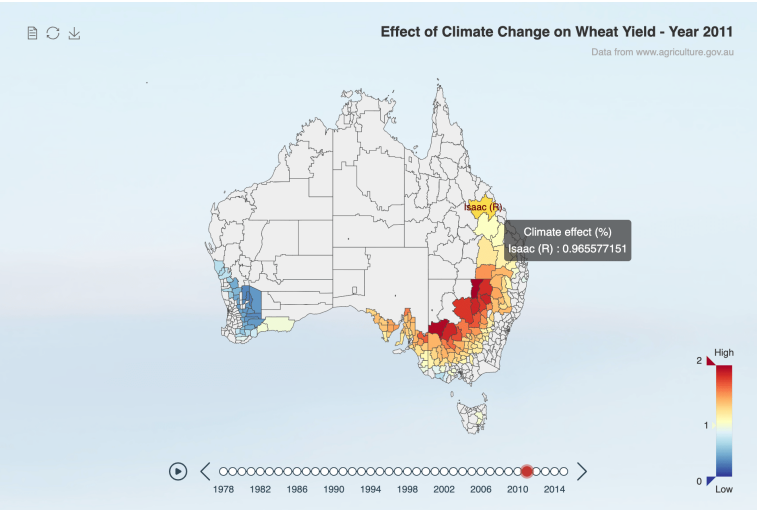

Figure 9: Principal Component Analysis of FTP from different regions of Australia

After analyzing the map above we see that in 1978 most regions of southeast Queensland and New South Wales were heavily impacted by climate change. The regions of Maranoa and Walgett were affected by 2%. This might not seem much, but it is a significant change from last year's percent. In 1983, the impact of climate change for almost all regions of New South Wales and Victoria decreased, but the following year the percent impact increased rapidly. This suggest that variations in climate change can have an immediate effect on wheat crops. From 1983-1998 we didn't have any significant changes, until 1999 when regions located in the center of Queensland and New South Wales were heavily affected by climate change. From 2000-2003 the impact of climate change decreased in almost all regions of Australia. From 2003-2015 the year most heavily impacted by climate change was in 2011. The Southern regions of Queensland and all wheat farms in New South Wales were heavily affected, including the regions of Brewarrina, Wentworth, Balranald, Cobar, Walgett, Coonamble, Bogan, Warren, Lachlan, and Hay. On the other hand, the majority of wheat farms in the Western Australia were hardly impacted by climate change.

The Principal Component Analysis in Figure 10 compares different years of climate change effect on wheat production from different regions. Looking at PCA1 and PCA2 which have the highest

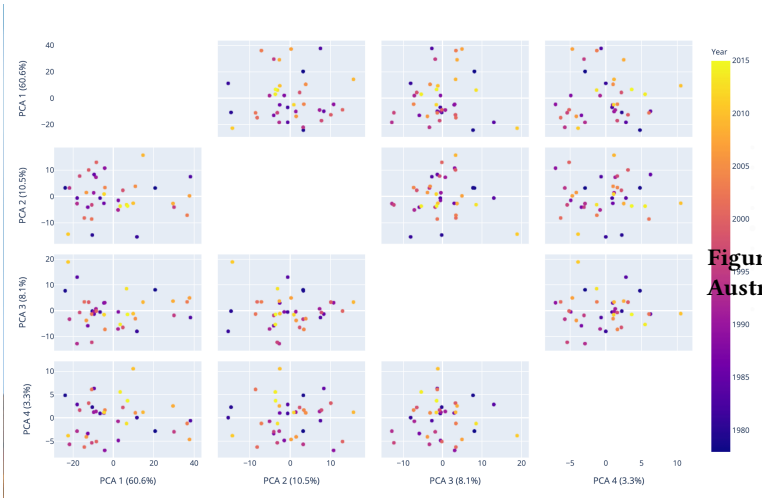

Figure 10: Principal Component Analysis of FTP from different regions of Australia

