UTILIZATION OF BIO-AGENCY AND ORGANIC FERTILIZER ON FOOD CROP MANAGEMENT IN UNPREDICTABLE CLIMATE CHANGE: A REVIEW

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Abstract. Climate change cannot be predicted with precision, so the aspects of mitigation and adaptation in food crop agriculture are merely plans and actions based on data regarding climate factors, land, as well as plant growth and production. The success of adapting food crops is a triumph of the farmers' mindset and the agricultural field advisors. Several key aspects determining the success of food crop adaptation can be traced through articles from both journals and textbooks; among them are the use of biological agents and organic fertilizers to enhance soil quality functions and strengthen plants in food crop production. This article is a review of various journals and textbooks. Actually, farmers are gradually implementing mitigation and adaptation strategies to cope with unpredictable climate changes, resulting in very distinctive planting patterns in response to shifting climate disruptions. The use of biological agents and organic fertilizers has indeed been proven to enhance soil quality and the resilience of food crops. This review uses the SWOT comparison method of relevant articles and is linked to survey base research on food agriculture practises. Biotic agents such as nitrogen-fixing organisms, phosphate solubilizers, and secondary metabolite producers play a synergistic role with the use of organic materials as fertilizers and soil amendments.

Keywords: unpredictable climate change, biological agents, organic fertilizers, synergetic role

A. Introduction

In the last decade and even the last five years 2019-2024, the phenomenon of climate change has been increasingly felt and it has become a warm public discussion both on social media and official news, both TV, newspapers, and official electronic news media on the internet. The event of climate change is generally referred to as climate change, whether weather change both on a large scale and regional scale due to the increase in carbon gases and nitrogen gas species in the atmosphere. The climate change that is felt in a wet tropical climate such as in Indonesia, and especially the author feels on the island of Java, is the shifting of the months of normal, above normal, and below normal rainfall. The shifting of the months of rainfall is certainly accompanied by the accompanying climate element events, namely: temperature, humidity, air pressure, and wind. These changes, which can be called shifts in the rainy and dry seasons in wet tropical climate areas, have certainly shifted the planting pattern with the order of rice cultivation with secondary crops and vegetables in one year. The shifting of the planting season data is said to have changed frequently during climate change in recent years. The impact of climate change on the shifting rainy season has certainly had an impact on the condition of excess water when rainfall is above normal, conversely the condition becomes a water shortage when rainfall changes to below normal.

One of the contributors to greenhouse gas emissions comes from the agricultural sector, namely CO_2, CH_4 and N_2O gases. Excessive use of chemical fertilizers and pesticides is one of the factors causing environmental degradation. This requires anticipatory action towards climate change, including mitigation and adaptation to climate change. Adaptation is an effort to overcome the impact of climate change so as to reduce negative impacts and take positive benefits. Meanwhile, mitigation actions are efforts to overcome the causes of climate change through activities that can reduce emissions or increase the absorption of greenhouse gases. Actions that can be taken to reduce emissions in the agricultural sector, especially in seasonal food crops (rice), are by implementing the SRI (System of Rice Intensification) rice cultivation method, using organic fertilizers, and implementing biological agents, as well as farmers learning to decide and allocate species with their varieties in planting patterns when the season changes above or below normal.

The changing seasons due to climate change that depends on the scalar has changed the mindset of farmers in mitigating and adapting. Mitigation and adaptation efforts that can be made by farmers to deal with climate change include: (i) obtaining knowledge and information related to climate change, early warning and climate information systems [1](Widyasunu & Maryanto, 2023), (ii) adjusting the planting calendar and types of commodities to be planted [1] (Widyasunu & Maryanto, 2023), (iii) selecting and developing types and varieties of plants that are resistant to climate change, including drought resistance and waterlogging resistance [1] (Widyasunu & Maryanto, 2023); specifically for coastal land is the selection of types and varieties that are resistant to brackish water, (iv) application of water-saving technology and application of organic mulch technology, (v) planting more than one type of plant (intercropping); these with crop health index was good method to identify [2] (Li *et al*., 2020), some findings was proofed that, (vi) development of soil and plant management technology to increase plant adaptability including the use of organic fertilizers and biological agents [1] (Widyasunu & Maryanto, 2023), (vii) modification and application of crop-livestock integration systems (crop livestock systems) to reduce risks and optimize the use of land resources [1] (Widyasunu & Maryanto, 2023), (viii) development of an agricultural crop insurance system from failure due to climate change (crop weather insurance) [3] (Sugiarto *et al*., 2017) and it's mitigation and adaptation strategy [4] (Surmaini *et al*., 2011).

