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BIODIVERSITY DECLINE: CONSEQUENCES OF CLIMATE CHANGE AND INTENSIVE AGRICULTURE

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ABSTRACT:
Background: The overuse of natural resources, invasive species, climate change, extensive livestock rearing, and agriculture significantly impact biodiversity. Intensive cultivation of soybeans has notably displaced the production of other crops, such as wheat and rice, due to its high demand for agrochemicals, posing detrimental effects on the environment and biodiversity.
Objective: This study aims to compile existing research on the decline in biodiversity resulting from climate change and intensive agriculture and to explore potential ramifications for human-nature interactions.
Methods: A systematic review was conducted in April 2021 using Boolean operators "AND," "OR," and "NOT" with the phrases "biodiversity," "climate change," and "agriculture" in Scopus, Web of Science, and Scielo databases.
Results: Findings indicate a significant loss of biodiversity due to climate change and the expansion of intensive agriculture. This loss extends beyond regions directly affected by soybean cultivation, impacting mountain areas indirectly through human and animal consumption of soy derivatives. Results were retrieved from Web of Science (99 topics), Scopus (155 topics), and Scielo (36 topics).
Conclusion: Biodiversity is crucial for sustainability, providing food security and disease prevention for humans. Its conservation necessitates robust public policies aligned with the objectives of the Convention on Biological Diversity.

Keywords: mountains, intensive farming, soybeans, biotechnology, agriculture, and meso-institutions.

INTRODUCTION:

One of the key industries for providing food for humans and other living things is agriculture. Nonetheless, the growth of intensive agricultural and livestock husbandry has an impact on biodiversity as well, contributing to a minimum 25% reduction in biodiversity over the next 50 years. In addition to increasing the amount of agrochemical products used, intensive agricultural practices are also increasing the amount of primary forests that are chopped down or parcelled for use as cultivable land or for pastoral purposes, which results in soil expansion and degradation. New areas and the disappearance of conventional agricultural ecosystems; in summary, invasive species proliferation, pollution from reactive nitrogen, and climate change (Danovaro et al., 2020).

Despite the conservation intent outlined in the Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification (UNCCD, UNCCD), where the goals of containing biodiversity loss worldwide and preventing negative environmental effects have not been achieved, intensive agriculture's effect on biodiversity is responsible for at least 80% of global deforestation. Consequently, the UNCCD and CBD goals have not been furthered by the existence of biotechnology research utilized in an attempt to increase agricultural output. Concerns concerning ecosystem services, biodiversity, and soil health are raised by intensified rotations and a greater reliance on pesticide inputs, all of which are critical to sustaining agricultural output and the welfare of farming communities (Sulis et al., 2020).

The great majority of farmers in Latin America still work their own plots of land, usually in isolated areas, and use conventional planting and harvesting techniques. Because of this, some low-income farmers view agrochemicals as a viable alternative even when ill-informed about all the potential negative effects. Among the agrochemicals used in intensive agriculture, 63% of the pesticides are deemed very harmful (HHP) to the environment due to their toxicity. The fast change in landscape structure caused by the development and intensification of agriculture worldwide has resulted in the direct loss of habitat and degradation of environmental quality due to the extensive use of agrochemicals (C. D. Correia et al., 2024; Magris et al., 2021).

In summary, biodiversity is threatened by the coexistence of pesticide contamination and landscape alterations. However, the primary cause of climate change has been human environmental activity. This is because fossil fuels are used, which releases greenhouse gases that trap heat globally and have an adverse influence on biological and cultural variety. Due to the loss of biodiversity brought on by climate change, questions about planetary health and human health as a result of interactions between locals and the environment are pertinent and need to be addressed. However, because transgenic options employ genetically modified organisms (GMOs) that are incompatible with the environment, the technology supporting these options may have future effects on farmers in developing nations (Medail & Quezel, 1999).

