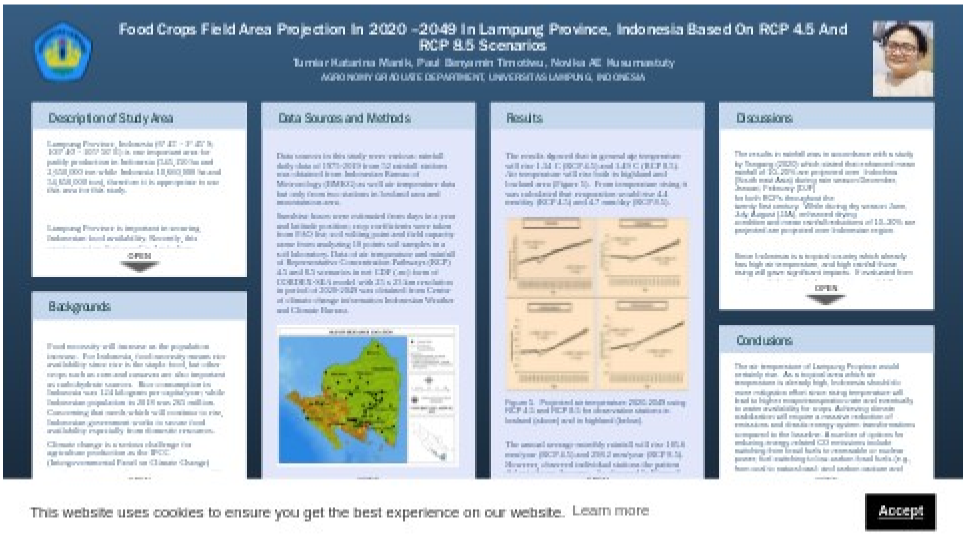
Food Crops Field Area Projection In 2020 –2049 In Lampung Province, Indonesia Based On RCP 4.5 And RCP 8.5 Scenarios



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PRESENTED AT:

DESCRIPTION OF STUDY AREA

Lampung Province, Indonesia (6^{o} 45' - 3^{o} 45' S; 103^{o} 40' - 105^{o} 50' E) is one important area for paddy production in Indonesia (545,150 ha and 2,650,000 ton while Indonesia 10,660,000 ha and 54,650,000 ton), therefore it is appropriate to use this area for this study.

Lampung Province is important in securing Indonesian food availability. Recently, this province got an first award in Agriculture achievement with the highest paddy productivity. In 2020 Lampung produced 2,65 juta tons ready for consumption paddy, increased 22,47% from 2019 production. Beside paddy, Lampung is also center of Maize, cassava and sago production, make it as an important province in food crops production.

