THE ECOLOGICAL SHIFTER

Trigger for a more sustainable world

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HOW TO MONITOR THE SHIFT TOWARDS AGROECOLOGY AND SUSTAINABLE AGRICULTURE AT REGIONAL AND INTERNATIONAL SCALE ?

PROPOSITION OF A COMPREHENSIVE SET OF INDICATORS

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Outline

Who are we ?

Founded in 2013, The Ecological Shifter, a pluralistic foundation for ecology, is a Think and Do-Tank with the aim of promoting ecology and sustainable development based on pragmatic and concrete proposals.

It is animated and supported by numerous and very diverse experts of all generations and backgrounds (business and NGO leaders, academics, unionists, parliamentarians, and former ministers of ecology from all political backgrounds, etc.). It is funded primarily through sponsorship, with full transparency and relying on an ethical charter guaranteeing its intellectual independence and freedom of action.

With numerous publications on various subjects and a network of nearly 800 listed and active experts, its work is recognized as particularly serious and innovative: in the annual think tank barometer conducted by the Think Institute, The Ecological Shifter stands at the top of the podium for the quality of its work and its transparency.
Our work revolves around six strong principles:

- Impeccable scientific rigor
- Pluralistic and cross-party demand
- Absolute transparency
- A European and international approach
- Concrete responses
- A unique positioning in the service of sustainable development

With this report, we aim to propose an innovative and comprehensive framework to monitor the shift towards agroecology and sustainable agriculture and measure the effectiveness of policies at regional and international scale.

Introduction

Since the 1960s, the recognition that industrialized agriculture exacts a substantial toll on non-renewable energy resources, engenders pervasive pollution, exacerbates the greenhouse effect, and jeopardizes food safety has catalyzed a burgeoning global environmental consciousness. Consequently, concerted efforts have been marshaled to explore alternative agricultural modalities conducive to harmonizing agricultural practices with environmental imperatives, fostering adaptability to ecological dynamics, and effectuating sustainable development paradigms. Termed the ecological transformation of agriculture, this epochal shift in agricultural development signifies a pivot towards models of agricultural production that are consonant with the exigencies of the natural milieu. The objectives of agricultural endeavors have transcended narrow economic considerations extending to not only economic prosperity but also social equity, ecological integrity, and cultural enrichment.

Notably, to facilitate discourse and comprehension, the adoption of agro-ecological transformation by different countries and regions often entails the attribution of distinctive nomenclature to novel agricultural modalities. Terminologies such as circular agriculture, low-carbon agriculture, organic agriculture, clean agricultural production, natural agriculture, and climate-smart agriculture are used in different countries and regions, serving to emphasize certain focuses within agroecology. In this report, the conception of ecological agriculture is construed as a comprehensive category, transcending singular indicators. We delineate ecological agriculture as a methodological approach that actively embraces ecologically sound practices, leverages the ecosystemic services rendered by agricultural ecosystems, and advances the imperatives of sustainable agricultural development. Central to this conceptualization is the dual mandate of ensuring that ecosystems fulfill human interests—encompassing the provision of material goods, ecological regulation, and cultural enrichment—while fostering a reciprocal relationship of reverence, preservation, and alignment with nature. By adhering to these principles, ecological agriculture is poised to engender multifaceted societal, economic, and ecological dividends, thereby engendering a virtuous and sustainable cycle of prosperity.

This report delves into the agricultural development trajectories, processes of ecological agricultural transformation, associated policies, and endeavors, as well as pertinent indicators within three pivotal global entities: Europe, China, and the United States. They are representative regions with expansive size, diversity, unique historical trajectory, and cultural distinctiveness. This broad scope allows for a comprehensive global analysis while enabling evaluations of the effectiveness of specific agricultural measures tailored to the unique needs and circumstances prevalent in each region. The comparative lens afforded by these representative countries and regions foster cross-cultural learning and the exchange of best practices, which promote a sustainable and equitable global agricultural landscape.

Case Study 1: Europe

1. History of agriculture

A hundred years ago, European agriculture was still shaped by small farms in the countryside and vegetables growing in urban houses' gardens. At that time the offer was based on seasonal products and meat was only an occasional dish. Alongside with the growing population and the effect of globalization, agriculture evolved from a local activity involving most of the european's workers to a global industry led by machinery.[1]

Today, "the European Union is one of the **world's leading agricultural powers**", with an agricultural production of 552 billions of euros in 2023 (European Commission). France is among the main contributors with 17% of EU production, followed by Germany, Italy, Spain, the Netherlands, Poland and Romania. The main crops are **wheat and spelt** (126.7 million tonnes in 2022)**, beet** (103.5 million), **vegetables** (59.8 million), **maize** (53 million), **barley** (52.0 million) and **potatoes** (47.5 million). Wheat alone represents half of all the cereals cultivated.[2]

Even though the increase in food production to answer the growing demand was a success, the development of intensive agricultural production came with the use of synthetic chemicals such as fertilizers and pesticides, with high impacts on the ecosystem, such as water contamination but also erosion and compaction of land and soil. The high productivity also came with less and less crop diversity, with vast areas devoted to a single kind of culture, drastically reducing biodiversity. Finally the growing production of meat implied an increase of GHG emissions from the cattle raising. All these impacts contribute to the need to rethink the agricultural system today, and the way we produce and consume food.[1]

In Europe organic farming covers today around 16 million hectares, or roughly 10% of agricultural land in 2021. Although this means the use of synthetic chemicals is still widespread, more and more resilient practices are being introduced, notably with the recent adaptations of the **CAP (Common Agricultural Policy)**, initially adopted in 1962 to organize and increase food production at the European level after the damages provoked by war. The policy targeted initially three main goals, included in the Treaty of Rome [3]:

- increasing productivity and stabilizing markets
- ensuring the availability of food at reasonable prices
- providing fair living standards to farmers

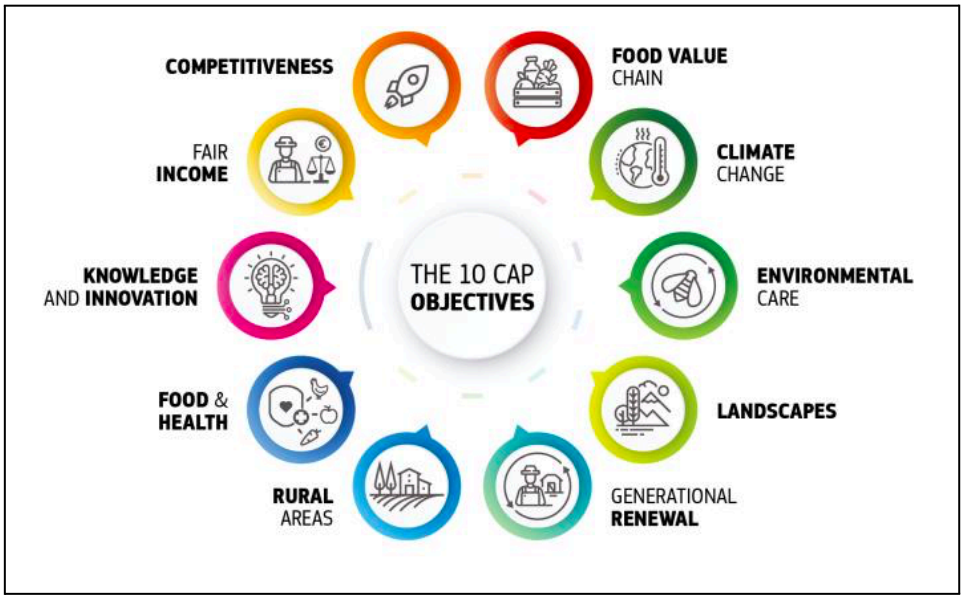
To face the increasing challenges of climate change, biodiversity loss and limits of natural resources, the 2023-2027 CAP is introducing more objectives in line with the Green Deal aspirations. Three out of ten are directly related to the environment. [4]

2. The main policies about agriculture: introducing agroecology principles

2.1. The objectives of the CAP

The 10 CAP objectives are based on the 3 pillars of sustainable development[5]:

- **Economy**: viable food production, with a focus on agricultural income, agricultural productivity and price stability
- **Environment**: sustainable management of natural resources and climate action, with a focus on greenhouse gas emissions, biodiversity, soil and water
- **Social**: balanced territorial development, with a focus on rural employment, growth and poverty in rural areas.



