SUSTAINABLE INTENSIFICATION
AS A TOOL FOR THE DEVELOPMENT OF ITALIAN AGRICULTURE

NEW, UPDATED AND EXTENDED EDITION

EXECUTIVE SUMMARY

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PREFACE

The Italian scientific community focused on agricultural sciences, gathered around the AISSA Association, has been discussing sustainable intensification and its role in the future of Italian agriculture for some time. In 2019, the first edition of the volume "Sustainable Intensification, a Tool for the Development of Italian Agriculture" was published. Since then, the agricultural landscape has partially changed, with rapid advancements in digital technologies, robotics, and biotechnology. The COVID-19 pandemic and the recent conflict in Ukraine have severely tested the agricultural and food system, significantly increasing production costs. These factors have indirectly highlighted the importance of agriculture for the country.

Italian agricultural research has received substantial resources, enabling significant investments through the Agritech project (PNRR). The European Union has had to reconsider its agricultural policies to balance income aspects with reducing the environmental impact of production processes, aligning with the initial goals of the Green Deal and the Farm to Fork strategy. The complexity of current and future challenges requires knowledge-based decisions, utilizing scientific and technological advancements.

Approximately five years after the first edition, AISSA, prompted by the Accademia dei Georgofili, decided to update and expand the volume, involving new expertise in a collaborative effort. The new edition features a clearer graphic format, with text separated from in-depth analyses in numerous "boxes" and a glossary to clarify various forms of agriculture often considered particularly sustainable. The introductory chapters now include an analysis of national agricultural production structures and poultry farming, with updated data and statistics frequently presented in graphs and tables.

The volume aims to provide guidelines to a broad audience to improve the sustainability of Italian agriculture, enhancing both the competitiveness of enterprises and environmental protection. The new edition is intended for agricultural sector operators, administrators, politicians, consumers, and civil society.

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1. ITALIAN AGRICULTURE OVERVIEW

Italian agriculture spans approximately 12.5 million hectares, covering 41.8% of the national territory. This includes 7.1 million hectares of arable land for crops, 2.2 million hectares of permanent crops, and 3.1 million hectares of pastures. An additional 12.0 million hectares are forested. The diversity of climates and terrains has resulted in varied agricultural systems and landscapes.
The agricultural sector contributes about 2% to Italy's GDP, while the agri-food system as a whole accounts for 15%. Employment in agriculture is 4.9% of the national workforce, while the food industry adds 1.8%. Products with geographical indications (DOP, IGP) play a key role, with Italy leading the EU with 319 certified products. These generate €19.1 billion annually, €11.6 billion of which comes from exports, engaging about 195,000 businesses and nearly 890,000 people.
Consumer interest in food origin is growing, with 40% prioritizing product origin in 2023 over taste or brand. Italians spend a higher share of their income on food (18.4%) compared to the European average (17.1%). However, the low food prices often harm farmers' incomes and the environment. A decline in agricultural revenue, particularly in challenging regions, leads to rural abandonment.

Agricultural Production Structures

Between 2000 and 2020, the number of active farms in Italy halved from 2.4 million to 1.1 million, while the total agricultural area decreased by 14%. The average farm size grew, reaching 11 hectares in 2020, partly due to the rising use of rented land (40%). Livestock farms also decreased significantly, though the number of animals declined less, reflecting a trend toward larger, more industrialized operations.

Food Origin and Sustainability

Italy is heavily reliant on imported food, including wheat, maize, and beef. Although the country exports high-value products like wine and processed foods, sustainability is a concern. Imports also come from countries with lower environmental and labor standards, raising challenges for Italian and EU producers competing on global markets.

Climate Change and Adaptation

Climate change increasingly affects Italian agriculture through rising temperatures, extreme weather, and pests. These factors are reducing crop yields and livestock productivity. Solutions include adopting new technologies, relocating production, and using irrigation and protective structures. Consumer choices toward sustainable products are vital for promoting eco-friendly farming practices.

