TRansition paths to sUstainable legume-based systems in Europe

D4.5 SDIs (Sustainable Development Indicators) for Quality Chains

Deliverable Work Package 4

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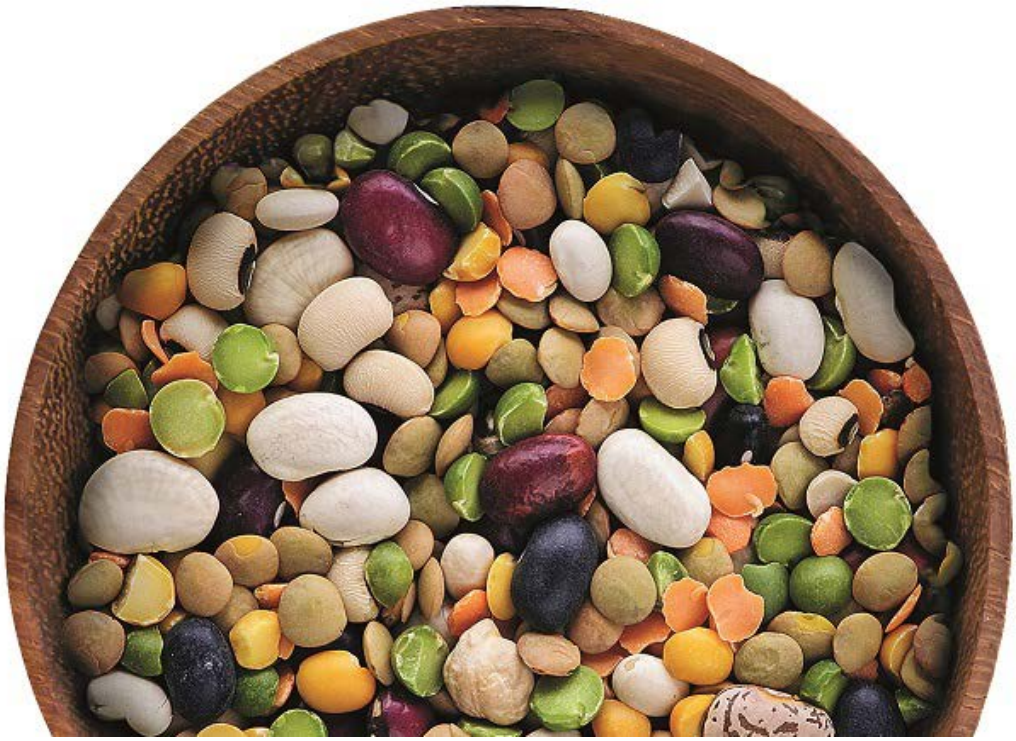

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1 Executive Summary

This Deliverable identifies a set of sustainability indicators for legume-based quality chains and builds on work carried out in WP4 including literature, case studies and stakeholder consultations.

For a supply chain to be sustainable, a fundamental requirement is that all actors operating in the chain achieve sufficient profitability. It is this quality which is in fact the main defining feature of such chain for businesses of all sizes. These are now to be referred to as "quality chain(s)". However, sufficient profitability is not the only parameter defining the qualities a sustainable quality chain. There are social impacts from the business transactions derived from engaging in the legume-based quality chains at personal (consumers and workforce) and societal levels. Sustainability is also a matter of better exploitation of resources, and without a negative impact on the environment. In a quality chain context, this could be related to transportation distance or means of transportation, but also packaging materials or waste production.

The report has identified a set of indicators which, if they exist or are applied, facilitate the functioning of the legume-based quality chains and if not, hamper the functioning of the chain. Some of the indicators are clearly related to the trade and business transactions. In a quality chain context, production (and processing) is regarded as a necessity for entering the quality chain and this leads to a set of related indicators. There are also a range of indicators which relate to the business environment and governance structures. These cross-cutting indicators are essential for trade and business actions in a market-oriented economy. The full set of sustainability indicators provided in this report is valid for legume-based quality chains in the food and feed market for short, local and international quality chains, and for conventional and organic quality chains. It should be noted however that the added value of using the indicators can only be derived if the context of the quality chain is included in the sustainability assessment.

The set of Sustainable Development Indicators (SDIs) provided in this report has been discussed with stakeholders at the Legume Innovation Network (LIN) meetings organised as part of the TRUE project, and at workshops organised by the EU. The conclusions from stakeholder consultations and research findings in the TRUE project are aligned, and this is taken as proof of the validity of the set of SDIs for legume-based quality chains.

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2 Background to the TRUE project

2.1 TRUE Project Executive Summary *(abbreviated)*

TRUE's perspective is that the scientific knowledge, capacities and societal desire for legume supported systems exist, but that practical co-innovation to realise transition paths have yet to be achieved. TRUE presents 9 Work Packages (WPs), supported by a *Intercontinental Scientific Advisory Board*. Collectively, these elements present a strategic and gender balanced work-plan through which the role of legumes in determining '*three pillars of sustainability*' – '*environment*', '*economics*' and '*society*' - may be best resolved.