The 10 CAP objectives [6]

For the period 2023-2027, the **CAP** has been reformed towards greener and fairer policies, in line with the SDGs (Sustainable Development Goals) and the EU Green Deal, slowly introducing more agroecological practices. [4]

- New requirements: protect wetlands and peatlands + inclusion of elements from Water Framework Directive and Directive on the Sustainable Use of Pesticides
- Improvement of existing requirements:
    - for soil protection, crop rotations are needed (sometimes crop diversification can be accepted and exemptions are possible for smaller holdings and organic farmers) ⇒ it should in the end apply to 86% of EU's arable land
    - for biodiversity, 4% of arable land to non-productive features and areas
- Eco-schemes: at least 25% of the budget allocated for eco-schemes, supporting voluntary actions (beyond conditionality and other obligations) in climate-and environment-friendly farming practices and approaches (such as organic farming, agro-ecology, carbon farming, etc.) as well as animal welfare improvements. A list of agriculture practices that could be supported by eco-schemes was furnished and includes for instance [7]:

- organic farming: conversion and maintenance of organic farming
- agroecology: mixed cropping and multi-cropping, use of crops/plant variety more resilient to climate change
- agroforestry: management and cutting plans of landscape features
- carbon farming: rewetting wetlands and peatlands, extensive use of grassland

The **Farm to Fork** strategy of the EU proves again this ambition of making the European food system a global standard for sustainability. It highlights again the urgent need to reduce dependency on pesticides and antimicrobials, reduce excess fertilization, increase organic farming, improve animal welfare, and reverse biodiversity loss.

However, the main policies need to be defined by each Member State, making them the final decision-makers. For instance in France, the requirements are defined and monitored also through the **GAEC** (Good Agricultural and Environmental Conditions), that give detailed information and criterias to establish good practices. The BCAE 7 on crop rotation precises the agricultors concerned, how to respect a proper rotation system, a list of categories of cultures considered different for rotation and a points system for crop diversity criteria. [8]

2.2. Applications and process

2.2.1. National Strategic Plan

Each EU country is in charge of designing its national CAP Strategic Plan, combining funding for income support, rural development, and market measures. When designing their strategic plans, EU countries contribute to the ten specific objectives through a toolbox of broad policy measures provided by the Commission, which could be shaped around national needs and capabilities. Member States also have a certain latitude to define the GAEC standards.[9]

2.2.2. Conditionality

Regarding CAP funding, one key element is the conditionality. In order to receive EU income support, farmers must respect a set of basic rules. The interplay between this respect for rules and the support provided to farmers is called conditionality. Rules farmers are expected to comply with include:

- **SMR** (Statutory Management Requirements) : they apply to all farmers whether or not they receive support under the Common Agricultural Policy. The SMR includes EU rules on public, animal and plant health, animal welfare, and the environment.
- **GAEC** (Good Agricultural and Environmental Conditions) : they apply only to farmers receiving support under the CAP.

Farmers violating EU law relating to environmental, public and animal health, animal welfare or land management will have their EU support reduced and may face other penalties.

Through conditionality (previously known as cross-compliance), farmers are encouraged to comply with high EU standards for public, plant, and animal health and welfare. Conditionality plays a role in making European farming more sustainable.

Compared to the previous CAP (2014-22), the rules for conditionality in CAP 2023-2027 include a higher level of ambition in several domains, as it includes the most effective aspects of the greening practices into new conditionality rules. For example, on every farm at least 3% of arable land is dedicated to biodiversity and non-productive elements, with a possibility to receive support via eco-schemes to achieve 7%. Wetlands and peatlands are also protected.[10]

2.2.3. Eco-schemes

Eco-schemes, one of the new elements of the common agricultural policy (CAP) 2023-27, support farmers in adopting practices that minimize the negative impact of agriculture on the environment and climate, and help them evolve towards more sustainable farming models.

To be supported by eco-schemes, agricultural practices should [11]:

- cover activities related to climate, environment, animal welfare and antimicrobial resistance;
- be defined based on the needs and priorities identified at national/regional levels in their CAP Strategic Plans;
- their level of ambition must go beyond the requirements and obligations set by conditionality;
- contribute to reaching the EU Green Deal targets.

2.2.4. Monitoring and evaluation

The **CMEF** (Common Monitoring and Evaluation Framework) was designed to assess the performance of 2014-2020 CAP and improve its efficiency. CMEF monitors today's developments in agricultural markets, rural development and the use of CAP funds. The assessment of the CAP performance is performed through key indicators [12]:

- Context indicators describing general information relevant to the policy (such as the amount of agricultural land available or information on the average age of farm managers);
- Income support and market measure output indicators, which provide information on things like the number of beneficiaries of CAP income support;
- Output indicators monitoring EU policies on rural development, for example, such public expenditure on investment;
- Results indicators for the income support elements of the CAP, measuring the direct and immediate effects of interventions (such as the percentage of farmers' income which came from income support);
- Rural development results indicators assessing the effect of rural development policy, such as preventing soil erosion and improving soil management. Most of these indicators are also target indicators. In addition, rural development complementary result indicators aim to assess the net effect of CAP intervention (2021 updates);
- Target indicators used to set quantified objectives at the beginning of the programming period for the rural development policy (some of which correspond to result indicators);
- Impact indicators measure the impact of policy interventions in the long term, ;and when there are effects beyond the immediate period (some of which are also included in the context indicator set).

The CMEF and the related indicators are presented in a dashboard and publicly accessible [13]: https://agridata.ec.europa.eu/extensions/DataPortal/cmef_indicators.html

With CAP 2023-2027 legislation, a new common set of indicators was introduced, as part of a new performance, monitoring and evaluation framework : the **PMEF** (Performance Monitoring and Evaluation Framework). The indicators will be monitored through annual performance reports and a biannual review of the performance of CAP Strategic Plans to assess the progress of EU countries in reaching their targets and the objectives of the CAP.

The PMEF supports the shift in policy focus from compliance with rules to performance and results. This new performance-based delivery model uses a set of common performance indicators, including [12]:

- output indicators, which will be used for monitoring the implementation of the CAP;
- result indicators, which will be used to monitor EU countries' progress towards pre-set targets;
- context and impact indicators, which will be used to assess the overall policy performance against CAP objectives.

2.3. Limits of the current policies

2.3.1. Member States Strategy

A study focusing on four Member States (France, Spain, Poland and Germany) revealed that, even though the CAP 2023-2027 aimed to increase EU ambition in terms of sustainability, countries did not take the opportunity to significantly increase environmental and climate action.
The main gaps in the Plan's intervention logics are :

- in the 4 countries, there were few interventions to reduce emissions from livestock and in some cases, they even provide coupled support for cattle
- there are several mismatches between the needs identified and the proposed interventions, in particular in relation to climate change mitigation and adaptation
- other environmental and climate needs are insufficiently addressed : soil protection biodiversity and climate change adaptation

Regarding the GAEC standards [14]:

- the countries occasionally go beyond the minimum requirements imposed by the regulation but overall they tend to choose the easiest and often less beneficial options when defining their GAEC standards
- the latitude given to each member state leads to different environmental and climate contributions between countries, and thus preventing a common ground between the different countries
- there is a potential for strengthening GAEC standards at EU level

2.3.2. Funding

In the study, the conclusions regarding funding are as follow [14]:

- the 4 countries allocate 55-69% of their budget to economic objectives and 20-30% to environmental and climate objectives. So CAP funding remains focused on economic objectives rather than environmental ones.
- it is necessary to increase budgets for eco-schemes, environmental and climate commitments and investments and cross cutting interventions targeting environmental and climate action
- environmental and climate commitments have small budgets, cover limited areas, not always well regionally targeted
- some CAP interventions still continue to support the most intensive and most environmentally damaging farms

Another limit is that the method to split the different kinds of funding is related to hectares, which is an historical method. [15]

The result is that EU funds are too much concentrated on big farms : in the EU 20% of farmers own 83% of land and receive 81% of CAP funding. [16]

2.3.3. Education

Education plays a key role in the transition towards sustainable agriculture but the shift in education towards agroecology encounters barriers. [17]

As an example, in french agricultural secondary high school, an article conducted a survey and listed the following difficulties for the transition to happen in education :

- reticence of teachers
- education program is based on a volume approach rather than a the systemic approach
- usually new farmers use the same methods and techniques as what they observe (often they inherit it from their parents who were also farmers)
- school board have representative of conservative union and have a significant influence on the school and the program
- a plan, called “Apprendre à Produire autrement”, aiming for more sustainable farming, was launched in 2014. The impacts for this plan were limited

3. A set of indicators for Europe

Considering the various objectives targeted by the CAP, and the obstacles and limits identified, we suggest here a set of indicators that would allow a relevant and comprehensive assessment of this transition toward a more sustainable food system at European level, with the instauration of agro-ecological practices. The measurements should be led at country level and the values further aggregated to represent European level.

