Predicting the impacts of climate change on Indonesia’s five main horticulture commodities

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Abstract. Global climate change has an enormous impact on agriculture, including horticultural commodities. Banana, oranges, shallot, chilies, and potatoes are among the main horticulture commodities for Indonesian. This study employed a multimarket model of partial equilibrium analysis to investigate the impact of global and environmental climate change on those Indonesia’s five horticulture commodities 2019-2030. The study appraised the impact of climate change by looking at changes in the production and consumption in the national and household level, and net trade at national level. The study revealed that all scenarios show negative impact on national aggregate level of productions and consumptions, however those scenarios can be lower or higher at regional and household levels under climate change compared to a no-climate change scenario in the short and medium term. Import will increase, and all commodities will be as net imported. As an implication, types and characteristics of commodity and regions and households should be strongly considered in research, extension, and development program with improving adaptation and mitigation to climate change. With its unique characteristics, more comprehensive studies for these commodities are recommended. Awareness of the impact of climate change, horticulture subsector needs to be treated in a consistent, comprehensive, and systematic ways.

1. Introduction

Global warming and climate change phenomena have been observed and studied extensively during the last two decades. This phenomenon has wide range implications of all aspects of life and economic activities, and particularly require a serious attention about the negative impact on macroeconomic and agricultural sector. There are many comprehensive studies that appraising climate change impact on agricultural commodity and food subsector, including horticulture commodity in Indonesia, such as 2050 [1,2], 2030 [3] and 2015-2019 [4]. However, studies that focus on more limited coverage and more disaggregated regions are apparently not many. Since each commodity has unique characteristics and climate change is not a short-term phenomenon of crop-cycle, more intensive and comprehensive studies are highly required, and looking in yearly conditions is of great importance. This paper employs a multimarket model of partial equilibrium [1,3,4] with modification in time projection for 2019-2030, using baseline data 2016, and focusing in production, consumption, and net trade of five horticulture commodities, namely banana, orange, shallot, chilies, and potatoes. The study aimed to appraises the impact of climate change by looking at changes in the production and consumption in the aggregate national and household level, and net trade at national level. The results
of analysis are expected to support Indonesian agricultural policymakers, planners, practitioners, and scholars about the consequences of the changing climate on specific horticulture commodities, horticulture subsector, and country’s agricultural systems.

2. Methodology

2.1. Description and structure of the model
A general description of the product and household categories used in the model Hutabarta [1,2] are as follows: (a) Product categories consist of the main agricultural outputs and inputs that drive Indonesia’s agriculture sector (23 products), such as (1) crop products—rice, maize, soybeans, cassava, bananas, peanuts, sweet potatoes, oranges, shallots, chilies, potatoes, palm oil, coconut oil, cocoa, coffee, sugar, and wheat; (2) Animal products—meat, eggs, and milk; and (3) Agricultural inputs—urea fertilizer, phosphorus and potassium fertilizer, and maize for animal feed; and (b) Household groups are made up of two main groups, namely: (1) Urban households, comprising urban—rich, urban—middle-income, and urban—poor, and (2) Rural households, comprising Java—rich, Java—middle-income, Java—poor, Off-Java—rich, Off-Java—middle-income, and Off-Java—poor. The structure of the model and the equations were formulated in the General Algebraic Modeling System (GAMS) and available from Hutabarat which was resumed in the model Hutabarat et al. [1,2].

The model applied here contains six blocks of equations in the multimarket model Hutabarat et al., [1,2]: Prices, supply, input demand, product consumption, income, and equilibrium conditions. The price block defines the relationship between producer prices and consumer prices in the domestic economy based on the degree of transactions costs. For tradable goods, domestic prices are related to world prices, whereas prices of non-traded goods are determined by supply-and-demand conditions. The supply block represents the domestic production of food crops, livestock, and nonagricultural production. The input demand block describes the household demands for agricultural inputs. The consumption block shows household demand for food and nonfood consumption items. The income block describes household income as the sum of income derived from agricultural production and exogenous nonagricultural income. The equilibrium conditions block contains equations that relate domestic supply and net import to demand for each of the 23 products.