Similarly, transgenic technologies that are mostly developed by foreign multinationals have the potential to undermine the extensive agriculture of local populations, further marginalizing farmers from society. Considering the experiences of farmers who continue to practice vast agriculture and their concern for ecosystems and environmental implications, it is important to recognize that new transgenic technology alternatives may make them less competitive, especially in export markets for natural products. Therefore, it is important to review the scientific literature on the many trends and effects that intensive agriculture and climate change have on biodiversity, as well as the potential adoption of new technologies and their failures(C. D. N. C. Correia et al., 2024).

Among these, the idea of biological and cultural variety being at risk is still prevalent, and its interplay is called into doubt, raising concerns about not just the historical persistence of local farming but also the sustainability of the environment in general. Therefore, the study's goal was to gather the scientific literature on the loss of biodiversity brought on by climate change and intensive agriculture, as well as any potential ramifications for how humans and the environment interact (Rozzi et al., 2008).

MATERIALS AND METHOD:

The PRISMA statement's recommendations for a sound systematic review were followed in conducting the April 2021 systematic review study (Figure 1).

Preliminary Investigation

Comparing the terms "biodiversity," "climate change," and "agriculture" in the databases Scopus, Web of Science, and Scielo allowed for the discovery of the scientific literature. It was then expanded to include the terms "climate change in agriculture," "impact of technology on agriculture," and "technology used in agriculture" in combination, using the Boolean operators AND, OR, and NOT where applicable. Numerous publications are found, some of which are redundant or unrelated to the review, according to these searches. The best combination of terms was (agrochemicals in agriculture OR roofology in agriculture) AND (climate change in agriculture OR biodiversity OR mountains). From Web of Science, 156 results were found, 38 results from Scielo, and 98 results from Scopus. Prior to selecting the articles, the criteria for inclusion and exclusion were established (Loft et al., 2024; Sutherland et al., 2018).

Criteria For Inclusion

- Be creative or go over the study.
- Allow them to discuss how biodiversity is impacted by climate change.
- Examine how agrochemicals affect agriculture.
- Let's discuss biodiversity in the Andes.
- Which connects intensive agriculture with biodiversity.
- Which connects intensive agriculture with biodiversity.

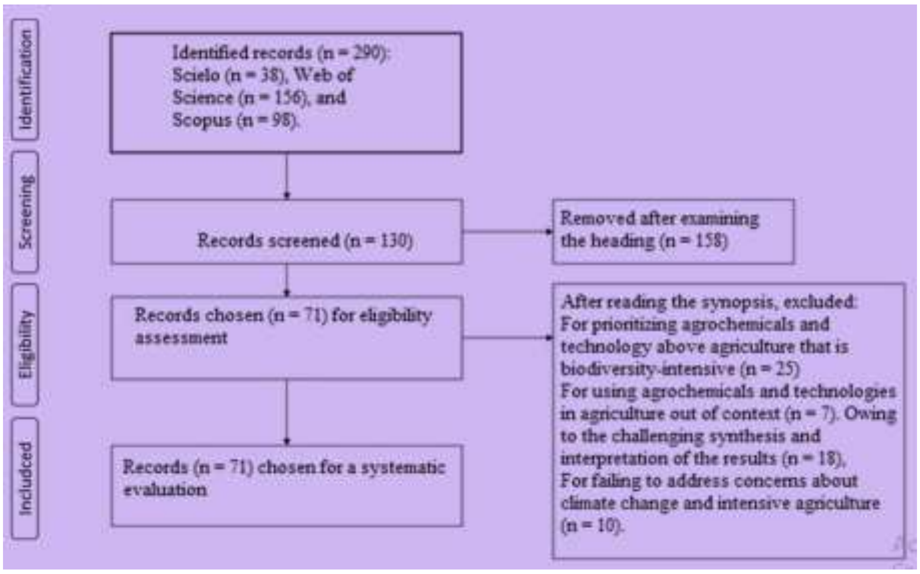

Figure 1: PRISMA flowchart with four levels.

