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WHAT ARE THE INDICATORS FOR ASSESSING AND MONITORING THE AGROECOLOGICAL TRANSITION AT THE TERRITORIAL LEVEL?

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ABSTRACT

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Agroecological systems stand as an alternative for sustainable agricultural production. This leads the stakeholders in farming to evolve towards sustainable farming that preserves ecosystems. However, the conventional production-oriented farming system generally uses imbalance and excessive chemical inputs that harm the environment and human health. The study observed the agroecological transition, compares yields between organic and conventional farming on the one hand, and between ecological and conventional farming on the other hand. The study also identifies variables that can be used to set up indicators to assess the agroecological transition. The results of this meta-analysis indicate a significant increase in yield with conventional farming compared to organic farming and a significant increase in yield with ecological farming systems compared to conventional farming systems. The results also highlight some indicators which can be used in the assessment of the agroecological transition at territorial level. These variables are included in the environmental, socio-territorial, cultural and economic dimensions. This article is part of a reflection upstream of a process of construction of a set of indicators to objectively assess the progress of territory on agroecological transition.

Key words: *meta-analysis, transition, agroecology, indicators, territory*

INTRODUCTION

Recently, the agricultural production model has focused on the intensive use of chemical pesticides and chemical fertilizers. Therefore, the conventional mode of production systems is a threat to the environment and biodiversity (Aubertot *et al*. 2005; Isenring 2010). Reducing chemical pesticide and fertilizer use to preserve the environment and human health is nowadays a societal demand. Consequently, it is imperative to reduce risks by increasing investment in more environmentally friendly production methods. A transition to agroecological production systems is necessary. Agroecology is based on traditional and ecological knowledge, values social capital (HLPE 2019). Farmers are increasingly being encouraged to adopt more sustainable production systems through programs that involve all agricultural stakeholders (researchers, local authorities, producers, NGOs, etc.). It is important to assess progress made in the ongoing paradigm shift. Previous research on assessing the performance of agroecological transition was more focused on the development of indicators to assess farm sustainability scores. Examples include the IDEA model of Vilain *et al*. (2008) in France that assesses the sustainability of mixed crop and livestock production systems, the IDPM model based on the IDEA model developed by Ahouangninou *et al*. (2016) in Benin, which evaluates sustainability scores of vegetable production farms, and the IDEM/BF model in Burkina-Faso (Ouédraogo *et al*. 2020). These models enable producers to make diagnoses and improve the performance of their farms on environmental, socio-territorial and economic dimensions.

The environmental issues related to the functioning of agroecosystems cannot be solved only at the farm level (Oxfam 2014). Environmental processes (biogeochemical and ecological) occur beyond the plot and farm scales. The territory remains the appropriate scale for analyzing the amplification of the agroecological transition. According to Oxfam (2014), significant results can only be expected at the scale of territorial entities where ecological and economic threshold effects can be understood and influenced. Including the landscape provides a better overview of the various interactions between agricultural activities, the environment and the resources it provides (soil, water, biodiversity), and thus enables new paths for agroecological management to be explored (Gascuel-Odoux and Magda, 2015).

By proposing an exhaustive review using meta-analysis methods, this paper aims to contribute to the existing literature on showing the performance of agroecology and to identify the factors leading to the development of agroecology, which will be used to propose agroecological transition assessment indicators at the territorial level.

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MATERIALS AND METHODS

This section describes the method of review selection and how the data was extracted. It also presents the meta-analytic method used to compare the yields of different types of farming as well as the qualitative analysis approach used.

Data collection

Using AJOL, AGRI and AGRICOLA indexing databases, two databases were created. The first one is related to agricultural yields in organic farming, conventional farming and sustainable farming forms. The second database is related to the selection of research papers that have dealt with the agroecological transition.

To establish the database on agricultural yields, the terms yields, productivity, conventional farming, organic farming, ecological farming, sustainable farming as well as associations of one of these themes and their meanings in French were used. Two hundred and thirty-two (232) documents (scientific articles, synthesis, communications, books) were listed, 38 of which included yield data, but only 21 studies with 28 extracted test results were selected for review (Table 1). For the second database, the terms agroecological transition, agroecological conversion, agroecological indicators, agroecological transition trajectories were used to investigate in the indexing databases. One hundred and twenty-six (126) documents (scientific articles, reviews, activity reports, communications, books) were identified. However, using the main criterion "agroecological transition", only thirty-nine documents (39) were considered for analysis.