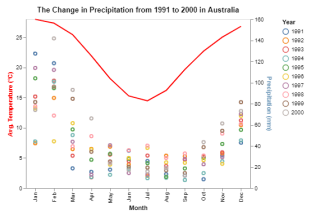

Figure 11: The Change in Precipitation from 1991 to 2000 in Australia

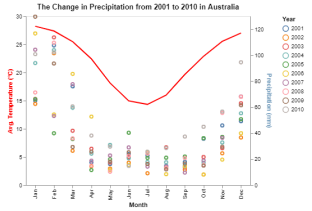

Figure 12: The Change in Precipitation from 2001 to 2010 in Australia

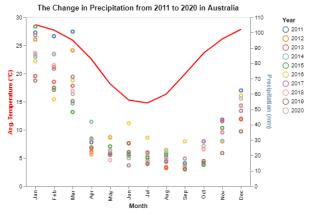

Figure 13: The Change in Precipitation from 2011 to 2020 in Australia

variance we don't see any clusters of points or any clear separation between the different years, meaning there is no special relationship between the different years of climate change effect on wheat production. This suggests that over the years there is high climate variability in different regions of Australia.

5 HOW DOES CLIMATE CHANGE AFFECT PRECIPITATION?

Current climate models indicate that rising temperatures will intensify the Earth's water cycle, increasing evaporation. Increased evaporation will result in more frequent and intense storms, but will also contribute to drying over some land areas. As a result, storm-affected areas are likely to experience increases in precipitation and increased risk of flooding, while areas located far away from storm tracks are likely to experience less precipitation and increased risk of drought. [7]

6 WHY IS PRECIPITATION IMPORTANT FOR THE PRODUCTIVITY OF AUSTRALIAN FARMS?

Rain is usually seen as a benefit to crops and fields, but there is an ideal amount of rainfall in any given growing season for most crops. If the average rainfall is much lower or higher than the ideal, it can lead to significant problems, from drowned crops to lower yields. Drought can kill crops and increase erosion, while overly wet weather can cause harmful fungus growth. The higher temperatures lead to more evaporation, so increased precipitation will not necessarily increase the amount of water available for industry.

7 HOW DOES THE CHANGE OF PRECIPITATION AFFECT THE FARMS?

The Visualization shows that a warming climate will increase the severity of rainfall in Australia, the higher the temperature is, the higher the precipitation is. It also shows that the average temperature is slowly increasing over time. A warmer climate increase soil evaporation, exacerbating droughts even in the absence of reduced precipitation.[10] Even though the TFP is constantly increasing due to economic growth and advanced technology, but the extreme climate change in precipitation will still affect the TFP.

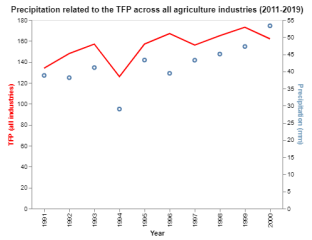

Figure 14: The Change in Precipitation related to the TFP from 1991 to 2000 in Australia

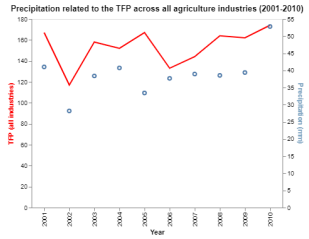

Figure 15: The Change in Precipitation related to the TFP from 2001 to 2010 in Australia

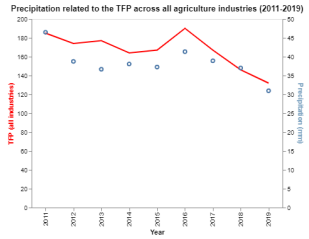

Figure 16: The Change in Precipitation related to the TFP from 2011 to 2020 in Australia

8 WHAT'S TREND IN PRECIPITATION REFLECT THE AUSTRALIA TFP ACROSS ALL AGRICULTURE INDUSTRIES?

The visualization above shows that higher precipitation increases Australia's TFP in general. The higher the precipitation, the higher the TFP is. For example, we can see the out-liners in the years 1994 and 2002, They have one of the lowest precipitations, because of that, the average TFP across all industries decreased in agricultural production. After researching, I found out that there's a drought in Australia during 2002-2003 [6], which shows that precipitation is indeed important for farms. Even though the temperature is slowly increasing every year, the precipitation is not increasing, and it has a downward trend in Australia.

9 WHAT WOULD HAPPEN IF THE CLIMAX CONTINUES TO WARM AND THE PRECIPITATION CONTINUES TO DECREASE?

Agriculture is strongly influenced by weather and climate. If the climax keeps changing, it will threaten the established aspects of farming systems. Low precipitation and a warm climate can result in dry soil, shallow streams, and shortages of municipal water supplies, which would lead to hunger. Therefore, we must act before it's too late.

