



SIDEA – Società Italiana di Economia Agraria  
LIX Convegno annuale

**Agricoltura, alimentazione e mondo rurale di fronte ai cambiamenti dello scenario globale: politiche e strategie per la sostenibilità e la resilienza**

Marina di Orosei (NU), 21– 22 settembre 2023

**BOOK OF ABSTRACTS**

## **S.P.1. FINAL CONSUMER, SUSTAINABILITY AND RESILIENCE**

### **Session A: Behavioural approach to consumer analysis**

1. Nudging towards a greener future: the effects of dynamic social norms on parents' school menu selection  
*Caso Gerarda, Vecchio Riccardo*
2. The effect of nudges on food choices of socioeconomically disadvantaged individuals: a systematic literature review  
*Sapio Silvia, Vecchio Riccardo*
3. Effect of framing message to replace meat consumption with mushrooms and mushroom products  
*De Cianni Rachele, Mancuso Teresina, Rizzo Giuseppina, Migliore Giuseppina*
4. Analisi delle preferenze del consumatore per il kiwi a polpa rossa mediante un esperimento di scelta tra diversi paesi  
*Bassi Ivana, Troiano Stefania, Mian Giovanni, Gori Enrico, Iseppi Luca*
5. Plant the pot! Understanding consumers' WTP for sustainability in garden shops products  
*Ruggeri Giordano, Mazzocchi Chiara*
6. Exploring the environmental impact associated with the abandonment of the Mediterranean Diet, and how to reduce it with alternative sustainable diets  
*Cavaliere Alessia, De Marchi Elisa, Frola Enrica Nadia, Benfenati Alessandro, Aletti Giacomo, Bacenetti Jacopo, Banterle Alessandro.*

## **S.P.1. FINAL CONSUMER, SUSTAINABILITY AND RESILIENCE**

### **Session B: Behavioural approach to consumer analysis**

1. Women's eating behavior through a food-related lifestyle model  
*Hamam Manal*
2. How information on improved working conditions in the farms affect consumers' preferences for chicken breast? An application of discrete choice experiment with participants from Emilia-Romagna region  
*Maesano Giulia, Xhakollari Vilma, Canavari Maurizio*
3. Fattori che influenzano l'intenzione di consumo verso il tartufo fresco e trasformato: un'applicazione del modello PLS-SEM  
*Laganà Valentina Rosa, Di Gregorio Donatella, Nicolosi Agata Carmela*
4. Measuring sustainability performances of Mediterranean olive ecosystems with Life Cycle approaches for SUSTAINOLIVE project  
*De Luca Anna Irene, Falcone Giacomo, Iofrida Nathalie, Spada Emanuele, Gulisano Giovanni, Garcia-Ruiz Roberto*
5. Nudge Theory, food, and the climate crisis: how behavioral economics can support sustainable choices  
*Vecchiato Daniel, Bonardi Pellizzari Carolina, Penazzato Irene*

## **S.P.1. FINAL CONSUMER, SUSTAINABILITY AND RESILIENCE**

### **Session C: Behavioural approaches to consumer analysis**

1. Taste Matters More than Origin: An Experimental Economics Study on Consumer Preferences for Native and Foreign Varieties of Walnuts  
*Raimondo Maria, Spina Daniela, D'Amico Mario, Di Vita Giuseppe, Califano Giovanbattista, Caracciolo Francesco*
2. Behavioural and diet quality profiles of food consumers: Evidence from twelve African cities  
*Marini Govigli Valentino, Alboni Fabrizio, Setti Marco*
3. Using K– means cluster analysis for profiling citizens on perception of key factors of food security  
*Facendola Rosalia, Ottomano Palmisano Giovanni, De Boni Annalisa, Acciani Claudio, Roma Rocco*
4. Global Antibiotic Use in Animal Farming: An Estimation for Cattle, Poultry, and Pigs  
*Ardakani Zahra, Aragrande Maurizio, Canali Massimo*
5. Measuring Shopping– Out in Italian Remote Areas. A Natural Experiment  
*Russo Carlo, Cardillo Concetta, Perito Mariangela*

## **S.P.1. FINAL CONSUMER, SUSTAINABILITY AND RESILIENCE**

### **Session D: The role of sustainable attributes**

1. The Water Footprint of the current Italian diet and how alternative low water–intensive diets can reduce it to tackle with future water scarcity scenarios  
*Frola Enrica Nadia, Cavaliere Alessia, De Marchi Elisa, D'Alessandro Felice, Giacomo Aletti Alessandro Benfenati, Banterle Alessandro*
2. Revealing perspectives towards health warning labels on wine: the Italian case  
*Solfanelli Francesco, Mandolesi Serena, Cubero Dudinskaia Emilia, Silvestri Ileana, Naspetti Simona, Zanolli Raffaele*
3. Economically valuing cultural ecosystem services: a review of the methods with a focus on green care  
*Sealy Phelan Aisling Rachael, Rigo Alessandra, Pisani Elena, Secco Laura, Masiero Mauro*
4. Consumers' preference for sustainable wines: an explorative analysis  
*Stanco Marcello, Nazzaro Concetta, Lerro Marco, Marotta Giuseppe*
5. Animal welfare and environmental sustainability in egg production. Consumer preferences for agroforestry farming models  
*Rossi Eleonora Sofia, Foschi Lorenzo, Tardani Paolo, Martella Angelo, Blasi Emanuele*

