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Indicators for agroecological transition: Food security, nutrition, well-being, promotion of a sustainable food model

Indicadores para la transición agroecológica: Seguridad alimentaria, nutrición, bienestar, promoción de un modelo alimentario sostenible

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Abstract

Agroecology is a viable alternative confronting the impressive model of industrial agriculture. To project the concept of Agroecology beyond theoretical definitions to practical and quantifiable principles, it is necessary to have analysis, communication and evaluation tools that support and allow the evaluation of positions. Indicators are quantifiable tools that make the obtention of numerical variables possible to compare the different models. This study aims to establish a proposal of quantifiable indicators to evaluate the direct impact of aspects related to food and nutritional quality, responding to the demand for an integrated evaluation of agroecological systems, thus improving the tools for calculating current indicators. The proposed parameters cover aspects that have a greater or lesser impact on the daily diet, such as the variability of the foods that make up the dish, their contribution to food safety, the nutritional composition and bioactive components, organoleptic aspects, degree of processing and transformation of the food consumed, environmental aspects that influence the production model and their influence on human well-being. As well as parameters of the social sphere, such as the impact on the economy of scale, on attributes of proximity, temporality, as well as indicators related to social justice. The proposal can help to obtain assessment before or after the implementation of agricultural policies towards the agroecological transition, allowing self-assessment, and provide verifiable data after a change in agricultural policies when redesigning or introducing agroecological strategies.

Resumen

La Agroecología es una alternativa viable frente al impresionante modelo de agricultura industrial. Para proyectar el concepto de Agroecología más allá de definiciones teóricas hacia principios prácticos y cuantificables, es necesario contar con herramientas de análisis, comunicación y evaluación que apoyen y permitan valorar las posturas. Los indicadores son herramientas cuantificables que posibilitan la obtención de variables numéricas para comparar los diferentes modelos. Este estudio pretende establecer una propuesta de indicadores cuantificables para evaluar el impacto directo de aspectos relacionados con la calidad alimentaria y nutricional, respondiendo a la demanda de una evaluación integrada de los sistemas agroecológicos, mejorando así las herramientas de cálculo de los indicadores actuales. Los parámetros propuestos abarcan aspectos que inciden en mayor o menor medida en la dieta diaria, como la variabilidad de los alimentos que componen el plato, su contribución a la seguridad alimentaria, la composición nutricional y componentes bioactivos, aspectos organolépticos, grado de procesado y transformación de los alimentos consumidos, aspectos ambientales que influyen en el modelo productivo y su influencia en el bienestar humano. Así como parámetros de la esfera social, como el impacto en la economía de escala, en atributos de proximidad, temporalidad, así como indicadores relacionados con la justicia social. La propuesta puede ayudar a obtener una evaluación antes o después de la aplicación de las políticas agrícolas hacia la transición agroecológica, permitiendo la autoevaluación, y proporcionar datos verificables después de un cambio en las políticas agrícolas al rediseñar o introducir estrategias agroecológicas.

Introduction

The different proposals for a common definition of Agroecology, conclude that this concept brings together the science that manages sustainable food systems, the technique based on environmentally friendly ecological practices and the social movement that promotes the transition to fair and sovereign food systems [1-4]. In some circles, Agroecology is often seen as a side-thinking discourse, which can help close the current gaps between conventional and organic farming, for example. The members of the agroecological movement do not accept these trends, since they may cause confusion, ignoring the existence of an agroecological movement or the scientific discipline that grows alongside it, with organic agriculture as a productive base.

Herren et al. [5] wrote that "agroecology is neither a defined system of production nor a production technique. It is a set of principles and practices intended to enhance the sustainability of a farming system, and it is a movement that seeks a new way of food production. Increasingly, agroecology is a science looking at ways of transforming the existing food system, and of further developing agriculture and adapting it to the changing environment – an approach which is vital for food security", incorporating aspects related to food safety in the definition. Previously, De Schutter [6] in his report presented at the 16th session of the United Nations Human Rights Council, also established links between agroecology and food, nutrition and food security, identified agroecology as a model of agricultural development that increases productivity at the field level, reduces rural poverty and contributes to improved nutrition. He also points out that the concept of agroecology includes the participation and empowerment of groups in food insecurity, since it is impossible to improve their situation without involving them in the process.

From the definitions of the early stages [7], as well as the most current ones, agroecology is a dynamic concept, evolving its meanings, thoughts, interpretations and approaches from the 20th century to the present day [8-10] where its nuances have increased and in response to the concerns and priorities that the different institutions and countries express and specify about agroecology. These definitions recognize the transdisciplinary nature of the agroecological concept which encompasses ecologically based agricultural science, a set of practices, and a social and even political movement. Thus, one of the most complete definitions of Agroecology is that of "Ecology of the food system" [11].

In 2009, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) documented the need for agroecological transformation of agriculture [12], food production and consumption and positioned the concept of agroecology in the global food policy debate. To project the concept of Agroecology beyond the theoretical definitions to the practical and quantifiable principles, it is necessary to have analysis, communication and evaluation tools that support and enable evaluating the positions. Indicators stand out among these tools.