2.2. Types and source of data
To empirically apply this type of structural model, it was necessary to first calibrate the model to the data. The model was calibrated to a baseline solution that describes Indonesia’s agriculture in 2016. The types of required data were: (a) Levels. Consists of production, consumption, income, and input levels that must be defined for all commodities and household groups. For 2016, aggregate levels were typically obtained from Central Bureau of Statistics (CBS) and Agricultural Census 2013 of CBS and the Ministry Agriculture (MoA) of Indonesia for land and production, and the National Socioeconomic Survey (SUSENAS) of CBS for household consumption; (b) Prices. These were initial consumer, producer, user, and border prices that must be defined for each commodity; these prices then defined the marketing margins. Producer and consumer prices were taken from CBS, the MoA, the Ministry of Trade (MoT) or other relevant sources; (c) Tariffs and Taxes. Imports and exports tariff and taxes and subsidized input prices were obtained from the Ministry of Finance (MoF); and (d) Behavioral parameters. Those were the elasticity of demand and supply and were mostly collated from research papers of Indonesian Center for Agriculture Socio-Economic and Policy Studies (ICASEPS), as in Hutabarat, Sumaryanto and Setiyanto[1-4]. A few others were best guesses in the absence of reliable data, specifically on elasticity for Government Spending and Research Expenditure of each commodity. Up until today the elasticity of productivity and or production with respect to Government Spending and Research Expenditure of each agriculture commodities was not available.
2.3. Basis for simulation
To predict the effects of climate change to the model, the simulation scenario applied in this study referred to data that were generated from the estimated impact of climate change on the productivity (see appendices A.2 and A.3) which were predicted and calculated using time series model refers to Sumaryanto and Setiyanto [3,4]. The calculation was based on and adjusted to predictions of climate change events in three climate change scenarios as listed in Appendix A.1, Scenario 1 (S-1), Scenario 2 (S-2), and compared to normal conditions Scenario 3 (S-3).

3. Results and discussions

3.1. Climate change impacts on production, consumption and net trade of commodities: national aggregate
The impact and the difference, include changes in the production of the two climate change scenarios and compared to the normal scenarios for 2019-2030 (Table 1), indicate that there are negative results S-1 and S-2 compare to normal scenario or S-3. However, the result between S-1 and S-2 was different. S-1 showed highest impact on banana and the lowest is shallot, but S-2 showed highest impact on potatoes and the lowest is banana. S-1 showed higher negative impact than S-2 for oranges, shallots, and chilies.

Table 1. Average and growth average of percentage change in national level of crops production, consumption and net trade under two climate change scenarios, as compared to normal condition, 2019-2030 (Percent per year)

| Commodity | Scenario 1 (S-1) | Scenario 2 (S-2) |
|-----------|-----------------|-----------------|
|           | Production      | Consumption     | Net Trade       |
|           | Average | Growth | Average | Growth | Average | Growth |
| Banana    | -1.4934 | -0.1958 | -2.0642 | -0.1118 | -1.6658 | 0.0136 |
| Oranges   | -1.0847 | -0.0955 | -1.7675 | -0.1718 | -1.9625 | 0.2236 |
| Shallot   | -1.0763 | -0.1264 | -1.4292 | -0.1064 | -2.2100 | -0.2618 |
| Chilies   | -1.1837 | -0.1341 | -1.1025 | -0.0873 | -2.7783 | -0.0464 |
| Potatoes  | -1.1719 | -0.1404 | -1.4400 | -0.1564 | -2.8042 | -0.2736 |

Source: Simulation results

The availability of commodity for population consumption will also adjust to the changes in such commodity production at the aggregate and household levels as a direct consequence of climate change. Table 1 reveals that the impact on consumption is different in the two climate change scenarios compared to the normal scenarios. All scenarios have negative impact in the period of 2019 to 2030. On production, the result between S-1 and S-2 is different compare to the normal scenarios. S-1 shows the highest impact on banana and the lowest is chilies, and S-2 shows highest impact on oranges and the lowest is chilies. S-1 shows higher negative impact than S-2 for banana and chilies, and lower negative impact for oranges, shallots, and potatoes.