2. WHAT INTENSIFICATION MEANS

Agricultural intensification involves using external inputs (like irrigation, fertilizers, and technology) to achieve higher yields per unit of land or livestock. While often seen negatively by the public due to a desire for "natural" food production, intensification can also mean integrating advanced knowledge, technology, and innovation (e.g., ICT, robotics, and digital processes) to optimize agricultural practices.
Key aspects of intensification:
- High plant or animal density in a given area.
- Use of high-yield genetic varieties.
- Application of substantial energy and materials to enhance productivity and minimize limiting factors.

Future-focused intensification should combine technology and knowledge ("more knowledge per hectare") to produce efficiently and sustainably.

Sustainable Intensification

Sustainable intensification aims to balance productivity with environmental responsibility, improving resource efficiency to "produce more with less." In developed regions like Europe, emphasis is on sustainability, ensuring current agricultural practices meet present needs without compromising future generations.
Sustainability is multifaceted:
1) Environmental: Practices should reduce negative impacts on the environment while optimizing resource use.
2) Economic: Economic viability is crucial, ensuring practices are affordable and profitable.
3) Social: Sustainability should enhance community well-being, product safety, accessibility, and social cohesion.

Sustainability Indicators

Indicators help measure sustainability across environmental, social, and economic dimensions. Effective indicators are measurable, transparent, and adaptable, aiding decision-making. For instance:
- Environmental indicators assess impacts on soil, biodiversity, and emissions.
- Social indicators include product safety, community cohesion, and the presence of youth in agriculture.
- Economic indicators address income equality and the stability of agricultural livelihoods.

Studies show trade-offs between organic and conventional systems: organic farming is more environmentally friendly per land unit but often less efficient per product unit due to lower yields.

Economic Sustainability

Economic sustainability includes ensuring fair and stable farmer incomes, comparable to other sectors, to maintain the agricultural workforce and rural development. Diversified income sources are vital in a varied agricultural landscape like Italy's.
In summary, sustainable intensification combines technology, efficiency, and equitable practices to address environmental, social, and economic challenges in agriculture.

3. OVERVIEW OF SUSTAINABILITY IN ITALIAN AGRICULTURE

Greenhouse Gases (GHGs):

· Italian agriculture emits GHGs primarily during primary production (crops and livestock) and in the processing and transport of food. Methane (CH_4), nitrous oxide (N_2O), and CO_2 are the main gases involved.

· Between 2003 and 2021, agricultural emissions decreased by 20%, accounting for 13% of Italy's total emissions in 2021. Measures such as reducing livestock numbers, optimizing manure management, reducing fertilizer use, and expanding renewable energy (e.g., biogas production) contributed to this reduction.

· Forests and grasslands play a key role in offsetting CO_2 emissions. However, forest carbon sequestration peaked mid-2010s and is now declining due to biomass loss from fires and other disturbances.

· Achieving further reductions requires enhancing carbon sequestration in agricultural soils and reducing nitrogen losses.

Pesticides:

· Pesticide use has declined significantly, with a marked reduction in highly toxic fungicides and insecticides.

· Between 2014 and 2021, sales of active ingredients fell by 15.3%. Organic farming products have doubled but represent only 1.3% of total pesticide use.

· Most Italian food products comply with EU residue limits, with less than 0.5% exceeding legal thresholds.

Fertilizers:

· The use of synthetic fertilizers has decreased, with mineral fertilizers dropping from 3.5 million tons in the early 2000s to 1.8 million tons in recent years.

· Organic and recycled fertilizers, such as livestock effluents, are increasingly being used. Advances in agronomic practices and digital tools have optimized fertilizer use, improving nitrogen efficiency.

Water Usage:

· Agriculture consumes 42% of Italy's total water, with a decreasing trend due to improved practices like drip irrigation and treated wastewater use.

· Many crops have adopted efficient irrigation methods, while traditional techniques persist for large-scale crops like rice. Innovations for high-value crops have significantly reduced water wastage.

