

# Geographical Indications, public goods and sustainable development goals: A methodological proposal

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## ABSTRACT

Geographical Indications (GIs) are examples of food production that leans towards sustainability through management rules laid down by consortia and a Code of Specifications (CoS) that guides good practices. The objective of this paper is to develop a methodology grounded in the European Union Horizon 2020 Strength2Food (S2F) project, which can measure the extent to which GI production systems contribute to the fulfilment of Sustainable Development Goals (SDGs). The analysis comprises three stages. The first two use the S2F methodology: i) the identification of the benefits that the activities codified in the GI CoS bring to the territory, and ii) the definition of indicators for measuring such benefits, classed as public goods (PGs), and their evaluation criteria. The third stage represents this study's contribution to the methodology, that is, iii) establishing connections between the identified PGs and SDGs. To this end, we discuss a Protected Designation of Origin Parmigiano Reggiano hard cheese case study. Our methodology aims to provide policymakers, operators, and managers of GI value chains with a tool to define which good practices in GI production systems should be supported over time to better achieve the SDGs.

## 1. Introduction

According to the Food and Agriculture Organization of the United Nations (FAO), sustainability is a type of development in which patterns of production and consumption respect natural resources, social welfare, and economic development. By stating that sustainable development “conserves land, water, plants and animals, genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable” (FAO, 1989), it is implied that sustainability is tied to the production activities of humans. Therefore, the underlying assumption of the FAO's concept of sustainability is that positive social, economic, and environmental externalities spill over into society when tangible and intangible goods are privately produced. These positive externalities become public goods (PGs) (Kaul and Mendoza, 2004; Vanni, 2013).

In this context, the 17 Sustainable Development Goals (SDGs) set by Colglazier (2015) are to be interpreted as the global PGs the planet needs for fairer and more sustainable development, in which agriculture and food systems take a central place for their fulfilment.

Indeed, besides the goals that are unambiguously tied to the agri-food system transition, such as the end of hunger (SDG#2), climate

action (SDG#13) and sustainable consumption and production (SDG#12), most of the remaining SDGs can be fulfilled through the responsible behaviour of economic agents when producing, processing and consuming agri-food products.

This research focuses on geographical indication (GI) products and their role in SDGs fulfilment. Therefore, our research question is methodological in nature and, specifically, confronts the issue of measuring the contribution of GI production systems to SDGs fulfilment.

The study defines a quantitative methodology which is then implemented to a case study concerning the Protected Designation of Origin (PDO) Parmigiano-Reggiano cheese.

The paper is organised as follows: Section 2 is a literature review of the positive externalities produced by GI production systems and their contribution to SDGs fulfilment, thus identifying a main gap of the available studies; Section 3 explains the data and methodology used for evaluating the contribution of GI production systems to SDGs fulfilment. We then apply the methodology to a case study on PDO Parmigiano Reggiano (PR) production system in Section 4. Section 5 presents the discussion, and Section 6 the concluding remarks.

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## 2. Literature review

The contribution of GI products to SDGs fulfilment must be framed in a context that jointly analyses value chain activities, the place where they are embedded, and the expectations of the consumer, which include both the intrinsic quality of the product and environmental, cultural, and social aspects (Giacomini and Mancini, 2015).

GI products are the result of managing activities that are collectively defined and codified by the Code of Specifications (CoS). The latter can be considered a technical, economic, and also social "compromise" between the agents of the value chain and between them and the territorial stakeholders (Brunori et al., 2016; Reviron and Chappuis, 2011; Giacomini et al., 2010). The CoS affects three important elements: i) production techniques, ii) value chain efficiency, and iii) production areas. The first aspect is subject to technological, economic, and social pressures (internal or external to the value chain) that not only influence the evolution of the production system, but also the sustainability of both the value chain and the territory, thus influencing the level of PGs (Arfini et al., 2019a; Quiñones-Ruiz et al., 2018; Belmin et al., 2015). The second element concerns the impact of the CoS on value chain competitiveness. In fact, the CoS introduces organizational and technological innovations that reduce the labour force and production times and ultimately benefit producer turnover (Mancini et al., 2019). The third aspect highlights the role played by the CoS in cultural heritage preservation to the extent that they guarantee the territorial quality of a GI product; that is, the credence attribute of "origin". Preserving from fraud and usurping geographical names positively impacts the local agroecosystem and rural development (Arfini 2010; Mancini et al., 2019).

Therefore, the CoS represents the governance tool that acts, on the one hand, on the production of private goods and, on the other hand, on the generation of PGs that ultimately support the fulfilment of SDGs (Belmin et al., 2015; Arfini et al., 2010; Belletti et al., 2017). Given that production rules are expressed in the CoS—which is, in turn, the result of collective decision-making—PGs are ultimately the effect of common rules (Reviron and Chappuis, 2011; Giacomini et al., 2010; Arfini et al., 2010). GI products and consumers' expectations interact in the "food environment", that is, the place where food production and consumption meet (HLPE, 2017). Specifically, the "food environment refers to the physical, economic, political and socio-cultural context in which consumers engage with the food system to make their decisions about acquiring, preparing and consuming food" (HLPE, 2017:28). Therefore, it is not merely an economic concept proposed as the ideal place where exchanged quantities and prices are set; it also entails technological, social, and political domains. Indeed, the "food environment" takes different forms in relation to the technologies used in production, processing and marketing. Traditional food environments consist of low-processed seasonal products that are sold in informal and local markets, whereas modern food environments deliver non-seasonal and processed products sold in formal and long-distance markets. The social dimension of the "food environment" deals with the rules, knowledge, and culture of economic agents, which, in turn, impact both production and consumption patterns (Turner et al., 2018; Baker et al., 2018; Swinburn et al., 2013). On the one hand, the traditional, cultural, and religious practices of society set cultural norms that influence food choices. On the other hand, both private (e.g., the food industry) and public actors (institutions at international, national, or local levels) play crucial roles in framing beliefs and norms about food. Specifically, private actors influence the food environment through marketing campaigns or lobbying, whereas governments influence food choices through information campaigns or by defining legal frameworks for private actors (Swinburn et al., 2013).

