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Cah. Agric. 2024, 33, 10

https://doi.org/10.1051/cagri/2024001

Cahiers Agricultures

Available online at:
www.cahiersagricultures.fr

Article de recherche/Research Article — Open Access

Assessing farm sustainability: the IDEA4 method, a conceptual framework combining dimensions and properties of sustainability

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Abstract – This article presents the conceptual framework for assessing farm sustainability using the IDEA4 method. IDEA4 combines a dual assessment approach based on sustainable agriculture objectives and the properties of sustainable farming systems. It is rooted in the domains of strong sustainability, strong agroecology and the multifunctionality of agriculture. It takes into account the overall issues of sustainable agriculture. This conceptual framework has been used to construct 53 indicators for analysing farm sustainability using two complementary approaches. The first assesses sustainability by organising these 53 indicators according to the 3 normative dimensions of sustainable development (agroecological, socio-territorial, economic), structured into 13 components. This assessment relies on a scoring system based on 100 sustainability units for each of the 3 dimensions, which cannot offset each other. The second approach is used to assess sustainability by organising the same 53 indicators according to the 5 properties of sustainable agricultural systems (ability to produce and reproduce goods and services, autonomy, robustness, territorial embeddedness, and overall responsibility), which are arranged in a tree structure with 15 branches. Indicators are aggregated in a qualitative and hierarchical manner using the DEXi tool. The exploratory potential of the concept of the properties of sustainable systems encourages a transdisciplinary approach for assessing farms. IDEA4's theoretical framework is now complemented by three information technology (IT) tools, which means that the method can be used to a much greater extent to support the agroecological transition.

Keywords: IDEA4 / agricultural sustainability assessment / properties of sustainable agricultural systems / objectives of sustainable agriculture / farm sustainability indicators

Résumé – Évaluer la durabilité des exploitations agricoles : La méthode IDEA4, un cadre conceptuel combinant dimensions et propriétés de la durabilité. Cet article présente le nouveau cadre conceptuel d'évaluation de la durabilité de l'exploitation agricole développé dans la méthode IDEA4. Il combine une approche évaluative basée sur les objectifs assignés à une agriculture durable et une évaluation des propriétés des systèmes agricoles durables. Il s'ancre dans le champ de la durabilité forte, de la multifonctionnalité et prend en compte les enjeux globaux d'une agriculture durable. Ce cadre conceptuel a permis de construire 53 indicateurs permettant d'analyser la durabilité de l'exploitation agricole selon ces deux approches complémentaires. La première évalue la durabilité en organisant ces 53 indicateurs selon les 3 dimensions normatives du développement durable (agroécologique, socio-territoriale, économique),

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structurées en 13 composantes ; l'évaluation repose sur un système de notation basé sur 100 unités de durabilité pour chacune des 3 dimensions qui ne se compensent pas entre elles. La seconde évalue la durabilité en organisant les 53 indicateurs selon les 5 propriétés des systèmes agricoles durables (autonomie, robustesse, capacité productive et reproductive de biens et services, ancrage territorial et responsabilité globale) qui sont structurées de manière arborescente en 15 branches ; l'agrégation des indicateurs y suit une démarche qualitative et hiérarchique mobilisant l'outil DEXi. Le potentiel pédagogique du concept de propriétés des systèmes favorise une approche transdisciplinaire de l'exploitation agricole. Le cadre théorique d'IDEA4 est complété par trois outils informatiques permettant d'utiliser la méthode dans une diversité d'usages (enseignement, recherche, conseil, accompagnement, action publique) pour soutenir la transition agroécologique.

Mots - clés : IDEA4 / évaluation de l'agriculture durable / propriétés des systèmes agricoles durables / objectifs de l'agriculture durable / indicateur de durabilité d'une exploitation agricole

1 Introduction

There is a growing demand in recent years for methods to assess the sustainability of farming systems. It is being driven by farmers seeking to identify the levers of action likely to improve the overall performance (level of sustainability) of their farms, by agricultural development entities wanting to broaden their technical advice to encompass sustainability, and by public action structures seeking to assess their systems in the light of the agroecological transition.

The most recent reviews of the state of the art (Schader *et al.*, 2014; Lairez *et al.*, 2015; De Olde *et al.*, 2016; Chopin *et al.* (2021); Konefal *et al.*, 2023) show a wide variety of indicator-based methods (around 60 listed methods). Among these, the IDEA method (French acronym for: *Indicateurs de durabilité des exploitations agricoles* [Farm sustainability indicators], Vilain *et al.*, 2008; Zahm *et al.*, 2008) is today one of the four most widely used methods in the European Union to assess sustainability (De Olde *et al.*, 2016). Although its initial objective, in the early 2000s, was to serve as an educational tool to make the concept of sustainable farming concrete and measurable to agricultural students and farmers, its use has gradually been extended to other purposes such as research studies, change management and agricultural development advice. After updating the method twice, in 2003 and 2008, the IDEA4 scientific committee undertook a major research project over the 2012–2023 period to thoroughly overhaul its conceptual framework, assessment grids and indicators, resulting in the IDEA version 4 (or IDEA4) method presented in this article. This substantial overhaul takes into account:

- proposals for changes arising from the national survey on the use of the IDEA method (Rousselet, 2011);
- the emergence of new societal issues (food, climate change, air quality, frugality in the use of resources);
- changes in public and private regulatory frameworks (Common Agricultural Policy, standards, benchmarks);
- the most recent data from public agricultural statistics to define performance thresholds and set various calculation coefficients.

This work resulted in an operational framework based on a dual assessment approach and the development of freely available operational information technology (IT) tools.

At the theoretical level, this revision was based on a broad review of the literature (Zahm *et al.*, 2015) which showed the need for an evolution of the initial conceptual framework (1998) given the emergence of complementary analytical frameworks in order to allow a broader analysis of the concept of sustainability in agriculture. This revision resulted in particular in the inclusion of the concept of properties of sustainable systems, the principles of strong agroecology, the circular economy and collective action in the ecological transition, and was based on a re-reading of the societal objectives ascribed to agriculture (United Nations, 2015).

The IDEA4 conceptual framework is based on the combination of two assessment approaches to farm sustainability: one through the objectives of sustainable agriculture and the other through the properties of sustainable farming systems. The end result of this combination are two assessment grids, structured respectively according to the 3 dimensions of sustainable agriculture (agroecological, socio-territorial and economic) and according to the 5 properties of sustainable agricultural systems (ability to produce and reproduce goods and services, autonomy, robustness, territorial embeddedness, and overall responsibility). The properties-based approach consolidates the systemic perspective of the farm by introducing a transversal reading of its sustainability.

The first part of the article places the two approaches in the literature and presents the methodological process used. The second part presents the IDEA4 conceptual framework and its two assessment grids that use an identical core of 53 indicators. The third part discusses the contributions, limitations and new uses of the method, before concluding with a discussion on its future development.

2 Approaches to assessing the sustainability of agriculture and methodological process

The IDEA4 conceptual framework is based on a combination of the two assessment approaches described in detail in the reference work (Zahm *et al.*, 2023) and outlined below.