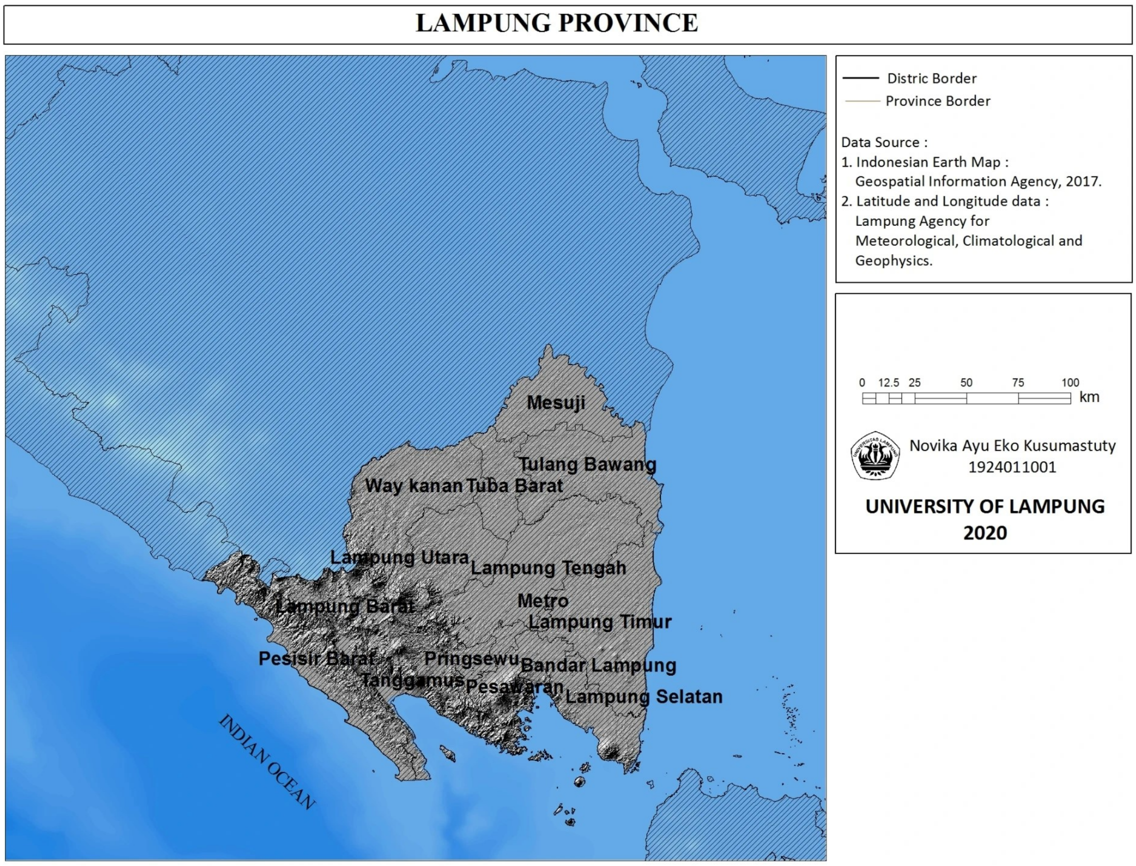

Figure 1. Lampung Province at the tip of Sumatra Island, Indonesia

BACKGROUNDS

Food necessity will increase as the population increase. For Indonesia, food necessity means rice availability since rice is the staple food, but other crops such as corn and cassavas are also important as carbohydrate sources. Rice consumption in Indonesia was 124 kilogram per capita/year; while Indonesian population in 2018 was 265 million. Concerning that needs which will continue to rise, Indonesian government works to secure food availability especially from domestic resources.

Climate change is a serious challenge for agriculture production as the IPCC (Intergovernmental Panel on Climate Change) mentioned that agriculture is one sector that will be affected severely by climate change and unstable agriculture productions will eventually affect the economy of developing countries (IPCC, 2014)

Figure 2. Main food crops in Lampung: Paddy, Cassava and Maize

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ED-16-42-F3-C5-4F-FA-89-AC-FB-12-81/Video/Maize_Field_fmj3gs.mp4

[VIDEO] https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1638244534/agu-fm2021/4C-07-0F-48-ED-16-42-F3-C5-4F-FA-89-AC-FB-12-81/Video/Cassava_Field_vc33dl.mp4

To predict how future global warming will contribute to climate change IPCC has developed new scenarios which are called as Representative Concentration Pathways (RCPs) with four pathways: RCP8.5, RCP6, RCP4.5 and RCP2.6. The purpose of scenarios was to better understand uncertainties and alternative futures, in order to consider how robust different decisions or options may be under a wide range of possible futures (Van Vurren, et al., 2011)

This study chose the pathway RCP 8.5 which a representative of scenarios in the literature that lead to high greenhouse gas concentration levels and the pathway RCP 4.5 which is a stabilization scenario in which total radiative forcing is stabilized shortly after 2100. RCP8.5 combines assumptions about high population and relatively slow income growth with modest rates of technological change and energy intensity improvements, leading in the long term to high energy demand and GHG emissions in absence of climate change policies; those might a representative condition of Indonesia. RCP 4.5 will be achieved if a country could mitigate the climate change with decreasing energy dependency on oil and coal.

The question for this study was: with the possible changes in air temperature and rainfall distribution, will Rice, Maize, and Cassava securely available in Indonesia?

DATA SOURCES AND METHODS

Data sources in this study were various: rainfall daily data of 1975-2019 from 52 rainfall stations was obtained from Indonesian Bureau of Meteorology (BMKG) as well air temperature data but only from two stations in lowland area and mountainous area.

Sunshine hours were estimated from days in a year and latitude position; crop coefficients were taken from FAO list; soil wilting point and field capacity came from analyzing 10 points soil samples in a soil laboratory. Data of air temperature and rainfall of Representative Concentration Pathways (RCP) 4.5 and 8.5 scenarios in net CDF (.nc) form of CORDEX-SEA model with 25 x 25 km resolution in period of 2020-2049 was obtained from Center of climate change information Indonesian Weather and Climate Bureau.