The meaning of mitigation in the dictionary (John M. Echols and Hassan Shadily) is reduction means effort to reduce gas emission, while adaptation means adjustment means how farmer do adaptation (agriculture). These two terms are important because they concern strategies for dealing with natural changes, thus the terms mitigation and adaptation are appropriately used to describe attitudes of improvement and adjustment in climate change including seasonal changes that are rather difficult to predict for agricultural crops. Climate change mitigation using biological agents allows for accelerated decomposition of organic material into compost and produces like-humic compounds that play a rapid role in conditioning soil aggregates into better media for plant roots and plants in general. Biological agents are also found to contain secondary metabolite compounds including elicitors that are useful for strengthening plants when agricultural land lacks water or excess water. Soil carbon storage in organic farming systems in Australia is reported to have superior soil carbon storage compared to conventional farming, an exception occurs in sandy soil even though the farming system is organic [5] (Biala, 2011). Global warming and climate change have an impact on life, human life in it which is very dependent on its existence for the existence of continuous and sustainable food production. The causes can be natural, but the role of humans is felt to be the greatest, so that review articles that raise human awareness that climate change must be recognized immediately and mitigation must be implemented [6] (Ainurrohmah and Sudarti, 2022).

B. Methods

This review uses a literature study method. Review materials are taken from literature studies taken from various sources such as journals, books, and the internet. Sources from the internet are taken from posts on Google Scholar, Google Books, as well as websites. Many literatures that were analysed and reviewed were 57 consisting of 12 books, 37 journals and 7 website, and one proceeding. The data that has been obtained is then described using a descriptive method and analysed using the SWOT method. The descriptive method in the review is needed to obtain a theoretical understanding that makes it easier for article users to understand [7] (Kurnia and Sudarti, 2021). Qualitative descriptive is a method that describes reality and social complexities. Descriptions can review a problem further so that clues can be found from the incident. Qualitative descriptive focuses on obtaining comprehensive facts [8] (Yuliani, 2018). Qualitative characteristics are characters that originate from the background and reality that is happening in society by interviewing or being directly at the scene; the SWOT analysis and discussion then help to comparatively more understood. According to [8] Yuliani (2018), qualitative descriptive is a research method that moves on a simple qualitative approach with an inductive flow. This inductive flow means that qualitative descriptive research begins with an explanatory process or event which can ultimately lead to a generalization which is a conclusion from the process or event. This theory is created from data and reality with narrative presentation and analysis [9] (Subandi, 2011).

C. Results and Discussion

1. Global warming, climate change, and it's mitigation adaptation

Global warming is described as a long period of increasing global average temperatures. Global climate change is a change in global and regional climate patterns that has been seen since the mid to late 20th century and is related to increasing levels of carbon dioxide ($CO2$) in the atmosphere due to the use of fossil fuels. The public has a negative view of global warming than climate change. This negative view is conveyed in the form of a description. The search volume for global warming is greater than climate change [10] (Lineman *et al.*, 2015). Global warming is an increase in the temperature of the ocean and land atmosphere on earth. Climate change is a long-term change in global weather or the average of a region, in the last ten years industrial and human activities have caused climate change to gradually accelerate, with an increase in average surface temperature every year. Climate change also has real negative impacts, such as changes in ecosystems and desertification, sea level rise, flooding, and drought [11] (Santos and Bakhshoodeh, 2021).

