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Towards Integrating Information Systems of Statistical Indicators on Traceability, Quality and Safety of Italian Agrifood Systems for Citizens, Institutions and Policy-Makers

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Abstract: This paper arises from an ONRR project on "New technologies and methodologies for traceability, quality, safety, measurements and certifications to enhance the value and protect the typical traits in agrifood chains". It has a first aim of performing an exhaustive review pertaining to the construction of indicators of the quality and safety of agrifood products, creating information systems dashboards of unidimensional and multidimensional indicators and applying such indicators, in the context of consumer choices and decisions of policy-makers and firms. Since it has been found that the literature offers no single proposal linking all such aspects, a second central and innovative aim is to propose an original step-by-step procedure for integrating information systems of statistical indicators for citizens, institutions and policy-makers with a specific focus on new technologies and methods for traceability, quality and safety of agrifood systems. The final output is a smart and user-friendly online database that is an absolute innovation on the topic.

Keywords: agrifood; stakeholders; database; surveys; indicators

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1. Introduction

One of the most urgent and difficult challenges that the world must tackle today is reconnecting agriculture (and the production systems linked to it), the environment, food and health [1]. The Agenda 2030) [2] and the EU Green Deal [3,4] require it, and 2030 is coming closer. Meeting this challenge requires a change of perspective, especially in the sector known as agrifood, a change that brings together all the involved perspectives: environmental, economic, ecological and social. This is not possible without making appropriate use of modern information, digital and industrial technologies to find new balances of what could be called an eco-socio-economic system. It is therefore necessary to measure the current state of the system and plan its evolution according to monitorable processes.

The paper has two aims. The first is to perform an exhaustive review of the literature pertaining to the construction of indicators of the quality and safety of agrifood products, to create information systems of unidimensional and multidimensional indicators, and to apply such indicators in the context of consumer choices and decisions of policy-makers and firms. Since the literature offers no single proposal linking all such aspects, the second aim and central research question is to propose an original step-by-step procedure for integrating information systems of statistical indicators for citizens, institutions and policy-makers with a specific focus on new technologies and methods for traceability, quality and safety of agrifood systems. The proposal is based on Italian experience but is readily

extended to other countries or to sub-regions of countries, for which small-area statistical estimation methods can be introduced.

The step-by-step procedure is implemented in the framework of the Italian PNRR-funded Agritech Project, Spoke 9 "New technologies and methodologies for traceability, quality, safety, measurements and certifications to enhance the value and protect the typical traits in agrifood chains", to define best practice at the international level. The procedure, even if applied at the Italian level, can easily be extended to other countries.

The proposed methodology consists of four main consecutive steps:

- Step 1: Focus groups to investigate how different stakeholders perceive the definition, qualification and quantification of the sustainability of agricultural production and agrifood chains. The insights gathered from these engagement activities foster a deeper understanding of the key factors influencing sustainability in the agrifood system at the national, regional and local levels;
- Step 2: Research of official secondary sources on agricultural production and agrifood chain sustainability to investigate the availability or lack of indicators and measures identified in Step 1. An integrated database containing available information will be built at the end of this step;
- Step 3: Sample surveys for both producers and consumers to collect information not available in Step 2 but considered important in Step 1;
- Step 4: An innovative and unique user-friendly online database with a back office and front end for easy access to the information.

Figure 1 shows the interconnection between each step. The first step is fundamental to defining and clarifying the needs of the final users of the database. Then steps 2 and 3 collect the required data from secondary sources or with ad hoc surveys. Then in step 4, all data are presented in the online dashboard. As can be seen from Figure 1, this step is not meant as the end of the process. Finally, there is a return to stakeholders to understand if the constructed database is in line with their expectations and needs. We can consider the process as a sort of iterative process that goes on until 'convergence', namely satisfaction of the needs. At the end of the process, our research question will be satisfied.

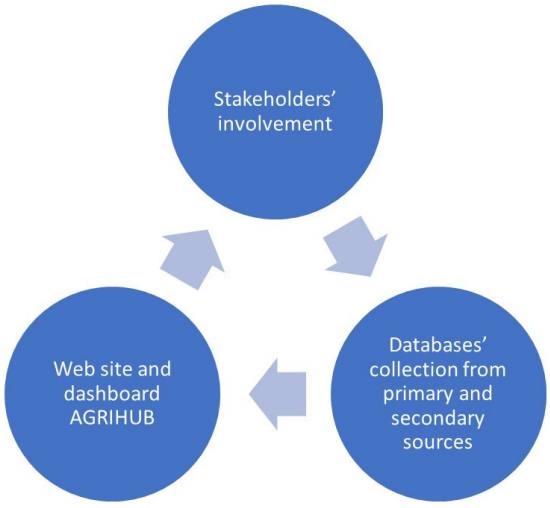

Figure 1. Workflow of the proposed methodology.

The paper consists of six sections. After this introduction, Section 2 briefly describes the scopes and the organization of the Agritech project. Section 3 concerns the literature review on the proposed steps. Section 4 introduces and describes the application of the step-by-step procedure developed so far. Section 5 introduces the smart database for agrifood productions. Section 6 concludes the paper.

2. The Agritech Project

The Italian National Research Centre for Agricultural Technologies (Agritech) is a Centre funded by the Next Generation EU—PNRR (Italian "Piano Nazionale per la Ripresa e la Resilienza) in 2022. Motivations for the proposed project came directly from the European Green Deal (COM2019 640 final), a fundamental part of the United Nations 2030 Agenda. The project has specific goals for the agricultural sector, aiming to preserve the stock of natural capital and to achieve climate neutrality by 2050.

The Agritech project has nine specific Spokes. Here we refer to Spoke 9 "New technologies and methodologies for traceability, quality, safety, measurements and certifications to enhance the value and protect the typical traits in agrifood chains". The new technologies and methodologies include special issues treated in well-defined Working Packages, namely WP1 on Integrating new data and metadata on origin and sustainability, WP2 on Integrating information on productivity, efficiency and sustainability for businesses, clusters and agrifood chains and WP4 on Blockchain and distributed ledger technologies, which will enable construction of an overall digital information platform defined as "METRIQA" in WP5. This paper mainly focuses on the link between these new technologies and methodologies and METRIQA: this is performed by integrating statistical indicators useful for citizens, institutions, and policy makers, and constitutes WP3 of Spoke 9 of the Agritech project.

3. Methods

3.1. Step 1: Focus Groups

The focus group is a type of qualitative survey, very different from a group interview. Interviews are characterised by targeted questions and fairly precise answers from individual components; focus groups are discussion groups on predefined topics facilitated by a moderator, where opinions, ideas and discussion are elicited in a natural and spontaneous way [5]. The basic idea is to promote discussion between various subjects in order to collect information and ideas that emerge from the dialogue and exchange of opinions. The moderator's task is to direct the focus and keep the discussion on topic. The preliminary phase for organising a focus group is formation of the group: the number and heterogeneity of participants are two dimensions to be considered. If one opts for a large heterogeneous group, the discussion is likely to focus on common opinions [6], not leaving space for differences between participants. To overcome this problem, the moderator may invite participants to express their ideas freely. It may otherwise be preferable to opt for less numerous and heterogeneous groups, or if the case arises, for large homogeneous groups. "Group cohesion", i.e., participants' sense of closeness in ideas and goals, is a key element for an effective focus group: the desire and interest of participants in contributing depends on this. Sometimes group cohesion is more important than group composition and is preferable when the aim of the focus group is to verify a theory and when the budget (in terms of money and time) allocated to the project is limited [5].

Focus groups and privileged-witness surveys are qualitative research techniques widely used in agrifood economics and marketing studies to explore the opinions and attitudes of supply chain stakeholders (consumers, producers, trade associations, etc.) towards product or process innovations, communication and marketing strategies, and other research activities or topics related to production. Focus groups are an analysis technique suitable for understanding food choices as they encourage participants to reveal their opinions by leveraging interactions between group members and bringing out insights that would not otherwise emerge [7]. Likewise, as highlighted in [8], privileged-witness surveys are based on structured interviews with a statistically non-significant sample of privileged witnesses. More than an analysis, a story emerges on relevant themes and issues. The story is not exact, but it serves to give an idea of the importance of complex issues such as agrifood chains.