An indicator is a qualitative and/or quantitative variable that allows identifying the starting point and corrective actions in decision-making [13]. The indicators are being used to identify successful agroecological experiences to scale them up, and promote greater political and financial support for agroecology [14-17]. It used of indicators on environmental, social, cultural and economic dimensions of agroecology at different spatial scales (field, agroecosystem, whole food system).

FAO [3] has established an analytical tool that includes 10 interrelated and interdependent elements to facilitate agroecological transformation: diversity, synergies, efficiency, resilience, recycling a co-creation and exchange of knowledge (describing common characteristics of agroecological systems, basic practices and innovation criteria); human and social values and food culture and traditions (revealing contextual aspects); the circular and solidarity economy and responsible governance (addressing with the enabling environment). In response to the methodological challenge of being able to use the 10 elements of agroecology as criteria and indicators for monitoring the agroecological transition, FAO has coordinated the participatory development of the Tool for Agroecology Performance Evaluation (TAPE), whose general objective is to generate consolidated evidence on the extent and intensity of the use of agroecological practices and the performance of agroecological systems across five dimensions of sustainability: environment, social and cultural, economic, health and nutrition, and governance [3,18].

The report entitled: "Agroecology and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition" by the High-

Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security [19], calls for a reorientation of investments and global efforts to design and implement models that open pathways to sustainable food systems. To this end, the report places agroecology at the center, a concept that includes practices that improve biological processes in agricultural production, the reduction of the use of fossil fuels and agrochemicals, local adaptation, the defense of biodiversity and social values or governance and participation in their management, among 13 principles described and related to the 10 elements of FAO.

Agroecology in its different dimensions encompasses the application of ecological principles to agriculture, by increasing farm diversification [20], eliminating of chemical inputs [21], increasing biodiversity in all its aspects [22], contributing to the improvement of soil biological fertility, addressing the relationships and interactions between organisms and their environment [23], managing agricultural ecosystems, including the food system in general, not only primary production, but also supply and distribution chains, food processing, marketing and food consumption [17]. Many of these dimensions already have defined and quantifiable indicators, and theoretically all these agroecological principles contribute differently, directly or indirectly, to food security and nutrition, but in reality, there are no defined indicators to assess nutritional quality and its impact on human health and well-being, in exclusive relation to agroecological principles.

The most current scientific evidence [24-27] concludes that the global food system is causing malnutrition, environmental degradation with loss of biodiversity and direct impacts on climate change, therefore a deep transformation of the prevailing food system towards more sustainable food systems is increasingly needed, considering agroecology, as the viable potential for food management and production and human well-being.

This study aims to establish a proposal for quantifiable, easily measurable indicators that allow the direct incidence of food and nutritional quality to be evaluated in order to respond to the demand for an integrated evaluation of agroecological systems, thus improving the tools for the calculation of current indicators. The global premise is that the proposed nutritional quality indices should contribute to the calculation of a food model sustainability index and to the development of methodologies that combine agroecological and socioeconomic indicators.

Methods

In the first phase, the methodology used consisted of a search for existing frameworks and indicators for the evaluation of agroecological approaches. This scientific basis was complemented by discussions at various expert workshops. The workshops were conducted during the months of April-July 2020 by the Spanish Society of Organic Agriculture [28] in online format. The values of different stakeholders (farmers, scientists, technicians, consumers, political agents, etc.) in the field of agroecology are collected. In the second phase, the results have been related to work on the set of indicators proposed by FAO, to fill some existing gaps in the area of food sovereignty and security and especially of indicators related by human welfare.

The measurement scale for each indicator is from 0 to 5, according to the writing skill classification [29], with 0 being the value least close to the agroecological criterion and 5 the closest. The total score for each parameter, divided by its indicators number, provides an overview of each parameter. The numerical value of each parameter can be represented in a diagram, e.g. a radar-type, to visualize the comprehensive analytical approach. These diagrams will make it possible to compare different models or agri-food systems and their influence on human well-being, and even to study the temporal evolution of the same system.

Results

The proposal presented is a consolidated set of ten parameters to quantify food security and sovereignty and their relationships with nutrition and human well-being. Each of these parameters is divided into a series of measurable indicators, which are those that qualitatively and quantitatively define the parameter. Each parameter is the combination of several indicators, as some of the proposed indicators may or may not be significant, or they may or may not be measurable.

The proposed parameters cover aspects that have a greater or lesser impact on the daily diet, such as the food variability that make up the dish, their contribution to food safety, the nutritional composition and bioactive components, organoleptic aspects, degree of processing and transformation of the food consumed and

environmental aspects. As well as parameters of the social sphere, such as the impact on the economy of scale, on attributes of proximity, temporality, as well as indicators related to social justice. With all of them it is intended to broaden holistic definition of agroecology, especially of those aspects that affect food security, nutrition and human well-being.

Results

Availability of basic and diverse foods that contribute to increase the diversity

The development of agriculture and the domestication of animals has entailed risks to the decrease in biological diversity and the proper functioning of agroecosystems. Effects that are more visible depending on the type of agriculture and livestock. Large-scale farming implies a greater simplification of the environmental structure, reducing biotic species and replacing innate biodiversity and the landscape with a reduced number of cultivated plants and domesticated animals. In some cases, this implies irreversible effects on the biodiversity of the system.

