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Agricultural resilience and agricultural sustainability – which is which?

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Abstract: Agricultural sustainability and agricultural resilience are two related concepts focus on maintaining the productivity and functionality of agricultural systems. Agricultural sustainability, a part of sustainable development, focuses on the long-term viability of agricultural practices, with conservation and efficient use of natural resources, the promotion of biodiversity and the enhancement of ecosystem services delivery to ensure the continued productivity of agricultural systems as central point of the concept. Agricultural sustainability seeks to balance the environmental goals with economic and social aspects of agricultural operations. Agricultural resilience is a narrower concept, focusing mostly on the ability of agricultural systems to withstand and recover from specific external disturbances (negative effects of climate change, market fluctuations). The interconnections between two concepts are currently underexplored. Agricultural resilience must be seen through the lens of a specific context or challenge to which it responds. Both concepts are essential for developing agricultural systems that can thrive in the face of evolving challenges and contribute to food security, environmental protection and economic stability. Agricultural sustainability provides a foundation for resilience, while improved agricultural resilience can contribute to long-term sustainability of agricultural systems. At the same time not all sustainable agricultural systems are resilient to specific shocks and stresses, and vice-versa. The aim of the study was to identify similarities and differences between the concepts of agricultural sustainability and resilience, with particular reference to their interaction.

Keywords: resilience, sustainability, adaptability, robustness, transformability, sustainable agriculture

INTRODUCTION

The sustainable development of modern agriculture is seen as key to the long-term well-being of society and the environment. It's a well-established concept that involves optimising agricultural practices to increase productivity while minimising negative impacts on natural resources and the ecosystem. The main practices that are in line with sustainability principles focus on biodiversity and genetic resources conservation, reducing greenhouse gas emissions, sequestering carbon, maintaining animal welfare and preserving soil and water quality (Osaki, 2013; Rockström et al., 2016; Liang et al, 2021; Demirkol, 2022).

Agricultural resilience refers to the ability of agricultural systems to withstand and recover from shocks and disturbances, such as climate change and natural disasters, while maintaining productivity (Boahen et al., 2023). It's a complex and interdisciplinary concept that is still being explored in research. Studies on agricultural resilience should focus on different contexts addressing specific agricultural challenges (international food price volatility, regional agrobiodiversity, adverse effects of climate change, soil organic matter loss, farm management, local market fluctuations). The principles of self-reliance, economic efficiency, consistency, transferability and diversification are often highlighted as important factors for farm resilience (Perrin et al, 2020; Morkunas et al., 2022; Yang et al., 2022).

Agricultural sustainability and agricultural resilience are related concepts which are often considered mutually supportive. Agricultural resilience is recently seen as essential strategy to cope with recent agricultural challenges, shocks and stresses. It is often described as concept design to mitigate negative effects of climate change and market fluctuations (Boahen et al., 2023). Risk management, general vulnerability of agricultural system and its resilience can have a significant impact on the sustainable development of rural economies – which makes both concepts interrelated. Sustainable development of modern agriculture requires a comprehensive understanding and implementation of resilience strategies to address various challenges to ensure long-term viability of agricultural systems (Anderies et al., 2013; Uhl et al., 2023). However, the interconnections of the two concepts are often underexplored. Research indicates that while resilience can enhance sustainability, the specific mechanisms through which they interact remain poorly understood (Morkūnas et al., 2022; Popescu, 2023). Also studies often lack the information on interaction of both concepts at farm level. The aim of this review is to briefly identify the relevance of the concepts of agricultural sustainability and agricultural resilience in modern agriculture, what they have in common and what is unique about them. Furthermore, the article briefly describes the interactions of both concepts at farm level and highlights if those are always mutually supportive.

AGRICULTURAL SUSTAINABILITY

Agricultural sustainability refers to the ability of agricultural systems to maintain or improve productivity and profitability while minimizing negative impacts on the environment, society, and future generations. It involves the responsible and efficient use of natural resources, such as soil, water, and biodiversity, to meet the current needs of the population without compromising the ability of future generations to meet their own needs. Agricultural sustainability encompasses multiple dimensions, recognizing the interconnectedness of economic, resource, environmental, and social aspects (Alshaal, El-Ramady, 2017; Janker et al., 2019; Adegbeye et al., 2020; Streimikis, Baležentis, 2020).

