1 Introduction

For this past century climate change has become concerning topic. This can be seen from the increase of global temperature over time which might harm the humans, flora, fauna and earth itself. According to IPCC (1990), climate change can be defined as gradual changes on climate due to human intervention or natural variability. The phenomenon mainly happens because the increase of carbon dioxide and CFC or chlorofluorocarbon which caused the earth warming for past centuries. Karl, Melillo & Peterson (2009) believed this trend has started since mid-1700, primarily it comes from emission such as burning fossil fuels and forest fire or deforestation. It is also believed that these issues could release more carbon dioxide into the atmosphere which is concerning. Moreover, in 1860 Mitchell (1989) found out the surface temperature has raised by 0.5 degree Celsius due to the increased of CFC and carbon dioxide gasses on the atmosphere. From the research, it is also estimated that global temperature could raise up to 1.5 degree Celsius in the next 40 years.

However, nowadays as we are living in cutting-edge world where electricity as primary needs and horde of new technologies were invented. This might address challenges for earth on maintaining average temperature. One example is the excessive use of air conditioner and refrigerator which might increase global temperature. This is due to the extensive amount of CFC come from both electronics which result in ozone depletion (Karl, Melillo & Peterson, 2009). Another side effects could occur from rising temperature. For instances,

- the increase of the sea level due to melting ice in the Antarctica and Artic,
- drought which is bad for vegetation or agriculture,
- many living things unable to survive in certain high temperature which lead to extinction,
- and less fresh water river flowing due to evaporation.

As I stated before, many factors that could affect climate change. In this report, I will focus on deforestation effect to the climate change and discuss the data that we have obtained.

2 Deforestation

2.1 Background of Deforestation and Climate Change

Before jumping into the connection of deforestation with climate change. First, we need to understand more about deforestation. Deforestation has recently become a major problem in the world. One of the reasons is because the vast growing population each year. Since the earth have limited resources of land, most tropical forest in this world was cut down to build neighbourhood or skyscraper. Another similar finding by Malhi et al. (2008), as the palm oil plants are only suitable to grow in wet climates and acidic soils, many of southeast Asia rainforests were cut down and replaced by palm oil tree. By clearing these forests many habitants lose their home or living place which end up could kill them. Besides that, by heavy cutting forest it means we lost places to store carbon which eventually it will rise up and dwell with the atmosphere. Therefore, this is the start of climate change.

Since on the atmosphere there are layers that protects the earth from heat and cold. When the atmosphere experiencing the excess carbon, the blanket of heat-trapping gasses in the atmosphere is thickened (Karl, Melillo & Peterson, 2009). This will eventually reflect to the earth as increased heat or we could say temperature rise.

2.2 Cause of deforestation

- **Human Activities**

  Above we stated whether the forest was cut down to make way for palm oil plantations. According to Okia (2012) not only palm oil, another agriculture such as rubber and timber also reason of deforestation by human. The incentive behind this is to maximize profits within the agricultural sector. However, most of factories did not realize if it will worsen the earth in the long term. Moreover, we also stated that forests are cut down as the result of growing urban sprawl. The land is later developed into houses and road access. This is more concerning compare to plantation since more emission will be produced from these areas. Another concerning issue is illegal logging or illegal forest practices by several irresponsible forestry officers. They tend to have contracts with

private enterprises. The contracts could be varied such as, smuggling forest products across border, under-declaring volume of trees cut and selling illegal harvesting permit (Okia, 2012). These are the example due to human activities.

- **Natural Variability**

  On the other hand, tree destroyed or deforestation also might cause by the nature itself. One of the foremost instances is due to natural wildfires. This mostly happens recently around 21th century, because the increased temperature of earth. This is very concerning since the tree itself already reach its limit on conserving heat which eventually overheating. Tsitsoni (1996) added, in Greece Pinus Halepensis forest or pine forest was experiencing wildfires due to climatic conditions in the summer with high temperatures and drought. It is also believed this type of tree is highly flammable which cause certain areas always burnt every year. Similarly, Hall (2007) found out in 1990 to 1998, more than 15.000 trees was naturally ignited by wildfires in Arizona and New Mexico. It is observed the fires came from the struck of lightning into the trees. They also found out the reason is due to fuel presence on the vegetation and the dryness or low moisture on the tree.

