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# Bio-economy Sustainable Agriculture Strategy In Cirebon Regency

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**Abstract.** The production of national agricultural products in the last 10 (ten) years has fluctuated and tends to decrease. Burning straw waste in rice fields contributes to greenhouse gas emissions, known as one of the causes of global warming that will decrease the quality and quantity of natural resources and impact the decline in agricultural product production. Analyzing these problems, the author conducted a literature review to find good practices based on the latest study's results. The results show that the bio-economy as part of agriculture can be a strategy to mitigate the impact of climate change to support sustainable agriculture. The bio-economy will manage waste into valuable products while reducing dependence on fossil fuels and minimizing environmental impact. To support this, the Regional Head and the Cirebon Regency legislature must draft a regional regulation on the prohibition of burning rice straw waste to support the reduction of greenhouse gas emissions.

**Keywords:** bio-economy, agriculture, strategy, Cirebon, sustainable

## INTRODUCTION

### Background

The rainy season in March 2024 has caused 1,330.5 hectares of rice fields and gardens in 9 (nine) sub-districts in Cirebon Regency to be affected by flooding and submerged. Meanwhile, the dry season that hit Cirebon Regency until August 2024 has caused 468 hectares of rice fields in 22 sub-districts to be affected by drought disasters, and around 2,109.5 hectares of rice fields spread across 40 sub-districts are threatened with drought. Floods and droughts often occur in Cirebon Regency and are feared to cause a decline in food production and threaten the economy of the village community.

Faced with these conditions, the Cirebon Regency Government, through the Agriculture Office, has implemented several programs, including pumping. During floods, pumping aims to discharge water from flood-affected land into the river. Meanwhile, in the dry season, pumping aims to take water from rivers or secondary irrigation so that farmers can still plant rice even in dry conditions.

Nationally, in the last ten years, this condition has occurred in almost most of the archipelago, causing fluctuations and declining food production and becoming a threat to national food security, so the Government calls it a "Food Emergency". As a government effort to overcome the "Food Emergency" in 2024, the Ministry of Agriculture seeks to maintain the availability of rice as a staple food for the people in Indonesia through 4 (four) programs: first, facilitating the mechanism for taking subsidized fertilizers only using farmer cards or identity cards (KTP) which previously had to go through a long process and mechanism to get it, second, expanding the planting area by pumping river water in 11 (eleven) provinces For rice fields, the third is the optimization of 400 thousand hectares of swamp land in 10 (ten) provinces to increase the area of rice cultivation and the fourth is the amount of subsidized fertilizer allocation added because in the last five years, subsidized fertilizers have decreased compared to the 2014-2018 period which amounted to 9.55 million tons.

The Cirebon Regency Government received a pumping program to irrigate rainfed rice fields and increase the planting area. In addition, the Government invites farmers to participate in the rice farming business insurance program (AUTP), which is available as an adaptation step to reduce losses due to puso during the rainy and dry seasons. A decrease in food production over a long period of time will cause a food crisis, which can be interpreted as a state of food scarcity experienced by most people in a certain area.

The world community, including the Indonesian government, is paying serious attention to the global food crisis because it concerns the livelihood of many people. The food crisis will cause food scarcity and force countries worldwide to prioritize their domestic food needs over exporting their food production. This will

certainly greatly influence the pattern of global food distribution across the globe. The high price of food due to limited availability became the beginning of a food crisis. Unstable conditions will cause commodity prices, especially energy and food, to rise, which will then drive inflation in the country