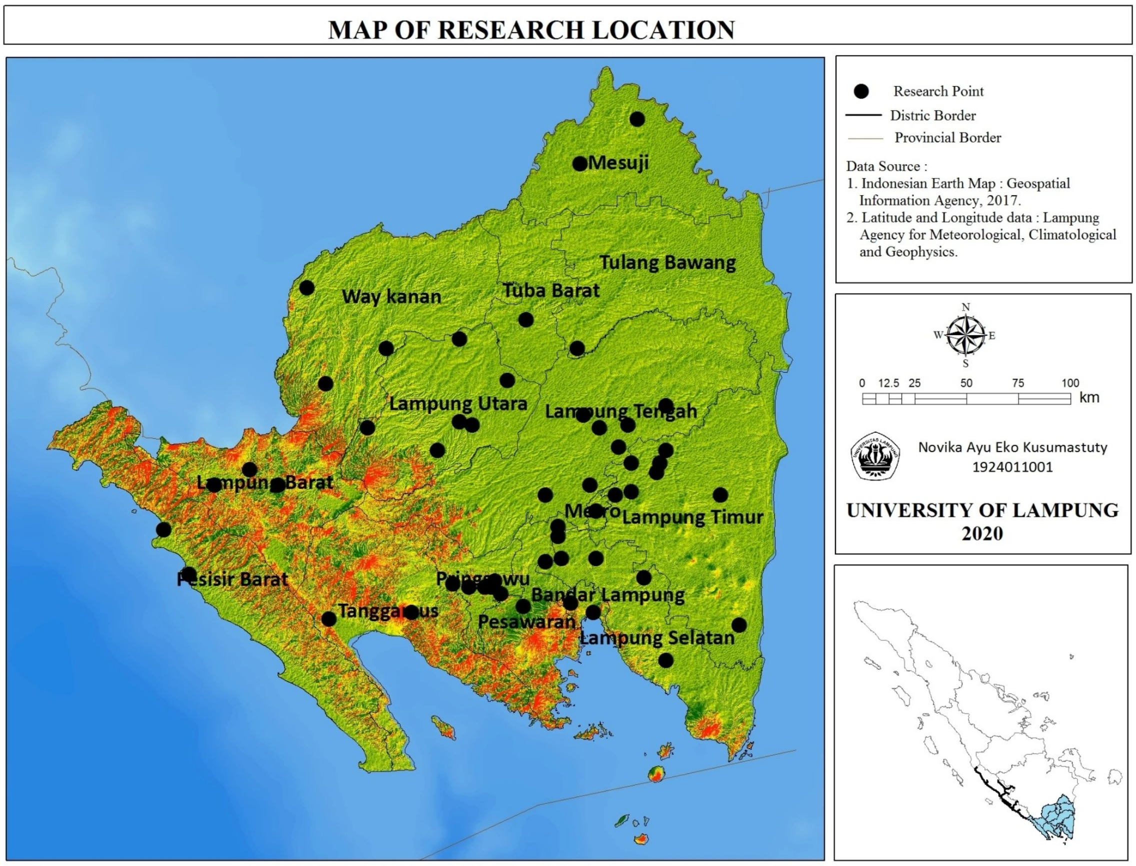


Figure 3. Observation rainfall stations over Lampung Province

The method for this study was as follow: from the projected air temperature and rainfall following those scenarios, evapotranspiration of the crops was calculated using Thornthwaite and Matter method and crop coefficients from the FAO list. Evapotranspiration and rainfall used to calculate crops water requirements and then the water availability. The water availability was divided in 5 criteria based on percentage of water availability which were: certainly enough (water availability was more than 90%), enough (water availability was between 90% to 60%), moderate (water availability was between 60% to 40%), not enough (water availability was between 40% to 10%) and extremely not enough (water availability was less than 10%). Overlaid the spatial of water availability with the basic map of Lampung Province would give the predicted area available for Paddy, Maize and Cassava plantation in the future.