Agroecology promotes the use of local biodiversity, including traditional foods from indigenous and local ecosystems with their many sources of quality, nutrient-rich, easily accessible, locally empowering and sustainable species and varieties.

Preserve biodiversity, including that related to culture and food and gastronomic traditions, the use of genetic resources, livestock, forest-based foods, and aquatic genetic resources, and avoid excessive hunting/fishing [30]. By promoting a diverse and varied diet, farm diversity increases. The healthy nutrition guidelines [31] propose that approximately 50% of the diet includes fruits and vegetables, 25% whole grains, and the remaining 25% protein (including legumes), fats and dairy products. The best way to meet these guidelines is to increase the number of variable foods per ration, to be consumed.

The proposed measurable indicators for this parameter in the daily diet are as follows: *i*) variable portions of food that make up the dish; *ii*) portions of native varieties and breeds and *iii*) contribution of the daily diet to cultural and gastronomic diversity. Table 1 shows the descriptive scales to quantify the contribution to diversity and diverse diet.

Table 1. Indicators characterization in varied and diverse diet

	Score					
Index	**0**	**1**	**2**	**3**	**4**	**5**
Variable portions of food	One or two ingredients in the main meal	Three to five ingredients in the main meal	Five ingredients without reaching 50% of fruits and vegetables	Five ingredients reaching 50% of fruits and vegetables	Meet the variability criteria of the healthy guidelines	Exceed the variability criteria of the healthy guidelines
Portions of native varieties and breeds in the meal	No indigenous varieties or breeds	5% indigenous varieties or breeds	10% indigenous varieties or breeds	15% indigenous varieties or breeds	20% indigenous varieties or breeds	More 20% indigenous varieties or breeds
Cultural and gastronomic diversity	Does not include traditional recipes	5% include traditional recipes	10% include traditional recipes	15% include traditional recipes	20% include traditional recipes	More 20% recipes are from the local gastronomy and contribute to the maintenance of culture

Contribution to food safety

Modern epidemiology relates pandemic processes not only to isolated microbiological elements [32], but to others closely related to the food production system. It is within this framework, that agroecology is more necessary than ever, since it addresses the agrarian systems and food transformation in a broad context that includes ecological variables that can contribute to define the principles of food safety and security.

In organic farming, no synthetic agricultural or livestock inputs are used, such as pesticides, herbicides, fertilizers, fungicides, veterinary drugs (antibiotics, growth hormones, etc.), neither synthetic preservatives nor additives. Food cannot be irradiated and genetic organisms modified (GMO) are not authorized. This avoids, as far as possible, the potential hazards posed by

residues of synthetic inputs. In addition, organic foods are microbiologically safe and do not present a risk of disease transmission associated with pathogens [33]. The proposed measurable indicators for this parameter in the daily diet are: *i*) presence of drugs or their metabolites; *ii*) use of chemical additives; *iii*) presence of pesticide residues; *iv*) presence of GMO; *v*) presence of nitrites and nitrates; *vi*) presence of heavy metals and *vii*) microbiological presence. Table 2 shows the descriptive scales to quantify the contribution to food safety.

Table 2. Indicators characterization in food safety

	Score					
Index	0	1	2	3	4	5
Drugs or their metabolites	Presence in concentrations harmful to all people	Presence in concentrations harmful to children	Presence in concentrations harmful to women	Presence in concentrations harmful to men	Signs of absence	Demonstrable absence
Use of alimentary additives	Demonstrable presence	Signs of presence			Signs of absence	Demonstrable absence
Pesticide residues	Presence in concentrations harmful to all people	Presence in concentrations harmful to children	Presence in concentrations harmful to women	Presence in concentrations harmful to men	Signs of absence	Demonstrable absence
GMO	Demonstrable presence	Signs of presence			Signs of absence	Demonstrable absence
Nitrites and nitrates	Presence in concentrations harmful to all people	Presence in concentrations harmful to children	Presence in concentrations harmful to women	Presence in concentrations harmful to men	Signs of absence	Demonstrable absence
Heavy metals	Presence in concentrations harmful to all people	Presence in concentrations harmful to children	Presence in concentrations harmful to women	Presence in concentrations harmful to men	Signs of absence	Demonstrable absence
Food microbiology	Presence in concentrations harmful to all people	Presence in concentrations harmful to children	Presence in concentrations harmful to women	Presence in concentrations harmful to men	Signs of absence	Demonstrable absence

Contribution to nutritional composition of food

The bromatological value of food is variable and depends on different factors, including techniques (genetic potential of the plant or livestock product), as well as the rest of the factors involved in the production system (fertilization, phytosanitary products, irrigation water, exposure to light, livestock feeding, animal welfare, prophylaxis, ...). In addition, the different methods and products used in post-harvest and elaboration process can be decisive for the final composition and quality of the food [34]. Reliable data on the nutritional composition of foods are becoming essential for the formulation of appropriate therapeutic diets to remedy population deficiencies of essential nutrients.

The proposed measurable indicators for the contribution to nutritional composition of food in the daily diet are: *i*) Dietary energy supply; *ii*) quality of the lipid profile of fat; *iii*) contribution and quality of protein; *iv*) fiber intake; *v*) vitamin intake; *vi*) mineral intake. Table 3 shows the descriptive scales to quantify the contribution to nutritional composition of food.

