TRansition paths to sUstainable legume-based systems in Europe

TRUE-Project Review: Impact & Legacy Plan I

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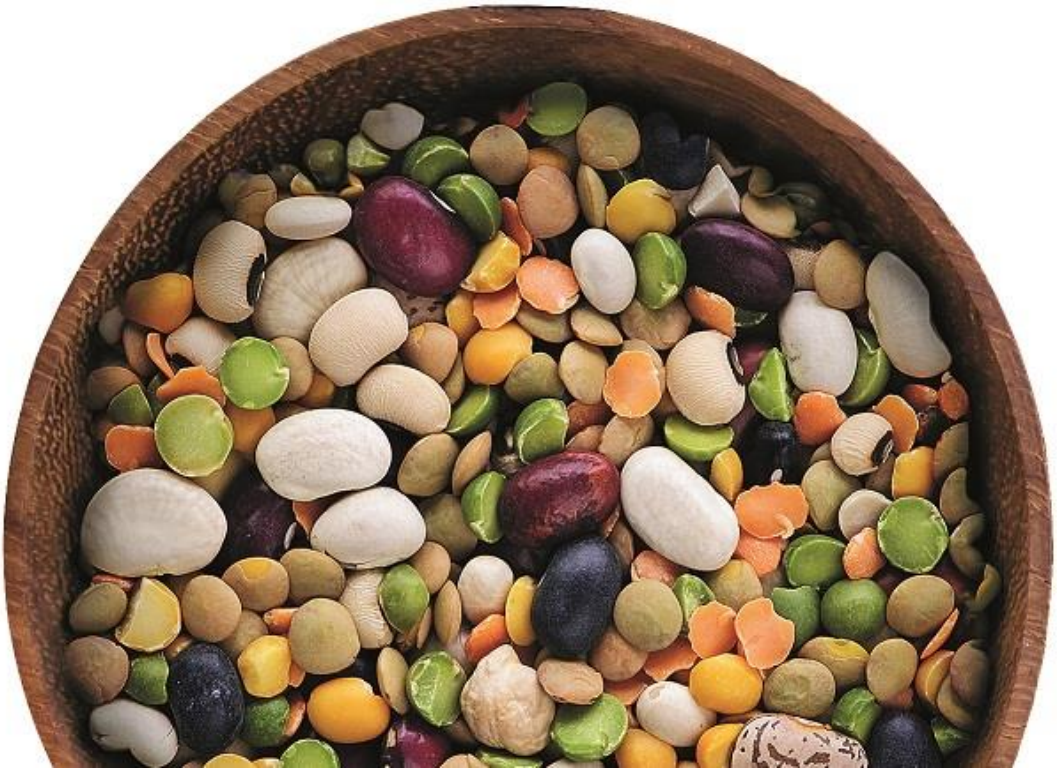

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Introduction: considering legumes in context

The TRUE-Project has been strategically designed to embody **multiactor and transdisciplinary approaches** to identify agroecological insights capable of realising more sustainable food and feed systems (*c.f.* Levidow et al., 2014). The main structure, objectives and partners are summarised here (Appendix I). The common unifying features of all the **actors who** have engaged with the TRUE-Project is an interest in all types of legumes, and the potential to **collaborate and implement 'legume-supported transition paths' to help realise more-sustainable food- and feed-systems**. From the multiactor perspectives, many contexts with respect to legumes have been recognised and this report serves as a first attempt to articulate these, and with respect to the TRUE-Projects impact and legacy plans. The insights gained point clearly to a range of specific opportunities and insights which are spread across the whole value network (click for definition of this term). These opportunities are presented here as a series of vignettes which are drawn from the broad range of TRUE-Project activities. Going forward, the TRUE-Project's implementation plans will be developed based on these insights. Also, delivered collectively, they are expected to encourage transition from current conventional food- and feed-networks, to those which are legume-based and more sustainable. These vignettes are punctuated with a detailed description of the events and outcomes of TRUE-Project that have, and will continue, to best support the promotion of home-grown legume cultivation and use in Europe.

Caring in a knowledge vacuum: realising regenerative food systems[1]

People usually care greatly about their own wellbeing, and that of wildlife, the environment, and farmed animals. This is demonstrated is many ways. Firstly, care for personal health and wellbeing, and a range of ethical and environmental issues surrounding the production and consumption of meat, has been demonstrated via the global market for **legume-based foods which is set to almost double from approximately $US 45 billion (2017) value to $75 billion by 2025** (Hexa Research, 2020). Several features are driving such market demand, including the fact that such commodities are globally accessible in one form or another, and that the main raw ingredients (often pulses, or their protein and/or starch fractions) are affordable and non-perishable if stored appropriately. Also, these products are geared to satisfy ethical concerns, and desire for personalised nutrition to secure

[1] Refers to food systems which can reproduce or renew functions which have, or may have been, lost.