On the net trade (volume of exports minus imports), the results show that net trade will decline compare to S-3. S-1 results show that potatoes have the highest negative value by average negative 2.80 percent annually and banana has lowest negative amounted to negative 1.67 percent annually. S-2 showed that chilies has highest negative impact on average negative 3.01 percent annually and oranges has lowest negative impact by average negative 1.02 percent annually. Import is predicted to increase and net importer will occur for all commodities. Statistical trade data of CBS recorded that in the period of 2006 to 2016, banana is net exported, while oranges, shallots, and potatoes are net imported.
Chilies is changing from net exported into net imported commodity for the last five years. Both S-1 and S-2 resulted in a prediction that Indonesia become the net importer country for all of five commodities in the period of 2019 to 2030 as all of commodities has negative average in percentage change compared to normal condition.

3.2. Climate change impacts on production of commodities: regional and household group

Table 2 showed the average and growth average of percentage change in household level of banana, oranges, shallots, chilies and potatoes production under S-1 and S-2 compared to S-3 in the period of 2019 to 2030.

Table 2. Average and growth average of percentage change in national level of crops production, consumption and net trade under two climate change scenarios, as compared to normal condition, 2019-2030 (Percent per year)

| Household Group | Banana | Oranges | Shallots | Chilies | Potatoes |
|-----------------|--------|---------|----------|---------|----------|
| Average         | Growth | Average | Growth | Average | Growth | Average | Growth | Average | Growth |
| Scenario 1(S-1) |        |         |          |         |         |         |        |         |        |
| Java Rich       | -1.3775 | -0.1945 | -1.4042 | -0.0718 | -1.6425 | -0.0900 | -0.8517 | -0.1318 | -1.3342 | -0.1491 |
| Java Middle     | -1.6708 | -0.1955 | -1.2450 | -0.0973 | 1.3658  | -0.2227 | -0.6450 | -0.1755 | -0.4892 | -0.1209 |
| Java Poor       | -1.6658 | -0.1955 | -1.6125 | -0.0955 | 0.8700  | -0.0882 | -2.2308 | -0.1518 | -1.7892 | -0.1264 |
| Oja Rich        | -1.3108 | -0.1964 | -0.7975 | -0.0927 | -2.4558 | -0.1273 | -1.9925 | -0.0718 | -1.0800 | -0.1418 |
| Oja Middle      | -1.3183 | -0.2018 | -0.9842 | -0.0991 | -3.1800 | -0.1364 | -0.6050 | -0.1309 | -1.2242 | -0.1418 |
| Oja Poor        | -1.5725 | -0.1891 | -1.2533 | -0.1245 | -2.9867 | -0.0764 | -2.7333 | -0.1264 | -1.8808 | -0.1182 |
| Scenario 2(S-2) |        |         |          |         |         |         |        |         |        |
| Java Rich       | -1.5283 | -0.1400 | -1.7592 | -0.0791 | -1.2508 | -0.1045 | -0.5233 | -0.1336 | -1.6917 | -0.1727 |
| Java Middle     | -0.0517 | -0.1327 | -1.4417 | -0.1300 | 0.0875  | -0.1709 | 0.1117  | -0.2227 | -0.0058 | -0.1182 |
| Java Poor       | -0.0700 | -0.1300 | -2.1725 | -0.1245 | -0.0308 | -0.1027 | -3.3475 | -0.0991 | -2.6017 | -0.1282 |
| Oja Rich        | -1.8700 | -0.1309 | -0.5458 | -0.1200 | -1.6408 | -0.1227 | -2.8067 | -0.0136 | -1.1850 | -0.1591 |
| Oja Middle      | -1.8225 | -0.1036 | -0.9192 | -0.1336 | -2.0833 | -0.1264 | -0.0300 | -0.1327 | -1.4725 | -0.1591 |
| Oja Poor        | -0.5433 | -0.1664 | -1.4558 | -0.1827 | -1.9583 | -0.0973 | -3.2900 | 0.0500  | -2.7825 | -0.1118 |