3.1. Social indicators

Name of indicator	In place	CAP objective	Goal	Measurement
Farmer education	**NO**	Knowledge and innovation	Assess education level on agroecology practices	% of hour spent on agroecology practices in agricultural trainings
General education	**NO**	Knowledge and innovation	Raise awareness	% of high school program dedicated to sensitization to sustainable farming and agroecology
Contribution to the global food balance	**NO**	Competitiveness - Food value chain - Climate change	The import of plant proteins undermines the global food balance and leads to deforestation. The goal is to assess the import of plant proteins imported for farms with livestock compared to the proportion of UAA devoted to the production of protein-rich plants.	Score based on 2 items: Import rate (TI) of concentrated feedstuffs for animals & Proportion of UAA devoted to the production of protein-rich plants
Food security	**NO**	Food & Health	Assess the amount of households still concerned by food insecurity	Based on household surveys with 8 questions ranging the level of food insecurity
Limitation of food wastes and losses	**YES**	Food value chain	Evaluate the effort put in reduction of economic, social and environmental cost of wastes and losses	Measure of a score according to a list of potential actions put in place in the limitation of wastes and losses
Rural development	**NO**	Rural areas	Balanced territorial development	Total CAP expenditure on rural development measures
Plant protein	**NO**	Food & Health	Encourage more plant based food	Ratio : plant based protein consumption / animal protein consumption

3.2. Environmental indicators

Name of indicator	In place	CAP objective	Goal	Measurement
Landcover	**YES**	Environmental care - Landscape	Increase surfaces of protected wetlands, forests and semi-natural area	% total area of agricultural/forestry/natural/artificial/other
Use of pesticides	**NO**	Environmental care	Decrease the use of pesticides (use of more agroecology practices instead (organic farming, land cover,...))	total pesticides and fertilizers per unit of cropland (kg/ha)
Water quality	**YES**	Environmental care	Assess the potential impact of agriculture on water quality due to pollution by nitrates and phosphates.	concentration of nitrogen and phosphorus on agricultural lands and nitrates in freshwater
Crop rotation	**NO**	Environmental care - Landscape	Increase the use of crop rotation practice	% of ha with crop rotation
GHG emissions from agriculture	**YES**	Climate change	Decrease GHG emissions from agriculture sector (including decrease from livestock)	tons of CO2 equivalent of agriculture (split between livestock, crops and others)
Intensive farming	**YES**	Environmental care	Reduce the share of intensive farming activities	% of UAA under high farming intensity

3.3. Economical indicators

Name of indicator	In place	CAP objective	Goal	Measurement
Funding dedicated to agroecology	**No**	Knowledge and innovation	Measure of CAP support toward agroecology	% of direct payments dedicated to agro ecology development budgets for eco-schemes, environmental and climate commitments and investments and cross cutting interventions targeting environmental and climate action
Funding support to environment and climate	**Yes**	Climate change	Asses the effort put by each member state to environmental and climate initiatives	Share of CAP expenditure on environment and climate (according to a list of criterias of the Rural Development Programme)
Jobs in agriculture	**Yes**	Competitiveness	Show the importance of agriculture sector in each country	Number of persons working in agriculture sector (in Full Time Equivalent)
Productivity of agroecological farms	**No**	Competitiveness	Assess if agroecological practices are sustainable	Yield (in ton/ha separated by crop categories) in farms using agroeco practices compared to conventional farming
Farmer income	**No**	Fair income	Ensure fair income of farmers between small and big farms	average income of farmers **per ha**
	Yes	Fair income	Ensure fair income of farmers compared to wage in other economy	% of average salary of labor workforce compared to average wage in the rest of the economy
	No	Fair income	Ensure fair income of farmers between various practices (encouraging agroecology)	CAP income support of farmers according to **agroeco score** (score established according to. list of good practices)

Case Study 2: China

1. History of Agriculture

China's agriculture, with the world's 9% of arable land, successfully feeds about one fifth of the world's population. When meeting the huge demand within the country, China has recently taken agricultural sustainability into account during policy development and implementation, and agroecological practices have been carried out in multiple regions in China. The history of agriculture in China is as vast and diverse as the country itself, stretching back thousands of years and encompassing a myriad of cultural, technological, and environmental influences. From the cultivation of millet and rice alongside the Yangtze and Yellow river to the modernization of the recent decades, the evolution of Chinese agriculture reflects the country's development from a pure agrarian civilization to a crucial player in the global economy.

After the establishment of PRC in 1949, the Chinese government launched a comprehensive land reform program. The program aimed to redistribute land from landlords to peasants, therefore addressing long-standing inequalities in land ownership. The First Five-Year Plan (1953-1957), though prioritized the advancement of heavy industry, also recognized the importance of agricultural development given the fact the approximately 80% of the Chinese population were farmers. During 1949-1957, collectivization and cooperative farming were taken as major strategies in increase agricultural output. The major crops were rice, wheat, and maize to satisfy the calorie demand within the country, and international trade, including both import and exports, were highly limited since the country primarily were focusing on achieving self-sufficiency.

The next important stage of China's agricultural history was the Great Leap Forward, a radical campaign launched by Mao Zedong that aimed at a swift transition from an agrarian society to a socialist one through extremely rapid industrialization. The initiative prioritized allocation of resources to industrialization while setting unrealistically high production goals for agricultural production, resulting in a massive and widespread famine that happened to the majority of Chinese population during 1958 to 1961. Because of the escalating food crisis within the country, international agricultural trade remained limited during this period.

The famine resulted from the Great Leap Forward lingered beyond 1961. To alleviate starvation of the population, China underwent a significant shift in agricultural policies under the leadership of Deng Xiaoping. Instead of the collectivist approach, farmers were given more power on their own lands, being allowed to manage their own farms and retain control over their production surplus. Besides, from 1962 to 1978, more pragmatic approaches aiming at immediately increasing agricultural output, such as massive usage of chemical fertilizers, were implemented. With the rapid increase agricultural output and the internal need were met, some cash crops, such as cotton and tobacco, were planted, signaling a gradual diversification fo the agriculture. Furthermore, after being self-sufficient, China also began to emerge as a major exporter of agricultural products at the international level.

However, the significant increase in agricultural output did not come with no price. While the introduction of new technologies and farming practices, such as high-yield crop varieties and mechanization, further improved productivity, problems such as environmental degradation, water scarcity, and over-usage of soil also took place. Recognizing the urgent need to address these issues, the government began to prioritize sustainable farming practices. Policies were implemented to promote soil and water conservation, reduce chemical inputs, and encourage the adoption of organic farming methods.

2. Current Policies & Initiatives

2.1 China's International Climate Pledge

To underscore China's commitment and accountability in combating climate change, China has put forth its Nationally Determined Contribution (INDC) objective, aiming to peak carbon emissions by 2030 and achieve carbon neutrality by 2060, a target known as the "double carbon" goal. This initiative not only showcases China's commitment to global climate governance but also presents a historic opportunity for the advancement of low-carbon practices within China's agricultural sector. Agriculture, notably in crop cultivation and animal husbandry, stands as a significant source of greenhouse gas emissions and remains highly susceptible to the impacts of climate change. Thus, fostering low-carbon agricultural practices emerges as a critical strategy for mitigating external climate influences and fortifying the resilience of domestic agricultural ecosystems. Since the inception of the United Nations Framework Convention on Climate Change in 1992, the international community has continually forged agreements addressing climate change. Concurrently, China has actively engaged in global climate change initiatives, assuming a pivotal role as a participant and contributor to the collective effort. Table 1 records the timeline, content, and China's involvement in global climate change agenda agreements since 1992 (Zheng & Yu, 2024).

Year	International negotiation	Main content	China’s response
1992	*United Nations Framework Convention on Climate Change*	Establish the basic principles of international cooperation to deal with climate change, mainly including the principle of “common but differentiated responsibilities”. Clarify that developed countries should take the lead in reducing emissions	*Formulation of China’s Agenda 21* and *The People’s Republic of China National Report on Sustainable Development*
1997	*Kyoto Protocol*	Set the annual average GHGs reduction targets of major industrialized countries during the first commitment period. Identify 6 GHGs for emission reduction	Promote international cooperation on Clean Development Mechanism (CDM) of voluntary emission reduction projects. Proclaim *Interim Measures for the Operation and*

			Management
2015	*Paris Agreement*	A long-term goal of "temperature control within 2℃". Proposal of a submission of "Intended Nationally Determined Contributions (INDC)" every 5 years	Launch the South-South Cooperation Fund for Climate Change in China; incorporate emission reduction action targets into the overall national development agenda
2020	General debate of the 75th United Nations General Assembly	General Assembly for climate change	Proposal of the goal of peaking carbon before 2030 and achieving carbon neutrality before 2060
2021	26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change	Follow-up negotiations on the implementation rules of Paris Agreement	Submission of China's Achievements, New Targets and New Measures in Implementing Its Intended Nationally Determined Contributions, and China's Mid-Century Long-term Low Greenhouse Gas Emission Development Strategy

2.2 Empowering Domestic and Local Agroecology

China's Five Year Plans serve as blueprints for social and economic development, with an increasing emphasis on green development, agroecology, and sustainable practices since the *11th Five Year Plan* in 2006. However, it was not until the *13th Five Year Plan* in 2016, coinciding with the signing of the Paris Agreement, that agroecology emerged as a pivotal component of national development strategies.

