BIBLIOGRAPHIC NOTE FROM D'A26
Transformation of sedentary agricultural and/or livestock farming systems

1. Agroecological transition

1.1. Definitions

First used in 1928 by American agronomist Basil Bensin to refer to the application of ecological principles to agriculture (Maitrepierre, 2024), **the term "agroecology " (AE)** was first used in 1928 by American agronomist Basil Bensin to refer to the application of ecological principles to agriculture (Maitrepierre, 2024), the term "agroecology" (AE) has since expanded beyond the field and farm level to encompass the agroecosystem and then the food system as a whole (HLPE, 2019). According to David et al. (2012), AE is "an integrated approach that simultaneously applies ecological, economic and social concepts and principles to the design and management of food and agricultural systems". Its objective is twofold: (1) to optimise the productivity of these systems while strengthening their resilience to new uncertainties imposed by climate change and the volatility of agricultural and food prices; and (2) to maximise the ecosystem services that agrosystems can provide (carbon storage, preservation of biodiversity and natural resources, Maitrepierre, 2024; Malézieux, 2012; Malézieux et al, 2009, 2019).

It is at once "a science, a set of practices and a social movement". According to the Agroecology Europe Association, "as a science, it prioritises action research, holistic and participatory approaches, and transdisciplinarity including different knowledge systems. As a practice, it is based on the sustainable use of local renewable resources, the knowledge and priorities of local farmers, the judicious use of biodiversity to provide ecosystem services and resilience, and solutions that deliver multiple benefits (environmental, economic, social) from the local to the global level. As a movement, it advocates for smallholders and family farming, farmers and rural communities, food sovereignty, local and short marketing channels, seed and indigenous breed diversity, and healthy, quality food"[1] .

Agroecological transition (AET) refers to "the process by which the principles governing a system are radically changed, leading to a set of changes affecting both the values of the actors and the techniques they use" (Hazard et al., 2024).

1.2. A systemic, multi-scale, multidimensional transformation that needs to be contextualised

ATE involves a change in agricultural[2] and food systems, sometimes drastic (Magrini et al., 2019), in order to implement the principles of AE and respond to the crises that this sector may face, whether social, economic or environmental. "AET is a multifaceted process that involves transforming agricultural systems to align them with ecological principles, with the aim of improving sustainability and resilience. This transition is characterised by changes in agricultural production methods, social structures and governance, and requires the integration of various actors and knowledge systems. AET is not only technical but also involves social and institutional innovations, reflecting a systemic transformation of agriculture and food systems" (Hazard et al., 2024).

AET involves **the articulation of different scales –** from the plot to the territories – and different levels of organisation, up to the entire food system (David et al., 2012). It should not be considered solely at the level of the plot or farm. Indeed, biogeochemical and hydrological cycles, epidemics and pest infestations are linked to much larger scales. This is why AET must also be considered at the territorial level.

According to Tittonell (2019, 2023), AET requires a technical and productive transition in agricultural systems, a socio-ecological transition at the level of families and rural communities, and a political and institutional transition at the territorial, regional and national levels. AET therefore usually requires the co-evolution of agricultural, social and economic

[1] Source:www.agroecology-europe.org/our-approach/our-understanding-of-agroecology/

[2] In this note, the term "agricultural systems" also includes sedentary livestock farming systems.

practices, among others. However, the diversity of agricultural and food systems requires a variety of AET pathways (different references, different levels of input use, different contexts, etc.) and therefore a diversity of actions to achieve it. These transformations must therefore be closely adapted to contexts that vary considerably between regions and countries. AET cannot be identical everywhere (Atta-Krah et al., 2022). AE does not propose a single type of agriculture but a multitude of approaches and practices. It thoroughly revises production systems, even going so far as to completely redesign them.

2. Relevance of AE for improving the resilience of agricultural systems to drought

EA systems are often described as being better suited to current and future climate change (Maitrepierre, 2024). *Ultimately*, EA practices increase the resilience and adaptation of agricultural systems to the effects of climate change and hazards such as droughts.