Source: Simulation results

3.2.1. Banana. Result of S-1 shows the average negative 1.38 to negative 1.67 percent annually in Java household and negative 1.31 to negative 1.57 percent annually in Off Java household, with growth at around negative 0.20 percent annually. Rich household has the lowest negative impact both in Java and Off Java, Middle household has the highest negative impact in Java while poor household has the highest negative impact in Off Java. In the same period, S-2 results show that the average household production of banana in Java are negative 0.05 to negative 1.53 percent annually and average negative 0.54 to negative 1.87 percent annually in Off Java. Rich household has the highest negative impact both in Java and Off Java.

3.2.2. Oranges. In the period of 2019 to 2030, S-1 results show the average negative 1.40 to negative 1.61 percent annually in Java household with growth average negative 0.07 to 0.10 percent annually, in Off Java the average is negative 1.25 to negative 0.80 percent annually, with growth average negative 0.93 to negative 0.12 percent annually. Rich household has the lowest negative impact both in Java and Off Java, and poor household has the highest negative impact both in Java and Off Java. In the same period, the results of S-2 show that the average household production of oranges in Java are negative 1.75 to negative 2.17 percent annually, with growth average at negative 0.08 to negative 0.13 percent annually, and in Off Java average negative 1.46 to negative 0.55 percent annually with growth average at negative 0.18 to negative 0.12 percent annually, respectively. Poor household has the highest negative impact both in Java and Off Java.

3.2.3. Shallots. In the period of 2019 to 2030, S-1 results show the average negative 1.64 to positive 1.37 percent annually in Java household with growth average at negative 0.22 to 0.09 percent.
annually, respectively, while in Off Java the average is negative 3.18 to negative 2.46 percent annually, with growth average at negative 0.14 to negative 0.08 percent annually. Rich household has the highest negative impact in Java but has the lowest negative impact in Off Java. In Java, middle and poor household have positive impact, but negative in Off Java and the middle household has highest negative impact in Off Java. In the same period, S-2 results showed that average household production of shallots in Java are negative 1.25 to positive 0.09 percent annually, with growth average at negative 0.10 to negative 0.17 percent annually, while in Off Java at average negative 2.08 to negative 1.64 percent annually with growth average negative 0.13 to negative 0.10 percent annually, respectively. Rich household has the highest negative impact in Java and lowest negative impact in Off Java. Middle household has positive impact in Java, but has the highest negative impact in Off Java.

3.2.4. Chilies. In the period of 2019 to 2030, S-1 results show average negative 2.23 to negative 0.65 percent annually in Java household with growth average at negative 0.18 to negative 0.13 percent annually, while in Off Java the average is negative 2.73 to negative 0.61 percent annually, with growth average at negative 0.13 to negative 0.07 percent annually. Poor household has the highest negative impact and middle household has the lowest negative impact, both in Java and Off Java. In the same period, S-2 results show that average household production of chilies in Java are negative 3.35 to positive 0.11 percent annually, with growth average at negative 0.22 to negative 0.10 percent annually, while in Off Java average negative 3.29 to negative 0.03 percent annually with growth average at negative 0.13 to negative 0.01 percent annually, respectively. Poor household has the highest negative impact and middle household has the lowest negative impact, both in Java and Off Java.

