Food Security Production Challenges in Indonesia as Impact of Global Climate Change
Dani Lukman Hakim¹, Dedi Herdiansah²

¹Associate Professor, Faculty of Agriculture, Galuh University
²Lecturer, Faculty of Agriculture, Galuh University

Abstract—Global food availability, including national as well as local, is highly dependent on the natural resources that will affect crop production. Although there is rain, soil temperatures and conditions have formed a natural system that will support agricultural efforts, but this state is unstable and always changes according to atmospheric conditions in an integrated manner. Human beings on certain boundaries can intervene with the natural resources.

Climate (generally a combination of rain, temperature, and sunlight) is the most important growth factor in crop production in the field. Any change in climatic conditions will have far-reaching effects on global food production.

Global climate change, excessive land and land exploitation, inaccurate land management, in its time will have an impact on the food production and availability of a region. Knowing well the characteristics of nature, then anticipating the impact that will arise and determine the ways of handling it, is a series of business and activities that must be done to achieve food security.

To anticipate climate change and its impacts on crop production, a broad outline can be made by considering the following physical technical aspects: 1) adjusting cropping patterns; 2) increasing the area of forest cover and catchment areas; 3) application of land and crop management technology. Some application of land and crop management technologies include: organic farming, implementation of Surjan system, food diversification, large tree planting, water pond production, etc.

The policies that need to be taken as a solution in anticipating the impact of global climate change are 1) the preparation and stipulation of special food agriculture scenarios, including the zoning of production potential and zonation of climate risk (drought, flood, landslide, etc.) with the updating of data every year; 2) reducing the conversion of agricultural land (food); 3) incentives for farmers; 4) changing the consumption pattern of the people, from the consumption of rice to alternative staple foods; 5) subsidies and protection of food farming; 6) climate monitoring and prediction (early rainy season, long growing period, and potential water availability; 7) Revitalization of watershed (DAS) functions; 8) Multiply the artificial water absorption area.

Keywords—Climate Change, Food Security, Land and Crop Management, Watershed.

I. INTRODUCTION

Increased concentrations of greenhouse gases in the atmosphere due to human activities around the world, causing increased radiation trapped in the atmosphere. The impact is the occurrence of an increase in average temperatures across the earth's surface, referred to as global warming.

Increasing the average temperature of the Earth's surface causes changes in other climatic elements, such as rising sea temperatures, increased evaporation in the air, and changing patterns of rainfall and air pressure that eventually change the pattern of world climate. This event became known as global climate change.
TABLE 1
CLIMATE CHANGE INDICATORS IN INDONESIA

| No. | Climate Elements | Phenomenon                          | Impact                                |
|-----|------------------|-------------------------------------|---------------------------------------|
| 1.  | Precipitation    | Longer dry season                   | Water shortage, crop failure          |
|     |                  | Shorter rainy season with high intensity | Flood, erosion, landslide, crop failure |
| 2.  | Air Temperature  | The temperature is hotter            | Increased evaporation, impaired growth |
| 3.  | Wind             | Strong local winds at the time of the rain | Disrupting plant growth               |

**FIGURE 1. AVERAGE GLOBAL SEA SURFACE TEMPERATURE, 1880-2015**

**FIGURE 2. TRENDS IN GLOBAL AVERAGE ABSOLUTE SEA LEVEL, 1870-2008**
II. Data and Fact

At the regional micro-scale in Indonesia, several climate elements that undergo changes include wind, temperature, and precipitation (Table 2).

Some studies of average historical data, air temperatures in Indonesia increased by 0.3 °C per year since 1900, in the 1990s was the warmest decade and 1998 was the warmest year, 1 °C above the 1961-1990 average. Increased temperatures occur throughout the season. Rainfall is reduced by 2 to 3% especially in December-February. In most parts of Indonesia rainfall is affected by El-Nino, major droughts occur in El-Nino years 1982/1983, 1986/1987, and 1997/1998.

| Location | Year        | Temperature | Precipitation (dry season) | Precipitation (wet season) |
|----------|-------------|-------------|----------------------------|----------------------------|
| Jakarta  | 1916-1987   | 0.03**      | *                          | *                          |
| Jakarta  | 1951-1987   | *           | - 0.1 %                    | 10 % **                   |
| Bogor    | 1951-1987   | *           | - 1.1 % **                 | 0.3 %                     |
| *Bogor   | 1976-1987   | 0.05**      | *                          | *                          |
| Bogor    | 1980-1998   | 0.14**      | -2.0 % **                  | 4.6 % **                  |

Data Source 1: Hidayati (1990), Hidayati, Abdullah, and Suharsono (1999).
Data Source 2: Hulme and Sheard (1999), Boer and Faqih (2004).