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the best possible wellbeing, providing benefits for diverse social groups including the infirm, and professional and amateur athletes with an interest in personal fitness and performance optimisation

Such care for the environment and biodiversity has been recently and strongly demonstrated via social media in response of plastic pollution and its impacts upon the marine environment and marine wildlife (Derraik, 2002). In consequence, government policies and business governance structures have shown how quickly they can act to implement adaptation and mitigation plans in response to mainly public pressure. For example, Directive 2019/904 of the European Parliament and the Council (June 5th 2019) on, '*the reduction of the impact of certain plastic products on the environment*' (www.legislation.gov.uk/eudr/2019/904/introduction), and which entered into force on July 3rd 2019 . In contrast, and despite the environmental damage and biodiversity loss associated with conventional food systems, there is limited social reaction by comparison. ***Why is it so challenging to generate an equivalent level of concern, and such rapid response, in establishing the pivotal role of legumes in realising regenerative food systems?***

There appears to be an absence of awareness and fundamental understanding among the public, including policymakers, regarding what constitutes a regenerative food system, and why legumes should be an essential feature of such a system. Even simple questions such as: "***what a is a legume?***"; or, "***what properties set legume crops apart from non-legume crops?***", are often left unanswered, or are answered incorrectly. As such, the vignettes shared below help justify why **legumes should be regarded as keystone species to help create 'regenerative food systems',** and some initial ideas regarding how to improve 'nutrition and health literacy' (Velardo, 2015), with special regard to legumes.

Legumes: vehicles to restore the food system-geochemical disconnect

The damage created by reactive nitrogen[2], from the over- and inefficient use of synthetic nitrogen fertilisers (and pesticides), is not easily visualised, and therefore most members of the general public are unaware of the damage it causes, and the long-term risks it generates. Or put another way: **it is**

[2] Reactive nitrogen or 'Nr', refers to a range of nitrogen compounds including ammonia (NH_3) and nitrate (NO_3), plus the gaseous compounds of nitrogen oxide (NO_x) and nitrous oxide (N_2O). All are associated with the inefficient use of (synthetic) nitrogenous fertilisers, and can led to eutrophication of fresh waters and an climate change *via* the accumulation of GHGs in the atmosphere.

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not commonly appreciated that locally grown legumes can help improve global geochemical cycles, reduce the contribution of reactive nitrogen to greenhouse gas emissions, and the consequent threat to food security through climate change impacts.

Human civilisation is near the limits of 'global-boundaries' or 'thresholds-of-tolerance' for key system functions (Rockström et al., 2009; Steffen et al., 2015), and one key factor emerges as critical: a dysfunctional nitrogen-cycle with excessive loss of reactive nitrogen to waterways and the atmosphere (Galloway et al., 2008; Erisman et al., 2008; Sutton et al., 2011). **The inefficient-use and mismanagement of reactive nitrogen has direct and severe negative impacts on the climate and food security.**

For example, **high inputs of synthetic nitrogen fertiliser cause lower rates of soil carbon sequestration** (Khan et al., 2007), **and depletion of natural soil fertility over the long term** (Mulvaney et al., 2009). Mulvaney et al., (2009) also goes as far as to recommend that, "***long term sustainability may require agricultural diversification involving a gradual transition from intensive synthetic nitrogen inputs to legume-based crop rotations***", or food- and feed-systems. This indicates that legumes offer a functional remedy to synthetic fertiliser misuse and consequent risks to agricultural soil health in Europe (Tóth, 2008), and globally (Foyer et al., 2016).

Such loss of soil function is linked to crop yield stagnation and decline, and this is seen throughout Europe due to economic policies which encouraged the almost complete removal of legumes from European cropping systems (Brisson et al., 2010; Ray et al., 2012).