3.2.5. Potatoes. In the period of 2019 to 2030, S-1 results show average negative 1.79 to negative 0.49 percent annually in Java household with growth average at negative 0.14 to negative 0.12 percent annually, respectively, while in Off Java the average is negative 1.88 to negative 1.08 percent annually, with growth average at negative 0.14 to negative 0.12 percent annually. Poor household has the highest negative impact, both in Java and Off Java. In Java, middle household has the lowest negative impact, but in Off Java rich household has the lowest negative impact. In the same period, S-2 results show that average household production of chilies in Java are negative 2.60 to negative 0.01 percent annually, with growth average at negative 0.17 to negative 0.12 percent annually while in Off Java average negative 2.78 to negative 1.19 percent annually with growth average at negative 0.16 to negative 0.11 percent annually, respectively. Poor household has the highest negative impact and middle household has the lowest negative impact in Java while rich household has the lowest negative impact in Off Java.

3.3. Climate change impacts on consumption of commodities: Regional and household group
Table 3 showed the average and the growth average of percentage change in household level of banana, oranges, shallots, chilies and potatoes consumption under S-1 and S-2 compared to S-3.

3.3.1. Banana. S-1 results show that in the period of 2019 to 2030, urban rich household has the highest negative impact on average amounted to negative 2.28 percent annually. S-2 results show that in the period 2019 to 2030, Off Java middle household has the highest negative impact on average amounted to negative 2.26 percent annually. Java middle household has the lowest negative impact at negative 1.10 percent annually in the period of 2019-2030.

3.3.2. Oranges. S-1 showed that urban rich household has the highest negative impact in the period 2019 to 2030 on average negative 1.92 percent annually. The lowest negative impact is for Off Java rich household on average negative 1.54 percent annually. Then for S-2, Java rich has the highest negative impact on average negative 2.64 percent annually. Java poor household has the lowest negative impact on average amounted to 1.92 percent annually.
3.3.3. Shallots. S-1 results show that Off Java rich household has the highest negative impact in period 2019 – 2030 on average negative 1.95 percent annually. Java middle household has the lowest negative impact by average negative 0.66 percent annually. The results of S-2 show that Java rich household has the highest negative impact on average negative 3.84 percent annually. Java middle household has the lowest negative impact on average amounted to negative 0.95 percent annually.

Table 3. Average and growth average of percentage change in regional and household level of crops consumption under two climate change scenarios, as compared to normal condition, 2019 – 2030 (Percent per year)