Soil Health:

· The concept of soil health emphasizes its ability to provide ecosystem services. Degradation processes like organic matter loss, compaction, pollution, and erosion threaten soil quality.

· Initiatives under EU strategies promote practices to combat soil degradation and enhance biodiversity, organic carbon content, and resilience against climate impacts.

Challenges and Opportunities:

· While Italian agriculture has made significant progress in sustainability, further advancements are necessary. Key focuses include reducing dependency on fossil fuels, enhancing resource efficiency, and adopting climate-adaptive strategies.

4. MAIN CROP PRODUCTION SYSTEMS

4.1. Tree Crops (Fruit, Vineyards, and Olives)

· These systems might promote biodiversity and carbon sequestration through practices like soil grassing and maintaining non-cultivated areas.

· Organic farming covers around 550,000 hectares (20% of cultivated land), with significant use for olives and vines.

· Challenges include high use of fungicides and insecticides, although their intensity has decreased in integrated systems. Organic systems avoid synthetic chemicals but face limits due to fewer available alternatives.

· Practices to increase sustainability include precision farming, minimizing chemical inputs, promoting carbon sequestration, and using renewable energy.

· Reducing the environmental impact of pesticides is crucial, with strategies like resistant crop varieties, natural pesticides, pheromone use, and promoting beneficial species.

· Advances in biotechnology and genetics hold promise for disease-resistant crops but face public resistance to genetic modification.

4.2. Arable Crops

· Historically, these systems have relied heavily on energy and chemical inputs, leading to low biodiversity and soil fertility depletion. This degradation has prompted a shift towards more sustainable practices, supported by increased environmental awareness among farmers and legislative measures at regional and European levels.

· Conservation Agriculture Principles include minimal soil disturbance, avoiding deep plowing to maintain natural soil profiles. It enhances organic matter accumulation on the surface.

· Maintaining continuous soil cover through crop residues, natural flora, or cover crops during fallow periods protects against erosion and improve soil health.

· Benefits of Conservation Agriculture include reduces fossil fuel consumption by eliminating plowing, decreases organic matter oxidation, and promotes balanced microbial populations for better organic matter recycling.

· Integrated Sustainable Practices involve crop rotation, mechanical input reduction, organic nutrient sources, precision fertilization and weed control, disease and pest management by adopting predictive models for infestations to enable timely and reduced treatments.

· Technological Innovations: leveraging satellite or drone monitoring and advancements in soil cultivation machinery to further enhance sustainability parameters.

4.3. Vegetable crops

· The horticultural sector is complex due to the high number of species with varying thermal and nutritional needs, production cycles, and agronomic approaches (open field, semi-forced, protected cultivation). Intensification and increased sustainability (both economic and environmental) can be achieved through various strategies.

· Low Intensification: Conventional techniques in open fields by non-specialized companies, using crops like tomatoes, radicchio, and peas in rotation with cereals. This method maintains soil fertility due to low land use intensity and crop residue input.

· Low-Impact Specialized Horticulture: Specialized companies using environ-

mentally friendly crop rotations, such as autumn/winter vegetables (e.g., radicchio in Veneto) and spring/summer brassicas, which leave significant residues in the field.

· Organic Horticulture: Small-scale systems using diverse species, wide rotations, green manure, organic fertilization, and biological control. Urban horticulture, often on small plots provided by local administrations, also falls into this category, using soilless systems like floating and Nutrient Film Technique (NFT).

· Medium Intensification: Specialized and intensive systems that use land for limited periods, such as strawberry fields, artichokes, and asparagus. Semi-forced crops like melons and pumpkins use agronomic techniques to advance production without reaching high intensification levels typical of greenhouse production.

· High Intensification: Protected cultivation in greenhouses, both soil-based and soilless. While increasing yields, this method poses environmental risks if not optimized, such as increased input use (water, nutrients, electricity, plastic, pesticides) and plastic waste disposal. However, it also offers benefits like reduced nutrient leaching and lower pesticide use due to biological control and microclimate management.