From 2016 to 2017, China's environmental agenda prioritized energy and emission reduction efforts. In the *13th Five-Year Plan*'s 2016 agenda, China outlined a comprehensive strategy to address greenhouse gas emissions, focusing on both mitigation and adaptation measures. The plan prioritized the control of total carbon emissions while concurrently enhancing carbon sink capabilities to mitigate the impact of climate change (Chen, Yin & Jiang, 2023). To achieve these goals, the plan emphasized the optimization of fossil energy use and the acceleration of non-fossil energy development, aligning with China's commitment to low-carbon technology innovation. In the subsequent year's plan, released in 2017, specific actions targeting energy saving and emission reduction were outlined. Notably, the plan addressed agricultural pollution control through the implementation of conservation technologies and clean production practices. Initiatives such as biogas power generation projects aimed to promote the utilization of crop straw, with a target utilization rate set at 85% (Chen, Yin & Jiang, 2023).

In 2018, China added a focus towards rural development, particularly emphasizing green agricultural policies, reflecting a strategic emphasis on holistic sustainability and inclusive growth. China unveiled

the *Rural Revitalization Strategic Plan (2018-2022)* and *Special Plan for Innovation-driven Rural Revitalization Development (2018-2022)*, marking a significant milestone in the nation's efforts to optimize and accelerate the transformation of rural development. The plan outlined a multifaceted approach aimed at fostering prosperity, creating livable ecologies, and ensuring an affluent quality of life in rural areas. Through targeted initiatives and investments, China sought to revitalize rural communities, bolstering economic opportunities and improving living standards for residents (Chen, Yin & Jiang, 2023). Subsequently, in 2021, the release of the *14th Five-Year Plan (2021-2025)* reinforced the nation's commitment to sustainable agricultural practices and rural development (14th Five-Year Plan Research Group, 2021). Emphasizing green production, food security, agricultural product quality, and modernization, the plan underscored China's dedication to enhancing agricultural productivity while prioritizing environmental sustainability. Central to these objectives was the continued focus on rural revitalization, highlighting the integral role of rural communities in China's broader development agenda. Together, these strategic frameworks epitomize China's comprehensive approach to promoting inclusive growth, environmental stewardship, and rural prosperity in the years ahead (14th Five-Year Plan Research Group, 2021).

2.3. 2015-2030 National Agricultural Sustainable Development Plan

In 2015, China announced the *2015-2030 National Agricultural Sustainable Development Plan*, laying the foundation for the next 15 years of agroecological development (Ministry of Agriculture and Rural Affairs of the People's Republic of China, 2015). This plan is production capacity-oriented, prioritizes conservation, and focuses on innovation, emphasizing resource-saving, environmental friendliness, and ecological conservation. It marks an important period for China, transitioning from extensive management reliant on resource consumption, agricultural input, and ecological environments to intensive management that emphasizes improving quality and efficiency.

As the most important policy document in recent years, the Plan represents a comprehensive blueprint for the nation's agricultural sector, outlining strategies and objectives to ensure long-term sustainability and resilience. The plan states clearly that, because of the varying geographical condition and different history of exploitation in different regions, the provinces in China should have strategies on sustainable agriculture that are tailored according to the region’s own conditions and needs. Specifically, the plan identifies three key areas in terms of sustainable agriculture: the optimized development area, the moderate development area, and the protected development area.

The optimized development area includes the northeastern region, Huang Huai Hai region, Middle and lower reaches of the Yangtze River, and southern China region. This region is the most productive region in China’s agriculture, with great potential in terms of natural resources. While there are potential ecological risks due to unsustainable exploitation that was done properly, the agriculture of the region shall prioritize output instead of environmental concerns when the two conflicts.

The moderate development area includes the northern, the Great Wall region, and the southwestern region. Even though each of those regions have their own characteristic agricultural product, they all encounter the problems of being ecologically vulnerable, having water and soil unevenly distributed, having severe shortages of both natural and engineered water resources, or having limited carrying

capacity of resources and environment. In those regions, the agricultural sector should seek for a balance between development and conservation, and enhance resource utilization efficiency.

The protected development area includes the Qinghai-Tibet region and the marine fishery area. Those two areas hold a particularly strategic position in terms of ecological protection. The Qinghai-Tibet region serves as the source of major rivers in China and an important ecological security barrier. Although rich in unique agricultural resources, the plateau's ecosystem is extremely fragile. While marine fisheries areas have seen rapid development, they also face challenges such as the decline of fisheries resources and prominent pollution issues. For those regions, environmental protection shall be considered as being more important than resource exploitation or agricultural development.

3. Set of Indicators for China

According to the *2015-2030 National Agricultural Sustainable Development Plan,* different sustainable agriculture strategies are taken in different regions of China. As a result, the indicators of agroecology vary accordingly. The social, environmental, and economic indicators mentioned below are not applied nationwide in China, but are applied only within specific regions.

3.1. Social indicators

Name of indicator	Region	Goal	Measurement
Education level of agricultural labors	All	Assess the time allocated to the formation and training on agroecology principles, to evaluate the effort put on spreading these good practices and the level of awareness among the population.	Population of junior high school and above population in rural population aged 6 and above (%)
Supporting People per Labor	Northeastern Region	Evaluate the agricultural output of the region. The indicator is applied especially in the northeastern region which is the main source of wheat and maize, securing the domestic food supply. The indicator also measures how sufficient the labor practices are	Number of people that one farmer's production can feed
Change in Agricultural Output	Northeastern Region, Huanghuaihai Region, Southern	Another way of evaluating the agricultural output of the region. This indicator measures the impact of agroecology on agricultural output. If the change is a negative one, then the output	the percentage change of agricultural output before and after implementation of agroecology

		would be prioritized over agroecology.	
Food security	All	Assess the amount of households still concerned by food insecurity, not specifically targeting agroecology.	Based on national studies
Agricultural Income	Southwestern Region	In the economically less developed region, the total income from agriculture is especially important. The goal of the indicator is to measure and track the change of income over the application of agroecology	Measure of a total income that comes from both raw products (rice, wood…) and secondary products (canned food, cotton clothes)

3.2. Environmental indicators

Name of indicator	Region	Goal	Measurement
Landcover	Northeastern, Southern China, Qinghai-Tibet	Increase surfaces of protected wetlands, forests and semi-natural area	% total area of agricultural/forestry/natural/artificial/other
Effective Use of pesticides and fertilizers	QInghai-Tibet, Huanghuaihai Region, Middle and lower reaches of Yangtze River	Decrease the use of pesticides (use of more agroecology practices instead (organic farming, land cover,...))	total pesticides and fertilizers per unit of cropland (kg/ha)
Light, Heat, Water, Land usage ratio	All	To promote the sustainable usage of these resources that could have been used in the traditional agriculture model.	**Water Use Efficiency**: Evaluate the amount of agricultural output (e.g., crop yield) per unit of water used **Photosynthetic Efficiency**: Measure the efficiency with which plants convert light energy into biomass through photosynthesis. Enhancing photosynthetic efficiency contributes to higher crop yields.
Energy transition ratio	All	The effectiveness with which energy is transformed and utilized within the agricultural system, including the effectiveness with which plants utilize nutrients for growth and development. Improving nutrient	**Photosynthetic Efficiency**: the efficiency with which plants convert solar energy into chemical energy through photosynthesis. Practices that enhance photosynthetic efficiency contribute to higher

		use efficiency is crucial for sustainable agriculture, as it minimizes nutrient losses, reduces environmental impact, and optimizes crop productivity.	energy conversion rates **Fossil Fuel dependency**: the reliance on fossil fuels in farming operations. Reduced dependency on non-renewable energy sources contributes to higher energy conversion efficiency. **Crop energy yield**: the amount of energy harvested in the form of crops per unit of solar energy input. This indicator reflects the efficiency of converting sunlight into edible or usable biomass.
Soil Erosion Rate	Northwestern and Great Wall, Southern, Southwestern, Hunaghuaihai	This indicator is applied in regions where soil erosion is especially severe because of removal of local forests, grassland, or pollution from nearby mining sites, monitoring and tracking the soil erosion rate for each year.	This indicator is measured with surface runoff rate, rate of transformation of saline-alkaline land, forest protection rate, area of recovered grassland, desertification area.