With particular regard to the sustainability and traceability of Italian agrifood chains, ref. [9] investigated the values and factors that influence the attitudes of ethical consumers

who choose short-chain commercial channels and highlighted the fact that knowledge shared among consumers and producers proves to be the most important aspect for participation and involvement in alternative agrifood networks, such as solidarity purchasing groups. Ref. [10] used the focus group technique to explore the relationship between consumers and local products in farmers' markets and found that in some contexts, consumers are interested in such purchasing channels in order to support farms and to promote development of the communities in which they live. The focus-group literature with consumers therefore shows that sustainable consumption habits linked to short supply chains are influenced by the degree of accessible information on the product and by social and environmental concerns, such as fair remuneration for producers and the reduction of carbon emissions [9–11].

Ref. [12] explored consumer perception, in particular ethical and social concerns about the consumption of rabbit meat, integrating a qualitative technique with a quantitative survey (structured questionnaire). The authors found that important aspects for consumers were: the well-being of farmed animals, which leads to a preference for meat obtained with extensive farming methods; food safety and hygiene, which lead consumers to buy products at supermarkets which are considered to offer greater guarantees of safety. The case study in question brings out an almost contradictory perception regarding the traceability and sustainability of the product: on the one hand, participants link intensive farming with the production of unsafe meat and poor animal welfare, while on the other hand they believe that meat purchased at supermarkets is better controlled than that from rural/domestic farms, without considering the origin of the meat or the treatment of the animals. Similar conclusions are reported in the study by [13], which investigated the perception of risk and the habits of Italian consumers regarding the purchase, management and consumption of shellfish. The study indicates that participants in the focus group showed very different and confused points of view concerning the risks associated with shellfish. Nonetheless, they agree on the fact that denominations of origin, local products and food traceability are reassurances about the wholesomeness of food, as if quality and food safety were in many ways overlapping concepts. These studies show that this contradictory or confused consumer awareness depends on a lack of knowledge of the production chain and the concept of traceability and safety.

Concerning sustainability in particular, ref. [14] evaluated the opinions of producers and consumers regarding "SOStain" wine sustainability certification by the focus group method. The authors showed that while wine producers were aware of the need to implement a change towards more sustainable production models, not all companies were ready to undertake this transition due to its higher costs. The authors therefore reflect on the need for the higher costs for companies to be compensated by public aid or by the market, in the form of a premium price for the certified product. The study also highlighted the information asymmetry existing between producers and consumers regarding the certification in question. Communication on sustainability certification is ineffective and the means of communication used by producers are not those recognised by wine consumers.

Similar results are reported by [15] who used the same survey technique to explore farmers' opinions about the introduction of a technological innovation that allows durum wheat to be cultivated more sustainably. The study reports that the innovation was appreciated by farmers, particularly due to its ease of use and low cost. However, farmers' reduced technological capabilities and uncertainty about sources of funding and support from public institutions are recognised as the main barriers to the spread of technological innovations.

Ref. [16], on the other hand, investigated the introduction of a geographical indication as a tool for sustainable development for olive growing and the production of extra virgin olive oil in the provinces of Emilia. Part of the analysis is conducted through focus groups with local olive growers who highlighted the main strengths and weaknesses of the pro-

posed sustainable strategy, with particular reference to the specificity of the supply chain and locality (e.g., climate variability, soils, exposures, the quality of production).

An interesting example of qualitative surveys using privileged witnesses and focus groups is the report of the University of Trieste with MIPAAF [8]. Stories and testimonies of the development and transformation of companies in the agrifood sector were collected through qualitative surveys, while focus groups were conducted with representatives of trade associations to explore supply chain features by tracing strengths and weaknesses.

In [17], a multidimensional analysis of supply chain sustainability was compared with large-scale distribution based on 19 criteria. A focus group of experts evaluated the discriminatory capacity concerning the local bread supply chain and large-scale distribution. In recent years, there have been many focus groups on sustainability issues in the agrifood sector, organised by various trade associations and local stakeholders with the aim of enhancing local production.

This brief excursus of the scientific literature on focus groups regarding Italian agrifood traceability and sustainability allowed us to highlight various empirical and methodological aspects. As regards the survey tool, it proved very effective for exploring a broad and little-known topic, precisely because it allows a flexible approach and can produce data suitable for generating hypotheses [18]. It obtained significant and relevant results only when the focus group was developed on a well-defined product, territory, or supply chain. Precisely because the method is based on the generation of ideas derived from interactions between a group of individuals (ideally not more than six) in a limited time, its effectiveness depends on the correct delimitation of the object of the survey and on a composition of participants matching the target population.

3.2. Step 2: Research of Official Secondary Sources on Agricultural Production and Agrifood Chain Sustainability

It is now commonly held that a major obstacle to the implementation of a sustainable model and the Circular Economy in the agricultural sector is the lack of information about the supply chain and its stakeholders [19]. There is also a need for data sources that respond to the information needs of consumers (linked also to food safety and quality), who play a central role in steering the market towards sustainable models [20]. It is clearly necessary to identify the data sources of the agrifood system in order to build a set of indicators that can enable a shift from farm-level solutions to a focus on interactions in the entire value chain, from production to consumption.

With the aim of identifying and quantifying appropriate indicators to monitor the sustainability of the agrifood system, the central objective of Step 2 was to contribute to the construction of an integrated database by collecting the information sources currently available on the reference theme. A first investigation of existing databases in the field of agrifood sustainability was therefore carried out. It highlighted the existence of many databases of a general nature, extremely different from each other in the characteristics and nature of the data processed. The results are listed in Table 1. With regard to data on the agricultural sector, it is first necessary to consider the ISTAT agricultural census, which provides a great deal of detailed information every ten years, including, for example, the characteristics of agricultural holdings, their regional distribution, crop types and areas, livestock, the workforce employed, and other remunerative activities related to farms besides agriculture.

The RICA database (Italian acronym for Farm Accountancy Data Network) includes data of a sample nature collected annually by a harmonised approach among all countries' member countries of the European Union. In Italy, the RICA survey is conducted by CREA and is a solid source of microeconomic data on the economic and structural dynamics of agricultural holdings and the evolution of incomes (economic and productive results, structural, social and environmental characteristics). Since 2003, the RICA survey has been conducted annually in coordination with the Farm Economic Performance Survey (REA), held by ISTAT, which, like the previous survey, collects, among other things, information

on the structure of costs and revenues, labour costs, subsidies received, stocks and shares, purchases and sales of fixed assets, the value of plant and livestock products reused by the holding as a means of production in the same financial year, etc. REA refers to a sample of small companies (standard output below €8000), while RICA considers medium to large companies (standard output greater than or equal to €8000).

Other relevant ISTAT agricultural databases are: (i) crops and farms, including crop statistics, sowing intentions, milk and milk product statistics, dairy products and livestock numbers; (ii) quality products and agritourism, including data on DOP/IGP and STG quality and on agrifood products and agritourism services; (iii) means of production, which include information on the distribution of fertilizers and on plant protection. In terms of plant protection, there is the FITOGEST portal created by a private company, Image Line, where it is possible to find a database on agro-pharmaceuticals that contains information on active substances and their rules of use, registration on crops, tanning, foodstuffs and other uses, safety intervals and maximum residue limits, legal notes related to the use of individual active substances, classification, chemical formula and structural formula, data on traps, pheromones and useful insects.

Table 1. Main secondary sources on agri-food.

Database Name	Source	Year	Time Series	Frequency	Territorial Detail	Type of Survey	Scope	Data Typology
7° Censimento dell'Agriculture	ISTAT	2020	1961–2020	10 Anni	Municipal	Census	Agriculture	Surfaces, Livestock, Enterprise, Environmental, Social
RICA	CREA	2020	2008–2020	Yearly	Country/Regional	Sample	Agriculture	Surfaces, Livestock, Enterprise, Input, Production, Trading, Environmental, Social
REA	ISTAT	2016	n.d.–2018	Yearly	Country/Regional	Sample	Agriculture	Surfaces, Livestock, Enterprise, Input, Production, Trading, Environmental, Social
Coltivazioni e Livestock	ISTAT	2022	n.d.–2022	Yearly/ Monthly	Provincial	Sample-Proxy-Census	Agriculture	Surfaces, Livestock, Enterprise, Input, Production
Prodotti di qualità e agriturismo	ISTAT	2017	2014–2017	Yearly	Provincial	Census	Agriculture e Agribusiness	Enterprise, Production, Social
Mezzi di Production	ISTAT	2021	2003–2021	Yearly	Provincial	Census	Agriculture	Input
ASIA	ISTAT	2020	1996–2020	Yearly	Regional	Census	Agribusiness	Enterprise, Social
ASIA Agriculture	ISTAT	2018	2017–2018	Yearly	Regional	Census	Agriculture	Enterprise, Social
Prezzi	Camera di Trading	2022	2020–2022	Weekly/ Monthly	Provincial	Sample	Agriculture e Agribusiness	Trading
Prezzi dei prodotti agricoli	ISTAT	2022	2017–2022	Monthly	Country	Sample	Agriculture	Trading
Spese per Consumption delle Famiglie	ISTAT	2021	1997–2021	Yearly	Regional	Sample	Agriculture e Agribusiness	Consumption
IRI	IRI	2022	n.d.–2022	Monthly	Regional	Census	Agriculture e Agribusiness	Consumption
Nielsen	Nielsen	2022	n.d.–2022	Monthly	Regional	Census	Agriculture e Agribusiness	Consumption
Coeweb	ISTAT	2022	1991–2022	Monthly	Provincial	Census	Agriculture e Agribusiness	Trading
BES	ISTAT	2022	2013–2022	Yearly	Provincial	Sample	Sustainability	Environmental, Social
Indagine multiscopo sulle famiglie "Aspetti della vita quotidiana"	ISTAT	2022	1993–2022	Yearly	Country/Regional	Sample	Social	Social
Annuario dei dati Environmental	ISPRA	2021	n.d.–2021	Not fixed	Not fixed	Sample	Environment	Environmental