Economic viability

Economic viability involves the ability of farms to generate sufficient income to cover all costs and ensure long-term profitability. Various indicators can be used to assess economic viability. Sustainable agriculture should secure both farm profitability and rural livelihoods. This involves optimizing production costs, accessing fair markets, and receiving equitable returns for their products as well as supporting rural livelihoods by creating employment opportunities, maintaining vibrant rural communities, and contributing to the overall economic well-being of rural areas (Barnett et al., 1995; Baumgärtner, Quaas, 2009; Slavickiene, Savickiene, 2014; Bertoni et al., 2018; Špička et al., 2019; Loughrey et al., 2022). The economic viability is particularly important at farm level, especially in family farms which are the dominant form of agricultural farms in Europe (Veveris et al., 2019; Poczta-Wajda, 2020). Economic viability of farms not only enhances farmers' quality of life and self-reliance but also sustains the profitability of the farm, contributing to improved wider social and economic sustainability (Kriesemer et al., 2016). The economic viability of farms is directly impacted by policy decisions, such as the redesigning of the Common Agricultural Policy, which aims to stabilize farm income and make agribusiness more viable and sustainable (Špička et al., 2019; Špička, Derenik, 2021).

Environmental conservation and protection

The balance between environment and agricultural production is a central point of agricultural sustainability. Modern, conventional farming, with its intensive agricultural practices is well-known for its negative environmental impacts. To mitigate these negative effects, sustainable agricultural practices such precision agriculture, improved water management strategies, reduced tillage, cover crops, organic farming, agroforestry and many other agroecological approaches are recommended (Barnett et al., 1995; Lampkin et al., 2015; Adegbeye et al., 2020; Babu et al., 2022; Khan, Rehman, 2022; Sawicka et al., 2022). Sustainable agriculture seeks to maintain and improve soil health through crop rotation, cover cropping, reduced tillage and responsible water use to enhance soil structure and fertility (Tully, McAskill, 2020; Kannan, Anandhi, 2020; Tahat et al., 2020; Troy et al., 2023). Biodiversity, a key aspect of sustainability, promotes the delivery of specific ecosystem services, such as pollination and pest control, which are important for sustainable agriculture and food security (Berbeć et al., 2018; Mamabolo et al., 2020; Renard, Tilman, 2021). The challenges related to climate change are also a part of environmental conservation addressed by sustainable agriculture. The adoption of conservation agriculture practices that involve minimum soil disturbance, maintenance of soil cover by crops or cover crop and increased crop diversity are important diversification strategies to increase soil organic matter content, and thus carbon sequestration in soil (Beddington et al., 2012; Pisante et al., 2015; Venkatramanan, Shah, 2019; Xie, Zhao, 2019).

Social aspects

Social aspects of agricultural sustainability include farmers social wellbeing, fair wages, collaboration between farmers, policy support, and innovation implemen-

tation capability. Understanding the complexity of social interaction in agriculture and identifying the interests and moral arguments of different stakeholders in agriculture is a key to address social justice issues within the agricultural sector (Janker et al., 2019; Janker, 2020). To do so, sustainable farming practices should involve and be beneficial for local communities. This can be supported by shorter value chains, direct marketing or community-supported agriculture (Flora, Bregendahl, 2012; Kane-Potaka et al., 2018; Jablonski et al., 2019; Samoggia et al., 2019). Sustainable agriculture should also recognize the cultural dimensions of farming practices, respecting traditional agricultural practices, local knowledge and adaptation and cultural values and ethics. Those cultural values often include environmentally friendly practices that contribute also to environmental aspect of sustainability (Daugstad et al., 2006; Edpluga-Trenc et al., 2021; Ferrario, 2021). Animal welfare and social acceptance of livestock production is also related to cultural values of society. This include not only farmers, but also consumers who have concerns about the welfare of animals (McGlone, 2001; Broom, 2010; Brennan et al., 2021; Broom, 2022). In terms of long-term sustainability, farmers' experience, knowledge, skills, qualification and willingness to adopt new techniques is crucial to both understanding the current challenges and be able to address them (Pretty, 2008).