Thus, the food environment depends on the value chains and territories where food production and consumption take place. In the case of GIs, the food environment is made up of production systems and consumer demand embedded in a specific region. This concept is

encapsulated by the French term *terroir*, which covers the specific nature of natural resources, the history and tradition of production, and local know-how (De Sainte-Marie et al., 1995; Bérard and Marchenay, 1995; Sylvander, 1995; Barjolle and Sylvander, 2002; Casabianca et al., 2005), coordinated by a governance system that impacts the value chain and the whole territory. The benefits across the territory differ based on the features of the value chains (at producing, processing and marketing levels), which may entirely lie inside the production region, or have no boundaries—when raw materials procurement and/or the consumer market are outside the area of production (Arfini et al., 2019a). The main narratives around GIs' contributions to producing positive externalities concern the ability to enhance skills, preserve quality, prevent unfair competition, and increase territory reputation (Barjolle and Sylvander 2002; Arfini et al., 2019c; Belletti et al., 2017). Further positive effects lie in facilitated relationships among stakeholders and product marketing, transaction cost reduction, and an increase in output value by raising the firm's reputation (Belletti et al., 2017). These mechanisms improve market efficiency and preserve local knowledge, cultural heritage, and biodiversity (Arfini et al., 2021). Therefore, while PGs are mainly delivered by governments (Reiss, 2021), they are considered beneficial in places where public and private actors interact.

To the best of our knowledge, however, only one recent study has explicitly and comprehensively investigated the ability of GI production systems to contribute to SDGs fulfilment as a result of the close connection between GI products and their local, natural and sociocultural environments (Kimura and Rigolot, 2021). The study shows how the SDG framework can address decision making to enhance the potential of GIs to respond to global priorities for sustainable development. To add to this limited contribution, we developed a methodology that uses the results of the European Union (EU) Horizon 2020 (H2020) Strength2food (S2F) project, in which the ability of the GI production system to produce PGs was investigated. Our contribution lies in connecting PGs production and SDGs fulfilment through the analysis of a case study.

## 3. Data and method

The ability of GI production systems to produce PGs was investigated using the EU H2020 S2F project. The S2F consortium, composed of 13 European academic partners and two third-country academic partners (Thailand and Vietnam), applied the methodology to 19 GI value chains (Bellassen et al., 2022; Arfini et al., 2019b). The main criterion for value chain selection was covering as many product categories and territorial contexts as possible within the countries involved in the project (Appendix 1).

The analysis comprised three stages. The first two use the S2F methodology: i) the identification of the positive externalities produced by the good practices codified in the GI CoS, and ii) the definition of indicators for measuring such externalities, classed as PGs, and their evaluation criteria. The third stage represents this study's contribution to the methodology, that is, iii) establishing connections between the identified PGs and SDGs. The methodology is described using a PDO PR cheese case study.

### 3.1. The identification of PGs as the result of the good practices defined in the CoS

The CoS of each GI product was analysed with the aim of identifying the codified activities (good practices) that produce PGs. To support the analysis of the CoSs, a list of questions was prepared (Appendix 2) that was used by the research units of the S2F project.

It was assumed that an activity produces PGs when it positively impacts one or more sustainability axes. Specifically: i) the socioeconomic texture of the production system (SE) 2. the environment (= use of natural resources - NR) and 3. the cultural heritage (CHP). Each good practice that was found in the CoSs was associated with a corresponding

PGs category.

3.2. The definition of indicators for PGs measurement and their evaluation criteria

The main source of inspiration for identifying the indicators able to measure to what extent CoS activities produce PGs was the FAO “Sustainability Assessment of Food and Agriculture (SAFA) guideline” (FAO, 2013a, 2013b), a holistic framework for the assessment of sustainability of food and agriculture value chains.

The SAFA approach provides more than 100 indicators for measuring PGs. Forty-two indicators were chosen to describe and measure all the good practices identified in the CoSs (Arfini et al., 2021; Mancini et al., 2022) (Table 1).

A 5-point Likert scale was adopted (1 representing the lowest contribution and 5 representing the highest) to measure to what extent

**Table 1**  
PGs indicators per PG category.

PG category	Indicators
Socio-economic (SE)	Governance actions- sustainability and corporate mission
	Governance actions-Market regulation systems
	Governance actions-agreement with local administration
	Governance actions-monitoring system
	Governance actions-certification system
	Governance actions-manage of conflicts and dispute
	Governance actions-updating rules democratically
	Governance actions-accounting for sustainable and good management
	Governance actions-use of quality mark definition
	Governance actions-Strategies or actions (research projects, etc.) aimed at improving sustainability
	Contribution to local economy
	Intensity of network relationship- relationship with local politics or administrations
	Intensity of network relationship- link between society and producers
	Gender Equality-role of women
	Partecipation to board association
	Role of cooperatives in the value chain governance
	Bargain power distribution-sustainability of value chain structure
	Bargain power distribution-individual or collective management of sustainable issues
	Fair marketing management- marketing strategies
	Fair marketing management- segmentation of product
	Short value chain organisation and management- direct sales
	Supply control and value creation- production quotas
	Use of Natural Resources (NR)
Animal stress from freedom	
Quality of resource appropriation	
Carbon foot print control and management	
Water quality creation and management	
Respect of ecosystem biodiversity	
Respect of species biodiversity	
Respect of genetic biodiversity	
Protection of soil quality- soil quality	
Protection of soil quality- land quality	
Cultural Heritage Preservation (CHP)	Link with territory-Historical elements and sustainability
	Communication activities-guarantee the quality certification mark
	Communication activities-external communication
	Educational activities for producers and consumers
	Education-Professional training on the FQS
	Product distinctivness
	Respect of the qualitative and traditional aspects
	Generational Change
	Productive system reaction to generational change
	Support touristic events

Source: authors' elaboration

each good practice plays a role in one or more PGs' production.