Contribution of bioactive components to the diet

Bioactive compounds are essential and non-essential compounds (e.g., vitamins or polyphenols) that are part of the food, are present in nature, and provide health benefits beyond the basic nutritional value of the food. Bioactive compounds are also referred to as antioxidants and nutraceuticals, a term that reflects their existence in the human diet and their biological activity [35]. Concerning the organic food, research show that higher levels of antioxidants have been found [36], possibly due to the higher stress suffered by plants in the organic system.

Some studies propose color as a tool to evaluate the presence of bioactive compounds in food products [37]. Sulfur aroma is another indicator of the presence of bioactive compounds.

Table 3. Indicators characterization to contribute to the nutritional composition of food

	Score					
Index	0	1	2	3	4	5
Dietary energy supply	Deficit contribution/ Excessive contribution	Deficit between 50-40% of caloric intake	Deficit between 40-30% of caloric intake	Deficit between 30-20% of caloric intake	Deficit between 20-10% of caloric intake	Balanced contribution according to age, physical activity and others questions
Quality of the lipid profile of fat	Deficit contribution/ Excessive contribution	Between 100-90% of fat consumption is saturated fatty acids	Between 90-60% of fat consumption is saturated fatty acids	Between 60-30% of fat consumption is saturated fatty acids	Between 30-10% of fat consumption is saturated fatty acids	Adequate ratios of fatty acids ω3, ω6 and ω9.
Contribution and quality of protein	Deficit contribution/ Excessive contribution	20% of the protein is of high biological value	40% of the protein is of high biological value	60% of the protein is of high biological value	80% of the protein is of high biological value	100% of the protein is of high biological value
Fiber intake	Deficit contribution	20% consumption according to the recommendations	40% consumption according to the recommendations	60% consumption according to the recommendations	80% consumption according to the recommendations	Consumption according to the recommendations
Vitamin intake	Deficit contribution	20% levels that meet the recommended daily doses	40% levels that meet the recommended daily doses	60% levels that meet the recommended daily doses	80% levels that meet the recommended daily doses	Levels that meet the recommended daily doses
Mineral intake	Deficit contribution	20% levels that meet the recommended daily doses	40% levels that meet the recommended daily doses	60% levels that meet the recommended daily doses	80% levels that meet the recommended daily doses	Levels that meet the recommended daily doses

The proposed measurable indicators for the contribution of bioactive components of the daily diet are: i) contribution in chlorophylls; ii) contribution in carotenoids; iii) contribution in polyphenols; iv) contribution to sulfur compounds, glycosylates, and organosulfur compounds. Table 4 shows the descriptive scales to quantify the contribution to bioactive components of food.

Table 4. Indicators characterization to the contribution of the bioactive components of food

	Score					
Index	0	1	2	3	4	5
Contribution in chlorophylls	No green foods	1 serving of green foods	2 serving of green foods	3 serving of green foods	4 serving of green foods	5 serving of green foods
Contribution in carotenoids	No yellow, orange or red foods	1 serving of yellow, orange or red foods	2 serving of yellow, orange or red foods	3 serving of yellow, orange or red foods	4 serving of yellow, orange or red foods	5 serving of yellow, orange or red foods
Contribution in polyphenols	No purple foods	1 serving of purple foods	2 serving of purple foods	3 serving of purple foods	4 serving of purple foods	5 serving of purple foods
Contribution in sulfur compounds	Not smell of sulfur foods	1 serving of foods with sulfur aromas	1 serving of foods with sulfur aromas	2 serving of foods with sulfur aromas	2 serving of foods with sulfur aromas	3 serving of foods with sulfur aromas

Contribution to organoleptic attributes by food in the diet

The smell, color, taste and texture are properties that strongly influence the acceptance or rejection of food by consumers. The sensory or organoleptic evaluation analyzes and interprets the reactions caused by these attributes or characteristics of the food. The perception of a sensory attribute involves information gathered by the senses, the physiology itself and the experiences that have shaped motivations and expectations. The taste is formed as a result of the interaction between taste and smell properties. It is one of the most important factors influencing food preference. Appearance and smell appear to be the most important sensory attributes when consumers buy food, while taste and aroma are the most important attributes when consumers taste a food. This implies that consumers differ between their perception of sensory attributes and their valuation in relation to specific foods. Among the most influential attributes for the acceptance of organic foods are the preference for natural flavor, the sensation of less sweetness, foods with more intense aroma, whole foods, preference for fresh foods, and preference to be obtained by traditional methods when they are transformed [38]. In general, the sensory attributes of agroecological foods are superior [39], or they are not of worse organoleptic quality [40].

The proposed measurable indicators for the contribution to the sensory attributes of the daily diet are: i) natural aroma recognition; ii) natural flavor recognition; iii) natural texture recognition; iv) the emotions evoked by food. Table 5 shows the descriptive scales to quantify the contribution to the sensory attributes of food.