Energy and technology

Sustainable agriculture promotes efficient use of energy, reducing reliance on fossil fuels and adopting renewable energy sources where possible. This allows farm to be less depended on off-farm energy. Farm sustainability can also be improved by the integration of elements of circular economy. Waste and organic matter recycling methods such as composting and vermicomposting can improve resource use efficiency and nutrient recycling (Bundschuh, Chen, 2014; Ghisellini et al., 2015; Tian et al., 2018; Ray, Adhya, 2020).

Sustainability is also about innovation and technology. The most recent innovations introduced to agriculture to improve its sustainability are e.g. nanomaterials used for fertilizers, pesticides and nano-sensors (Behl et al., 2022; Dutta et al., 2022) or plant factories with artificial lighting implemented in urban buildings (Mandriota et al., 2022). The concept of digitalization (Internet of things, cloud computing, big data, artificial intelligence and decision support systems) is also being introduced in the agro-industrial complex as Agriculture 4.0 (Dayioğlu, Turker, 2021). Those new technologies can address production, environmental, and socio-political challenges of sustainable agriculture. The implementation of autonomous machines in agriculture can improve working conditions (workload), increase productivity, and reduce dependency on labour force (Sparrow, Howard, 2021; Khadatkar et al., 2022; Monslave et al., 2022; Pearson et al., 2022; Srivastava, Raturi, 2022).

EU strategies and sustainability assessment

Agricultural sustainability has been of the significant importance for European Union for years, and it is now embedded in a central place in various policies, initiatives, and programs. One of the most important partnerships between agriculture and society trying to balance agricultural productivity with environmental conservation, rural development, and social wellbeing is Common Agricultural Policy (CAP). The latest reform of the CAP, known as the CAP 2023-27, emphasizes the "green architecture," which includes environmental and climate objectives. The plans included in the CAP 2023-27 are designed to support key European initiatives: European Green Deal, Farm to Fork Strategy, and Biodiversity Strategy (EC, 2019). The European Green Deal is an ambitious, yet controversial plan, and if its goals are achieved, it will greatly contribute to European agriculture's sustainability. However, it is likely that at least some of the plans (e.g., planned 'at least 25% of the EU's agricultural land under organic farming by 2030') may be difficult to achieve under current conditions, both at the level of individual countries and the EU level as a whole (Beckman et al., 2020; Gradziuk et al., 2021; Lampridi, Kateris, 2021; Uzunov, Marinov, 2021; Giannou, 2022).

The institutional support for sustainability over the years, requires an assessment of its implementation effectiveness. Over the years, many different tools and methods have been introduced to assess the agricultural sustainability at different levels, with indicator sets being the most commonly used (Chopin et al., 2021). These tools, implementing a large set of indicators of each sustainability category, can be classified into different groups also based on stakeholder participation and the model used for calculating sustainability. There is still a need to choose tools which are widely accepted by broad range of stakeholders (Lampridi, Kateris, 2021). Moreover, many of these tools focus on drivers, pressures or states of the agricultural systems, rather than on the impacts of the agricultural system on the sustainability (Zhang et al., 2021). There is a need for more complex sustainability framings that consider emerging system properties such as resilience, viability, and stability, and emphasize governance and institutional dimensions (Nadaraja et al., 2021). This can be addressed by the second concept discussed in this paper – agricultural resilience**.**

AGRICULTURAL RESILIENCE

The concept of system's resilience is, in general, a capacity of the system to maintain its functions despite occurring disturbances (stresses and/or shocks). The concept

is evolving since 1970s, mostly from ecological sciences. However, it is also widely used in mechanics, indicating materials' ability to return to its previous state after deformation due to the external force. In 1973, the concept was used by Holling in ecology to describe ecosystems ability to remain stability (Holling, 1973). The force that can make system unstable can be of different nature: those could be both external factors such as climate change negative effects, earthquakes, political instability, wars, global epidemics or internal such as management errors or technology failures (Spiegel, 2021). The concept evolved and since then it is used in a number of different scientific fields (from construction and mechanics through transportation and medical sciences to social sciences (Sood et al., 2011; Medir et al., 2017; Esraz-Ul-Zannat et al., 2020; Jasiūnas et al., 2021; Anelli et al., 2022; Boahen, 2023; Tasmen et al., 2023).