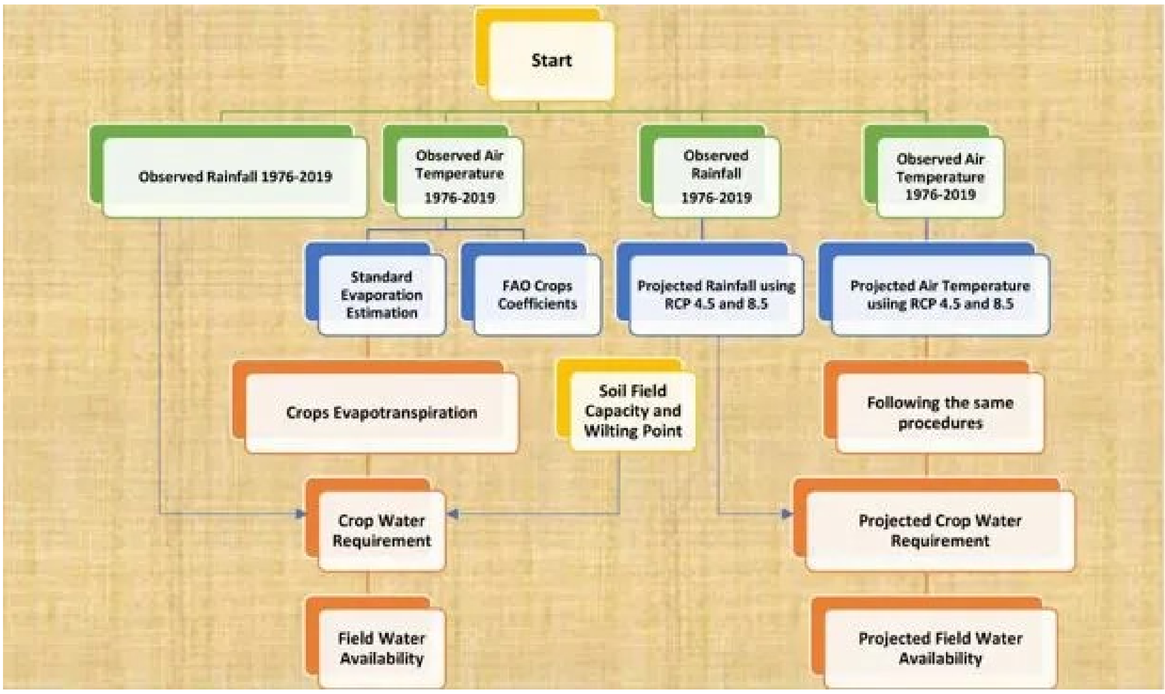


Figure 4. Research methods chart

RESULTS

The results showed that in general air temperature will rise 1.34°C (RCP 4.5) and 1.49°C (RCP 8.5). Air temperature will rise both in highland and lowland area (Figure 5). From temperature rising it was calculated that evaporation would rise 4.4 mm/day (RCP 4.5) and 4.7 mm/day (RCP 8.5).

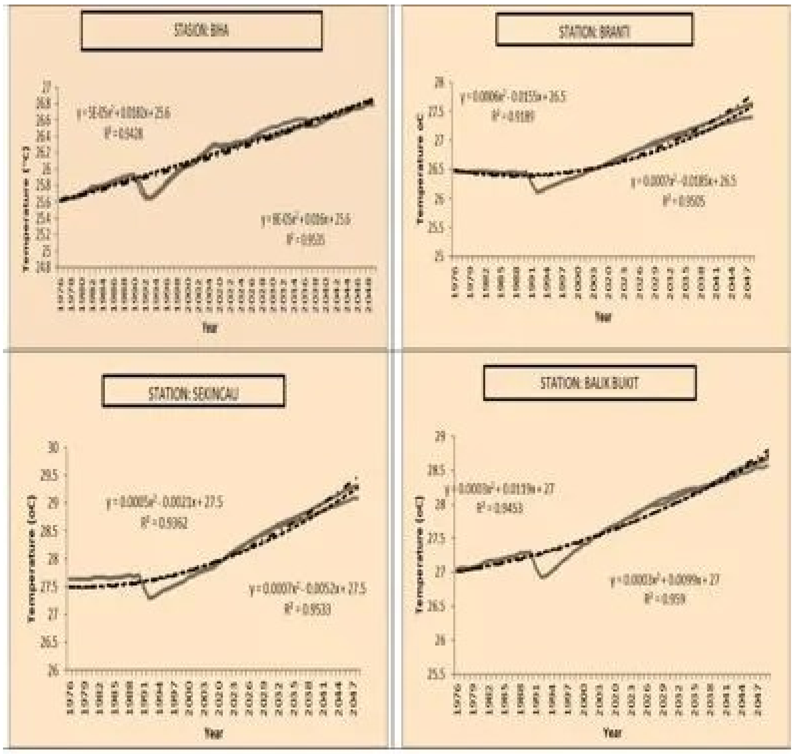


Figure 5. Projected air temperature 2020-2049 using RCP 4.5 and RCP 8.5 for observation stations in lowland (above) and in highland (below).

The annual average monthly rainfall will rise 105.6 mm/year (RCP 4.5) and 298.2 mm/year (RCP 8.5). However, observed individual stations the pattern did not always the same. As observed In Figure 6 rainfall in lowland area might decrease especially in dry season. Even in highland area there was a station that showed decreasing rainfall both in rain and dry season (Figure 7 and Table 1).