TRUE realises a genuine multi-actor approach, the basis for which are three *Regional Clusters* managed by WP1 ('*Knowledge Exchange and Communication',* University of Hohenheim, Germany), that span the main pedo-climatic regions of Europe, designated here as: *Continental*, *Mediterranean* and *Atlantic,* and facilitate the alignment of stakeholders' knowledge across a suite of 24 Case Studies. The Case Studies are managed by partners within WPs 2-4 comprising '*Case Studies'* (incorporating the project database and *Data Management Plan*), '*Nutrition and Product Development'*, and '*Markets and Consumers'.* These are led by the Agricultural University of Athens (Greece), Universidade Catolica Portuguesa (Portugal) and the Institute for Food Studies & Agro Industrial Development (Denmark), respectively. This combination of reflective dialogue (WP1), and novel legume-based approaches (WP2-4) will supplies hitherto unparalleled datasets for the '*sustainability WPs*', WPs 5-7 for '*Environment'*, '*Economics'* and '*Policy and Governance'.* These are led by greenhouse gas specialists at Trinity College Dublin (Ireland; in close partnership with Life Cycle Analysis specialists at Bangor University, UK), Scotland's Rural College (in close partnership with University of Hohenheim), and the Environmental and Social Science Research Group (Hungary), in association with Coventry University, UK), respectively. These *Pillar WPs* use progressive statistical, mathematical and policy modelling approaches to characterise current legume supported systems and identify those management strategies which may achieve sustainable states. *A key feature* is that TRUE will identify key *Sustainable Development Indicators* (SDIs) for legume-supported systems, and thresholds (or goals) to which each SDI should aim. Data from the *foundation WPs* (1-4), to and between the *Pillar WPs* (5-7), will be resolved by WP8, '*Transition Design',* using machine-learning approaches (*e.g. Knowledge Discovery in Databases*), allied with *DEX* (*Decision Expert*) methodology to enable the mapping of existing knowledge and experiences. Co-ordination is managed by a team of highly experienced senior staff and project managers based in The Agroecology Group, a Sub-group of Ecological Sciences within The James Hutton Institute.

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2.2 Purpose of the Deliverable

This Deliverable provides a list of validated sustainability indicators for legume-based food and feed chains. It should be noted that hitherto, such chains will be referred to as 'quality chains', in acknowledgement of the fact that they operate functionally and with a view to specific "qualities" being achieved, and this is with particular respect to trade activities and consequent business (*i.e.* fiscal) transactions. The Deliverable builds on the Case Studies linked to WP4, Legume Innovation Network (LIN) workshops and discussions with stakeholders. In addition, literature sources provided the framework for defining sustainable quality chains and supports to determine indicators for quality chains.

This Deliverable builds on Milestone MS4.1 on Legume System Sustainability Indication for use in Transition Path Modelling, which provides a compiled list of sustainability indicators for legume-based quality chains and markets at an aggregated level. This Deliverable, however, goes deeper into the legume-based quality chains to demonstrate the importance of bringing the sustainability assessment into the specific context of the quality chain. Examples of the diverse contexts that form legume-based quality chains are provided as evidence of the complexity related to the assessment of the sustainability of a quality chain. There is more to a sustainability assessment of a chain than mere economic motivation as quality chains are unique and dynamic.

To use the indicators provided in this report, the quality chain in question needs to be clearly defined (*i.e*. how many steps of the chain are included into the sustainability assessment?) as well as the context of the chain (*i.e.* is it a chain in a rural area in developing countries or is it a chain for marking of food products retailers in European cities?). Indeed, **legume-based quality chains must be treated on a case-to-case basis if the sustainability of specific chain is to be assessed.**

The sustainability indicators provided in this report are connected with **trade and business transactions.** This encompasses indicators that are relevant for a trade relationship or business transaction between two parties, and indicators that target the functioning of the quality chain. The sustainability indicators which are related to agricultural production (*e.g.* fertiliser effects, yield *per* hectare or water use), production processes (*e.g.* energy use, production efficiency or waste generation), or nutrition (*e.g.* overweight or protein consumption) are not considered as connected with trade and business transactions, and therefore are not considered relevant to this deliverable.

The outcome of D4.5 primarily supports the policy work in WP7 and the development of the decision support tool in WP8.

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2.3 Definitions

Actor: a business of any size or other categories of stakeholder (*e.g.* authority or institution) that engage in or frame quality chain activities

Business transaction: the activity (transaction) where goods or services from one quality chain actor changes ownership to another actor in exchange for money. A business transaction can be mediated by financial institutions such as banks.

IPR: Intellectual Property Right(s)

HACCP: Hazard Analysis and Critical Control Point, an acronym used to describe an internationally recognised approach to improve standards in food safety

Legume-based: having legumes (as crop, fresh, dried or processed) as the basis for a product or quality chain

PDO and PGI: quality labels defined by the EU and to be used for 'Products of Designated Origin' (PDO), and 'Products with Geographic Identification' (PGI). The labels are used for locally produced special varieties of legumes.

Quality chain: a term applied in the context of the TRUE project for a quality chain for a legume-based product. The "quality" aspect refers to the integrated and added value that legumes contribute in relation to economic, social and environmental aspects in comparison to relevant alternatives.

Sustainability indicator: critical factor that hampers or facilitates the functioning of a quality chain.

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3 Sustainability and quality chains

3.1 Quality chains in food systems

The Food and Agriculture Organization (FAO) defines sustainable food systems as: "*a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised*" (FAO, 1984). Based on this definition, the food system is not an explicitly defined structure but rather a dynamic system of integrated relations linking actors together. The purpose of building relations in the food system is first to survive (people need food to live), and secondly for economic gain. More reasons exist but, in a market-oriented context and with a focus on quality chains, the most important purpose of building relations is economically motivated, be it in a local or global context.

In its nature, quality chains articulate the connectivity between two or more parties that have a shared motivation of improving their prospects by linking with one another, *i.e.* in an economic context to benefit from business opportunities – buying and selling goods and services for profit. Hence, a continuous sequence of buying and selling transactions forms a quality chain. In this context, a quality chain can be regarded as backwards (upstream) if the attention is given to the business' suppliers, or forwards (downstream) if the attention is focussed on the market.

If quality chains are not enabling the flow of goods and money from one actor to another, the quality chain is not coherent, *i.e.* one of the connections in the quality chain will significantly hamper the functioning of the chain leading to insecurity about the transactions. For example, if logistics are not functioning well, a seller may have concerns that the buyer will not receive the goods, which in turn would lead to doubt in securing an agreed payment. In this example, logistics is the weak point that hampers the functioning of the chain. Logistics is a complex issue as it may cover the means of transportation, transportation time, required certificates and infrastructure. When looking at sustainability indicators for quality chains it is necessary to relate key issues for the functioning of the chain to a specific context. In the previous example for a legume-based quality chain, logistics could be regarded either in the context of a quality chain (*e.g.* for frozen food) or in the context of global trade for a specific commodity (*e.g.* soybeans for feed). Both examples are equally relevant. "Quality chains and sustainability" are therefore a challenging topic to operationalise. In the following section considerations on how to define sustainable quality chains will be provided as well as a definition of the concept.