Criteria For Exclusion

- Those unrelated to the agricultural industry.
- Things older than ten years.
- Those who avoid discussing agriculture and biodiversity.

One hundred thirty articles were considered appropriate based only on the title alone and these criteria. After reading the summary, 60 items were eliminated. For not addressing issues related to intensive agriculture and climate change (n = 10), for being out of context between the technology used in agriculture and agrochemicals (n = 7), for its difficult interpretation and synthesis of results (n = 18), and for focusing on technology and agrochemicals rather than the effects of intensive agriculture on biodiversity (n = 25). Ultimately, seventy papers were found to be eligible for inclusion and were chosen to undergo a systematic review based on the standards set forth in the PRISMA statement (Tobias & Pigot, 2019).

RESULTS AND DISCUSSION:

Printed Works

43 study articles were obtained in North America, 22 in South America, and 5 in Central America. Research on agriculture, biodiversity, and climate change is largely what has the biggest influence on the subject of current investigations(Huntley, 2023a).

Articles arranged by publishing year

The age of the papers examined between 1991 and 2021 is highlighted by comparing the year of publication and the total number of articles published. It also shows the progression of research on the subject of "Biodiversity loss caused by intensive agriculture and climate change" up to these recent years. They show an increase in biodiversity research beginning in 2019 with respect to biodiversity loss, which is blamed for recent increases in agricultural production and climate change (Butchart et al., 2012).

Figure 2 demonstrates that the years 2019, 2020, and 2021 account for the great bulk of research publications examined and published in this review. It is emphasized that, as of right now, these research articles are no older than thirty years. Of the reality that global awareness of climate change has grown. Article count broken down by publishing nation(Zhang et al., 2023).

The number of nations that donate the most to the research on the subject of biodiversity loss brought on by agriculture and climate change should be made public. Figure 3 displays publications by nation along with the percentages that correspond to each depending on the total amount of publications in the United States (Dobrovolski et al., 2011).

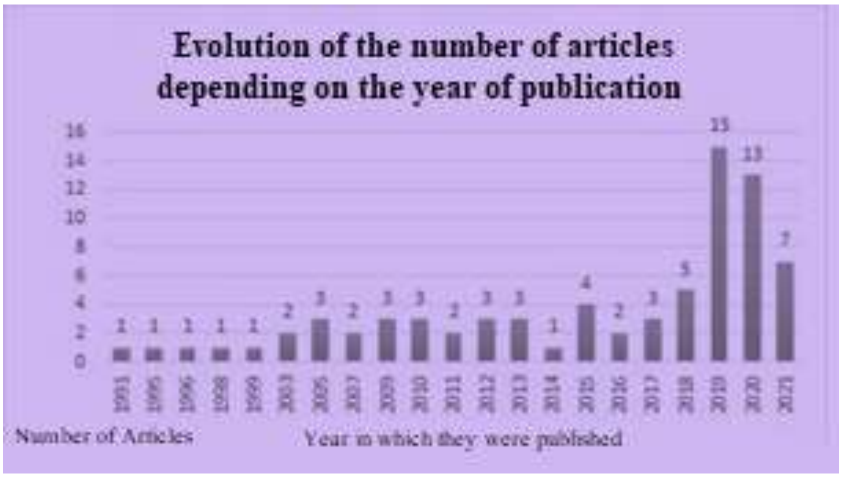

Figure 2 presents an analysis of the quantity of articles according to their publication year.

Figure 3: Country-specific publication percentage.

5%, followed by Argentina and Brazil, each with 1%. Climate change's effects in various domains Intensive agriculture and the effects of climate change are two of the main causes of biodiversity loss. Thus, a summary of studies demonstrating detrimental effects on biodiversity can be found below (Table 1).