However, in this policy respect some caution is warranted, since **the decline in legumes within cropped systems in Europe preceded the introduction of synthetic nitrogen fertiliser by many years,** and perhaps as many as 60 years. That is, the demise of legumes was compounded by the introduction of synthetic nitrogen fertilisers, but the foundation of **their demise was rooted in how the food system had become industrialised**[3]**.** Specifically, that large scale food (and feed)

[3] There is evidence in the UK, including Scotland, that the decline in the diversity of arable crops, and including legumes, began in 1880's (Squire, 2020). This coincided with several years of bad weather (starting 1879). In response to the consequent UK-grain shortage, food was imported from North America. The severe depression

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processing plants throughout Europe were mainly designed to handle small grain crops, such as wheat. Also, that such industrial development was linked to the demands and labour shortages associated with war, and especially the World Wars I and II. Such state sponsored support of food value network industrialisation has modern day ramifications which may be characterised as: the need to balance the desire for more-environmentally sustainable and -ethical food systems, with commercial demands for ever increasing levels of crop production and profitability (Lang, 2003)

Food supplied from coastal areas is also affected by nitrogen fertiliser loss *via* deoxygenation of marine coastal environments and open oceans (Breitburg et al., 2018) driven by climate change and exacerbated by direct rapid nitrogenous fertiliser losses, and slower lower and longer term losses from nitrogen already accumulated in the vadose zone, that zone between the capillary fringe (or bedrock) and soil surface. Nitrogen held in the vadose layer has accumulated since the intensive use of synthetic nitrogen fertiliser was initiated, from around mid-1950's to the present day. Currently, levels in the worst affected areas reach almost 4,500 kg ha^{-1} of latent stored nitrogen (Ascott et al., 2017). **This emerging scenario has been likened to a 'nitrogen time bomb', and concerted global action was initiated via launch of the 'UN Global Campaign on Sustainable Nitrogen Management' (in 2019).**

High environmental dependency for high legume productivity is a plus

Despite the damage done by synthetic nitrogen fertiliser, the main aim of agricultural activities is to increase yield of all crops including legumes, and rhetoric that, "yield is king" is especially concerning (in addition to the fact it is gender-biased). Nevertheless, **the yield gap[4] of legume crops are larger than that experienced by non-legume crops, and major legume crops such as soybean. This probably reflects the fact that the yield gap is narrowed as research and commercial interest in a crop is intensified** (Sinclair, 2004). Research effort in legumes (beyond soybean) must be increased, and for legume traits that are critical to actors across the value network and a variety of end-users or consumer types. Therefore, we argue that the challenge is not only to

of agricultural diversity and production in the UK was maintained until around the 1950s-60s and the onset of the 'green revolution' (Cleaver, 1972; Pingali, 2012). Whether the demise of crop diversity was seen elsewhere in Europe is not clear. **There should be more research on the history of agriculture in Europe, and with special respect to crop diversity and home-grown legume (protein) production.**

[4] The 'yield gap' is the difference between the maximum potential yield and realised yield of a crop species.

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achieve higher (and more stable) yields, but also to increase the area sown to legumes, and to improve grain quality attributes such as nutritional factors and processing qualities for markets, which ensure high product value. To conclude, we propose here that: **narrowing of gap between the legume yield and yield-potential (the 'yield-gap') should be utilised as an indicator by which the quality of the agroecosystem has been optimised.**

However, **estimates of theoretical maximum yields for legume crops are rare in the peer-reviewed literature**. Research by the pea and faba bean specialists with the UK Yield Enhancement Networks (YENs; www.yen.adas.co.uk/) estimate that actual average yields in the UK are around 40% of their yield potential (Costello, Keith, et al., unpublished data). This proportional shortfall is similar that estimated for faba bean in Ethiopia (Mulugeta et al., 2019). It would appear (again), that plant varieties and agronomy are generally good – and that the yield gap is determined mainly by soil functional properties, including nutrient management and prevailing weather conditions during the whole crop life cycle.

Hawes et al., (2019) has also highlighted the trade-off between environmental and economic sustainability from a long-term study of legume (faba bean, i.e. pollinator dependant) supported crop systems. As such, **it may be no accident that pea and soybean are the most cultivated grain legumes crops in Europe as neither are insect pollinator dependent. It is likely that such non-dependence benefits commercial yields.** However, there are also other attributes which underpin their popularity such as short-life cycle (pea), and high protein content (soybean), while both grain types demonstrate high-functionality for feed- and food-uses. Nevertheless, this highlights the risk that these common legume crop types offer less support to the environment compared to other types, and have been the subject of intense breeding and agronomy to serve commercial needs - and not necessarily the diversity and resilience of the production environment (Lin, 2011).