The values were then normalised to have comparable indices, and a single index for each PG category was calculated (Arfini et al., 2019c). As a result, PG indices are multidimensional and describe a complex system of different phenomena (Arfini et al., 2019c).

3.3. The analysis of the relationship between PGs and SDGs

The indicators were then grouped per relevant SDG and target (Table 2), with the support of the limited literature available on the relationship between GIs and SDGs (cfr. Belletti et al., 2017; Kimura and Rigolot, 2021).

In most cases, there is a clear correspondence between good practices, PGs indicators, and SDGs, thus making any explanation superfluous. In a few cases, the relationship is not evident, but it becomes clear when good practices and the PGs indicators are associated with the target of each SDG, as shown in Table 2. This connection is evident in the case study described below.

4. A case study: the PDO PR production system

4.1. The Parmigiano Reggiano production system

The above methodology was applied to the PDO PR production system mainly because the PR CoS represents an insightful example of rules that are fulfilled by producers from different socioeconomic and environmental contexts. Thus, the good practices of the PR CoS can inspire and be implemented in several models of GI systems.

PDO PR cheese has a long tradition and history, and its production by Benedictine monks can be traced back to 1254 in an area on the right bank of the Po River in Northern Italy (Arfini et al., 2019a). Today, the PR value chain comprises both small- and large-scale actors. The former are small-scale farmers and cheese dairies, mainly located in marginalised areas in the mountains where PR production is the main (if not only) means of income. The latter are large-scale farmers and cheese dairies that are predominantly in economically favourable areas, mainly in the hills and flat areas, close to urban settlements.

It is the second most produced Italian PDO cheese, by producing 156,620 tons in 2021 for a total value of about € 1,715,000 at producer level (CFPR, 2023). The PR chain included 2373 breeders/milk suppliers and 305 dairies for a total of 50,000 people involved in the production chain in the same year (CFPR, 2023). PR is a hard, granular cheese with a long, natural ripening period. The Control Quality Body of Parmigiano Reggiano guarantee product quality and protect its reputation against fraud and usurpation. The objectives of the quality scheme have remained the same, although the CoS has developed over time with technical and legal amendments (Arfini et al., 2010). In addition to the producers and cheese dairies, the PR chain comprises ripeners, wholesalers, and traders, and the consortium—Consortio Formaggio Parmigiano-Reggiano (CFPR)—governs its members by playing three main functions: (i) guaranteeing cheese quality, (ii) protecting PR producers against unfair competition, and (iii) promoting PR in the market.

Some other actors play important roles (such as research centres—including the five universities of the Emilia-Romagna region—and technical laboratories) by providing farmers and dairies with technical assistance and promoting innovation processes, and the Chambers of Commerce strengthen relationships among stakeholders and take part in the economic governance of the whole territory (Fig. 1).

4.2. Results

Table 3 shows the contribution of PR production systems to SDGs fulfilment by measuring the extent to which they produce PGs connected to the SDGs.

The findings show the important contribution of the PR production system in the fulfilment of three SDGs; SDG#12 (0.78), SDG#4 (0.75)

**Table 2**  
Indicators of PGs and their correlation with SDGs and targets.

PG Indicators	SDGs	SDG Targets
Productive system reaction to generational change	#1 No Poverty	1.2: Reduce poverty
Profit-to-labor ratio		
Contribution to local economy		
Educational activities for producers and consumers	#4 Quality Education	4.3: Equal access to affordable technical, vocational, and higher education
Education-Professional training on the FQS		
Role of women	#5 Gender Equality	5.1: End discrimination against women and girls/ Target 5.5: Ensure full participation in leadership and decision-making
Water quality creation and management	#6 Water and Sanitation	6.6: Protect and restore water-related ecosystems
Contribution to local economy	#8 Decent work and economic growth	8.1 Sustainable economic growth
Governance actions-research actions		8.2: Diversify, innovate and upgrade for economic productivity
Education-Professional training on the FQS		
Fair marketing management-segmentation of product		
Communication activities-guarantee the quality certification mark		8.4: Improve resource efficiency in consumption and production
Communication activities-external communication		
Fair marketing management-marketing strategies		
Short supply chain organisation and management- direct sales		
Supply control and value creation- production quotas		
Productive system reaction to generational change		8.6: Promote youth employment, education and training
Role of cooperatives in the value chain governance		8.8: Protect labour rights and promote safe working environments
Bargain power distribution-sustainability of value chain structure		
Bargain power distribution-individual or collective management of sustainable issues		
Support touristic events		8.9: Promote beneficial and sustainable tourism
Intensity of network relationship- link between society and producers	#12 Responsible Consumption and Production	12.1: Implement the 10-year sustainable consumption and production framework
Short supply chain organisation and management- direct sales		
Support touristic events		12.b: Develop and implement tools to monitor sustainable tourism
Link with territory-Historical elements and sustainability		
Product distinctiveness		
Respect of the qualitative and traditional aspects		
Quality of resource appropriation		12.2: Sustainable management and use of natural resources
Governance actions-sustainability and corporate mission		12.6: Encourage companies to adopt sustainable practices and sustainability reporting
Governance actions-monitoring system		