2.3 Why Forest is important to climate change?

There is belief whether having forest will increase the rainfall rate, or deforestation reduces rainfall. Nasi, Wunder, & Campos (2002) proof it by showing that forest has evapotranspiration which is one of the crucial roles in water recycling process. Evapotranspiration is the water evaporation from land and ocean to atmosphere. Therefore, water that being stored in the forest trees will help the cycle going and keep the drought or temperature rise. Moreover, many Brazilian cities still rely on the water cycles through South American Rainforest which has been key to their water supply.

Beside store water, forest also works as carbon storages. Most of the time carbon can be referred as carbon dioxide. However, tree not only absorbing carbon dioxide that human exhale but also the heat-trapping greenhouse gasses that human emits. It is estimated that a closed primary forest can store 250

tons of carbon per ha (Nasi, Wunder, & Campos, 2002). When it is converted to swidden agriculture, it will release 200 tons of carbon into the atmosphere. If we refer back to the reason of climate change this carbon will thicken the blanket of heat trapping gasses which increased the earth's temperature eventually.

3 Data Collection

First to explain the deforestation, data on how large the forest is covered and deforestation in every country. Below is the data,

Country	Total forest area (km^2)	Percent of world total	Deforestation rate, 1970s (km^2)	Percent of world total	Deforestation rates, late 1980s			
					Myers (km^2)	Percent of world total	WRI (km^2)	Percent of world total
Brazil	3,562,800	30.7	13,600	19.7	50,000	36.1	80,000	48.4
Indonesia	1,135,750	9.8	5,500	8.0	12,000	8.7	9,000	5.4
Zaire	1,056,500	9.1	1,700	2.5	4,000	2.9	1,820	1.1
Peru	693,100	6.0	2,450	3.6	3,500	2.5	2,700	1.6
Columbia	464,000	4.0	8,000	11.6	6,500	4.7	8,200	5.0
India	460,440	4.0	1,320	1.9	4,000	2.9	15,000	9.1
Bolivia	440,100	3.8	650	1.0	1,500	1.1	870	0.5
Papua, New Guinea	337,100	2.9	210	0.3	3,500	2.5	220	0.1
Venezuela	318,700	2.7	1,250	1.8	1,500	1.1	1,250	0.8
Burma	311,930	2.7	920	1.3	8,000	5.8	6,770	4.1
Others*	2,829,930	24.4	33,300	48.3	44,100	31.8	39,610	23.9
Total	11,610,350	100.0	68,900	100.0	138,600	100.0	165,440	100.0

*Sixty-three other countries.

Figure 1: *The total forest area. The deforestation rate in 1970 based on Food and Agriculture Organization. The deforestation in 1980 is according to Myers and World Recourses Institute.* (Skole and Tucker, 2010)

As we can see, Brazil has the highest forest covered in the world with 3.562.800 km^2 which followed by Indonesia and Zaire with 1.135.750 km^2 and 1.056.500 km^2 respectively. We know the reason Brazil contain the most of world's forest which is Amazon forest that located in Brazil. Amazon forest determine as the host almost 25% of the world's species and account for 15% of global photosynthesis (Malhi et al., 2008). If we consider the fact, we can say that Brazil forest has important role as carbon storage with 30.7% of world's forest covered.

We also can see the deforestation rate in both 1970 and 1980. In 1970 the total deforestation rate reached 68.900 km^2. However, in 1980 there is dramatic increase for both Myers and WRI with 138.600 and 165.440 respectively. Apparently, both has different value but here we are going to use WRI to measure since WRI has been focusing on deforestation due to climate change.

Next due to the deforestation we want to estimate the carbon loss from tropical forest loss. Many findings from 1980 -1990 data, below is the data,

	Houghton (1999)	Fearnside (2000)	Malhi & Grace (2000)	DeFries *et al.* (2002)	Achard *et al.* (2002)
region	1980–1990	1981–1990	1980–1995	1980s	1990–1997
America	0.55 ± 0.3	0.94	0.94	0.37	—
Africa	0.29 ± 0.2	0.42	0.36	0.10	—
Asia	1.08 ± 0.5	0.66	1.08	0.18	—
total	1.90 ± 0.6	2.00	2.40	0.65	0.64 ± 0.21