Table 1. Selected research papers comparing yields between conventional and organic farming

Codes	Authors	Publication year	Country
ABR	Abrina *et al.*	2002	Philippine
POP	Popovic *et al.*	2013	Serbia
BIR	Birkhover *et al.*	2008	Germany
ILK	Ilker *et al.*	2010	Turkey
KRO	Kromberga *et al.*	2013	Latvia
ALA	Alaphillipe *et al.*	2014	France
HAN	Hanakhova and Hlinku	2004	Slovakia
OPL	Oplanic *et al.*	2009	Croatia
SAR	Sardana *et al.*	2013	India
ALAR	Alaru *et al.*	2014	Estonia
ESP	Espiritu *et al.*	2008	Madagascar
NAS	AL-Ghumaiz	2014	Saudi Arabia
ROD	Rodriguez *et al.*	2006	Brasilia
DUM	Duman *et al.*	2018	Turkey
ADA	Adamtey *et al.*	2016	Kenya
WOO	Woomer *et al.*	2004	Kenya
MEA	Meaza *et al*.	2007	Ethiopia
BRE	Brezeanu *et al.*	2013	Roumania
GET	Getachew *et al.*	2012	Ethiopia
GIR	Girma and Grebeyes	2017	Ethiopia
DAR	Dargie *et al.*	2018	Ethiopia

Quantitative meta-analysis

The meta-analysis was carried out using the R version 4.0.4 software with the "rmeta", "meta" and "forestplot" libraries (Gaudart *et al*. 2010). The meta-analysis was carried out on a continuous variable "yield" using the "metacont" function where MD (Mean Difference) was the simple difference of the means. Yields in organic and conventional farming were compared on the one hand, and yields in conventional farming and other forms of ecological farming were compared on the other hand. In addition, these analyses were replicated separating the yields of cereal crops and other crops (fruits and vegetables). The command forest was used to generate the forest plot. Finally, a linear regression was used to identify the factors determining the non homogeneity between the results of the studies.

Qualitative analysis

The qualitative analysis was carried out based on data on the agroecological transition. For each paper, the names of the authors, country, title of the paper, type of study and year of study were provided in an Excel spreadsheet. Through an examination of all these documents, the different themes related to the agroecological transition measurement indicators were extracted. The occurrences of these themes or words in each study were determined. A Multiple Correspondence Analysis (MCA) followed by an Ascending Hierarchical Classification (AHC) coupled with K-means was then performed to identify groups or types of similar studies using R4.0.4 software. Finally, at the end of this analysis, relevant indicators to assess the progress of territory in agroecology were identified.

RESULTS AND DISCUSSION

Comparison of the system of production

Organic versus Conventional Farming

The results presented in Figure 1 show that a very high degree of heterogeneity exists between these researches.