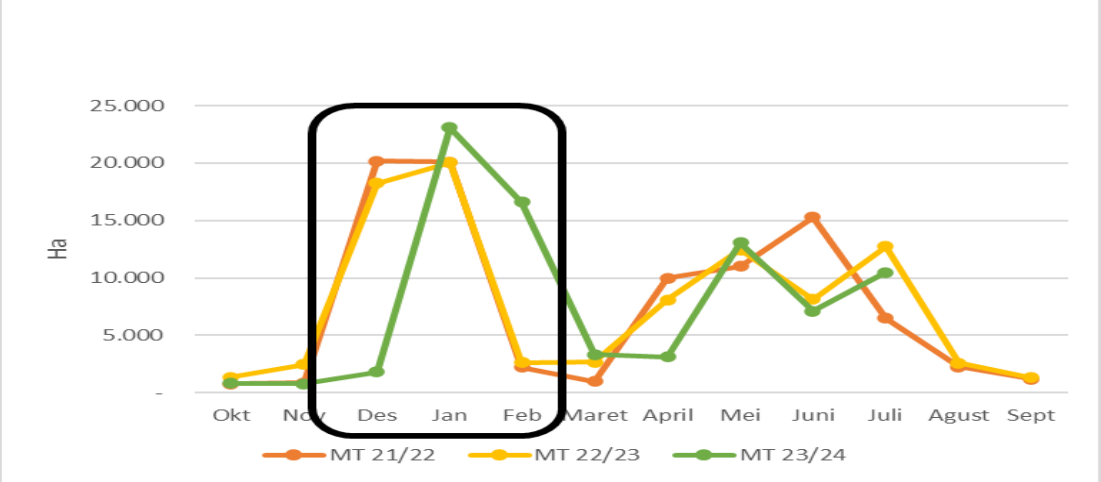
Inflation in agricultural commodities has been frequent lately, mostly because their availability is lower than the demand for public consumption. Data on food crop production for the last 10 (ten) years provides an overview of fluctuations in food crop production and tends to decrease, especially rice, including corn and soybeans. In aggregate, national food availability is not too significantly greater than the national food consumption needs, so there is often an imbalance between food demand and supply, which causes food prices to increase over a certain period. [1, 2].

The development of rice production data in 2023 in West Java Province also decreased by 3.11% from 2022 [3]. Meanwhile, the National Food Agency (Bapanas), at a coordination meeting held by the Ministry of Home Affairs in the context of controlling inflation on September 9, 2024, said that rice production data for the January-October 2024 period is estimated at 26.93 million tons, 1.41% lower than the January-October 2023 rice production (28.34 million tons). This decrease in production was influenced by shifts in the planting season, including the rice planting season in Cirebon Regency, which shifted due to drought and impacted rice production in aggregate.

The rice planting schedule in Cirebon Regency in 2023 has shifted so that the peak of the planting season, which generally occurs from December 2023 to January 2024, has shifted to January-February 2024. The shift in planting time due to the continued impact of El-Nino (warming sea surface temperature that increases drought) has caused rice production at the peak of the 2023/2024 Planting Season (MT) I and II not to be optimal. As a result, the grain supply decreases, and the price of rice rises, resulting in inflation. The picture of the decline in planting area also occurs in the production of shallots and red peppers. The planting area of shallots in 2023 and

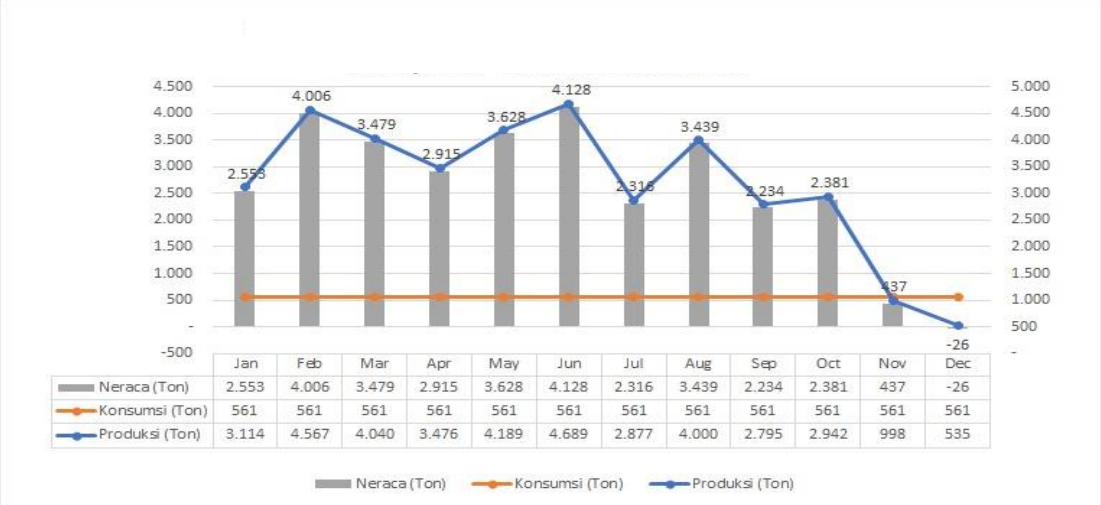
2022 is 3,761 Ha and 3,121 Ha, respectively. The planting area of large red peppers in 2023 and 2022 is 675 Ha and 373 Ha, respectively. [4].