Originally, Holling (1973), described ecological resilience as "the persistence of relationships within a system and measure of the ability of these systems to absorb changes of state variables, driving variables and parameters and still persist". In 2004, Walker et al. (2004) used more detailed description of ecological resilience as "capacity of a system to absorb disturbance and re-organise while undergoing change so as to retain essentially the same function, structure, identity and feedbacks". Since agricultural system can be considered as functional agro-ecosystem, agricultural resilience is seen as similar as ecological resilience. Nowadays, nevertheless there is no precise definition of agricultural resilience, it is mostly seen as the ability of agricultural system to anticipate, absorb, accommodate or recover from a disturbance in a timely and efficient manner (Folke et al., 2010; Darnhofer et al., 2016; de Sá Souza et al., 2019; Darnhofer, 2021). According to Venkatramanan and Shah (2019), the concept of resilience is encompassing issues such as disaster risk reduction, adaptation, and food and nutritional security.

Adaptive capacities of resilience

In the context of agricultural resilience, robustness, adaptability, and transformability are the three key capacities that describe different aspects of a system's ability to respond to shocks, disturbances and changes (Folke et al., 2010; Meuwissen et al., 2019). Those capacities are linked with different features of agricultural system which, in turn, can boost (or undermine) one or more of resilience adaptive capacities. In other words, robustness, adaptability and transformability are essential for farming systems to effectively respond to various challenges and changes in their environment. Resilient agro-ecosystems can withstand shocks and stresses through robustness, adjust and learn to new conditions (through adaptability) and significantly redesign its systems (through transformability). These three capacities of resilience are interconnected and often mutually supportive (Meuwissen et al., 2019; Buitenhuis et al., 2020a; Yan et al., 2022; Nicholas-Davies et al., 2021; Daniele et al., 2022). Robustness, adaptability, and transformability are beginning to be widely recognized by scientists as 3 basic manifestations of resilience. This is reflected in the increasing number of scientific papers published recently on various areas of agriculture (Anderies et al., 2013; Meuwissen et al., 2019; Buitenhuis et al., 2020a; Buitenhuis et al., 2020b; Manevska-Tasevska et al., 2021; Nicholas-Davies et al., 2021; Daniele et al., 2022; Yan et al., 2022) and also other field of sciences (Restemeyer et al., 2015; Karrasch et al., 2021).

According to Boahen et al. (2023), currently the topic of agricultural resilience is gaining more are more interest worldwide, as the number of natural and human-induced disasters worldwide is increasing, and scientist are trying to address those issues. European studies on agricultural resilience focuses mostly on all three adaptive capacities of resilience to respond to economic, environmental, social, and biological shocks while studies from Asia and Africa focuses on adaptive capacity as methods to address agricultural resilience issues related to environmental shocks. Understanding and assessing these three dimensions of resilience can help guide the development of strategies and policies to enhance agricultural systems' capacity to respond to uncertainties, shocks, and long-term challenges. It recognizes the importance of both short-term stability and long-term transformation in building resilient and sustainable agricultural systems (Meuwissen et al., 2019; Buitenhuis et al., 2020a; Nicholas-Davies et al., 2021; Daniele et al., 2022; Yan et al., 2022). The main differences in robustness, adaptability and transformability have been described in Table 1.

Robustness. Robustness is the "strength" of the ecosystem. It is its ability to withstand and absorb shocks and disturbances while maintaining functionality and productivity. A robust system has built-in mechanisms and capacities to resist or recover quickly from disruptions without experiencing significant declines in performance (e.g. loss of yield quality and/or quantity). It focuses on maintaining stability and continuity in the face of short-term shocks and/or stresses. This capacity can also be described as persistence (Folke et al., 2010; Meuwissen et al., 2019; Czekaj et al., 2020).