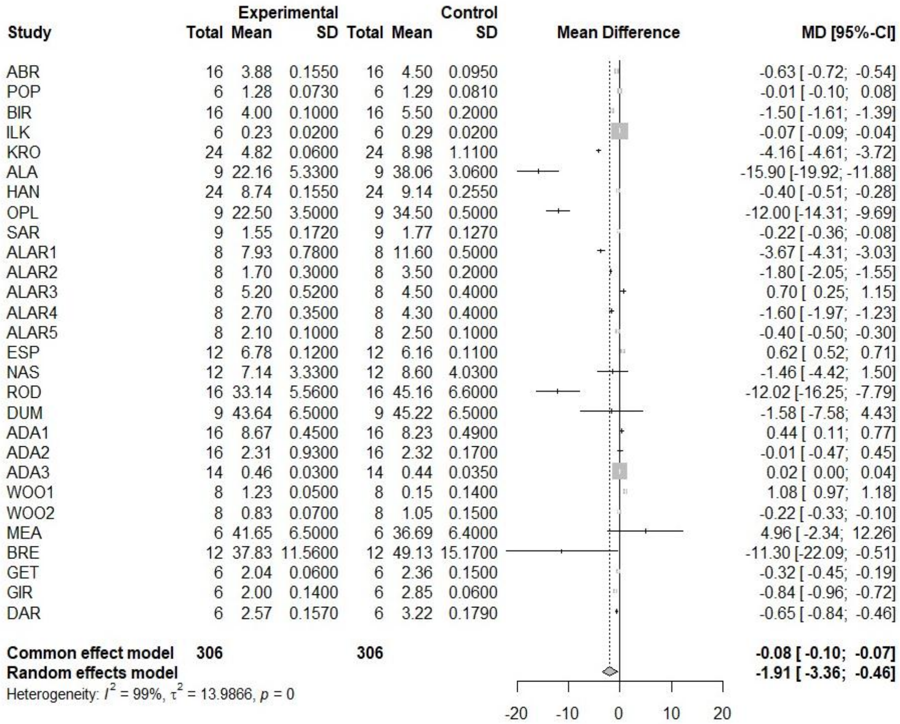

Fig. 1. Forest plot of organic versus conventional farming

A significant difference is observed at 5% threshold between conventional and organic yields for several studies, except for the results of Popovic *et al*. (2013), AL-Ghumaiz (2014), Duman *et al*. (2018), Meaza *et al.* (2007). The fixed-effect model and the random-effect model produce the same results and conclude that a significant difference in yields between conventional and organic farming is observed at the 5% threshold.

Multiple linear regression was used to identify the factors determining the non-homogeneity of the results. The final model was selected based on AIC criteria. From this model, it appears that non-homogeneity is influenced by the region in which the study was conducted (Table 2). Significant coefficients are noted for the "America" and "Europe" regions. The results for these two regions differ significantly from those of the studies conducted in Africa.

Table 2. Determinants of heterogeneity among study outcomes

	Estimate	**Std. Error**	**t-value**	**Pr(>|t|)**
(Intercept)	0.4950	1.3404	0.369	0.71514
America	-12.5150	4.2387	-2.953	0.00694 **
Asia	-0.9185	2.4164	-0.380	0.70721
Europa	-4.3294	1.7180	-2.520	0.01880 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1;
Residual standard error: 4.021 on 24 degrees of freedom
Multiple R-squared: 0.353, Adjusted R-squared: 0.2722;
F-statistic: 4.365 on 3 and 24 DF, p-value: 0.01373

Focusing on cereal crops, there is also a high degree of heterogeneity among study results with similar results between fixed-effect (common effect) and random-effect models (Figure 2). The results show a significant increase in yields with conventional cereal crops compared to organic. A significant coefficient is observed for the "Europe" region compared to the "Africa" region.