America's Biodiversity

Natural forest ecosystems are disappearing as a result of intensive soybean (Glycine max) farming in Argentina, one example of how agricultural growth destroys natural habitats and threatens biodiversity. The purchase and leasing of fields for the planting of soybeans has a similar effect on nations like Bolivia and Uruguay, albeit the effects are not constant and rely on the ability of ecosystems and species to withstand the rapid and drastic changes. Furthermore, agricultural productivity will be impacted by climate change. Research indicates that manufacturing earnings will generally drop, albeit this effect is unknown (Huntley, 2023b; Purvis & Hector, 2000).

2050 will see agriculture.

Climate change and human activity have harmed terrestrial ecosystems and will continue to do so, while high flooding in certain aquatic systems has a detrimental effect on the biodiversity of terrestrial creatures, including insects, birds, mammals, reptiles, amphibians, and amphibians. Controlling invasive species can help lessen the consequences of climate change since they are related to the ecosystem's capacity to adapt to changes in its surroundings. The conversion of natural ecosystems into manmade ecosystems and the overuse of biological resources, however, pose the biggest risks to world biodiversity. Because, on a medium- to long-term scale, anthropogenic changes have the potential to be detrimental atmospheric stressors for biodiversity and habitats (Pimm et al., 1995).

Alterations in the proportion of paleovegetation units on a periodic basis imply altitudinal migrations in response to worldwide climatic change. The mountain ecosystems of North America are among the environments; they support a wide variety of remarkable species and have been essential to our understanding of the mechanisms generating biodiversity in terrestrial ecosystems. Additionally, they perform a variety of ecosystem services that help the nearby human societies. The desert areas of central and southern Baja California, Mexico, which have numerous distinctive characteristics that set them apart from other places, are also included in the ecosystems (Arnold et al., 2011).

The desert areas of central and southern Baja California, Mexico, which have numerous distinct qualities that set them apart from other deserts worldwide, are also included in the ecosystems. However, given the frequency of summer fog in desert regions, this area can become unstable in the face of future climate change. Similarly, a large portion of the global biodiversity is concentrated in the forests of South America. However, data indicates that 83% of deforestation has occurred in tropical dry forests, shrublands, temperate forests, and tropical forests. If existing tendencies toward deforestation persist unchanged in the ensuing decades, native forests will drastically diminish. Evergreen (ElShahed et al., 2023; Noss, 1999).

The west coast of North America is the last region we will discuss. It offers a wide range of climatic, geological, and historical conditions that have led to the development of a rather rich flora and fauna. The west coast of North America shares some species with the continental biota since, unlike South America, it is a part of a large temperate zone. Numerous species are restricted to the coastal area, indicating that they have adapted to the mild maritime climate, particularly those in the temperate rainforest zone. Because there aren't enough ongoing, comprehensive satellite records, the indicators of climate change in America, biodiversity loss, flooding, and heat waves have remained mostly invisible (Cabral et al., 2023; Larsson, 2001; Omotoso et al., 2023).

Climate niche models, which influence species distribution and ecological niches, predict that climate change will impact ecosystem functions on lands that support extensive vegetation. Despite this, organisms are adapting to climate change by changing their shape, phenological behavior, and geographic range. Plastic and evolutionary responses mediate these changes, which lead to broad changes in emergent qualities such as vulnerability to biological invasions, productivity, and species interaction.

Natural diversity in the highlands

At the moment, 300 meters above sea level is the minimum elevation required under the definition of a mountain. However, a local height of at least 300 meters or a specific slope inclination (≥ 5° up to 1500 meters altitude or ≥ 2° above) within a radius is also necessary in places between 300 and 2500 meters altitude. 7 miles. Despite their great biodiversity and ability to offer ecological services to their residents, mountains are currently under threat from changes in land use and land cover (LUCC). Mountain regions support around 1 billion people from a wide range of languages, ethnicities, faiths, and philosophies. They are also vital to life on Earth. They make up over 22% of the planet's surface, produce between 60% and 80% of its freshwater supplies, and are home to 28% of its forests and 25% of its wildlife (Clark & McLachlan, 2003).

