Low Carbon Agriculture

Nowadays, the term "Climate Change" has been brought out frequently, yet many organizations still define it distinctively which led to ambiguity. To make it simple, "Climate Change" is a phenomenon of long-term change in the average weather patterns which defines our global climates (NASA)[1]. For example, since our earth's temperature is keep rising each year, this phenomenon can be defined as climate change. Generally, climate change is popular being associated with the negative and harmful towards social and environmental sector. This issue not just linger only for short-term but also the future which have become concerned for our society. NASA[1] observed the changes of earth's climate occurred since 20th century, primarily due to the human activities. The European Union[2] also added the greenhouse gas effect is the main driver of the climate change. They also believed human activities are the reason why the concentration of the greenhouse gases like CO_2, CH_4, N_2O and F-gases increased. Nevertheless, there are many different sectors of human activities that influence the earth's temperature such as transportation, energy usage, agriculture, building and manufacturer. In this report we are going to focus precisely on the agriculture sector include addressing the issues with solution to reach future sustainable agriculture.

It is inevitable that agriculture has become essential sector towards world economy and welfare. In China, agriculture is considered as the basis of the national economy (Zhu, 2002)[3]. However, conventional agriculture still exists nowadays which is the main reason of climate change. Beside its inefficiency, it also produced large amount of carbon emission equivalent from the greenhouse gases. Cheng and Pan (2021)[4] found arable and livestock farming account for 10%-12% of global emissions of carbon dioxide equivalents (CO_2e). Both Methane (CH_4) and Nitrous Oxide (N_2O) are considered as the main agriculture emission. Below graph shows the 2 gases (CH_4 & N_2O) produced by China agriculture sector between 2007 and 2018.

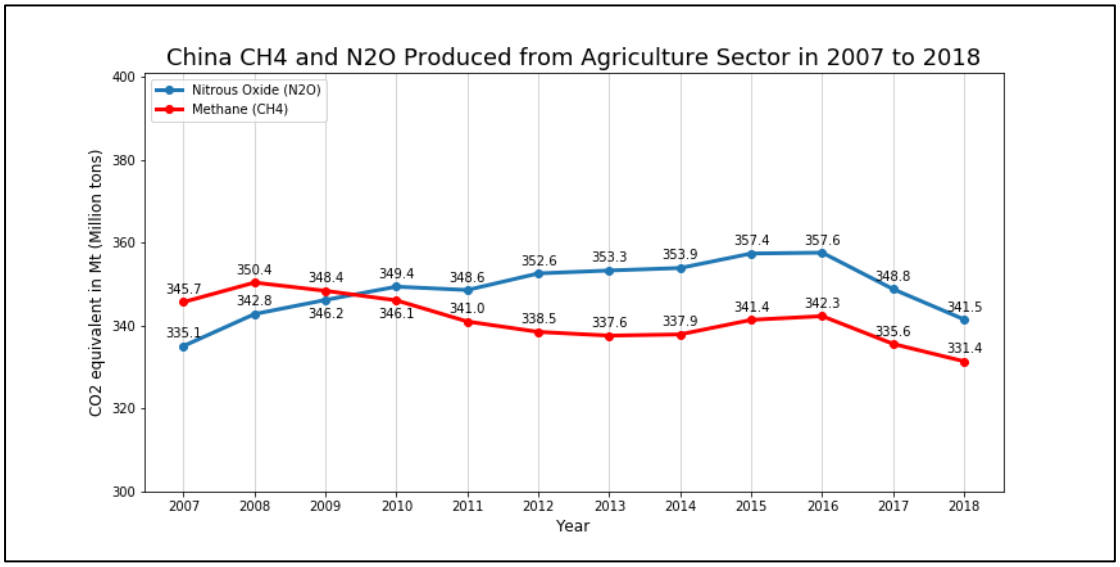

Figure 1. *Methane (CH_4) and Nitrous Oxide (N_2O) produced by China's Agricultural Sector from 2007 to 2018* (Source: Climate Watch)[5]