## **S.P.1. FINAL CONSUMER, SUSTAINABILITY AND RESILIENCE**

### **Session E: The role of sustainable attributes**

1. How does health-related information impact willingness to pay for olive oil?  
An incentivised lab experiment among Moroccan and Tunisian consumers  
*Piras Simone, Barlagne Carla, Clement Jesper, Mokhtari Nouredine, Thabet Chokri, Tura Matilde*
2. Comparative assessment of the land footprint and regulating ecosystem services embodied in the Italian's consumption of vegetable oils: an environmental trade-off analysis among substitute goods  
*Bausano Giovanni*
3. Dishes order as a game changer? A cluster randomized control trial in school canteens  
*Petruzzelli Mara, Iori Elisa, Ihle Rico, Vittuari Matteo*
4. Consumer Preferences for Circular Economy Products: a case study in Italy  
*Pucillo Flavia, Cavaliere Alessia, De Marchi Elisa*
5. The communication to consumers of the characteristics of dealcoholized and partially dealcoholized wines through company websites  
*Seccia Antonio, Di Maria Giuliana, Viscecchia Rosaria, De Devitiis Biagia*

## **S.P.1. FINAL CONSUMER, SUSTAINABILITY AND RESILIENCE**

### **Session F: The role of sustainable attributes**

1. Understanding consumer preferences for potted plants: the role of phytosanitary diagnostics and eco-friendly cultivation practices  
*Petrontino Alessandro, Frem Michel, Fucilli Vincenzo, Bozzo Francesco*
2. Circolarità, sostenibilità e qualità del caffè venduto nei distributori automatici: cosa preferiscono i consumatori italiani?  
*Bertossi Alberto, Troiano Stefania, Marangon Francesco*
3. What determines short food supply chain purchases? Revealing the influence of beliefs about public effects versus private motivations  
*Gerini Francesca, Contini Caterina, Casini Leonardo*
4. Consumers' preferences for Pecan Nuts: exploring the Italian market via a multiple discrete continuous choice approach  
*Franceschinis Cristiano, Thiene Mara, Scarpa Riccardo*
5. Driving Better Choices: Understanding the Decision-Making Through the Lenses of Health, Sustainability, Naturalness, and Price in Atypical Situations  
*Fantechi Tommaso, Contini Caterina, Casini Leonardo, Lähteenmäki Liisa*

## **S.O.1 PROMOTING A LONG-TERM VISION FOR RURAL AREAS: PROJECTS, INITIATIVES AND TOOLS**

### **Sessione organizzata da AISRe**

1. The New Intelligent, Multilevel and Territorial Governance: Between Innovations and Regional Transitions  
*Provenzano Vincenzo*
2. Critical mass of innovation actors in revitalizing peripheral, non-urban areas: Insights from the COWORK4Youth Project  
*Papageorgiou Antigoni*
3. The role of collaborative spaces in promoting rural areas: evidence from Cost Action-CA18214 and CORAL-ITN projects  
*Mariotti Ilaria*
4. Strengthening the institutional capacity of local actors in rural areas and production territories: the role of evaluation  
*Celano Serafino*
5. The EC Startup Village Forum. Concept and analytical research  
*Merida Martin Fernando*
6. Social Innovation and youth participation in remote rural areas: evidence from a research action in Italian inner areas  
*Storti Daniela*

## **S.P.1. FINAL CONSUMER, SUSTAINABILITY AND RESILIENCE**

### **Session G: The role of sustainable attributes**

1. Trade-off between interest in health and sustainability and the adherence to the Mediterranean Diet: Evidence from Italy  
*Cammarelle Antonella, Viscecchia Rosaria, De Devitiis Biagia, Nardone Gianluca, Bimbo Francesco*
2. Climate Change Impact on Agriculture in Italy: A Literature Review  
*De Leo Simonetta, Di Fonzo Antonella, Giuca Sabrina, Lupia Flavio, Pulighe Giuseppe, Gaito Marco*
3. Is local beef preference associated with health-related attitudes? A study on Italian consumers  
*Testa Riccardo, Vecchio Riccardo, Rizzo Giuseppina, Vella Francesco, Schifani Giorgio, Migliore Giuseppina*
4. Citizens-consumers' willingness to pay for sustainable functional foods: an explorative analysis in Italy  
*Uliano Anna, Stanco Marcello, Nazzaro Concetta*
5. The Empirics of Freshwater Ecosystems: a Global Meta-Regression Analysis  
*Amatucci Achille, Ventura Vera*

6. Freedom of choice – Italian consumers' preferences for labelled new genomic techniques in tomato paste  
*Cubero Dudinskaya Emilia, Mandolesi Serena, Naspetti Simona, Cavallo Carla, Migliore Giuseppina, Zanoli Raffaele*