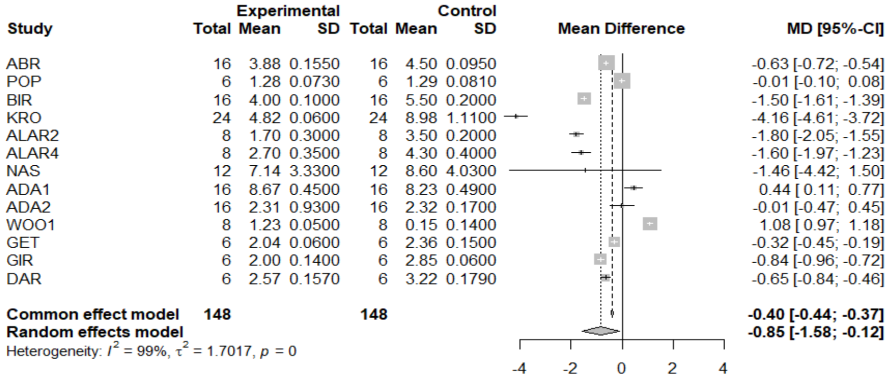

Fig. 2. Forest plot of Organic versus conventional cereal crops

Considering the other types of crops (vegetables and fruits), the results also indicate a strong heterogeneity between the studies (Figure 3). A significant difference between conventional and organic was obtained for all studies considered except for Duman *et al.* (2018) and Adamtey *et al.* (2016). Overall, when considering the fixed (common) and random effect models, a significant increase in yield of vegetables and fruits was observed in conventional compared to organic at the 5% threshold. The source of the heterogeneity is the region factor. A significant coefficient is observed for the "America" region compared to the "Africa" region. This study is in line with Seufert *et al*. (2012) who report that organic farming has a yield 13% to 34% lower than conventional farming and also with Pellejero *et al.* (2017) who find higher lettuce yields with the urea-based production system compared to those based on compost.

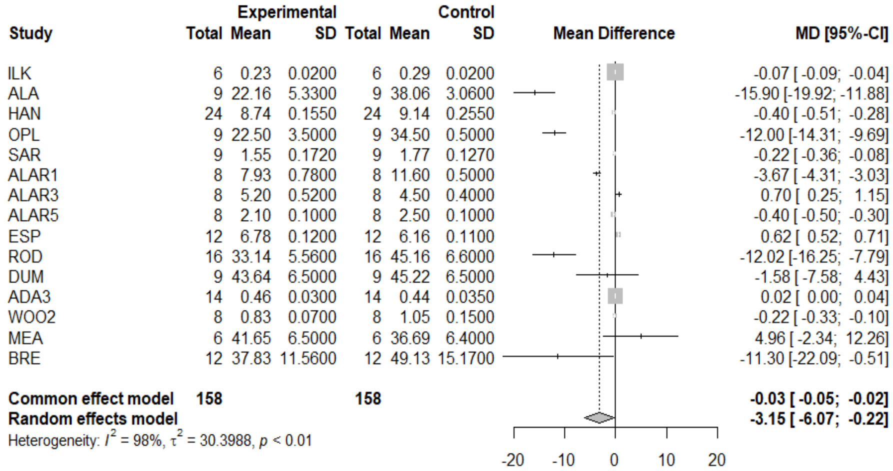

Fig. 3. Forest plot of Organic versus conventional vegetables and fruits

Agroecology compared to conventional farming

There is also non-homogeneity between studies comparing conventional systems and forms of ecological farming not organic (Figure 4). No significant difference between the two systems is observed based on the findings of Abrina *et al*. (2002) and Alaphillipe *et al.* (2014), although yields in the conventional system appear to be higher. Only the study by Struck *et al*. (2019) shows a significant yield difference between conventional and ecological farming at the 5% threshold. However, a significant increase in yield is observed in the studies of Sardana *et al*. (2013) and Bruelle *et al*. (2014) for ecological forms of farming compared to conventional farming. Soltoft *et al*. (2010), find a higher yield in conventional farming compared to ecological farming in their studies.

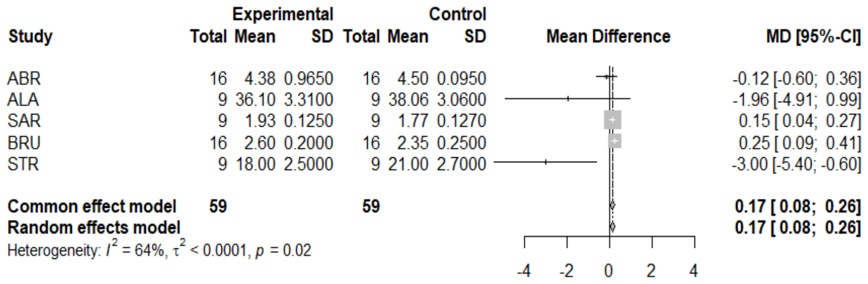

Fig. 4. Forest plot for ecological versus conventional farming

Overall, there is no difference in results between fixed-effect (common effect) and random-effect models. The fixed-effect and random-effcet model indicate a significant increase of yield in ecological production compared to the conventional production systems of vegetables, fruits and legumes.

Identified clusters of studies contributing to the literature on agroecological transition

Keywords in dimension 1 of ACM are principles of agroecology, the definition of agroecology, conventional farming, the productivity of agroecology, conversion, history of agroecology, policies, certification, organic farming, conservation farming, sustainable farming, trajectories (Table 3, Figure 5).