3.2 Sustainable and resilient quality chains

Companies establish quality chains to ensure the consistent supply of their goods and services. Many companies have diversified their supplier base in order to achieve greater and faster responsiveness to unforeseen challenges, which can include, market disruptions, loss of key suppliers or lack of materials. In addition, collaboration with a diverse supplier base can trigger innovation and encourage information sharing in the quality chain. Therefore, companies will aim to establish quality chains that can **react and adapt** to external challenges and opportunities to

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maintain business continuity (Ernest & Young, 2016). Such structures are termed, '**responsive and resilient quality chains**'.

The UN Global Compact framework defines quality chain sustainability as, "*the management of environmental, social and economic impacts and the encouragement of good governance practices throughout the lifecycles of goods and services, with the objective to create, protect and grow long-term environmental, social and economic value for all stakeholders involved in bringing goods and services to the market*" (UN Global Compact and BSR, 2015). This definition frames the three pillars of sustainability in a quality chain context for the business as well as its suppliers. In addition, literature on quality chain sustainability points to the fact that, **"quality chain sustainability relates to how businesses can use their quality chain connectivity to encourage actions** (internally and with their suppliers) to apply practices that improve social, environmental and economic impact'' (Searcy, 2015). For example, a business can demand from its suppliers compliance with the UN Global Compact dossier (UN Global Compact and BSR, 2015), and by this, operate to respect proper working conditions, environmental responsibility and anti-corruption business practices. Hence, **quality chain sustainability is regarded as a tool for improving business practices.**

What then defines sustainable quality chains? Quality chains may operate within legal and responsible guidelines, but still not be sustainable. To be sustainable, a quality chain must operate within the thresholds imposed by nature and society (Searcy, 2015). Quality chain strategies are hierarchical in the sense that first, quality chains must operate within **legal boundaries**. Secondly, they must be **ethical** with respect to operational integrity, and "do what is right". In relation to the food sector, the use of Supplier Codes of Conducts is a widely adopted approach for ethical quality chains. An example of a Code of Conduct is the Danish Agreement on Organic Pig Production (Organic Denmark, 2018). In this agreement, it is stated that only feed of 100 % organic origin can be used in Danish organic pig production. This Code of Conduct is stricter than the EU requirements, where 95 % organic feed is required to comply with the organic production scheme. Thirdly, quality chains must operate in a **responsible manner**, and partners within them must be committed to continuous improvement and making positive contributions to their communities. This could for example include investing in capacity building in local communities or implementing resource-efficiency measures. Finally, sustainable quality chains must demonstrate that their **activities can be supported by nature and society over the long term** – and this extends to consistent and sufficient economic performance - an additional key feature of a sustainable quality chain. Once environmental and social thresholds have been set, they come first, and this implies that the economic activities of the quality chains take place within established thresholds that recognise the limits of environmental and social resources in various contexts (Searcy, 2015).

Based on the above discussion and the analyses and stakeholder involvement carried out in WP4, **a sustainable and resilient quality chain is defined by**:

- operating within the thresholds of nature and society;
- having a sufficient economic performance and provides value for the actors in the chain;
- being a collaborative structure encouraging diversity and inclusiveness;
- passion of a capacity to be responsive and resilient; and,

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- adapting to challenges and opportunities, and so become long-lasting;

3.3 Defining SDIs for quality chains

A sustainability indicator is regarded as a **critical factor for enabling the function** of quality chains for legumes as commodities or legume-based products in a positive (**facilitating**) or negative (**hampering**) manner. The work performed in WP4 has identified a range of indicators that appear across the quality chains in the food, feed and food ingredients markets, and for a diverse range of legumes and legume-based products.

Taking the three pillars of sustainability into a quality chain context requires the economic, social and, the environmental outcomes or impact to be related to the **activities and structures associated with trade**. For example, a lack of access to financing is a serious inhibitor for business transactions with a direct implication on economic performance of the quality chain actor. Thus, "lack of access to financing" (for example) is regarded as an indicator for the sustainability of a quality chain, and by its nature this indicator is related to the **economic pillar**. Similarly, if food safety requirements are not fulfilled, consumers may incur serious health issues. In a quality chain context, "food safety" would be regarded as an indicator related to the **social pillar** as it has a direct implication for consumers and society. Finally, goods need to be packaged before being shipped or traded and therefore the use of packaging becomes relevant in a quality chain context. Packaging materials can be biodegradable or not - such as plastic, metal or glass, and therefore packaging needs to be considered within the **environmental pillar** of sustainability.

The list of sustainability indicators identified for markets and quality chains is presented in an aggregated format and must be adapted to suit the needs of specific quality chains or markets. These indicators have been related to the three pillars of sustainability: economic, social or environmental (Table 1). Some indicators are especially relevant to aspects of trade and decision making related to entering a market and are categorised as **trade related indicators**. Other indicators have production related aspects, that is without processing the legume crop will not enter into a quality chain and subsequently a market. The **production related indicators** cover these specific aspects. Some indicators are critical factors for the general functioning of production, trade, and business transactions. Such indicators are categorised as **cross-cutting indicators**, with examples being related to financing or agile governance.