| Household Group | Banana Average Growth | Oranges Average Growth | Shallots Average Growth | Chilies Average Growth | Potatoes Average Growth |
|-----------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|
| Scenario1 (S-1) |                       |                        |                        |                       |                        |
| Urbrich         | -2.2758                | -0.1118                | -1.9183                | -0.1736               | -1.8567                | -0.1218                | -1.6125                | -0.0818               | -1.6967                | -0.1691                |
| Urbmidd         | -2.0192                | -0.1127                | -1.7542                | -0.1709               | -1.5058                | -0.0964                | -0.8100                | -0.0918               | -0.9692                | -0.1400                |
| Urbpoor         | -1.7550                | -0.1082                | -1.5767                | -0.1736               | -1.6475                | -0.0836                | -1.2308                | -0.0982               | -1.5450                | -0.1536                |
| Javarich        | -2.0075                | -0.1091                | -1.8700                | -0.1755               | -1.6642                | -0.0882                | -0.9208                | -0.0827               | -1.5717                | -0.1627                |
| Javamidd        | -2.2283                | -0.1100                | -1.8983                | -0.1691               | -0.6625                | -0.1382                | -0.8133                | -0.1100               | -1.0908                | -0.1445                |
| Javapoort       | -2.2017                | -0.1109                | -1.9050                | -0.1764               | -0.7417                | -0.0991                | -1.4733                | -0.0955               | -1.5008                | -0.1545                |
| Ojarich         | -1.9592                | -0.1109                | -1.5417                | -0.1636               | -1.9450                | -0.1118                | -1.8108                | -0.0327               | -1.3550                | -0.1564                |
| Ojamidd         | -1.9942                | -0.1127                | -1.6742                | -0.1764               | -1.6725                | -0.1136                | -0.7650                | -0.0818               | -1.4533                | -0.1564                |
| Ojapoort        | -2.1250                | -0.1073                | -1.8383                | -0.1664               | -1.4033                | -0.1100                | -1.8942                | -0.0773               | -1.6592                | -0.1491                |
|Scenario2 (S-2) |                       |                        |                        |                       |                        |                        |                       |                        |                        |                        |
| Urbrich         | -1.8558                | -0.0791                | -2.3600                | -0.2173               | -1.8917                | -0.1664                | -1.0233                | -0.0436               | -2.3467                | -0.1927                |
| Urbmidd         | -1.7242                | -0.0800                | -2.2300                | -0.2073               | -1.6325                | -0.0755                | -0.0742                | -0.1064               | -0.8983                | -0.1336                |
| Urbpoor         | -1.5925                | -0.0764                | -2.1367                | -0.2109               | -1.8492                | -0.0791                | -2.4300                | -0.0836               | -2.0433                | -0.1618                |
| Javarich        | -2.1925                | -0.0873                | -2.6442                | -0.2536               | -3.8358                | 0.1082                 | -0.5933                | -0.4646               | -2.0992                | -0.1809                |
| Javamidd        | -1.0908                | -0.0818                | -1.9892                | -0.1982               | -0.9508                | -0.1673                | -0.3767                | -0.1018               | -1.1383                | -0.1445                |
| Javapoort       | -1.2200                | -0.0800                | -1.9192                | -0.1873               | -0.9583                | -0.1473                | -1.7208                | -0.0482               | -1.9558                | -0.1636                |
| Ojarich         | -2.4400                | -0.0809                | -2.0492                | -0.2427               | -1.5342                | -0.1536                | -2.3692                | 0.0518                | -1.6675                | -0.1682                |
| Ojamidd         | -2.2617                | -0.0664                | -2.4325                | -0.2145               | -1.4208                | -0.1545                | -0.2792                | -0.0445               | -1.8650                | -0.1673                |
| Ojapoort        | -1.6058                | -0.0964                | -2.1875                | -0.1673               | -1.2867                | -0.1527                | -2.0692                | 0.0436                | -2.2725                | -0.1536                |

Source: Simulation Results

3.3.4. Chilies. Impact on household consumption of chilies for S-1 show that in Off Java, poor household has the highest negative impact on average negative 1.89 percent annually. Off Java middle household has the lowest negative impact by average negative 0.77 percent annually. Meanwhile, S-2 results showed that, Urban poor household has the highest negative impact on average negative 2.43 percent annually. Urban middle household has the lowest negative impact on average up to negative 0.07 percent annually.

3.3.5. Potatoes. The results for potatoes show different pattern among the other commodities. S-1 and S-2 results show that urban rich household has the highest negative impact and urban middle household has the lowest negative impact. S-1 results show that urban rich household has negative impact in the period of 2019 to 2030 on average negative 1.70 percent annually. The nearest of urban rich household which has high negative is Off Java poor household. Urban middle household has negative impact by average negative 0.97 percent annually. The nearest of urban middle household which has low negative is Java middle household. S-2 results showed that urban rich household has the highest negative impact on average negative 2.35 percent annually. Urban middle household has negative impact on average negative 0.89 percent annually. The nearest of Urban rich household which has high negative is also Off Java poor household, and the nearest of Urban middle household which has low negative is also Java middle household.
4. Conclusion and implication