· Vertical Farming: Closed-cycle systems using advanced technology (LED lighting, climate control, multi-level cultivation) to increase production and resource efficiency. Challenges include high electricity consumption and market placement difficulties.

Sustainability Strategies:

· Increase quality production to meet demanding markets.

· Rationalize water use with modern irrigation systems.

4.4. Forage crops

· The forage crop systems in Italy have evolved over the last century to maximize efficiency in livestock farming. In northern Italy, this has led to a predominance of maize (for grain or silage) or tight rotations based on maize. In the south, dry forage systems like mixed grasslands or silage crops and protein-rich crops like fava beans and peas are more common. These systems have resulted in several issues: an imbalance in animal feed rations favoring energy over protein, increased external protein inputs, and reduced biodiversity and effectiveness of biotic control substances.

· To enhance environmental sustainability, it is essential to increase the complexity of the cropping system by incorporating crop rotations and other forage crops, potentially returning to permanent and semi-permanent grasslands. Designing more sustainable cropping systems involves considering market trends, territorial suitability, and productivity potential, as well as the quality and nutritional value of the forage and/or produced meals.

· Successful examples of sustainable forage systems include those used for "Parmigiano Reggiano DOP" and "Grana Padano DOP," where rotated grasslands, primarily alfalfa, are integrated with maize or other cereals for silage and concentrates. Prioritizing long-term grasslands in the farm's cropping plan is the most sustainable choice economically, agronomically, and environmentally.

· Maintaining the quantity and quality of grass swards requires proper management of mowing or grazing, fertilization, and reseeding. This includes using species and varieties suited to the local soil and climate, incorporating self-reseeding annual legumes, and perennial species in deeper soils.

· Proper grazing management, if the livestock system allows, is crucial for ensuring long-term production and quality of the grassland. Grazing should be carefully planned based on available resources and involve frequent herd movements, possibly using mobile fences. The ideal grazing time should consider the physiological development of the species. An example is the "Voisin Rational Grazing" method, which optimizes the balance between forage quantity and quality without compromising plant persistence.

· The most significant sustainable agronomic intervention is fertilization management. The primary goal is to increase the ratio of livestock effluents to mineral sources for fertilizing forage systems and to increase the percentage of organic fertilizers used. This approach enhances sustainability by improving the efficiency of input use and maintaining soil health.

4.5. Forestry

· Currently, almost 40% of Italy's national territory is covered by forests, with about 80% of this area potentially available for increased wood harvesting, as it lacks significant legal, physical, or regulatory limitations. A significant portion of these areas consists of newly formed forests on former agricultural or pasture lands. Despite this potential, the traditional cautious approach of Italian forestry suggests careful consideration before intensifying forest management to increase wood extraction. Presently, the annual wood harvest from Italian forests is no more than one-third of their natural volume growth, allowing for a continuous accumulation of biomass and wood stock.

· Italy is a leading global producer and exporter of finished wood products but imports nearly 80% of its wood and timber needs. This reliance on imports has economic and ecological costs, including global environmental damage and ethical concerns. The deforestation linked to the production of raw materials for Italian industries, such as coffee, cocoa, and meat, results in significant forest loss in tropical countries. The European Union is indirectly responsible for 16% of global forest loss, ranking second worldwide after China.

· The overall productive capacity of Italian forests is high, estimated at around 30 million cubic meters of wood annually. However, only a portion of this wood is economically retrievable due to accessibility issues and current market prices. Sustainable intensification of forestry could potentially increase wood utilization by up to 50% over the long term, prioritizing the protection and improvement of national forest heritage. This includes transitioning from coppice to high forest management systems, which are considered advanced in Europe for their structural and compositional diversity, crucial for future climate resilience.

· Most Italian forests have not yet reached biomass equilibrium and continue to act as carbon sinks. However, relying solely on their carbon sequestration capacity is risky due to conflicts with other ecosystem services. The EU's new forest strategy aims to reduce greenhouse gas emissions by at least 55% by 2030 and achieve climate neutrality by 2050. Currently, forests and wood products offset approximately 10% of the EU-27's greenhouse gas emissions. Ensuring the stability of forests' carbon and species benefits requires greater resilience to increased disturbances.