Figure 1. Rice Planting Area (Ha) in Cirebon Regency in the Planting Season 2021/2022 and 2023/2024




Source : Cirebon Regency Agriculture Office Statistical Data in 2024

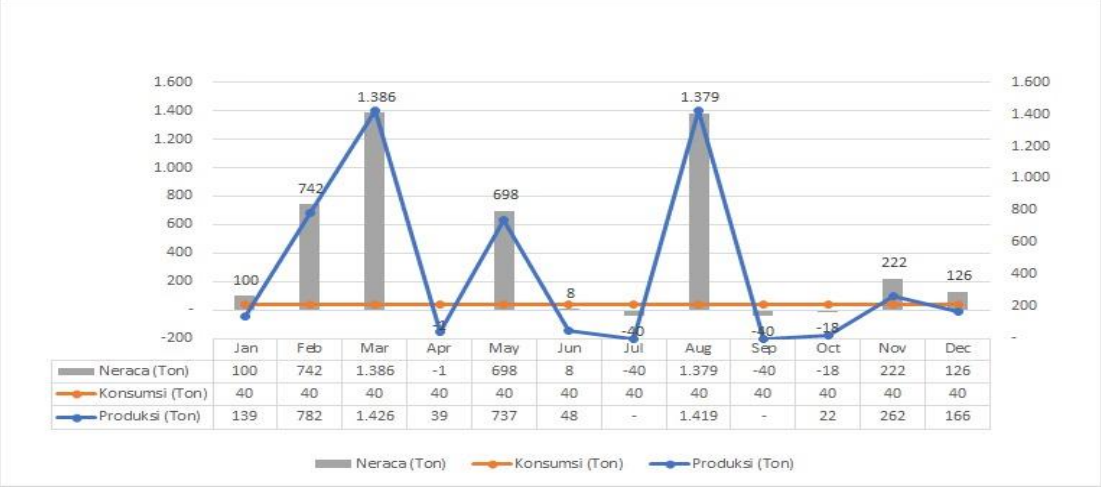
Figure 2. Production, Consumption and Balance of Shallots in Cirebon Regency Year 2024




Source : Cirebon Regency Agriculture Office Statistical Data in 2024

The current production of shallots and large red peppers is not much different from 2022 and 2023, and it is tending to decline, which triggers inflation.

Figure 3. Production, Consumption and Balance of Large Chili in Cirebon Regency Year 2024




Source : Cirebon Regency Agriculture Office Statistical Data in 2024

The threat of declining food production that is currently occurring is caused by several things, including:

1. Declining quality and quantity of natural resources;
2. Changes in people's lifestyles;
3. Economic disincentive.

Many problems cause the threat of declining food production. These problems are:

1. Decline in the quality and quantity of natural resources

Problems that cause a decrease in the quality and quantity of natural resources are:

a. Climate change

Climate change is caused by increased global temperatures, marked by changes in rainfall patterns and an increasing frequency of extreme weather events. The global temperature increase due to increased emissions and concentrations of greenhouse gases in the atmosphere is an anthropogenic disaster, namely a disaster due to human activities and negligence. Ideally, the earth absorbs and re-emits some of the heat radiation emitted by the earth's surface, but greenhouse gases limit the amount of heat that can escape from the atmosphere, causing an increase in the earth's temperature.

The results of observations by the Meteorology, Climatology and Geophysics Agency (BMKG) show that the rate of change in air temperature starting from 1981-2022 on average nationally in Indonesia increased by 0.6°C per 30 years [5].

The average annual rainfall for the period 1991 – 2020 generally experienced a small change. Areas that experience an increase in annual rainfall include northern Sumatra, parts of Kalimantan, the southern coast of West Java, central to southern Bali, East Nusa Tenggara, central and southern Sulawesi, western Maluku, West Papua and northern Papua. The dominant areas experiencing a decrease in annual rainfall include central to southern Sumatra, the northern coast of Java, eastern Kalimantan, and northern and southeastern Sulawesi [6].

The increase in global temperatures can be caused by:

a.1. Increased emissions and concentrations of greenhouse gases in the atmosphere due to natural activities such as volcanic eruptions, animal respiration and forest fires. But these things do not cause significant global warming.

a.2 Increased greenhouse gas emissions and concentrations in the atmosphere due to human activities, namely activities that cause an increase in greenhouse gas concentrations (carbon dioxide, methane and water vapor). Sectors that produce a lot of greenhouse gases include:

a.2.1. Energy

To obtain energy, fossil fuels are still widely used and account for 82% of the world's total energy consumption and contribute GHG emissions to 46.35% of Indonesia's total GHG emissions [7].

a.2.2. Agriculture

- The agricultural sector accounts for around 13% of total GHG emissions at the national level. The projected greenhouse gas emissions in the Agricultural Sector to greenhouse gas emissions in Indonesia in 2030 are estimated at 478,503.66 Gg CO2 e [8].
- The follow-up result of the rice harvest is straw, which is obtained around 25-30 tons of wet per hectare each harvest. Currently, rice straw is still mostly burned, causing pollution because it releases several pollutants into the air, these pollutants include carbon dioxide (CO2) by 70%, followed by methane (CH4) by 0.66%, carbon monoxide (CO) by 7%, and nitrogen oxides (N2O) by 2.09% [9].

b. Increasing conversion of agricultural land

Agricultural land conversion is agricultural land that changes its function to non-agricultural use.