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Table 1. A list of sustainability indicators for legume-based markets and quality chains

Indicator	Sustainability Pillar(s)		
	Economic	Social	Environmental
Trade related indicators			
Transparent terms of trade	X	X	
Access to alternative markets	X		
Adequate infrastructure (ports, storage facilities *etc*.)	X		X
Transparent market conditions	X		
Production related indicators			
Efficient use of raw materials	X		X
Continuous access to materials (and supplies/input)	X		X
Access to adequate technology	X	X	X
A marketable product	X	X	X
Cross-cutting indicators			
Meeting customer expectations	X	X	X
Transparent information and ownership rights	X	X	
Profitability at all steps of the chain	X	X	
Reduction of waste	X		X
Motivation for investments	X		
Access to financing and functioning financial system	X		
Diversity in business structure (large and small companies)	X	X	
Access to skilled workforce	X	X	
Decent working conditions	X	X	
Stable business environment	X	X	X
Quality assurance system	X	X	X
Reliability and trust	X	X	
Agile governance	X	X	X

All indicators listed in Table 1 are relevant when considering the sustainability of quality chains, and economic aspects are fundamental for the longevity and hence the sustainability of quality chains. These indicators are articulated in a **generic format** and therefore must be **adapted to a specific context(s), as this defines the indicator**.

In the following section, each of the indicators are discussed to show the diversity of contexts, which emphasises the importance of defining the context.

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4 Trade- and Production- and Cross Cutting related indicators

4.1 Trade Related Indicators

Transparent terms of trade

Transparent terms of trade refer to the availability and access to information on prices, price determination systems, and the conditions for the business actions. The terms of trade are an issue between buyer and seller. International trade can be organised as "CIF" (cost, insurance and freight) or "FOB" (free on board). These are merchant terms that make it clear to buyer and seller who will pay the costs associated with the deal. Another example of terms of trade is linked to trading protein crops. When trading protein crops such as soybeans or soybean concentrate, the price is determined by the crop and protein content as for example soybean concentrate has 40-42% protein and faba beans 23%. The buyer in the agribusiness company, the trader, and the farmer are familiar with this system, hence the terms of trade are transparent.

Farmers have access to information regarding the prices of the crops and therefore can decide when to sell the crop and to whom. Information regarding prices is available from Commodity Exchanges in Paris and Chicago, and from daily quotes from local or national traders. When farmers grow crops on contracts the price of the crop would be negotiated beforehand, *e.g.* the price to growers who supply peas to canning facilities. When food producers have contracts with retailers, the terms of trade are laid down in similar contracts including requirements for certifications, deliveries and volumes, quality and prices. From interviews with food producers and retailers, we see that retailers hold the power to define the contract, *i.e.* set the terms of trade.

The contracted relationship between buyer and seller gives both parties a certain security in terms of income and costs but, the contract also limits flexibility in case of better opportunities elsewhere. Examples of contracted relationships could be agreements between retailers and food producers, between suppliers of crops to the freezing industry, or contracts between farmers and agribusiness companies about supplies of feed.

Access to alternative markets

Trade can occur as individual or 'spot' market deals where buyer and seller trade "on the spot" *e.g.* farmers selling to local or regional brokers. This is in contrast to contracts where trade has been agreed upon. The advantage of spot markets is the freedom to act in a situation where buyer and seller can choose whom to trade with. The disadvantage is the uncertainty on prices (which would depend on supply and demand), and volumes available in the market. Spot markets exist in the format of global commodity markets for crops such as soybeans but for much smaller scales too. In some cases, the access to market is a major barrier for increasing the cultivation of a specific crop.

Food products including pulses and processed legume-based products are not by definition limited to being traded in only one market, though access to such a range of markets is geographically determined. Food can be traded in open-air markets, and through farm- and internet shops, and through the retail sector and food service market. This issue is that the food producer must comply with the requirements of the various selected market(s). The more requirements the producer can

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comply with, the more opportunities there are to identify the best markets for the product and for making prosperous business deals in small scales as well as large scales.

In the mentioned examples, the turning point is access to the market but, access is also connected with the logistics of bringing products to the market. For example, if producers in rural areas are deprived of good roads, the possibilities for accessing a market may be seriously hampered. In many European rural areas, there are small-scale producers who produce a specialty pulse crop, some of which are even certified as PGI or PDO products, but access to a market beyond the region is limited.

Adequate infrastructure

Infrastructure is a fundamental requirement for trade and includes ports, roads, storage facilities and the relevant institutions such as customs service and food safety inspection officers. Trade cannot take place if the movement of goods is hampered by lack of physical structures and institutional framework around trade. A basic but essential example is the lack of sufficient or adequate facilities to store the harvests or issues related to the risk of cross-contamination between crops.

Transparent market conditions

The basic principles of a market economy rest on the relationship between supply and demand to define the price and so the existence of a competitive situation in the market. Considering this in the context of legume-based quality chains, it would mean that market actors have insights into the conditions for acting in the market, and how the market functions. For example, EU Directive 2014/24 on Green Public Procurement requires that public procurement contracts above a threshold value of 200,000 EUR must be put out for public tendering, allowing all interested suppliers to submit a bid under the same conditions, hence avoiding the favouring of one supplier over another, and guaranteeing the tax-payer fair value for money (taxes).

In retail stores, the prices of goods are shown to the consumers to allow them to make an informed purchase. Retailers may use marketing tools to promote certain purchasing patterns by for instance promoting “two for the price of one”, a pattern that is also used for legume-based food products. Given the multitude of other stores to buy from and the alternative marketing channels, consumers can still make the choice of their own. This situation illustrates how transparent market conditions could be regarded from the consumers’ perspective.

4.2 Production related Indicators

Efficient use of raw materials

Developing a new legume-based feed, such as protein powder from organic clover grass, is both costly and technologically challenging as demonstrated by a TRUE Case Study carried out in Denmark. If this new quality chain is to be established, farmers need to be convinced that the business idea (*i.e.* agree to grow clover grass for processing instead of feed) and the bio-refining process are as efficient as possible to retrieve the best output from the process. In this example, efforts made to improve processing efficiency and finding ways to use the co-products (fibres for cattle feed) mean that the venture could become economically feasible. In this given example, the

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key issue that the more efficient the resources are applied, the better chance for a feasible business cases, hence a higher motivation of an actor to engage in the quality chain.