· There are significant motivations and operational tools (e.g., D.Lgs. 34/2018 and the National Forest Strategy) for a calibrated increase in wood resource supply from Italian forests through precise forest planning and sustainable management. This includes expanding existing old-growth forests and those of particular natural value. Sustainable forestry practices that promote diversification are increasingly pursued across Europe. Multifunctional landscapes, historically characteristic of Italy, can ensure a positive carbon balance while preserving species diversity, soil conservation, traditions, property rights, and multiple ecosystem services. Achieving this requires high-quality governance and active involvement of landowners and civil society.

· There is growing interest in innovative wood-based products that meet responsible consumption needs. These include wood materials for sustainable construction, such as bio-building and furniture made from laminated wood, CLT, X-lam, wood flour, and similar products. Other significant innovations include textile materials, bioplastics, and smart packaging made from wood. These innovations form the foundation of a circular bioeconomy, bringing attention to Italy's internal and mountainous areas and contributing to reducing social and territorial inequalities.

4.6. Agroforestry systems

· A recent analysis by a European Commission Focus Group highlighted agroforestry as a form of agriculture that enhances resource efficiency, productivity, and overall ecosystem resilience. These systems sustainably intensify agriculture by integrating tree crops (for wood or fruit) with herbaceous crops (for grain or forage) and potentially including livestock to utilize forage resources.

· These systems offer multiple income streams from the same hectare of land: selling wood or fruit, selling grain, and converting forage into meat or milk. Additionally, they help mitigate greenhouse gas emissions from livestock and improve animal adaptation to climate change. Trees in these systems sequester significant amounts of carbon in both above-ground and root biomass, protect soil from erosion, and increase biodiversity.

· In Italy, particularly in regions like Sardinia, traditional agroforestry systems have long been part of agricultural landscapes. There is a need to preserve, enhance, and promote these systems to combat the abandonment of marginal areas and conserve landscapes, bringing biodiversity back to overly simplified territories. Developing new, modern, and efficient agroforestry models for intensive agricultural areas is also necessary to improve environmental sustainability, combat erosion, organic matter loss, and greenhouse gas emissions, while maintaining high productivity standards.

· Extensive livestock systems are crucial in marginal areas at risk of abandonment, requiring careful management to maintain economic viability and ecosystem services. These systems face higher production costs and lower output per unit compared to other systems. Economic sustainability is essential and can be supported through subsidies, recognizing the social function of these systems, or through consumer willingness to buy these products for their nutritional value, organoleptic qualities, and societal role awareness.

5. MAIN ANIMAL PRODUCTION SYSTEMS

· In the coming decades, there is expected to be a significant increase in the demand for animal products due to population growth and changing socio-economic conditions in various parts of the world. Globally, livestock production systems use between 30% and 40% of the available agricultural land, primarily for grazing. Since expanding the land for livestock is not feasible, these systems must adopt sustainable intensification techniques to improve productivity. This aligns with the European agricultural policy, which emphasizes animal welfare, reducing environmental impact, and maintaining ecosystem integrity.

5.1. Dairy Cattle Farming

· In Italy, dairy farming is characterized by high productivity systems, with peak productions reaching 20,000 kg of milk per lactation. However, these systems face challenges related to environmental impact (greenhouse gas emissions and waste pollution) and animal welfare. Studies have shown that more efficient dairy farms have higher environmental and economic sustainability.

· Key strategies for improving sustainability include genetic improvement through genomics, better management practices, and advanced technologies for individual and environmental monitoring. Enhancing animal welfare involves providing adequate space, improving calf management, and addressing health issues.

5.2. Beef Cattle Farming

Italy primarily relies on fattening imported cattle, with intensive systems due to high production costs. There is limited scope for further intensification, and the focus should be on sustainability. This includes optimizing environmental impact through certified evaluation systems and integrating livestock activities with energy production.