2.1. Environmentally friendly agricultural practices

AE aims to produce differently. It involves making maximum use of living organisms without threatening them. It refers to a set of agricultural practices whose coherence is based on the use of ecological processes and the enhancement of (agro)biodiversity (David et al., 2012) and on the interactions between plants, animals, humans and the environment within agricultural systems (Gliessman, 2007). To this end (Maitrepierre, 2024):

- AE encourages positive interactions, synergies, integration and complementarities between the elements of agroecosystems (element 3 of the FAO[3]).
- It optimises natural processes by recycling nutrients and biomass in agricultural and food systems (element 5 of the FAO).
- It preserves biodiversity above and below ground, over time and space (at the plot, farm and landscape levels, elements 1, 3 and 6).
- It reduces dependence on external chemical inputs by promoting ecological processes to control diseases, pests and weeds (element 4).

2.1.1. Biodiversity management

According to the FAO (2018b), agroecological approaches can preserve and increase wild and domesticated biodiversity by up to 30% compared to conventional agriculture. The AE approach consists of reintroducing and maintaining biodiversity in systems in order to make the best use of the range of conditions and resources available and to take advantage of the complementary adaptive and functional characteristics of species (Reboud and Malézieux, 2015).
For example, through:

- Creating a landscape mosaic by diversifying crops, introducing crop rotations, or landscaping (meadows, hedges, silvopastoralism, etc.) (Sirami et al., 2019; Vialatte et al., 2019);
- The use of traditional breeds and varieties (farmers' seeds) adapted to local conditions, reducing the vulnerability of agricultural systems to extreme weather events and heat stress (Maitrepierre, 2024);
- Reducing pesticide use, thereby avoiding their negative impact on biodiversity Research has shown that certain farming practices (crop rotation and intercropping in particular) disrupt the habitats and life cycles of pests and diseases (Corbeels et al., 2020);
- Enhancing the diversity and activity of soil microorganisms that benefit plants (mycorrhizal fungi, nitrogen-fixing bacteria, etc.), etc.

AI combines and "collaborates" plants. Different species grown in the same space lead to better distribution and use of available resources (light, water, nutrients, Gliessman et al., 2007), thus reducing the risk of depletion of these resources:

[3] The ten elements identified by the FAO (2018a) are used here: Diversity (element 1), Co-creation and knowledge sharing (2), Synergies (3), Efficiency (4), Recycling (5), Resilience (6), Human and social values (7), Food cultures and traditions (8), Responsible governance (9), Circular and solidarity economy (10).

- In diversified agricultural systems, plants compete less for water and nutrients because they occupy different ecological niches, which stabilises or even increases production even during periods of water stress (Justes et al., 2014).
- Some plants draw water from deep in the soil and can act as a "hydraulic lift" (Cardinael, 2022 in Atta-Krah, 2022) by capturing water from deep soil layers and redistributing it to surface layers, where water is scarcer.
- Some plants that are more tolerant to water stress can support other more sensitive species by providing shade, thereby reducing evapotranspiration and extreme variations in soil temperature and moisture, for example.
- The biological synergy between plants and soil microorganisms helps plants to better absorb nutrients and water, even during periods of water stress. For example, arbuscular mycorrhizal fungal *inoculants* can improve phosphorus availability, reduce dependence on phosphate fertilisers (by approximately 25-50%), and improve water use efficiency in crops such as cassava, potatoes, etc., as well as protecting crops such as bananas from parasitic nematodes (Duponnois and Prin, 2022 in Atta-Krah et al., 2022).

2.1.2. Soil management

According to the FAO (2018b), AE approaches can restore and improve soil health and fertility. Healthier soils are less sensitive to drought because they can retain more moisture, thereby reducing water stress on plants. Certain soil management practices can be effective in preserving soil structure and fertility and its ability to retain water (Corbeels et al., 2020):