10 RELATIONSHIP BETWEEN INPUT, OUTPUT, SEA SURFACE TEMPERATURE, SURFACE AIR TEMPERATURE AND THE TFP (TOTAL PRODUCTIVITY FACTOR) IN AUSTRALIA FROM 1977 TO 2012

As we talk about the impact of climate change in the agricultural production , it is convenient to analyze the anomalies in see-surface temperatures and surface air temperatures in the same Australia region. We will then observe what is the relationship between the variables 'Input', 'Output' , 'TFP', 'see-surface temperatures' and 'surface air temperatures' that we think participated in the overall productivity in cropping over the period of 1977 to 2012. We will finally be able to answer the following question: Do the variations in see-surface temperatures and surface air temperatures affect the TFP?

For the data, we collected two different data from two different sources that we cleared and matched based on the time (year).

Before we find relationships if there are any, we want to be curious to see between the 'Pie chart' and the 'Line chart', which one will help us better determine the year in which we have more TFP. To get a result, we have to apply these two methods to our data. These are our findings:

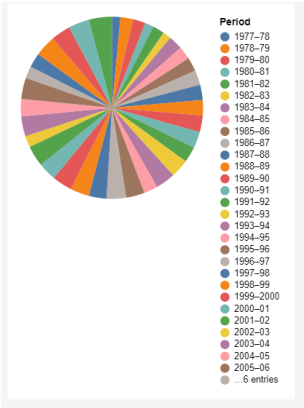

Figure 17: Pie chart TFP from 1977 to 2012

and

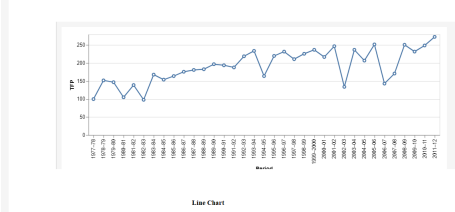

Figure 18: Line chart TFP from 1977 to 2012

In our actual case we see it difficult to read the Pie chart vs easy to read the Line chart and the year of more TFP is 2011-12. Our curiosity is then satisfied.

Now to find the different relationship that we want, we use the scatter plot visualization. Let start by observing the relationship between the input, the output and the TFP (Total Productivity Factor) in Australia from the year 1977-78 to year 2011-12.

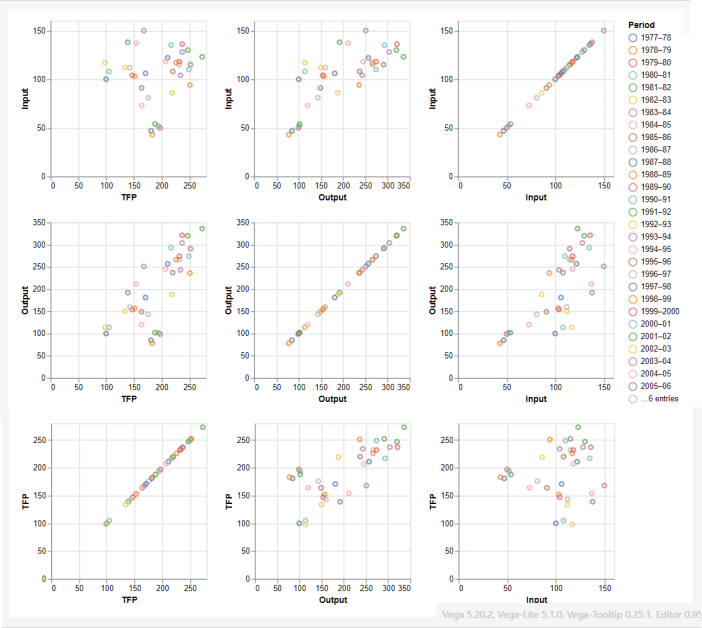

Figure 19: Relationship between Input, Output, TFP from 1977 to 2012

From the image above, we see that there is no direct relationship between the Input and the TFP. We are saying that because the dots are all over the place. For the relation between the input and the output, we can say that it exists, but it is not strong. We see that for most of the time, when the input increases, the output also increases. We have the same argument when it comes to what is the relationship between the output and TFP. The increase of the output also shows an increase in the TFP.

Using the same method, let us find if there is a relationship between the variations of the see surface temperatures and those of the surface air.

The plot reveals that there is no relationship in between variations of the surface air temperatures vs the see surface temperatures. We ca see how dots are all over the place on the plot.