Land use and cover in 2017 was dominated by paddy fields (50,235 ha or 47.3%) and the second largest was dominated by built-up land (21,389 ha or 20.1%). Within a decade there was a decrease in the area of rice fields by 470.6 ha every year, switching functions to built areas which eventually reduced the number of

farmers, so that farmers preferred to work in other livelihoods rather than the agricultural sector [10].

This occurs due to:

b.1. Increasing infrastructure development due to population growth

The increasing population has led to an increase in the need for land for settlement, infrastructure and industrial development.

b.2. Socio-economic conditions of farmers

Farmers who face economic difficulties or high-risk land for farming have the potential to sell their land so that other users will switch their functions from rice fields to non-rice fields.

b.3 Government regulations

Government policies affect the acceleration of the agricultural land conversion process. Suboptimal attention from the government cannot support sustainable agriculture.

c. Declining availability of water sources

The availability of water sources is currently decreasing due to the increasing rate of deforestation which has led to a decrease in the number of water catchment areas. This condition is shown from the data on the land cover quality index in Cirebon Regency which fluctuates and tends to decline from 2019-2023, each figure is 33.81%; 38,10%; 27.2% and 27.56% [11].

2. Changes in people's lifestyles

The increasing transformation of information as well as science and technology increasingly provides easy access to people to consume various types of food, causing competition in natural resource management by the industrial sector in order to produce food. Changes in people's lifestyles are caused by several things, namely:

a. Improving education

Increasing education can broaden people's horizons and horizons of thinking so as to encourage better and more diverse food consumption. Human development indicators in Cirebon Regency have increased, as seen from the increase in the

average length of schooling (years) from 2020-2023 which tends to increase consecutively by 6.92; 7,10; 7,40; 7,64 [4].

b. Increased revenue

Improving income will improve people's welfare so that it will increase the need for foods with high protein content, such as increasing demand for meat, milk and eggs which will encourage an increase in livestock production and other foods that will increase their contribution to greenhouse gas emissions. The increase in income can be seen from the Regional Domestic Product (GDP) per capita, the average GDP growth rate in Cirebon Regency has increased from year to year which illustrates an increase in community income, although in 2020 it decreased to -1.08 due to the Covid-19 pandemic, but in 2021 to 2023 the GDP growth rate in Cirebon Regency tends to increase to 4.85 [4].

3. Economic disincentives

Economic disincentives are efforts used to prevent, limit, or reduce the implementation of activities that are not in accordance with the desired spatial plan or economic policy. In the agricultural sector, economic disincentives are used to prevent or ensure the sustainability of agriculture. However, the policies of stakeholders in Cirebon Regency have not optimally provided economic disincentives to the agricultural sector, the reasons are:

a. Regional regulations (Perda) for sustainable agricultural land protection (LP2B) do not exist yet, so it has the potential to increase the conversion of agricultural land to non-agricultural use;
b. The food system is still controlled by market mechanisms which causes low bargaining positions for farmers. Although the government has set the cost of goods sold (COGS) for rice commodities, it often does not help farmers to get decent profits, where the profits obtained are not much different from the production costs that must be incurred by farmers. In addition to government policies, macroeconomics, and climate change can also affect the position of low-cost farmers.

From this description, the root of the problem that is important to be solved immediately to prevent a decline in food production is the control of agricultural sector activities as the cause of increased emissions and greenhouse gas concentrations so that climatechange occurs which has an impact on the decline in the quality and quantity of natural resources.

**Purpose**

The purpose of this paper is to identify good practices as an effort to mitigate the impact of climate change in Cirebon Regency in order to provide consideration to policy makers to support the realization of sustainable agriculture.

## ANALYSIS AND DISCUSSION OF THE PROBLEM

**Method**

The method used by the author in analyzing the problems faced is to review both national and international literature to find out the latest studies that examine climate change impact mitigation strategies in the agricultural sector as good practices to encourage practical steps and regulatory materials that will be prepared by the local government to support sustainable agriculture in Cirebon Regency.