- **Acting on these nutrient and organic matter cycles**: for example, through the implementation of crop rotations and intercropping that mimic natural ecosystems (Nicholls et al., 2016); or by adding biomass to the field (ploughing in crop residues, introducing intermediate crops into rotations, adding animal manure from pastures or adding manure, compost, etc.). Other examples include the integration of legumes, fallow land or zero tillage.
- **Promoting spatial management of soil fertility**: crop-livestock integration, for example, is an AE strategy that optimises resource use by coordinating agricultural and livestock activities at the landscape or farm level. The aim is to create a system where soil fertility is maintained or even improved through synergies between crops and livestock, while reducing dependence on chemical inputs (Vall et al., 2023).
- **Storing atmospheric carbon in the soil in the form of organic matter**. Certain AE practices promote C storage in the topsoil (zero tillage, livestock-crop integration, agroforestry, etc.), thereby improving soil fertility.
- **Limiting soil erosion**: Reducing (or even eliminating) tillage, maintaining vegetation cover and mixing species reduces soil erosion through better coverage and rooting, while promoting rainwater retention and reducing evaporation and nutrient leaching (Nicholls et al., 2016; Gliessman et al., 2007).
- **Preserving and enhancing soil biodiversity**: for example, by promoting earthworm activity and root microbiota function, or by using biological control methods to encourage the action of crop auxiliaries without polluting the soil with pesticides and their metabolites. For example, intercropping systems with legumes are important for maintaining soil biodiversity in highly fragile ecosystems (such as those in the mountainous regions of Vietnam, Fouillet et al., 2019).
- **Using soil biodiversity to benefit crops:** for example, microorganisms (rhizobia, mycorrhizal fungi, etc.) play a key role in humus formation and maintaining the physical and chemical properties of soils. It should be noted that mycorrhizal fungi can be exploited because they associate with plant roots, increasing their ability to absorb water, even at depth. During a drought, this allows crops to make better use of water reserves in the soil, prolonging their survival in periods of water deficit. Scientific studies have shown that mycorrhizal symbiosis facilitates plant development in environments subject to abiotic stresses, particularly water stress (Ramirez-Flores et al., 2020; Wahbi et al., 2016). Let us not forget earthworms (and termites in the tropics, Jouquet et al., 2020; Cheik et al., 2019), which are discreet yet essential contributors to soil fertility, particularly in arid areas.

2.1.3. Water management

AE approaches to water management aim to optimise water collection at the plot level, make optimal use of it and conserve it in the soil while limiting losses (Hazell et al., 2001). Certain practices make it possible to maintain agricultural production while conserving water and minimising its consumption:

- **Rainwater capture and infiltration** on plots: for example, zaï, terraces, stone barriers.
- Reduction of water losses through runoff and evaporation: cover crops, fallow land, mulching, etc.

- **Optimisation of soil water retention capacity**: zero tillage, installation of windbreaks, agroforestry, etc.
- **Water demand management,** by adapting to reduced water supply: selection of species, cultivars and breeds suited to such conditions.
- **Optimised irrigation**: for example, micro-irrigation, drip irrigation or precision irrigation. These systems enable optimised water management by limiting losses through evaporation and excessive infiltration (Holman et al., 2021).
- **Water recycling:** for example, reusing nutrient-rich wastewater or agricultural drainage water to irrigate new crops while reducing the need for chemical fertilisers. This includes collecting and storing rainwater (e.g. in cisterns or retention basins) for later use, particularly during periods of drought.

2.2. Risk reduction and greater economic autonomy

AE promotes both the diversification of agricultural income and the independence of producers from external inputs. Farmers are then less financially dependent, more technically autonomous, and less exposed to market risks (price volatility or losses due to hazards such as droughts) (FAO elements 1, 10). AE provides jobs and livelihoods for producer s and rural communities, and helps to strengthen local economies and local markets (FAO elements 7 and 10).

"AE systems can thus improve the economic viability of farms and provide decent living conditions for producers, especially the poorest. According to the FAO (2018b), AE approaches have, in some cases, increased farmers' incomes by 30%, notably through diversification of production, reduced dependence on external inputs, and marketing of products through alternative channels. In addition, AE methods can be labour-intensive, particularly during their start-up phase, and thus contribute to job creation in rural areas (Maitrepierre, 2024).

2.2.1. Risk reduction through economic diversification

Diversifying agricultural production by growing a wider variety of crops that are adapted to conditions of low water availability minimises the economic risks for farms (in addition to maintaining minimum food production and ensuring a certain level of food security despite water shortages). This diversification avoids dependence on a single crop, reducing economic risks in the event of market price fluctuations or poor harvests due to drought. For example, smallholder farmers in Niger have significantly increased agricultural productivity and their incomes through agroforestry based on *Ziziphus mauritiana* (the Sahel apple) (Bado et al., 2020).