## **S.P.1. FINAL CONSUMER, SUSTAINABILITY AND RESILIENCE**

### **Session H: New products acceptance**

1. Beauty and naturalness: exploring consumer perspectives and purchase intentions of edible flowers  
*Ricci Elena Claire, Del Giudice Teresa, Olivieri Giuseppina, Cicia Gianni, Cavallo Carla, Begalli Diego, Stranieri Stefanella*
2. Innovative and sustainable solutions to increasing the shelf life of fresh meat industry and consumer acceptance  
*Spada Emanuele, Di Vita Giuseppe, De Cianni Rachele, Mancuso Teresina*
3. Natural wine and consumer awareness  
*Tortonese Valentina, Benedetto Graziella*
4. The current state of the insect industry within the context of a circular bioeconomy  
*Hamam Manal*
5. Consumers' awareness of animal welfare issue and livestock innovations: a PLS–SEM approach  
*Mazzocchi Chiara, Ruggeri Giordano, Corsi Stefano, Bava Luciana*
6. Consumers' preferences and acceptance towards traditional thistle–curdled cheeses  
*Mandolesi Serena, Ozturk Emel, Cubero Dudinskaya Emilia, Solfanelli Francesco, Naspetti Simona, Zanoli Raffaele*

## **S.P.1. FINAL CONSUMER, SUSTAINABILITY AND RESILIENCE**

### **Session I: New products development**

1. Methods, tools, and theories to assess the propensity to introduce innovations in the agrifood sector  
*Tria Emanuela, Campobasso Adele Annarita, Petrontino Alessandro, Fucilli Vincenzo, Bozzo Francesco*
2. Agricultural challenges for a more sustainable future: is the "green" consumer more willing to consume insect–based foods?  
*Merlino Valentina Maria, Brun Filippo, Borra Danielle, Tarantola Martina, Mosca Oriana, Roma Rocco*
3. Consumers' response to genetically modified food: an Italian case study

*Demaria Federica, Gazza Laura, Nocente Francesca, Romeo Lironcurti Simona, Quarto Angelo*

4. Cultivating Trust: Navigating Perceptions of RNAi Technologies in Agriculture After COVID–19 Vaccine Era

*Califano Giovanbattista, Pappalardo Gioacchino, Caracciolo Francesco, Spina Daniela, Raimondo Maria, D'Amico Mario*

5. Would consumers buy upcycled foods? Evidence from a Discrete Choice Experiment in Italy

*Cavicchioli Daniele, De Marchi Elisa, Consonni Gabriella, Cappa Carola, Cavaliere Alessia, Rollini Manuela*

6. Millennial consumer analysis of novel food purchasing attitudes: an application of the means–end chain (MEC)

*Calderoni Federica, Petrontino Alessandro, De Boni Annalisa, Ottomano Palmisano Giovanni, Roma Rocco, Bozzo Francesco*

## **S.P.2. TERRITORIAL PRODUCTION SYSTEMS**

### **Session A: Cooperation and resilience in territorial systems**

1. New support for co–operation provided by Integrated Chain Projects in Emilia–Romagna Rural Development Programs 2014–2022

*Cisilino Federica, Giampaolo Antonio, Licciardo Francesco, Orlando Matteo, Tarangioli Serena*

2. Food districts: a methodological proposal for territorial cooperation in agriculture

*Henke Roberto, Mazzocchi Giampiero, Cisilino Federica, Licciardo Francesco, Tarangioli Serena*

3. Metodi e approcci per l'identificazione di obiettivi e priorità per la digitalizzazione della filiera ovina in Toscana: il caso del Caseificio di Manciano

*Ortolani Livia, Lai Maria Bonaria, Mignani Chiara, Ferrara Annapia, Silvi Alina, Brunori Gianluca*

4. Crop Selection Tool for the resilience of the Salento area after the Xylella Fastidiosa outbreak: a Decision Support System for farmers

*Agnusdei Giulio Paolo, Miglietta Pier Paolo, Krstić Mladen*

5. Co–progettazione di una filiera alimentare comunitaria come strategia per la rigenerazione e la resilienza alimentare delle aree interne

*Torquati Biancamaria, Stella Giordano, Giulietti Giacomo, Paffarini Chiara*

6. Quality of life in inland areas

*Andreoli Maria, Cozzi Mario, Romano Severino, Viccaro Mauro*

## **S.P.2. TERRITORIAL PRODUCTION SYSTEMS**

### **Session B: Sustainability in territorial systems**

1. Differences in sustainability outcomes between agritourism and non-agritourism farms based on robust case evidence from the Tyrol/Trentino Mountain region  
*Grillini Giulia, Sacchi Giovanna, Streifeneder Thomas, Fischer Christian*
2. Exploring the sustainability of bioenergy systems through the land–water–energy nexus approach  
*Pulighe Giuseppe, Pirelli Tiziana, Lupia Flavio*
3. Climate change and the quality of wine: a preliminary study on Collio whites  
*Carmeci Gaetano, Gallenti Gianluigi, Campisi Barbara, Bogoni Paolo, Carzedda Matteo, Millo Giovanni*
4. Fostering farmers towards ecological transition through nudges. A systematic literature review  
*Vella Francesco, Migliore Giuseppina, Rizzo Giuseppina, Lombardi Alessia, Schifani Giorgio, Vecchio Riccardo*
5. Assessing the role of agriculture in generating ammonia emissions by the analysis of manure–ammonia relationship. A case study in Lombardy, Italy  
*Maranzano Paolo, McConville Kelly, Otto Philipp, Carillo Felicetta*
6. Indicatori di sostenibilità sociale per le imprese agro–alimentari: definizione, tipi di KPI e loro utilizzo  
*Briamonte Lucia, Pergamo Raffaella, Nazzaro Concetta, Salerno Chiara*