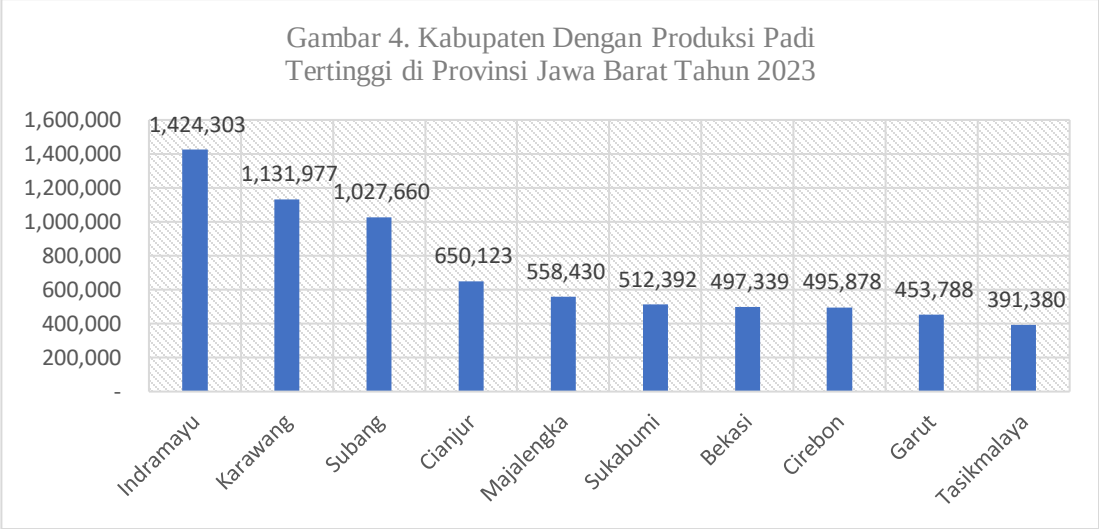
**Overview**

Cirebon Regency is one of the rice-producing districts in West Java Province and is in the 8th position out of the 10 largest rice-producing districts. Cirebon Regency has 40 sub-districts with 412 villages and 12 sub-districts with an area of 1,070.29 square kilometers and is geographically located between 108$^{o40'\text{ and }108o48'}$ south latitudes, as well as between 6$^{o30'\text{ and }7o00'}$ East Longitude, as part of West Java Province, Cirebon Regency borders several other districts/cities in West Java Province, namely [4]:

- Indramayu Regency, Cirebon City and the Java Sea to the north,
- Majalengka Regency and Kuningan Regency to the south,
- Majalengka Regency and Indramayu Regency to the west, and

- Central Java Province, namely Brebes Regency to the east.

Along with the increasing impact of climate change, the status of rice producers is a threat to Cirebon Regency, and efforts are needed to keep the agricultural sector productive all the time. Therefore, it becomes increasingly relevant and urgent to pay attention to the strategies that must be prepared as mitigation efforts so that sustainable agriculture supports food security for a long time.




Source : BPS (2023)

**Sustainable Agriculture**

The phenomenon of declining rice production due to climate change is projected to increase in all provinces in Indonesia in 2020-2045. The decline in rice production from high to very high levels occurred in several provinces in the east-north [8].

Meanwhile, on the other hand, Indonesia's population growth is still at a positive pace with the fourth largest population in the world, in 2020 at 270.2 million people and the United Nations (UN) estimates that it will be 300 million people by 2050. One of the tough challenges in dealing with this condition is to meet the food

needs in a sustainable manner for all citizens [12]. The number of population until mid-2024 will reach 281.6 million people [13]. This condition is inversely proportional to the trend of food production that continues to decline.

The increase in population must be followed by an increase in food availability to ensure the welfare of current and future generations. This can be done by planning and managing natural resources effectively including air, water, soil, flora, and fauna. Therefore, the government as a policymaker must prioritize the maintenance and increase of the earth's capacity to produce renewable resources [14].

Ensuring food and nutrition security for current and future generations requires an economically viable, environmentally friendly, socially inclusive and institutionally responsive approach, which collectively and individually contributes to a sustainable food system [15]. However, currently the extractive food system known as agricultural intensification has been implemented as a food management policy by the government for the purpose of food security and nutrition [16]. Various forms of capital, natural resources, human resources and other tangible resources, are utilized with the explicit purpose of increasing agricultural yields and profitability. It is crucial to realize that the adoption of extractive practices leads to unsustainable food production in the future [17].