2.1 An assessment approach based on the normative objectives assigned to sustainable agriculture

Conceptual frameworks based on indicators centred on the objectives of sustainable agriculture are known as 'goal-oriented conceptual approaches' (Von Wirén-Lehr, 2001) or as 'goal-oriented frameworks' (Alkan Olsson *et al.*, 2009). They are part of a normative vision of sustainability corresponding to 'a capacity to achieve a set of objectives' (Hansen, 1996) and structure a representation of sustainable agriculture based on the objectives it seeks to achieve (Robert *et al.*, 2005; Chia *et al.*, 2009). This approach indicates the direction to take towards sustainable agriculture, based on the vision and objectives defined (Sala *et al.*, 2015). This is the normative dimension of sustainability 'which discusses what is agreed upon and prescribes the framework for priorities and actions to be implemented' (Hubert, 2004). This approach is based on the values that society aspires to adopt (Pope *et al.*, 2004). Such a representation is tied both to the societal challenges facing farmers and agriculture (extended sustainability) and to the farm's internal objectives (restricted sustainability). This is the approach adopted by the United Nations (2015) in its 17 sustainable development goals.

2.2 An assessment approach based on the properties of sustainable agricultural systems

A second approach for assessing sustainability in agriculture is based on conceptual frameworks that use properties of sustainability. The properties of a system correspond to emergent qualities that cannot be directly deduced from its sub-systems or the parts that it consists of. They originate from the organisation of the production system, in particular from the interactions between its sub-systems and interactions with its environment (Gliessman, 2005). It is the characteristics of these interactions, rather than those of its constituent parts, that determine the sustainability of the system analysed as a whole. Described as a 'system-based framework' (Van Cauwenbergh *et al.*, 2007) or a 'systemic property-oriented framework' (Alkan Olsson *et al.*, 2009), this approach involves a reasoned selection of indicators on the basis of their ability to qualify the state of a system in terms of the systemic properties of sustainability (Conway, 1987; Bossel, 1999; Gliessman, 2005; López-Ridaura *et al.*, 2005). For example, such an approach was used by the MESMIS (*Marco para la Evaluación de Sistemas de Manejo en Recursos Naturales incorporando Indicadores de Sustentabilidad*) research programme, which uses seven properties (productivity, stability, resistance, resilience, adaptability, equity, autonomy) to assess sustainability in agriculture for case studies analysing different rural projects in Latin America (Astier *et al.*, 2011).

2.3 Methodological process

2.3.1 Method design process

The members of the IDEA scientific committee represent a wide range of disciplines, including agronomy, economics, geography, management sciences and zootechnics. They undertook a multi-year research process structured around:
- an ongoing literature review (scientific and professional) based on an initial detailed analysis of 60 sustainability assessment methods;
- the development of the conceptual framework;
- the design of assessment grids and indicators;
- inputs from external actors (researchers, teachers, experts and users).

The successive prototypes of the IDEA4 method were analysed in three types of use tests over the 2018–2023 period, first on just over 700 farms representing a wide range of production systems, territorial contexts and markets, second during training sessions (students, teachers and professionals), and third during use by farm advisory and territorial development professionals.

Finally, performance thresholds for the indicators were validated in two ways: by systematic comparison with the literature, and then, by an additional calculation for 14 indicators using three national databases from the Farm Accountancy Data Network, the Agricultural Census and the French Agency for Ecological Transition (ADEME).

2.3.2 Explanation of the methodological choices

The choice and definition of objectives, properties and indicators were the subject of in-depth preliminary work, which was followed by a debate and finally by arbitration. They are based on the following two principles: 1) consistency with the adopted theoretical framework and 2) compliance with quality standards (relevance, frugality, scientific basis, robustness, accuracy of analysis, measurability, pedagogy, transparency) (Reed *et al.*, 2006).

The indicators were constructed based on the following criteria. They should be easily calculable by a farmer, advisor or student; be transparent; and have performance thresholds adapted to French agriculture in order to help and guide interpretation. Twelve objectives (Box 1) were chosen based on an overhaul of the 18 objectives in IDEA version 3 (IDEAv3, Zahm *et al.*, 2008) in the light of the literature on the new sustainable development challenges and objectives proposed by United Nations (2015). A literature review (12 academic articles on agricultural sustainability framework in agriculture) helped identify 36 characteristics (attributes) of sustainable systems that the authors grouped into 5 properties based on their conceptual proximity: ability to produce and reproduce goods and services, autonomy, robustness, territorial embeddedness, and overall responsibility.

This decision to retain only a limited number of objectives and properties is the result of a trade-off between the operationality of the method and the need to remain faithful to the concepts retained in the conceptual framework. The analytical framework for each of the 5 properties was the subject of a literature review, which led to the construction of a mind map (Fig. 1) structured into branches and sub-branches, which were then broken down into indicators. Indicators were chosen on the basis of the construction of the mind map organised according to the 5 properties of sustainable agricultural systems, combined with the consideration of the 12 objectives (Box 1). This led to 53 indicators, which are used all together and simultaneously to:
- assess the dimensions of farm sustainability;
- assess the properties of the agricultural production system.

The methods used to calculate the indicators (formulas and performance thresholds) are the result of a trade-off between the applicability of IDEA4 to all production systems and the feasibility of taking their specific features into account.

Box 1. ***The 12 objectives of sustainable agriculture***

– Conserve natural resources (biodiversity, soil, water and air)
– Conserve non-renewable resources
– Conserve and/or develop landscapes
– Respond to the challenge of climate change (combating and adapting)
– Contribute to food security and sovereignty
– Contribute to employment and regional development
– Ensure the economic viability and sustainability of the farm
– Contribute to quality of life
– Maintain freedom of action and independence
– Be part of responsible approaches and commitments
– Ensure animal well-being
– Produce and share knowledge and know-how

3 IDEA4's conceptual framework

3.1 Theoretical framework

Our literature review showed that in order to ascribe concrete meaning to sustainable agriculture objectives, it is necessary to structure a conceptual framework for assessing sustainability based on a normative sustainability objectives approach, *i.e.* the same framework adopted in the IDEAv3 method. However, while this approach has proven its educational and operational value, it does not allow a systemic characterisation of the state of a system in terms of its various properties (Binder *et al.*, 2010). Consequently, the conceptual framework of IDEA4 (Fig. 2) has been expanded and enriched by a theoretical approach based on the properties of sustainable agricultural systems. To qualify the concept of farm sustainability, 12 objectives (Box 1) and 5 properties have been selected.

The 5 properties are defined as follows:

Ability to produce and reproduce goods and services: This property corresponds to a farm's ability to produce and reproduce goods and services efficiently over time, generating sufficient income to maintain the activity without damaging or depleting its natural and social resource base.

Autonomy: The autonomy of a farm corresponds to its capacity (i) to produce goods and services from its own or local collective resources (human, natural, physical, cognitive, etc.) and (ii) to allow the farmer to have decision-making freedom and develop methods of action that limit the farm's dependence on public instruments (subsidies, quotas, production rights, etc.) and on upstream and downstream actors.