## **S.O.2. DINAMICHE ORGANIZZATIVE E RELAZIONALI NELLA TRANSIZIONE AGROECOLOGICA E DIGITALE**

Sessione organizzata nell'ambito delle attività di ricerca e di scambio relative al progetto Prin 2020 – *Puzzling Out Smart Ruralities, Sound Knowledge And Rural (Agricultural/Agrifood) Entrepreneurial Ecosystem – SmARTIES*

1. Exploring the role of GIs for the twin transition: the case of the PDO Parmigiano Reggiano  
*Ciliberti Stefano, Martino Gaetano, Brunori Gianluca, Frascarelli Angelo*
2. Governance in policy mix for sustainable transition: insights from a rural Region in Southern Italy  
*Di Santo Naomi, Del Giudice Teresa, Brunori Gianluca, Sisto Roberta*
3. Digitalization and Artificial Intelligence for Sustainable Food Systems: operationalizing a new conceptual model for EU–funded case projects analysis  
*Gabellini Sara, Gerini Francesca, Casini Leonardo, Scaramuzzi Silvia*

4. Territorial innovation and proximity economy for the regeneration of inner areas  
*Nazzaro Concetta, Salvia Rosanna, Quaranta Giovanni, Sardaro Ruggero, Contò Francesco, La Sala Piermichele, Marotta Giuseppe*
5. Contextualising digitalisation through ambidexterity and new territorial proximities  
*De Rosa Marcello, Francescone M., Lioutas E., Charatsari C., Masi M., Vecchio Y.*

### **S.P.3. FARMS AND ECONOMICS OF PRODUCTION**

#### **Session A: Innovation, sustainability, and economic performance**

1. How to promote adoption of sustainable innovations by African smallholders?  
A randomised controlled trial approach  
*Piras Simone, Kuhfuss Laure, Nchimbi–Msolla Susan, Mokhtari Noureddine, Kisakye Josephine, Setti Marco*
2. Sustainability vs efficiency in the fishery sector: an analysis of the rapido fleet  
*Ceccacci Alberto, Russo Elisabetta, Mulazzani Luca, Malorgio Giulio*
3. Assessing the economic profitability of viticultural precision systems: some case studies in Italy  
*Agosta Martina, Sofia Serena, Asciuto Antonio, Crescimanno Maria, Galati Antonino*
4. Developing a taxonomy of costs and benefits for the digitalization of Agriculture and Rural Areas  
*Vergamini Daniele, Lepore Fabio, Ortolani Livia, Brunori Gianluca*
5. Performance assessment of Parmigiano–Reggiano dop dairies: a comparative analysis by altitude range and legal form  
*Iotti Mattia, Bonazzi Giuseppe*

### **S.P.3. FARMS AND ECONOMICS OF PRODUCTION**

#### **Session B: Sustainable farm management**

1. A comparative Life Cycle Costing (LCC) analysis for economic sustainability assessment of three Mediterranean Crops  
*Spada Emanuele, Falcone Giacomo, Iofrida Nathalie, Gulisano Giovanni, De Luca Anna Irene*
2. The adoption of fungus–resistance grapevines: an analysis of producers approach in the Italian region of Veneto  
*Maggio Elena, Bastioli Francesca, Fucile Franceschini Caterina, Pomarici Eugenio, Di Chiara Valentina*

3. Sustainable pest management practices: an experiment on Apulian olive-growers  
*Russo Ilaria, Vecchio Riccardo, Viscecchia Rosaria, Germinara Giacinto Salvatore, Cembalo Luigi, De Devitiis Biagia*
4. Economic outputs of organic and conventional farms: effects of size on permanent crops  
*Casolani Nicola, Chiodo Emilio, Coderoni Silvia, Perito Maria Angela*
5. The contribution of economics to agroecology: a scoping review  
*Fiore Vincenzo, Borrello Massimiliano, Carlucci Domenico, de Gennaro Bernardo Corrado, Giannoccaro Giacomo, Stemple Sarah*

### **S.P.3. FARMS AND ECONOMICS OF PRODUCTION**

#### **Session C: Sustainability and efficiency in the animal production sector**

1. Trade-off between the economic and environmental sustainability in the sheep farms using the FADN database  
*Sau Paola, Arru Brunella, Cisilino Federica, Furesi Roberto, Pulina Pietro, Madau Fabio A.*
2. Cost evaluation of internal biosecurity measures in the Italian pig sector  
*Suprani Valentina, Romanelli Costanza, Aragrande Maurizio, Canali Massimo*
3. Monitoring technical and economic indicator to improve farm economic sustainability  
*Sechi Gian Simone, Cannas Antonello, Atzori Alberto Stanislao*
4. How the digital readiness affects the economic profitability of livestock farms  
*Righi Selene, Moretti Michele, Okoye Felicitas*
5. The economic burden of the bluetongue disease for the sheep industry in Sardinia: an evaluation of private and public costs of the 2017 BTV-4 epidemics  
*Canali Massimo, Romanelli Costanza, Aragrande Maurizio, Giovanni Savini*