For millennia, people have shaped the topography of the world's mountains in order to mine for natural resources, establish pathways for trade, and build infrastructure for commercial, recreational, and religious purposes. These effects can modify local river systems and spark changes downstream for millennia. Because of their detrimental effects on biodiversity, water supplies, and protection from natural dangers like avalanches, landslides, and floods brought on by glacial lake overflow, mountains are particularly vulnerable to climate change. Mountain biodiversity is impacted by topography and altitude, but as global warming gets stronger, species distribution contracts(Huntley, 2023c).

Due to the glacial recession brought on by climate change, there are more and larger glacial lakes, which changes the water availability and balance of the glacial mass and can result in catastrophic floods when the lakes burst. All of this has an impact on the hydrology of hilly environments, which has implications for agriculture, drinking water, and hydroelectric electricity production (Gardner et al., 2009).

As a result, they have unique and significant difficulties in mountainous areas since the pressure they endure influences the migration of species' habitats to higher elevations. They were connected to the progressively negative effects of environmental and climatic change. Climate change also affects mountain socio-ecological systems, affecting how communities respond to changing climate conditions and how they perceive risk (Gardner et al., 2009; Simberloff, 1999).

America's Agriculture

Since 40% of the Earth's surface is used for agriculture, with 46% of that area in some regions of Europe, most agricultural land is subject to intense techniques meant to maximize food production. Over two-thirds of the population in South America is dependent on agriculture, which accounts for a large portion of the country's economy. Nevertheless, there is a significant degree of yield fluctuation in production since this agricultural base is frequently closely associated with ecosystems, which are threatened by temperature variations and are causing changes in the areas suitable for crops. Storms, floods, and droughts have also had an impact on Central American agriculture over the past century. Among crops, the intensive cultivation of soybeans (Glycine max) has reduced soil biodiversity and replaced other products like rice, corn, sunflower, and wheat, resulting in a 24.5% drop in production units (see figure 4) (Raven & Wagner, 2021; Tsiafouli et al., 2015).

Growing regions in North America often vary by latitude, with areas of Canada most impacted by increasing temperatures and decreasing water availability. While the World Meteorological Organization and the United Nations have reported that severe droughts that worsen sea level rise are one of the other events that could worsen if humanity's emissions of greenhouse gases continue, reports also indicate that Latin America would be among the most affected regions where the effects of climate change would break the record of hurricanes (as is already happening) (Hansen et al., 1991).

Because of the kinds of crops grown and the degree to which agricultural land deviates from the natural environment, freshwater ecosystems are the most threatened in the world. These factors can be linked to the growth and intensification of agriculture. Ecosystem. Concerns regarding soil health, biodiversity, and important ecosystem services that are crucial for preserving agricultural productivity and well-being are raised by intensified rotations and a growing reliance on pesticide inputs in many Andean highlands.

Table 1: Effects Of Several Factors On Biodiversity

Impact	**Factors**	**References**	**Keywords**
Ecosystems (Wetlands)	Effect of climate change on wetland efficiency.	(Taillardat et al., 2020)	Carbon dioxide removal, agreement, ecological restoration, peatland, blue carbon, nature-based solutions
Biodiversity and Arid Ecosystems.	I am changing rainfall patterns.	(Hu et al., 2021)	An aridity-driven shift in biodiversity, soil multifunctionality
Vegetation in rainforests	Temperature and precipitation	(Green et al., 2022)	carbon cycle, land surface temperatures, surface energy fluxes,
Global Biodiversity.	Global conservation strategy.	(Belote et al., 2020)	Global Conservation Efforts, Global Biodiversity.

Figure 4. Glycine max, or intensive soybean cultivation

Many tiny farming settlements spread out across the area. Thus, in order to enable the spatial identification of areas at risk in the processes of soil loss and surface runoff, the use of spatial information on climate models is required. Advanced technologies, such as robotics, artificial intelligence, and sensors, are increasingly used to combine diversity in DAG (diversified annual grains) and RED (reduced) inputs in food production while maximizing resource utilization. To lessen the effects of climate change by stopping the loss of NO3-N and P from the soil. This will enable agriculture to adapt sustainably to impending seasonal fluctuations in temperature and precipitation, thereby minimizing the negative environmental effects of agriculture. Since microalgae don't always require fresh water or fertile soils, they could be a viable substitute for current biofuel production methods (Ortiz et al., 2021).