**Table 2 (continued)**

PG Indicators	SDGs	SDG Targets
Carbon footprint control and management	#13 Climate Action	13.2: Integrate climate change measures into policy and planning
Animal health	#15 Life on land	
Animal stress from freedom		
Protection of soil quality- soil quality		15.3: End desertification and restore degraded land
Protection of soil quality-land quality		
Respect of ecosystem biodiversity		15.5: Protect biodiversity and natural habitats
Respect of species biodiversity		
Respect of genetic biodiversity		
Governance actions-sustainability and corporate mission	#16 Peace, justice and strong institutions	16.6: Develop effective, accountable and transparent institutions
Governance actions-agreement with local administration		
Governance actions-accounting for sustainable and good management		
Governance actions-monitoring system		
Governance actions-certification system		
Governance actions-use of quality mark definition		
Governance actions-updating rules democratically		Target 16.7: Ensure responsive, inclusive and representative decision-making
Governance actions-manage of conflicts and dispute		
Participation to board association		
Bargain power distribution-sustainability of supply chain structure		
Bargain power distribution-individual or collective management of sustainable issues		
Role of cooperatives in the value chain governance		
Intensity of network relationship- relationship with local politics or administrations		Target 16.8: Strengthen the participation in global governance
Governance actions-Market regulation systems		

Source: authors' elaboration

and SDG#8 (0.74); an intermediate contribution for SDG#6 (0.50), SDG#16 (0.48); a lower contribution for SDG#1 (0.21) and SDG#15 (0.37), whereas no good practices were found that contribute to SDG#13 and SDG#5 (Fig. 2).

For the sake of our research, we describe the connection between PGs and SDGs by focusing on the most outstanding results and the lowest contributions of the PR production system to SDGs fulfilment.

SDG#12 (Responsible consumption and production) is fulfilled specifically through Target 12.1 (Implement the 10-year sustainable consumption and production framework) that calls for actions and programmes that construct sustainable food systems, including short supply chains which limit some highly polluting activities (e.g. long distance transportation), support consumers access to quality foods (Malak-Rawlikowska et al., 2019), and foster the involvement of the local community and stakeholders.

These aspects—measured by several indicators such as “link with territory-historical elements and sustainability”, “product distinctiveness” and “respect of the qualitative and traditional aspects”—play a

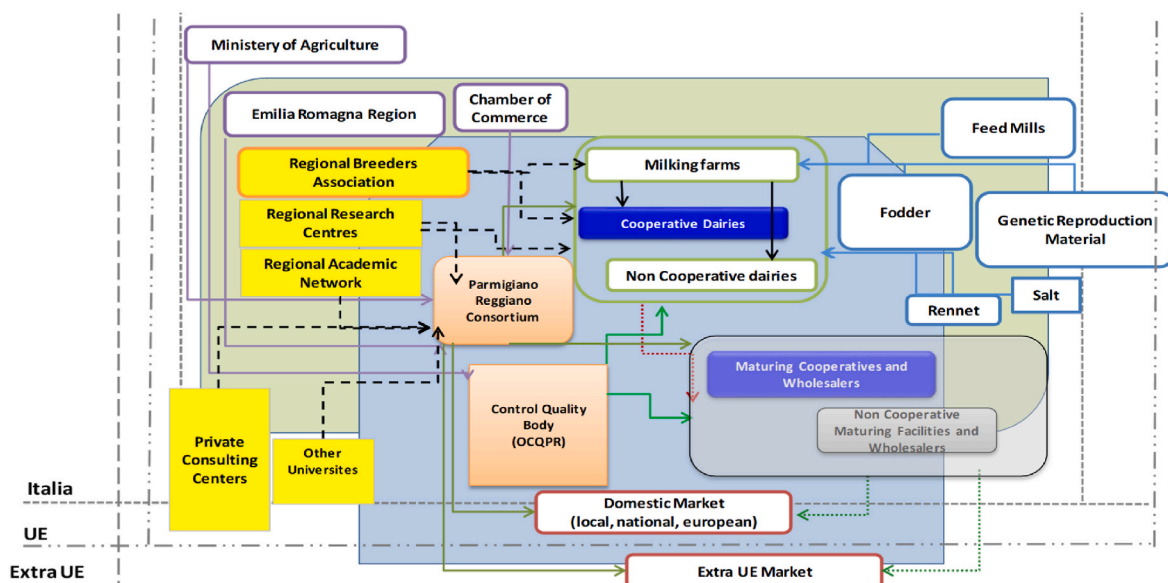


Fig. 1. The Parmigiano Reggiano value chain and its territory - Source: authors' elaboration.

central role in the PR production system. The historical background and cultural heritage represent key features of the product as the know-how and processing activities do not differ greatly from those used centuries ago. Indeed, PR “is still considered an artisanal product since the cheesemaker still plays a fundamental role in defining the quality through his knowledge and ability to manage milk produced (potentially) in different natural and managerial contexts” (Arfini et al., 2019a:10). The uniqueness of the product is also due to the characteristics of the soil, climate conditions, and composition of the natural flora, which directly affect the enzymatic processes that make the taste of the cheese distinct. All traditional features are described in the CoS and have been acknowledged in the designation of origin since 1957 (Cozzi et al., 2019).

Target 12.2 (Develop and implement tools to monitor sustainable tourism) is fulfilled by Consortium support through several recreational and touristic events aimed not only at promoting the GI products, but also enhancing and preserving local resources. Another important aspect of the PR production system pertinent to the above-mentioned target lies in good practices that connect the local community and the production system. These range from research to tourism activities jointly promoted by the consortium and local research institutions (e.g. universities) and bodies (the municipality or the region), and include guided tours, dairy visits, and tasting events for local and foreign tourists. Consequently, short PR supply chains and direct sales have significantly increased over the last two decades. Small PR dairies have increased their profits by selling products in their farm shops and proved to be resilient in the face of the 2008–2012 economic downturn (Mancini and Arfini 2018). Direct-to-consumer dairies are also supported by the consortium, which provides uniforms to personnel, gadgets and gifts to be displayed in the shops, and farmers with assistance on legal health and safety requirements.

Consortium marketing strategies include multichannel strategies (e.g., sales through online shops, home delivery, restaurants, and direct sales) to make GIs more accessible and convenient for consumers and rewarding for small-scale and independent producers (Arfini et al., 2021; Mancini et al., 2022). Both consumer communication activities and the promotion of alternative distribution channels drive a new model of consumption and production in which environmental, social, and economic sustainability together play a crucial role (Mancini and Arfini, 2018).