Table 5. Indicators characterization to contribution at sensory attributes of food

	Score					
Index	0	1	2	3	4	5
Natural Aroma	Not natural aroma	20% of food shows its natural aroma	40% of food shows its natural aroma	60% of food shows its natural aroma	80% of food shows its natural aroma	100% of food shows its natural aroma
Natural flavor	Not natural flavor	20% of food shows its natural flavor	40% of food shows its natural flavor	60% of food shows its natural flavor	80% of food shows its natural flavor	100% of food shows its natural flavor
Natural texture	Not natural texture	20% of food shows its natural texture	40% of food shows its natural texture	60% of food shows its natural texture	80% of food shows its natural texture	100% of food shows its natural texture
The positive emotions evoked by food (childhood memories or similar)	Not evoke positive emotion	20% of food evoke positive emotions	40% of food evoke positive emotions	60% of food evoke positive emotions	80% of food evoke positive emotions	100% of food evoke positive emotions

Impact on the level of food processing

Food processing is closely linked to anthropological aspects of human evolution. Since the domestication of fire, humans have treated food with the basic objective of preserving its nutritional and organoleptic properties, in addition to eliminating/reducing biological risks, obtaining a microbiologically safe food and increasing shelf life. Public health policies have led to the emergence of different food classification systems according to their degree of processing. Among the different food classification systems based on the degree of processing is the NOVA system [41], which is used in most studies to analyze and document the effect of ultra-processed food consumption on various diseases or markers of disease, health or mortality. NOVA system describes four groups, natural and minimally processed, processed culinary ingredients, processed foods, and ultra-processed food (food that can hardly be recognized in their original state). The proposed measurable indicators for the impact on the level of food processing of the daily diet are: i) natural diet or with minimally processed foods, including commonly used culinary ingredients, with little modification of the original structure of the food. Boiled, filtered, ground, powdered, squeezed food; ii) diet that includes processed foods, includes processed foods with added salt, sugar and fat; iii) diet that includes ultra-processed foods, which have lost the original structure of the food and are formulated with ultra-processed ingredients and with a very high

number of additives. Table 6 shows the descriptive scales to quantify the contribution to level of food processing.

Table 6. Indicators characterization to contribution at level of food processing in the daily diet

	Score					
Index	0	1	2	3	4	5
Natural diet or with minimally processed foods	Lower 10% of diet is minimally processed	10-20% of diet is minimally processed	20-40% of diet is minimally processed	40-60% of diet is minimally processed	60-80% of diet is minimally processed	More 80% of diet is minimally processed
Diet that includes processed foods	More 80% of diet is processed	60-80% of diet is processed	40-60% of diet is processed	20-40% of diet is processed	10-20% of diet is processed	Lower 10% of diet include processed
Diet that includes ultra-processed foods	More 80% of diet is ultra-processed	60-80% of diet is ultra-processed	40-60% of diet is ultra-processed	20-40% of diet is ultra-processed	10-20% of diet is ultra-processed	Lower 10% of diet include ultra-processed

Contribution to reduce the environmental impact, with special contribution to carbon and water footprint by the diet

Globally, agriculture uses about 70% of all freshwater with-drawls for irrigation, although there are discrepancies exist in the quantified amount [42], with most irrigation concentrated in densely populated developing countries. The consumption of water from crops, green water (evapotranspiration stemming from precipitation on crop-land) and blue water (evapotranspiration on cropland stemming from irrigation) has increased with the extension of agricultural land, and particularly irrigated areas. The use of blue irrigation water is in direct competition with the use of water by households and industry. The proposed measurable indicators for the contribution to reduce the environmental impact, with particular contribution to carbon and water footprint of the diet are: i) energy use; ii) type of energy; iii) use of packaging; iv) water consumption in agri-food system; v) closure of cycles and recovery of inputs. Table 7 shows the descriptive scales to quantify the contribution to the reduction of environmental impact.

Table 7. Indicators characterization for the contribution to the reduction of environmental impact, with special contribution to the carbon and water footprint of the diet

	Score					
Index	0	1	2	3	4	5
Energy use	More 80% of the diet depend on fossil energy in production, cold chain, transport and others	60-80% of the diet depend on fossil energy in production, cold chain, transport and others	40-60% of the diet depend on fossil energy in production, cold chain, transport and others	20-40% of the diet depend on fossil energy in production, cold chain, transport and others	10-20% of the diet depend on fossil energy in production, cold chain, transport and others	Lower 10% of the diet depend on fossil energy in production, cold chain, transport and others
Type of energy	Lower 20% of energy comes from non-fossil sources	20% of energy comes from non-fossil sources	40% of energy comes from non-fossil sources	60% of energy comes from non-fossil sources	80% of energy comes from non-fossil sources	100% of energy comes from non-fossil sources
Use of packaging	More 80% of the food is packaged	60-80% of the food is packaged	40-60% of the food is packaged	20-40% of the food is packaged	10-20% of the food is packaged	Lower 10% of the food is packaged
Water in agro-food system	More 80% comes from blue water	60-80% comes from blue water	40-60% comes from blue water	20-40% comes from blue water	10-20% comes from blue water	Lower 10% comes from blue water
Closure of cycles and recovery of inputs	Lower 10% of waste is recycled	10-20% of waste is recycled	20-40% of waste is recycled	40-60% of waste is recycled	60-80% of waste is recycled	More 80% of waste is recycled

The idea of food system circular implies that the value and utility of products are increased and that waste from production and consumption is used as secondary resources, promising solutions and co-benefits to a range of economic and environmental problems [43]. The food system must be kept within environmental limits and agroecology can be an alternative to establish the necessary balance between food production and environmental impact.