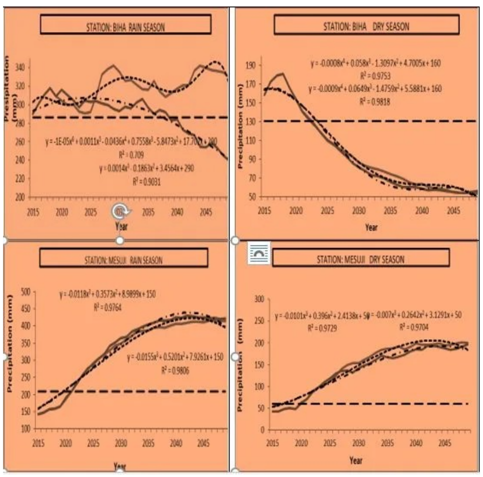


Figure 6. Projected rainfall 2020-2049 using RCP 4.5 and RCP 8.5 for observation stations in lowland area for rain season (left) and dry season (right)

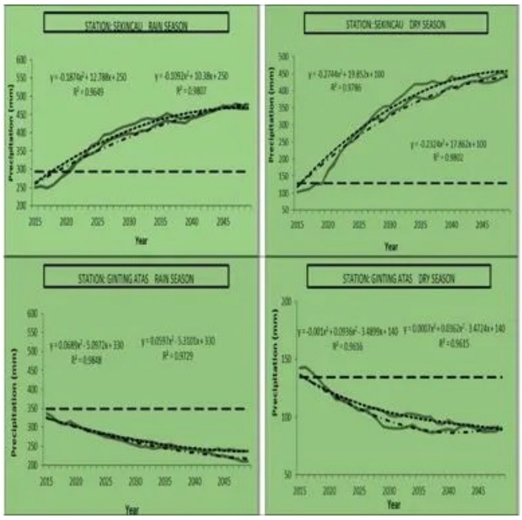


Figure 7. Projected rainfall 2020-2049 using RCP 4.5 and RCP 8.5 for observation stations in highland area for rain season (left) and dry season (right).

Table 1. Projected rainfall (mm) using RCP 4.5 and RCP 8.5 for some stations in rainy and dry seasons

No	Stations	Rain Season			Dry Season		
		Base	RCP 4.5	RCP 8.5	Base	RCP 4.5	RCP 8.5
1	Sekincau	256.91	473.41	479.37	132.94	453.25	444.37
2	Jabung	340.56	370.94	367.23	117.94	112.35	113.15
3	Kelapa Tujuh	286.51	431.35	423.17	113.34	180.00	176.00
4	Bumi Agung	303.81	415.86	406.93	90.39	133.04	136.08
5	Biha	255.18	342.36	318.11	169.98	141.53	140.85
6	Panaragan	287.25	418.68	423.02	120.89	163.42	162.41
7	Sidodadi	341.15	256.86	259.67	111.62	95.55	91.92
8	Pringsewu	250.00	551.25	531.80	77.00	166.91	169.37
9	Mesuji	274.51	417.51	430.36	112.83	201.37	196.71
10	Way Tuba	256.42	442.74	443.48	123.35	138.56	136.75

As an humid tropical country, Indonesia has various type of rainfall distribution, therefore, the projected reinfall could not be one pattern for the whole area.

Following processes as in methods, field water availability and projected areal for Paddy, Maize and Cassava were presented respectively in Figures 8 - 11. These pictures only for August month the ussual driest season in Lampung.

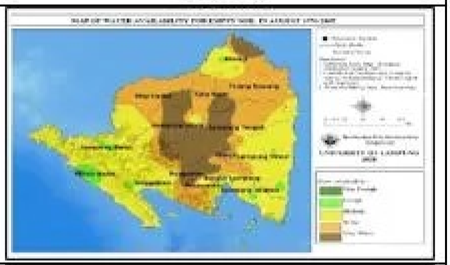
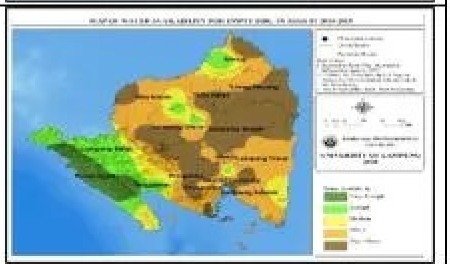
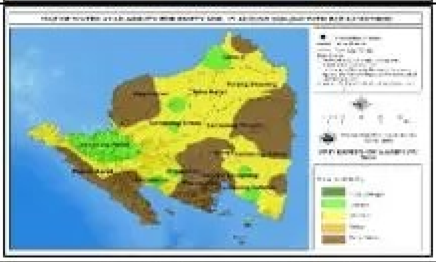
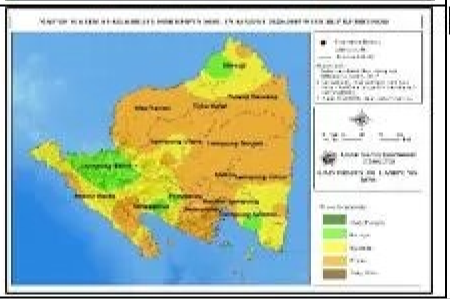
Period	Bare Soil
1979-2005	
2010-2019	
2020-2049 RCP 4.5	
2020-2049 RCP 8.5	