The data is originally from (Climate Watch)[5], all measurements are converted to CO_2e million tons for comparing reason. The red line represents the Methane (CH_4) production, whereas the blue line represents the Nitrous Oxide (N_2O) production. As we can see, in 2007, methane production is only 10 CO_2e Mt over nitrous oxide production. However, in the mid-2009 the

total of nitrous oxide took over the methane. Similar finding from Cheng and Pan (2021)[4], they estimated in 2010, the China's agriculture actually produced 45% methane emissions which mainly from rice farming, livestock manure and crop stubble breakdown. The remaining 55% was nitrous oxide which came from non-organic fertilizer use, manure and chemical pesticide. Later in 2016, methane and nitrous oxide reached a peak at 342.3 CO_2e Mt and 357.6 CO_2e Mt respectively. However, it began to decrease since 2016 due to restriction of GHG emission and future goals for low carbon agriculture declared by the Chinese government as well (the State Council, 2016)[6]. This also supported by Statista (2021)[7] about the chemical pesticide production for China's agriculture. She found that the production plummeted since 2015 which contribute to the fact of decreasing N_2O production since 2016. Finally, Oliver and Peters (2019)[8] believed out of the total methane produced in 2018, the 22% was actually came from the rice cultivation which was considered as the second largest agriculture methane source in China.

Beside methane and nitrous oxide, the agriculture also could produce raw carbon dioxide. Many manufacturers would like to cut down trees or forest to create new space for agriculture farm. The data below shows the carbon dioxide (CO_2) produced by China agriculture sector between 2007 and 2018.

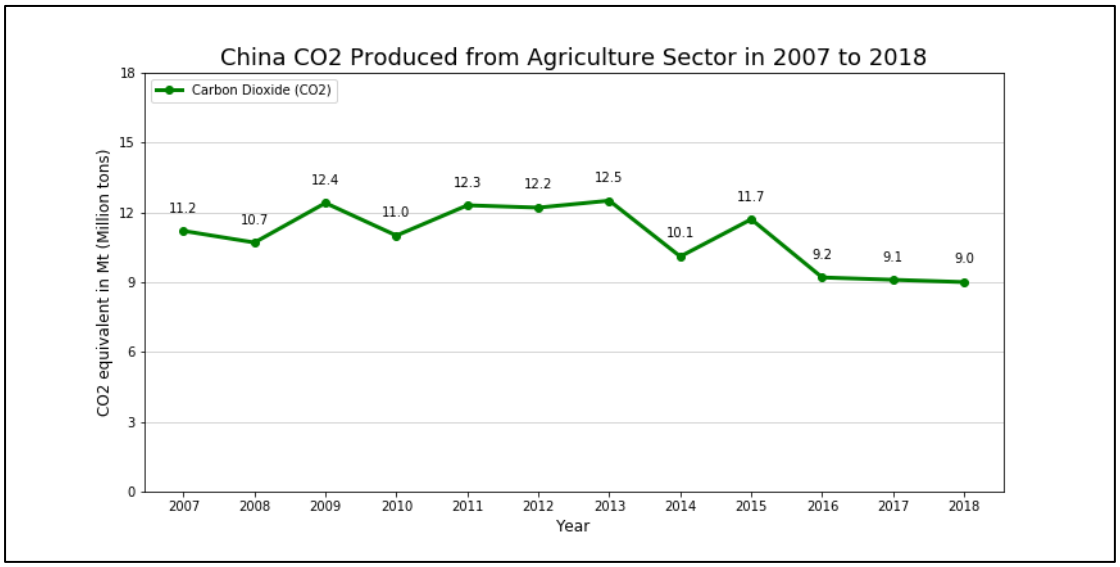

Figure 2. *Carbon Dioxide (CO_2) produced by China's Agricultural Sector from 2007 to 2018* (Source: Gutschow et al., 2021)[9]

The data is originally from Postdam Institute for Climate Impact Research (PIK). The amount of raw carbon dioxide produced from the China's agriculture sector is not too significant compared to previous gases (CH_4 & N_2O). It fluctuates through years and end up reached the lowest CO_2 production in 2018 with only 9 Mt. According to Cheng and Pan (2021)[4], the reason agriculture only emit small of carbon dioxide is due to agriculture's absorption which naturally balanced out the emission from the tree cutting.