Diversification of economic activities (crafts, agrotourism, local gastronomy, certified processed products, salaried activities, etc.) helps to make producers less vulnerable by offsetting crop losses due to drought. The valorisation of agricultural by-products and waste (e.g. biogas, biomass) can also help to diversify farms' sources of income. This economic diversification gives farmers access to a variety of markets: the sale of agricultural products (cash crops, vegetables, fruit), craft products, processed products, or even niche markets with high added-value products (e.g. PGI-labelled products, fair trade, etc.).

The circular and solidarity economy promoted by the AE encourages short supply chains, i.e. direct sales to local consumers and in local markets, which:

- Reduces farms' dependence on long supply chains and fluctuating markets, which are often affected by drought;
- Stimulates local economic development and short food supply chains;
- Reduces dependence on – and uncertainties associated with – transport and exports
- Enables farms to adjust their production to the needs of local communities and available resources, supporting a recovery that is adapted to environmental and economic shocks.

In addition, in a circular economy system, farmers can also share expensive equipment, such as irrigation systems, through sharing or rental models. This sharing of equipment reduces initial costs, enables the acquisition of equipment suitable for managing resources during periods of drought, and increases the autonomy of farms. The solidarity economy facilitates the pooling of resources at the local level (seeds, compost, labour, etc.), reducing production costs and making them less sensitive to the economic impacts of drought.

2.2.2. Reducing dependence on inputs

Certain AE practices reduce farms' dependence on costly external inputs, which are often less available during periods of drought. For example:

- **Recycling** promotes the establishment of agricultural systems where waste from one process becomes an input for another. For example, livestock by-products can be used as fertilisers for crops; compost or organic fertilisers, produced from the recycling of plant and animal waste, provide natural nutrients for crops. By mimicking natural ecosystems, these practices improve nutrient cycling and reduce dependence on external inputs, thereby promoting the self-sufficiency of agroecosystems (Nicholls et al., 2016; Gliessman, 2004).
- **Reduced use of plant protection products**: For example, in Réunion, experiments based on the principles of agroecological protection of vegetable and fruit crops have shown a drastic reduction, or even elimination, of pesticides, restoration of biodiversity, reduction in production costs (without loss of production) and working time (Deguine et al., 2018, 2019). Another example is the use of plants in the form of aqueous extracts or essential oils to protect crops against pests and diseases, in fields or in grain storage granaries in sub-Saharan Africa (Silvie et al., 2021).
- **Pest management**: for example, trees (e.g. agroforestry systems) can be used in three ways: (1) they modify the physical environment and affect pest development directly or indirectly, through the development of natural enemies or by modifying the physiology of cultivated plants; (2) they modify the biological environment and favour natural enemies (birds, certain arthropods and micro-organisms); (3) they create physical barriers that limit the movement of pests (Avelino et al., 2011, 2018).

2.2.3. Improved food security and public health

According to the High Level Panel of Experts on Food Security and Nutrition (HLPE, 2019), AE approaches reinforce the four dimensions of food security: availability, access, stability and utilisation of food. Bezner Kerr et al. (2021 in Maitrepierre, 2024) analysed 56 studies (between 1998 and 2019) that included AE practices (crop diversification, crop-livestock integration, soil conservation, etc.) and socio-economic approaches (farmer networks, local markets, etc.), mainly in South and Central American and African countries. In 78% of cases, AE practices had positive results for food security and nutrition, and the greater the number of AE practices implemented, the more positive the results. Indeed, AE promotes:

- Diversified and resilient production systems that provide diverse and nutritious food throughout the year;
- traditional diets of populations living in drought-prone regions, which are often based on local crops adapted to water scarcity and rich in nutrients (such as legumes);
- local culinary skills, including food processing and preservation methods such as drying and fermentation, which enable products to be stored for periods of scarcity and reduce dependence on external supplies. It should be noted that crop residues stored for livestock feed are a major factor in EFA in agropastoral systems in West Africa (Vall et al., 2023).