Robustness: A farm's robustness corresponds to its ability to cope with internal and external variations of varying intensity (fluctuations, disturbances, shocks) and nature (environmental, social, economic), and to maintain or return to a state of equilibrium that may differ from its initial state. This property encompasses the concepts of resilience, adaptation and flexibility.

Territorial embeddedness: A farm's territorial embeddedness corresponds to its capacity to contribute to a process of co-production, development and leveraging of territorial resources. It also characterises the nature and intensity of the commercial and non-commercial links that the farm builds with its territory, its inhabitants, its stakeholders and its social group.

Overall responsibility: A farm's overall responsibility corresponds to the degree of commitment of the farmer (or the farm's managers) to a comprehensive approach, which takes into account the environmental, social and economic impacts of the farm at different scales (the farm, the region, the country, the rest of the world), resulting from its choices of activities or agricultural practices. This commitment is structured around ethical, fair and just values.

The conceptual framework of IDEA4 is rooted in the current of strong sustainability (Daly, 1990), which rejects the hypothesis of perfect substitutability or offsetting between natural resources and manufactured capital. It also refers to sustainability in its agroecological dimension of agricultural activities as well as in the socio-territorial dimension of agriculture and in the economic dimension of the farm. They refer to the two levels of sustainability proposed by Terrier *et al.* (2013):

– restricted sustainability, which describes the farmer's self-centred objectives corresponding to his internal factors of sustainability;
– extended sustainability, which identifies a farm's societal objectives that contribute to the sustainable development of larger scales and organisations (territory, community, country, rest of the world).

The 12 objectives and 5 properties were then used to define the authors' shared values and visions so that the paradigmatic framework could be constructed, which led to the definition of the two concepts: sustainable agriculture and sustainable farm (Box 2).

3.2 Operational framework

The operational framework (Fig. 2) describes the process of aggregating the core of 53 indicators selected from the construction of the mind map. These same indicators, aggregated according to the two assessment approaches below, provide two complementary analyses of farm sustainability.

3.2.1 The assessment approach based on the 3 dimensions of sustainability

This approach aggregates indicators according to the 3 dimensions of sustainable agriculture (agroecological, socio-territorial, economic). For all these 3 dimensions, the indicators are structured into 13 components as follows:

– the 53 indicators are organised into components (or themes);
– each of the 13 components of the dimension is assigned a weightage;
– the scores of indicators within each component can be offset between them.

The scoring is based on a system of sustainability units according to a scale adapted to each indicator: the scores for each indicator range from zero to a capped maximum sustainability value (Fig. 3). The score for each component is the sum of the scores for each of its indicators, capped at a maximum value of between 20 and 35 depending on the

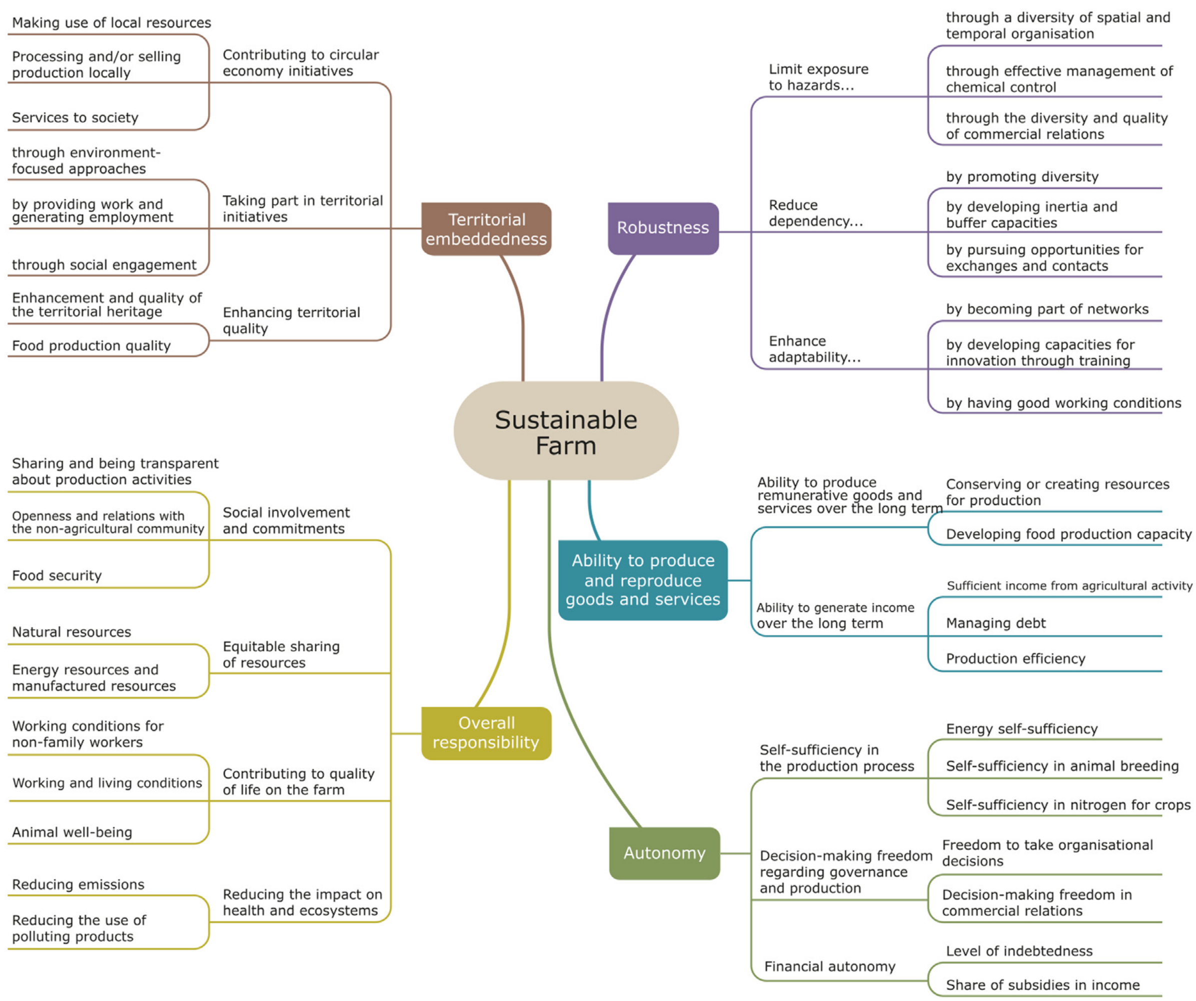


Fig. 1. Mind map of the 5 properties of a sustainable farm.
Note: for reasons of readability, this mind map is only developed up to level-2 branches and does not show all 53 indicators.
Fig. 1. *Carte heuristique des 5 propriétés d'une exploitation agricole durable.*
Note : pour des raisons de lisibilité, cette carte heuristique n'est développée que jusqu'aux branches de niveau 2 et ne présente pas les 53 indicateurs.