Pulses are generally recognised as a source of protein, but pulses also have significant starch and fibre fractions that should be valorised – with the aim of improving the economics of the processing and reducing resources waste. In Scotland, it has been demonstrated that the starch fraction from faba beans can be used for brewing beer and making spirits. These products are now available in the market. It is clear from workshops and stakeholder consultations that an essential issue for increasing the sustainability of a quality chain is to find ways to valorise the "whole bean". Stakeholders point to multi-disciplinary collaborative projects as a way forward as improved exploitation of resources relies on proper technologies, logistics and knowledge. For example, in the vining pea industry, only peas of first and second quality grades are used to produce frozen peas for the consumer market (Vickers, 2019). Peas of lower quality standards are either wasted or used for feed. This is a resource that if properly valorised could improve the overall sustainability of the pea sector as well as hold options for new business opportunities.

Continuous access to materials (and input / supplies)

The livestock farming sector in Europe is developing towards larger units. To fulfil demand for the animal feed, farmers buy feed (on contract) from agribusiness companies on terms of continuous supplies. In this context, it is the agribusiness companies who are taking on the responsibility of securing supplies of feed sources in order to fulfil their contracts with the farmers and, of course, sustain their business through continuous sales. The feed companies import, for example, soybeans from the Americas to be used in compound feed for the European livestock production. The huge volumes imported, 30 million tons of soybean (EC Commission, 2018), demonstrate the necessity to secure a continuous supply of feed. If market conditions or policies drive demand towards alternative protein sources, the gap between present protein supplies and alternative (maybe limited or insufficient) supplies must be fulfilled as urgently as possible as there are livestock to be fed.

In the consumer market, the demand for meat alternatives is increasing rapidly and, a growing number of entrepreneurial and existing large food producers have started to manufacture and distribute such products. Meat alternatives have demonstrated their relevance in the retail stores and in the food service, and such products have also become available through retailers and wholesalers. Through these, listing buyers can request the product on short-term delivery, which a manufacturer is under obligation to supply to the distributor quickly. Many of the meat alternatives are currently made with pea protein concentrates or texturised pea protein. This has proven to be a growing business for companies providing such ingredients, and significant investments have been made in new processing facilities. For example, the French Company Roquette has invested in a new factory in Canada to process peas, besides already operating factories in France and Belgium - all these facilities produce pea protein. Similarly, Cargill a major global agribusiness has invested 75 million USD in Puris (a North American company) to produce pea protein (*www.foodnavigator.com*, 2019). Cargill's investment is a result of contracts to supply the Beyond Meat company that produce plant-based burgers. The scale of such investments and the inter-continental nature of the quality chains clearly demonstrate that continuity in sales is fundamental for investments in production.

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Adequate technology

Before a legume crop can enter a quality chain, at least minimal processing is required. This processing could be merely drying and cleaning of seeds to achieve a crop that can be stored for later use or sales. Various discussions at relevant workshops have revealed that growers with smaller volumes of pulse crops and small-scale processors incur higher costs for not having adequate technology available. The main claim is made against the lack of adequate technology that is affordable for smaller businesses. The example mentioned above with the bio-refining of organic clover grass shows the importance of having the right technology in place. One of the challenges in this production system is to harvest the clover grass without picking up too much sand. In order to overcome this challenge, grass harvesting machinery has been developed as prototypes, waiting to be commercialised once the system is scaled up.

Many consumers are not in favour of legume-based food because of the “beany taste”, and the characteristic smooth (and sometimes grainy) texture of cooked pulses. This is claimed by processors and distributors to be a major obstacle in increasing the use of pulses in processed food manufacturing. But, there are solutions to this issue as enzymes and flavours can be used to mask the texture and taste of the pulses in the product. The questions therefore become: are ingredients like enzymes and flavours available to the producers needing these ingredients? And, is product development being hampered from modifying adjuncts not being available?

From more stakeholder’s consultations, it was made clear that access to proper seed varieties is considered as a turning point for increasing the area under legume crops. Stakeholders identified local or regional varieties as options for breeding companies to take up on commercial scale, as such varieties may have better profiles for human or livestock nutrition, or higher disease resistance. The seed industry claims that volumes are a major barrier for expanding the assortment of specialty seeds. To mitigate the lack of local seed varieties, farmers engage in seed breeding themselves through networks formed around heritage seeds. The breeding and multiplication of heritage seeds is restricted by EU rules that limit the breeding activities of non-registered breeders. This example demonstrates the contradictory interests from different stakeholder groups; a situation that complicates the development of sustainable legume-based quality chains.

Access to technology

When farmers and processing companies want to grow, process or distribute legume-based products or crops having the proper technology is fundamental. In areas where legume crops are rare, farmers are forced to make a choice of either: to invest in proper technology (for agricultural production, storage or processing) and increase the legume crop, or to consider alternative crops that can be cultivated with the available technology. This situation is an important driver for farmers to start working together in cooperatives as a strategy to increase legume cultivation. There are more examples from France and the UK following this approach. The cooperative structure reduces the costs for technology as farmers share available resources. In addition, the cooperative approach contributes to produce a larger crop and hence strengthen the cooperative’s bargaining power when selling the crop.

Innovation is a key driver for development in the European food market, and legume-based products are surely enjoying the increased attention from food processors and consumers. For food processors, the competition in the market makes it crucial for a company to provide new products

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on a continuous basis. Developing a new product for the food market requires know-how, the right machines, proper raw materials and ingredients, and packaging materials for small-scale producers and multi-national companies. Established food processing companies will consider if a new product can be manufactured by using the existing production lines (with some adaptations), whereas entrepreneurs may be challenged by the lack of the proper (costly) production equipment. Going from kitchen trials to pilot scale, and later scaling-up to large commercial volumes is a development path which has proved challenging, especially for start-ups where the anticipated sales have not materialised in due time. Having the right technology available at costs that make production feasible must be given a high priority for new productions to gain a foothold in each quality chain.