Table 1. *Cont.*

Database Name	Source	Year	Time Series	Frequency	Territorial Detail	Type of Survey	Scope	Data Typology
Banca Dati Monitoraggio sul valore tecnologico-qualitativo delle varietà di frumento coltivate in Italia: anni 1963–2014	MIPAAF	2014	1963–2014	Yearly	Provincial	Sample	Agriculture	Production
Registro Country degli stabilimenti produttori di uova da cova e pulcini	MIPAAF	2022			Provincial	Census	Livestock	Production
Registro nazionale delle varietà di vite	MIPAAF	2022			Country	Census	Agriculture	BIO
Repertori regionali agrobiodiversità	Regional Authorities	2022		Yearly	Regional	Census	Agriculture/ Livestock	BIO
Anagrafe Nazionale biodiversità	MIPAAF	2022		Yearly	Regional	Census	Agriculture/ Livestock	BIO
Impronta Carbonica Aziende Agricole Italiane	CREA	2013			Country/Regional	Sample	Sustainability	Environmental/Consumption
Database consumo di suolo in Italia	SNPA	2022	2006–2022	Yearly	Regional/Municipal	Census	Agribusiness	Environmental/Surfaces
Banca dati del germoplasma	CREA	2021			Country	Census	Agriculture	BIO
Banca dati degli agrofarmaci	Image Line	2022			Country	Census	Agriculture	Environmental
Banca dati oli monovarietali italiani	ASSAM	2022	2006–2022	Yearly	Regional	Sample	Agriculture	BIO/Production
BANCA DATI ISOTOPICA PRIVATISTICA dei vini italiani	Fondazione Edmund Mach e Unione Italiana Vini	2022		Yearly	Local	Sample	Agriculture	BIO/Production

As regards the search for data relating to the agro-industry sector, the Statistical Archive of Active Enterprises (ASIA), an ISTAT survey, performs an annual census of all active enterprises and their personnel, demographic and stratification characteristics (economic activity, legal form, workforce, turnover, and so on). The ASIA Agriculture register extends the latter by including the economic data of the agricultural sector, excluded from the general register. Another source of data relating to crops, specifically wheat production, is the database of the technological and qualitative value of wheat varieties cultivated in Italy, years 1963–2014, made available by the Ministry of Agricultural, Food and Forestry Policies (MIPAAF), which contains scientific information for employees in the industry regarding the qualitative-technological characteristics of soft and hard wheat varieties grown throughout the country. Still in the field of crops, MIPAAF provides the National Register of vine varieties on its website. It contains the list of vine and cloned varieties in the national register with details concerning the registration, designation of origin and geographical indication of wines, production of rooted cuttings by variety, clone and category, a brief description of the main characteristics, and a photo gallery of the different clones. Regarding livestock, the MIPAAF website offers the national register of establishments producing hatching eggs and chicks, with the following information by enterprise: registration number, name and address, legal representative, ASL code, date of registration, and species stocked.

Economic data on the prices of agricultural products can be found on the websites of the Italian Chambers of Commerce. These data are updated weekly and are grouped by category of goods. A summary of the main markets for the principal products is offered by ISMEA. Data on prices of agricultural products can also be found in ISTAT's Prices of Agricultural Products database, updated monthly with national details. Coeweb, on the other hand, is the ISTAT database that collects monthly foreign trade statistics and gives

access to all information on the value and quantity of agrifood products exchanged by Italy with other EU and non-EU countries.

Regarding the demand for agrifood products, a major source is the ISTAT database for household consumption expenditure, which collects information on the annual consumption habits of Italian households in terms of average monthly expenditure, composition of the shopping basket and changes in habits compared to previous years. Other important consumption surveys are those carried out by private agencies IRI and Nielsen, which collect data scans from large-scale distribution and provide information on sales in value and volume of agrifood products, the characteristics of the products and their producers.

In terms of sustainability, ISTAT makes available BES (Italian acronym for fair and sustainable well-being) project data and indicators which annually monitor and evaluate the quality of life and the level of well-being of society from economic, environmental and social points of view. Thus, BES is an extremely variegated database providing spatial assessments of economic well-being (e.g., risk of poverty, low labour intensity, per capita gross disposable income, etc.), social relations (e.g., social participation, voluntary activities, non-profit organizations), landscape and cultural heritage (e.g., erosion of rural areas by urban sprawl, abandonment, etc.) and environment (e.g., emissions of CO_2 and other climate-altering gases; air quality, consecutive days without rain, etc.). For information of a strictly social nature, the ISTAT annual multi-branch family survey "Aspects of daily life" collects information on citizens' habits and lifestyle, such as leisure, political and social participation, health, school, work, family and social life and satisfaction with public utilities. Regarding environmental sustainability in the strict sense, the Yearbook of Environmental Data edited by ISPRA describes the characteristics of different environmental matrices such as air, soil, water and biodiversity and their time trends.

For environmental data, the National System for the Protection of the Environment maintains the Soil Consumption Database in Italy, which provides land cover for agricultural, urban and industrial use on a national scale. In the panorama of databases/repositories in the field of environmental sustainability, we have the Carbon Footprint of Italian Farms, an electronic report by CREA, containing the carbon footprint of companies in the RICA sample for the year 2014.

As regards databases with information of a chemical-biological nature, meeting the needs of food safety, traceability and anti-counterfeiting, there is the Germoplasm database, created by CREA; the Database of Italian Monovarietal Oils created by ASSAM (Agenzia Servizi Settore Agroalimentare Marche); and the Private Isotopic Database of Italian wines held by the Edmund Mach Foundation and the Italian Wine Union. The first contains the genetic makeup of 60 plant species of agricultural interest cultivated in Italy. The second is an accurate description of the organoleptic profile of monovarietal oils evaluated during the "National Review of Italian Monovarietal Oils" (from the ASSAM Panel Marche) and a description of the profile of their main fatty acids. For each monovarietal type, the average organoleptic profile, the 95% confidence limits of the profile, fatty acid composition, total phenol content, the list of regions from which samples were analysed and the reference years for the Review are listed. The Private Isotopic Data Bank of Italian wines, currently accessible only to wine sector operators, contains the isotopic abundances of carbon, hydrogen and oxygen by harvest of wines with a trademark registered with the Italian Wine Union.

Table 1 lists the databases found and summarises their characteristics. Databases are also classified by target of the new PAC 2023–2027. There are collections of data on various aspects of agriculture at the municipal or provincial level by the Regional Agencies for Environmental Protection related to their territorial units. There are noteworthy extra-national sources providing regional environmental data (NUTS 2) such as the portal Greenhouse Gas Emissions at sub-national level (EDGAR), which is an independent and reliable source of information to support the analysis and development of sub-national regional policies in the field of climate action. The portal also provides data on greenhouse gas emissions from 1990 to 2021 for Italian regions.

3.3. Step 3: Sample Survey for Missing Information

The central objective of the third step of the proposed method is the implementation of specific sample surveys aimed at collecting the information necessary to define and build the indicators highlighted as important in Step 1 but found missing in Step 2. In this sense, investigation into the state of the art of sustainability and traceability of agrifood products looked at scientific articles on consumer and producer behaviour at the national level. On the consumer analysis side, the literature also highlighted many papers focused on the Italian market (often but not only on individual supply chains), while on the supply side, fewer papers were found and they mainly concerned technical/economic aspects related to the adoption of traceability systems along the supply chain. Papers examining aspects concerning blockchain were not considered as they are not yet directly relevant to these activities.