Adaptability. Adaptability makes agricultural system able to recognize, adjust, learn, and modify its structures, strategies and practices in response to changing conditions (climate change negative effects, market fluctuations, pest and disease outbreaks). An adaptable system can actively adjust its management practices, utilize new technologies, and adopt innovative approaches to maintain productivity and thus enhance resilience. Adaptability makes agricultural system able to adjust while maintaining its development along current strategy (Walker et al., 2004; Folke et al., 2010; Meuwissen et al., 2019).

Table 1. Differences between three adaptive capacities of agricultural resilience.

Feature	Robustness	Adaptability	Transformability
Time perspective	Mostly short (immediate response)	Average	Mostly long-term
Nature of response	Immediate response to maintain system stability	Feedback-driven short-term evolution – through learning and adjustment	System reconfiguration to align with new conditions
Change intensity	Minimal or no changes. System stays productive without significant alteration	Incremental changes. Existing practices are adapted to new conditions.	Complete reconfiguration of practices, structures, and/or principles of the agricultural system.
Main Farm's resources to support capacity	Input Resources and production intensity	Knowledge and experience	Economic viability and willingness to change
Examples			
Example practices	Already-implemented practices (no need to change)	Change of practices within same management strategy, e.g.: change of sowing date; switching to drought resistant varieties	Transition to new practices and new management strategy; change of crop types; introduction of whole new agricultural system
Farm Example	A farm with complex crop rotation, including use of multiple crop varieties can be considered robust as it can endure adverse weather conditions or pest outbreaks without significant productivity loss	A farm able to learn from past experiences and adjusts planting schedules or crop varieties in response to changing climate patterns exemplifies adaptability	A (conventional) farm that, based on knowledge and/or experience, can convert to agroecological/organic/agroforestry system in response to severe climate impacts

Sources: Walker et al., 2004; Folke et al., 2010; Sposito et al., 2013; Meuwissen et al., 2019; Slijper et al., 2020; Manevska-Tasevska et al., 2021

Transformability. Transformability is capacity of agricultural system to redesign its strategy and/or structure in response to long-term or persistent challenges (in environmental, production, political or socio-economic context). Transformability allows for fundamental change in the system's structure, practices, goals and/or management strategy. Transformability aims to create a more sustainable and resilient agricultural system in the long run (Walker et al., 2004; Folke et al., 2010; Meuwissen et al., 2019).

Resilience in EU strategies

Strengthening the resilience of European agriculture is supported by the European Union indirectly through several initiatives. The main factors behind agricultural resilience that are targeted by the Union's activities are related mostly to climate change and its negative impact. The EU emphasizes the importance of adaptation strategies. This includes supporting farmers in implementing practices that enhance the resilience of their operations due to negative climatic change effects. Among many European strategies, regulations and directives European Green Deal (EC, 2019), 2030 Climate Target Plan (EC, 2020a), European Climate Law (CLR, 2021), Renewable Energy Directive (RED II) (Official Journal of the European Union, 2018), Energy Efficiency Directive (EC, 2012), Circular Economy Action Plan (EC, 2020b), Farm to Fork Strategy (EC, 2020c), Biodiversity Strategy for 2030 (EC, 2020d) and Adaptation Strategy: Climate Resilient EU (EC, 2021) are those which are directly, or indirectly aimed to support climate change adaptation of agriculture. Some of those strategies emphasize agroecological principles as an essential component of their objectives.

Agroecology is a holistic approach to agriculture that integrates ecological principles into farming practices. It aims to achieve an acceptable balance between the environment, crops, livestock and people (Ewert et al., 2023). The agro-ecological practices and principles that enhance the capacity of farming systems to withstand and recover from stressors while promoting long-term environmental and social well-being are core of both system sustainability, but also can make the system resilient (Altieri et al., 2015). Diversified, agroecological management practices promote agrobiodiversity – a source of ecosystem services – reducing negative impact on the environmental and reducing the need for off-farm inputs (Kremen, Miles, 2012; Nicholls et al., 2016; Baiardi, Pedroso, 2020). The application of agroecological systems is increasingly relevant for overcoming extreme climate events and building system resilience to climate change (Peano et al., 2020).