III. Materials and Method

The methodology used in this research is the systematic review method. As with the methodology of individual research, in principle, systematic review research begins by making a systematic review research protocol and the next stage of
conducted systematic review research. Sequentially, the process of systematic review research is shown in Table 4. Analog with general research methodology, where there are quantitative and qualitative methods, then in systematic review there are also quantitative methods and qualitative methods.

Quantitative method of systematic review is used to synthesize the results of research with quantitative approach. For example, Randomized Control Trials (RCTs), Cohort Study, Case-Control Study, or prevalence studies. The statistical approach in synthesizing the results of quantitative research is called "meta-analysis". By definition, meta-analysis is a technique of aggregating data to obtain statistical power in identifying causal relationships between risk factors or treatment with an outcome (Perry & Hammond, 2002). Meanwhile, qualitative approach in systematic review is used to synthesize qualitative descriptive research results. The method of synthesizing (summarizing) the results of qualitative research is called "meta-synthesis". By definition, meta-synthesis is a technique of integrating data to gain new theories and concepts or deeper and more thorough understanding levels (Perry & Hammond, 2002).

**TABLE 4**

**SEQUENCE OF SYSTEMATIC REVIEW PROCESS (PERRY & HAMMOND, 2002)**

| No. | Sequence of Process                                      | Objective                                                                 |
|-----|----------------------------------------------------------|---------------------------------------------------------------------------|
| 1.  | Identify questions research                             | Make a transformation climate change problems into question research       |
| 2.  | Develop protocol research systematic review             | Giving guides in doing systematic review                                   |
| 3.  | Set location Data-base results research as search area  | Provide restrictions search area against the results of the study which is relevant |
| 4.  | Selection of results relevant research                  | Collect the results relevant research with questions research             |
| 5.  | Select good quality results of research                 | Conducting exclusion and inclusion of research to be entered in systematic review based on quality |
| 6.  | Data extraction from individual studies                 | Perform data extraction from individual studies to get the findings importance |
| 7.  | Result synthesis by method Meta-analysis (if allow), or narrative method (if impossible) | Conducting synthesis of results with metaanalysis techniques (forest plot) or narrative techniques (metasintesis) |
| 8.  | Presentation of results                                 | Write down the results research in the document reports systematic results review |

**IV. RESULTS AND DISCUSSION**

4.1 Impact of Climate Change

4.1.1 Floods and Drought

Indonesia there have been 46 major drought events, 30 of which occurred in the period 1844-1960 (for 117 years), and the remaining 16 events in the period 1961-2006 (only for 46 years). While the floods, became a common occurrence almost every rainy season in various provinces (Ministry of Environment Republic of Indonesia, 2007). During the period of 2001-2004 there have been 530 flood events in various regions in Indonesia.
FIGURE 5. NUMBER OF FLOOD CASES AND VICTIMS DEATHS PER PROVINCE 1822-2011 (DATA SOURCE BNPB, 2012)

FIGURE 6. NUMBER OF FLOOD CASES AND VICTIMS DEATHS PER YEAR 1822-2011, (DATA SOURCE BNPB, 2012)

TABLE 5
SITUATION OF DROUGHT AND HARVEST FAILURE IN INDONESIA

| Year  | Drought Impact (Decreasing Production in Hectares) | Harvest Failure in Hectares |
|-------|---------------------------------------------------|-----------------------------|
| 1990s |                                                   |                             |
| 1994  | 489,178                                           | 150,319                     |
| 1995  | 18,462                                            | 3,385                       |
| 1996  | 48,490                                            | 11,485                      |
| Total | 556,130                                           | 165,162                     |
| 2000s |                                                   |                             |
| 2001  | 145,545                                           | 11,344                      |
| 2002  | 298,678                                           | 30,694                      |
| 2003  | 430,258                                           | 82,690                      |
| Total | 874,481                                           | 124,728                     |

Data Source: Indonesian Department of Agriculture, 2007.
### Table 6
**Condition of Watershed (DAS) in Java Island**