Now we get the idea of different greenhouse gases produced by the agriculture sector and how they affect the global climate change. In the long-term, the climate change will actually ruin the agriculture sector, from production to the market price. For example, increase in temperature and random rainfall pattern could lead to inevitable drought, soil problem and water management issue. Moreover, they will affect the crops quality, productions and the

worst part is resulting in crop failures. Yu and Wu (2018)[10] stated beside the production issue, the quality such as food safety has become challenge for China agriculture sector, especially given the current degraded status of the country's soil and water resources.

Similarly, North China which is the region famous for its grain production has experienced huge production loss due to the drought since 1995 (Lin, Deng and Jin, 2013)[11]. In the long term, they also claimed consumption declines and market fluctuation are potential indirect economic effects of this natural disaster. Surprisingly, market price plays huge role on determining the production rate. This showed by Chen, Chen and Xu (2014)[12], despite the climate change influenced the rising corns and soybean prices in China, yet it just triggered the Chinese farmers to increase corns and soybean production by 7 million hectares and 2 million hectares respectively during 2001 to 2009. Despite the beneficial effect, the adverse effects of climate change on crop yields still actually far outweigh them.

It is true that climate change has become a major threat for the agriculture sector, the greenhouse gases are the reason why this climate change occur. Thus, several agreement and goals set by the world to tackle this problem. For instance, **The Paris Agreement in 2015** which adopted by 196 countries including China, aims to substantially reduce global greenhouse gas emissions and project to limit the temperatures increase only by 2 degree at the end of century. Moreover, in **2020 UN General assembly** President Xi Jinping declared that China will strive to achieve carbon peak by 2030 and carbon neutrality by 2060.

In agriculture sector, Chinese Governments also encourage the farmers to adapt on green agriculture practice by provide subsidies and incentives. In 2019 the Governments issued 5 key points for green agriculture development (MARA China, 2019)[13]. This includes promoting the green culture production, increase efficiency and prevention for agricultural pollution. Moreover, in 2021 the State Council (2021)[14] issued Guidance on Accelerating the Green, Low-carbon and Circular Development. In the section 5, they stated on improving the green agriculture development which includes reducing the agricultural pollution, improving land quality and promote healthy & integrated agricultural farming system. Similarly, in order to reach the carbon neutrality goals, the Chinese Government also declared 14th Five-Year Plan on 11 March 2021 (Xinhua Net, 2021)[15]. There is one section that they emphasized the plan to achieve zero-carbon agriculture, which is:

> **Chapter 38, Section 4:** In order to achieve 2030 carbon peak, the plan to address climate change is implemented. There are 3 key points which I found correspond to the aims for zero-carbon agriculture. First, promote cleaner, low-carbon and more efficient use of energy. Second, increase the control of greenhouse gas emission. Third, improve the carbon sink capacity. Moreover, this section also pointed out to improve the agricultural production while these plans are carried out.

As we can see, to achieve the green agriculture, it is important to thrive for the low-carbon or even zero-carbon agriculture without degraded its production and quality. Moreover, to reach the low carbon agriculture there are 2 factors that we need to consider, which are the efficiency issue and greenhouse gas issue.

One way is to promote the high efficiency agriculture, this means the efficiency from the production (input) to the results (output) need to be optimized. Normally, we would like to reduce input and increase the output efficiency.

In agriculture sector, lessen input refers to lower the production resources. In 2007, Biala et al.[16] introduced "The Low Input Farming System" which seek to optimise the management inputs and minimize the production inputs. For instance, reduce or omit the pesticides use if possible, it will save the production cost since low input, as well as create more eco-friendly and healthier product eventually. They also claimed with no soil tillage will improve the soil quality and fertility which leads to input reduction (less fertilizer use).

Moreover, one modern agriculture system has been introduced to reduce the input of the energy which is **Vertical Farming**. This technique only requires 8% of the normal water consumption used to irrigate field crops, yet it still yields 20 times of normal production (VertiCrop, 2015)[17]. However, the huge electrical bill is the drawback to this technique and due to this it possibly leaves carbon footprints as well. As modern agriculture aims to reduce carbon emission, therefore solution need to be addressed to prevent these issues.