Contribution to the economy of scale with the daily diet

The often-unequal power relations between smaller and bigger players in the global food supply chain generate significant tensions. Small scale agricultural production and consumption that support local products are being overshadowed worldwide [44]. At the local level, it means that the quantity and the demand are declining, as is the diversity of products, leading to the gradual disappearance of local characteristics, traditional knowledge and confidence. Small farms face serious challenges that make their future precarious. The danger for many small farms is that they are not yet in a position to compete and access global markets and many will simply be left behind. In developing countries, smallholder farmers also face unfair competition from farmers in richer countries in many of their domestic and international markets.

Short food supply chains, which promote agroecology, offer a solution to these problems

They reduce the physical distance between producers and customers, give small farmers opportunities to produce and sell high-quality local goods directly and facilitate consumer access. Agroecological approaches promote fair solutions based on local needs, resources and capacities, creating more equitable and sustainable markets. For this reason, agroecology seeks to reconnect producers and consumers through a solidarity and economy of scale that prioritizes local markets and supports the local economy [45]. The proposed measurable indicators for the contribution of the diet to the economy of scale are: *i*) marketing system; *ii*) co-responsibility and community cooperation; *iii*) fair trade; *iv)* food sovereignty. Table 8 shows the descriptive scales to quantify the contribution of the diet to the economy of scale.

Table 8. Indicators characterization to contribution at the economy of scale by the diet

	Score					
Index	0	1	2	3	4	5
Marketing system	Lower 10% food comes from direct or local farmers markets or cooperative models	10-20% food comes from direct or local farmers markets or cooperative models	20-40% food comes from direct or local farmers markets or cooperative models	40-60% food comes from direct or local farmers markets or cooperative models	60-80% food comes from direct or local farmers markets or cooperative models	More 80% food comes from direct or local farmers markets or cooperative models
Co-responsibility, community cooperation	No participation in cooperative work, consumer training, etc.	Participation of 2 h/month in cooperative work, consumer training, etc.	Participation of 3 h/month in cooperative work, consumer training, etc.	Participation of 4 h/month in cooperative work, consumer training, etc.	Participation of 5 h/month in cooperative work, consumer training, etc.	Participation of more 6 h/month in cooperative work, consumer training, etc.
Fair trade	Lower 10% of food comes from fair trade	10-20% of food comes from fair trade	20-40% of food comes from fair trade	40-60% of food comes from fair trade	60-80% of food comes from fair trade	More 80% of food comes from fair trade
Food sovereignty and responsible governance	Lower 10% of consumption model contributes to food sovereignty	10-20% of consumption model contributes to food sovereignty	20-40% of consumption model contributes to food sovereignty	40-60% of consumption model contributes to food sovereignty	60-80% of consumption model contributes to food sovereignty	More 80% of consumption model contributes to food sovereignty

Contribution to the rationality of the consumption model with the daily diet

Irrational farming systems lead to a series of injustices for farmers and consumers. The pressure to provide out-of-season food forces local farmers to grow food in

greenhouses, which may require as much or more energy than transporting it from areas with more favorable climates. Small-scale marketing venues are becoming increasingly scarce, and the prices of local products cannot compete with the low-cost of imported products due to the kilometer-long agri-food system. Out-of-season food production, transport and marketing causes a great socio-environmental impact. In addition, the use of fossil fuels is necessary, with significant expense both at the points of processing, packaging, storage and distribution before reaching consumers.

Local and seasonal agroecological food establishes a fundamental relationship with local farmers and with points of sale that favor economies of scale and sustainable and local agriculture [46]. On the other hand, the link with the territory is not only productive, but is also related to the support of cultural strategies, traditional systems, ecosystem services, bartering, etc. The proposed measurable indicators for the contribution to the rationality of the consumption model with the daily diet are: i) temporality; ii) proximity; iii) territorial personality. Table 9 shows the descriptive scales to quantify the contribution to the rationality of the consumption model with the daily diet.

Table 9. Indicators characterization to contribution at the rationality of the consumption model with the daily diet

	Score					
Index	0	1	2	3	4	5
Temporality	Lower 10% food is seasonal	10-20% food is seasonal	20-40% food is seasonal	40-60% food is seasonal	60-80% food is seasonal	More 80% food is seasonal
Proximity	Lower 10% food comes from less than 100 km	10-20% food comes from less than 100 km	20-40% food comes from less than 100 km	40-60% food comes from less than 100 km	60-80% food comes from less than 100 km	More 80% food comes from less than 100 km
Territorial personality	Lower 10% of consumption model contributes to development of territory	10-20% of consumption model contributes to development of territory	20-40% of consumption model contributes to development of territory	40-60% of consumption model contributes to development of territory	60-80% of consumption model contributes to development of territory	More 80% of consumption model contributes to development of territory

Contribution to commitment and social justice with the daily diet

Social injustice and inequality range from the realm of international policies to the household level, training centers and the other institutions of society. Social injustice cuts across the intersectional dimensions of gender, age, class and caste, religion, health, rural and urban areas and poses a major obstacle to the development of sustainable food systems [47]. Agroecology is developed in social aspects related to human well-being and addressing aspects of equity, such as the networking and community self-organization. Specifically, gender inequality is a critical barrier in agroecological transformations. Women generally have less access to land and other productive resources and decision-making, while they remain disproportionately responsible for household chores and the care of agricultural practices, such as seed guardians or food processors. Finally, agroecology is directly aligned with healthy and sustainable food and therefore with the SDGs of the 2030 agenda.