Box 2. Definitions of the concepts of sustainable agriculture and sustainable farms in IDEA4 (from Zahm et al., 2015)

Agriculture is defined as sustainable when it is economically viable, ecologically sound, socially just and humane. It contributes, on the one hand, to the sustainability of the territory in which it is embedded through the multifunctionality of its activities, and, on the other hand, to the supply of global ecosystem services that meet the non-territorialisable objectives of sustainable development (combating climate change, preserving air quality, contributing to food security and sovereignty, etc.).

A sustainable farm is a viable, liveable, transferable and reproducible farm whose development is part of a socially responsible approach. This approach refers to the farmer's choices regarding the effects of his activities and production methods on the development of the territory in which his farm is located and the quality of life of its stakeholders, as well as its contribution to non-territorialisable global objectives. Its development is based on 5 emerging properties of sustainable agricultural systems: ability to produce and reproduce goods and services, autonomy, robustness, territorial embeddedness, and overall responsibility.

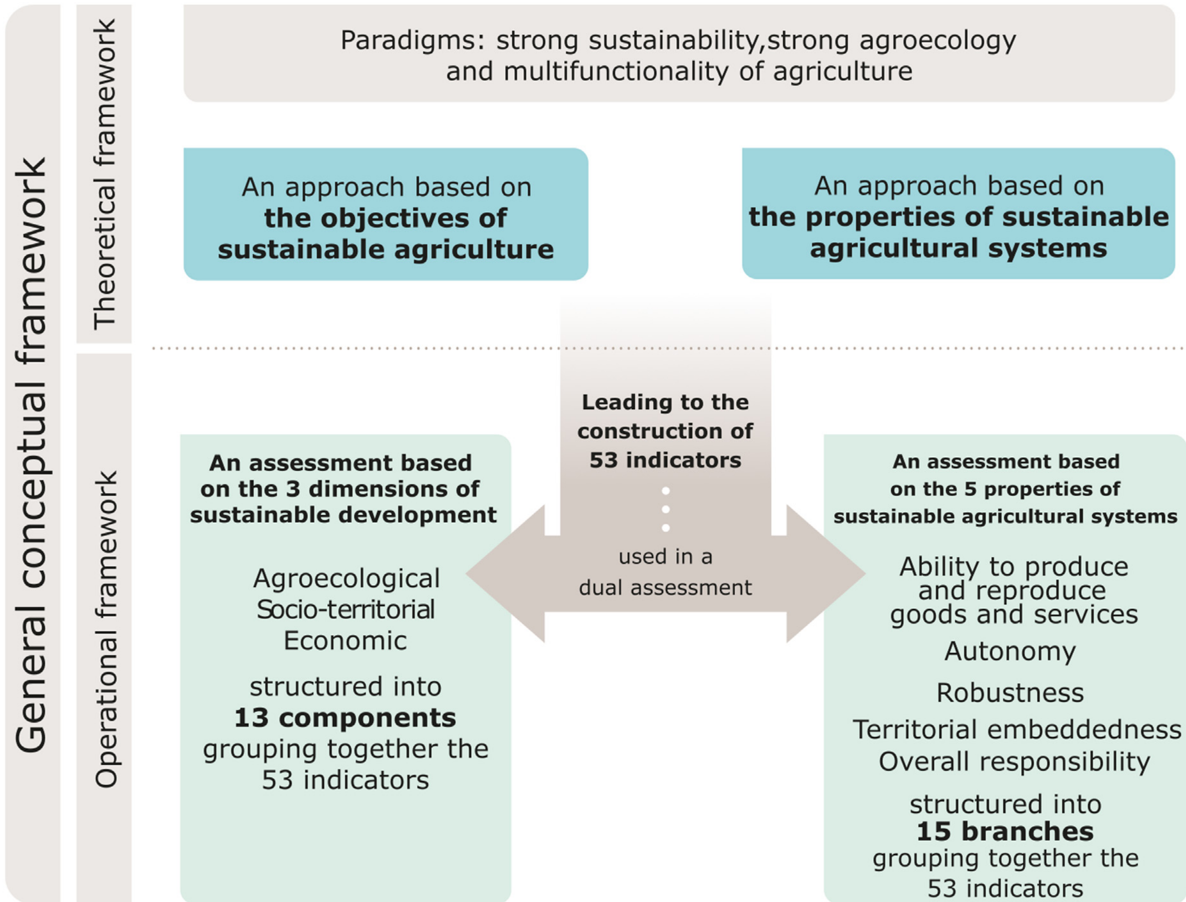


Fig. 2. Overview of the conceptual framework of the IDEA4 method.
Fig. 2. *Vue d'ensemble du cadre conceptuel de la méthode IDEA4.*

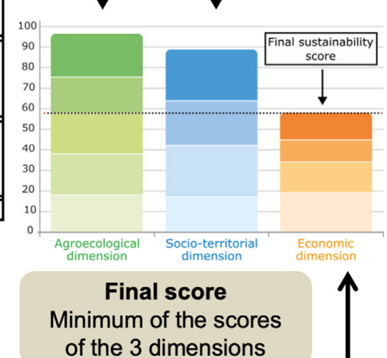
component. This capping allows for offsetting between values of indicators within each component. It reflects the principle that there can be no unique model of sustainability. Different socio-technical and socio-ecological combinations can exist and there are many possible ways of achieving the same level of sustainability. These capped-scoring rules make it possible to take the diversity of contexts (human and natural environments), production systems and their specific technical features into account. Then, the score for each dimension is the sum of its component scores. The maximum score for each dimension is 100 sustainability units, corresponding to the highest possible level of sustainability. Given that there is no offsetting between components within a dimension, the maximum score must be obtained for each component to achieve the highest level of sustainability for a dimension (100). The final sustainability score for a farm corresponds to the lowest score of the 3 dimensions (a principle derived from the strong sustainability movement, which implies that there can be no offsetting between the 3 dimensions). This rule of non-cumulation of the 3 dimensions also enables the farmer to identify where he has the greatest scope for progress (example of a score of 58/100, Fig. 4).