Figure 8. Changes of water availability of land without any crops

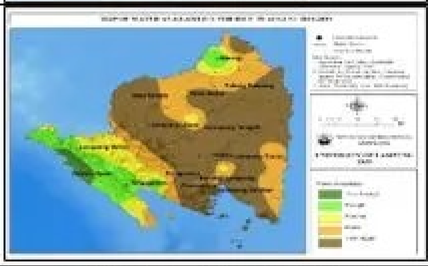
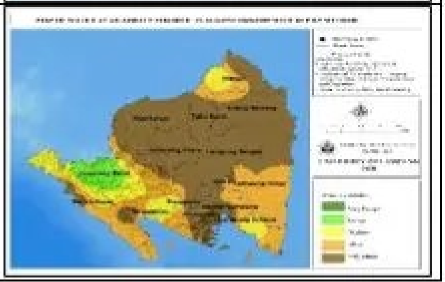
Period	Paddy Field
1979-2005	
2010-2019	
2020-2049 RCP 4.5	
2020-2049 RCP 8.5	

Figure 9. Paddy field area in the past and projected area of paddy field in the future based on RCP 4.5 and 8.5

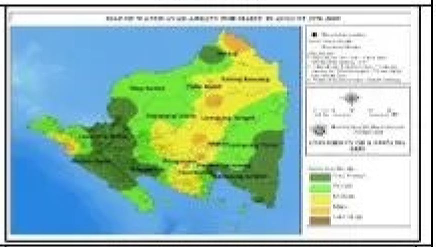
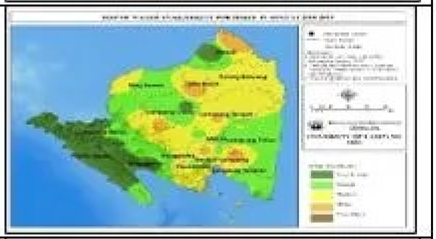
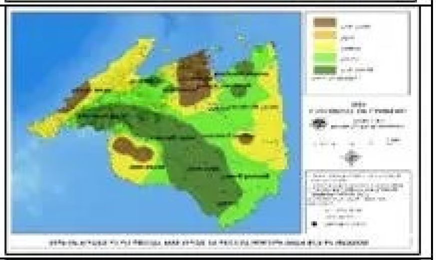
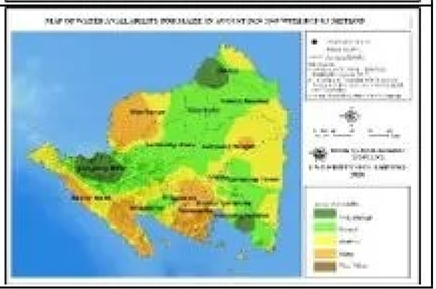
Period	Maize Field
1979-2005	
2010-2019	
2020-2049 RCP 4.5	
2020-2049 RCP 8.5	

Figure 10. Maize field area in the past and projected area of paddy field in the future based on RCP 4.5 and 8.5