· Increasing the number of breeding cows and improving productivity efficiency are crucial for addressing the shortage of calves for beef production.

5.3. Sheep Dairy Farming

· Sardinia is the national reference point for sheep dairy farming, but productivity levels are low, with an average of just over 150 liters per lactation. Factors contributing to low efficiency include inadequate feeding techniques and high incidence of infectious diseases.

· To ensure sustainability, it is necessary to intensify production levels and improve efficiency while maintaining pasture-based feeding systems. Strategies include genetic improvement, better feeding practices, and rationalizing pasture use.

5.4. Poultry Farming

· Poultry farming has seen the most significant growth in animal product production globally. In Italy, poultry production is self-sufficient, with high consumption of white meat.

· The main challenges are animal health and welfare, and environmental impact. Strategies for sustainability include adhering to biosecurity protocols,

improving animal welfare through genetic selection, and adopting innovative technologies for resource management and environmental monitoring.

· Overall, the focus is on improving productivity and sustainability across various livestock farming systems through better management practices, advanced technologies, and adherence to environmental and animal welfare standards.

· Italian agri-food products enjoy a strong reputation, both industrially and artisanally, thanks to prestigious brands and numerous DOP (Protected Designation of Origin) products that enhance raw materials, their regions of origin, and producers' expertise. Over the past fifty years, research has focused on improving food preservation techniques, protecting production diversity, and now, on process sustainability.

· Environmental impact reduction in food production often focuses on primary production, but transformation and preservation processes also play a crucial role. These processes are influenced by energy consumption, waste management, packaging choices, and distribution logistics. Studies show that logistics often have a greater impact on CO2 emissions than the transformation process itself.

· To enhance environmental sustainability, projects should analyze the entire production cycle using Life Cycle Assessment (LCA) to quantify environmental impacts and communicate them through Environmental Product Declarations and carbon, water, and ecological footprints. The LCA approach, standardized by ISO 14040 and 14044, helps identify high-emission resources and processes within a product's life cycle.

Key areas for innovation include:

· Production Environments: Reducing fossil fuel, electricity, and water use through passive efficiency systems, optimized building designs, and smart monitoring technologies. Innovations in non-thermal processes, such as high-pressure processing, pulsed electric fields, and cold plasma, can also reduce environmental impact.

· Conservation and Transformation: Improving efficiency and organization of processes, developing energy and water consumption indicators, and designing nearly Zero Energy Agroindustrial Buildings (ZEB/nZEAB) that are energy and water self-sufficient. For fruit and vegetable preservation, intelligent air exchange control and renewable energy use can reduce environmental impact.

· Byproduct Valorization: Utilizing agricultural and agro-industrial byproducts for energy recovery (biogas, biomethane) or as organic matter for plant nutrition and soil carbon sources. Recovering valuable fractions from winemaking, olive oil extraction, and fruit processing can enhance the value of finished products.

· Packaging: Developing biodegradable and compostable packaging from agricultural residues to replace plastic. Innovations include materials derived from low-amylose cereals, legume flour, and biodegradable thermoplastic composites like Mater-Bi. The University of Foggia's patent for biodegradable packaging from food industry waste using entirely physical processes is noteworthy.

These innovations aim to make food transformation and preservation processes more sustainable, reducing waste, energy, and water use while enhancing product quality and environmental impact.

7. COEXISTENCE BETWEEN INTENSIFIED AND EXTENSIVE FARMING

If the goal is to increase production, maintain fair income levels for operators, and reduce environmental impacts, this requires a thorough analysis of the territory and existing farming systems to determine where intensification is feasible and where extensive farming remains the best option. Estimates suggest that over 40% of Italy's utilized agricultural area (SAU) is unsuitable for further intensification due to soil characteristics.

Mountain and hill areas in the Alpine and Apennine regions, which are at high risk of abandonment and erosion, present opportunities for agricultural production. These areas constitute about 45% of central and northern Italy's territory. Strategic choices and targeted policies are needed to make these marginal areas productive. Among various agricultural activities, livestock farming, particularly in semi-extensive forms, is well-suited to these areas.