The temperature conditions in the atmosphere have increased drastically. This results in global warming originating from the air columns throughout the earth's surface. [12] Aldrian (2007) noted that indications of climate change include: rising air temperatures, drought, flooding, short rainy seasons. In addition, rising sea levels and extreme climates [13] (Ruminta and Handoko, 2016). There are records from the IPCC that: in the period 1899-2005 the average increase in global temperature reached 0.760℃, in the period 1961-2003 the average global sea level increase was 1.8 mm per year, the intensity of rain and flooding increased, the frequency of drought and erosion increased, and extreme weather (El Nino, La Nina, tornadoes, hailstones and cyclones) also increased [14] (IPCC, 2007). Indonesian Climatology Stations in 13 places, recorded an increase in the amount of annual rainfall ranging from 490 mm per year (South Sulawesi) to 1,400 mm per year (East Java), day and night temperatures increased between 0.5-1.1 ℃ and 0.6-2.3 ℃ [15] (Syahbuddin *et al.*, 2004. In the western part of Indonesia there was a decrease in annual rainfall of around 135 mm-860 mm per year, day and night temperatures increased between 0.2-0.4 ℃ and 0.2-0.7 ℃. The El-Nino period in Indonesia is getting faster, which was initially once every 5-6 years to once every 2-3 years (Runtunuwu and Kondoh,

2008) [16]. Climate change has entered a critical phase. The plan to be achieved, namely to keep global temperatures below 1.5 ℃, is likely to fail. According to the analysis of the United Nations (UN) environmental program or called the UN Environment Programme (UNEP), the earth continues to warm at 2.7 ℃). [17] World Bank (2021) showed that during year of 2000 – 2021 mean temperature in Indonesia was 0.14 ℃C, with 21 years smooth increment was 1.09 ℃; but higher increment from year 1961 to 2021 that was 0.27 ℃ and 1.33 ℃ for mean temperature and smooth increment respectively.

[18] EPA (2022) stated that the global air temperature in 2022 is 0.86 ℃ higher than in the previous years of the 20th century. The NOAA report (2022) [19] stated that since 1977 for the past 46 years it has exceeded the global temperature. With this trend, [20] Fang Wang *et al.* (2023) the sustainability of life on planet earth is threatened due to bad human behaviour. Excessive use of fossil fuels has resulted in bad human anthropology having an impact on increasing the carbon dioxide content of the atmosphere. This condition gave birth to the idea that all countries should carry out climate change adaptation mitigation.

How aspect, model or method way to understanding impact of climate change on agriculture? [21] Liu *et al.* (2014) explained in China cases: during La-Nina and El-Nino phases, wheat yields was decreased lead to lower precipitation but was increased led to availability of irrigation and sun hours prolonged. Still case in China, [22] Shuai *et al.* (2016) said: in El-Nino years the yield was different between north and south China, where was decreased maize production in south region but increased in the north region, the same trend was occurred when it was La-Nina phases. They using the benefit of modelling on crop simulation. [23] Rojas *et al.* (2014) reported: local crop phenology has good performance aspect (wheat and rice) when adapting in condition at impact during La-Nina and El-Nino phases; they found of prominent thing as they had identified how impact was the phases and the crops had changed character in adaptation during low temperature and stress of water. Just couples year before, [24] Kogan *et al.* (2005) explained that vegetation health index (VHI) can be used as important aspect as model vegetation indexing value from NDVI "the normalized difference vegetation index"; that showed the way of equation minus the minima value compare to NDVI maxima minus NDVI minima. The VHI and NDVI then be employed as a prospectus way to find out how affected was La-Nina and El-Nino to crop production. [25] Liu *et al.* (2014) explained that in three phenomena change of El-Nino-La-Nina-normal, they found and argued that long year's data on daily temperature, precipitation, and sunshine hours were good materials when then be using as aspects analysed to build climate scenarios for three categories of ENSO; they had worked on rain fed and irrigated wheat (winter) and maize (summer). Three factors: (i) accessing crop phenology, (ii) the NDVI, and (iii) climate phenomena change La-Nina-El-Nino-the normal phase though we found to be useful method in determining how impact was and will those climate phenomena change as weather change in mitigation and adaptation when will fit better if it collaborate with the application of organic matter and biological agent to preserved carbon in soil.