3.3. Economical indicators

Name of indicator	Region	Goal	Measurement
Effective Irrigation Area	All	To ensure efficient utilization of water resources for agricultural purposes by maximizing the area under effective irrigation through well-planned and properly implemented water conservancy projects.	Whether a water conservancy project construction is effective
Urban-Rural Coordination	All	To foster sustainable development by promoting synergy and collaboration between urban and rural areas, ensuring balanced socio-economic growth, equitable access to resources, and enhanced quality of life for all residents, irrespective of their location.	Income ratio between urban and rural residents: Net income of disposable income of urban residents / rural residents (%)

			Urban and rural consumption level: consumption level of urban residents / consumption level of rural residents (%)
Regional Coordination	All	To enhance regional coordination and cooperation in agricultural development: achieve balanced agricultural growth, promote rural prosperity, and contribute to overall food security and economic stability.	Monitoring and optimizing the growth rate of agricultural output value across different regions: growth rate of agricultural output value (%)
Value input/output ratio	All	To evaluate efficiency of resource utilization in agricultural production, then optimize resource utilization and enhance agricultural productivity by improving the value input/output ratio.	(1) Evaluation of input factors such as labor, capital, land, water, fertilizers, pesticides, and machinery used in agricultural activities; (2) Analysis of output metrics including crop yield, livestock production, and overall agricultural output; (3) Calculation of the ratio between the total costs incurred in production and the total revenue generated from agricultural products.
Increment Ratio of Farm Product Machining	All	To promote agricultural modernization and enhance value creation within the agricultural sector. To foster innovation, improve infrastructure, and support entrepreneurship in agro-processing industries to unlock the economic potential of agricultural products, generate higher value chains, and create employment opportunities.	Assessing the increase in the proportion of agricultural products undergoing value-added processing or machining activities: Percentage growth in the volume or value of agricultural products that have undergone value-added manufacturing (processing, packaging, ...); Trends in the adoption of agricultural processing technologies, such as milling, canning, drying, or freezing, across different agricultural sectors

Case Study 3: USA

1. History of Agriculture in the USA

The term "sustainable agriculture," as defined in the U.S. Code Title 7, Section 3103, encapsulates an integrated system of plant and animal production practices characterized by site-specific applications aimed at achieving long-term objectives. These objectives encompass the satisfaction of human food and fiber needs, the enhancement of environmental quality and the natural resource base essential for sustaining agricultural economies, and the optimization of resource utilization through the incorporation of natural biological cycles and controls. Additionally, sustainable agriculture endeavors to sustain the economic viability of farm operations while concurrently fostering improvements in the quality of life for farmers and society as a whole. Despite the enduring essence of sustainable agriculture, its conceptualization and practice in the United States have undergone evolutionary trajectories spanning centuries. This evolution has been shaped by a multitude of influences, including indigenous agricultural knowledge, colonial legacies, technological advancements, policy interventions, and the dynamic interplay of socio-economic factors.

1.1. Pre-Colonial Era: The indigenous peoples of North America established sustainable farming systems long before European colonization. Central to their agricultural practices was the "Three Sisters agricultural system," characterized by the intercropping of maize, beans, and squash. This symbiotic cultivation method not only enhanced soil fertility but also ensured a balanced nutritional intake, exemplifying an early manifestation of sustainable agricultural principles[1].

1.2. Colonial Era: The arrival of European settlers in the 17th century heralded significant transformations in American agriculture. Introduction of livestock and cultivation of crops such as wheat, barley, and potatoes altered the agricultural landscape. The plantation system, particularly prevalent in the South, relied heavily on cash crops, accentuating socio-economic disparities. Moreover, the utilization of forced labor, initially through indentured servitude and later through the transatlantic slave trade, became integral to agricultural production, laying the foundation for enduring structural inequities[2].

1.3. 19th Century: The 19th century witnessed pivotal technological advancements that revolutionized American agriculture. Innovations such as Cyrus McCormick's mechanical reaper and John Deere's steel plow enhanced efficiency and productivity, facilitating westward expansion and agricultural intensification. The enactment of the Morrill Act of 1862 exemplified the government's commitment to agricultural education and research by establishing land-grant colleges, thereby fostering innovation and knowledge dissemination in the agricultural sector[3].

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[1] Marsh, Emily. “The Three Sisters of Indigenous American Agriculture | National Agricultural Library.” *Www.nal.usda.gov*, 2021, www.nal.usda.gov/collections/stories/three-sisters.

[2] National Geographic Society. “The Plantation System | National Geographic Society.” *Education.nationalgeographic.org*, 20 May 2022, education.nationalgeographic.org/resource/plantation-system.

[3] “Morrill Act (1862).” *National Archives*, 16 Aug. 2021, www.archives.gov/milestone-documents/morrill-act#:~:text=Passed%20on%20July%202%2C%201862.

1.4. Early 20th Century: The early 20th century witnessed concerted efforts to promote agricultural extension and modernization. The passage of the Smith-Lever Act of 1914 facilitated the establishment of extension services, aimed at disseminating scientific knowledge and best practices among farmers. However, this period was also marred by socio-economic challenges, notably the Dust Bowl of the 1930s, attributed to drought and unsustainable land management practices (https://archivesfoundation.org/documents/smith-lever-act-1914/). The subsequent implementation of New Deal programs, under President Franklin D. Roosevelt's administration sought to ameliorate agricultural distress through price stabilization and conservation initiatives[4].

1.5. Mid-20th Century: The post-World War II era witnessed heightened government intervention in agriculture, characterized by price supports and infrastructural development initiatives. The advent of the Green Revolution, propelled by technological innovations and scientific advancements, ushered in a paradigm shift in agricultural production. The widespread adoption of high-yielding crop varieties, irrigation techniques, and agrochemical inputs significantly augmented agricultural productivity, albeit with concomitant environmental concerns and socio-economic implications[5].

1.6. Late 20th to Early 21st Century: The latter half of the 20th century witnessed the consolidation of agricultural production, epitomized by the ascendancy of agribusiness conglomerates and the decline of family farms. The introduction of genetically modified organisms (GMOs) in the 1990s engendered debates surrounding food safety, environmental sustainability, and ethical considerations. Concurrently, the organic farming movement gained momentum, reflecting a growing consumer preference for environmentally sustainable and health-conscious agricultural practices[6].

1.7. Contemporary Era: In the contemporary era, U.S. agriculture is undergoing a paradigm shift towards sustainability and innovation. Precision farming techniques, leveraging GPS and IoT technologies, are optimizing crop yields while minimizing environmental impacts. Sustainable agricultural practices such as crop rotation, conservation tillage, and integrated pest management are gaining prominence, underpinned by growing awareness of environmental stewardship and climate resilience. Additionally, urban farming and vertical agriculture are emerging as viable solutions to address food security challenges in densely populated areas. Policy frameworks and consumer preferences are increasingly shaping the trajectory of U.S. agriculture, with ongoing debates centering on climate change mitigation, biotechnological innovation, and the transition towards sustainable food systems[7].

1.8. Current agricultural landscape of the USA: The agricultural landscape of the United States exhibits a diverse array of land uses, reflecting the nation's multifaceted agricultural sector and its significance in global food supply and trade dynamics. The cultivation of a wide spectrum of crops, ranging from staple grains such as corn, wheat, and soybeans to specialty crops like fruits, nuts, and cotton, underscores the richness and versatility of agricultural production in the U.S. This agricultural diversity not only caters to domestic needs but also positions the country as a prominent player in

[4] History.com Editors. “New Deal.” *History*, A&E Television Networks, 29 Oct. 2009, www.history.com/topics/great-depression/new-deal.
[5] “Green : USDA ARS.” *Www.ars.usda.gov*, www.ars.usda.gov/oc/timeline/green/.
[6] Bigelow, Daniel, and Allison Borchers. *Major Uses of Land in the United States, 2012*. 2017.
[7] GPS.Gov. “GPS.gov: Agricultural Applications.” *Gps.gov*, 2018, www.gps.gov/applications/agriculture/.

the global agricultural market, contributing significantly to both global food supply and trade. As a major agricultural exporter, the United States plays a pivotal role in meeting global food demand, with key export commodities such as soybeans, corn, wheat, and various fruits and nuts (notably almonds) serving as cornerstones of its export portfolio. These exports not only bolster the U.S. economy but also enhance global food security by providing essential commodities to markets worldwide. Against this backdrop, the distribution of lands in the U.S. reflects a strategic allocation aimed at meeting the demands of agricultural production, with significant portions dedicated to grassland pastures and croplands, constituting 29% and 17% of total land use respectively[8].

2. Agricultural Policies in the USA - Farm Bills

The United States Farm Bill stands as a cornerstone of federal agricultural and food policy, embodying a comprehensive legislative approach that undergoes renewal approximately every five to six years. Rooted in the purview of agencies such as the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA), this omnibus legislation, often referred to simply as the Farm Bill, encompasses a myriad of programs addressing farming, nutrition, rural development, and environmental stewardship, among other facets crucial to the nation's agricultural landscape.