SIMILARITIES AND DIFFERENCES

Both concepts of sustainability and resilience share some similarities but also have distinct differences. Agricultural sustainability, directly linked with sustainable development strategy, primarily focus on the long-term viability of agricultural systems. The environmental impact of agricultural practices, economic viability of farms and social equity of farmers are the three goals sustainability is aiming at (Williams et al., 2018). The utilization of practices and technologies that minimize damage to the environment while providing income to the farmer over a long time is often seen as main area of focus of agricultural management practices supporting sustainability (Tatlidil et al., 2008). Agricultural resilience also aims at maintaining system productivity (and economic viability) of agricultural system over time, however – the focus of resilience is on system stability and how it can withstand and recover from various external and internal disturbances, such as climate change, market fluctuations, pandemics, spread of pests and diseases and many others, while maintaining essential functions, structures and feedbacks. In this context sustainable agriculture practices contribute to the overall resilience of agricultural systems by promoting resource efficiency and minimizing environmental damage (Maltou, Bahta, 2019; Michler et al., 2019; Constantin et al., 2022; Gugissa et al., 2022; Yang et al., 2023).

At the same time, the primary focus of agricultural resilience (in particular the robustness) which is maintaining system stability may largely overlook environmental or social aspect of agroecosystem- focusing on maintaining the presumed productivity of the agroecosystem. The other important difference between agricultural resilience and sustainability is the way they achieve their goals – resilience focuses on a response to shock, while sustainability focuses on preventive measures (Kremen, Miles, 2012; Popescu et al., 2023).

The interconnections and differences of the agricultural sustainability and resilience in terms of farms economy have been described by Volkov et al. (2022). Authors have found that economic resilience indicators and sustainability-related indicators cannot be used interchangeably, and economic resilience should be considered as an additional factor of economic sustainability when developing composite indicators.

INTERACTIONS BETWEEN AGRICULTURAL RESILIENCE AND AGRICULTURAL SUSTAINABILITY

On the surface, it looks like agricultural sustainability and agricultural resilience share a common goal – but in detail, their goals are only convergent in its direction (maintain productivity) but in its essence are complementary to each other. Both concepts of agricultural sustainability and agricultural resilience are complementing each other in various ways. Sustainable practices, such as diversification, integrated and biological pest control, biodiversity conservation or adoption of more environmentally-friendly farming system (organic farming system, agroforestry) can be a measure of both system sustainability and system resilience (Kremen, Miles, 2012; Macfadyen et al., 2012; Hoang et al., 2023). Farmers who are adopting sustainable ways of farming are often of higher environmental and climatic awareness. Their understanding of environmental processes, linkages between farm operations, ecosystem services provision and crop performance helps them adopt sustainable management strategy for their farm (Jayakrishnan, 2023). Unfortunatelly, not every sustainable farming system is resilient to specific shocks.

Sustainable yet not resilient agricultural systems

Sustainable agricultural systems, focused on balancing environmental, economic and social performance can also lack resilience to some specific disturbances. For instance, an organic farm focused on production of few high-value crops may be sustainable in terms of environmental impact and resource use but could be vulnerable to shocks related to low species diversity. A reliance on a limited number of organic crops and/or building system's stability only on a basis of basic agricultural practices (e.g. farm does not use certified biological plant protection products) can make a system susceptible to pests or diseases that target those specific plants especially under strong climate-related shocks (Vroegindewey, Hodbod, 2018; Acevedo et al., 2020; Volkov et al., 2021). Low input systems, based on traditional agricultural practices, may be sustainable due to their low environmental impact, reliance on local resources and economic viability. However, these systems often lack the flexibility to adapt to changing climatic conditions or changing market demands which can undermine their resilience (capacity to change). Also productivity of such systems under strong pressures may be insufficient to support farmers' capacity to introduce new or improved ways of farming (Vroegindewey, Hodbod, 2018; Prusty et al., 2022; Yoshida, 2024). Sustainable farms, with well-balanced environmental, economic and social aspects of farm management can be of low resilience to some market-related shocks if they have limited access to new markets, financial resources, or technical support. Such farms can suffer from low ability to adapt to changing conditions. (Calo et al., 2021). Also water-management strategy of farms can undermine their resilience to negative effects of climate change. Sustainable practices such as rainwater harvesting combined with drip irrigation can enhance water use efficiency. However, if these systems are not able to cope with prolonged droughts, heavy rainfall or field inundations – their productivity might be at risk (Peterson et al., 2018; Joseph et al., 2021; Pool et al., 2021).