Paying attention to this information, a form of sustainable agriculture is needed in an effort to ensure abundant food production in line with efforts to conserve the earth's resources and avoid environmental pollution. In addition, sustainable agriculture also embodies social values, as its success is inseparable from the vitality of rural communities, the welfare of farmer families, and the provision of nutritious food for all [18].

Sustainable agriculture is part of sustainable development. Regional conservation efforts are needed to protect soil and water resources that serve as the main line of defense in meeting current and future food needs [19].

Realize Sustainable development, safeguarding the environment and ensuring a decent life for all are the goals of all countries on the planet. This is stated

in the 17 Sustainable Development Goals (SDGs) set by the United Nations (UN). PSustainable development is defined as development that meets the needs of the present without sacrificing the ability of future generations to meet their own needs". At Earth conference in Rio De Janeiro in 1992, it was agreed that the main global action known as "Agenda 21" which carries the idea of "sustainable development" has three dimensions, namely economic, social, and environmental dimensions [20].

**Climate Change Impacts**

In the last two decades, the intensification program of the use of various agricultural production facilities (seed assistance, subsidized fertilizers, organic fertilizers, and irrigation improvements) has had an impact on increasing national rice production.

The means of agricultural production used for plant cultivation, about 60% are for fertilizer, but even so, fertilizer can not be completely absorbed by plants, about 40-70% nitrogen, 75-90% phosphorus, and 50-70% potassium from fertilizer will be lost to the environment either through washing, fixation by soil or erosion [21].

In order to support the food emergency program, the government makes it easier for farmers to obtain subsidized fertilizers and increases the subsidized fertilizer quota by 100% from 4.7 million to 9.5 million tons. In addition, the government also prepares policies through Ministerial Regulation No. 01 of 2024 as a revision of Ministerial Regulation No. 10 of 2022 concerning Procedures for Determining the Allocation and HET of Subsidized Fertilizers which aims to improve the governance of subsidized fertilizers and increase agricultural production [22].

Many scientists said that the use of agricultural chemical products to increase food production will continue to have a detrimental effect on natural ecosystems and the environment. which causes limited food production capacity [23]. Synthetic chemical fertilizers and pesticides have disadvantages, one of which is that they are not environmentally friendly and can cause soil damage, resistance and resurgence of OPT and damage human health. Chemical fertilizers can cause degradation of agricultural

land fertility, namely changing physical, chemical and biological properties and causing a decrease in soil pH [24].

The success of intensification programs causes fluctuations in climate conditions, which are exacerbated by the potential negative impacts of climate change that result in decreased productivity or an increase in pest and disease attacks. Another threat is the increase in extreme climate phenomena that can cause floods and droughts, resulting in crop failure or crop failure [25].

Temperature rise $1^{Oc}$ As a result of the greenhouse gas effect and a 5% increase in rainfall, rice productivity will decrease by up to 0.33 tons/ha. Meanwhile, extreme climate events that often result in floods and droughts in Indonesia also have a negative impact on food crop production. Global warming projections can increase the frequency of El Nino events (events where relatively longer summers have implications for drought events) and La Nina (high rainfall intensity that impacts flooding) [25].

Extreme climatic events in the form of floods and droughts cause plants that experience puso to become more widespread. Changes in rainfall patterns and rising air temperatures cause agricultural production to decline significantly. In addition, rising sea levels cause shrinkage of rice fields in coastal areas and crop damage due to salinity. The impact of climate change is so large that it requires active efforts to anticipate it through mitigation and adaptation strategies. Mitigation technology aims to reduce greenhouse gas (GHG) emissions from agricultural land while adaptation technologies that can be applied include adjusting planting times, using superior varieties that are drought resistant, soaking and salinity, and developing water management technology. Although chemical/inorganic fertilizers play a role in increasing food production, due to the use of chemical fertilizers/synthetic fertilizers and pesticides, soil damage, OPT resistance and resurgence and damage to human health [24].

In response to this, the government began to encourage the implementation ofenvironmentally friendly agriculture by increasing the use of organic fertilizers, including the organic planting movement. In line with this, the Cirebon Regency

Regional Government since 2022 has begun to focus on efforts to utilize and develop organic fertilizers aimed at increasing rice production and reducing the use of chemical fertilizers in Cirebon Regency with an Environmentally Friendly Agriculture strategy. This is an effort to overcome the problem of declining fertility of agricultural land and the increasingly limited availability of subsidized fertilizers, the activity is in the form of disseminating the use of organic fertilizers driven through the UPPO (Organic Fertilizer Processing Unit) scheme by utilizing the potential of available resources. Its implementation has been supported by the issuance of the Decree of the Head of the Agriculture Service Number 065/Kep.332/Sekret/2022 concerning the Determination of the Guidebook for the Implementation of the Environmentally Friendly Agriculture Strategy (War) at the Cirebon Regency Agriculture Office. Furthermore, in 2023, it will be strengthened by Cirebon Regent Regulation Number 83 of 2023 concerning organic farming systems. In addition, the increase in greenhouse gas emissions also occurs due to the burning of rice straw in rice fields, this is still done by most farmers, including in Cirebon Regency.