### **S.P.4. FILIERE E CATENE DEL VALORE ALIMENTARI**

#### **Sessione A: Sostenibilità**

1. Exploring the path to sustainability in olive oil production: Stakeholder perspectives on the Tuscany supply chain  
*Piracci Giovanna, Gerini Francesca, Casini Leonardo*
2. The Cocoa Value Chain in Ghana: sustainability constraints and linkages to SDGs  
*Romano Sara*
3. Production contracts for the ecological transition in the agri-food supply chain: a best-worst scaling analysis of farmers' preferences  
*Ciliberti Stefano, Frascarelli Angelo, Palazzoni Luca, Martino Gaetano*

4. Reducing food waste at retail stores: Sales forecasting results from Machine Learning-based software in Italy  
*Pietrangeli Roberta, Malefors Christopher, Svensson Erik, Eriksson Mattias, Nasso Marco, Cicatiello Clara*
5. Agro-biodiversity oriented food systems: exploring the potential of the lentils value chain in Italy  
*Verza Marta, Camanzi Luca, Malorgio Giulio, Rota Cosimo, Mulazzani Luca*
6. Understanding the Determinants of Sustainability Strategies in the Beef Value Chain  
*Marschner Stella, Orsi Luigi, Stranieri Stefanella*

#### **S.P.4. FILIERE E CATENE DEL VALORE ALIMENTARI**

##### **Sessione B: Competitività**

1. Improving the transparency of the wine supply chain (WSC) with block chain technology (BCT)  
*Rosa Franco, Mian G., Zironi A.*
2. Strategie di cattura e di creazione del valore nella filiera mandorlicola siciliana: un'analisi di casi studio  
*Borsellino Valeria, Galati Antonino, Varisco Michele, Mirabella Claudio, Schimmenti Emanuele*
3. Sparkling wines throughout Europe. Studying their demand to characterize potential export markets  
*Cei Leonardo, Rossetto Luca*
4. Supporting the Apulian regional development through sustainable post xylella regeneration strategies: an ANP-ADAM approach  
*Coluccia Benedetta, Tunno Vittoria*
5. Adoption of technological innovation and farmers' perception in the bakery Italian supply chain  
*Cappella Maria Teresa, Blasi Emanuele, Toscano Piero, Foschi Lorenzo*
6. The foresight technique applied to the value chain of pasta filata cheeses in the central-southern Apennines: first evidences for an effective planning of rural development policies in remote and mountainous areas  
*Belliggiano Angelo, Bindi Letizia, Bispini Sara, Ievoli Corrado*

#### **S.P.4. FILIERE E CATENE DEL VALORE ALIMENTARI**

##### **Sessione C: Filiere e catene del valore alimentari**

1. The role of upstream actors in the management of fresh fruit & vegetables surplus and losses  
*Nasso Marco, Alcon Francisco, Cicatiello Clara, Pietrangeli Roberta, Blasi Emanuele*
2. Unearthing the determinants of intention to adopt blockchain: a preliminary study on the Italian wine sector  
*Bentivoglio Deborah, Chiaraluce Giulia, Staffolani Giacomo, Santori Nicola, Finco Adele*
3. Factors influencing the adoption of Blockchain technology based solutions in the wine and olive oil industry: evidence from Italian cases study  
*Galati Antonino, Crescimanno Maria, Schimmenti Emanuele, Vella Francesco, Finco Adele, Bentivoglio Deborah, Contò Francesco, Chiaraluce Giulia, Staffolani Giacomo, Fiore Mariantonietta*
4. La valutazione economica dei soprassuoli di castagno attraverso un modello geo-spaziale: prima applicazione in Valle di Susa  
*Bruzzese Stefano, Galliano Fabio, Blanc Simone, Brun Filippo*

#### **S.P.5. ITALIAN FOOD SYSTEM**

##### **Session A: Italian food system**

1. Indagine conoscitiva sulle strategie delle cooperative agroalimentari e della pesca per la ripresa dalla crisi provocata dalla pandemia da COVID-19  
*Tocaceli Daniela, Ciliberti Stefano, Pacciani Alessandro, Martino Gaetano*
2. Exploration of farmers' perception of urban food policies: the case of Bologna farmers' market Regulation  
*Monticone Francesca, Samoggia Antonella*
3. Women entrepreneurship in agriculture – a bibliometric analysis  
*Vuciterna Rina, Manzella Sara, Mazzocchi Chiara, Corsi Stefano*
4. Understanding how twin transition materializes in agrifood: an exploratory study  
*Checchinato Francesca, Cinzia Colapinto, Vladi Finotto, Christine Mauracher, Chiara Rinaldi*
5. L'approccio Living Lab nella transizione ecologica degli allevamenti: il caso della montagna abruzzese  
*Forzoni L., Righi S., Riccioli F., Noretti M., Di Iacovo F.*
6. Analisi delle strategie e delle politiche per rafforzare i sistemi di conoscenza e innovazione nel micro-AKIS del contesto ovino del sud della Toscana  
*Mignani Chiara, Ferrara Anna, Brunori Gianluca*