3.2.2 The assessment approach based on the 5 properties of sustainable agricultural systems

In this approach, the same 53 indicators are organised differently according to the 5 properties, which are themselves made up of 15 'level 1' branches (Figs. 1 and 5). The first principle behind this approach is a decision not to aggregate the scores for the 5 properties into an overall sustainability score. Indeed, a totalling of the scores would make it impossible to identify the levers for action specific to each property and therefore to discuss with the farmer how the least sustainable properties can be improved. The second principle is a bottom-up aggregation of indicators via the various intermediate nodes of the constituent branches of each property (Fig. 5). The third principle is to use the DEXi tool (multi-criteria decision support software) for aggregation of the indicators in a qualitative and hierarchical tree (Bohanec *et al.*, 2008). This scoring system is based on the allocation of sustainability classes for each indicator: unfavourable, intermediate or favourable. In addition, each node and lastly each property are evaluated in four possible ways: very unfavourable, unfavourable, favourable, very favourable. This evaluation using four classes is designed to

4 Components	Indicators of the Socio-territorial dimension	Max. score	Capped at
Food production	Food production on the farm	6	25
	Contribution to the global world food balance	6	
	Food production quality	6	
	Limitation of losses and waste	6	
	Social, hedonic and cultural links to food	6	
Local development and circular economy	Commitment in contractual and territorial environmental initiatives and measures	5	25
	Commercial services to the territory	3	
	Valuation through short or local food supply chains	5	
	Leveraging of local resources	5	
	Enhancement and quality of the territorial heritage: buildings, landscapes, genetic resources and local knowledge	3	
	Accessibility of space	3	
	Non-organic waste management	3	
	Innovation networks and pooling of equipment	3	
Employment and quality of work	Contribution to employment and employee management	6	25
	Sharing/pooling of work	6	
	Intensity and quality of work	6	
	Hospitability, health and safety at work	5	
	Training	5	
Ethics and human development	Territorial social involvement and solidarity	6	25
	Transparency in farm activities	6	
	Quality of life	6	
	Isolation	6	
	Animal well-being	6	
	Total	118	**100**

5 Components	Indicators of the Agroecological dimension	Max. score	Capped at
Functional diversity	Diversity of species cultivated	5	20
	Genetic diversity	5	
	Temporal diversity of crops	5	
	Quality of spatial organisation	5	
	Management of pollinating insects and crop auxiliaries	5	
Closed-loop material and energy flows in pursuit of autonomy	Self-sufficiency in energy, materials, equipment, seeds and plants	8	20
	Self-sufficiency for animal feed in animal breeding	8	
	Self-sufficiency in nitrogen for crops	8	
Frugality in the use of resources	Frugality in the use of water and sharing of this resource	8	20
	Frugality in the use of phosphorus	8	
	Frugality in the consumption of energy	8	
Favourable conditions for production in the medium and long term	Optimisation in managing and reducing the use of water	8	20
	Promotion of soil fertility	8	
	Maintenance of effective crop and animal health protection	4	
	Availability of means of production	4	
Reduction of the impact on human health and ecosystems	Reduction of the impact of practices on water quality	6	20
	Reduction of the impact of practices on air quality	6	
	Reduction of the effect of practices on climate change	6	
	Reduction in the use of pesticides and veterinary treatments	6	
	Total	121	**100**



4 Components	Indicators of the Economic dimension	Max. score	Capped at
Economic and financial viability	Economic capacity	20	35
	Ability to repay debt	12	
	Structural debt ratio	6	
Independence	Diversification in production	10	25
	Diversification in customers and contractual relationships quality	10	
	Dependence on direct payments	6	
	Contribution of external income to farm independence	4	
Transferability	Economic transferability	15	20
	Likelihood of permanence	8	
Overall efficiency	Production process gross efficiency	12	20
	Frugality in the use of inputs in the production process	8	
	Total	111	**100**

Fig. 3. IDEA4 assessment grid – approach based on the 3 dimensions of sustainable agriculture.
Fig. 3. *Grille évaluative IDEA4 – approche par les 3 dimensions de la durabilité.*

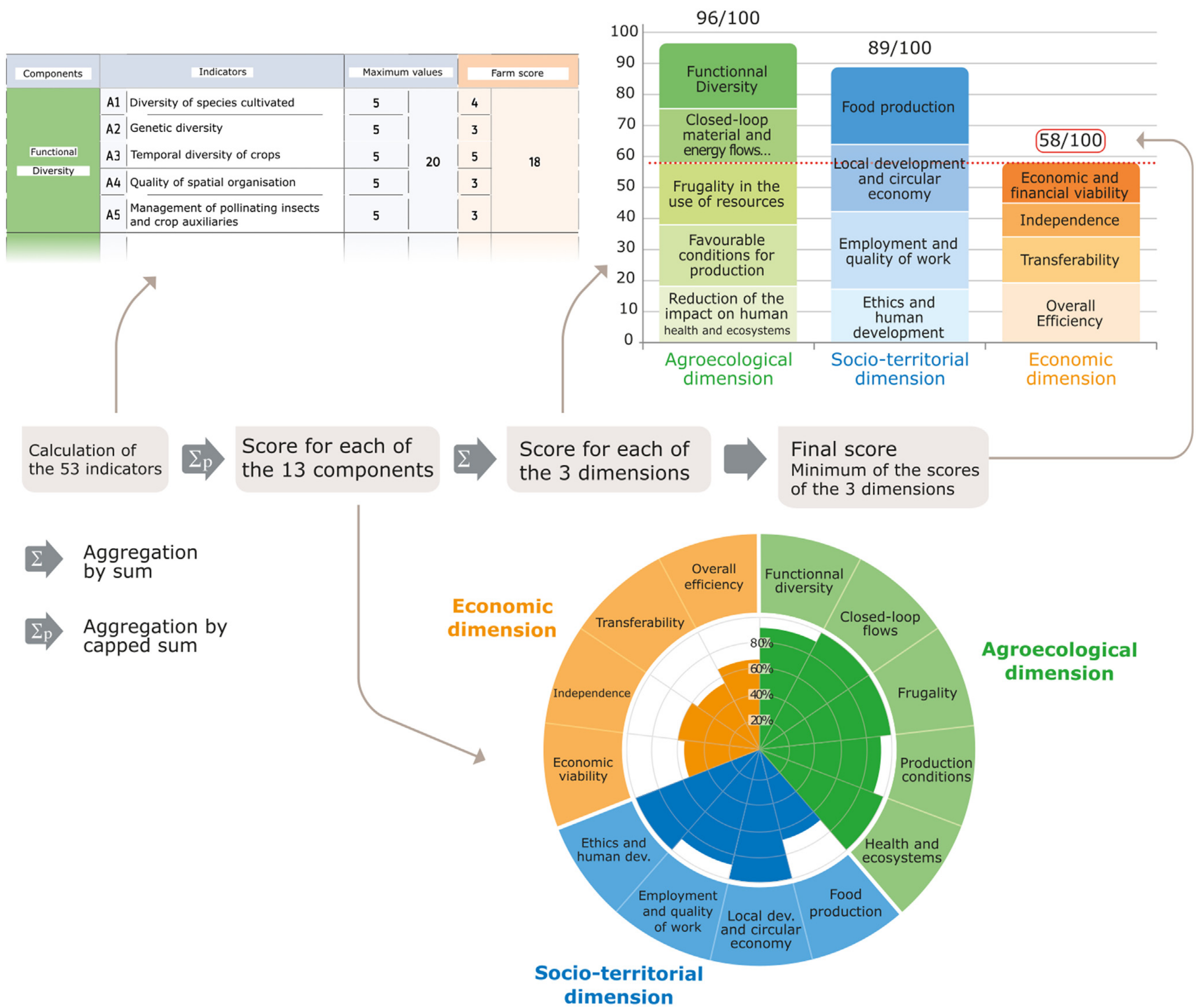


Fig. 4. Example of an assessment of a farm's final level of sustainability (according to the 3 dimensions of sustainable agriculture).
Fig. 4. *Exemple de lecture évaluative du niveau final de durabilité d'une exploitation (selon les 3 dimensions de la durabilité).*

optimize the discriminating power of the aggregation criteria (nodes and properties). Aggregation within each property is carried out step by step, following the tree structure shown in Figure 1. It is based on decision rules arranged in tables. The results can then be viewed at the level of the intermediate branches in the form of an illuminated tree, as shown by way of example in Figure 5 for the 'Autonomy' property.