Extensively managed forage areas (pastures and meadows) provide many ecosystem services, such as landscape maintenance, biodiversity conservation, and preservation of local breeds. However, extensive management reduces productivity, so high-quality livestock products must be recognized for their value in terms of sale price. Authentication and traceability processes are also necessary to ensure product genuineness and effectively communicate ecological and social values.

"Heroic, part-time, subsistence, family, and youth entrepreneurship" farming, enhances agrobiodiversity and contributes to landscape and forest care. These forms of agriculture must differentiate their products through authentication, traceability, and marketing strategies to be economically sustainable.

The importance of the landscape is emphasized, with research and policies needing to balance economic and environmental sustainability with landscape preservation. The landscape is seen as a resource, integrating various sectors and actions. Sustainable landscape planning and design are key, considering the complex functions of rural landscapes and their interactions with socio-economic systems. New-generation landscape planning should be active and demonstrate its strategic value, particularly in conservation and integration with rural development funding criteria. traditional products have high growth potential also in the context of rural hospitality and tourism. Effective storytelling and marketing can help preserve and promote these products. Extensive farming systems are linked to environmental goods and services demanded by locals and tourists. Integrating and managing territorial niches helps maintain typical products and rare raw materials, even in economically marginal areas.

8. CONCLUSIONS

The analysis in this volume highlights the complexity of the topic "sustainable intensification" and the fact that there cannot be a single interpretation of sustainability for Italian agriculture, given its wide variety of environments, species, and production systems. For each crop or supply chain in a specific environment, problems and solutions must be identified, always considering the need to reconcile ecological sustainability with profitability for the farm. Every choice should be based on cost-benefit evaluations and examined in the medium to long term, considering effects not only at the farm level but also at the district level and the impact on the landscape. Indicators to characterize, measure, and report the degree of sustainability of a production system are often available, but much work remains to identify the thresholds to aim for and those not to exceed.

The complexity of the problem and the presence of many sustainability indicators require defining priority scales and suggest the need to analyze the effects of a cultivation technique or transformation process, a crop, or a supply chain through "Life cycle assessment," which simultaneously considers the various impacts of all phases of the production and transformation process.

Sustainable intensification, with a high use of "knowledge" and integrated into a bioeconomy system, can and should be promoted and implemented through various forms of agriculture, such as integrated, organic, conservation, agro-ecological, regenerative, etc., all aiming in the same direction and able to borrow virtuous practices from each other. Intensive and environmentally sustainable agriculture must also be able to use all the tools provided by scientific and technological progress, including new biotechnologies and communication and information technologies, which have seen unimaginable progress in recent years. Italy must invest in innovation, infrastructure, and education to help the national agricultural sector catch up with other European countries like the Netherlands, Germany, and France. The context characterized by change and innovation requires a qualitative leap in the transfer and sharing of knowledge. The context of knowledge transfer is no longer that of traditional technical assistance, which has been significantly weakened in Italy, but rather new approaches based on Agricultural Knowledge and Innovation systems (AKIS). In this sense, the coordination of initiatives is important, although difficult in an Italian context characterized by regional governance systems and fragmentation of research centers. A central point of this change lies in the need for new professional skills and the improvement of current ones, enabling them to better use the technologies available today.

Some forms of agriculture in certain environments, such as organic farming for some horticultural crops, will inevitably become more intensive, at least in terms of the use of knowledge and technology; for other crops and in other environments, it is necessary to ensure that even low-intensity farms can be sustainable both ecologically and economically, thanks to a recognized identity connection with production sites or through tourism and catering.

The time is ripe for further progress in sustainability in Italian agriculture. Once again, we must emphasize the importance of Science for Society: relying on scientific evidence is the best choice we can make. At the same time, it is absolutely necessary for civil society to be well-informed about sustainability in agriculture, and we hope that our analysis will serve as a useful reference point for citizens, consumers, various stakeholders, administrators, and political representatives.