Table 3. Dimensional Variables from the ACM

Variables	Dimension 1		Dimension 2		Dimension 3	
	R2	P-value	R2	P-value	R2	P-value
Principles_agroecology	0.587	0.000				
Conventional_Farming	0.518	0.000				
Definition_agroecology	0.489	0.000				
Productivity_agroecology	0.489	0.000				
Conversion	0.479	0.000				
History_agroecology	0.415	0.000				
Organic_Farming	0.316	0.0002				
Politicies	0.317	0.0002	0.134	0.02		
Certification	0.304	0.0003				
Sustainable_farming	0.223	0.002			0.179	0.007
Conservation_Farming	0.217	0.003	0.282	0.0005		
Positive_impacts_agroecology	0.189	0.005	0.194	0.003	0.109	0.04
Trajectoires	0.169	0.009			0.247	0.003
Regulation	0.138	0.02			0.128	0.02
Transitions					0.258	0.0009
Regions_and_Territories			0.433	0.000		
Monitoring_Tools_Evaluation			0.373	0.000		
sustainability_indicators			0.352	0.000		
Irrigation			0.312	0.0004		
Indicators_agroecology			0.256	0.001		
Economy			0.246	0.001		
Agroecological_evaluation_transition_indicators			0.232	0.002	0.435	0.000
Phytosanitary_Practices			0.132	0.02	0.188	0.006
Agroecological_transition					0.516	0.000
Fertilization					0.366	0.000
Monitoring and evaluation tools					0.233	0.003
Certification					0.175	0.008

In the second axis, the following groups of words are identified: conservation farming, positive impacts of agroecology, regions and territories, monitoring-evaluation tools, sustainability indicators, irrigation, economy, policies. Dimension 3 is correlated to the groups of words: sustainable farming, transition, trajectory, phytosanitary practices, fertilization, monitoring- evaluation tools, transition evaluation indicators, certification.

An Ascending Hierarchical Classification (ACH) coupled with K-means was used to identify four groups of observations (Figure 5).

Class 1: it includes:

-100% of the observations in this class concern conversion and 50% of the observations concerning conversion belong to this class.

-90% of the observations in this class cite sustainability indicators and 56.25% of the observations addressing sustainability indicators belong to this class.
-90% of the observations in this class report indicator that can assess transition and 50% of the observations report indicators that can assess transition belong to this class.
100% of the observations concern agroecology transition and productivity
The CIR observation is the paragon (close to the center of gravity) of this class and CLA the most characteristic of this class (the furthest from the other classes).

Class 2: it includes:
-63.63% of the observations in this class are about conservation farming.
-62% of the observations in this class concern the history of agroecology.
-66.66% of the observations deal with organic farming.
-12.5% address agroecological indicators.
The LAM observation is the paragon (close to the center of gravity) of this class and BAT the most characteristic of this class.

Class 3: it includes:
-100% of observations in this class concern phytosanitary and irrigation products and 87.5% of observations citing these themes belong to this class.
-62.5% of observations in this class cite the word transition
The BRI observation is the paragon (close to the center of gravity) of this class and ZAH2 the most characteristic of this class.

Class 4: it includes:
-69.23% of observations in this class cite fertilization and policies
-46.15% cite "sustainable farming".
-31% cite "productivity in agroecology and phytosanitary products".
The PIG observation is the paragon (close to the center of gravity) of this class and MID the most characteristic of this class.