2.1 Recent U.S. Farm Bills:

In 1996, the farm bill underwent significant reforms, shifting away from subsidizing farmland and purchasing extra grain towards a system where farm incomes were determined by free market forces. Instead of direct subsidies, farmers were required to enroll in a crop insurance program to receive farm payments. This change resulted in years of the highest farm subsidies in American history. Additionally, direct payments were introduced to support struggling farmers, irrespective of crop output, providing them with a government check annually based on previous decade's yields and acreage records.[9] The Farm Security Act of 2002, signed into law in May 2002, marked the first farm bill of the new millennium. It introduced changes compared to the 1996 bill, including modifications to the farm payment program and the introduction of counter-cyclical farm income support. This bill also emphasized conservation efforts on farms, mandated the expansion of conservation land retirement programs, and restored the eligibility of legal immigrants to food stamps. Furthermore, it relaxed previous rules to allow more borrowers to be eligible for Federal farm credit assistance and included provisions on labeling commodities by their country of origin and animal welfare.[10] Additionally, in 2008, the Food, Conservation, and Energy Act was passed, allocating approximately $100 billion annually for Department of Agriculture programs, with a significant portion designated for food stamps and other nutritional programs. This bill faced controversy due to its substantial increase in spending, reaching $288 billion, leading to concerns over budget deficits. The bill further expanded subsidies for biofuels, which were identified as major

[8] Bigelow, Daniel, and Allison Borchers. *Major Uses of Land in the United States, 2012*. 2017.
[9] September 26, 2011. "The Farm Bill: From Charitable Start To Prime Budget Target." *Iowa Public Radio News*, 26 Sept. 2011, https://www.npr.org/sections/thesalt/2011/09/26/140802243/the-farm-bill-from-charitable-start-to-prime-budget-target.
[10] Young, Edwin. "The 2002 Farm Bill: Provisions and Economic Implications." *U.S. Department of Agriculture Logo*, 1 Jan. 2008, http://www.ers.usda.gov/publications/pub-details/?pubid=42674.

contributors to the 2007–2008 world food price crisis[11]. However, despite the increase in spending, a considerable portion of farmers did not receive subsidies from the farm bill[12]. The Agricultural Act of 2014, known as the 2014 farm bill, introduced modifications across various areas such as conservation programs, support for upcoming farmers, and bioenergy initiatives. It repealed previous commodity programs and introduced new ones like the Price Loss Coverage (PLC) and Agriculture Risk Coverage (ARC) programs to provide support when crop prices or revenues fell below certain levels. Additionally, it enhanced the crop insurance safety net and maintained the food stamp program. With a forecasted budget reduction of $17 billion over ten years, the bill subsidized crop insurance and maintained the food stamp program, covering 62 percent of farmers' premium expenditures[13]. The Agriculture Improvement Act of 2018, commonly known as the 2018 farm bill, reauthorized many programs from the 2014 bill. While a significant portion of the budget was allocated for nutritional programs like SNAP, emphasis was placed on conservation efforts. New initiatives like the CLEAR 30 and SHIPP aimed to improve soil and water quality. The bill also declassified hemp and hemp seed products, entrusting oversight to the FDA and spurring innovation in areas like pediatric treatments. Moreover, titles in the 2018 farm bill funded efforts to reduce farming's environmental impact and address climate change through conservation, forestry, and energy programs[14].

2.2. Legislative processes:

The formulation of agricultural policies undergoes a meticulous process involving several crucial stages. Initially, the agricultural committees of both the House of Representatives and the Senate assumed pivotal roles in drafting the Farm Bill. These committees convene hearings wherein a diverse spectrum of stakeholders, including farmers, agribusiness entities, environmental advocacy groups, rural development organizations, and proponents of food security, offer their perspectives and insights. These hearings serve as indispensable platforms for comprehensively gauging the multifaceted needs, challenges, and opportunities within the agricultural domain. In addition to formal hearings, these committees actively solicit written testimony and engage in substantive dialogues with subject matter experts and stakeholders. This extensive consultation process ensures that the Farm Bill is imbued with a nuanced understanding of contemporary issues concerning agriculture, conservation, and nutrition. Subsequently, leveraging the insights gleaned from hearings and stakeholder inputs, the agricultural committees of both legislative chambers undertake the drafting of the Farm Bill. Further hearings are convened to solicit input from a diverse array of stakeholders, including farmers, industry representatives, environmental advocates, and rural communities, thereby enriching the legislative discourse. Following the drafting phase, the bill undergoes rigorous scrutiny and deliberation within both the House of Representatives and the Senate, encompassing debates, amendments, and voting procedures. In instances where discrepant versions of the bill are passed by the House and Senate, a conference committee is convened to reconcile disparities and forge consensus. The culmination of this legislative journey entails the bill's

[11] Neuman, Scott. “Why The Farm Bill’s Provisions Will Matter To You.” NPR, 13 June 2012, https://www.npr.org/2012/06/13/154862017/why-the-farm-bills-provisions-will-matter-to-you.
[12] September 26, 201112:41. “The Farm Bill: From Charitable Start To Prime Budget Target.” Iowa Public Radio News, 26 Sept. 2011, https://www.npr.org/sections/thesalt/2011/09/26/140802243/the-farm-bill-from-charitable-start-to-prime-budget-target.
[13] “2014 Farm Bill | The United States Senate Committee On Agriculture, Nutrition & Forestry.” Senate Committee On Agriculture, Nutrition & Forestry, 2 May 2013, https://www.agriculture.senate.gov/issues/farm-bill/.
[14] Stratégies, Agriculture. “Le Farm Bill 2018 : Une Quasi-Reconduction à l’identique de La Politique Agricole Américaine.” *Agriculture Stratégies*, 26 Mar. 2024, https://www.agriculture-strategies.eu/2019/01/le-farm-bill-2018-une-quasi-reconduction-a-lidentique-de-la-politique-agricole-americaine/.

approval by both chambers of Congress before being transmitted to the President for signature. The President retains discretionary powers to sign the bill into law, veto it, or allow it to become law without a signature, contingent upon specific conditions[15].

2.3. Implementation and oversight by Federal agencies:

Federal agencies undertake crucial roles in translating the mandates of the Farm Bill into operational initiatives. The United States Department of Agriculture (USDA), in conjunction with pertinent federal entities like the Environmental Protection Agency (EPA), shoulders the responsibility of executing the Farm Bill's provisions. This process encompasses the development and dissemination of regulations aimed at operationalizing the bill's mandates into tangible programs and directives. Central to this regulatory endeavor is the incorporation of public notice and comment periods, which serve to solicit additional stakeholder input, thereby fostering a participatory approach to policy implementation. Additionally, the USDA assumes administrative oversight over a plethora of programs delineated within the Farm Bill framework, spanning agricultural subsidies, crop insurance, conservation endeavors, and nutrition assistance initiatives. This administrative purview entails tasks ranging from fund allocation to the provision of technical assistance and enforcement of programmatic requisites. Furthermore, federal agencies undertake the pivotal responsibility of monitoring compliance with the Farm Bill's provisions and enforcing associated regulations. This oversight function encompasses the conduct of audits, investigation of violations, and implementation of enforcement measures as warranted, all geared towards ensuring adherence to statutory requirements and the attainment of program objectives[16].

2.3. Current challenges in agriculture:

Several pressing challenges confront the agricultural sector in the United States, spanning various dimensions. Firstly, farmers grapple with significant escalations in input costs, notably fertilizers, which witnessed a staggering increase of over 60% from 2021 to 2022[17]. Concurrently, the sector contends with labor shortages despite rising wage rates and heightened utilization of the H-2A visa program. Moreover, apprehensions loom large over potential trade disruptions, particularly concerning Mexico's envisaged phase-out of biotech corn imports, which could have profound ramifications for U.S. farmers. Additionally, the implementation of new water regulations, exemplified by the Waters of the U.S. rule, augments governmental oversight over private property and water resources, posing considerable challenges for agricultural stakeholders. Furthermore, the heavy reliance on subsidies within U.S. farm policies raises concerns regarding market distortions and the inhibition of diversification and innovation efforts. Policies favoring large-scale monoculture production further exacerbate issues related to soil degradation and biodiversity loss, underscoring the necessity for diversification endeavors. Despite initiatives like the Pandemic Cover Crop Program (PCCP), policy support for sustainable practices remains limited, necessitating concerted efforts to promote sustainability within the agricultural domain.

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[15] "USDA ERS - U.S. Farm Policy and Policy Process." *Www.ers.usda.gov*, www.ers.usda.gov/topics/farm-economy/farm-commodity-policy/u-s-farm-policy-and-policy-process/.
[16] "Farm Bill Implementation." *National Sustainable Agriculture Coalition*, sustainableagriculture.net/our-work/campaigns/fbcampaign/farm-bill-implementation/. Accessed 2 Apr. 2024.
[17] The World Bank. "Food Security Update". June 2023. Available at: https://thedocs.worldbank.org/en/doc/40ebbf38f5a6b68bfc11e5273e1405d4-0090012022/related/Food-Security-Update-LXXXVIII-6-29-23.pdf

2.4. Challenges in developing agro-ecology:

The burgeoning interest in sustainable agriculture and agro-ecology in the USA encounters impediments hindering widespread adoption. Research highlights the potential of sustainable agriculture to mitigate challenges arising from climate change, ecosystem services depletion, food insecurity, and farmer livelihoods. However, several hurdles impede the transition to agro-ecological practices. Foremost among these challenges are the high initial costs associated with transitioning to sustainable practices, which serve as a formidable barrier, dissuading stakeholders from embracing sustainable agriculture. Moreover, existing policies may resist change due to entrenched political influences, particularly emanating from large agribusinesses, potentially impeding legislative reforms conducive to agro-ecological advancement, especially in the context of presidential elections. Addressing these challenges necessitates augmented research endeavors and educational initiatives aimed at elucidating the efficacy and feasibility of agro-ecological practices, thereby fostering their wider adoption. Furthermore, adequate investments are imperative to bolster the requisite infrastructure and support mechanisms for facilitating the transition to agro-ecological practices, underscoring the critical importance of financial commitments from both public and private ties.