Furthermore, by improving the incomes of small-scale producers, AE enables them to have access to sufficient and varied food (De Schutter 2010 in Maitrepierre, 2024).

According to Maitrepierre (2024), AE also contributes to improving **human health** in several ways:

- By reducing the use of pesticides, chemical fertilisers and antibiotics in livestock farming, agroecology reduces the exposure of rural populations and consumers to these substances.
- By promoting diverse, healthy and sustainable diets. "It encourages the consumption of 'healthy foods' such as fruit, vegetables and legumes, and discourages the consumption of animal products and ultra-processed foods, the excessive consumption of which increases the prevalence of non-communicable diseases such as diabetes and cardiovascular disease" (Duru 2023 in Maitrepierre, 2024).

2.3. Social change

"Beyond agronomic approaches, FA is also a social movement [...] that supports farmers and rural populations, local knowledge, social justice, and food sovereignty" (MaitrePierre 2024):

- FA is rooted in the culture, identity, tradition and knowledge of local communities (FAO elements 7 and 8).

- It provides farmers and communities with healthy, diverse food that is adapted to the seasons and crops (FAO elements 7 and 8).
- It promotes horizontal relationships (between farmers) for sharing knowledge and skills (element 2 of the FAO).
- It brings producers and consumers closer together in shorter, more local value chains and promotes trust and solidarity in the producer-consumer relationship (FAO element 10).
- It recognises and supports the role of women in agriculture and encourages their involvement (FAO elements 7 and 8).

Regarding the political dimension (Maitre-Pierre 2024):

- CSR encourages greater participation by small producers and consumers in policy decisions concerning food systems and proposes new decentralised governance structures (FAO element 7).
- It aims to secure small producers' access to productive resources (land, water, seeds, FAO element 9).

In addition, AE approaches promote social sustainability by strengthening local economies and promoting a more equitable distribution of resources and benefits.

2.3.1. Integration of traditional local and scientific knowledge

The integration of traditional local knowledge and scientific knowledge promotes innovation in AE and can help create agricultural systems that are less sensitive to droughts. Agricultural and natural resource management practices have adapted over time to local climatic, soil and geographical conditions (Utobo and Esakkimuthu, 2017; Jabulile et al., 2024). For example, AE values the extensive knowledge of livestock farmers in using spontaneous fodder resources scattered across heterogeneous and constrained environments (Toutain et al., 2012). Scientific knowledge can improve these practices through innovations for greater efficiency. One example is the biological restoration approach to degraded land used in Niger, whereby women participate in the restoration of degraded land through a combination of new and indigenous techniques (Zemadim Birhanu et al., 2020; Tabo et al., 2011).

This integration of traditional and scientific knowledge also involves the circulation of knowledge, with an emphasis on local knowledge but also on co-innovation and participatory approaches between different stakeholders (Tittonell, 2023). Knowledge-sharing networks between stakeholders facilitate the rapid dissemination of innovative drought-adapted techniques and scientific information on appropriate management practices and available resources, taking into account local needs, which strengthens farmers' capacity to respond quickly and even adapt their practices in real time. For example, impact analyses of decentralised participatory breeding programmes conducted by CIRAD have shown (1) widespread adoption and dissemination of varieties superior to traditional cultivars due to their adaptation to prevailing soil and climate constraints, intensification objectives and local food preferences (e.g. sorghum in Burkina Faso, Vom Brocke et al., 2014, 2020, and rainfed rice in Madagascar, Breumier et al., 2018); and (2) the organisation of a new framework enabling farmers, extension agencies and scientists to work together to disseminate future new varieties while developing better cropping systems.

2.3.2. Strengthened social networks

Social change induced by EA requires the transformation of social relations and the consolidation of social networks (Piraux et al., 2010). According to Delay and Piou (2019), uncertainty linked to resource scarcity creates conditions where competitive individual strategies are less viable than mutual aid strategies. Individuals or groups that adopt cooperative behaviours are better able to manage access to limited resources. This cooperation can take the form of resource sharing, coordination for the management of common goods, or mutual assistance in the search for food or shelter. As a result, cooperation becomes an advantageous strategy, as it allows for a more stable and sustainable use of environmental resources (Delay, forthcoming).