| No. | Province   | Broodstock | DAS Square (Km²) | Min | Max   | Qmax/Qmin | Condition |
|-----|------------|------------|------------------|-----|-------|-----------|-----------|
| 1.  | Banten     | S. Ciujung | 1.563            | 1.0 | 1.880 | 1.880     | Critical  |
| 2.  | West Java  | S. Cisadane| 820              | 1.0 | 1.150 | 1.150     | Critical  |
|     |            | S. Ciliwung| 158              | 0.1 | 390   | 3.900     | Critical  |
|     |            | S. Citarum | 1.675            | 2.0 | 370   | 185       | Critical  |
|     |            | S. Cimanuk | 1.966            | 1.0 | 710   | 710       | Critical  |
|     |            | S. Citanduy| 1.416            | 0.1 | 1,250 | 12,500    | Critical  |
| 3.  | Central Java| K. Pemali  | 856              | 0.1 | 850   | 8,500     | Critical  |
|     |            | K. Serang  | 98               | 0.1 | 100   | 1000      | Critical  |
|     |            | K. Juana   | 46               | 0.1 | 110   | 1,100     | Critical  |
|     |            | B. Solo    | 3,207            | 3.0 | 9,990 | 4,495     | Critical  |
|     |            | K. Serayu  | 723              | 0.1 | 1,580 | 527       | Critical  |
|     |            | K. Progo   | 423              | 0.1 | 900   | 9,000     | Critical  |
|     |            | K. Opak    | 30               | 0.1 | 10    | 100       | Critical  |
| 4.  | DIY        | K. Brantas | 7,112            | 10.0| 3,180 | 316       | Critical  |
|     |            | K. Sampean | 612              | 0.1 | 850   | 8,500     | Critical  |
|     |            | K. Pekalen | 163              | 0.1 | 200   | 2000      | Critical  |

*Data Source: DBPSDA-PU, 2009.*

#### 4.2.2 Agriculture Production (Paddy)

Notes in the Indonesian Meteorological and Geophysical Agency show that the dry periods Indonesia has experienced are 1991, 1993, 1994, 1997, 2000, and 2001, while the times of excess water are 1992, 1996, 1999, and possibly 2002 (Table 5). This fact can be used to predict and simultaneously inform not only when the right planting, but also the type of plant that best fits the condition. This will greatly assist food security efforts and reduce the risk of crop failure.

### Table 7
**Area of Rice Crops Affected by Floods, Drought, and Harvest Failure (Puso) in Hectares (1988-1997)**

| Year | Remark   | Flood  | Drought | Puso  |
|------|----------|--------|---------|-------|
| 1987 | El-Nino  | ***    | 430,170 | ***   |
| 1988 | La-Nina  | 130,375| 87,373  | 44,049|
| 1989 | Normal   | 96,540 | 36,143  | 15,290|
| 1990 | Normal   | 66,901 | 54,125  | 19,163|
| 1991 | El-Nino  | 38,006 | 867,997 | 198,054|
| 1992 | Normal   | 50,360 | 42,409  | 16,882|
| 1993 | Normal   | 78,480 | 66,992  | 47,259|
| 1994 | El-Nino  | 132,975| 544,422 | 194,025|
| 1995 | La-Nina  | 218,144| 28,580  | 51,571|
| 1996 | Normal   | 107,385| 59,560  | 50,649|
| 1997 | El-Nino  | 58,974 | 504,021 | 102,254|

*Data Source: Jasis and Karama, 1999; Yusmin, 2000.*
4.2 Projection of Food Production

The effect of climate change on crop production depends on factors, namely: 1) the magnitude of changes in influencing climate variables; and 2) plant adaptability. According to Rosenzwig and Iglesias (IPCC, 1996), there will be a decline in some food commodities in some countries as follows (Table 8). The most influential aspects of climate elements to production are air temperatures and rain.

| Countries | Impact to Agriculture Production |
|-----------|----------------------------------|
| Indonesia | Rice -2.5 %; Soybean -2.3 %; Maize -40 % |
| Malaysia  | Rice -22 % to -12 %; Rubber -30 % to -3 % |
| UK        | Land Productivity (+5 % to +15 %) |
| USA       | Wheat -14 % to -2 %; Maize -29 % to -15 %; rice -23 % |

Figure 7. Projection of Global Food Production Decrease (Data Source IGI CDC Advisory, 2015)

4.3 Adaptation and Mitigation

To anticipate climate change and its impact on crop production, the outline can be done by considering the following physical technic aspects:

1. Adjusting cropping patterns;
2. Increasing the area of forest cover and catchment areas;
3. Application of land and crop management technology. Some application of land and crop management technologies include: organic farming, implementation of Surjan system, food diversification, large tree planting, water pond production, etc.

V. Conclusion

The policies that need to be taken as a solution in anticipating the impact of global climate change are:

1. The preparation and stipulation of special food agriculture scenarios, including the zoning of production potential and zonation of climate risk (drought, flood, landslide, etc.) with the updating of data every year;
2. Reducing the conversion of agricultural land (food);
3. Incentives for farmers;
4. Changing the consumption pattern of the people, from the consumption of rice to alternative staple foods;
5. Subsidies and protection of food farming;
6. Climate monitoring and prediction (early rainy season, long growing period, and potential water availability.
7. Revitalization of watershed (DAS) functions.
8. Multiply the artificial water absorption area.

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