Rice straw is often burned because it takes a long weathering time. Rice straw consists of leaves, fronds and segments or books with high silica and cellulose content, has a characteristic composition of lignocellulose residues, cellulose content ranges from 30-45%, hemicellulose 20-25%, and lignin 15-20%, a number of minor organic compounds C-organic around 44.71%, total N-around 1.08%, P reaches 0.17% and element K reaches 2.7%. As a result of straw burning, the current condition of most rice fields contains organic content of less than 2%, in normal conditions the organic content of rice fields is at least 3%. Soil nutrients lost as a result of straw burning include nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) reduced by 80%, 25%, 21%, and between 40% to 60% respectively, as well as the loss of several other organic matter [26].

In a bid to reduce air and soil pollution, India has created a rule banning the burning of straw as well as crop residues. To raise awareness among farmers about the dangers of burning to reduce air and soil pollution, a movement to manage crop residues

using machines was carried out in addition to the Government of India also introducing biogas power plants in villages and bio-composting methods [9].

Table 1. Straw Management Strategy and By-Product Development [9]

| In Situ | Ex Situ | |
|---|---|---|
| 1. Straw burning | Sector: | |
| 2. Plant mulching | Agriculture | Composting, immersed in rice fields, mushroom plant media |
| | Farm | Cattle barn mats, animal feed |
| | Energy | Biogas, electricity, fuel, biochar (charcoal), biofuel |
| | Industry | Silica extraction, aromatic compounds, metabolite production, nanomaterials |
| | Factory | Wood mds, building materials, acoustic materials, 3d objects, packaging, biopellets, paper production |
| | Other | Conventional breeding, low-silica rice, genome editing, microbial degradation |

**Bioeconomy**

Agriculture is part of the bioeconomy and the bioeconomy is integral to the green economy. The definition of bioeconomy is the production and utilization of biological resources based on knowledge, innovative biological processes, and principles for the sustainable provision of goods and services in all sectors of the economy [20].

In this regard, one of the right strategies to support sustainable agriculture is the bioeconomy, because the bioeconomy improves relations with the environment, reduces greenhouse gases and encourages economic growth through the sustainable use of biological resources. Bioeconomics integrates scientific advances, policy frameworks, and innovative practices with the goal of developing a sustainable direction for the future. The implementation of the bioeconomy needs to be supported by increasing environmental awareness and economic prospects. In this context,

agriculture and agroindustry have an important function in providing raw materials and converting them into valuable commodities [27].

The bioeconomy includes a network of actors from various sectors (academics, private sector, government, media and community organizations) who have some aligned interests and some conflict. They interact through various processes, leading to various governance challenges. The three types of governance challenges [20]:

a. Political Economy Challenges. Governments can play a broad role by creating framework conditions that are conducive to bioeconomic development. Participatory and deliberative policy processes have considerable potential in improving policy processes related to the bioeconomy. For example, Finland engages citizens in a forest-based bioeconomy with the aim of ensuring responsive governance.
b. Coordination Challenges. Another challenge of bioeconomic governance is coordination. Fostering the bioeconomy requires collaboration between sectors (economy, agriculture, environment, as well as research and education). Forming intersectoral working groups can help address these challenges. However, there is also a need to build coordination mechanisms across the public, private and third-level coordination sectors at various levels of government.
c. Global Bioeconomic Governance. Global governance mechanisms for the bioeconomy will be crucial to address various global issues, such as aligning food security with increasing biomass production and agreeing on common international standards to ensure sustainability in the bioeconomy.

## POLICY OPTIONS

In order to optimize the management of rice straw in Cirebon Regency, which is currently mostly still burned, thereby increasing greenhouse gas emissions in the atmosphere, causing global warming and for a long time resulting in a decrease in the

quality and quantity of natural resources and having an impact on the decline in agricultural production in Cirebon Regency, it is necessary to prepare supporting policies that support the management of rice straw into renewable resources through application of bioeconomy. Bioeconomy is a field related to natural resource management and economic development based on sustainability principles.