3.3.1. Surveys on Consumers

The main works on consumer preferences and willingness to pay for sustainability certification of agrifood products were filtered using the following eligibility criteria: (i) study focused on consumer preferences regarding sustainability labelling applied to food products; (ii) objective of study to obtain consumer willingness to pay; (iii) study on a sample of Italian consumers. We can group the findings into four groups.

Product Certification and Labelling Studies

Ref. [21] investigated consumer preferences for environmental (organic, "environment friendly", carbon footprint) and social (SA8000 which certifies working conditions) sustainability certifications in Italy and Germany. The study looked at how these preferences are influenced by individual values. Using the Schwartz scale (Schwartz Portrait Values Questionnaire), the study demonstrated that the value category "self-transcendence", which identifies those who are moved by concern for others and the environment, is positively related to preferences for sustainability certifications.

Ref. [22] conducted a consumer survey to determine whether certain organic labelling schemes are preferred to others and to provide recommendations to market stakeholders in the organic sector. The research was based on a sample of 2441 consumers of organic products in six different European countries, including Italy.

Many studies under this heading concern wine certifications [23] explored consumer preferences for information associated with the naturalness of wine, such as sustainability certifications. The case study considered organic certification, biodynamic certification and "biodiversity friend" certification. Ref. [24] investigated the preferences of millennials for two sustainable wine labels: indication of the carbon footprint and the "winescape aesthetic" claim which certifies the landscape value of the product. Ref. [25] evaluated the preferences of Italian consumers for non-alcoholic wines and included organic certification among the characteristics observed.

Analysing the value attributed by consumers to social and environmental sustainability certifications, ref. [26] considered three certifications: (i) the carbon footprint; (ii) Centopassi—Libera Terra (which indicates social commitment in the fight against organised crime); (iii) ref. [27] evaluated the importance of certain honey characteristics for consumers, including sustainability certifications. The biological attribute was more important than other factors, such as landscape value, but less important than country of origin. In some research dedicated to exploring the preferences of Italian consumers for different food products, traceability was included in the set of product descriptors (choice attributes), for example for beef [28] and fresh-cut salad [29].

Surveys on Consumer Willingness to Pay More for Certified Products

Ref. [30] explored consumer evaluations of local and organic food products and the influence of consumer personality on their preferences. Consumers are willing to pay more for local and organic products, especially the organic attribute. Ref. [31] investigated Italian

consumers' willingness to pay for carbon footprint certifications. Other studies explored consumers' willingness to pay for Corporate Social Responsibility (CSR) certification [32,33]. Ref. [34] evaluated consumers' willingness to pay for fair-trade certification and verified the effect of information on consumer preferences for the social sustainability attribute. Fair-trade purchases were also studied by [35,36]; this concept was also investigated specifically for coffee [37].

Other studies looked at specific productions: fish [16,38,39], dairy [40–43], wine-growing [44–46], olives [47] and beef [48].

Surveys on Perception of Alternative Cultivation Systems

These surveys investigate consumer perception and preferences for alternative cultivation systems. For example, ref. [49] investigated the preferences of apple consumers for alternative production systems, including organic, integrated pest control and biocontrol. Besides preferring organic production, interviewees did not seem to perceive the potential benefits of other sustainable production methods. Indeed, they were indifferent to such indications on the label or even expected a discount for choosing a product with these characteristics. Consumers also failed to perceive the importance of practices with low greenhouse gas emissions, preferences for this type of attribute being low. Ref. [50] analysed consumer preferences for different eco-sustainable production systems for carrots (organic, biodynamic, integrated pest management). Integrated pest management was preferred to biodynamic as an emerging method, but consumers' top preference was for organic cultivation. The authors also showed that local origin was favoured by consumers.

Consumer Sensory Surveys

The impact of sustainability information on consumer perception, in terms of liking and sensory properties, has been extensively studied by the sensory sciences [51]. Studies that have used the paradigm of expectations, comparing evaluation with tasting of a product in blind conditions, evaluation of information only (for example on the packaging) and evaluation of the product presented under informed conditions (tasting + information) have shown that information on sustainability changes the perception of the product, increasing approval [52,53]. Some studies also showed that information relating to sustainability not only affected liking but also modified the perception of sensory properties, e.g., in a study on salami [54].

It is clear that certain reasons for choosing food, such as concern for the environment, can support sustainable food choices, while other reasons can be perceived as barriers to sustainable choices (e.g., when sustainable food is perceived as less tasty or more expensive). It has been highlighted that these reasons and information can have different effects on consumer evaluation of products [55]. For example, in a study on yoghurt, information on sustainability only helped increase liking in the case of subjects interested in sustainability or uncertain, but not for persons who were not interested [56]. In fact, not all consumers assign the same importance to sustainability. The Sustainable Food Choice Questionnaire (SUS-FCQ) (developed by [57]) is a self-report questionnaire for determining the general importance an individual attributes to sustainability, considering environmental, ethical and animal welfare, and a concept of sustainability more linked to consumption of local and seasonal products. This tool responds to the increasingly pressing need to classify consumers on the basis of individual differences. From a methodological point of view, different sensorial methods can contribute to the study of the perception of sustainability and can be implemented for the study of expectations. Besides measuring consumer satisfaction, it is in fact possible to measure their perception of the sensorial properties of products and how this is influenced by the information provided or by beliefs. In the last ten years, several reliable protocols for the sensorial description of products have been developed for increasingly direct involvement of consumers, e.g., the development of "rapid methods" capable of guiding consumers in expressing acceptability and preferences,

but also in indicating sensorial, cultural and affective drivers of choice [58], fundamental for the development of products.

Besides intensity scales, an effective method for obtaining elements to correlate product characteristics and preferences and to segment consumers on that basis is the Check-All-That-Apply (CATA) survey [59]. The RATA (Rate-All-That-Apply) variant also provides an evaluation of the selected elements [60]. The method can be implemented by Penalty Analysis [61] which defines the dynamics of consumer satisfaction more precisely and is useful for creating or reformulating a product. To better investigate interest in products and the relative importance of their attributes, including the economic and logistic aspects (packaging, purchasing methods, . . .), Conjoint Analysis approaches [62] and/or Discrete Choice (DCE) models [63,64] can be used. There are also quick methods that can be implemented in presence (consumers complete their response to questionnaires with taste assessments) and remotely (conducted on expectations and preferences, "virtual" products, but also with assessments of products delivered to the home) [65]. Online CATI surveys (or surveys by telephone) are useful for contacting large numbers of consumers, profiling them, segmenting them, then involving a selected group in a second, more operational phase (e.g., those who can be considered "ready" for a new food). CATA has been used to determine consumer attitudes to sustainability-related aspects such as packaging and food waste [66]. RATA methodology has been used to study consumer preferences for various products, including fruit and vegetables [67]. DCE has been used in research into the acceptability of bio-fortified apples [68], and Conjoint Analysis for evaluation of consumer perception of functional foods [69].

3.3.2. Producer-Side Surveys

Analysis of recent research in the literature concerning the issue of traceability from the producer's side showed different lines of research on the Italian context. We can divide these studies into six themes.

Integration and Identification of Sustainability Indicators to Support Agrifood Companies

Ref. [70] investigated indicators to monitor progress and areas of intervention in the transition to circular economy models by various food-sector operators. Their aim was to create a dashboard that can be used at various spatial levels to guide the agrifood sector towards circularity and sustainable development. They identified 102 indicators in the literature classified according to three areas of sustainability (environmental, economic and social) and spatial dimensions (macro-meso-micro) in eight areas. The dashboard highlighted missing aspects related to: (1) new indicators not covered by the tool; (2) new fields not yet explored in the literature; (3) the need to adopt cross-cutting indicators.

Ref. [71] analysed a GIS method that manipulates heterogeneous traceability data collected along food chains to calculate a dashboard of multidisciplinary indicators related to safety, cost and environmental sustainability. A real-world distribution process was analysed for three batches of fresh fruit handled and shipped by a logistic service provider based in northern Italy. The authors found that the tool helped shed light on impacts occurring during food distribution and helped logistic and quality managers make decisions, as well as improving consumer awareness about the shelf life and ecological footprint of products.

Ref. [72] conducted a case study of two alternative fruit chains in a Piemonte production area. To obtain a systematic approach and support for decision-making situations, they evaluated the environmental impact of the two production chains (field phase and storage/warehouse conditioning) from a technical-operational point of view. The evaluation was conducted through interviews with producers, field and warehouse technicians and commercial managers in order to highlight the strengths and weaknesses of the two systems. Life cycle assessment (LCA) was applied to the field system, while SWOT analysis was used to analyse the entire supply chain (field and warehouse management). Finally,

TOWS analysis was used to integrate the results of LCA and SWOT, highlighting development strategies.