Networks, particularly those based on solidarity between farmers or members of a community, facilitate:

- **Pooling resources** (infrastructure, inputs, tools, etc.), knowledge, practices, etc., thereby strengthening collective resilience to hazards. For example, communities can develop collective water storage systems, agricultural cooperatives, local food banks, etc. Initiatives such as the creation of water banks and informal water collection groups facilitate temporary water trading between farmers. This mechanism allows those who need water to access it from those who have too much, thereby optimising water use and supporting agricultural productivity during periods of drought (Holman et al., 2021). Seed sharing networks and community seed banks give farmers quick and direct access to suitable varieties. In some regions, community "livestock banks" provide livestock farmers with access to quality breeding stock or animal loan schemes, which provide a safety net. This community solidarity facilitates herd rebuilding (e.g. Ethiopia, Gemechu et al., 2021).

- **Support and mutual aid, particularly for the most vulnerable households**, through solidarity-based economic systems, both formal (e.g. insurance) and informal (e.g. tontines, remittances from migrants), social protection mechanisms or safety nets. For example, farmers can receive low-interest loans, deferred repayment periods or investment grants/subsidies to restart their farming activities after a drought. This is the case in Kenya, where the World Bank-funded Kenya Livestock Insurance Programme (KLIP) combines agricultural loans and livestock insurance. Loans are paid to farmers to rebuild their herds after a drought (Plevin and Lindsey, 2023).
- Ultimately, community **social cohesion** is strengthened, enabling collective mobilisation for joint actions such as digging wells, constructing erosion control measures or installing irrigation systems. strong social cohesion also helps to prevent conflicts by establishing consultation mechanisms and resource-sharing policies and promoting peaceful and equitable solutions to resource sharing.

2.4.4. Decentralised governance

FAO promotes forms of social organisation adapted to decentralised governance and local management of food and agricultural systems. It also encourages self-organisation and collective management of groups and networks at different levels, from local to global (farmers' organisations, consumer organisations, etc.). Communities with strong local structures are better able to

These local institutions (farmers' associations, village councils, drought committees, etc.), based on "human and social" values (transparency, justice, citizen participation, etc.), play a key role in:

- The distribution of resources and coordination of responses to droughts;
- The participation of all stakeholders, including farmers, in decision-making to enable flexible and adaptive drought management (Hauser, 2024).
- Mediation of conflicts over access to water or land that may arise in the event of prolonged droughts;

"Successful community adaptation strategies to the effects of climate change cannot be developed in isolation. Community involvement in identifying and implementing new solutions is therefore essential to ensure the sustainability of interventions (IUCN, 2010). The various parties (farmers, herders and others) must be involved in the process of developing and applying tools so that their concerns are truly taken into account (Faye, 2016). According to Hilhorst (2008), the productivity of natural resources in West Africa in general, and in the Sahel in particular, varies between regions, seasons and years in response to changes in rainfall. This requires adaptive management systems, as resources are used by several groups that may have competing interests. Thus, the involvement of communities in defining and implementing strategies is essential for the sustainability of resource use practices, livelihoods and local peace. (Djohy et al 2022).

3. Barriers to the AET of agricultural systems

The transition to sustainable agriculture "faces many obstacles, including technical, economic, psychological, cognitive and socio-cultural barriers. There are also multiple barriers at all levels of food systems." (Maitrepierre, 2024). All these barriers are closely interconnected. In the following, we focus on **the farm level**.

3.1. Typology of barriers to AE

Barriers to the adoption of AE practices by farmers can be classified into several categories[4] (table below).

[4] We are using the typology presented in the thesis by H. Maitrepierre (2024).

Main categories of barriers to the adoption of agricultural practices by farmers
Adapted from Schwarz et al. (2021), Mills et al. (2020), Wreford et al. (2017), in Maitrepierre, 2024.