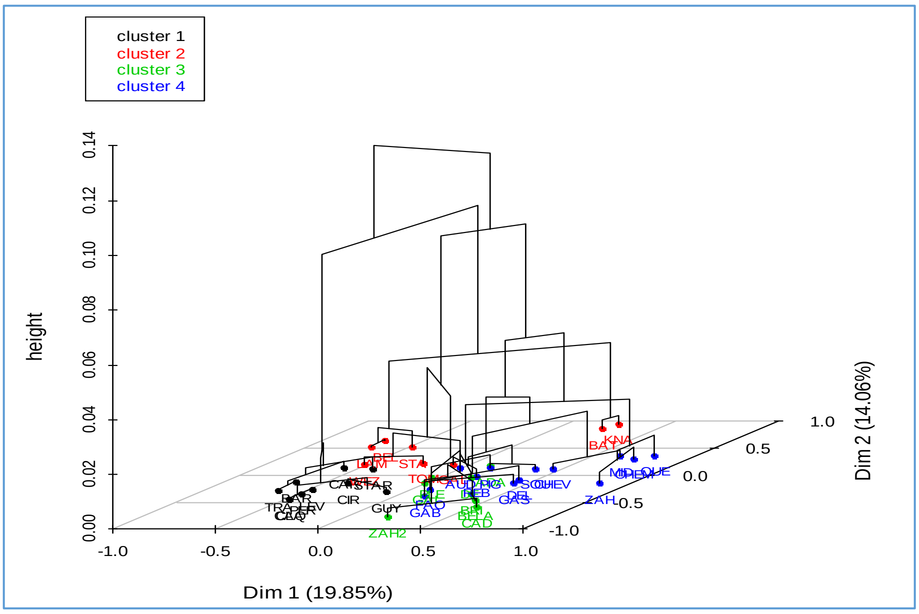

Fig. 5. K-means coupled Hierarchical Ascending Classification of observations and 3D visualization

Agroecological conversion and transition

All of the selected research papers included the words "transitions" (89.74%) or "conversion" (51.28%) or both (43.59%).

Transition is the process of moving from one state to another or from one idea to another. It can be seen as a way or a link in this change. It also relates to the word conversion, which evokes " transformation " or a change in practices. These words have often been associated with the themes: agroecology, conventional farming, organic farming, ecological farming, sustainable farming, conservation at the level of the selected studies.

Every farming system other than conventional farming can be part of an ecological farming system that integrates sustainability and can be qualified as sustainable. Conventional farming uses chemical inputs (pesticides and fertilizers) which leads to land impoverishment through structural degradation (Calvet *et al.* 2005), loss of biodiversity (earthworms, beneficial/auxiliary insects) (Pimentel *et al.* 1993 and 1997; van der

Werf, 1997; Aubertot *et al*. 2005; Isenring 2010), pollution of water and rivers (Pazou *et al*. 2006a; 2006b), impact on human health (Baldi *et al*. 2013) does not guarantee continuity of agricultural production on the same farms in a medium and long term. A new paradigm towards a more ecological farming that guarantees sustainable production is necessary. Agroecological transition is associated with this paradigm in the literature. 71.79% of the selected studies cited the theme "agroecological transition". Most of the studies such as those of Zahm (2013); Trabelsi (2017) and Perez *et al*. (2019) focused on the assessment of transition at farm level. Trabelsi (2017) finds that existing tools are only suitable for assessing the sustainability of conventional farms and not adapted to organic and agroecological systems. By comparing IDEA, RAD and DIALECTE on three agroecological production farms, she obtains different rankings according to these indicators. The IDPM (Ahouangninou *et al*. 2016) and IDEM/BF (Ouédraogo *et al.* 2020) tools, adaptations of the IDEA model (Vilain *et al*. 2008; Zahm 2013) in tropical Africa are also tools for assessing practice change that only consider the plot and the farm on the three dimensions of Sustainable Development. Organic or ecological farming that preserves the environment and the health of the producer but does not ensure that he can feed his family and support their needs is unsustainable. Considering mainly the agroecological dimension, these indicators can be used to assess transition from conventional farms to a more ecological farming. However, what about organic or agroecological farms, how can they be compared? Trabelsi (2017) contributes to the literature by developing indicators that can better discriminate ecological farms based on their level of intensification. If there are tools to measure the progress of farms towards sustainability, this is not the case at the territorial or regional level. No study in the literature consulted has objectively constructed indicators to measure the agroecological transition at the territorial level.

Some studies refer to indicators or variables to assess the transition (Audoin *et al*. 2018; Gascuel-Odoux and Magda, 2015; Bellon 2016; Caquet *et al.* 2019), while other papers such as those of FAO (2019) and Lévard *et al.* (2019) further provide a set of qualitative indicators to assess agroecological transition at the territorial level.