To conclude, these two assessment approaches are complementary. The assessment approach based on the 3 dimensions of sustainable development (environmental, social and economic) remains an essential methodological reference for research as well as for development engineering. However, the assessment approach based on the 5 properties makes it possible to go beyond the hitherto unthought-of aspects of sustainability as promoted in the normative vision of sustainable development in 3 dimensions, *i.e.* to highlight the issues of the ability to produce and reproduce goods and services, autonomy, robustness, territorial embeddedness and overall responsibility. This approach consolidates the systemic conception of the farm: its properties are materialisations of the production system that crystallise the fact that the farm is a whole whose performance is more than that of its parts. Properties allow a transversal reading of the 3 dimensions of sustainable agriculture (agroecological, socio-territorial, economic). They allow us to examine the synergies and trade-offs between each of these dimensions.

4 Discussion

The new IDEA4 conceptual framework was designed with the following objectives in mind:
- broadening its theoretical framework by taking the properties of sustainable agricultural systems into account;
- maintaining its educational aspect so that it can continue to be used in agricultural education;

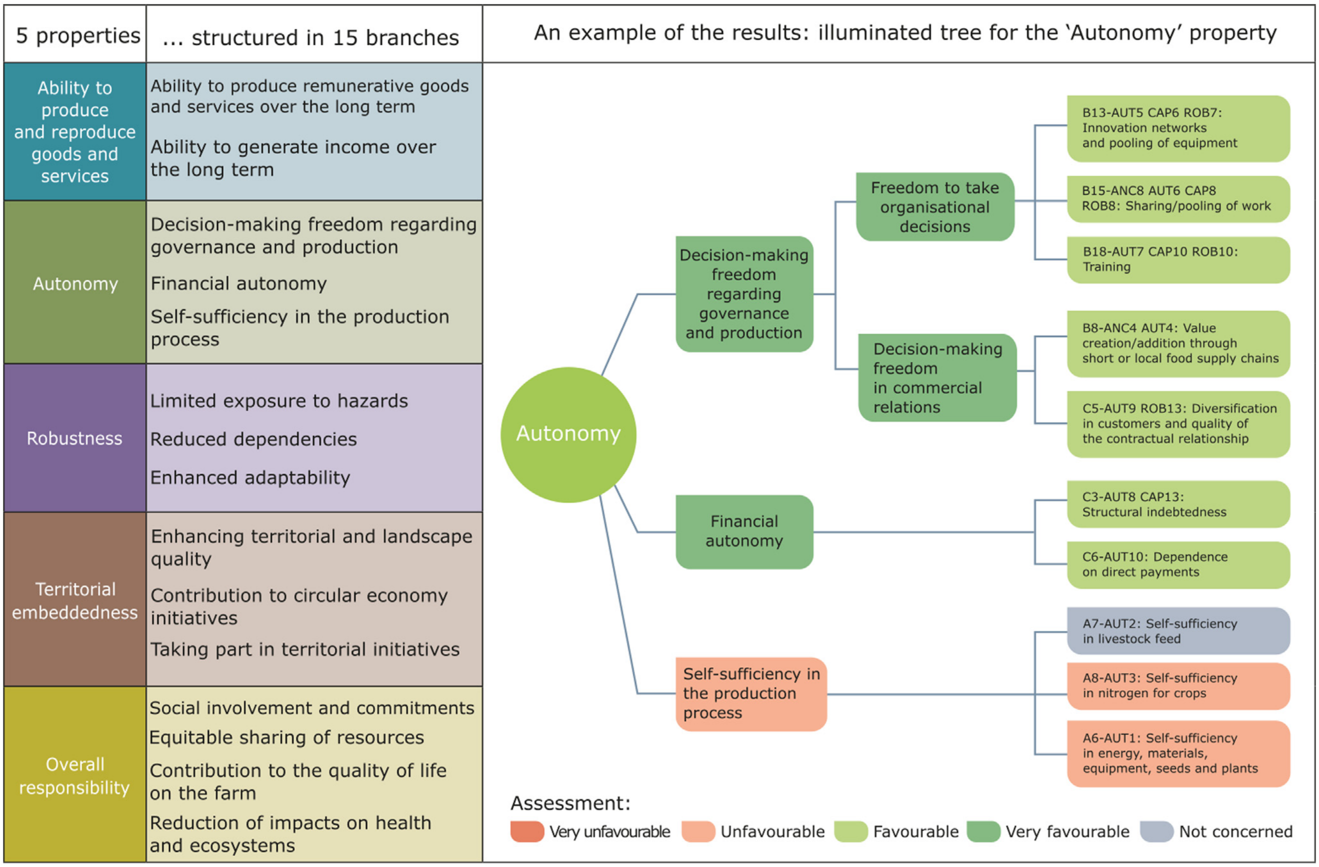


Fig. 5. Structure of the assessment according to the 5 properties of sustainable agricultural systems: example of an illuminated tree for the 'Autonomy' property.
Fig. 5. *Lecture évaluative des propriétés de la durabilité : exemple pour la propriété 'autonomie'.*

- consolidating its scientific basis by incorporating new knowledge available since the publication of IDEAv3 in 2008;
- maintaining its status as a recognised operational instrument for agricultural development entities (chambers of agriculture, consultancy firms, national agricultural and rural organisations, etc.).

This work takes account of new societal issues (food security, climate change, air quality, frugality in the use of resources) and enriches the method's theoretical framework for analysing sustainability (principles of strong agroecology, circular economy, place of collective action, frugality in the production process).

Previous versions of IDEA were considered 'non-participatory', in the sense that farmers and other stakeholders were not involved in defining sustainability objectives (Binder *et al.*, 2010). In IDEA4, while the authors decided the essential principles of the method (properties, objectives, strong sustainability, calculation rules, weightage), they then opened up their proposals to criticism and improvement by other stakeholders and users during the 10 years of work required to develop this new version. Furthermore, for its users, the method retains its principle of transparency by making accessible all the information that underpins it (theoretical corpus, methodological guide and reference frameworks), unlike other 'black box' methods or those reserved for restricted professional access under certain conditions. Along with the Swiss RISE method (Häni *et al.*, 2003), the IDEAv3 method was already the most widely used in the world of agricultural development and research in Europe (De Olde *et al.*, 2016). The IDEA4 method, with its dual assessment on the basis of dimensions and properties, has further consolidated the diversity of its uses (agricultural advice, agricultural education, research, implementation and assessment of public action). Our analysis of 60 methods for assessing sustainability in agriculture, supplemented by our re-reading of the meta-analysis by Chopin *et al.* (2021) on the 7 types of approaches for assessing sustainability, confirms the innovative nature of such a combination of two assessment grids (dimensions and properties) based on the same corpus of indicators.