Type of barriers	Description
Technical or biophysical	Barriers related to the technical aspects of agroecological practices, e.g. specific infrastructure or equipment required for their implementation, or biophysical constraints limiting their adoption, e.g. climatic and soil conditions.
Economic	Barriers related to the capital needed to invest in new practices or adapt existing practices; obstacles related to creating added value for products resulting from agroecological practices.
Socio-cultural and cognitive	Barriers related to (i) farmers' attitudes towards agroecological approaches, cultural norms and traditions that oppose change, (ii) beliefs and perceptions about agroecology and its benefits, costs and risks, (iii) lack of cooperation and coordination between stakeholders.
Knowledge system barriers	Barriers related to gaps in the knowledge system (research, education, training, advisory services) limiting the availability or accessibility of the knowledge and skills required to implement agroecological approaches.
Policy and regulatory	Barriers related to regulatory or administrative constraints, lack of policy support for agroecological practices, or lack of coordination between different policy areas.

These factors can be grouped into three spheres: the personal sphere (farmers' values, beliefs and visions, corresponding to cognitive factors), the political sphere and the practical sphere, which includes technical, economic and social aspects. The interaction between these three spheres creates areas of 'friction' and 'traction'. Areas of 'friction' distance farmers from transforming their practices, while areas of 'traction' bring them closer. This approach illustrates the complexity of the barriers and drivers of EAT. **The same factor can be considered both a barrier and a driver depending on the context or the actor interviewed.** For example, subsidies can help farmers overcome the initial costs of adopting sustainable practices, but they can also encourage unsustainable practices. (Maitrepierre, 2024).

3.2. Technical and biophysical barriers

The adoption of AE practices may be limited by:

- **The biophysical environment, including** climate **(temperatures, precipitation) and** soil characteristics (texture, structure, pH). For example, cover crops or agroforestry may require stable moisture conditions and may be poorly suited to regions with irregular rainfall or prolonged periods of drought (FAO 2020c).
- **Access to land**: Land tenure security is important for encouraging the long-term investments that can result from the adoption of AE practices. "When farmers do not have long-term prospects for their land, they are reluctant to implement measures whose ecological and economic benefits may take several years to materialise and which require investments of time, labour or capital, such as planting trees or managing soil carbon" (Wreford et al. 2017; Mills et al. 2020 in Maitrepierre 2024).
- **Access to seeds**, particularly traditional varieties, is increasingly threatened by the spread of modern varieties, mainly hybrids, and by the expansion of intellectual property rights regimes in agriculture, which tend to create a seed market dominated by a few large companies (Parmentier 2014 in Maitrepierre 2024).
- **The lack of storage, collection or processing infrastructure adapted to products from AE systems:** the diversified systems that form the basis of AE systems can pose logistical constraints related to the collection, storage or processing of varied products.

AE practices may be associated with:

- **Logistical and organisational complexity**, which can lead to more complex work organisation. For example, "polyfarming farmers must store several types of feed, adapted to the nutritional needs of each species, in smaller storage units. In addition, collection, processing and distribution processes must be adjusted to accommodate lower volume and more varied production, which can lead to additional logistical costs" (Maitrepierre 2024);
- **More knowledge and skills**, while training, extension or advisory services may be poorly developed;
- **More work and therefore more labour:** for example, "integrated crop management requires monitoring of pest populations and more interventions to maintain ecological balance and crop health, using methods such as the introduction of natural predators, whereas pesticide application is simpler and less time-consuming" (Maitrepierre 2024). Farmers and livestock breeders may therefore prefer more familiar and less complex practices (Davidova et al. 2022 in Maitrepierre 2024).

3.3. Economic and financial barriers

The adoption of AE practices may be limited by (Maitrepierre 2024):

- **The cost of adopting new practices or adapting existing practices**: AE practices may be associated with high adoption costs at the farm level (e.g. due to the purchase of specific equipment), which may deter farmers, particularly those with limited financial resources, in a context of limited access to credit and a lack of economic incentives for adopting such practices.
- **Uncertainty about the profitability of AE approaches**: "The low economic viability of agroecological approaches, whether real or perceived, is a major barrier to their adoption by a large number of farmers [...] The idea that agroecological systems generate lower yields [and therefore profits] than conventional systems is still widespread and hinders their dissemination, particularly in Europe."
- **Lack of market access**: if local markets (on which AE systems rely for the processing and marketing of their production) are not sufficiently developed or accessible, this can hinder the adoption of AE practices by farmers.