Which indicators to evaluate agroecological transition at the territorial context?

By examining the FAO (2019) indicators on the one hand, and those developed by the GTAE (Lévard *et al*. 2019) on the other hand, and cross-checking them with relevant themes or words found on the literature, it appears that some of these indicators occur most often. The indicators: soil organic matter, soil health, agrobiodiversity or agricultural biodiversity, productivity or yield, exposure to pesticides/pesticides come most often in the literature with respective frequencies of 76.92%, 74.36%, 87.17%, 71.79% and 56.41% (Table 4). Moreover, there are also some indicators not as frequently cited as the previous ones, with however, quite high citation frequencies in the literature of 48.71%, 46.25%, 38.46%, 33.33%. They are respectively: food diversity or food and nutritional security, net income or performance estimation and evaluation, productivity stability, land tenure security.

Table 4. Frequency of occurrence of FAO and GTAE indicators in the consulted literature

	FAO (2019)		GTAE (Lévard *et al.* 2019)	
Dimensions	**Criteria**	**Performance Indicators**	**Indicators**	**Frequency of Indicators Appearing in Consulted Literature (%)**
Environment and Climate Change	Soil health	Soil organic matter		76.92
		Soils health	Soils health	74.36
	Biodiversity	Agrobiodiversity	Soils health, the effectiveness of bio-aggressor regulation	87.17
Health and Nutrition	Food security and nutrition	Food diversity	Food and nutritional security	48.71
		Experience of food insecurity		25.64
	Health	Pesticide Exposure		56,41
Culture and society	Gender and equity	Empowerment of women	Empowerment of women	7.69
	Decent work, migration and well-being	Youth Employment Opportunity	Attractiveness of farming for young people	38.46
Economy	Incomes	Net Income	Estimation and evaluation of performance	46.15
		Incomes stability		23.16
	Inequality	Repartition of incomes		7.9
		Productivity	Yields	71.79
		Stability of Productivity		38.46
Governance	Access to the land	Security of land tenure	Land security	33.33

Besides the FAO (2019) and GTAE (Lévard *et al.* 2019) indicators, other indicators likely for assessing the progress made in agroecology at the territorial level have been identified in the literature (Table 5). Regarding the environmental dimension, the following groups of words or similar are identified: management of biodiversity (87.18%), management of nitrogen flows (69.23%), quantitative water management (61.54%), pest management (56.41%), management of non-cultivated areas and interfaces (51.28%), sustainable farming (organic amendments and compost, reduction of chemical pesticides) (51.28%), management of interstitial spaces, grassed strips and hedges (48.72%), implementation of hedges and flowering strips (46.15%). Biodiversity management appears as an indicator of agroecological transition in the FAO (2019) "biodiversity" and for GTAE (Lévard *et al*. 2019) "agrobiodiversity" indicators. According to Enjalbert *et al.* (2019), the agroecological transition involves, firstly, the use of high biodiversity to reduce the negative impacts of agricultural systems. The agroecological transition is thus largely based on a diversity of plant species that promotes the establishment of wildlife biodiversity, which plays an important role in regulating pest populations. Biodiversity is a fundamental component on which organic production systems are developed, which favour the development of high biodiversity and therefore integrate the agroecological transition indicators. Bellon (2016) reports that organic farming provides a reference for agroecology to highlight the potential for agroecological transition. Organic farming is thus a model of agroecological transition (Bellon 2016). But it is not the only model of transition to agroecology. Other models minimizing the use of chemical inputs, such as conservation farming, can also serve as models for agroecological transition.