3. Set of indicators for the USA

In this section, we delve into a set of social indicators tailored for the United States, each offering insights into critical aspects of agricultural dynamics. From farmers' rights to education and food security, these indicators illuminate the intersection between agricultural practices and societal well-being. Through analysis of existing policies, goals, and measurement methodologies, we aim to uncover pathways towards enhanced inclusivity, sustainability, and prosperity within the agricultural sector.

3.1. Social indicators

Name of indicator	In place	Existing Policy	Goal	Measurement
Farmers' nationality	NO	Farm Workforce Modernization Act (In discussion)	Encourage better social protection to farmers and better living conditions as 73% of agriculture workers are immigrants and are not protected by the labor laws.	- Proportion of undocumented immigrant farmers (%) - Labor rights violations - Proportion of immigrants workers naturalized (%)
Education	NO	None	This indicator measures the level of knowledge, skills, and awareness that a population or a household has about sustainable and agro-ecological agriculture practices. It is interesting because it can influence the	The unit of measurement can be schools, programs, events, educated people and the frequency of measurement can be yearly.

			adoption, adaptation, and innovation of such practices.	
Food security	NO	None	This indicator measures the availability, access, utilization, and stability of food for a population in each States. It is important as 13.8 million U.S. households (about one-tenth of all U.S. households) were food insecure at least part of the time in 2020.	- Food insecurity rate: % of households experiencing food insecurity (e.g., skipping meals due to lack of resources). - Proximity to food outlets: Distance to grocery stores, farmers' markets, and food banks. - Transportation access: Availability of reliable transportation to reach food sources.
Food quality - health of citizens	NO	Food Safety Modernization Act (Adopted)	This indicator measures the quality and the safety of food produced and consumed in the USA. It is important as high-quality food contributes to public health so to both the sustainability of the environment and of social conditions in the USA.	- Nutrient content: Measured in milligrams (per exemple vitamin C content in fruits). - Pesticide residues: Parts per billion (ppb) of pesticide residues in food. - Foodborne illnesses: Cases reported per year.
Gender equality	NO	Farm Workforce Modernization Act (In discussion)	This indicator measures the empowerment of women in agriculture by measuring the degree of equality of genders. Gender equity can enhance agricultural productivity and social justice. It is important as American farms run by women generate nearly 40% less income than those run by men.	- Female participation: % of women involved in decision-making (per exemple on farm management + Farm Bill drafting). - Land ownership: Hectares of land owned by women. - % of women employed in agricultural activities - Median salary of women compare to those of men
Food sovereignty	NO	None	This indicator measures food sovereignty and ensures that each States have control over their food systems, promoting resilience and social security. It would measure the dependence on other States to be able to feed their whole population.	R = (Number of food produced per State Workers) / (Number of food needed per State) R < 1: Food shortage. R = 1: Food meeting the needs of the State R > 1: Surplus of food.

3.2. Environmental indicators

Name of indicator	In place	Existing Policy	Goal	Measurement
Agrochemical Dependency	NO	The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Agrochemicals affect soil, water, and ecosystem and exposure to agrochemicals can have health implications.	- Pesticide use intensity: Pesticide application per unit area (kg / ha for each States). - Herbicide, insecticide fungicide Use: Breakdown by type. - GMO use intensity (% per types of crops)
Crop Diversity	NO	None	This indicator measures the variety of crops grown on a farm or in a region, it can reflect the resilience, productivity, and environmental impact of the agricultural system.	It can be measured by calculating the Simpson's diversity index, which takes into account both the number and the relative abundance of different crop types.
Biodiversity	NO	None	This indicator measures the diversity of living organisms in a farm or in a region, it can indicate the health, stability, and ecosystem services of the agricultural system.	It can be measured by calculating the Shannon diversity index, which takes into account both the number and the relative abundance of different species or groups of organisms.
Agro-ecology Projects Implemented	NO	None	This indicator measures agro-ecological projects which enhance biodiversity and ecosystem services and they optimize land use	- Number of agro-ecology projects: count of implemented projects. - Land area covered: hectares under agroforestry or agro-voltaic practices
Energy used (energy consumption in relation to the amount of food produced)	NO	None	Efficient energy use reduces greenhouse gas emissions and production costs.	- Energy consumption: Kilowatt-hours (kWh) used for irrigation, machinery, and processing. - Crop yield: Measure crop size per amount of food produced (per exemple bushels of corn, kg of tomatoes).

Soil health	NO	The Agriculture Improvement Act of 2018	This indicator measures the health of soil which is the foundation for regenerative, climate-smart agriculture.	Measured using indexes of nutrient retention; soil fertility; soil structure; soil stability; and soil erosion
Carbon Emissions / Sequestration	NO	Clean Air Act (CAA)	This indicator measures the Carbon emissions from the agricultural sector and it is compared to the carbon sequestration developed by farms at the national level. It measures the balance required for a carbon neutral agricultural system.	- Total carbon emissions: Measured in tons of CO_2-equivalent per year per States from the agriculture sector - Soil organic carbon accumulation: Measured as tons of carbon per hectare per year. - Forest growth: Assessing tree biomass increase (tons of carbon per hectare).
Nitrogen/ Phosphorus Pollution	NO	Clean Water Act (CWA)	This indicator measures excess nutrients which can harm water quality and aquatic ecosystems.	Nitrogen/Phosphorus content measured in parts per million (ppm), or kilograms per hectare (kg/ha) for specific nutrients like nitrogen, phosphorus, potassium, etc.)
Water Use Efficiency	NO	Title II of the 2018 Farm Bill, also known as The Agriculture Improvement Act of 2018	This indicator measures the efficiency of water use through conservation of freshwater resources and water-efficient practices which help during droughts.	Water consumption in liters or cubic meters per unit of crop yield (e.g., liters per kilogram of grain).
Animal Welfare	NO	Farm Security and Rural Investment Act of 2002	This indicator measures animal welfare. Insuring the well-being of farm animals is not only an ethical imperative but also directly impacts productivity and food safety. Healthy animals lead to better production outcomes.	- Mortality rates: the percentage of animals that die during production (%). --Disease incidence: frequency of diseases affecting livestock (per year). - Stress levels: assessing stress through behavioral observations. - Access to natural behaviors: measured by the time animals spend grazing, roaming, or engaging in other natural activities

3.3. Economical indicators

Name of indicator	In place	Existing Policy	Goal	Measurement
Farmers income equality	NO	Food, Agriculture, Conservation, and Trade Act (1996 Farm Bill)	This indicator attempts to measure and address income disparities among farmers, ensuring that agricultural policies provide equitable support to all farmers regardless of their scale or location.	Gini Coefficient, Income Ratio
States Investment in Agriculture R&D	NO	None	This indicator aims to promote advancements in agricultural science and technology, supporting research that benefits farmers, enhances crop yields, and addresses challenges such as pests, diseases, and climate change.	U.S. Dollar
Employment in agriculture	NO	Farm Security and Rural Investment Act (2002 Farm Bill)	The goal of this indicator is to maintain and improve employment opportunities in agriculture, fostering robust rural communities and ensuring a reliable labor force for agricultural production.	Number of Jobs, Labor Force
Value of Agricultural Exports/Net Farm	NO	Farm Security and Rural Investment Act (2002 Farm Bill)	This indicator attempts to measure and Increase the value of agricultural exports, strengthen the agricultural economy, and support farmers' incomes through access to international markets.	U.S. Dollar
Share of Agriculture in GDP	NO	Food, Conservation, and Energy Act (2008 Farm Bill)	This indicator attempts to measure the contribution of agriculture to the overall GDP, reflecting the sector's importance to the national economy and rural livelihoods.	Percentage (%)
Food Waste & Losses	NO	None	It aims to assess food waste when compared to overall food production in the USA.	Tons, Production-waste ratio (%)

International indicators

The three study cases chosen highlight the fact that the challenges of the food industry vary a lot depending on the region of the world. The political context as well as the climatic conditions or even the culture of each country have a huge impact on the way food is produced but also consumed. Therefore the introduction of agroecological practices in these three regions is a disparate process, progressing at various speeds and focusing on different matters. We tried however to identify similarities among the threethree study cases that could reflect a common progression toward sustainable agriculture. After considering and comparing the various indicators developed in each region studied, we suggest below a list that to our sense could be used at the international scale.