2. The role of soil organic matter, organic fertilizer, soil biota, and biological agents in mitigating climate change adaptation

Soil organic matter is lost due to the acceleration of mineralization, erosion, and leaching processes in the process of land cultivation, planting, and harvesting. [5] Biala (2011) reported that in Queensland Australia, soil carbon reserves have decreased by 30-60% since 100 years of land clearing and decreased by 50% since 20 years of crop cultivation in Victoria Australia. He said that the condition of soil carbon levels reached a new steady state after a long time. The steady state condition is related to the new composition of organic matter content from residuals that is in line with the length of time the organic matter decomposes. However, carbon emissions due to changes in land use are difficult to determine the magnitude of which is due to the process of occurrence that lead to the implementation of intensification in the agricultural production system.

Furthermore Biala (2011) [5] reported that related to climate change mitigation in the agricultural sector, opportunities to mitigate greenhouse gases include efforts to reduce emissions through: (i) efficient management of carbon and nitrogen flows in agricultural ecosystems, (ii) biomass production that absorbs atmospheric carbon and then sequesters it in the form of soil carbon, (iii) use of plants that eliminate gas emissions through bioenergy production. In addition, plant cultivation provides a generic function to reduce greenhouse gas emissions through: (i) cultivation practices that increase crop yields and are intended to increase soil carbon storage, (ii) improving the efficiency of nitrogen fertilizer use from all fertilizer sources that are not directly or indirectly able to reduce greenhouse gas emissions related to the manufacture of manufactured fertilizers, (iii) as little disturbance as possible (minimal tillage) during tillage which ultimately reduces organic material decomposition and soil erosion. Sometimes but not necessarily this will increase soil carbon stocks, (iv) improving and expanding irrigation can strengthen soil carbon stocks through increased crop yields and returned residues, (v) restoring degraded agricultural land that provides the possibility of carbon sequestration (FAO, 2007 [26]). [27] UNFCCC (1999) said that as climatic patterns have change, so also do the spatial distribution of agroecological zones, habitats, distribution patterns of plant diseases and pests, fish populations and ocean circulation patterns which can have significant impacts on agriculture and food production. Further cuts in emissions across every sector; deeper collaboration to establish the pathway to 1.5°C alignment; specific plans on how each country will align every element of national life to their climate commitments (UNFCCC, 2022) [28]. FAO (2007) [29] has developed and tested a livelihood-based approach to promote climate change adaptation processes at grass root level building on the assumption that most rural communities work on the basis of day-to-day priorities rather than for the longer-term. To facilitate this process science-society integrators who orient climate modelling research to meet farmers' need and vice versa can provide feedback to the climate science community on the application value of their research. These integrators need to be part of the initial institutional set-up, with specific responsibilities and terms of reference. Climate change adaptation for agricultural cropping systems requires a higher resilience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods). A key element to respond to both problems is soil organic matter (SOM). The SOM improves and stabilizes the soil structure so that the soils can absorb higher amounts of water without causing surface run off, which could result in soil erosion and, further downstream, in flooding. Sustainable agriculture impossible without a sustain of soil, then that has argued that in turn sustainable soil is has truly largely depend on the organic matter in it. Lead to that Snyder and Wolf (2003) [30] explained that returning big amount of organic matter-fertilizer to the soil is a wise to keep high soil's productivity which in turn crop production reach satisfactorily. Further cuts in emissions across every sector; deeper collaboration to establish the pathway to 1.5°C alignment; specific plans on how each country will align every element of national life to their climate commitments (UNFCCC, 2022) [28].