Vertical Farming (TIME)

Increase the output is another alternative to optimized the agriculture efficiency. As we stated before, whether the Vertical Farming has yields 20 more times than the normal crop production. Furthermore, back in 1970, our deceased father of grain, Yuan Long Ping developed hybrid strains that yielded 20% more rice than conventional grains, which is very significant for the agricultural sector in China (Smith, 2021)[18]. Not only for China, these hybrid strains have influence to the world rice production which accounted about 15% in 2021. Credit for deceased Yuan Long Ping for his dedication and innovation to feed the growing planet with fewer resources.

Another way to reach low carbon agriculture is by reduce the greenhouse gas emission. Like we stated before, we found that Methane (CH_4) and Nitride Oxide (N_2O) are two major gasses that emit from the agricultural sector, yet small portion of CO_2 also produced by the agricultural sector due to balancing out. This is concerning as these gases will lead to more severe temperature increase. Therefore, there are several ways to reduce the greenhouse gases.

First, use more renewable clean energy or bio-energy agricultural technology to reduce carbon footprint. For example, Agrophotovoltaic (APV) serves as one of many solar-panel prototype innovations which specifically used in agriculture sector. Basically, it is ground-mounted solar panels built over growing crops (IRENA, 2019)[19]. According to researcher, the shade provided by the solar panels will benefit the crops. Beck et al. (2019)[20] also confirmed that APV will generate more electric production, higher crop yields and less water used. This might also provide a win-win situation for modern agriculture such as hydroponic and aeroponic. As we know that modern agriculture practices consume huge amount of electricity, yet APV could mitigate this problem by providing the high output electricity from the solar panels. Moreover, they will not leave any carbon footprint behind.

Agrophotovoltaic – APV (BayWa r.e.)

Similarly, in Beijing, Goldwind owned a Green Agricultural Park which specifically to promote low-carbon agricultural production technology. Among many technologies, they owned new energy photovoltaic power generation system as well. Moreover, soilless cultivation and three-dimensional planting technology to increase yield, less-tillage technology and crop rotation technology also available in the park (Goldwind, 2021)[21].

Second, reduce the use of chemical fertilizer and pesticide in agriculture. As both products emit reasonable amount of Nitride Oxide (N_2O). We also know that it is one of the major gas emitted by the agricultural sector. Cheng and Pan (2021)[4] recorded the nitrogen fertilizer accounted for 47% of China N_2O emission in 2014. Thus, in the 14th Five-Year Plan **Chapter 23, Section 2**; Chinese governments implemented plan to reduce fertilizer and pesticide use. (Xinhua Net, 2021)[15]. Moreover, Cheng and Pan (2021)[4] encourage to use more of organic compost from fruits, vegetables and tea instead.

Third, increase the amount of carbon sink as well as carbon trading system to reach zero or even negative carbon emission for agricultural sector. Despite, Carbon Dioxide (CO_2) is not the

primary gas emitted by agricultural sector, but in overall industry, CO_2 makes up the vast majority of greenhouse gas. One way is, increase the soil carbon content, by doing so it can offset the greenhouse gas concentrations in the air. Cheng and Pan (2021)[4] also added that Chinese farmland could sequester twice as much carbon if they able to apply more measure such as combining organic and inorganic fertilisers, incorporating straw back into the soil and reduced-till farming. Besides that, plant more trees or afforestation is another alternative. In China, Wang et al. (2020)[22] found out progressive afforestation pattern for certain provinces which previously underestimated as carbon sink, such as Southwest China (Yunnan, Guizhou and Guangxi provinces) and Northeast China (Heilongjiang and Jilin provinces). They also added, the provincial forests over 10 to 15 years had increased between 0.04 million and 0.44 million hectares in these provinces. Another way is by implement more carbon trading practices. The major goal of the carbon trading market is to serve companies to reduce carbon emissions by controlling their carbon quota. Dan and Jie (2021)[23] recorded that China has tested carbon credit trading at a local level since 2011. By March 2021, the programs have covered over 20 industries, about 3,000 major companies which cover about 440 million tons of carbon discharge and created the turnover of 10.47 billion yuan.