Referring to the principles of sustainable development, sustainable agriculture and bioeconomic challenges, there are several policy alternatives that can be prepared to optimize rice straw management in Cirebon Regency, namely:

a. Develop regional regulations to improve bioeconomy-based straw waste management;
b. Increasing collaboration between sectors (economy, agriculture, environment, research and education) supports bioeconomy-based straw management.
c. Scaling up campaigns to use straw waste into renewable resources to reduce reliance on fossil fuels and minimize environmental impact.

The policies are analyzed with criteria based on Bardach's theory, including factors such as effectiveness, feasibility/economy, administrative simplicity, political acceptance, and legality. [28].

Table 2. Alternative Straw Waste Management Policy Supports Agriculture Sustainable in Cirebon Regency

| Criterion | Policy a | Policy b | Policy c |
|---|---|---|---|
| Effectiveness | Becoming a guideline for bioeconomy-based waste management to support sustainable agriculture | Developing sustainable agriculture alternatives | Raising awareness/ Education of the community |
| Economics | There is legal certainty, comprehensive and sustainable from the economic aspect | Having the strength of various organizations collectively addressing the problem of straw burning. | Requires materials, outreach efforts, not directly addressing the root of the problem |
| Politics | Engaging and widely accepted | Engage multiple stakeholders | Need awareness and Education for change |

| | | | |
|---|---|---|---|
| Administration | Requires complicated procedures for its implementation and enforcement | Requires complex planning and execution | Planning and execution are easier |

Policy analysis uses several criteria to evaluate and compare various policy alternatives in order to get the right decision. This criterion is used in conditions where there are multiple policy options available, and policymakers need to assess the potential impact, feasibility, and effectiveness of each option before making a decision. With this policy selection, policymakers can ensure that the chosen policy aligns with the desired outcome and addresses relevant issues. The results of the analysis of policy alternatives are as follows:

1. Effectiveness

While collaboration between government agencies, private organizations, NGOs, academia, and local communities can help develop sustainable alternatives to phasing out straw burning and implement effective solutions in bioeconomy-based straw management and campaigns to harp waste into renewable resources to reduce reliance on fossil fuels and minimize environmental impacts can raise awareness and educate the public about the impacts However, the preparation of local regulations is more effective because it is a guideline and has clear consequences for straw burning and straw management based on bioeconomy as has been done by the Indian state which has made rules prohibiting straw burning [27].

2. Economical

Local regulations give legal certainty, comprehensive and sustainable from the economic aspect Although in terms of economic efficiency, collaboration is the most economical approach because it involves a wide range of stakeholders, both government agencies, the private sector, NGOs, academics and local communities, to collectively address the problem of straw burning. Bringing together resources, expertise, funds, collaboration can result in more efficient use of funds and minimize

cost duplication. While the m campaignEducational materials, and outreach efforts, which may not always directly address the root causes of straw burning [20] .

3. Politics

In the realm of political discourse, strategic support aimed at reducing straw burning may differ according to the priorities and interests of various stakeholders. Regulatory measures can gain greater acceptance among policymakers emphasizing the importance of an explicit and enforceable legal framework to address environmental concerns. A collaborative approach can be of interest to those who underscore the importance of engaging multiple stakeholders and fostering cooperative problem-solving mechanisms. While public campaigns may be preferred by individuals who prioritize raising public awareness and educational initiatives as a catalyst for promoting behavioural transformation [27].

4. Administration

Administrative simplicity, campaign policies may be relatively simpler compared to regulation and collaboration. Campaigns to minimize straw burning typically involve raising awareness, public education, and promoting alternative practices through various communication channels such as social media, community events, and educational materials [29]. While planning and executing local regulation enforcement or multi-stakeholder collaborative coordination requires careful strategy and coordination, the administrative process may be more complex and complex compared to the campaign [20].

## CONCLUSIONS AND POLICY RECOMMENDATIONS

Climate change is caused by greenhouse gas emissions, which will result in a decrease in the quality and quantity of natural resources and have an impact on a decrease in food production. Rice straw burning is one of the activities in the agricultural sector that causes increased greenhouse gas emissions, so it is necessary to manage rice straw waste. The strategy offered to solve this problem is to implement

the bioeconomy, by managing straw waste into a valuable product while reducing dependence on fossil fuels and minimizing environmental impact.

Policy analysis has been carried out on 3 (three) policy alternatives, so it is concluded that the preparation of regional regulations has many advantages from the criteria analyzed. The preparation of regional regulations provides certainty and legality so that the Regional Head and Cirebon Regency Legislature must prepare regional regulations on bioeconomy-based straw management to support the reduction of greenhouse gas emissions.

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