[31] Ontl and Schulte (2012) provide details of the components of soil organic matter, including soil microbes (bacteria, fungi), decomposed material from animals and plants, animal waste, and various products formed as a result of decomposition. Soil organic matter storage is directly related to the amount of organic matter content in the soil and is often detected and measured in the soil. Soil organic matter levels are the result of mutual action between ecosystem processes whose keys include the phenomena of assimilation, respiration, and decomposition. Photosynthesis involves binding atmospheric CO_2 to produce plant biomass which in its cycle can be deposited into potential soil organic matter (litter, leaves, twigs, and roots), in addition there is a transfer of carbon-rich compounds from the roots to microbes in

the soil. This implies that the absorption of atmospheric CO_2 by plants has a positive effect on soil carbon storage via the decomposition process. The incorporation of compost fertilizer into the soil is also the same. The presence of biomass (soil microbes) also has a positive effect on the storage of stable black compounds called humus, which is formed into original soil compounds that strengthen soil aggregation whose continuity is to improve the physical and chemical properties of the soil, then cyclically to soil biota. However, if the soil is intensively cultivated in very humid conditions, it will trigger a decomposition process that produces CO_2 (microbial respiration) and CH_4 which are greenhouse gas emissions. Humus becomes a durable inhabitant in the soil because of its reactive nature which is an agent for strengthening soil properties (soil quality). When soil carbon is in balance (input and output), the carbon content in the soil is stable. Stable and even increasing carbon stocks in the soil in addition to the addition of organic fertilizers will be maintained when the carbon input from photosynthesis of cultivated plants is incorporated. An important lesson here is that organic fertilization provides benefits in maintaining the stability of the life of agricultural soil microbes. Traditional farmers have long used their local wisdom that the remaining crops are good to be returned to the land so that the carbon stock in the soil is balanced which in its cycle becomes energy in the soil for soil biota. Healthy soil is essential for water infiltration and groundwater turnover, and more than 90 percent of our food needs depend on soil. Land degradation often occurs in areas characterized by: land scarcity and increasing population (Hannam, 2021) [32].

[33] Adamczewska-Sowińska and Sowiński (2020) stated that the mulching of living plants in an agricultural land is very important. The important value is when the accompanying plants (cover plants) whose biomass then becomes mulch play a strategic role in reducing soil and land degradation so that soil fertility is maintained and increased. Seeing this, the practice of using cover crops or protective trees can increase the environmental benefits of agricultural land in the form of: (i) soil protection from rainwater, (ii) stabilizing soil body temperature, (iii) soil becomes an important water reservoir during drought, and (iv) important in maintaining physical, chemical and biological fertility of the soil. Points (i) - (iv) will play a good role as part of the agricultural mitigation technology model in dealing with the impacts of climate change.

Related to the relationship between climate change and vegetation growth and loss of C, N, and P. Climate change can exacerbate the loss of these nutrients, which by [34] Batterman *et al*. (2013) with a comparison that N can be renewed because of the relationship with N fixation by microbes; but P will go to the water deposit (Lal, 2008) [35]. Loss of soil carbon by increasing air temperature due to global warming is more dependent on other nutrients, especially N and P (Craine *et al*., 2007) [36], which was then stated by Meyer *et al*. (2018) [37] that the loss of N and P nutrients is a feedback event that jumps. As a result of climate change that leads to a time when there will be very high intensity rain, there is a high risk of loss through denitrification phenomena, leaching down the soil horizon, and of course by surface flow (Batterman *et al*. 2013) [34].