As we can see, with current plans and goals declared by the president and Chinese governments to achieve 2030 carbon-peak and 2060 carbon neutrality. Moreover, with specific key points on addressing the climate change and agricultural emission issue. The future of China low-carbon agriculture is very promising.

The government role is very crucial to succeed the future green agriculture. For instance, the incentives and subsidies provided by the governments specifically for the farmers. They can be in form of financial subsidies, farm tools or technologies subsidies and farmer's welfare. Another instances, the ability for the governments to measure greenhouse gas emission (GHG). Generally, the government agencies use the standard tools such as carbon inventory and carbon audit to measure the GHG. These tools are crucial to project future improvement, hence, further training and research subsidies also required.

On the other hand, state owned enterprises also can promote and encourage the community to support the low-carbon agriculture movement. This can be done by purchasing the company product that shows carbon label. The product with carbon labelling indicates that it is certified by certain authorities or governments as part to thrive the low carbon movement. One instance comes from a coffee product namely **Nespresso**, they have committed the carbon neutral movement since 2017 and will achieve full carbon neutrality across its supply chain and product life cycle. Nespresso also has committed that every cup of Nespresso coffee, both for at-home and for professional customers, will be carbon neutral by 2022. Through this, together the society will be able to contribute to the future of our earth safety.

To sum up, it is true that Methane (CH_4) and Nitrous Oxide (N_2O) are the two primary gases emitted by agricultural sector that drive the world climate change. In the long-term, climate change will bring negative effect to the crop production and quality as well. Despite that, China has gotten into agreements by setting goals and plans to reach future carbon-neutrality and zero-carbon agriculture. To achieve this, both the governments and private enterprises need to work together to promote the green agriculture. Increase investment on agricultural research, provide farmers with reliable information consulting service and more education on green/sustainable agriculture for farmers still need to be brought in the future. Thus, farmers acceptance of low-carbon agricultural measures will be strengthened and eventually low-carbon agriculture will turn into a habit in the future.

Reference:

[1] NASA: *Overview: Weather, Global Warming and Climate Change.* [Online] Available at: https://climate.nasa.gov/resources/global-warming-vs-climate-change/

[2] the European Union: *Causes of climate change.* [Online] Available at: https://ec.europa.eu/clima/climate-change/causes-climate-change_en

[3] Zhu, Z., (2002). *The First National Agricultural Census in China*. National Bureau of Statistics of China [Online]. Available at: http://www.stats.gov.cn/english/specialtopics/IntConferenceOnAgCensus/200205/t20020520_29924.html

[4] Cheng, K. and Pan, G. (2021). *How can China cut emissions from its farms? China Dialogue* [Online]. Available at: https://chinadialogue.net/en/food/how-can-china-cut-emissions-from-its-farms/

[5] Climate Watch (2021) Historical GHG Emissions. Washington, DC: World Resources Institute. [Online] Available at: https://www.climatewatchdata.org/ghg-emissions

[6] the State Council (国务院) (2016) *国务院关于印发"十三五"控制温室气体排放工作方案的通知* [Online]. Available at: http://www.gov.cn/zhengce/content/2016-11/04/content_5128619.htm

[7] Statista (2021) *Production of chemical pesticide for China's agriculture from 1990 to 2019*. statista.com [Online]. Available at: https://www.statista.com/statistics/275859/chemical-pesticide-production-for-chinas-agriculture/

[8] Olivier J.G.J. and Peters J.A.H.W. (2019) *Trends in global CO2 and total greenhouse gas emissions: 2019 report.* PBL Netherlands Environmental Assessment Agency, The Hague [Online]. Available at: https://www.pbl.nl/sites/default/files/downloads/pbl-2020-trends-in-global-co2-and-total-greenhouse-gas-emissions-2019-report_4068.pdf

[9] Gütschow, J., Günther, A., Jeffery, L., Gieseke, R. (2021) *The PRIMAP-hist national historical emissions time series v2.2 (1850-2018)*. zenodo. doi:10.5281/zenodo.4479172. [online] Available at: https://www.climatewatchdata.org/ghg-emissions?breakBy=gas&chartType=line&end_year=2018&gases=co2&regions=CHN&sectors=agriculture&source=PIK&start_year=2007