Figure 2: *Estimates of carbon loss (Gigatons carbon per year) due to deforestation in 3 regions among the time period.* (Cramer et al., 2004)

DeFries et al., (2002) shows initially in 1980s the carbon emission still low for all 3 regions where America produces the most with 0.37 gigatons carbon per year. For the first three findings, they have similar time period which is around 1980 - 1990s, where all the 3 regions emit more average carbon per year compare to 1980s only with total estimate of 2 gigatons carbon per year. This indicates that in 1990s more tree were cut and more carbon loss which might affect global temperature eventually. Finally, Achard et al. (2002) did not give enough information for analyse, yet the carbon loss reduces to the total estimate of 0.64 gigatons carbon per year.

Next, for carbon dioxide emission from forest loss from 2001 to 2017. Below is the data,

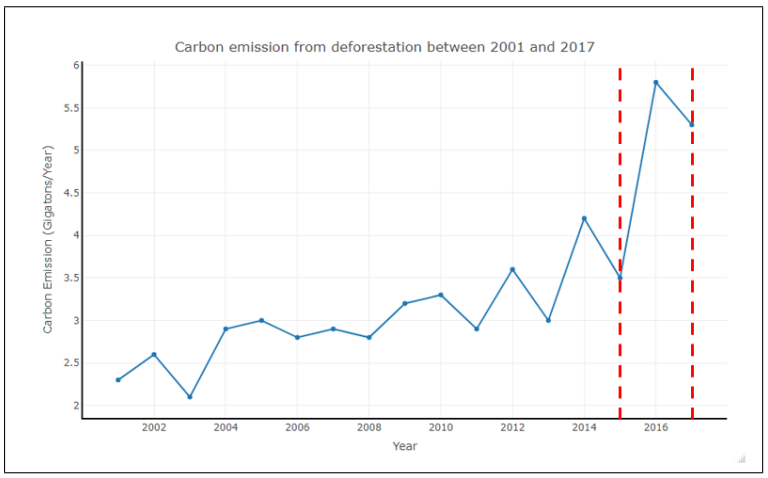

Figure 3: *Average of annual carbon emission from forest tree attribute to deforestation from 2001 to 2017.* (Seymour and Busch, 2016)

The data shows the extension from previous findings. As we obtained last, from 1990 – 1997 we have total carbon being emitted is approximately 0.64 gigatons per year. In the graph above, it started with slightly over 2 gigatons carbon per year in 2001. It keeps fluctuate across the years until 2015. There is sudden jump in 2016 from around 3.5 gigatons carbon per year to almost 6 gigatons carbon per year. Ending with a slight drop around 5.5 gigatons carbon per year in 2017. From the trend 2015 to 2017 we can see there is 63% higher than usual average carbon emission for past 14 years. This might show in 2015 to 2017 there is huge forests loss in the world. This could be found in further research.

For the further research, we have found the data of amazon deforestation from 1988 to 2017 which maybe could support the reason on sudden increase in carbon loss from 2015 to 2016. The reason we choose amazon forest is because it is the largest rainforest in the world and it can represent the world carbon emission. Below is the data found in Mongabay website which is environmental science webpage that extend their feature information about tropical rainforests and deforestation statistics,

year	sq km	change
1988	21,050	
1989	17,770	-16%
1990	13,730	-23%
1991	11,030	-20%
1992	13,786	25%
1993	14,896	8%
1994	14,896	0%
1995	29,059	95%
1996	18,161	-38%
1997	13,227	-27%
1998	17,383	31%
1999	17,259	-1%
2000	18,226	6%
2001	18,165	0%
2002	21,651	17%
2003	25,396	19%
2004	27,772	9%
2005	19,014	-31%
2006	14,285	-49%
2007	11,651	-18%
2008	12,911	11%
2009	7,464	-42%
2010	7,000	-6%
2011	6,418	-8%
2012	4,571	-29%
2013	5,891	29%
2014	5,012	-15%
2015	6,207	24%
2016	7,893	27%
2017	6,624	-16%

Figure 4: *The area of amazon deforestation with percentage change from 1988 to 2017.* (Mongabay)

As we can see from **Figure 4**, in 2016 it has total rise of 27% which has positive result with the outcome from **Figure 3**. Since **Figure 3** consists of all tropical forest in the world and **Figure 4** only consider amazon rainforest, therefore there are some contrast results between **Figure 3** and **Figure 4**. However, the trend that we want to point out is proven since amazon experiences more deforestation on 2016 compare to 2015.