3.4. Personal and socio-cultural barriers

"Many factors influence farmers' decisions regarding the choice of production methods or the marketing of their products. These include socio-demographic characteristics, [...], the biophysical, economic, social, institutional and political context in which they operate, but also the personal characteristics of farmers: their values, goals, beliefs and attitudes towards change. " (Maitrepierre 2024). Among the "personal" and socio-cultural barriers for farmers that can affect AE include (Maitrepierre 2024):

- **Farmers' attitudes towards AE approaches and change in general:** they must be convinced that implementing them will have positive consequences for their farms, both from an agronomic and financial point of view. The benefits must be visible in the short term.
- **Fear of change or resistance to change**: the lack of economic guarantees and financial stability discourages many farmers from adopting such practices.
- **The complexity of AE approaches and their high demands in terms of time, knowledge and skills** reinforce farmers' reluctance, who then prefer familiar, less complex practices with known effectiveness.

Resistance to change can also be exacerbated **by social norms and traditions**. "Traditions and values deeply rooted in a culture can stand in the way of introducing new ideas or practices. Farmers, especially older ones, may be strongly attached to certain traditional practices, such as ploughing, or to specific production systems. Furthermore, traditional practices contribute to farmers' cultural identity, both individually and collectively. [...] In some cases, farmers' emotional or cultural attachment to their land or their activity may encourage them to take measures to preserve their land and farms for future generations, thereby becoming a driving force for the transition to more sustainable practices. In other cases, change may be perceived as a threat to their identity. These norms can discourage collaboration between stakeholders, even though collaboration is essential for the dissemination of AE practices. Farmers' lack of knowledge about AE practices and their benefits is also a barrier to AET.

3.5. Political and regulatory barriers

AET faces significant political and regulatory barriers that hinder its adoption. Examples include (Maitrepierre, 2024):

- According to a report co-authored by three UN agencies (FAO, UNDP & UNEP 2021 in Maitrepierre, 2024), "agricultural support policies around the world, although not accessible to all producers, have encouraged agricultural practices that are harmful to nature and health and largely focused on certain products, preventing the development of healthy, sustainable, equitable and efficient food systems".
- Trade policies, together with agricultural policy subsidy programmes, contribute to promoting intensive and highly industrialised agricultural systems (HLPE 2019; Niggli et al. 2021 in Maitrepierre, 2024).
- Existing agricultural policies do not promote land tenure security or equitable access to natural resources.
- The fragmentation of policies between sectors (agriculture, environment, trade) leads to ineffective support for LAS (e.g. the EU's CAP).

- Regulations may conflict with AET. For example, French regulations prohibit direct interaction or contact between poultry and other animal species on farms (to avoid the risk of cross-contamination), which hinders the development of more diversified farming systems in France.

Difficulties in adopting agroecology on a large scale

Example in West and Central Africa

AE practices are difficult to adopt on a large scale for four reasons:

1. **High labour requirements.** For example, direct seeding under plant cover (SCV) can require more labour than conventional cultivation (with ploughing and mechanical weeding) when the cover mulch is not dense enough to prevent weeds from sprouting.
2. **Incompatibility with certain recent developments**: for example, well-mastered and still popular tractor-based cultivation reduces the drudgery of work, especially for crop maintenance (mechanical weeding and ridging). The intercropping recommended in AE is difficult to reconcile with the mechanisation of weeding and ridging. Farmers are reluctant to return to manual maintenance work, which is time-consuming and tedious.
3. **Delayed return on investment:** some innovations to improve soil fertility take several years to pay for themselves, which poses a difficult economic challenge for farms with limited savings, no access to medium-term credit and no subsidies for land improvement. In addition to this more or less lengthy "return on investment" period, there is also the risk taken by farmers who adopt the innovation.
4. **The difficulties of breaking away from "traditional" systems:** there is a phenomenon of dependence on traditional production systems and on input supply and advisory services. This phenomenon of "lock-in" to a production system that is efficient enough to ensure (in the short term) an acceptable income for farmers is very common in agriculture in both the South and the North.

Source: Dugué, 2013

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