Resilient yet unsustainable agricultural systems

Agricultural systems can demonstrate resilience even when they are fundamentally unsustainable. For example, a monoculture of single crop, with strong reliance on chemical plant protection products, chemical fertilization and irrigation system may be able to withstand short-term climate-change driven shocks, such as a pest outbreak or a drought, due to its established practices and infrastructure. However, the resilience of such system is superficial and does not address the underlying unsustainability of the system. Such systems may adapt to immediate challenges but ultimately degrade the soil, reduce biodiversity, and lead to long-term environmental harm (Weiner, 2017; Zarei, 2017; Dariati et al., 2021). Similarly, farming systems built on cash crops (like tobacco or cotton) can be resilient as they generate a significant income which helps farmers in building their robustness (economic efficiency allows farmers to use large amounts of industrial inputs (plant protection products and mineral fertilizers) and intensive irrigation. Farm management strategy aimed at prioritizing economic goals (over biodiversity conservation and/or environmental health) resulting in soil and resources depletion or water overuse can't be considered as sustainable (Rockström et al., 2016). The adaptation to pressures by intensifying production through unsustainable methods is described as "undesirable resilience". Such systems are adapting to maintain their current state rather than transition to more sustainable practices (Dornelles et al., 2020). Also some low-intensive farming system can be seen as resilient systems, yet often their low productivity and low economic viability can make them unsustainable. Organic farms with high share of subsidies in overall income can be an example of such system. These farms may be environmentally friendly, but their dependence of external financing (and often low level of market productivity) can lead to economic and social instability making them un-sustainable (Mzoughi, 2011; Baležentis et al., 2019; Chaudhary, 2022).

SUMMARY

The main features that makes both agricultural sustainability and resilience similar are (Table 2):

1. Focus on agricultural system success: Both agricultural resilience and sustainability is focused at continued success of agricultural systems over time. They emphasize the role of agricultural practices and management strategies and they share common goal of maintaining system productivity.

2. Systems focus: Both approaches recognise the importance of considering agricultural systems as complex and interrelated entities with environmental, social and economic factors needed to be addressed simultaneously.

3. Capacity to adapt: Agricultural sustainability aims to build systems that can adapt and respond to challenges to preserve system productivity, economic viability while protecting the environment and ecosystem services provision and general social well-being for future generations. Resilience also highlights the importance of the system ability to adapt but also absorb shocks to recover from different perturbations. The adaptive capacity inherent in sustainability contributes to the resilience of agricultural systems, which is reflected in adaptive capacity of resilience.

4. Farm management and development as a key success strategy: Both resilience and sustainability involve the ability of agricultural systems to adapt and respond to changes, challenges and shocks, mostly through the management strategy adopted by farms. They seek to build holistic systems that include management strategies for farms, households and the surrounding environment to help build up a system that can withstand and recover from perturbations or disruptions.

The key differences between the agricultural concepts of sustainability and resilience include (Table 2.):

1. Timeframe: Agricultural resilience and sustainability both aim to achieve long-term positive effects. However, some capacities of agricultural resilience often are linked with short-term responses to shocks and stresses. Resilience often aims to improve the system's ability to bounce back and recover quickly from disturbances. Agricultural sustainability, on the other hand, takes a longer-term perspective and focuses on the sustainable viability of the system over a long run.