The agricultural world must better communicate with the rest of civil society, which, in turn, must become more aware of the complexity of the sustainability issue, which cannot be dismissed with a few slogans. The difficult period experienced by our country, partly as a consequence of the Covid-19 pandemic and conflicts in

Europe, has at least temporarily strengthened Italians' awareness of the importance of the agri-food system. This period also seems to have contributed to restoring Science to the role it should have in a modern country, namely providing Politics and citizens with competent opinions free from partisan and contingent interests and proposing scenarios based on scientific evidence. We need to continue on this path and keep increasing awareness of the centrality of agricultural production and the Italian agri-food system for the future of our country. It would be dangerous to jeopardize food security and sovereignty and the products of renewable forest natural resources, further exposing the country to uncontrolled imports of foodstuffs or products of dubious origin, in the name of a free international market without common and controllable rules that guarantee the quality of production processes. Citizens have the right to know the level of sustainability of the products they buy, but they must also be willing to adequately remunerate the most sustainable productions. Shared choices between producers and consumers will be needed to modify some current paradigms of product quality. Achieving some of the quality standards required for certain products (e.g., fruit shape and size, color, absence of aesthetic defects, etc.) has an additional ecological cost that can often be avoided. Improving sustainability in the field and in transformation processes is not enough. Everyone must pay great attention to food consumption, both in terms of quantities consumed and waste.

Agricultural operators and scientists are ready to engage with civil society to constantly improve the sustainability of Italian agriculture. Everyone must commit to reasonableness and responsibility.

ABSTRACT

Italian agriculture, in its great variety of environments, species and production systems, faces important challenges related to the improvement of farm profitability, product quality and ecological sustainability of production, in a scenario of climate change and geopolitical crises involving Europe. While the population's attention to the quality of agricultural production, the wholesomeness of food and the ecological sustainability of the production process in the field is growing, this is happening in a context in which the income of many entrepreneurs, especially in marginal areas, is being jeopardised by rising production costs that are not matched by an increase in product selling prices. There is a growing demand for Italian products, which are basically recognised as safer, but Italy imports many of the raw materials of agricultural interest that it needs, even from countries that do not provide guarantees of sustainable production. The scientific community dealing with agricultural sciences in Italy, through the Italian Association of Scientific Agricultural Societies (AISSA), has been discussing sustainable intensification and its role for the future of agriculture in our country for some time and has decided to update and expand the volume Sustainable intensification, a tool for the development of Italian agriculture published in 2019. The new edition, which represents AISSA's position on this important issue, starts with an analysis of the concept of intensive agriculture and emphasises that intensification in agriculture is not just a question of using technical means, but the application of knowledge and new technologies, including digital ones, to effectively manage resources, minimise the impact on the natural environment and achieve better environmental and socio-economic results, often using concepts of circular bio-economy. The central theme of sustainability is addressed through the examination of indicators that allow it to be contextualised from ecological, social and economic perspectives. For each plant and animal production system considered, critical issues are analysed and strategies and interventions to improve the level of sustainability are proposed. The book, enriched by 10 thematic in-depth studies (boxes) and a glossary, provides up-to-date data on the contribution of agriculture and agro-industry to greenhouse gas emissions, the use of fertilisers, plant protection products and irrigation water. It is emphasised that a basic analysis of the territory and existing cultivation systems is necessary in order to distinguish where one can think of further intensifying certain areas of the country or certain forms of agriculture, and where, instead, extensive cultivation remains the best possible form. While at the country level the increase in yields is an objective to be pursued, in view of the great diversity of cultivation situations and markets, for the individual farm or area the equation 'increase in yields=increase in income' is not always necessarily true. There is no single path or interpretation of sustainability, but the different forms of agriculture should all tend in the same direction and mutually mutually borrow virtuous practices. The volume intends to contribute to the debate in order to raise the level of sustainability in Italian agriculture and help the competitiveness of businesses on the one hand and the protection of the environment on the other.