Now let us observe the relationship between the variations of the surface air temperature vs see surface temperature vs TFP for the period of 1977 to 2012.

The following is the visualization that we generated for the analysis:

These visuals also confirm the fact that there is no relationship between the changes in temperatures of the see surface vs the surface air. Also, we can observe that there still no relationship between the variation of the TFP vs the Surface air temperature.

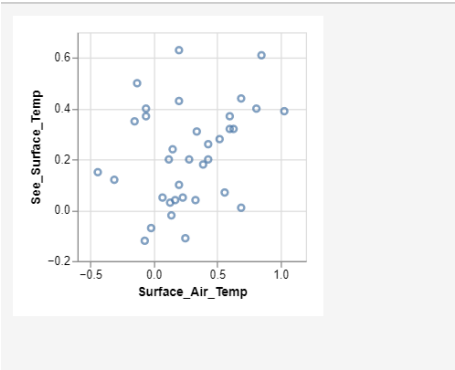

Figure 20: Relationship between Surface air and see surface temperatures from 1977 to 2012

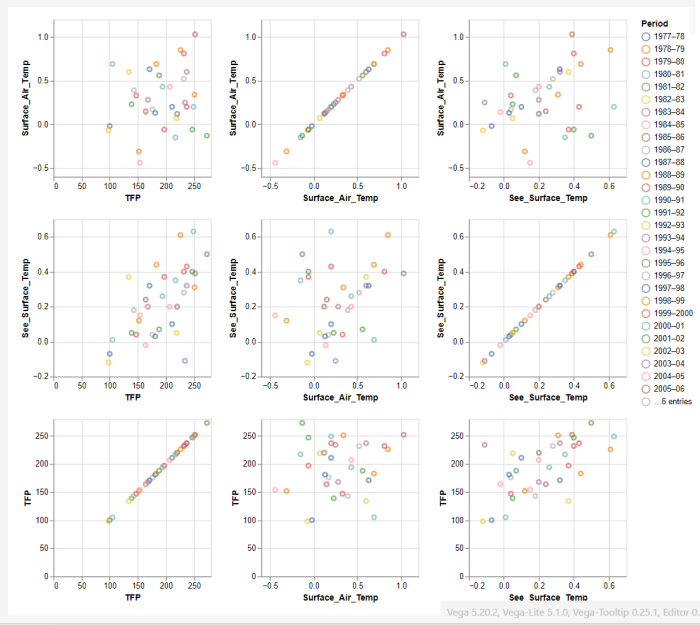

Figure 21: Relationship between see surface, air surface and TFP from 1977 to 2012

Burt surprisingly, the is some light relationship between the variations on the see surface vs the TFP. We can start thinking that the variation of the see surface's temperature affect the overall TFP.

11 HOW HAVE DROUGHTS AFFECTED BROADACRE INDUSTRY IN AUSTRALIA?

Australia's agriculture sector faces number of pressures, including climate variability, declining terms of trade and increased international competition [1]. As the sector is highly export oriented – with around two-thirds of agricultural production exported – remaining profitable and sustainable is an increasing challenge for Australian farmers [1]. In 2006-07, agricultural exports were valued at 27.6 billion dollars and accounted for 16 percent of merchandise

exports [1]. To maintain export competitiveness in the medium and longer term, ongoing productivity growth is crucial for Australian farmers [1].

ABARES (Australian Bureau of Agriculture and Resource Economics and Sciences) produces estimates of total factor productivity (TFP) growth for the broadacre and dairy industries using a unique data-set of farm-level records collected through its farm survey program [3]. This data set allows a detailed estimation and analysis of productivity and factors that affect productivity at the agricultural and industrial level [3].

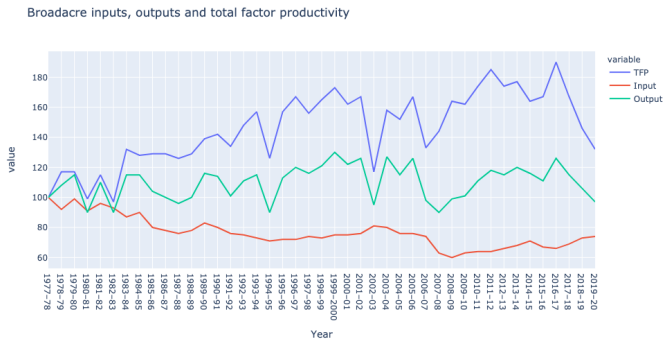

Figure 22: Broadacre inputs, outputs and total factor productivity

From 1977–78 to 2019–20, the total factor productivity growth in the broadacre sector averaged 1.0 percent a year. Broadacre output recorded little growth. The output growth was 0.2 percent a year while the input was -0.8 percent a year. We can conclude that the broadacre productivity growth has been driven by declining input use. Broadacre productivity growth slowed between 1998–99 and 2004–05, in part due to drought during the 2000s. Productivity returned to growth between 2005–06 and 2011–12 before slowing down again in recent years between 2017–18 and 2019–20. The slowdown in growth can be attributed to drought years.