## **S.P.6. ROLE AND OBJECTIVES OF AGRICULTURAL POLICY**

### **Session A: Food policy: public goals and market scenarios**

1. Comparing Food Governance Networks in Rome and Barcelona: An Exploratory Study  
*Gori Francesca, Castellini Alessandra*
2. Future scenarios for insect protein production in Europe by year 2035  
*Gambelli Danilo, Vairo Daniela, Zanolli Raffaele, Alleweldt Frank*
3. What Europeans Want: Insights on Citizens and Research Debate on Nutri-Score  
*Stiletto Alice, Cei Leonardo, Trestini Samuele*
4. Food (in)security, Environmental Sustainability and Europe – Exploring future policy scenarios  
*Paparella Antonio, Cembalo Luigi, Del Giudice Teresa, Freda Roberto*
5. The role of research in the sustainability transition(s) in rural areas: a survey on Living Labs operated in EU– funded projects  
*Arcuri Sabrina, Knickel Marina, Brunori Gianluca*
6. Insights into consumer views on nutri–score labeling: a comprehensive analysis using q–methodology  
*Rizzo Giuseppina, Mandolesi Serena, Testa Riccardo, Vella Francesco, Zanolli Raffaele, Migliore Giuseppina*

## **S.P.6. ROLE AND OBJECTIVES OF AGRICULTURAL POLICY**

### **Session B: Agricultural policy and ecological transition**

1. The governance of the Common Agricultural Policy 2023–2027: analysing the role of partnership through Text Mining and Sentiment Analysis  
*Pomponi Tommaso, Henke Roberto, Mazzocchi Giampiero, Monteleone Alessandro, Vassallo Marco, Sorrentino Alessandro*
2. Exploring participation in eco–schemes on Italian farms: a qualitative analysis  
*Martignani Federica, Cacchiarelli Luca, Sorrentino Alessandro*
3. Economic and environmental outcomes of alternative economic policy tools to curb GHG emissions from Italian livestock sector  
*Dell'Unto Davide, Coderoni Silvia, Cortignani Raffaele*
4. Climate and environment: The directions of innovation studying Italian Operational Groups  
*Menna Concetta, del Puente Francesco, Ugati Rossella, Lai Maria Bonaria, Del Giudice Teresa, Sapio Alessandro*

# ***Using K-Means cluster Analysis for profiling citizens on perception of key factors of food security***

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food security; agri-food systems; sustainable food systems; urban food policy; PCA; cluster analysis

## **INTRODUCTION**

Food security is currently at the centre of the global economic and social debates, so it has a crucial role in ensuring economic physical access to food for present and future generations, one of the dimensions of food security (FAO, 2021). Agri-food system security has been reported on in recent years (Ingram, 2011). Conventional agri-food systems actually have limited resilience, being vulnerable to several shocks such as increasing occurrence of extreme natural events (Guo *et al.*, 2021), COVID-19 pandemic (Zollet *et al.*, 2021) and the current Russia–Ukraine conflict (Nasir *et al.*, 2022). This situation threatens the achievement of the Sustainable Development Goals (SDGs), particularly the Zero Hunger Goal (SDG 2), aiming at fighting hunger and granting food security and quality-wise food from sustainable farming systems. Cities have been increasingly involved in the development of food policies and fostering the transition to sustainable food systems. The urban agro-ecological transition, including food policies, may be crucial in facing environmental emergencies and improving agri-food systems, but is also key in solving political and social issues with an agro-ecological approach (Isaac *et al.*, 2018). Metropolitan areas are a key point and must be acknowledged in research and policy (Filippin *et al.*, 2023) (Zasada *et al.*, 2019).

The aim of this study is to identify citizens' profiles of the area of Metropolitan City of Bari (MCB), based on citizens' perceptions on the key factors related to food security and their socio-demographic characteristics. This is the first study attempting to classify citizens into different categories based on their viewpoints on food security. The segmentation and classification of these citizens could provide concrete basis to guide policy makers and other stakeholders toward a more effective creation of the MCB and to propose effective long-term measures aimed at ensuring safe, healthy, sustainable, and nutritious food for residents and surrounding communities.

## **MATERIALS AND METHOD**

Data were collected using an online questionnaire and an initial sample of 600 citizens of the MCB was obtained. The survey was preliminarily tested through a pilot study involving members of the research group and a panel of experts on food security, in order to check the validity and reliability of the questionnaire.

Data collection took place from July to November 2022. Moreover, to make data collection less costly and time-consuming, a convenience sample was applied. The questionnaire included the concept of food security as established at the World Food Summit in 1996 (Mechlem, 2004), as well as the objective of the research. The questionnaire was structured in two parts: the first section containing 46 items on food security taken from the existing thematic scientific literature. For each question, corresponding to the item, participants were asked to assign a score through a 10-point Likert rating scale, explained by verbal anchors (-5 to -1 = obstacle; 0 = irrelevant; +1 to +5 = incentive). Starting from a 5-point Likert rating scale, which is considered the one that produces data of higher quality according to the scientific literature (Revilla *et al.*, 2014) (Robinson, 2018), we also included negative scores for helping the respondents in evaluating items as obstacles. The second section collected data on the socio-demographic characteristics of the respondents, such as age, gender, education level, employment status and average annual income. A preliminary analysis showed that most of the respondents aged 20-30 years old and >70 years old gave irrelevant answers (0 score) for at least 70% of the items. This may be due to their limited involvement and/or interest in food security issues. Therefore, these respondents were excluded from the sample. The final eligible study sample consisted of 377 respondents.