4 Data Analysis

On data analysis part, we try to fit regression model to the amazon deforestation data by setting output (y) = Total Area Deforestation and input (x) = Year. Using **Figure 4** as initial data, we put into R-studio and run the **glm()** command which is the fitting linear regression model. Moreover, use the **predict()** function on top of our linear model will give us the figure below (setting year until 2030),

Year	Current Data	Prediction
1988	21050	20818
1989	17770	20368
1990	13730	19917
1991	11030	19466
1992	13786	19015
1993	14896	18564
1994	14896	18113
1995	29059	17662
1996	18161	17211
1997	13227	16760
1998	17383	16309
1999	17259	15858
2000	18226	15407
2001	18165	14956
2002	21651	14505
2003	25396	14054
2004	27772	13604
2005	19014	13153
2006	14285	12702
2007	11651	12251
2008	12911	11800
2009	7464	11349
2010	7000	10898

Year	Current Data	Prediction
2011	6418	10447
2012	4571	9996
2013	5891	9545
2014	5012	9094
2015	6207	8643
2016	7893	8192
2017	6624	7741
2018	*NA*	7290
2019	*NA*	6840
2020	*NA*	6389
2021	*NA*	5938
2022	*NA*	5487
2023	*NA*	5036
2024	*NA*	4585
2025	*NA*	4134
2026	*NA*	3683
2027	*NA*	3232
2028	*NA*	2781
2029	*NA*	2330
2030	*NA*	1879

Figure 5: *Comparison of total area attribute to amazon deforestation for current data and prediction from 1988 to 2030.*

The prediction shape into straight line since the input function is only year and it is linear. Therefore, if we plot the data it will generate us such figure below,

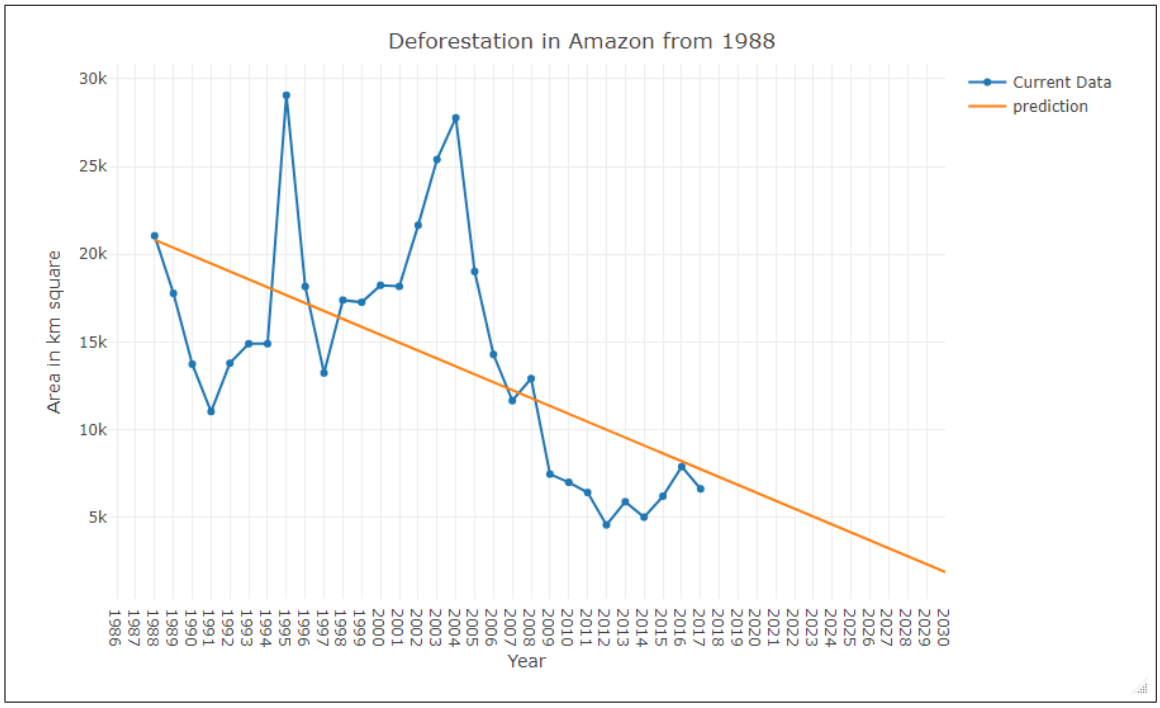

Figure 6: *Line graph between the comparison of current and prediction data for total area of Amazon deforestation.*