A marketable product

The discussion around the relationship between climate change and biodiversity loss and the impact of a diet rich in meat and dairy products has significantly increased the growth of the vegan and (perhaps more significantly) flexitarian or demitarian diets. This has led to growth in the market for legume-based products. Within the past few years, the assortment of legume-based products has significantly widened. Examples of new products are mayonnaise made from lupins; salted snacks made from faba beans or peas; crisps made from lentil flour; pasta made with chickpea flour; and even “milk” made from yellow peas. Some of the new products have proven successful, but many others have failed after a short period on the market. Focus groups and stakeholder consultations clearly identify, “consumer liking” as the most important criterion for a new product to be accepted in the food market. If consumers do not like the taste or mouthfeel, they are less willing to buy the product a second time reducing the chance of a product staying on the market, which ultimately has an impact all along the quality chain.

For a food or feed product to be recognised as “marketable”, the product (or crop) must be in a condition or format that allows for ease of handling. In the case of a food product, this could mean appropriate method of packaging and hygienic processing. It could also refer to a guarantee such as “free from’ allergens a claim which cannot be sustained if the food product (or quality chain equipment) is contaminated by lupins, soybeans or wheat (for example).

Overall, a marketable product is a product that complies with pending legislation and is safe and appealing. Export of fresh French beans from Kenya is such an example. When the crop leaves growers in Kenya they are inspected by Kenyan authorities *and* representatives from the importers in the EU to ensure agreed compliance with pending legislation and food safety requirements of the exporting *and* importing countries. Then, the beans are cleaned, packed, labelled and shipped by air freight to a warehouse in Europe from where the beans are distributed to retailers in several European countries. Before the French beans are purchased and shipped from Kenya, buyers in Europe (retailers) have ensured that the quality complies with imposed standards like BRC and HACCP. The French beans are positioned in the supermarkets and purchased by consumers. Payment is transferred from consumers to the growers *via* financial institutions. This example demonstrates the complexity of international quality chains and the many actors involved to produce and transport the product to facilitate trade, and to connect a quality chain for a marketable product.

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4.3 Cross-cutting indicators

In the sections above, the sustainability indicators with special relevance to trade and production aspects have been discussed. Companies can influence the trade and production related indicators to a certain extent, as these indicators are directly connected with business transactions. In this section, sustainability indicators that are important for the functioning of the quality chain are considered: the cross-cutting indicators. A common denominator of the cross-cutting sustainability indicators is that they frame the business environment and the authorities, financial institutions and other institutional actors are the key stakeholders, not individual companies.

Profitability at all steps of the chain

The overarching aim of a company to engage in a quality chain is to make a profit, hence all actors in the quality chain would aim to sustain and hopefully grow their business. Under the right conditions, exploiting the opportunities for growing the business would increase the motivation for investments and further development. This approach (ensuring adequate profit levels) for business development is important for small-scale producers selling small crops at local markets, and for international companies investing millions in new factories in other parts of the World. In essence, the motivation to grow a business is a key driving force for sustaining collaboration in existing and/or new quality chains. The framework surrounding the business has a huge impact on the opportunities for developing the business, and therefore also on the sustainability of quality chains.

Meeting customer expectations

A business offers a product to the market to generate an income from sales. The success of a sale depends on how the customer perceives the product before and after making the purchase. Hence, marketing and communication are important tools for providing information to the market and to customers regarding that specific product, or a broader product category. For example, media attention to plant-based meat alternatives provides many consumers with the impression that plant-based meat alternatives would give the same eating experience as meat. Some plant-based meat alternatives have proven more successful than others, so it could be argued that such products did not fully meet customers' expectations.

From focus groups in Germany and Denmark, it was clear that consumers' liking of the legume-based product was an essential feature to ensure their re-purchase of the product. Consumers who were asked to try new foods made with pulses expressed views about taste, texture, mouthfeel and general appearance of the food. It was a clear conclusion from the focus groups that if consumers did not like to eat the product, it was of much less relevance that the product was healthy or made from legumes.

Reduction of waste

Sustainable use of resources has become an overarching feature of the modern agro-food system, yet there is still a gap between intention and praxis. From looking at diverse legume-based quality chains, it seems that quality definitions play a key role for defining food waste, for example in the farm sector. If crops including vegetables like peas and beans do not fulfil the quality requirements from processors or traders the crop will be either wasted in the field or marketed as a lower-priced item.

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In the food quality chain, waste is relevant in the context of food packaging. Transportation and marketing of food and drink products is among the top sectors for generating packaging waste. As consumers turn towards eating-on-the-go and demand more snack food or convenience products, the use of packaging becomes a central issue. Many new snack products made from pulse flours have been introduced in the European food market in recent years, but none of these have so far taken to the use of biodegradable packaging materials (Hamann *et al*., 2019).

Access to financing and functional financial system

A functioning financial system is fundamental for business transactions. In developing countries, micro-loans have proven to have a huge impact by making it possible for small-scale businesses to expand (Barilla Center for Food and Nutrition 2018 and IPES, 2018). In the digital era, crowd-funding has become a new way of raising capital – also in the food sector. The established financial system with banks and credit institutions is an essential infrastructure in a capitalist society, and farmers and companies operating in the legume-based quality chains are dependent on a functioning and reliable financial system handling daily money transfers and for providing funds for investments.

Transparent Information and Ownership Rights

Ownership rights to the means of production (land, buildings or machinery but also IPR) must be clarified and transparent. If ownership rights are not clear, investments may be hampered as there will be difficulties in providing sufficient securities for a loan. Therefore it must be clear who owns what. Here, it must be stated that ownership can be organised in many formats such as cooperatives, shareholding companies, family-owned business or sole traders – to mention a few. Contracts regarding the rights to use the means of production (and processing) must also be considered here, *e.g.* a tenant's right to farm land he does not own, or the option to use a processing technique (under licence). The core issues are clarified rights and transparency.