Social	Environment	Economic
● Education (farmer, general) ● Food security ● Food sovereignty	● Landcover ● Use of pesticides ● Water quality ● Crop rotation ● GHG emissions from agriculture ● Intensive farming ● Calory ratio ● Soil erosion ● Water use efficiency	● Jobs in agriculture ● Productivity of agroecological farms ● Farmer incomes (in 3 categories)

Bibliography

Case Study 1

[1] 'Changing menus, changing landscapes — Agriculture and food in Europe — European Environment Agency', Available: https://www.eea.europa.eu/signals-archived/signals-2019-content-list/articles/changing-menus-changing-landscapes-agriculture. [Accessed: Mar. 01, 2024]

[2] R. T. l'Europe, 'L'agriculture européenne en 10 chiffres clés', *Touteleurope.eu*, Jan. 29, 2024. Available: https://www.touteleurope.eu/agriculture-et-peche/l-agriculture-europeenne-en-10-chiffres-cles/. [Accessed: Mar. 01, 2024]

[3] 'Feeding Europe: 60 years of common agricultural policy'. Available: https://agriculture.ec.europa.eu/system/files/2022-04/60-years-cap_en_0.pdf. [Accessed: Mar. 01, 2024]

[4] 'A greener and fairer CAP'. Available: https://agriculture.ec.europa.eu/document/download/89b607ec-8a43-4073-bafd-f2493da7699e_en?filename=factsheet-newcap-environment-fairness_en.pdf. [Accessed: Feb. 28, 2024]

[5] 'CAP at a glance - European Commission', Feb. 13, 2024. Available: https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en. [Accessed: Feb. 15, 2024]

[6] 'Key policy objectives of the CAP 2023-27 - European Commission', Feb. 26, 2024. Available: https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27/key-policy-objectives-cap-2023-27_en. [Accessed: Feb. 29, 2024]

[7] 'List of potential AGRICULTURAL PRACTICES that ECO-SCHEMES could support'. Available: https://agriculture.ec.europa.eu/document/download/2445d833-7a35-4974-8ecb-ee7d5a0332e6_en?filename=factsheet-agri-practices-under-ecoscheme_en.pdf. [Accessed: Mar. 04, 2024]

[8] 'La conditionnalité des aides PAC', *Ministère de l'Agriculture et de la Souveraineté alimentaire*. Available: https://agriculture.gouv.fr/la-conditionnalite-des-aides-pac. [Accessed: Mar. 04, 2024]

[9] 'CAP 2023-27 - European Commission', Mar. 27, 2024. Available: https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_en. [Accessed: Apr. 03, 2024]

[10] 'Conditionality - European Commission', Feb. 22, 2024. Available: https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/conditionality_en. [Accessed: Apr. 03, 2024]

[11] 'Eco-schemes - European Commission', Feb. 13, 2024. Available: https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/eco-schemes_en. [Accessed: Apr. 03, 2024]

[12] 'CMEF - European Commission', Mar. 27, 2024. Available: https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cmef_en. [Accessed: Apr. 02, 2024]

[13] E. C.-D.-G. for A. and R. Development, 'European Commission | Agri-food data portal'. Available: https://agridata.ec.europa.eu/extensions/DataPortal/cmef_indicators.html. [Accessed: Apr. 02, 2024]

[14] 'Environmental-and-climate-assessements-of-CAP-Strategic-Plans_IEEP-2023.pdf'. Available: https://ieep.eu/wp-content/uploads/2023/04/Environmental-and-climate-assessements-of-CAP-Strategic-Plans_IEEP-2023.pdf. [Accessed: Apr. 03, 2024]

[15] 'Comment la PAC soutient-elle le revenu des agriculteurs ?', *INRAE Institutionnel*. Available: https://www.inrae.fr/actualites/comment-pac-soutient-elle-revenu-agriculteurs. [Accessed: Apr. 03, 2024]

[16] R. T. l'Europe, 'Budget de l'UE : à qui profite la politique agricole commune (PAC) ?', *Touteleurope.eu*, Feb. 26, 2024. Available: https://www.touteleurope.eu/agriculture-et-peche/budget-de-l-ue-a-qui-profite-la-pac/. [Accessed: Apr. 02, 2024]

[17] 'Dans les lycées agricoles, une transition écologique semée d'embûches', *vert.eco*, Feb. 27, 2024. Available: https://vert.eco/articles/dans-les-lycees-agricoles-une-transition-ecologique-semee-dembuches. [Accessed: Apr. 02, 2024]

Case Study 2

ZHENG Y Y, YU F W. *Low-carbon agricultural development in the context of climate change: International experiences and China's strategies[J]*. Chinese Journal of Eco-Agriculture, 2024, 32(2): 183−195. DOI: 10.12357/cjea.20230261

Notice on the issuance of the "National Sustainable Agricultural Development Plan (2015-2030)", Ministry of Agriculture and Rural Affairs of the People's Republic of China, Sep 16, 2015, http://www.moa.gov.cn/ztzl/mywrfz/gzgh/201509/t20150914_4827900.htm

CHEN F, YIN X G and JIANG S C. 2023. "*Climate Smart Agriculture in China: From Policy to Investment*." FAO invests in National Investment News Center No. 20. Rome, FAO. https://doi.org/10.4060/cc2200zh

14th Five-Year Plan Research Group, "*Where will the increase in China's reform be in the next five years? — An in-depth comparison of the "14th Five-Year Plan" and the "13th Five-Year Plan" outlines*," Chongyang Institute for Financial Studies, Renmin University of China, China Development Observation, Jun 03, 2021, https://cdo.develpress.com/?author=5

Cui, X., Cai, T., Deng, W. *et al.* Indicators for Evaluating High-Quality Agricultural Development: Empirical Study from Yangtze River Economic Belt, China. *Soc Indic Res* **164**, 1101–1127 (2022). https://doi.org/10.1007/s11205-022-02985-8

LUO Shiming. Agroecology transition and suitable pathway for eco-agricultural development in China[J]. Chinese Journal of Eco-Agriculture, 2017, 25(1): 1-7. DOI: 10.13930/j.cnki.cjea.160838

LIN W X, CHEN T. Transition of agricultural systems to ecologicalizaton and new vision of modern eco-agriculture development in China. Chinese Journal of Eco-Agriculture, 2019, 27(2): 169-176. DOI: 10.13930/j.cnki.cjea.181056

Case Study 3

Stratégies, Agriculture. "Le Farm Bill 2018 : Une Quasi-Reconduction à l'identique de La Politique Agricole Américaine." *Agriculture Stratégies*, 26 Mar. 2024, https://www.agriculture-strategies.eu/2019/01/le-farm-bill-2018-une-quasi-reconduction-a-lidentique-de-la-politique-agricole-americaine/.

"Farm Bill Implementation." *National Sustainable Agriculture Coalition*, sustainableagriculture.net/our-work/campaigns/fbcampaign/farm-bill-implementation/. Accessed 2 Apr. 2024.

The World Bank. "Food Security Update". June 2023. Available at: https://thedocs.worldbank.org/en/doc/40ebbf38f5a6b68bfc11e5273e1405d4-0090012022/related/Food-Security-Update-LXXXVIII-6-29-23.pdf

"USDA ERS - U.S. Farm Policy and Policy Process." *Www.ers.usda.gov*, www.ers.usda.gov/topics/farm-economy/farm-commodity-policy/u-s-farm-policy-and-policy-process/.

"2014 Farm Bill | The United States Senate Committee On Agriculture, Nutrition & Forestry." Senate Committee On Agriculture, Nutrition & Forestry, 2 May 2013, https://www.agriculture.senate.gov/issues/farm-bill/.

September 26, 2011. "The Farm Bill: From Charitable Start To Prime Budget Target." Iowa Public Radio News, 26 Sept. 2011, https://www.npr.org/sections/thesalt/2011/09/26/140802243/the-farm-bill-from-charitable-start-to-prime-budget-target.

Neuman, Scott. "Why The Farm Bill's Provisions Will Matter To You." NPR, 13 June 2012, https://www.npr.org/2012/06/13/154862017/why-the-farm-bills-provisions-will-matter-to-you.

Young, Edwin. "The 2002 Farm Bill: Provisions and Economic Implications." *U.S. Department of Agriculture Logo*, 1 Jan. 2008, http://www.ers.usda.gov/publications/pub-details/?pubid=42674.

September 26, 2011. "The Farm Bill: From Charitable Start To Prime Budget Target." *Iowa Public Radio News*, 26 Sept. 2011, https://www.npr.org/sections/thesalt/2011/09/26/140802243/the-farm-bill-from-charitable-start-to-prime-budget-target.

Bigelow, Daniel, and Allison Borchers. *Major Uses of Land in the United States, 2012*. 2017.

GPS.Gov. "GPS.gov: Agricultural Applications." *Gps.gov*, 2018, www.gps.gov/applications/agriculture/.

"Green : USDA ARS." *Www.ars.usda.gov*, www.ars.usda.gov/oc/timeline/green/.

History.com Editors. "New Deal." *History*, A&E Television Networks, 29 Oct. 2009, www.history.com/topics/great-depression/new-deal.

"Morrill Act (1862)." *National Archives*, 16 Aug. 2021, www.archives.gov/milestone-documents/morrill-act#:~:text=Passed%20on%20July%202%2C%201862.

National Geographic Society. "The Plantation System | National Geographic Society." *Education.nationalgeographic.org*, 20 May 2022, education.nationalgeographic.org/resource/plantation-system.

Marsh, Emily. “The Three Sisters of Indigenous American Agriculture | National Agricultural Library.” *Www.nal.usda.gov*, 2021, www.nal.usda.gov/collections/stories/three-sisters.