The proposed measurable indicators for the contribution to commitment and social justice with the daily diet are: *i*) decrease in food waste; ii) impact on the SDGs; iii) gender equity; iv) access to land; v) generational change; vi) quality of life of producers.

Table 10 shows the descriptive scales to quantify the contribution to commitment and social justice with the daily diet.

Table 10. Indicators characterization for contribution to commitment and social justice with the daily diet

	Score					
Index	0	1	2	3	4	5
Decrease in food waste	There is 25% food waste	There is 20% food waste	There is 15% food waste	There is 10% food waste	There is 5% food waste	No food waste
Impact on the SDGs	Alignment with less 6 SDGs	Alignment with 6 SDGs	Alignment with 9 SDGs	Alignment with 11 SDGs	Alignment with 14 SDGs	Alignment with the 17 SDGs
Gender equity	Gender equity is decreased in governing bodies	Gender equity is decreased in governing bodies	Gender equity is equated in governing bodies	Gender equity is equated in governing bodies	Gender equity is exceeded in governing bodies	Gender equity is exceeded in governing bodies
Access to land	Contrary to land access policies	Contrary to land access policies	It does not influence land access policies	It does not influence land access policies	In accordance with land access policies	In accordance with land access policies
Generational change	No intergenerational activities and young farmers	No intergenerational activities and young farmers	Incorporation of young farmers	Incorporation of young farmers	Intergenerational activities and young farmers are carried out	Intergenerational activities and young farmers are carried out
Quality of life of producers	Food income affects less than 50% on producers and their quality of life	Food income has a 50% impact on producers and their quality of life	Food income has a 60% impact on producers and their quality of life	Food income has a 80% impact on producers and their quality of life	Food income has a 90% impact on producers and their quality of life	Food income has a 100% impact on producers and their quality of life

Discussion

The diet pattern is the dominant driver of the planet's growing environmental footprint and its effects on climate change. Global food consumption has undergone a rapid increase and a major structure transition as a consequence of population growth and economic development. The food system is increasingly threatening the environment by depleting water resources, degrading water bodies, aggravating climate change, degrading ecosystems, etc. The environmental impacts of food can be reduced through relations between producers and consumers [48].

Food production, commercialization, composition, transformation and consumption of food, social and cultural factors, and the health of people in rural and urban areas, are descriptive components of any agri-food system, with an impact on human well-being. In an increasingly global, urban and commercial environment, harnessing the potential of local resources, through local, seasonal and proximity production are essential factors in defining the sustainability of the food system.

The most recent evidences conclude that the world food system is not providing good nutrition to people and is leading to environmental degradation and loss of biodiversity. It is therefore necessary to generate an intense agri-food transition to face the challenges of constant malnutrition and rural poverty, aggravated by the growing consequences of climate change. Recently, agroecological food experiences have multiplied around the world. These experiences constitute important innovation niches for a new and more sustainable diet [49]. They generate greater social equity in terms of prices at origin and destination [50]. Agroecology is the effective tool to transform the agri-food system in depth. Thus, agroecological practices can regenerate the soil, protect water, promote biodiversity, and mitigate the effects of climate change. But it also brings benefits in terms of human well-being, through parameters of social, cultural, health, employment, gender equality, generational renewal and revitalization of the rural world.

Given the importance of diet, as a determinant of good health, and the need to prevent the main chronic diseases related to nutrition, it is necessary that agroecology as a science sensitive to nutrition, sustainable production and consumption of food, be in line with the dietary guidelines, contributing to its holistic character. In this sense, the present study proposes to measure the dietary diversity by quantifying three indicators, which assess the

plurality of foods that make up the daily intake, the incorporation of native varieties and breeds, and the gastronomy associated with the territory. The greatest dietary diversity is achieved by increasing the intake of fruits and vegetables, since the intake of vegetable protein is more diverse. The increased consumption of fruits and vegetables is in line with the Harvard Plate Dietary Guidelines, where 50% of the meal configuration should be fruits and vegetables. This is achieved with a diverse configuration of the dish, fun in colors, textures and flavors, to make the meal a pleasant moment.