In this study, data were submitted to two types of analyses. First, a descriptive analysis was carried out to describe the sample, through computation of percentages and cumulative frequencies. Then, two multivariate analyses were conducted: Principal Component Analysis (PCA) and cluster analysis (k-means technique).

PCA was applied to reduce the initial 46 variables into fewer new variables, called principal components (PCs), which can explain maximum variability out of the total variability. PCs were extracted using an Eigenvalue of 1 as a cut-off, according to Guttman-Kaiser criterion. In this research, correlation matrix was calculated.

Then, K-means method was applied and the selection of the number of clusters *k* has to be chosen a priori; four clusters resulted the optimal number. K-means clustering was carried out based on the resulting PCs; once clusters were obtained, they were characterised, taking into account both citizens' socio-economic characteristics and their perceptions of the key factors related to food security.

## RESULTS

Descriptive analysis highlights the characteristics of the initial study sample based on the following variables: gender, age, education, level of income and employment. The majority are males (54%) and middle-aged (30% are 30-39 years old), with a middle-class of income from 25,100 to 40,000 €/year (45%). The most frequent job descriptions were full-time employment (64%); the unemployed, including housewives, were 2%. The majority hold high school degrees (44%) and university or postgraduate degrees (42%). Moreover, the majority of citizens attributed a role of incentive to most of the 46 items. In particular, the main items evaluated as incentives to achieve food security were ICT services (91%), food policy (88%), qualification of workforce (84.7%), quality control (84.2%), EU support and food banks (83.7% and 83.5% respectively). On the contrary, the main items considered as obstacles to achieve food security (from -5 to -1 score) were: price volatility (74.1%), climate change and crop genome adaptation (67.4%), market globalization (51.6%), and large-scale retail (LSR) power (47%). Additionally, about one third of the respondents declared that intensive production system is also considered an obstacle.

PCA, performed using all 46 items and taking into account the final sample, enabled the definition of eight new components. These components showed eigenvalues higher than one, and the cumulative variance explained by the eight new components was 72.2%. Only the first four PCs, were considered, due to their highest significant contribution to explained variance, their easier interpretability and labelling.

According to the factor loading of the variables for each component, the selected four components were labelled. The first component highlighted those social aspects, such as social certification, fighting illegal hiring and food policy, have to be the basis of current and future urban food policy. This component was labelled as a "governance" macro-area.

In the second component, labelled the “market” macro-area, market aspects caused the main drivers of food security. In the third component, environmental certification, quality control, and certification of Protected Designation of Origin - Protected Geographical Indications (PDO-PGI) showed factor loading with maximum scores, in such a way that this third component was labelled the “quality” macro-area. The fourth component was labelled “sustainability of production systems”, because it mainly included sustainable production technology, such as food waste recycling technology, intensive production and food loss and waste strategies variables, with maximum factor loading.

The next step was to use these four main components and related items for the application of the k-means clustering. A four-cluster solution according to the components PC-1 (governance), PC-2 (market), PC-3 (quality) and PC-4 (sustainability of production systems) emerged as the optimum for k-means clustering. In particular, cluster 1 was represented by MCB citizens sensitive to components PC-2 (market) and PC-4 (sustainability of production systems), and therefore interested in the market and sustainability aspects of production systems as levers for achieving food security. Cluster 2, instead, was represented by MCB citizens convinced that components PC-1 (governance) and PC-3 (quality) could be drivers for food security. Cluster 3 was represented by MCB citizens believing that only the PC-3 component (quality) was not a driver to achieving food security; finally, MCB citizens belonging to cluster 4 considered PC-1 component (governance) a driver for food security, while remaining indifferent to other PCA components.

The four clusters of MCB citizens were profiled according to the socio-economic variables; only 10 items were considered. The items were grouped in four macro-areas: governance (food policy, food loss and waste, EU support), market (LSR power, price volatility, market globalisation), sustainability of production systems (intensive production, FW recycling technology) and quality (PDO-PGI certifications, environmental certification).