The blue line shows the current data we obtained from the Mongabay website. Despite reaching the peak nearly 30.000 km^2 in 1995. Amazon managed to recover by cutting the tree loss until below 15.000 km^2 in 1997. However, in 2005 there is rise of felled tree with approximate area of 27.500 km^2. Since then it decreased significantly and reached area over 7.500 km^2 in 2016.

The orange line shows the prediction data we create in R-studio. The data is a linear regression line we obtained to the subject of deforestation area. As we can see, after 2017 it is predicted that the number of felled trees in Amazon rainforest will decrease significantly until it reaches approximate 2.500 km^2 in 2030. This result show positively that deforestation in amazon would getting lower and lower in the future.

However, this not always be true since natural disaster is random occurrence and it can happen in the nick of time. Similarly, since human

population is growing every day. There would be moment where more illegal activities or irresponsible human deeds that might ruin the forests for their own benefits. So, these moments could happen anytime. Furthermore, in the **Figure 6** it can be seen from the sudden growth in total deforestation areas on 1995 and 2005.

5 Discussion

Since the global earth's temperature is guarantee to increase annually, it is very concerning if in the future the condition gets worsen. This is because the aspect of climate change is not only due to deforestation, yet more other greenhouse gasses produced by human activities such as burning fossil fuel, using refrigerator or air conditioner and aerosol spray. These activities might also release certain greenhouse gasses which going to be trapped in the atmosphere and eventually it will affect our earth's temperature.

If we can keep one factors like deforestation out of the temperature rise equation. Probably, in the future the earth warming will be slower than expected. Since, trees and forests are very important assets to the earth with their function to store carbon, release oxygen, keep environment stable (away from heat or drought), and maintain the water cycle. Thus, deforestation plays very huge part in the climate change nowadays.

To tackle this problem there are some ways we can do to preserve the forests such as,

- plant more trees,
- buy product that has the attribute of 3R (Reuse, Reduce and Recycle),
- buy certified wood product as it is trusted and legal company,
- and lastly, we can raise awareness on community or circle.

In January 2020, there is recent instance where a youtuber star self-challenge to raise over 6 million dollars to plant trees around the world. Eventually, due to his popularity a total of 20 million dollars which equally to 20 million trees was raised. Those trees later were planted on National Park in United States. As we can see, it is possible by doing simple act such as

planting tree and share awareness. This could help to preserve our earth in the future by slowing the temperature rise.

6 Conclusion

Deforestation has positive effect to climate change. Since, we know forest has huge role on balancing both the ecosystem and global temperature. It is estimated whether in 2030 it will be less forest being cut on Amazon rainforest. Despite that the human activities and natural variability on deforestation is inevitable. Company and irresponsible forestry officer tend to gain profit from these illegal actions. This might be prevented if countries set more strict rules towards illegal deforestation. Furthermore, plant tree, buy recycled product, buy certified wood product and raise awareness also another solution to help preventing deforestation which lead to climate change in the future.

7 Reference

Achard, F., Eva, H.D., Stibig, H., Mayaux, P., Gallego, J., Richards, T. & Malingreau, J. (2002) 'Determination of Deforestation Rates of the World's Humid Tropical Forests', Science, 297, 999-1002 [Online]. Available at: https://www.researchgate.net/profile/Philippe_Mayaux/publication/11216758_ Determination _ of_ Deforestation_ Rates_ of _ the_ World%27s_Humid_Tropical_Forests/links/0912f50cb0057798af000000.pdf **(Accessed: 13 April 2020)**

Cramer, W., Bondeau, A., Schaphoff, S., Lucht, W., Smith, B. & Sitch, S. (2004) 'Tropical forests and the global carbon cycle: impacts of atmospheric carbon dioxide, climate change and rate of deforestation', Philosophical transaction of the royal society of London, 359(1443), 331-343 [Online]. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1693328/pdf/15212088.pdf **(Accessed: 11 April 2020)**