2. Scope: Agricultural sustainability seems to be seen as a broader concept that focus on different dimensions of agricultural systems, including environmental, economic and social sustainability. It aims to meet the needs of the present without compromising the ability of future generations to meet their own needs. In contrast, agricultural resilience focuses primarily on the ability of the system to absorb shocks, adapt to change and recover from perturbations. This makes resilience oriented on system productivity, with economic, environmental and social aspects as side goals or strategies to achieve the primary goal of maintaining productivity – a key short- and mid-term objective of farmers.

3. Context: Agricultural sustainability is a broad concept directly linked with sustainable development strategy – arguably the most significant development strategy to emerge in recent years, with implications for all current strategies, plans, and activities within the European Union. Agricultural resilience, on the other hand, have to be linked with specific perturbation or challenge (e.g. climate change negative effects).

4. Strategies and drivers: Agricultural resilience often involves strategies such as disaster preparedness and risk management to reduce vulnerability to shocks and maintain production levels. Agricultural sustainability focuses on a multi-dimensional approach to farm management, of-

Table 2. Similarities and differences of agricultural sustainability and agricultural resilience.

Agricultural sustainability	Common features	Agricultural resilience
Mostly long-term focus	Long-term productivity	Also, mid- and short-term focused
Broader concept	Systems focused	Narrower concept
Multiple goals and targets	Capacity to adapt	Specific shocks and disturbances as priority
Disaster and risk management included in broader system approach	Focused on management strategies	Often include disaster and risk management as specific key strategies
Mostly prevention of shocks and stresses	Counteracting or preventing shock and stresses	Response to effects of shocks and stresses
Focus on system long-term viability	Focus on preventing the failure of the system	Focus on system stability

ten supporting farmer decisions or management practices that will also have a multi-directional, indirect positive impact on the whole agricultural system, with disaster and risk management mostly supported indirectly (e.g. supporting biodiversity as a multi-annual objective).

5. Strategy to achieve its goals: Agricultural resilience is mostly focused on maintain system stability through direct response to the negative effects of shocks and stresses. Agricultural sustainability on the other hand aims at maintaining or improving system viability through prevention of shocks and stresses.

Linking agricultural sustainability and agricultural resilience means recognising their interrelationship and understanding how they complement each other to provide a robust and reliable framework for the vision of quality transformation in the agri-food sector.

Strengthening agricultural resilience can contribute to long-term sustainability by building resilience to shocks and disturbances, such as extreme weather events or pest outbreaks, so that agricultural systems can maintain productivity, reduce vulnerability and prevent degradation of natural resources. Resilience measures such as diversification, risk management and adaptive practices can support sustainability goals of conserving resources, reducing environmental impacts and improving livelihoods.

Agricultural sustainability provides a foundation for resilience. Practices and management strategies that promote environmental stewardship, resource efficiency and social equity enhance the overall resilience of agricultural systems. Sustainable agricultural approaches and methods, such as agroecology, organic farming and good practices such as soil conservation, can contribute to ecosystem resilience, while sustainable livelihoods and equitable access to resources strengthen social resilience.

It is crucial to understand that goals of both concepts are complementary to each other. This means that not all sustainable agricultural systems have to be resilient to shocks and stresses and not every resilient farming system is sustainable.

Sustainability, in its very assumptions of being "balanced" (sustainable), recognizes the long-term importance of each "element" of the system – its productivity, economic viability, biodiversity and environmental conservation and also social factors. Each of those factors is important and sacrificing at least one to improve the other means that the system cannot be called sustainable. Resilience seems to be more about maintaining system productivity. In some resilient agricultural system, utilization of economic, social or environmental values can be considered a side goal, or even only a way to achieve system resilience to specific disturbance. This means that sometimes a resilient farming system doesn't have to be sustainable (and vice-versa).

Assessment of the environmental, economic and social impact of an agricultural system must take into account both its sustainability and its resilience to system-specific stresses and shocks. Only in this way the development of agricultural systems with low risk of losing their functions both in the short term and over extended periods, can be achieved, thus paving the way for the development of a sustainable economy. Most of the studies on interactions between two concepts are context-specific and mechanisms through which agricultural sustainability and agricultural resilience interact remain poorly understood.

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