Another article writing is about application of organic fertilizer dose azolla base and it has benefit: the compost 5% of soil weight in plastic house in Purwokerto has ability to increase N uptake, increase weight of rice grain, and reduce Inceptisol muddy along when use as paddy soil and weight of grain per hill (Utami and Widyasunu, 2018) [38]. Further, they stated that larger spacing of rice hill was able to right hold when Azolla compost used and was gained the N and P Pandanwangi rice uptake (Utami and Widyasunu, 2018) [38]. That shows an important role Azolla biomass function (benefit) as benefit organic fertilizer to rice production in irrigated paddy field when dry season was able in maintained to the soil not to be compacted. [39] Widyasunu and Suwardi (2021) had stated: the biomass of *Azolla microphylla* (*Am*) has excellent ability as bio-renewable compost and organic liquid fertilizer which was in a range as Indonesian Fertilizer Regulation (Permentan 2009/2013). Biomass of *Am* has another good futurology as: (i) a renewable carbon resources sink in biomass and can be useful as future bio-renewable energy (Widyasunu and Suwardi 2021) [39], (ii) as of bio protecting of paddy field water body to protect N from urea fertilizer or N-organic (as NH_4^+) not easily to be converted to ammoniacal (aq) form then after going to ammonia a one of a strong atmospheric greenhouse gas (Widyasunu *et al.*, 1998) [40].

Tabel 1. The SWOT of organic fertilizer and micro biotic agent usage on climate change mitigation and adaptation of food crops land agronomic

No	Writer / Council	Statement	Strength	Weakness	Opportunity in mitigation and adaptation
1.	UNFAO [41]. www.fao.org/soilsportal/about/all-definitions/en/	Soil body with natural layers namely horizon over time as carbon sink.	Natural resources as sink home of the earth carbon. The function has prevented and stored carbon in long time.	When soil being tillage heavily and in high moist the carbon proposes to be emitted as carbon GHG.	▪ Minimum tillage ▪ Deep incorporation of compost ▪ Tillage a soil as not too moist ▪ Litter or other organic matter need to landfill (Biala, 2011) [5].
2.	The UNCCD, the Paris Agreement 2015. [42]. UNCCD., 2016. [43]. (accessed 23 July 2021) 68pp. UNCCD., 2019. [44].	Relating to climate change, and other relevant international treaties, strategies, and policies concerning the conservation of nature, biodiversity, and sustainable land management.	Principles and elements of the legislation supported by UNCCD.	Farmer's tropical soil land threat from high rainfall, when land is open easily to degrade. Compost still of expensive resources.	▪ Organic matter amendments will help famer lead to its function to maintain soil aggregation and as it will storage in soil as will of a well mitigation technique (Biala, 2011) [5]; as a healthy soil (Hannam, 2021) [32].
3.	Utami and Widyasunu 2018 [38]. IOP Conf. Ser.: Earth Environ. Sci. 215 012032 IOP Conf. Series: Earth and Environmental Science doi :10.1088/1755-1315/215/1/012032	Compost incorporation (5% of soil weight) into mud of paddy rice good to increase N and P plant uptake and grain and able reduces soil compaction.	Shows an important role Azolla biomass function as benefit organic fertilizer to rice production in irrigated paddy field when dry season was able in maintained to the soil not to be compacted.	Develop Azolla biomass regeneration and production for renewable compost biomass has become "a difficulty" when farmers not willing to develop.	*Azolla microphylla* (*Am*) biomass has huge ability in mitigation and adaptation. First: the *Am* biomass when inoculate onto flood water has able to protect water body not to induce NH_4^+ volatilization (Widyasunu *et al.*, 1998) [40]. The *Am* has a good functionality as good compost (Widyasunu and Suwardi, 2021). [39].
4.	Muhammad Husein [45]. https://typset.io/papers/role-of-microorganisms-as-climate-engineers-mitigation-and-39wq1sdn https://typeset.io/	Microbes in aquatic and terrestrial environment produce and consume the greenhouse gases CO_2, CH_4 and N_2O. Soil and aquatic microbes produce these gases when decomposing	Microbes are sources of nutrient cycles for crop and soil, and so too for aquatic environment. But if no stake holders are not committing in mitigation though HGH	Warming and physical changes to soil can affect nutrient availability and cycling by microbes, which will have unknown cascading effects on the environment	Organic fertilizer contains of microbes, secondary metabolite and humic acid has a positive role in maintaining low land productivity (Case of La-Nina 2020-2022 in Banyumas District (Widyasunu and Maryanto, 2023). [1].