Life Cycle Assessment in the Agrifood Sector

Since this line of research is particularly broad, only a few recent works concerning supply chains are cited as examples. Ref. [73] investigated the environmental sustainability of peas, beans and chickpeas produced in Italy by a group representing a major European agrifood company, in order to guide the eco-design measures of the packaging. Analysis of the processes by LCA pinpointed environmentally critical points in the life cycle. Ref. [74] considered the environmental, economic and social sustainability of bioplastics used in the fruit supply chain, specifically the case of raspberry supply chains in north-western Italy. Different analyses (LCA, life cycle costing (LCC) and externalities assessment) were used to evaluate impacts along the supply chain by an integrated approach. The results showed that the biobased plastic scenario had lower environmental and social impacts than the conventional scenario, while the latter was the best choice according to a classic economic approach.

Perception of Traceability by Supply Chain Operators and Consumers

Ref. [75] explored the perception of traceability of certain supply chain operators (HO.RE.CA), comparing it with that expressed by consumers. [76] evaluated the perception of traceability of various stakeholders in the agrifood chain in different countries, including Italy.

Analysis of the Economic Impact of Adopting Traceability Systems

Several studies have explored the costs and benefits deriving from the application of traceability systems. Ref. [77], for example, addressed the issue of costs/benefits in the field of fish processing; Ref. [78] investigated the design and validation of a traceability system based on radio frequency identification technology, intended to solve the interconnection and cost implementation problems typical of traceability systems.

Impact of the Adoption of Traceability Systems on the Efficiency of Production Systems

One line of research is concerned with the application of traceability systems to increase the efficiency of production systems in various ways: some authors have proposed innovative traceability systems to increase the perceived value of the final product [79], the efficiency of production systems and information management [80] and safety [81]. Others have dealt with voluntary traceability systems in the meat [82], cheese [83], fruit and vegetable [84,85] and wine sectors [86].

Communication of Traceability to Consumers

Research has been conducted on the link between traceability and systems for communicating it to consumers. For example, ref. [87] analysed the role of food labels in supporting consumer information on food traceability. Ref. [88] studied some Italian companies to determine whether they conceived and used social media as a tool for disseminating and amplifying their sustainability, responsibility and traceability results. The efficiency of new technologies for traceability communication was also examined in a recent study by [89].

3.4. Step 4: User-Friendly Database

The main objective of Step 4 is to develop an integrated user-friendly database to include in the METRIQA digital information platform, which brings together the databases produced by Steps 2 and 3. This integrated database should provide data and indicators at any level of disaggregation and allow users to choose indicators and their level of analysis. The research conducted on the state of the art for Step 4 was therefore aimed to check the literature for agrifood product databases and web and stand-alone software systems containing information on products identified as of interest. Our survey of the literature

did not reveal many appropriately maintained databases that disseminate information on the products of the agrifood supply chains identified in the study, namely olive oil, wine, dairy and cereals. The data proposed by the few found is indeed approximate, dated, heterogeneous, redundant and unstructured. This points to the need for strong innovation in the agrifood sector. However, the examples listed below can serve as a basis.

For the wine sector: https://vitisdb.it (accessed on 30 May 2024) and https://www.lavinium.it/doc-e-docg/ (accessed on 30 May 2024).

The site http://www.inumeridelvino.it (accessed on 30 May 2024) contains databases on import, export, production statistics, consumption and financial data on wine, aggregated by product and at different spatial and temporal scales.

For the olive-oil sector: https://www.ismeamercati.it/olio-oliva (accessed on 30 May 2024)

Related to several sectors:

Data warehouse CREA-PB (http://aries.crea.gov.it:8080/dwh-inea/ (accessed on 30 May 2024)) is a database repository created by the Agricultural Research and Analysis Council (CREA). It allows fast interactive analysis of large quantities of data related to agricultural production by product groups, agricultural production by region and product, production, intermediate consumption and added value, main intermediate consumption of agriculture, added value of the food industry, food industry employee statistics, credit, agricultural machinery, registrations, regional expenditure for agriculture, and agricultural workforce statistics.

Agrifood Monitor (https://www.agrifoodmonitor.it (accessed on 30 May 2024)) is the first online platform on Italian agrifood chains. It provides figures and skills for companies and policy-makers and market intelligence solutions to support the strategic decisions of companies and the supply chain. It contains reports (which can be downloaded—there is no possibility to query or filter reports) on markets, production, market structure and financial performance and on consumption preferences. Agrifood Monitor is promoted and coordinated by Nomisma in partnership with CRIF S.p.A.

The FAO, John Hopkins, and GAIN sites (https://www.foodsystemsdashboard.org/ (accessed on 30 May 2024)) are of similar structure and relevant to other countries besides Italy for environmental and agro-industrial data.

For holdings:

Veterinary Information System (https://www.vetinfo.it/j6_statistiche/#/ (accessed on 30 May 2024)) was created at the behest of the Ministry of Health to collect and present health and other data useful to the government for the National System of Animal Health and Food Safety, with particular attention to the definition of health risks in the production chain from the production of animal feed to the marketing of food for human consumption. The livestock statistics are based on data recorded (by census) in the National Database of the Livestock Registry (BDN) for the different animal species. The information is shown in reports with interactive graphs that enable users to filter the data, highlight only data of interest, and export it as Excel 2018 or CSV files. Different indicators are reported on a regional basis. The portal also contains maps that show geographical data in relation to statistical data.

Related to sustainability:

The Yearbook of Environmental Data (https://annuario.isprambiente.it (accessed on 30 May 2024)) contains data, statistics and information on the state of the environment in Italy. It is created and curated by the Institute for Environmental Protection and Research (ISPRA) in collaboration with regional agencies and autonomous provinces in the National System for Environmental Protection (SNPA). The Yearbook of Environmental Data describes the conditions of different environmental matrices such as air, soil, water and biodiversity and their time trends by productive sector. The data is mostly in databases that can be searched using filters by region, year and production sector.

Our literature and web search showed that the collation and dissemination of information, and the creation of integrated databases on agricultural production and the food industry are gravely deficient in general and in relation to the sectors here identified as of interest.

4. Results: Towards Implementation of the Step-by-Step-Procedure

Our analysis of the literature and data sources described in the previous sections enabled us to define the steps necessary to meet the needs of stakeholders and consumers in the agrifood sector. We report the first results of the application of the proposed methodology, with the aim to clarify each step and the interconnection between them.

4.1. Example of Step 1

Below is a summary of the results of the first focus group among all that have been conducted as an example.

Five participants and a moderator took part in the focus group. To safeguard the privacy of the participants, they are indicated by letters:

R—small farm;
S—small farm;
B—wine-producing company, involved in research projects;
C—medium-sized company
E—university agrifood researcher.

The key points emerging from the group discussion were:

- The participants had poor (if any) knowledge of data sources;
- The adoption of good practices depends on economic feedback ("there are major expenses").

The transcript of the discussion was analysed by quantitative methods such as an adjacency matrix and Latent Dirichlet Allocation (LDA). The adjacency matrix is a valuable technical tool for assessing the level of interaction in a focus group. It takes the form of an $n \times n$ square matrix, where n is the total number of participants in the focus group. This matrix provides a standard approach for depicting relationships between actors. The adjacency matrix of Focus Group 1 is shown in Table 2.

Table 2. Adjacency matrix of Focus Group 1.

	R	**S**	**B**	**C**	**E**	**Tot. Emissions**
R		1	0	7	0	8
S	1		0	1	0	2
B	0	0		2	0	2
C	7	1	1		2	11
E	1	0	0	2		3
Tot. Receptions	9	2	1	12	2	

The matrix indicates that C played a leading role in the discussion, with 11 emissions and 9 receptions, most of which involved R. The two participants belong to medium-sized companies, managed by few employees, and both demonstrate knowledge in the field of sustainable practices. The discussion did not involve many interactions between the participants, who often merely responded in turn to the moderator.

In LDA it is assumed that the corpus is divided into a series of documents, and that there are k latent topics according to what documents are generated. Each topic is represented as a multinomial distribution over words in the documents. A document is generated by sampling a mixture of these topics and then sampling words from that mixture. Since the multinomial distribution that generates the documents is not observable,

the conjugated distribution is used, that is, the distribution of Dirichlet, to make inferences on the distribution. An evaluation of the latent themes that generate the corpus documents can be obtained from inferences on the parameters of Dirichlet's distribution. Note that this model provides a membership function that defines the probability with which words belong to themes. The result of the procedure is the estimation of a conditional probability, i.e., the probability that one of the words in the corpus is extracted if a certain theme is extracted. Several algorithms are used to simulate sampling from the Dirichlet distribution; many are Monte Carlo methods based on the Markov chain that estimate parameters by seeking a steady state of the Markov chain. We used a method of this type, namely the Gibbs sampling method. A parameter that must be decided a priori to implement LDA is the number of topics. To estimate this number, we used the complementary CaoJuan and Griffith methods.