Agriculture's use of technology and climate change

In an attempt to increase agricultural output, several research institutes, as well as national and international organizations in Latin America and the US, are employing biotechnology. To supply the finest growing media in order to accomplish this goal is, however, a fairly open subject. The bulk of farmers in Latin America are still peasants who use traditional subsistence techniques to cultivate tiny parcels of land, usually in isolated areas. Nonetheless, the 16 million farmers play a significant role in regional food security. Empirical studies have demonstrated the productivity of peasant systems that rely primarily on local resources and sophisticated agricultural models, even in the presence of land availability and minimal utilization of external phytosanitary inputs (Beyer et al., 2022).

In order to improve crop quality and lessen environmental effects, Agriculture 4.0 gathers and analyzes field data. This facilitates improved supply chain decision-making, which helps farmers save time by making objective, data-driven decisions. Furthermore, using fewer resources enhances the efficiency of food production—the systematic, quantitative, and restriction-focused approach to evaluating Agriculture 4.0's possible effects. Explain and use cultural technologies to help potato cultivars in Bolivia and Peru's Altiplano withstand frost. The average potato production rises by 26 and 40%, respectively, when frost resistance increases from 1°C to 2 or 3°C. This process has been described in terms of optical transduction and chemical transduction biosensors. Cloud cover (CCF) frequency can affect these biosensors, particularly during the wet season (Wilson & Fox, 2021).

Big Data technology is being applied to agricultural products as a trend in information services development to increase farmers' revenue and lower poverty through advertising. Overall, the farm sector is thought to benefit from increased production and sustainability as a result of digitalization since it opens up new markets for its products. Nonetheless, the digitalization (installation, upkeep) of agricultural innovation systems is probably going to have wider effects. Advisory networks and agricultural knowledge are crucial components of innovation systems that could be altered digitally. Numerous estimates of how climate change would affect agricultural output worldwide suggest that weather patterns will adjust and that agricultural losses could rise by as much as 50% by the year 2080.

The primary reasons for the emission of greenhouse gases are linked to climate change issues. Fossil fuels, including coal, natural gas, and oil, are burned to power agricultural machinery's internal combustion engines, which accounts for a portion of these emissions. Since the vermicomposting technique ensures bio-oxidation, degradation, and stabilization of organic matter for sustainability in agriculture and the environment, it offers a more ecological way to manage biological waste. In addition to recovering microbially safe water for agricultural reuse, the mixotrophic algae system lowers the abundance of bacteria to 16.8% and eradicates 11 out of 13 harmful virus genera from the primary effluent (Hendershot et al., 2020).

All of the technologies mentioned above argue for a new Green Revolution, in which biotechnological innovation that possesses significant qualities from an economic and nutritional standpoint needs to be thoroughly and critically evaluated, that is, so long as it does not resolve the sociocultural issue. Utilize new information to fight against upcoming environmental changes.

Encourage ongoing development of agricultural ecosystem management strategies that balance the needs of people and the environment (Rosa, 2022).

In this instance, the adoption of environmental technologies is the main goal of meso-institutions, which serve as a link between macro and micro institutions. Due to the adoption of integrated cultivation and livestock systems (ICLS), the Brazilian climate change policy has made it possible for this research by establishing or modifying a number of meso-institutions to expedite and oversee the actions and goals of the Brazilian Low-Carbon Agricultural Plan. In addition, suggestions for further research are made in light of frequent problems encountered when using blockchain and ICT (information and communication technologies) in agriculture in the following fields: the creation of policies and regulations about common standards for market stability; (iv) security and privacy protection; (ii) scalability and interoperability solutions; (iii) high-cost, high-consumption solutions and high expertise demands in the application of technology (Vanbergen et al., 2020).