DeFries, R.S., Houghton, R.A., Hansen, M.C., Field, C.B., Skole, D. & Townshend, J. (2002) 'Carbon emissions from tropical deforestation and regrowth based on satellite observations for the 1980s and 1990s', PNAS, 99(22), 14256-14261 [Online]. Available at: https://www.pnas.org/content/pnas/99/22/14256.full.pdf **(Accessed: 13 April 2020)**

Hall, B.L. (2007) 'Precipitation associated with lightning-ignited wildfires in Arizona and New Mexico', International Journal of Wildland Fire, 16(2), 242-254 [Online]. Available at: https://doi.org/10.1071/WF06075 **(Accessed: 13 April 2020)**

IPCC (1992) 'CLIMATE CHANGE: The 1990 and 1992 IPCC Assessments', Canada, World Meteorological Organization/ United Nations Environment Programme [Online]. Available at: https://www.ipcc.ch/site/assets/uploads/2018/05/ipcc_ 90_ 92_ assessments_ far_ full_ report.pdf **(Accessed: 10 April 2020)**

Karl, T.R., Melillo, J.M. & Peterson, T.C. (2009) 'Global Climate

Change Impacts in United States', Ambridge University Press [Online]. Available at: http://aquaticcommons.org/2263/1/climate-impacts-report.pdf **(Accessed: 11 April 2020)**

Malhi, Y., Roberts, J.T., Betts, R.A., Killeen, T.J., Li, W. & Nobre, C.A. (2008) 'Climate Change, Deforestation, and the Fate of the Amazon', Science, 319, 169-171 [Online]. Available at: http://web.natur.cuni.cz/fyziol5/kfrserver/global/pdf/2008%20Malhi_ CC,%20Deforest%20fate%20of%20amazon.pdf **(Accessed: 11 April 2020)**

Mitchell, J.F.B. (1989) 'The Greenhouse Effect of Climate Change', American Geophysical Union, 27, 115-139 [Online]. Available at: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/RG027i001p00115 **(Accessed: 11 April 2020)**

Nasi, R., Wunder, S. & Campos A. J.J. (2002) 'Forest Ecosystem Services: CAN THEY PAY OUR WAY OUT OF DEFORESTATION', Bogor, CIFOR for the Global Environmental Facility (GEF) [Online]. Available at: https://vtechworks.lib.vt.edu/bitstream/handle/10919/66870/2379_ Nasi2002_ Forest_ ES_ pay_ deforestation.pdf?sequence=1 **(Accessed:13 April 2020)**

Okia, C.A. (2012) 'GLOBAL PERSPECTIVE ON SUSTAINABLE FOREST MANAGEMENT', Rijeka, InTech [Online]. Available at: https://www.researchgate.net/profile/Gopal_ Shukla2/publication/224830694_ Deforestation_ Causes_ Effects_ and_ Control_ Strategies/links/0deec53a13ffa765fc000000/Deforestation-Causes-Effects-and-Control-Strategies.pdf **(Accessed: 13 April 2020)**

Seymour, F. & Busch, J. (2016) 'WHY FOREST? WHY NOW?', Washington DC, Center for Global Development [Online]. Available at: https://www.cgdev.org/sites/default/files/Seymour-Busch-why-forests-why-now-full-book.PDF **(Accessed: 14 April 2020)**

Skole, D. & Tucker, C. (2010) 'Tropical Deforestation and Habitat Fragmentation in the Amazon: Satellite Data from 1978 to 1988', Science, 260(5116), 1905-

1910 [Online]. Available at: https://pdfs.semanticscholar.org/8c52/e59f79f13c5e1934ecef77d30af4
(Accessed: 14 April 2020)

Tsitsoni, T. (1996) 'Conditions determining natural regeneration after wildfires in the Pinus Halepensis forests of Kassandra Peninsula (North Greece)', Forest Ecology and Management, 92(1997), 199-208 [Online]. Available at: http://users.auth.gr/users/5/9/050495/public_html/files/eng/61%20Forest%20ecology%20and%20Managment.pdf
(Accessed: 12 April)