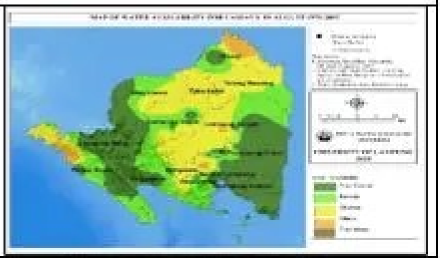
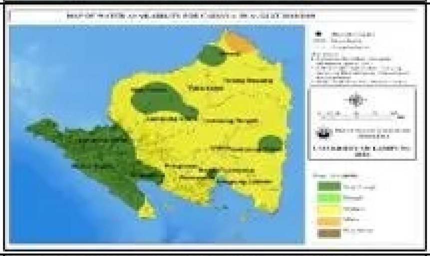
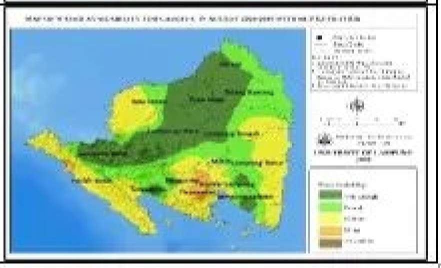
Period	Cassava Field
1979-2005	
2010-2019	
2020-2049 RCP 4.5	
2020-2049 RCP 8.5	

Figure 11. Cassava field area in the past and projected area of paddy field in the future based on RCP 4.5 and 8.5

DISCUSSIONS

The results in rainfall was in accordance with a study by Tangang (2020) which stated that enhanced mean rainfall of 10–20% are projected over Indochina (South east Asia) during rain season December, Januari, February (DJF) for both RCPs throughout the
twenty first century. While during dry season June, July, August (JJA), enhanced drying condition and mean rainfall reductions of 10–30% are projected are projected over Indonesian region.

Since Indonesia is a tropical country which already has high air temperature, and high rainfall those rising will gave significant impacts. If evaluated from each month for the whole year, water availabilities comparison from past, present and future conditions for those crops were: for period of 1976-2005, water was not available for Paddy on June – November, for Maize on August- October and for Cassava on September-October. For period 2010-2019 water was not available for Paddy on May – December, for Maize on August- November and for Cassava on Augustus-October. With the RCP 4.5 the water availability on period of 2020-2049 will be: water was not available for Paddy on July – December, for Maize on August- September and for Cassava would always be available and with the RCP 8.5 the water availability on period of 2020-2049 will be: water was not available for Paddy on June – November/December, for Maize on August- October and for Cassava on August- September/October.

Based on spatial map of those water availabilities eventually could be measured that in total area available for paddy in Lampung Province in the future somewhat increase compared to the recent condition (301,345 ha), RCP 4.5 (441 ha) and RCP 8.5 (423 ha); similar results for Maize, recent (201,237 ha), RCP 4.5 (261,89 ha) and RCP 8.5 (216,37 ha) while for Cassava would be decrease with recent (366,83 ha), RCP 4.5 (278,62 ha) and RCP 8.5 (207,17 ha). However, considering the planting time as described above water will not available every month, especially that on dry season the rainfall would be even lower.

Moreover, these projections did not consider the possibility of weather disturbances or anomalies such as El Nino/La Nina that frequently occurred in tropical area. Another weakness in this research was lack of air temperature data for each locations that the data used was only representatives for highland and lowland area. Lack of air temperature data made the evapotrasnpirastion calculation could be less accurate.

CONCLUSIONS

The air temperature of Lampung Propince would certainly rise. As a tropical area which air temperature is already high, Indonesia should do more mitigation effort since rising temperature will lead to higher evapotranspiration rate and eventually to water availability for crops. Achieving climate stabilization will require a massive reduction of emissions and drastic energy system transformations compared to the baseline. A number of options for reducing energy-related CO emissions include switching from fossil fuels to renewable or nuclear power; fuel switching to low-carbon fossil fuels (e.g., from coal to natural gas); and carbon capture and storage (both fossil and biomass based).

The rainfall was projected increasing in rain season and in some area would be decreasing in dry season. In general area available for planting the food crops (Paddy, Maize and Cassava) would increase. In securing food availability it would be more sustainable with intensifying the planting period such as made it possible to plant crops during dry season with irigation facilities. Abundant water in rain season could be saved for dry season need. Extensifying to new area eventhough from this study the water would be available should be considering that landuse change could also lead to climate change (Austin et al., 2018)

AUTHOR INFORMATION

Dr. Tumiar Katarina Baritauli Manik graduated from Math and Science Dept, Bogor Agricultural University, Indonesia (Bachelor Degree), Faculty of Agriculture, Dept. Agronomy, Iowa State University (Master Degree) and Faculty of Geography, National University of Singapore, Dept of Geography (PhD Degree).

Recently works at Universitas Lampung, Indonesia under Agronomy and Horticulture Department. She teaches Introduction to Climatology and Crops Microclimate (Undergraduate level), Climate change and crops production and Crops Ecology (Master Degree level).