4.1. Conclusion
Under the two scenarios, this study has predicted that climate change is affecting the performance of banana, oranges, shallots, chilies, and potatoes and will continue to a more severely condition in the next period of 2019 to 2030. The model predictions have mixed results for the production of the five commodities being studied. Those are shown on the production impact of those commodities at national aggregate, at the regional basis, and at the group of households. At the national level, all of scenarios of production resulted negative signs as production of commodities in the regional and household level also lower compared to normal condition. However, in the short term and medium term, production can be lower or negative, and higher or positive compared to the normal condition for some commodities, namely banana, shallots, and chilies. All scenarios of climate change show negative impacts for national level consumption and in the long term of regional and household consumptions. However, it can be positive in the short term for shallot for S-1 Java middle and chilies for S-2 urban middle and Java middle household groups. High negative impact is not only dominated by urban regions, but also rural regions both in Java and Off Java. The results show mixed negative impact on urban and rural household groups, but overall, poor household has a tendency to have a large negative impact, both in urban and rural regions of Java and Off Java. The impact on imported of commodities appear to have negative results and increased both in short term and medium and long term. In general, banana, oranges, shallots, chilies, and potatoes will be as net imported commodities.

4.2. Implication
The study findings revealed a serious impact the climate change brought to Indonesia’s horticulture subsector as indicated by the scenarios for the five commodities. It would be a strong warning for all concerned given that horticultural commodities play a very important role in the national economy. It is highly suggested that a comprehensive exercise is required to each of the strategic horticultural commodities with special consideration to the unique characteristics of each of commodity. The exercise should be thoroughly considered analysis over a period of time, i.e., short, medium, and long term as well as the typical regions and households. Those components are important to be taken into consideration in research, extension, and development program, particularly in improving adaptation and mitigation to climate change. Global climate change may cause severe agricultural risks, and risks could be eased through appropriate adaptation. Anticipation on the impact of global climate change on agriculture sector, especially on horticultural commodities is therefore strongly required. Awareness and understanding on the impact of global climate change on the Indonesian horticulture subsector should be developed in many ways in a consistent, comprehensive, and systematic applications. To this point, the use of applied technology is particularly suggested in the respect to the fast growing of agricultural development approaching the era of industry 4.0.

Appendices
A.1 Scenarios of 2019-2030 climate change condition

| Year | Scenario 1 (S-1)* | Scenario 2 (S-2)* | Scenario 3 (S-3) |
|------|-------------------|-------------------|------------------|
| 2019 | La Nina           | El Nino           | Normal           |
| 2020 | El Nino           | La Nina           | Normal           |
| 2021 | El Nino + Normal  | La Nina + Normal  | Normal           |
| 2022 | El Nino + Normal  | La Nina + Normal  | Normal           |
| 2023 | El Nino + La Nina | La Nina + El Nino | Normal           |
| 2024 | El Nino           | La Nina           | Normal           |
| 2025 | El Nino + La Nina | La Nina + El Nino | Normal           |
| 2026 | La Nina + El Nino | El Nino + La Nina | Normal           |
| 2027 | El Nino + Normal  | La Nina + Normal  | Normal           |
| 2028 | Normal            | Normal            | Normal           |
| 2029 | El Nino + Normal  | La Nina + Normal  | Normal           |
| 2030 | El Nino + Normal  | La Nina + Normal  | Normal           |

*Indonesia Climate Change Sectoral Roadmap (ICCSR), Marine and Fishery Sector Report, March 2010 [5]
*Indonesia Climate Change Sectoral Roadmap (ICCSR), Synthesis Report, December 2009 [6]
### A.2 Changes in crop yields under various scenarios compared to normal condition (Percent)