The first is a measure of similarity between possible word clusters that optimizes the number of themes through the minimum of the similarity index. The second method is based on the distance between possible word clusters, and therefore sees the optimal number of themes as that corresponding to the maximum distance. All these procedures were implemented with R 4.4.0 software, TM package. For details of the methods used, see [90]. Figure 2 shows that the estimated number of themes (topics) converges to two, although the moderator endeavoured to elicit interactions on a greater number of themes.

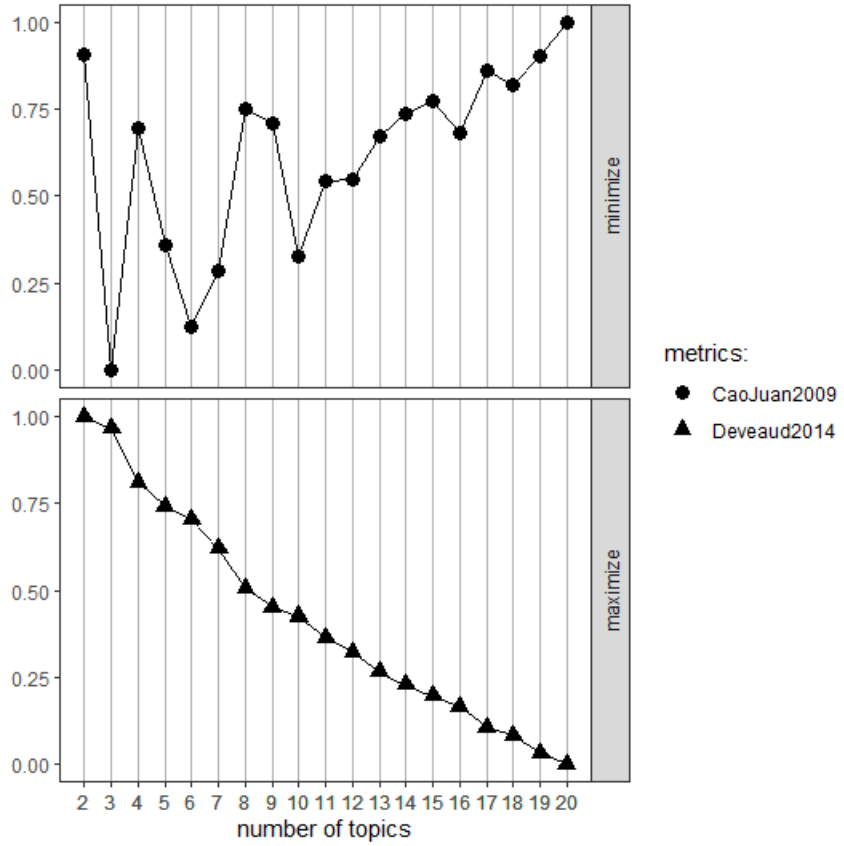

Figure 2. Estimation of topics by CaoJuan and Griffith methods.

We used LDA to characterize these two topics (number of themes = 2) by identifying latent themes in the corpus (Figure 3). "Sustainability" was most likely attributed to topic 1, which seemed to be characterized by discussion of what the participants believe sustainability to be (terms such as "believe", "say", "according" to me), without any concrete references.

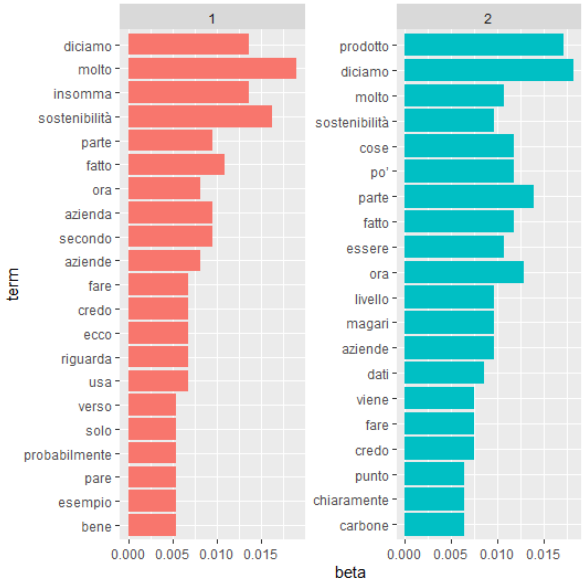

Figure 3. LDA of Focus Group 1 corpus transcript.

Topic 2, on the other hand, was characterized by more concrete interventions, linked to personal experience or knowledge (terms such as "product" and "coal") and to the theme of measurement ("data", "level"). The search for the number of latent themes and their characterization reflects and refines the qualitative analysis of the transcription. The corpus can be divided into two parts. The first shows firms' lack of knowledge of sustainability issues and their attempts to give the topic a subjective meaning (topic 1). The second shows a desire to monitor aspects somehow considered to be related to sustainability, through recounting personal experience, but always with a view to improving productive performance ("product").

The multidimensionality of the sustainability concept and the consequent importance of a multi-actor and holistic approach to the definition of indicators and evaluation of sustainability performance was recognized from the conducted focus groups. However, the lack of knowledge/awareness about sustainability issues in certain domains (consumers, small companies, local areas) and the consequent lack of trust between supply chain actors can hamper the practical implementation of multi-actor/holistic approaches. Overall, the economic dimension of sustainability was seen as the main pillar, also impacting consumers' and small operators' concerns about costs, so incentives were identified as a main enabling factor. The impact of challenges posed by climate change was mentioned several times when thinking about environmental sustainability. The insights gathered from these engagement activities contribute to a deeper understanding of the key factors influencing sustainability in the agrifood system at national, regional and metropolitan (city) levels. They can also put the basis to define a model approach to be replicated for other supply chains or to fine-tune and validate the obtained results. Surely, they will drive the work of the following steps.

4.2. Example of Step 2

After identifying and organising available information on the Italian agrifood system, we used the following framework to construct the first database and to develop shared indicators for monitoring the agrifood sector in Italy.

The secondary sources we identified online can be classified into three types:

1. datasets with entirely downloadable microdata (sets of records containing information on enterprises or on small regional aggregates), such as provincial crop data provided by ISTAT (http://dati.istat.it/Index.aspx?QueryId=37850 (accessed on 30 May 2024)) or RICA (https://rica.crea.gov.it/ricercatori-751.php (accessed on 30 May 2024));

2. datasets from which individual or group indicators can be downloaded, containing indicators developed from microdata not reported in the dataset and which may cover all levels of regional detail, such as the RNN-ISMEA Database of structural agricultural indicators (https://www.ismeamercati.it/flex/FixedPages/IT/IndicatoriDati.php/L/IT/ID/ALL001/SEZ/A2 (accessed on 30 May 2024));
3. (a) downloadable tables (often in pdf format) aggregated by themes and regional details, such as those on the site of the National System for the Protection of the Environment (https://www.snpambiente.it/2022/07/26/consumo-di-suolo-nel-2021-il-valore-piu-alto-degli-ultimi-10-anni/ (accessed on 30 May 2024));
   (b) Reports containing tables referred to in point a, which can only be downloaded in full, such as the National Emissions Inventory (provincial level of detail) on the ISPRA site (https://www.isprambiente.gov.it/contentfiles/00003600/3620-rapporto-85-2008-inventario-nazionale-agricoltura-alta.pdf/ (accessed on 30 May 2024)).

The types of data referred to in points 1 and 2 are not widespread, while those referred to in points 3a and 3b are frequent and very often retrospective. The heterogeneity and fragmentation of the sources is evident, and examination of the contents shows a lack of homogeneity in the definitions and the methods of detection. After identification of the available data sources, the next step is to select those with data that can be harmonised to obtain indicators with the properties required by international regulations. Table 3 describes the properties (with their definitions) desirable for an indicator according to the international literature and standards.

Table 3. Properties of statistical indicators.