		organic matter to provide nutrients for plants and marine life, respectively.	increment will higher.	(Andrade-Linares *et al.* 2021). [46].	
5.	Stephanie Hands and Malcolm D. 2016. [47]. http://dx.doi.org/10.1080/14615517.2016.1228340	Incorporating climate change mitigation and adaptation into environmental impact assessment.	Justifications relating to climate policy, climate science, the effect of climate change on the develop-ment and its vulnerability to climate risks were well explained in most projects. Can do by work environmental impact assessment to formalise its inclusion in the decision-making process for major developments, for example, China (Chang & Wu 2013) [48], [IEMA] [49].	Many projects lacked detail of climate change mitigation and adaptation measures and their benefits, whilst evidence of commitment to mitigation and adaptation or to post-decision monitoring was poor or non-existent; reportedly due to costs, time constraints and absence of mandatory requirements.	Climate change has become a key environmental issue in the past decade, with a growing attention towards mitigating and adapting to the potential effects of extreme weather events, increased global temperatures and rising sea levels (IPCC 2014). [50]. Long terms data on daily temperature, precipitation, and sunshine hours can be build climate impact scenario (Liu *et al.*, 2014) [21]. and that though good to build agricultural mitigation and adaptation. [51]. Alan (2019): Carbon storage still sink is important.
6.	Hoover and Rath, 2023. [52].	Composting helps the climate by restoring soil health, which helps build resilience to climate-related changes, reduce reliance on synthetic fertilizers, and sequester carbon.	Composting is one way out to mitigate climate change in land crop management.	Owusu *et al.* (2023) [53] found of a significant proportion of micro- and nano plastics occurrence in most organic substrates (e.g., compost manure, farmyard manure, and sewage sludge) compromises its role in climate change mitigation.	[53] Owusu *et al.* (2023): as a global strategy to mitigate climate change: organic amendments play critical roles in restoring stocks in carbon (C) depleted soils, preserving existing stocks to prevent further soil organic carbon (SOC) loss, and enhancing C sequestration.

What can compost do for soil in climate change? Compost can help build soil organic matter, which decreases bulk density, increases porosity, water retention, and infiltration, promotes nutrient cycling and retention, and stabilized soil aggregates, reducing the risk of erosion. Compost then able to increase soil ability to hold water and improves soil drainage, helping reduce the amount of water needs of irrigate soil crops and then reducing the impact of climate change driven extreme weather events such as drought and flood.

How roles are of microbes on climate change mitigation and adaptation. The Microbiology Society says that microbes have a role as a key in some functioning phenomenon of nutrient cycling, biodegradation/biodeterioration, climate change, food spoilage, the cause and control of disease, and biotechnology. Microbes play key roles in many thankfulness as they have a role in drugs, biofuels, cleaning up pollution and producing/processing food and drink. While humankind has only relatively recently started to alter the composition of the atmosphere and the energy balance of the planet, micro-organisms have been dictating global climate for billions of years. Microbes play an important role as both users and producers of greenhouse gases. Both natural and human-induced fluxes of carbon dioxide, methane and nitrous oxide are dominated by microbiology. They (microbes) interact within environment as they play a role as part of living organisms in organic fertilizers (compost, organic liquid fertilizer, biotic agency). Climate change is a hot topic and global warming is a big concern, the microbes are involved in many processes, including the carbon and nitrogen cycles, and are responsible for both using and producing greenhouse gases such as carbon dioxide and methane. Microbes can have positive and negative responses to temperature, making them an important component of climate change models. The role of microbes in climate change cannot be ignored; as scientist ask: they support the existence of all higher lifeforms and are critically important in regulating climate change (Bannister, 2019) [54]. They play an important role as both users and producers of greenhouse gases. Both natural and human-induced fluxes of carbon dioxide, methane and nitrous oxide are dominated by microbiology. So that we have to have a wise to manage agricultural soil. Continuation of all higher trophic life forms has stated supported by eyes unseen what we call them as microorganism; "humanity has on consciousness that the impact of climate change will depend heavily on responses of microorganisms, which are essential for achieving an environmentally sustainable future" (Cavicchioli *et al*., 2019) [55].