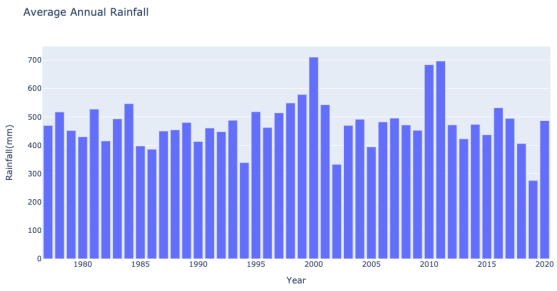

Figure 23: Average Annual Rainfall

Agricultural productivity volatility is often caused by water availability, especially when drought causes water to be a limiting factor to production [1]. In this project, the water availability will be the climate change variable. We utilized the dataset of the average annual rainfall in Australia. I have created a visualization showing the average annual rainfall in millimeter from 1978 to 2020. the average rainfall was noticeably low in 1994, 2002. 2005 and 2019. In fact, the average annual rainfall in 2019 was in significant drought as it had the lowest rainfall level since 1978. We can see that during these drought years the total factor productivity was decreasing from its previous year. Therefore, broadacre productivity growth slowed between 1998–99 and 2004–05, in part due to drought during the 2000s.

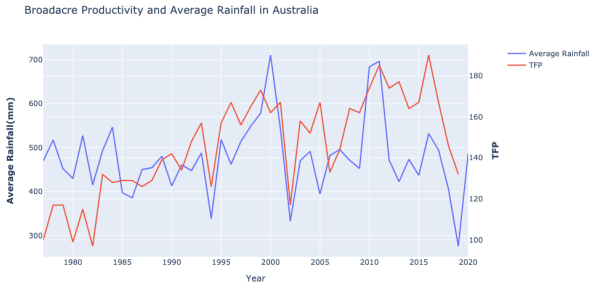

Figure 24: Average Annual Rainfall

In order to see how agricultural productivity changes with regards to the water availability throughout the years, we created a visualization with two y-axes to take account for the average rainfall and total factor productivity and the x-axes is the years. The effect of average annual rainfall on Australian broadacre total factor productivity is evident in this visualization, which demonstrates that when water is a limiting factor to production—such as during a prolonged drought– the effect is reflected in the total factor productivity. The strong correlation or direct relationship between water availability (on the right axis) and the total factor productivity (on the left axis). The two traces on the visualization follow the same pattern since rainfall the independent variable have a direct relationship on dependent variable average rainfall. For example, the total factor productivity fell between 2017- 2020 because the average annual rainfall was decreasing during these years. Similarly, the total factor productivity increased between 2011- 2012 because the average annual rainfall was decreasing during these years.

The strong correlation occurs between rainfall and total factor production is because water (specifically, rainfall) is not included as an input to production [3]. This is because rainfall is neither a market input nor under the control of farmers. This means that when drought causes water to be a limiting factor to production, the measured quantity of inputs generally falls, if at all, by less than the measured quantity of outputs, and so total factor productivity falls [3].Therefore, droughts have an negative impact on the broadacre productivity.

12 CONCLUSION

In conclusion, we have have analyzed the temperature and how climate change affects different agricultural industries in Australia.

We discovered that climate change has a big affect on Australia, specifically on its agricultural production. This suggest that if temperature continues to increase, it will have a big impact on global food security. We also discovered that dry regions are affected more than wet regions when temperature increases and that over the years there has been high climate variability in different regions of Australia. In addition, warming climate will increase the severity of rainfall and lower precipitation will decrease the Australia's TFP in general. Also, we found that severe droughts cause water and rainfall to be a limiting factor to agricultural production. Finally, this project demonstrate the importance of continuing to analyze the effects of climate change in agriculture around the the world.

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