Motivation for investments

Several of the large fast food chains in Europe and USA now offer plant-based burgers and this endeavour has proven successful for the chains. Sales have increased, assortments have become more diversified, and prices on these shares in the stock markets have risen significantly. Companies like McDonalds, Kentucky Fried Chicken and the Swedish chain Max could be mentioned as successful fast food chains offering plant-based items on the menu. Companies who are rooted in the red meat industry have also taken to the plant-based trend. For example the British company ABP and the American meat companies Tyson Foods and Smithfield Food have introduced plant-based "beef", "poultry" and "pork". The examples illustrate how motivation for establishing production of plant-based meat spurred new development in the meat industry as well as the fast food industry.

When farmers are considering which crops to plant in the next season a central question is: which crops would provide the best income and be most useful (*e.g.* use a feed for the livestock on the farm)? If planting of legumes is considered as an option, then the farmer would maybe have to invest in relevant machinery for the cultivation as well as storage and cleaning facilities. Such investments can be very costly. Among the factors that can motivate the farmer to invest is the long-term sustainability of producing the legume crop. If prices, market outlook, on-farm facilities, demand for the crop, then these factors can motivate investments. Especially for legumes, the environmental

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benefits in relation to fertility and soil quality may very well spur the motivation for investing in legume cropping.

Stable Business Environment

A reliable and stable business environment is important for ensuring continuity and longevity of businesses. For example, a regulatory environment that constantly imposes new (contradicting) requirements for *e.g.* environmental impact will hamper investments and other economic activities. To demonstrate: if requirements for having legumes as cover crops constantly change, farmers will choose an alternative crop and so potentially reduce the sustainability of the legume-based quality chain. Also, requirements for the use of bio-based packaging materials or for calculating emissions can have significant impact on manufacturing and marketing of products. These situations demonstrate that a stable business environment encompass more than financial institutions, and that the alignment of governance decisions is also essential to encourage and sustain business development.

Agile Governance

Governance in companies and by the authorities is a key issue for ensuring resilient quality chains. Companies are responsible for bringing into the market, only products that comply with regulations, but issues with certain products can occur. In this case, it is important that relevant structures are in place and that governance is enacted promptly and adequately to reduce the damage. The organic sector in Europe is expanding and organic livestock production (pigs and poultry) need to be fed organic protein feed. Today, ca. 80 % of the organic feed protein (particularly soybeans) are imported from China, with remaining shares coming from Ukraine and Kazakhstan. Stakeholders have pointed to occasional mistrust in Chinese authorities with regards to the authenticity of the organic soybeans that were imported to the EU. This example reveals how trust in certified productions can be influenced by governance and the role of governance for instigating and ensuring trust is maintained. Without trust, the quality chain for organic soybeans from China would be severely hampered.

Quality Assurance System

To facilitate trade, it is essential that certification systems and standards are acknowledged by the quality chain partners, and by the authorities too. In the EU, standards for food and feed safety are laid down in the EU Food Law (Regulation no. 178/2002 of January 2002). The overall requirement for food safety standard is the HACCP standard which is mandatory for food products traded in the EU market – also for products imported to the EU. Quality schemes such as organic production or the EU labels of PGI and PDO are internationally recognised, which facilitates trade in the EU and with third countries. If trading partners do not mutually recognise a given certification *e.g.* organic production or a standard (*e.g.* Codex-standards, HACCP or the EU marketing standards), trade will be obstructed rendering the quality chain unsustainable.

Reliability and trust

Business transactions are dependent on reliability and trust. For example, the issue of reliability could relate to transparency, *i.e.* that the product or crop matches the description, or the information provide on the label. Much trade is carried out at a distance where the buyer places an order (electronically) with the supplier and expects that the ordered goods are delivered in a condition and format as expected/ordered. This example, takes place every day in the hospitality

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sector where staffs responsible for cooking the meals, orders the food products from wholesalers. The product information available is described in the wholesaler's catalogue.

In relation to legume-based quality chains trust could be manifest through recognition of quality assurance schemes. In praxis, trust can be incorporated into the branding and communication of a product by, for example, using the EU logos of Organic Production, Protected Designation of Origin, or Protected Geographic Indication. Such schemes are highly relevant for pulses since they are backed by defined criteria designed to ensure trust in the brand(s). Without this trust, the market actors including consumers will not pay the price premium connected with products certified under these schemes.

Diversity in Business Structure

Diversity is important in spurring innovation and creating opportunities. In the context of legume-based quality chains, diversity is an overarching feature. Diversity could be identified in numerous ways, including the: crop species, business model, farming method, applied technology, size and organisation of the business, organisation of quality chain and many more factors. From stakeholder discussions, it is claimed that established quality chains do not lead to a dynamic and innovative agri-food system but are fundamental for sustaining volumes. Examples could be large canning factories, or pasture-based dairy production where the cows are fed on clover grass and alfalfa. A major barrier for driving radical innovation in the examples of the canning factory or pasture-based dairy farming is the rigidity of the large and established productions and their quality chains.

In contrast hereto, the food entrepreneurs are developing a wide range of innovative products that are introduced into the European food market – some products with more longevity than others. If a product proves to be a good and viable concept, there are many examples of such concepts being acquired by larger players and this transaction sustains and develops the innovative concept further. An example is the Dutch entrepreneurial company The Vegetarian Butcher that was founded a decade ago and acquired by Unilever in 2018 (Hamann *et al.*, 2019). The Vegetarian Butcher produces legume-based meat alternatives and the brand name is enrolled in Unilever's brand portfolio.

Decent Working Conditions

Working in a food factory can be dangerous and, work can be undertaken under conditions that are not aligned with the Global Compact, or merely just decent conditions. The European food industry is currently facing the challenge of a widening labour shortage gap (Deloitte Report UK, 2017), hence the issue of recruiting more workers becomes central to the sustainability of the industry. From stakeholder consultations, it has come clear that a career in food processing is not high on the agenda of workers due to low income and unpleasant working conditions. This situation has an implication for the processing of legumes, in *e.g.* the canning industry, where companies may face labour shortages. Stakeholders from industry explain that automation of the production can be a solution (for example in large-scale producers of baked beans or frozen vegetables), whilst other industries claim that manual work is required (due to tradition or small-scale production). Hence, if workers or the necessary skills are not available, this will have an impact on production and possibly also on investments in technology and organisation of the quality chain.