SDG#4 (Quality education) is mainly supported by two indicators: “Educational Farm Activities” and “Education-Professional training on

the GIs”. Indeed, the PR consortium also provides technical assistance, supports trade fairs and events, and helps dairies to comply with health and safety, labelling, and traceability regulations. Technical assistance, research, and consultancy services are also offered by public (e.g., Regione Emilia Romagna, Regione Lombardia, and many universities involved in testing and research projects related to PR) and private bodies (Regional Breeders Association, Animal Production Research Centre [CRPA], trade union associations, and agricultural cooperatives). The pilot project on “low-sodium, freeze-dried and low-seasoned” PR was carried out by the Interdepartmental Centre for Food Safety, Technology and Innovation (SITEIA) of the University of Parma, in collaboration with the University of Bologna, Regione Emilia Romagna, the CRPA and CFPR. The project, named “PARENT: from the Parmigiano Reggiano supply chain new products for new consumer targets”, was developed between 2016 and 2018.<sup>1</sup> Additionally, the initiative, “Ethical cheese: commercial valorisation of Parmigiano Reggiano based on production diversification and additional certifications beside PDO: organic and animal welfare” was implemented between 2019 and 2022 by private producers and breeders (Montanari Gruzza SPA; Agricola Valparma S.r.l; Bertoni etc.), the CRPA and the Emilia Romagna Region. The initiative aimed to enhance the commercial value, especially for export, through elements of ethics and sustainability identified in the animal welfare and organic production system, as a productive choice linked to a non-intensive production.<sup>2</sup>

The third high level contribution is provided to SDG#8 (Decent work and economic growth) which is fulfilled by practices codified in the PR CoS that meet Targets 8.1 (Sustainable economic growth), 8.2 (Diversify, innovative and upgrade for economic productivity) and 8.4 (Improve resource efficiency in consumption and production).

Indeed, the PR CoS’s restrictions on forage promote production in the area, whereas the high number of slaughterhouses in the area guarantees calf rennet. Moreover, farmers and cattle breeders who supply dairies with milk must be located inside designated areas to support local performance. All processing steps, from production to ripening, cutting, grating, and packaging, must occur within the local area. This restriction has contributed to the development of an excellent cluster for

<sup>1</sup> <https://www.centritecnopolo.unipr.it/siteiparma/ricerca-e-progetti/progetti/parent/>.

<sup>2</sup> <https://ec.europa.eu/eip/agriculture/en/find-connect/projects/valorizzazione-commerciale-del-parmigiano-reggiano>.

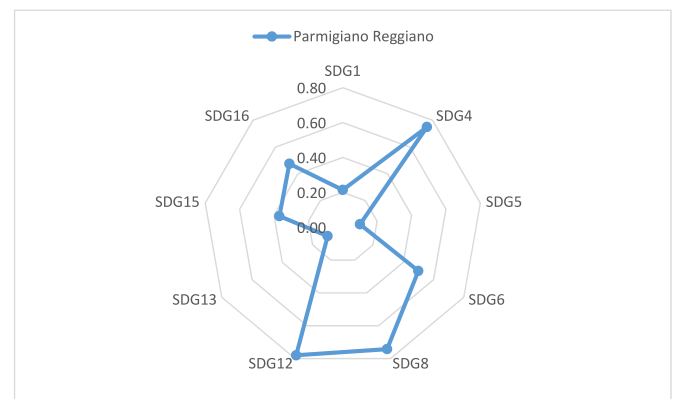
**Table 3**  
PG indicators per PG category, SDG and SDG Index.

PGs category*	PG Indicator	PG Index	SDG	SDG Index
CHP	Productive system reaction to generational change	0.10	SDG1	0.21
CHP	Profit-to-labor ratio	0.10		
SCs	Contribution to local economy	0.98		
CHP	Educational activities for producers and consumers	0.75	SDG4	0.75
CHP	Education-Professional training on the FQS	0.75		
SEs	Gender Equality	0.10	SDG5	0.10
NR	Water quality creation and management	0.50	SDG6	0.50
CHP	Education-Professional training on the FQS	0.75	SDG8	0.74
CHP	Communication activities-guarantee the quality certification mark	0.98		
CHP	Communication activities-external communication	0.75		
CHP	Productive system reaction to generational change	0.10		
CHP	Support touristic events	0.98		
SEs	Contribution to local economy	0.98		
SEs	Role of cooperatives in the value chain governance	0.98		
SEs	Bargain power distribution-sustainability of value chain structure	0.75		
SEs	Bargain power distribution-sustainability issues management	0.75		
SEs	Fair marketing management-segmentation of product	0.75		
SEs	Fair marketing management-marketing strategies	0.75		
SEs	Short supply chain organisation and management- direct sales	0.98		
SEs	Supply control and value creation-production quotas	0.98		
SEs	Governance actions-research actions	0.98		
CHP	Link with territory-Historical elements and sustainability	0.98	SDG12	0.78
CHP	Product distinctiveness	0.98		
CHP	Respect of the qualitative and traditional aspects	0.98		
CHP	Communication activities-guarantee the quality certification mark	0.98		
CHP	Support touristic events	0.98		
SEs	Governance actions- sustainability and corporate mission	0.10		
SEs	Governance actions-monitoring system	0.98		
SEs	Short supply chain organisation and management- direct sales	0.98		
SEs	Intensity of network relationship-link between society and producers	0.98		
NR	Quality of resource appropriation	0.98		
NR	Carbon foot print control and management	0.10	SDG13	0.10
NR	Animal welfare -animal health	0.98	SDG15	0.37
NR	Animal-welfare- animal stress from freedom	0.10		
NR	Respect for Eco-system biodiversity	0.98		
NR	Respect for species biodiversity	0.98		
NR	Respect for genetic biodiversity	0.98		
NR	Protection of soil quality- soil quality	0.10		
NR	Protection of soil quality- land quality	0.10		
SEs	Governance actions- sustainability and corporate mission	0.10	SDG16	0.48
SEs	Intensity of network relationship-relationship with local politics or administrations	0.98		
SEs	Governance actions-Market regulation systems	0.98		
SEs	Governance actions-agreement with local administration	0.10		