[10] Yu, J., and Wu, J. (2018). *The Sustainability of Agricultural Development in China: The Agriculture–Environment Nexus*. Sustainability 2018, 10, 1776; doi:10.3390/su10061776. [online] Available at: https://www.mdpi.com/2071-1050/10/6/1776/pdf

[11] Lin, Y., Deng, X., and Jin, Q. (2013). *Economic Effects of Drought on Agriculture in North China*. Int. J. Disaster Risk Sci. 2013, 4 (2): 59–67 doi:10.1007/s13753-013-0007-9. [online] Available at: https://link.springer.com/content/pdf/10.1007/s13753-013-0007-9.pdf

[12] Chen, S., Chen, X., and Xu, J. (2014). *Impacts of Climate Change on Agriculture: Evidence from China*. Environment for Development. March 2014. EfD DP 14-07. [online] Available at: https://media.rff.org/documents/EfD-DP-14-07.pdf

[13] 农业农村部发展规划司 (MARA China). (2019). *农业农村部办公厅关于印发《2019 年农业农村绿色发展工作要点》的通知.* [online] Available at: http://www.moa.gov.cn/ztzl/2019gzzd/sjgzyd/201904/t20190416_6179510.htm

[14] the State Council (国务院). (2021). *国务院关于加快建立健全绿色低碳循环发展经济体系的指导意见* . [online] Available at: http://www.gov.cn/zhengce/content/2021-02/22/content_5588274.htm

[15] Xinhua Net (新华社). (2021). *中华人民共和国国民经济和社会发展第十四个五年规划和 2035 年远景目标纲要*. 中国政府网. [online] Available at: http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm

[16] Biala, K., Terres, J., Pointereau, P., and Paracchini, M. L. (2007*). Low Input Farming Systems: an Opportunity to Develop Sustainable Agriculture*. JRC Scientific and Technical Reports. [online] Available at: https://agriculture-de-conservation.com/sites/agriculture-de-conservation.com/IMG/pdf/lifs-jrc.pdf

[17] VertiCrop. (2015). *Why VertiCrop ™ Vertical Farming?* [online] Available at: https://grow.verticrop.com/vertical-farming/

[18] Smith, H. (2021). *Yuan Longping, whose hybrid rice helped feed the world, dies at 90. The Washington Post*. [online] Available at: https://www.washingtonpost.com/local/obituaries/yuan-longping-dead/2021/05/25/e23a377e-bd5a-11eb-b26e-53663e6be6ff_story.html

[19] IRENA. (2019). *Future of Solar Photovoltaic: Deployment, investment, technology, grid integration and socio-economic aspects (A Global Energy Transformation: paper)*, International Renewable Energy Agency, Abu Dhabi. [online] Available at: https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Nov/IRENA_Future_of_Solar_PV_2019.pdf

[20] Beck, M., Bopp, G., Goetzberger, A., Obergfell, T., Reise, C., Schindele, S. (2012). *Combining PV and Food Crops to Agrophotovoltaic – Optimization of Orientation and Harvest.* DOI:10.4229/27thEUPVSEC2012-5AV.2.25. [online] Available at: https://www.eupvsec-proceedings.com/proceedings?paper=18297

[21] Goldwind. (金风科技). (2021). *金风科技碳中和解决方案：中国首个可再生能源"碳中和"智慧园区。*

[22] Wang, J., Feng, L., Palmer, P.I. et al. (2020*). Large Chinese land carbon sink estimated from atmospheric carbon dioxide data*. Nature 586, 720–723. https://doi.org/10.1038/s41586-020-2849-9. [online] Available at: https://www.nature.com/articles/s41586-020-2849-9#citeas

[23] Zhang, D., and Shan, J. (2021). *China to launch nationwide carbon trading market by June. Global Times*. [online] Available at: https://www.globaltimes.cn/page/202105/1224509.shtml

[24] Nestlé Nespresso SA. (2020). *EVERY CUP OF NESPRESSO COFFEE WILL BE CARBON NEUTRAL BY 2022. nestle-nespresso.com*. [online] Available at: https://nestle-nespresso.com/news/every-cup-of-nespresso-coffee-will-be-carbon-neutral-by-2022