| Commodity    | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Scenario 1 (S-1) |      |      |      |      |      |      |      |      |      |      |      |      |
| Banana       | -0.11| -0.21| -0.20| -0.24| -0.21| -0.23| -0.19| -0.25| -0.22| 0.00  | -0.21| -0.22 |
| Orange       | -0.20| -0.09| -0.12| -0.06| -0.09| -0.11| -0.10| -0.09| -0.12| 0.00  | -0.13| -0.15 |
| Shallot      | -0.11| -0.21| -0.11| -0.09| -0.13| -0.21| -0.13| -0.21| -0.11| 0.00  | -0.11| -0.12 |
| Chilli       | -0.14| -0.10| -0.13| -0.11| -0.14| -0.11| -0.22| -0.11| -0.20| 0.00  | -0.19| -0.20 |
| Potato       | -0.15| -0.17| -0.13| -0.14| -0.14| -0.14| -0.18| -0.20| -0.14| 0.00  | -0.16| -0.16 |
| Scenario 2 (S-2) |      |      |      |      |      |      |      |      |      |      |      |      |
| Banana       | -0.12| -0.09| -0.13| -0.15| -0.21| -0.08| -0.19| -0.21| -0.11| 0.00  | -0.11| -0.12 |
| Orange       | -0.11| -0.18| -0.18| -0.13| -0.10| -0.21| -0.12| -0.08| -0.13| 0.00  | -0.14| -0.14 |
| Shallot      | -0.17| -0.12| -0.06| -0.05| -0.13| -0.14| -0.21| -0.13| -0.13| 0.00  | -0.18| -0.20 |
| Chilli       | -0.09| -0.05| -0.22| -0.18| -0.14| -0.16| -0.21| -0.20| -0.17| 0.00  | -0.11| -0.12 |
| Potato       | -0.11| -0.20| -0.18| -0.16| -0.15| -0.18| -0.16| -0.16| 0.00  | -0.20| -0.19 |      |

Source: Author calculation using model prediction of climate change impact on yield of [3] and [4]

### A.3 Changes in crop yields under various scenarios compared to base year (2016) condition (Percent)

| Commodity    | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Scenario 1 (S-1) |      |      |      |      |      |      |      |      |      |      |      |      |
| Banana       | 0.05 | 0.00 | 0.02 | 0.01 | 0.01 | 0.00 | 0.05 | 0.05 | 0.05 | 0.26 | 0.05 | 0.04 |
| Orange       | -0.07| 0.01 | 0.02 | 0.03 | 0.00 | 0.01 | 0.04 | 0.03 | 0.01 | 0.14 | 0.02 | 0.01 |
| Shallots     | 0.30 | 0.21 | 0.32 | 0.33 | 0.30 | 0.23 | 0.31 | 0.30 | 0.34 | 0.42 | 0.32 | 0.30 |
| Chilies      | 0.09 | 0.14 | 0.17 | 0.15 | 0.13 | 0.14 | 0.07 | 0.07 | 0.07 | 0.23 | 0.07 | 0.07 |
| Potatoes     | 0.00 | 0.05 | 0.06 | 0.07 | 0.05 | 0.05 | 0.05 | 0.02 | 0.07 | 0.21 | 0.06 | 0.06 |
| Scenario 2 (S-2) |      |      |      |      |      |      |      |      |      |      |      |      |
| Banana       | 0.04 | 0.09 | -0.04| 0.01 | -0.11| 0.15 | -0.11| 0.00 | 0.11 | 0.10 | -0.10| -0.02 |
| Orange       | 0.02 | -0.09| 0.03 | 0.00 | 0.04 | -0.08| 0.11 | 0.00 | -0.03| 0.14 | -0.13| 0.01 |
| Shallots     | 0.23 | 0.07 | 0.07 | 0.01 | -0.07| 0.00 | -0.07| 0.07 | 0.02 | 0.11 | -0.19| -0.01 |
| Chilies      | 0.14 | 0.06 | -0.12| 0.00 | 0.05 | -0.05| -0.02| 0.00 | 0.03 | 0.13 | -0.07| 0.00 |
| Potatoes     | 0.05 | -0.03| 0.00 | 0.03 | 0.00 | -0.04| -0.04| 0.03 | 0.16 | -0.19| 0.00 |      |

Source: Author calculation based on A.2

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[6] [BAPPENAS] Badan Perencanaan Pembangunan Nasional 2009 *Indonesia climate change sectoral roadmap-I CCSR* Synthesis Report December 2009 (Jakarta: BAPPENAS) p 118