Generating the need to consume traditional dishes, made with native varieties, enhances the demand for varied crops in the area, contributing to the increase of cultivated genetic diversity reducing the loss of biodiversity. Traditional cultivars have been grown for a long time (>50 years), and have a heritage that has been preserved by regional, ethnic, or family groups. Heirloom cultivars also are closely associated with organic and sustainable farming systems, and generally perform much better under these conditions than in modern, industrialized farming systems [51]. This brings us to the second, third and fourth contributions of indicators, related to food safety and nutritional composition, and the need to build clean food systems free of chemical loads, with nutritionally balanced foods that have an impact on good health. Currently, natural food is one of the most demanded products and this partly overlaps with their perception of organic food [52]. Some authors have established criteria to quantify the degree of nutritional quality [53] and comprehensively conceptualize the naturalness of foods [54], but these metric evaluations do not contemplate the agroecological dimension of food.

Food preferences can change over time, and the nutritional transition from traditional diets to diets rich in meat, refined sugars and saturated fat is a clear example of significant changes that occur in a short period of time. Dietary transition is highly influenced by the organoleptic attributes of food, but specific emotions have also been considered determinants of consumption responses and can predict the individual's food choices more accurately than taste scores. Assessment of emotional responses to organic foods may reveal previously unknown product attributes that can be a valuable source of information and go beyond traditional sensory and acceptability measures. Therefore, it is important to obtain valid and reliable combinations of measurements of sensory attributes and emotions evoked by food and developed in the fifth group of indicators.

The food consumed by a certain group conveys a cultural meaning about the social hierarchy, social systems and the relationships between human and the environment. As Springmann [48] suggests, per capita food emissions translate into different diets, according to regional contexts, including cultural and gender norms. Alliances between farmers and consumers must be strengthened through agroecology. The information will make it possible to make an appropriate choice of food, linked to a specific origin, produced in a sustainable way and capable of generating human well-being. On the one hand, consumers must be informed about the nature, origin and composition of food and the impact of food systems. On the other hand, farmers should also have more flexible market structures, allowing small farmers to have physical and/or virtual spaces for the commercialization of their food, without intermediaries, complying with the proximity that ensures a solid structure of the base economy.

Agroecology based on short food supply chains is an initiative that allows small farmers to have greater visibility in local markets, better control the prices of their products and be more independent with respect to what they produce, as well as better relationships with their clients [55]. These direct and trusting relationships with consumers contribute to reducing the metabolic profile of food systems by reducing energy consumption through the promotion of short distribution channels, increasing consumption of fresh and seasonal food and using less packaging and additives, to preserve food [56].

Attending farmers markets or buying directly from local producers has been shown to change worldviews [57] and eating habits towards healthier diets [58]. The physical proximity of the food makes it possible to purchase more frequently and acquire smaller volumes per occasion, adjusted to needs, avoiding waste. Physical proximity also means that fossil resources do not have to be spent for transportation to sales areas.

Agroecology focused on small producers ensures that they have a fair income. The establishment of appropriate links between farm labor and the area of management that can be executed, this guarantees a greater incorporation of farmers to the primary sector, with degrees of training and knowledge exchange between similar, but also intergenerational, cropping is valued as an enveloping factor in agricultural activity. These aspects of the food system are quantified in the different indicators of the other categories. All the proposed parameters and

indicators are very much in line with the sustainable development goals. The 17 SDGs and their 169 targets largely coincide with the determinations of agroecological nutrition and the quantification criteria expressed in this paper, picking up the interaction of economies of scale, social, environmental and human well-being aspects. Agroecology is not viable without linear and reciprocal cooperation between responsible production, distribution, logistics and consumption [59]. In this cooperation, each link in the food chain is a product of the previous links and a premise for the followings. In the case of the SDGs, both the Goals that favor agroecological nutrition and those that favor it, are integral and cross-cutting nature, so the indicators proposed in this study could be used to assess the degree of compliance of some Goals.

Conclusions

A list of ten consolidated parameters with quantifiable indicators is elaborated and discussed, in the context of food systems evaluations, based on holistic aspects affecting food security, nutrition and human well-being.
For a diet to be healthy, it must be good for people, for soil, water and for any other resource on the planet, therefore it must be varied and mainly vegetable, seasonal, local, socially fair, accessible through a short marketing channel, nutritionally balanced, free from health risks, with beneficial substances contribution and with a high impact on environmental, cultivated, gastronomic and cultural biodiversity.

Agroecology should help to recover the gastronomic cultural heritage against the food standardization, recovering local biodiversity and its use in cooking and offering healthy, tasty and pleasant food. Agroecology is an engine of change and a solution agent for the entire agri-food system. It is necessary to understand food as a right and not as a business, i.e. a shift towards agri-ecological models, that allow proper management of agriculture, livestock, forestry and aquaculture, and that the result of good productive management is to offer nutritious food to all people, as well as a decent income to producers, supporting the sustainable development of the rural model, environmental protection, food security, good nutrition and human well-being. A sustainable lifestyle is essential for the population to achieve human well-being and the way to reach this goal is through the agroecological transition of the global food system.

The proposal should provide an evaluation tool before or after the implementation of agricultural policies towards agroecological transition; a form of self-assessment, internally managed and repeated after a certain period or after a change in agricultural when redesigning or introducing diversity strategies. It would also be useful as a consumer choice guide for buying. Finally, it can also be used to assess the degree of compliance with the SDGs, especially those related to food.

Consent for publication

The authors read and approved the final manuscript.

Competing interest

The authors declare no conflict of interest. This document only reflects their point of view and not that of the institution to which they belong.

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