Are biological agents and organic fertilizers as way to crop adaptation in climate change?

[53] Owusu *et al.* (2023) stated that as a global strategy for mitigating climate change; they highlight that: (i) giving organic matter to soil as organic soils that given a remediation by which can be the climate change mitigation strategy, though (ii) organic matter restores as of soil organic carbon then subsequently declines atmospheric greenhouse gases potent (from soil), and though then (iii) a microplastics in organic substrates compromise soil organic amendment acts as a climate mitigation option, which threatening global biodiversity. They found of a significant proportion of micro and nano plastics laid in most organic substrates (e.g., compost manure, farmyard manure, and sewage sludge) compromises its role in climate change mitigation.

Composting helps the climate by restoring soil health, which helps build resilience to climate-related changes, reduce reliance on synthetic fertilizers, and sequester carbon (Hoover and Rath, 2023) [52]. What can compost do for soil in climate change? Compost when stored in soil body it can help build soil organic matter, which will decrease bulk density, though then increases soil: porosity, water retention, and infiltration, afterward promotes nutrient cycling and retention, and stabilized soil aggregates, so then reducing the risk of erosion. As the result, compost then competent to increase soil ability to hold water and improves soil drainage, helping reduce the amount of water needs of irrigate soil crops, and afterward reducing the impact of climate change driven extreme weather events such as drought and flood.

[56] Alvarenga *et al*. (2020) argue that under climate change conditions, many regions are related to water scarcity, decreased soil organic matter content, and increased soil erosion, potentially leading to desertification. Here it can be said that soil organic matter management is needed through the provision of biological agents and the provision of organic matter so that the soil organic matter cycle occurs until the soil humification poses successively. Seeing this, the mitigation and adaptation scenarios in food crop cultivation must lead to improving

integrated soil quality and fertility. In order to realize this, it is good to pay attention to the opinion of Alvarenga *et al*. (2020) [56] further that practical agronomic actions must be directed at minimizing the system outflow of soil organic carbon and instead strive to maintain the status of soil organic carbon. Thus, it is very appropriate and reasonable for climate change mitigation to amend the soil with organic matter, thereby maintaining the stock of soil organic carbon in the agricultural ecosystem and improving and perfecting soil quality in the climate change mitigation and adaptation scenario. The scenario related to the position of soil organic carbon should not decrease because mineralization and depletion of soil organic matter always accompany the history of plant cultivation.

[57] Gao *et al*. (2024) stated that the carbon balance of terrestrial ecosystems is critically influenced by the activity of soil microbial carbon, in fertile soil it is greatly influenced by dissolved organic carbon. Carbon metabolic activity by mediation of microbial diversity and by its interactions in infertile soil, all of which are indirectly influenced by the physicochemical properties of the soil. Furthermore, Gao et al (2024) [57] stated that for the first time there was a potential for interdependence between soil layers in the interaction work modelling which emphasized the importance of microbial diversity and its interactions in regulating soil carbon metabolism activity. The interesting thing above is the potential for climate interaction with the decomposition of soil organic matter with the landscape in river basin units at certain topography. This phenomenon leads to the pre-hypothesis that soil fertility and land marginality can be overcome using organic materials where the function of providing compost can increase plant adaptation to climate change (Widyasunu and Maryanto, 2022) [1].

D. Conclusion

Biotic agents play a synergistic role with the use of organic materials as fertilizers and soil amendments. The synergism among biotic agent and compost makes them beneficial to built agricultural soil living to future land quality as soil quality will nursery and that hopefully help human to mitigate and adapt climate change in agriculture.

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F. References

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