Beside teaching, she also doing research and extention service and her recent publications include Identification of temperature and rainfall pattern in Bandar Lampung and the 2020 -2049 projection, Prediction of Nitrous Oxide (N_2O) Emission Based onPaddy Harvest Area in Lampung Province Indonesia using ARIMA on IPCC Model and The role of university community programs in disseminating agriculture innovation: a case study in Sekincau Region, West Lampung, Indonesia.

She also part of Universitas Lampung SDGs committee as the research coordinator.

ABSTRACT

Rice, Maize and Cassava are important in Indonesia. Climate change is a serious challenge for agriculture production while more food is required to feed more people. To predict how future global warming will contribute to climate change IPCC has developed some new scenarios, the Representative Concentration Pathways (RCPs) with four pathways: RCP8.5, RCP6, RCP4.5 and RCP2.6. The question for this study was with the possible changes in air temperature and rainfall distribution will Rice, Maize, and Cassava will securely available in Indonesia? Applying RCP 8.5 and RCP 4.5, it was showed that air temperature raised 1.34^{0}C (RCP 4.5) and 1.49^{0}C (RCP 8.5); the annual average monthly rainfall raised 105.6 mm/year (RCP 4.5) and 298.2 mm/year (RCP 8.5) and calculated evaporation would rise 4.4 mm/day (RCP 4.5) and 4.7 mm/day (RCP 8.5).

The water availability comparison from past, present and future conditions for those crops were: for period of 1976-2005, water was not available for Paddy on June – November, for Maize on August- October and for Cassava on September-October. For period 2010-2019 water was not available for Paddy on May – December, for Maize on August- November and for Cassava on Augustus-October. With the RCP 4.5 the water availability on period of 2020-2049 will be: water was not available for Paddy on July – December, for Maize on August- September and for Cassava would always be available and with the RCP 8.5 the water availability on period of 2020-2049 will be: water was not available for Paddy on June – November/December, for Maize on August- October and for Cassava on August- September/October (Fig. 1). Based on spatial map of those water availabilities eventually could be measured that paddy area of Lampung Province in the future somewhat increase compared to the recent condition (301,345 ha), RCP 4.5 (441 ha) and RCP 8.5 (423 ha); similar results for Maize, recent (201,237 ha), RCP 4.5 (261,89 ha) and RCP 8.5 (216,37 ha) while for Cassava would be decrease with recent (366,83 ha), RCP 4.5 (278,62 ha) and RCP 8.5 (207,17 ha). These results could not assure that Lampung Province Indonesia would be able to preserve food security in the future since the population will sure increase and that often lead to uncontrolled land use changes and more energy uses.

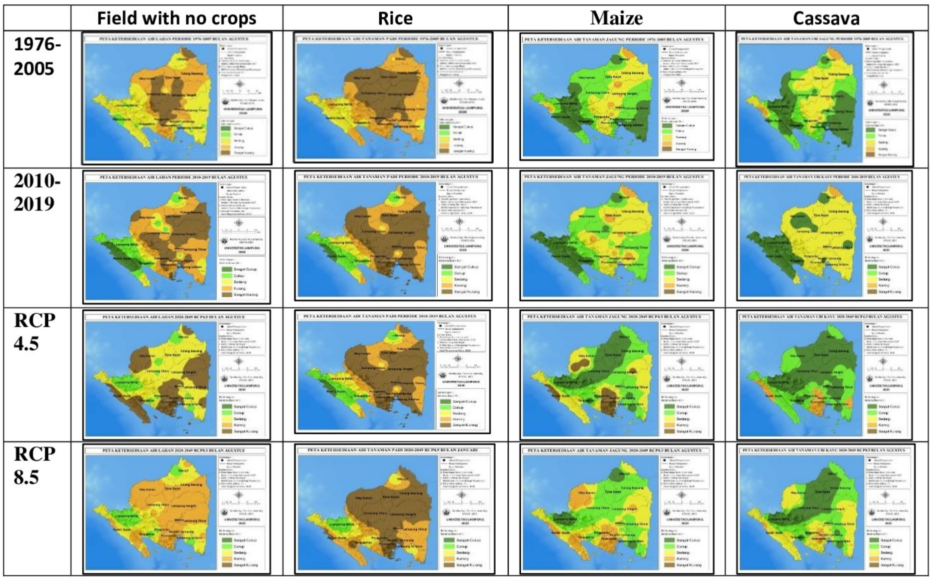


Figure 1. Changing water availabilities in peak of dry season (August) in the past, recent and predicted future in Lampung, Indonesia

(https://agu.confex.com/data/abstract/agu/fm21/1/2/Paper_821721_abstract_766467_0.jpg)

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