**Table 3 (continued)**

PGs category*	PG Indicator	PG Index	SDG	SDG Index
SEs	Governance actions-monitoring system	0.98		
SEs	Governance actions-certification system	0.98		
SEs	Governance actions-conflicts and dispute	0.98		
SEs	Governance actions-updating rules democratically	0.10		
SEs	Governance actions-accounting for sustainable and good management	0.10		
SEs	Governance actions-use of quality mark definition	0.98		
SEs	Partecipation to board association	0.98		
SEs	Role of cooperatives in the value chain governance	0.98		
SEs	Bargain power distribution-sustainability of value chain structure	0.75		
SEs	Bargain power distribution-sustainability issues management	0.75		

PGs category\* = CHP= Cultural Heritage Preservation, SEs= Socio-Economic PGs, NR= Use of Natural Resources.



**Fig. 2.** PR contribution to the achievement of SDGs.

the food machinery industry in Emilia Romagna, specialising in cutting-edge technologies for preservation, cutting, and storage.

The Consortium also introduced “production quotas” that ensure the economic and social sustainability of the production system, avoiding oversupply to national and foreign markets, thus supporting a fair standard of living for producers. Production quotas have long been debated. In 1982, the Consortium launched production plans to set annual maximum production targets, but the Italian “Anti-Trust Authority” banned them in 1996 in an alleged attempt to restrict competition in the PR cheese sector. Nevertheless, when the Common Agricultural Policy quota regime quit, the consortium set a “cheese quota” regime to protect the farm assets, thus replacing the “milk quotas” with “cheese quotas” (Mancini et al., 2019). This initiative is still in place and proves to be a tool capable of facing strong variations in stocks and production that negatively affect product quality, investments, and the transmission of know-how, as well as preventing overproduction, degrading natural resources, and protecting product quality.

As mentioned, the SDG#8 is also fulfilled through practices that meet target 8.2 (Diversify, innovate and upgrade for economic productivity). Indeed, the Consortium and producers’ associations expend efforts to increase product value through innovation, for instance, by delivering courses to farmers on genetics, nutrition, and production to stimulate innovation (Arfini et al., 2021). By supporting the upgrading of value chain activities, the Consortium and other institutions play important

roles in maintaining the local territory socially and economically (Mancini and Consiglieri, 2016).

Moreover, many CoS practices result in fulfilling both SDG#12 and SDG#8 (Target 8.4 “Improve resource efficiency in consumption and production”), especially activities aimed at providing consumers with information about a product’s intrinsic and extrinsic characteristics, which ultimately enhance its reputation. These include communication on the PDO label and the Consortium certification mark, the development of websites to promote the product and disseminate news about the consortium, publishing books of recipes and information pamphlets for consumers (the latter with particular attention towards students), strengthening the alliance with the out-of-home sector such as restaurants, and facilitating contact between consumers and producers/distributors to promote direct sales (Arfini et al., 2021). Mancini and Arfini (2018) point out that such communication tools contribute to strengthening the reputation of not only the value chain, but also the territory where it is embedded, as well as providing practical information. The Consortium’s website shows the locations of the dairies, specifies whether they sell on-site or via e-commerce, and provides consumers with contact details for outlets.

The analysis of the connection between good practices and SDGs #12, 4 and 8 shows that a single good practice supports more SDGs simultaneously and proves that a comprehensive approach to sustainability must identify the contributions produced by each good practice on multiple SDGs.

With respect to the intermediate contribution of PR production system to the SDGs, we would like to mention SDG#6. In this case, PR CoS requires a comparatively low use of water to produce animal feeding, by forbidding the use of silage in animal feeding that is a water highly demanding practice.

However, the PR system showed lower values for the indices connected to SDG#1 and SDG#15. SDG#1 (No poverty) is supported by three indicators: “Productive system reaction to generational change”, “Profit-to-labour ratio” and “Contribution to local economy”. Despite the latter ranking very high because of the tight value chain connection with the territory that promotes local economic activities, there are no data available regarding the other two indicators, thus decreasing the synthetic index to 0.21. Nevertheless, we believe that the PR production system supports “generational change”, by offering profitable jobs to young people within the local economy, although there are no explicit rules on this.

Indeed, the CoS anchors the origin of the raw materials and/or other processing activities to the designated geographical area, supporting employment and income generation in the production area, favouring knowledge transmission and stimulating the economic performance of local actors (Arfini et al., 2019d, 2021). This is another example of a good practice that has multiple effects on sustainability.

However, SDG#15 is negatively impacted by the lack of formalised good practices on “animal freedom from stress” and the “protection of soil quality”, thus decreasing the overall contribution of the PR system to the SDG fulfilment, even though high values of the indicators “animal health” and “respect of biodiversity” strongly support SDG#15. Indeed, many CoS requirements promote animal health, especially for feeding (Article 3.3, CoS). Strict rules ensure a proper animal diet and forage origin (at least 50% of forage must be hay, and at least 75% of forage is produced in the production area). The diet also positively affects natural resources, and the local procurement requirement for feeding implies that a substantial part of the animal’s diet is covered by alfalfa, for which no fertiliser is needed.

Moreover, a register of suppliers of animal feed is regularly updated by the CFPR to ensure a high-quality level of raw materials, and antibiotics are forbidden because they prevent fermentation, which is clearly a positive improvement in the care of animals’ health and physiology, and positively impacts biodiversity as well as landscape maintenance (Arfini et al., 2019c). We believe that there is a close connection between animal health and animal freedom from stress;

therefore, the weakness is about formalising rules rather than the lack of good practices.