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Access to Skilled Workforce

Skills can be considered in a consumer context in the sense that many consumers are not familiar with how to cook with dried pulses. This situation impacts the quality chain in many ways. One is that consumers do not buy dried pulses, resulting in a reduced market demand for dried pulses. Another option is that food processors develop convenience products and use dried pulses for *e.g.* ready meals. The impact on the quality chain from the latter example could mean a new trading route or demand for specific types of pulses (organic?).

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5 Concluding remarks

The report has provided a set of indicators that can be used to assess the sustainability of legume-based quality chains. The indicators provided specifically relate to trade and business transactions and are valid for diverse legume-based quality chains. **The sustainability indicators related to markets and quality chains** identified here are dependent on a specific context, and only when the context is accurately defined can the sustainability indicators be, in turn defined. However, the essence of sustainability indicators related to quality chains is that **should these indicators be lacking, the quality chain would be hampered. In contrast if they are present, the quality chain is facilitated**.

A **central conclusion** is that there must be a **fair generation and sharing of profit for *all* the actors** involved in the quality chain, otherwise the chain will break up and actors will seek alternative options for generating an income. Current actions for profit generation should be conducted in a long-term perspective so future options for generation of profits are not comprised. Successful initiatives need to adapt to local conditions and provide measures that can bridge the gap between quality chain actors. Managing the strategic collaboration with quality chain partners is a key parameter for developing sustainable quality chains and consequently **promote sustainable food systems**. In addition, 'good governance' should also be ensured, and in this context good governance is defined as the "*generation, protection and fair distribution of the wealth (or value across the three pillar) which is generated*", and it may be argued that it is with respect to that latter that the greatest challenges are faced.

This is pointing to another central conclusion: quality chains are dynamic structures that constantly change and adapt to the prevailing conditions. Therefore, the sustainability of a quality chain depends on the options for adapting to changing requirements which could be instigated by factors such as a failed harvest, regulatory issues or technological innovations. When quality chains can **adapt** to change, they **become resilient** and this is the **way forward to ensure long-term sustainability for legume-based quality chains** in all its diverse forms.

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Appendix 2: Methodology

The identification and validation of indicators for sustainable legume-based supply chains is framed within an explorative research approach building on qualitative methodology. The explorative approach has contributed to maintaining an open mind towards "legume-based quality chains" in the meaning that any chain that promotes trade with legumes, vegetables or pulses could be relevant to investigate; this included historical chains, current chains and emerging chains and with no limitations to scale, crop, sector or geography.

The qualitative research has been centred round the question: **What factors are important for making trade and business transactions possible within the legume-based quality chain?** The research question is narrowed down from similar questions and supply chain oriented topics that have been discussed at TRUE workshops as well as addressed in TRUE Deliverables from WP4 about markets and consumers. WP4 only addresses challenges and opportunities related to an increase of legumes for food, food ingredients, and feed in EU supply chains and markets. Hence, the activities and analyses performed in WP4 have targeted:

- food supply chains (targeted at retailers and food service providers) in the EU market;
- food retail market in the EU at European, regional and local levels;
- European food service market with special emphasis on market opportunities for pulses;
- local food supply chains targeted the food market in several EU countries;
- European and international supply chains for food ingredients (particularly pea protein);
- European food processing industry with special emphasis on companies processing pulses;
- international supply chains for commodities and fresh produce;
- regional and European supply chains for feed;
- European feed industry; and
- sustainability issues related to markets, supply chains, and business cases.

The list of sustainability indicators has been derived from an array of sources including: literature review, data gathering, case studies and focus groups, analyses and stakeholder consultations carried out within the TRUE project.

Consultations with stakeholders have aimed at identifying and subsequently validating the sustainability indicators to ensure their relevance for legume-based quality chains. Stakeholder consultations have been organised at workshops and roundtable meetings, but also as implicit in Case Study activities in the TRUE project. Stakeholder consultations have taken place at the TRUE Legume Innovation (LIN) workshops hosted in Peterborough (UK), Hohenheim (Germany), Athens (Greece), Budapest (Hungary), Porto (Portugal), and Nyborg (Denmark). Participants at the workshops have represented farmers, companies processing or trading legumes for food and feed, advisors, knowledge providers, research, organisations, financial institutions, suppliers of input and technology for legume growing and processing, and other stakeholder groups.

In addition to these consultations, consumers' perceptions of sustainability indicators have been identified in focus groups hosted in Denmark, Germany, Portugal, and Hungary. Workshops with

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farmers have been hosted in Denmark (focus on organic production) and Scotland. Stakeholders in the food service market have been consulted through project activities in TRUE and at a targeted workshop organised in Denmark.

From workshops on supply chains (hosted in France) and markets (hosted in the Netherlands) in connection with the development of the EU Protein Plan insights about market policies and supply chains for feed and food have been collected. The ISAB (International Scientific Advisory Board) member of the TRUE project have also provided their views on sustainability indicators through presentations and discussions at TRUE project meetings in Athens and Porto.

Overall, it is estimated that more than 300 stakeholders across Europe have provided statements regarding supply chains for food, feed, food ingredients, the food service market and many other topics, which are relevant for understanding what factors contribute to a functioning supply chain.

The information gathered from stakeholders, TRUE activities and literature is related to specific supply chains and, provides data about factors that may hamper or facilitate the functioning of named legume-based supply chains. Grouping of the mentioned factors has led to an assumption of the importance of a given factor. Based on this assumption, the factor has then been defined in such way that it can be applied in the context of diverse legume-based supply chains. This is the aggregated level presented in Table 1. Once a sustainability indicator has been defined, it has been assessed in different contexts (*e.g.* at several workshops or with reference to literature and case studies) and if found valid, the indicator has remained on the list (Table 1).

"Valid" thus refers to the identification of a **factor that is important** or not important for making trade and business transactions possible for legume-based quality chains.

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