As for its use in teaching, the new conceptual framework improves its educational potential for teaching farm sustainability by encouraging transdisciplinarity (agronomic sciences, human and social sciences) based on the systemic and transversal characteristics of each property. From an educational point of view, the properties-based qualitative assessment is also likely to dispel some of the reservations that have been expressed about the dimensional scoring system, which was thought to lead users to refer only to numerical results without interpreting the scores that take the farmer's rationale for action into consideration.

As for its use in farm advisory services, the IDEA4 method can also lead to revised and updated practices, in particular to support the agroecological transition, as shown by the first tests of its use in advising dairy farmers wanting to reduce greenhouse gas emissions (Manneville *et al.*, 2018). For the purposes of analysing these changes, the properties-based qualitative assessment should lead to an improved understanding of the systemic functioning of a farm as well as to a better strategic analysis by advisors, whose work and actions are still often compartmentalised by sector (Capitaine and Jeanneaux, 2016).

The IDEAv3 method has often been used, albeit in a partial way, in public action (High Environmental Value certification, territorialised agri-environmental measures, economic and environmental interest groups, water quality service contracts, etc.). The authors caution that these uses systematically require prior testing and possible adaptation. For this reason, the results of the two IDEA4 assessment grids should be considered as a barometer of sustainability and not as a *modus operandi* for a future action plan or as an administrative control or monitoring tool. It should also be emphasised that IDEA4, like its predecessors, is valid in the context of French and European agriculture. The IDEAv3 method has, however, been used in many non-European regions (Maghreb, Near East, West Africa, Canada, Latin America, etc.). While the IDEA4 analytical framework can be used for all types of agriculture, the authors recommend that the method be adapted to take account of specific local conditions (additional or different objectives assigned to sustainable agriculture, different socio-economic or environmental conditions, etc.).

Finally, how easy is it to use the IDEA4 method? Tests carried out on more than 800 farms have shown that the survey time for data collection does not exceed four hours per farm. A trained user can process and format the data in half a day using an Excel spreadsheet created for the purpose (Girard *et al.*, 2022). This spreadsheet is easy to use and can be obtained from the method's official website (https://methode-idea.org/). It can be used to calculate the 53 indicators from data collected on the farm and to implement the dimensions-based approach (automated calculation of components and dimensions, and associated graphical output). A software package called IDEATools (Carayon, 2022), written in the R language, is required to implement the properties-based approach, and in particular to produce illuminated trees for each farm. It can also be used to carry out group analyses by processing data from several farms together. The WEB-IDEA platform allows users to access the IDEATools functions via a push-button interface (see https://web-idea.inrae.fr/). By pooling users' work, the platform also generates reference data on the sustainability of farms on a national or regional scale.

5 Conclusion

The main contributions of the formalisation of a new conceptual framework in IDEA4 for assessing farm sustainability are:

– a detailed listing and explanation of the properties of a sustainable agricultural production system;
– the affirmation of a normative reference system based on 12 objectives of sustainable agriculture to qualify the values associated with this concept;
– a proposal for assessing farm sustainability in two ways, one based on the 3 dimensions of sustainable agriculture (agroecological, socio-territorial and economic) and the other based on the 5 properties of sustainable agricultural systems (ability to produce and reproduce goods and services, autonomy, robustness, territorial embeddedness and overall responsibility);
– the development of three operational IT tools that are freely available (IDEA4 Excel Calculator, IDEATools and WEB-IDEA platform) and of the official IDEA method website, which provides access to the most up-to-date versions of these tools.

Future research will focus on three areas. The first is the consolidation of the open data approach to sustainability data by developing version 2.0 of the WEB-IDEA platform. This will make it possible to use data in addition to that already collected by the calculator to enhance the platform's analytical capacity and to conduct research into the determinants of sustainability. The second is the examination of the ability of this dual assessment to support development actors in undertaking an agroecological transition, in order to understand this transition's effects and identify the levers for action on farms. The third is a broader analysis of how this dual assessment approach contributes to the strategic management of farms.

Acknowledgements

The authors would like to thank Educagri éditions for the graphic design of the figures. The development of the IDEA4 method was financially supported by the Ministry of Agriculture and Food Sovereignty as part of the ACTION project (CASDAR innovation and partnership, 2017–2022).

This article is an updated translation of an article originally published in French in *Cahiers Agricultures*, 'Évaluer la durabilité des exploitations agricoles. La méthode IDEA v4, un cadre conceptuel combinant dimensions et propriétés de la durabilité', DOI: 10.1051/cagri/2019004

References

Alkan Olsson J, Bockstaller C, Stapleton L, Ewert F, Knapen R, Therond O. 2009. A goal-oriented indicator framework to support integrated assessment of new policies for agri-environmental systems. *Environmental Science & Policy* 12(5): 562–572. https://doi.org/10.1016/j.envsci.2009.01.012

Astier M, Speelman EN, López-Ridaura S, Masera OR, Gonzalez-Esquivel CE. 2011. Sustainability indicators, alternative strategies and trade-offs in peasant agroecosystems: analysing 15 case studies from Latin America. *International Journal of Agriculture Sustainability* 9(3): 409–422. https://doi.org/10.1080/14735903.2011.583481.

Binder CR, Feola G, Steinberger JK. 2010. Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture. *Environmental Impact Assessment Review* 30 (2): 71–81. https://doi.org/10.1016/j.eiar.2009.06.002.

Bohanec M, Messéan A, Scatasta S, Angevin F, Griffiths B, Krogh PH, *et al.* 2008. A qualitative multi-attribute model for economic and ecological assessment of genetically modified crops. *Ecol Modeling* 215: 247–261.