Concerning the socioterritorial and cultural dimension, the following groups of words have appeared in the reviewed literature: relationships with the stakeholders of the territory (69.23%), co-production and sharing of knowledge (69.23%), relationships between consumers and producers (66.66%), relationships between farming professionals (61.54%), political will at the collective scale (66.66%), territorial governance (existence and application of texts and standards) (56.41%), collective management (56.41%), the definition of objectives and priorities for action (51.28%), re-appropriation of traditional knowledge (48.72%), involvement of farmers' cooperatives (35.89%), mass training and monitoring (35.89%). The paradigm of Sustainable Development considers the multifunctionality of farming as an activity with economic, social and environmental functions, responding to the needs of the surrounding population without causing any nuisance (Poulot 2014). Thus, relations between farmers and consumers are important, as are relations between farmers and decision-makers and extension practitioners. The interrelationships between producers contribute to knowledge sharing in order to optimize yields. Policy levers are also important in the agroecological transition (Côte *et al*. 2018).

With regards to the economic dimension, four groups of words or related terms have been identified. First, the independence of farms (38.46%), second, the profitability of farms (38.46%), third, the circular economy/ solidarity-based economy (33.33%), and fourth, the transferability of farms (28.20%). The relationship between circular economy and ecological farming is clearly established by the fact that the circular economy integrates the collection of biodegradable waste and its biotransformation into compost that can be used for soil improvement and fertilization in farming. The use of organic waste in farming contributes to the independence of the farm from other entities. Morel-Chevillet (2018) supports the same view, writing that urban agricultural projects are one of the solutions for integrating the circular economy in cities. The social economy, instead, is a result of a willingness to include the community, the public interest and not just the individual in the economy (Lasida 2008). However, in order to participate in this solidarity economy, farming must be both profitable economically and transmissible from generation to generation or within the same generation. Such transmissibility has been documented in the work of Vilain *et al*. (2008) on the IDEA method.

Table 5. Frequency of words/groups of words and related terms appearing in the literature

Environmental Dimension		**Socio-territorial and cultural dimension**		**Economic Dimension**	
Indicators	**Frequency (%)**	**Indicators**	**Frequency (%)**	**Indicators**	**Frequency (%)**
Uncultivated space and interface management	51.28	Relations between farming professionals	61.54	Circular economy and solidarity economy	33.33
Setting up of hedges, flowered strips	46.15	Relations avec les acteurs du territoire	69.23	Profitability	38.46
Interstitial space management (grassed strips, hedges)	48.72	collective management	56.41	independence	38.46
Ecological infrastructure management (bocage, wetlands)	33.33	Territorial governance: existence and application of texts and standards	56.41	transmissibility	28.20
Water quantitative management	61.54	Mechanical activity reduction	12.81		

Nitrogen flow management	69.23	Political will at the collective stage	66.66
Erosion Management	48.71	Outlining objectives as well as prioritizing actions	51.28
Biodiversity management	87.18	Community group animation and monitoring	35.89
Pest Management	56.41	Development of partnerships with local stakeholders and community-based solutions	20.51
Nocturnal raptors and bats nesting due to the conservation of flat trees.	7.69	Consultative structures as involved civil societies	17.95
Reasoned farming (organic amendments and compost, reduction of chemical pesticides)	51.28	Involvement of farmers' cooperatives	35.89
Collective management, water withdrawal and taxation	30.77	Re-appropriation of traditional knowledge	48.72
Diagnosis and environmental assessment	51.28	Food culture and traditions	33.33
Farming systems, landscape structures, and practice change scenarios	35.89	Consumer-producer relations	66.66
		Collaborative production and knowledge sharing	69.23

These various groups of words/assimilate identified in the literature might serve as a basis for the construction of a corpus of indicators on an objective basis associating various stakeholders involved in agroecology. Other indicators not yet identified could be added after brainstorming. Therefore, the stakeholders involved will examine the scales of measurement and the required adjustments to propose objective indicators.

CONCLUSION

Due to the negative impacts of a conventional farming system characterized by high productivity in the short term, it is imperative to develop other forms of farming. Agroecology offers an alternative for sustainable production, minimizing impacts on the environment and human health while ensuring stable production and productivity in the medium and long term. Results of this meta-analysis show a significative increase in yields with ecological farming system than conventional farming (considering fixed-effect and random-effect) and increase in yields with conventional farming system than organic farming. They also identify some indicators that can be used in the evaluation of the agroecological transition of a territory. This article is part of a reflection upstream of a preliminary process that aims to build a set of indicators for objective measurement of a territory's progress in agroecological conversion.

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