Finally, a synthetic index was calculated for each PG category. The findings show that the PR production system mostly contributes to cultural heritage preservation (0.57) and the production of socioeconomic benefits in both the value chain and the territory (0.50), whereas the correct use of natural resources has a lower index value (0.31).

## 5. Discussion

The case study is an opportunity for discussion on two aspects: the first concerns how the developed methodology can contribute to SDGs fulfilment; the second is a methodological issue, that is, how it captures the ability of GIs to contribute to SDGs fulfilment.

We argue that the implementation of such a methodology contributes to SDGs fulfilment by highlighting both the strengths and weaknesses of GI value chains in producing PGs that contribute to SDGs fulfilment.

These strengths must act as a source of inspiration for the production of good practices to be applied by other GI production systems. In the case under analysis, the PR cheese production system has been shown to play a key role in the fulfilment of three SDGs – “Responsible consumption and production”, “Quality education”, “Decent work and economic growth” by succeeding mainly in two categories of strategies, the first one concerning the governance of the GI production system and the second one concerning the communication of the social value of GIs to all the stakeholders, from producers to citizens.

In the case study under investigation, the first category implies the development of governance that can prevent the concentration of decision-making processes and strengthen the relations between value chain actors, local institutions, and value chains. From this analysis, a first recommendation can be made; that is, public intervention must drive and strengthen co-creation dynamics through ad hoc policies that enhance local institutions’ interaction with the communities’ issues and concerns. The second aspect of the first category of strategies concerns the ability of local institutions, mainly the PR consortium, to enhance traditional production processes, which are intrinsic to GI production systems and foster the fulfilment of the cultural, socioeconomic, and environmental priorities of local communities. While much literature is available on the socio-economic impacts of GI production systems (Bramley, 2011; Török et al., 2020), the relationship between GI production systems and their environmental effects has only recently begun to be investigated (Malak-Rawlikowska et al., 2019). The early findings show that the traditional characteristics of GI processes enhance the sustainable use of natural resources in several ways; traditional diets increase cattle lifespan and reduce the “carbon deadweight” of unproductive heifers and cull cows, whereas sustainable forage implies less fertiliser and fuel for field operations than the amount required by silage maize (Mancini et al., 2022).

SDGs fulfilment also goes through an analysis of the relationship between traditions and innovation. Indeed, in cases where the traditional and territorial nature of products is institutionalised in origin-based certifications, there are limitations to innovation. Although innovations, particularly organizational ones, can be efficient in lowering costs along the value chain, they can be met with resistance from some actors (Kühne and Gellynck, 2009) in small and medium enterprises, which are not always receptive to changes; thus, it takes a long time for innovation to be introduced and codified in the CoS (Mancini and Consiglieri, 2016). The main point is to find the right balance between technology and traditional practices that aim to preserve historical heritage, natural resources, landscapes, biodiversity, and economic sustainability. Indeed, while technological progress is an effective method for improving the efficiency of the production system, traditional practices and extensive production systems respect biodiversity and landscapes. Therefore, technologies that entail lower energy use through the reduction of fertilisers, diesel for cultivation, electricity for

storage, and the shorter-distance transportation of raw materials are recommended. To this end, research on the environmental sustainability of innovations, knowledge transfer, and technical assistance should be supported by local administrators and decision-makers.

The second category concerns promoting communication to raise awareness of the territorial quality attributes of GI products and the positive externalities of GI production systems. Indeed, communication is an important aspect of the overall enhancement process of the production system and must take place both along the value chain and outside of it between actors in the value chain and consumers/citizens, both in the local area of production and in distant environments, as it increases awareness of the territorial quality attributes of GI products.

Some recommendations can also be formulated by analysing the weaknesses of PR's contributions to SDGs fulfilment. There is still room for improvement in enhancing the socioeconomic and environmental sustainability of PR production.

On the economic and social sides, the system has to find more efficient dynamics to support generational changes and family profitability in less favourable areas—that is, in the mountains—and an equitable gender balance as no rules are defined to support the empowerment of women in the decision-making processes (Cozzi et al., 2019). Other issues that must be addressed involve environmental topics to the extent that there are no explicit rules or practices concerning carbon footprint management, protection of soil, and land quality. This raises a methodological issue: whether the weaknesses captured by this methodology are intrinsic to the system or rather a bias due to the lack of formalisation in the CoS. This potential bias may be overcome by conducting a broader analysis through interviews with stakeholders, thus reducing the potential gap between good practices formalised in the CoS and other good practices that are not formalised but in use along the value chain. The second issue concerns the reproducibility of our results. As the evaluation of the PG indices is subject to researchers' interpretation, some interventions should be considered to reduce the variability of the assessments, such as training or providing guidelines. All these are challenges for future research to improve this methodology.

Moreover, a multidisciplinary approach is strongly recommended to comprehensively assess the impact of each practice on additional indicators along the triple bottom line of sustainability.

However, we believe that this methodology can be used for research in at least two ways. First, it compares practices adopted by several GI production systems for the same activity or goal. This could help understand the extent to which different social, economic, and environmental contexts impact how activities are implemented. Second, this method provides an opportunity to draw on the evolution of practices defined in a CoS for a given GI product over time. The revision of a GI product's CoS reflects the evolution of the environment in which the product is embedded, although it often takes a long time to obtain CoS revision approval.

## 6. Conclusion

According to EU Regulation 1151/2012, GIs contribute to rural

## Appendices

### Appendix 1

PDO and PGI value chain analysed in S2F project

Food category	PDO	PGI
Cereal		TKR Horn Mali Rice
Dairy	Comte Cheese	Siemica Cheese
	Parmigiano Reggiano Cheese	
Meat		Dalmatian Prosciutto
		Gyulai Sausage
		Sobrasada Porc Negre

(continued on next page)

development policy objectives, as the generation of PGs is expected to result in several benefits (Kaul et al., 1999), ultimately identifiable in SDGs, which are produced by the collective rules defined in the CoS. These rules may contribute positively to the sustainable development of local production systems and rural communities. However, this result cannot be assumed without the awareness of all actors along the value chain and within the territory. To this end, evidence is required to measure the PGs produced by GI production systems.