In agriculture, agrochemicals

Agrochemicals comprise continuously developing pesticides, insecticides, herbicides, fungicides, nematicides, and other varieties used to promote productive growth. They are regarded as the concentrate of agricultural chemicals. Nonetheless, habitat loss and deterioration of environmental quality are unavoidably brought about by the expansion and intensification of intensive agriculture, which drives this development and modifications in landscape structure. Because so many pesticides are employed in modified crops, there has been an increase in environmental contamination, the emergence of novel diseases, alterations in the community of soil microorganisms, and changes observed in weed communities. Within this framework, worries exist regarding the detrimental impacts of pesticides and agricultural chemicals, which are characterized as issues with the environment and human health (Poniatowski et al., 2020).

The necessity of using a hazard category is shown by the fact that at least 63% of pesticides sold with modest acute toxicity are regarded as highly hazardous pesticides (HHP) to persons or the environment. Agrochemicals must be properly controlled in order to meet the objectives of high-yield food production, which suggests that dangers to the environment and human population must be considered. It endures during every stage of manufacture. Over 4 million people in Latin America alone are at risk of being adversely affected by agrochemicals. The coexistence of pesticide pollution and landscape changes poses a threat to biodiversity and may have interaction consequences, even in cases where the use of agrochemicals is intended to increase agricultural productivity. This is particularly true for creatures with intricate life cycles, like frogs (Shin et al., 2022).

Therefore, using agricultural chemicals indiscriminately to increase crop yields has negative impacts on the environment, including the air, water, soil, and organisms, as well as human health. As a result, despite their drawbacks, agricultural chemicals like polysaccharides must be developed responsibly because they are hydrophilic and biodegradable polymers, additionally to therapies based on biochar for pesticide removal. In order to shift the agricultural model away from relying heavily on agrochemicals and toward the creation of a more sustainable environment for intensive agriculture, genetically modified organisms (GMOs) that are resistant to pesticides are being implemented in South America. Because RFID tags contain the following crucial information, they are also suggested as the best storage systems for the monitoring and control of agrochemical products: the country of registration, the type of chemical product, the unique registration number of an agrochemical product, the size of the container, the specific gravity, the unit of measurement, and a digital signature (Hendershot et al., 2020).

The Food and Agriculture Organization of the United Nations (FAO) and the Intergovernmental Science and Policy Platform on Biodiversity and Ecosystem Services (IPBES) state that agroecology is a path to address several Sustainable Development Goals (SDGs) and that, as a result, they preferred the friendliest and most adaptable mitigation processes to climate change in order to stimulate the various ecological processes in agricultural, livestock, and forestry production, along with other food systems. Finally, various additional options for sustainable agroecology appear to be compatible with multiple ecological processes in agricultural, livestock, and forestry production, along with other food systems. Farmers and food systems change, strengthening the relationship between local people's knowledge and the environment (Outhwaite et al., 2022).

CONCLUSION:

The literature review highlights some issues, including the loss of biodiversity brought on by the consequences of climate change, the growth of intensive agriculture, the addition of intensive livestock farming, such as the transgenic soy case, and the expansion of the agricultural frontier at the expense of regional production. Natural vegetation, forests, and other crops, as well as the uprooting of local inhabitants, all of which conflict with food security options and biodiversity sustainability. Conversely, greater soy intake by animals for milk and meat could cause poisons consumed through soy to enter the food chain.

Agrochemicals, extensive crop rotations, and climate change are the main causes of the harm that manmade activities, including intensive agriculture, do to terrestrial ecosystems. Extensive agriculture harms natural patterns of biodiversity. As in the case of agroecological biotechnology and agriculture, this necessitates the adoption and application of innovative, environmentally friendly technologies that are the result of ongoing research to support ongoing advances in the interactions of the agricultural ecosystem with people and the environment.

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