The first group of citizens, identified as cluster 1 and labelled as “Capitalists”, represents 15% of the sample. They are mainly males between 30-39 years old, full-time employees with high annual income (more than 60,000 €/year). In relation to the governance macro-area, these citizens showed a negative perception (i.e. barrier to food security achievement) towards the items belonging to this area, namely “food policy” (-0.7), “food loss and waste (FLW)” (-0.1) and “EU support” (-0.9). This result is in contrast with findings by other authors (Minotti *et al.*, 2022) (Calori *et al.*, 2017), who defined governance as key factor for development of urban food policies that support sustainable nutrition and diets, food production availability and distribution and management of food waste. Furthermore, these citizens showed, in relation to the “market” macro-area, a perception of irrelevance (score equal to 0) of “LSR power”, and negative scores for the items “price volatility” (-2.7) and “market globalisation” (-0.6). This is in line with other scholars, who found that the seasonal variation in food prices leads consumers to uncertainty and risk (Amolegbe *et al.*, 2021) (Duarte and Ozaki, 2019). Regarding the “sustainability of production systems” macro-area, these citizens showed a positive score for the item “intensive production” (3.3). Indeed, they assumed that intensive production could improve food availability and liberate these economies from the risk of hunger and poverty (Giller *et al.*, 2021). Conversely, they attributed a negative score to the item “food waste recycling technology” (-0.1). Moreover, these citizens attached a negative score for the quality macro-area, in particular for “PDO-PGI certifications” (-0.1 score) and “environmental certification” (-1.0), these items were thus considered barriers to food security achievement.

The second group of citizens, identified as cluster 2 and labelled as “Hedonists”, represents 36% of the sample. It includes mainly males with a high education level (university degree or postgraduate) and high-level annual income (more than 60,000 €/year). These citizens showed positive scores for the items within the “governance” macro-area: 3.2 for “food policy”, 3.3 for “food loss and waste (FLW)” and 2.8 for “EU support”; these items were thus considered drivers for achieving food security. As suggested by the literature, governance is a key component of sustainable food systems and a requirement for the development of food policies (del Valle M *et al.*, 2022) (Boylan *et al.*, 2019). Moreover, the Hedonists showed negative scores in relation to the “market” macro-area. In particular, the “LSR power” score was -0.4, the “price volatility” score was -3.2 and the score for the “market globalisation” item was -2.8.

Therefore, these citizens identified the “market” macro-area as a significant barrier to food security achievement. A further interesting point is related to the “quality” macro-area. In particular, the citizens of MCB assigned positive scores to the items “PDO–PGI certifications” and “environmental certification” (3.6 and 5, respectively). In this regard, quality certification schemes could reduce consumers’ concern for food security (Tran and Goto, 2019). The labelling as “Hedonists” is due also to a negative score attributed to the item “intensive production” (−0.6) as well as to a positive score for “food waste recycling technology” (1.8) within the macro-area “sustainability of production systems”.

The third group of citizens, identified as cluster 3 and labelled as “Law-confidants”, represents 45% of the sample. It consists of males with an average level of education (high school). These citizens indicated that all the items belonging to the governance macro-area are strong drivers for achieving food security. In fact, the “food policy” score was 3.5, while the scores for both “food loss and waste (FLW)” and “EU support” were 4.0. According to the literature, efficient governance in urban areas can be achieved through the development of EU lighthouse projects focused on food policies and food security issues (Martin *et al.*, 2019) and the implementation of approaches for sustainable management of biowastes (De Boni *et al.*, 2022). Moreover, the “Law-confidants” indicated “intensive production” (score 1.1) and “food waste recycling technology” (score 3.2) as drivers to food security achievement. In this regard, some scholars suggested the bioprocessing of food by-products and wastes (FBPW) as a sustainable strategy for food loss and waste management (Minervini *et al.*, 2022). Positive scores were also assigned to the “quality” macro-area, particularly to the items “PDO-PGI certifications” (3.4) and “environmental certification” (2.9), which are considered important elements for food security achievement.

The fourth group of citizens identified as cluster 4 and labelled as “Conservatories” represents 4% of the sample. They are mainly women with a low-to-medium annual income level (from 25,100 to 40,000 €/year). The items belonging to the “governance” macro-area are considered as significant drivers for food security achievement: the score for “food policy” was 2.9, while the scores for “food loss and waste (FLW)” and “EU support” were 0.8 and 2.9 respectively. In this regard, urban food policies can represent a key factor in achieving food security in European cities (Martin *et al.*, 2019). In addition, strategies and initiatives carried out in EU cities may positively affect the “food waste behaviour” of citizens (Mondéjar-Jiménez *et al.*, 2016). Conversely, MCB citizens attached an irrelevant score (0) to the items “intensive production” and “PDO-PGI certifications; the irrelevance of PDO–PGI certifications may be linked to the contribution of food certification schemes in increasing food sale prices (Tran and Goto, 2019). Moreover, “food waste recycling technology” (score -2.5) and “environmental certification” (score -1.2) are considered barriers to achieving food security. “Conservatories” also considered the market macro-area as an evident obstacle to food security, particularly regarding the item “price volatility” (-5).

## CONCLUSIONS

Cities are increasingly involved in the development of food policies, becoming key points in achieving food security and fostering the transition to sustainable agri-food systems. This study is a contribution to advancing knowledge of urban food policies. Indeed, four groups of citizens were clearly characterized taking into account their perceptions of key factors affecting food security, within four macro-areas (governance, market, quality and sustainability of production systems). These overall results may be a starting point for setting up tailored strategies in the framework of the food policy of the MCB.

The proposed approach and results may support EU policy makers in identifying key macro-areas and matters toward which to direct public funding in order to improve food security in urban areas, and to put in place actions enhancing citizens’ knowledge and awareness of key issues of food security.

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