Bossel H. 1999. *Indicators for sustainable development: theory, method, applications*. Winnipeg (Canada): IISD, 118 p..
Capitaine M, Jeanneaux P. 2016. *Agriculture en mouvement : innovations stratégiques et performance globale*. Educagri Éditions, 120 p.
Carayon D. 2022. IDEATools: A Collection of Tools Dedicated to the IDEA4 Method. R package. Version 3.3.1 Zenodo. https://doi.org/10.5281/ZENODO.6811276.
Chia E, Rey-Valette H, Lazard J, Clément O, Mathé S. 2009. Évaluer la durabilité des systèmes et des territoires aquacoles: proposition méthodologique. *Cahiers Agric* 18 (2-3): 211–219. https://doi.org/10.1684/agr.2009.0298
Chopin P, Mubaya CP, Descheemaeker K, Öborn I, Bergkvist G. 2021. Avenues for improving farming sustainability assessment with upgraded tools, sustainability framing and indicators. A review. *Agronomy for Sustainable Development* 41(2): 1-20. https://doi.org/10.1007/s13593-021-00674-3.
Conway GR. 1987. The properties of agroecosystems. *Agricultural Systems* 24(2): 95–117. https://doi.org/10.1016/0308-521X(87)90056-4.
Daly HE. 1990. Towards some operational principles of sustainable development. *Ecological Economics* 2(1): 1–6. https://doi.org/10.1016/0921-8009(90)90010-R.
De Olde EM, Oudshoorn FW, Sørensen CA, Bokkers EA, de Boer IJ. 2016. Assessing sustainability at farm-level: lessons learned from a comparison of tools in practice. *Ecological Indicators* 66: 391–404. https://doi.org/10.1016/j.ecolind.2016.01.047.
Girard S, Aroyo-Bishop A, Steinmetz L, Zahm F. 2022. Calculateur IDEA4: un outil transparent pour faciliter la mise en œuvre de la méthode IDEA4-Excel Workbook. Zenodo. https://doi.org/10.5281/ZENODO.6945803.
Gliessman SR. 2005. Agroecology and agroecosystems. In: Pretty J (ed.), *The Earthscan reader in sustainable agriculture*. London (UK): Earthscan, pp. 104–114.
Häni F, Braga F, Stämpfli A, Keller T, Fischer M, Porsche H. 2003. RISE – a tool for holistic sustainability assessment at the farm level, *International Food and Agribusiness Management Review* 6(4): 78–90.
Hansen JW. 1996. Is agricultural sustainability a useful concept? *Agric Systems* 50 (2): 117–143. https://doi.org/10.1016/0308-521X(95)00011-S.
Hubert B. 2004. Agricultures et développement durable enjeux de connaissances et attitudes de recherche. Johannesbourg – L'INRA face au développement durable. *Dossier Environnement INRA* 27: 41–54.
Konefal J, de Olde EM, Hatanaka M, Oosterveer PJM. 2023. Signs of agricultural sustainability: A global assessment of sustainability governance initiatives and their indicators in crop farming. *Agricu Systems* 208: 103658. https://doi.org/10.1016/j.agsy.2023.103658
Lairez J, Feschet P, Aubin J, Bockstaller C, Bouvarel I. 2015. Évaluer la durabilité en agriculture. Guide pour l'analyse multicritère des productions animales et végétales. Versailles (France): Quae, 231.
López-Ridaura S, Van Keulen H, Van Ittersum MK, Leffelaar PA. 2005. Multiscale methodological framework to derive criteria and indicators for sustainability evaluation of peasant natural resource management systems. *Environment Development Sustainability* 7: 51–69. https://doi.org/10.1007/s10668-003-6976-x.
Manneville V, Girard S, Zahm F. 2018. Les propriétés de la durabilité en agriculture pour préparer la transition agroécologique face à l'enjeu du changement climatique, projet LIFE Carbon Dairy, IDELE, Collection Résultats.
Pope J, Annandale D, Morrison-Saunders A. 2004. Conceptualising sustainability assessment. *Environmental Impact Assessment Review* 24 (6): 595–616. https://doi.org/10.1016/j.eiar.2004.03.001
Reed MS, Fraser ED, Dougill AJ. 2006. An adaptive learning process for developing and applying sustainability indicators with local communities. *Ecological Economics* 59 (4): 406–418. https://doi.org/10.1016/j.ecolecon.2005.11.008.
Robert WK, Parris TM, Leiserowitz AA. 2005. What is sustainable development. *Environment Science and Policy Sustainable Development* 47 (3): 8–21. https://doi.org/10.1080/00139157.2005.10524444.
Rousselet A. 2011. Durabilité des exploitations agricoles et méthode IDEA. Analyse de l'utilisation et perception de la méthode sur la période 2000 à 2010. Mémoire d'ingénieur AgroSup Dijon sous la direction de F. Zahm (Irstea) et L. Guichard (INRA), 328 p.
Sala S, Ciuffo B, Peter Nijkamp P. 2015. A systemic framework for sustainability assessment. *Ecologilcal Economics* 119: 314–325. https://doi.org/10.1016/j.ecolecon.2015.09.015.
Schader C, Grenz J, Meier MS, Stolze M. 2014. Scope and precision of sustainability assessment approaches to food systems. *Ecology &Society* 19 (3): 42. https://doi.org/10.5751/ES-06866-190342.
Terrier M, Gasselin P, Le Blanc J. 2013. Assessing the sustainability of activity systems to support households farming projects, In: Marta-Costa A (ed). *Methods and procedures for building sustainable farming systems: application in the European context*. Netherlands: Springer, pp. 47–61. https://doi.org/10.1007/978-94-007-5003-6_5.
United Nations. 2015. *Transforming our world: the 2030 Agenda for Sustainable Development*. New York.
Van Cauwenbergh N, Biala K, Bielders C, Brouckaert V, Franchois L, Garcia V, *et al.* 2007. SAFE-A hierarchical framework for assessing the sustainability of agricultural systems. *Agriculture Ecosystems & Environment* 120 (2-4): 229–242. https://doi.org/10.1016/j.agee.2006.09.006.
Vilain L, Boisset K, Girardin P, Mouchet C, Viaux P, Zahm F. 2008. La méthode IDEA Indicateurs de durabilité des exploitations agricoles, 3e édition. Dijon (France): Ed. Educagri, 184 p.
Von Wirén-Lehr S. 2001. Sustainability in agriculture – an evaluation of principal goal-oriented concepts to close the gap between theory and practice. *Agriculture, Ecosystems & Environment* 84 (2): 115–129. https://doi.org/10.1016/S0167-8809(00)00197-3
Zahm F, Viaux P, Vilain L, Girardin P, Mouchet C. 2008. Farm sustainability assessment using the IDEA method. From the concept of farm sustainability to case studies on French farms. *Sustainable Devlopment* 16: 271–281. https://doi.org/10.1002/sd.380.
Zahm F, Alonso Ugaglia A, Boureau H, Del'homme B,Barbier JM, Gasselin P, *et al.* 2015. Agriculture et exploitation agricole durables : état de l'art et proposition de définitions revisitées à l'aune des valeurs, des propriétés et des frontières de la durabilité en agriculture. *Innovations Agronomiques* 46: 105–125.
Zahm F, Girard S, Alonso Ugaglia A., Barbier JM., Boureau H, Carayon D, *et al.* 2023. La Méthode IDEA4-Indicateurs de durabilité des exploitations agricoles. Principes & guide d'utilisation. Évaluer la durabilité de l'exploitation agricole. Dijon (France): Ed. Educagri 339 p. https://www.edued.fr/LS/IDEAV4.

Cite this article as: Zahm F, Ugaglia AA, Barbier J-M, Carayon D, Del'homme B, Gafsi M, Gasselin P, Gestin C, Girard S, Guichard L, Loyce C, Manneville V, Redlingshöfer B, Rodrigues I. 2024. Assessing farm sustainability: the IDEA4 method, a conceptual framework combining dimensions and properties of sustainability. *Cah. Agric.* 33: 10. https://doi.org/10.1051/cagri/2024001