Feature	Definition	Source
Accessibility	Accessibility refers to the general conditions under which users can access statistical information.	Accessibility Statement https://ec.europa.eu/eurostat/help/accessibility (accessed on 30 May 2024)
High quality and accuracy	The accuracy of statistical information is how correctly the information describes the phenomena for which it was designed.	[91] https://www.oecd.org/publications/oecd-handbook-for-internationally-comparative-education-statistics-9789264279889-en.htm (accessed on 30 May 2024)
Clarity	Clarity is the measure of how easily a source's indicators and underlying data are accessible, clear and understandable to users.	[92] https://ec.europa.eu/eurostat/documents/3859598/6651706/KSGQ-15-003-EN-N.pdf/18dd4bf0-8de6-4f3f-9adb-fab92db1a568 (accessed on 30 May 2024)
Coherence	Indicators should be complementary and coherent.	[92] https://ec.europa.eu/eurostat/documents/3859598/6651706/KSGQ-15-003-EN-N.pdf/18dd4bf0-8de6-4f3f-9adb-fab92db1a568 (accessed on 30 May 2024)
Comparability	Comparability concerns the impact of differences in statistical concepts, tools and measurement procedures applied to different geographical areas, non-geographical domains or over time. There is both temporal and internal comparability.	[92] https://ec.europa.eu/eurostat/documents/3859598/6651706/KSGQ-15-003-EN-N.pdf/18dd4bf0-8de6-4f3f-9adb-fab92db1a568 (accessed on 30 May 2024)
Feasibility	In the definition of an indicator, the availability of data to measure it and its replicability and updating over time must be considered.	[93] https://www.agenziacoesione.gov.it/wp-content/uploads/2021/02/CPT_AnalisiDEFR.pdf (accessed on 30 May 2024)
Measurability	Measurement of an indicator should be cost-effective and practicable. It should be possible to develop a regular data collection mechanism at a reasonable cost. The indicator should be regularly updatable by reliable procedures, which can then be used for trend analysis.	[92]
Parsimony	The selected indicators should be limited in number.	[92]

Table 3. *Cont.*

Feature	Definition	Source
Relevance	A relevant indicator provides a representative picture of the phenomenon it describes, and in the case of performance indicators, is clearly linked to the objective it aims to measure. It is sensitive to changes, and in the case of performance indicators, to the actions implemented. It provides a basis for international comparisons and is able to show time trends. It is easy for policy-makers, the general public and other stakeholders to understand.	[92]
Sensitivity to economic policies	For the evaluation of public policies, an indicator needs to be sensitive to these policies, possibly within a three-year period or the reference horizon of public finance documents.	[93] https://www.agenziacoesione.gov.it/wp-content/uploads/2021/02/CPT_AnalisiDEFR.pdf (accessed on 30 May 2024)
Specificity	Indicators should measure a particular set of governance institutions or a defined output, such as an agrifood supply chain.	[92]
Timeliness, extent and frequency of time series	The timeliness of data reflects the time lag between its availability and the event or phenomenon it describes, in a time context that allows the information to be valuable and usable.	[92]
Transparency	Indicators should be replicable by a well-documented process and the data should come from official sources.	[93] https://www.agenziacoesione.gov.it/wp-content/uploads/2021/02/CPT_AnalisiDEFR.pdf (accessed on 30 May 2024)

At present, the following official sources have been used to download from the web the main databases:

RICA: from https://rica.crea.gov.it/APP/documentazione/?page_id=2378 (accessed on 30 May 2024), all the available tables have been downloaded through a specific request form;

ISTAT: https://www.istat.it/it/agricoltura?dati (accessed on 30 May 2024);

ISPRA: https://www.isprambiente.gov.it/it/banche-dati (accessed on 30 May 2024)

ISMEA: https://www.ismeamercati.it (accessed on 30 May 2024)

SNPA: https://www.snpambiente.it/dati/ (accessed on 30 May 2024)

EDGAR: https://edgar.jrc.ec.europa.eu/dataset_ghg70_nuts2 (accessed on 30 May 2024)

At present, about 300 tables of data have been downloaded. Once downloaded, data have been uniformed to a common structure.

Below in Figure 4, we report an extract of a summary table that has been constructed for the collected sources; it contains more than 500 tables of data.

Indicatore	Dimensione SAFA	Dataset	Fonte	ambito	sito	# 1-4 accessib.	Download	Note	Livello aggregazione	Serie storiche	Tipo di indicatore
Frantoi	Economia locale	FiliereAgroalimentari_OLIO_Produzione	ISMEA	agroindustria	https://www.ismeamercati.it/ortofrutta/ortaggi	3a	scaricati	Numero di frantoi	regionale	2006-2021	quantitativo
Olive molite per frantoio	Gestione olistica	FiliereAgroalimentari_OLIO_Produzione	ISMEA	agroindustria	https://www.ismeamercati.it/ortofrutta/ortaggi	3a	scaricati	Volume di olive molite in media da ciascun frantoio	regionale	2006-2022	quantitativo
Resa in olio	Gestione olistica	FiliereAgroalimentari_OLIO_Produzione	ISMEA	agroindustria	https://www.ismeamercati.it/ortofrutta/ortaggi	3a	scaricati	Resa in olio, calcolata come rapporto tra il volume di olio prodotto e quello di olive molite	regionale	2006-2023	quantitativo
Superficie in produzione		FiliereAgroalimentari_OLIO_Produzione	ISMEA	agroindustria	https://www.ismeamercati.it/ortofrutta/ortaggi	3a	scaricati	Superficie agricola in produzione di olive da tavola e da olio	regionale	2006-2022	quantitativo
SAT		Report_Caratteristiche_strutturali	RICA-CREA	agroindustria	https://rica.crea.gov.it/	3a	scaricati	Superficie Totale	Regionale	2008-2021	quantitativo
SAU		Report_Caratteristiche_strutturali	RICA-CREA	agroindustria	https://rica.crea.gov.it/	3a	scaricati	Superficie Agricola Utilizzata	Regionale	2008-2021	quantitativo
SAU_P		Report_Caratteristiche_strutturali	RICA-CREA	agroindustria	https://rica.crea.gov.it/	3a	scaricati	SAU in proprietà	Regionale	2008-2021	quantitativo

Figure 4. Extract of a summary tables of the downloaded databases.

4.3. Example of Step 3

Fieldwork sample surveys are conducted both from the producers' side and from the consumers' side. The surveys follow all steps required for sampling, namely, defining the population, ii. developing the sampling frame, iii. determining the sample size, iv. specifying the sampling methodology, and v. selecting the sample. Appropriate questionnaires are developed, and they are validated through pilot surveys. Sampling data will be analysed through multivariate statistical methodologies that will enable the construction of missing indicators and new metrics.

The survey on companies of the agrifood sector has reached a final sample of 3000 firms stratified at the regional level and by 6 production chains, namely wine, olive oil, milk, cereals, fruit and vegetables and honey. A proper questionnaire has been developed with a core common set of questions that collect indicators on all the dimensions of sustainability plus specific sections for different production chains. The survey was administered through CATI and CAWI.

The fieldwork for the second survey on consumers is currently open. This survey aims to reach a final sample of 3500 consumers stratified at the regional level and by gender and age. This survey is also administered through CATI and CAWI, and the questionnaire contains about 30 questions. This survey aims to investigate consumer preferences and evaluate the willingness to pay for products carrying specific sustainability certifications. The selection of these indicators was informed by the findings of the focus groups conducted with consumers in Step 1.

In order to better define the questionnaire for the survey on consumers we have also conducted a pilot study. We report below in Figure 5, an example of a possible output.

Gender	Without Animals being in pain	With respect for Animal rights	Sufficient space for Animal	Free range product	Without exploitation	Traded in a fair way	Without disturbing ecosystem balance	With minimal CO_2 emissions	Packaging ecofriendly	KM0	Seasonal product	Comes from close by
Female	4.05	4.23	4.13	4.32	4.51	4.45	4.33	4.17	4.10	4.05	4.06	3.83
Male	3.20	3.73	3.90	4.05	4.26	4.43	4.25	3.97	3.95	4.11	4.20	3.98
Totale	3.58	3.96	4.00	4.17	4.37	4.44	4.29	4.06	4.02	4.08	4.14	3.91

Figure 5. Example of output from the survey.

The results of these two surveys will enable us to construct new indicators, especially multidimensional indicators, both at national and local levels. The multidimensional indicators could assess the quality of productions [94] and will use the multidimensional fuzzy approach [95].

5. The First Smart Database for Agrifood Products: A Pilot Study

In the meantime, a Relational Database Management System to contain all the information will be designed (Figure 6).