Therefore, we proposed a methodology grounded on the SAFA approach to analyse the good practices codified in the CoS that play a role in SDGs fulfilment. To this end, a list of indicators was defined to analyse a number of aspects related to the GIs production systems, ranging from their environmental impact, the role of governance and communication in raising stakeholders' awareness and the part played by innovation. The analysis provided the opportunity to make some recommendations to stakeholders and policy makers for increasing family profitability, strengthening gender equality, and supporting generational change.

We concluded by defining some issues concerning the methodology accuracy and reproducibility that need for further improvements. However, the project paves the way for more research on quantitative measurement methods to be used by GIs producers groups, as self-assessment tools to highlight the GIs sustainable outcomes and improve their production practices, but also by public authorities and other stakeholders in charge of supervising and supporting GIs development.

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## Authors contributions

Marianna Guareschi: Conceptualization; Data curation; Investigation; Formal analysis, Methodology; Writing - original draft. Maria Cecilia Mancini: Conceptualization; Formal analysis; Writing - original draft; Writing - review & editing; Supervision; Validation. Filippo Arfini: Conceptualization; Funding acquisition; Methodology; Project administration; Resources; Supervision; Validation.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.



**Appendix 1 (continued)**

Food category	PDO		PGI	
Fish	Saint Michael Bay Bouchot Mussels	France	Loften Stockfish	Norway
			Ternasco de Aragorn Lamb	Spain
Fruit and vegetable	Opperdoezer Ronde Potatoes	Netherlands	Kastoria Apples	Greece
	Zagora Apples	Greece	Kaszubska Strawberries	Poland
Coffe and dressings	Kalocsai Paprika	Hungary	Buon Ma Thuot Coffee	Vietnam
	Istra Olive Oil	Croatia	Doi Chaang Coffee	Thailand
	Phu Quok Fish Sauce	Vietnam		

Source: authors' elaboration

**Appendix 2**

## Guide questions per PG category

PG category	Guide Questions
Cultural Heritage Preservation (CHP)	<p>Do historical elements of the product linked to sustainability exist?</p> <p>Which good practices does the CoS use to guarantee the quality certification mark?</p> <p>Which good practices the consortium or companies use to generate an external communication strategy that can encourage an economic sustainability?</p> <p>What training/educational activities for producers and consumers are guaranteed by the consortium/companies and how?</p> <p>Which good practices create and improve educational and training systems that support the product (referred to university/research body that support the product innovation) ?</p> <p>Is the product sufficiently distinguishable by characteristics and names? If yes, how?</p> <p>How the CoS includes and guarantees the respect of the qualitative and traditional aspects that concern to sustainability?</p> <p>How the productive system react to generational change? Explain good practices.</p> <p>Which good practices allow the sustainability of profitability for families?</p>
Socio-economic (SE)	<p>What good practices the consortium or companies do to support tourism activities?</p> <p>Do companies/consortia have included sustainability as a corporate mission (implicitly or explicitly)? If yes, how?</p> <p>Does the CoS/consortium introduce market regulation systems to ensure an economic sustainability? If yes, how?</p> <p>What good practices make the certification system effective?</p> <p>How the CoS define the use of quality mark?</p> <p>Is there a monitoring system aimed at sustainability? If yes, explain.</p> <p>Which practice of accounting are introduced to have a sustainable and good management?</p> <p>Which methods the consortium/companies provides for managing conflicts and disputes?</p> <p>Does the consortium update the rules democratically? If yes, please, explain</p> <p>Which policies of the consortium/companies are aimed at territorial development and are developed in agreement with local administrators?</p> <p>Does the consortium/companies introduce strategies or actions (research projects, etc.) aimed at improving sustainability? If yes, please explain</p> <p>Does the product contribute to the local economy? If yes, please, identify the relevant practices</p> <p>Are there good practices to create relationship with local politics or local administrations?</p> <p>Which good practices favour a link between society and the productive world to strength sustainability?</p> <p>Does the productive system recognize the role of women and other vulnerable categories? If yes, please explain.</p> <p>Does the statute guarantee the representativeness of the value chain in the consortium? If yes, how?</p> <p>What good practices allow cooperatives to have a role in value chain governance?</p> <p>Which good practices favour the sustainability of the value chain structure?</p> <p>Are sustainability issues managed individually or collectively (among companies)? If yes, explain</p> <p>Which good practices the consortium/companies introduce in term of marketing strategies development?</p> <p>How the consortium/companies manage the segmentation of product and the use of products as ingredients in food, in terms of contracts and regulations?</p>
Use of Natural Resources (NR)	<p>Which good practices are used to improve direct sales?</p> <p>Are productive quotas introduced? How?</p> <p>How the CoS include and guarantee respect for animal welfare aspect in term of animal health?</p> <p>How the CoS include and guarantee respect for animal welfare aspect in term of freedom from stress?</p> <p>How the CoS includes and guarantees the respect of the qualitative aspects connected to resource appropriation?</p> <p>Which actions the CoS/consortium/companies do to manage CO2 emissions?</p> <p>Which actions the CoS/consortium/companies do to manage water use?</p> <p>How the CoS includes and guarantees the respect of the biodiversity aspects connected to ecosystem diversity?</p> <p>How the CoS includes and guarantees the respect of the biodiversity aspects connected to species diversity?</p> <p>How the CoS includes and guarantees the respect of the biodiversity aspects connected to genetic diversity?</p> <p>Which good practices consortia/companies or institutions use to assess and guarantee soil quality?</p> <p>Which good practices consortia/companies or institutions use to assess land quality and avoid land degradation?</p>

Source: authors' elaboration on S2F.

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