SmartAgrifoodDB is an intuitive integrated database that sprang from the need to provide information and indicators on agrifood and its sustainability. Analysis of the literature showed a lack of recipients of this type designed to collect and publish information on agrifood supply chains. Stakeholders need: (i) to be able to trace and make information on origin and supply chain, from production to distribution, accessible to consumers; (ii) the transfer of a plethora of information stored in hard copy archives to digital format. Since the agrifood web is in its infancy, SmartAgriFoodDB is the first candidate pilot study for the Italian market, designed to promote excellence in a major sector of the national economy, thus enhancing the sector and promoting the transparency of the final products.

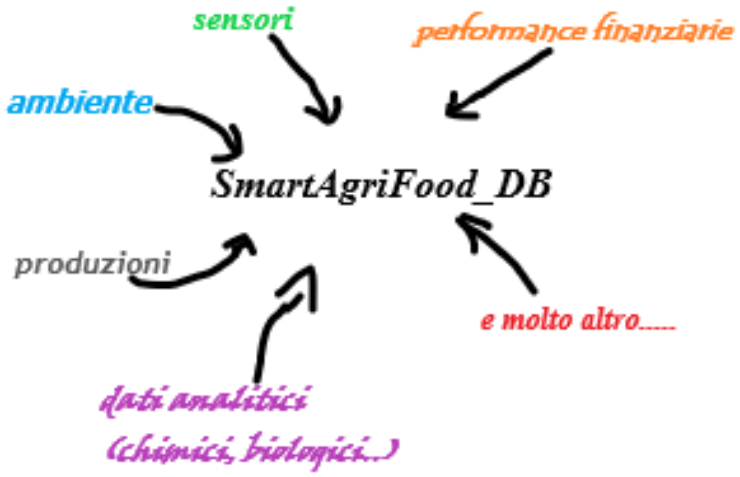

Figure 6. Structure of the online dashboard.

5.1. SmartAgrifoodDB, the First RDBMS in the Agrifood Environment

To develop good software, a primary task is to carry out a correct requirements analysis. At a glance, our survey of the literature showed that the data collected and stored is difficult to manage, being limited, approximate, dated, heterogeneous, redundant and above all unstructured. Lack of a single integrated resource capable of collecting all or most of the information on agrifood products such as olive oil (1), wine (2, 3, 4) and dairy-cereal (5, 6) guided the first steps of the project towards implementation of a "Relational Database Management System" (RDBMS) structured in tables that organize the relationships appropriately in datasets.

SmartAgriFoodDB is a dynamic web-oriented RDBMS. It represents an innovation in the agrifood sector as its relational architecture allows all information on agrifood products to be integrated as follows:

- relational: data is related and shared at multiple levels (data sharing), i.e., within and between supply chains;
- scalable: performance remains intact as the amount of data stored increases or decreases;
- consistent: the data must be meaningfully and effectively usable in business applications;
- safe: the database must be designed in such a way as to prevent damage on the software and hardware sides;
- intact: it must guarantee data conservation without loss;
- cloud: the database can exploit the cloud computing paradigm.

Implementing such a tool means separately developing two sides of the same object (usually denoted as back end and front end) that are later properly interfaced in order to obtain the final result. The back end or more commonly back office is the first to be implemented. It includes all the data structures of the project at different levels and all the specific functions for their management. In practice, the back office is everything that the user cannot see, but which allows the creation of outputs in response to his/her dynamic requests.

Conversely, the front end is the only part visible to the user, which means all the information retrieved from the database, suitably structured by the programmer and displayed as output for the user.

5.2. An Example of the Application of Step 4: The Smart Online Database

All the collected databases have been inserted in the created online platform and are presented and analysed through AI and machine learning processes. Below we report examples of it (Figure 7).

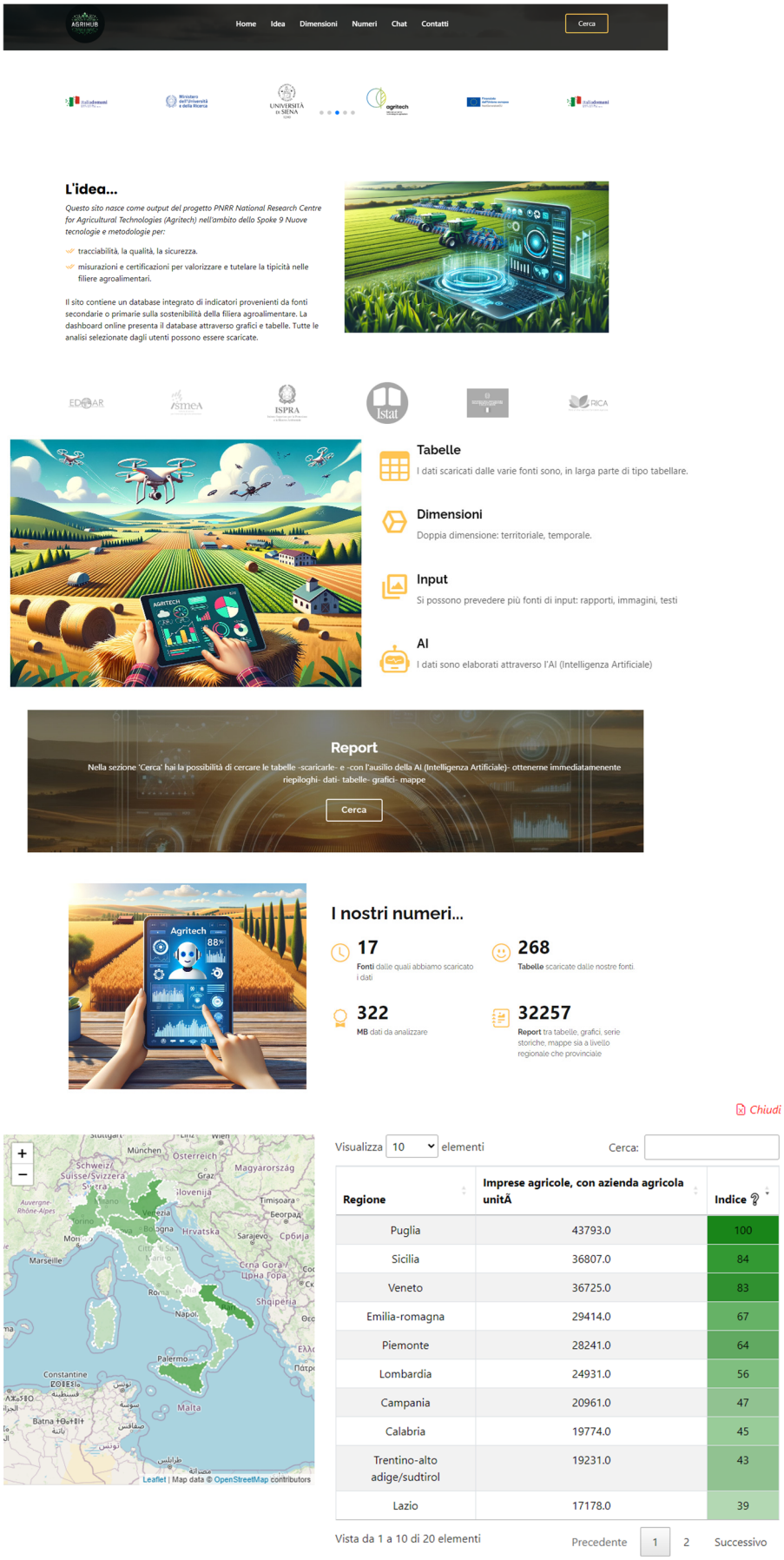

Figure 7. Examples from the online dashboard.

6. Concluding Remarks

Here we propose an innovative approach towards an integrated information system of statistical indicators regarding new technologies and methods for traceability, quality and safety of agrifood. Secondary official sources on agrifood are present on the web in a really large number of sites. This makes the final use of data very difficult because they are very difficult to be found, especially for non-expert users. Not only that, several important indicators are still missing. This opens the space for our innovative proposal.

We developed a step-by-step procedure to achieve the objective to integrate into a unique online platform all the useful secondary sources and the new metrics from ad hoc surveys. A survey of the literature was conducted to support the method. The methodology has been applied, for research purposes, to Italy, but it can be easily extended and applied to any other country. This is surely the strength of the proposed method.

We have shown that the proposed methodology enables us to answer our research question, namely to create an innovative integrated database that will serve as support for citizens, institutions, policy-makers and firms. Policy-makers and stakeholders can use it to drive their actions, firms to obtain information about their sector and competitors, citizens to increase their awareness of agrifood sustainability.

The level of analysis of the databases can range from national to regional and possibly local, and it contains also the time dimension of data. The database also contains specific case studies at the local level or for specific chains.

New indicators are going to be developed thanks to the conducted surveys that will strongly contribute to increase the knowledge on the agri-food sector.

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