Considering the cropped system, legumes should be characterised as a crop type that 'gives something back' to the production environment. For example, properly managed legumes fix atmospheric nitrogen into biologically useful forms, as nitrogen- and fibre-rich crop residues left in-field can improve soil fertility and functions such as water retention and biocontrol of non-legume crop pests (Iannetta et al., 2013; Stagnari et al., 2017). **These net contributions to the system must**

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be understood as essential crop attributes. The extent of this provision among legume types grown primarily for their grain is not equal, with crops such as lupin and faba bean serving as larger net contributors (Peoples et al., 2009; Preissel et al., 2015). In this context, it may be questioned: **that research targeted to improve yield may compromise benefits partitioned to the environment and or non-cropped biodiversity?** That is, efforts to increase the commercial competitiveness of grain legumes *via* higher and more stable yields may reduce the quantity and nature of the carbon and nitrogen resources which are partitioned to vegetative structures such as roots and crop residues left in-field. This may also be true for reproductive structures too, since the floral (calorific/energy) rewards among modern faba bean varieties vary greatly (almost 20-fold), and a preferred nectar sugar concentration of 55% [w/v] is preferred by pollinators (Bailes et al., 2018). It remains to be shown whether these differences, which were found in *ex situ* trials, may relate to the partitioning of resources to yield (*e.g.* grain off-take) and return (*e.g.* crop residues).

If the environmental provisions of grain legumes *are* compromised by the trend to increase yield (off-take), we might anticipate that **the utility of legume-based cover crop mixtures to emerge as increasingly important. and capable of compensating of any lost agroecosystem functions due to a lack of contribution from grain legumes**. These functions include but are not limited to: nitrogen- and carbon-containing crop residues; integrated pest management; and promotion of above- and below-ground agrobiodiversity (*e.g.* soil microbiota, pollinating and beneficial insects).

Common bean (*Phaseolus vulgaris* L.) remains the most popular grain legume cultivated almost entirely for food throughout the world, including mainly the Continental and Mediterranean pedoclimates of Europe (Zeven, 1997). Its popularity is also due to the crop's high functionality. Common bean will nodulate readily *via* a capacity to associate with a wide range rhizobia types, and the crop yields both green pods (as vegetables) and dry grains with high nutritional and organoleptic characteristics. In addition, commercial yields can be enhanced by providing significant levels of synthetic nitrogen fertiliser (*e.g.* 60 kg ha^{-1}). However, this has been shown to have a negative effect on the attractiveness of the crop to pollinators (Ramos et al., 2018), though the crop is characterised as self-pollinating. **The main point here being that a legume which is supplied with synthetic fertiliser to attain commercial level yields, may forfeit environmental benefits which it may have provided in the absence of the fertiliser inputs.** This

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also indicates that the research effort which has been invested into soybean should be matched for all grain legume types (Magrini et al., 2019), and perhaps that those legumes which already have a place in European food cultures should be prioritised.

To conclude this section, the possibility that remains to be tested: **breeding and agronomy efforts should not only be targeted to optimise yield, but should be allied to attributes that multiply other functions that safeguard environment, biodiversity and cultural values.** This transition would be via a crop diversification approach to optimise this trade-off and achieve more effective complementarity between crop types (*i.e.* traits) across species and varieties, rather than trying to attain all objectives via single crop types.

Soil function as a core environmental provision

Agronomic management should be geared towards ensuring that soil nitrogen content is monitored and that residue mineralisation rates of soil organic nitrogen and carbon is reduced (Peoples et al., 2019), especially for organic and conservation-tillage approaches which boast higher capacities than conventional systems for soil carbon sequestration (Freibauer et al., 2004; Johnson et al., 2007). Though it may be useful to highlight, that organic and conservation agricultural practices (*i.e.* no or minimum tillage) aim to be more environmentally sensitive, they do so from different and even differing and seemingly opposing management regimes. For example, conservation agriculture practices often depend upon intensive use of man-made herbicides (and pesticides) as an approach to minimise soil-disturbance, -GHG emissions, -erosion and optimise other soil functions including soil carbon sequestration. Yet organic and conservation agricultural approaches can be combined, and from discussions with organic specialists at TRUE-LIN workshops it is suggested that lowest GHG emission and maximum soil carbon sequestration in organic cropping systems may be best achieved via first transitioning to a conservation-agriculture, rather than *vice versa*.

We now start to look outside the production environment itself and the need to encourage natural nitrogen and carbon cycling, towards narratives that question how we currently conceive food systems, and therefore our expectations of them.

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Public-agrobiodiversity connectivity: pollinator-dependant legumes

The public appear especially sensitive to insect loss, and pollinating insects. Such biodiversity-loss and/or the role of pollinators remains a strong (visual) motivator to help encourage the public's interest in the wellbeing of agroecosystems. This narrative is central to the increasing popularity of products from organic agriculture which avoid the use of man-made agrochemicals, especially pesticides and herbicides which are lethal to many non-target species.

To optimise legume yield, certain environmental and biotic dependencies should be satisfied, such as the presence of the most effective plant genetic and rhizobia combinations, to nodulate well and biologically fix nitrogen (Peoples et al., 1995), and a healthy growing environment (e.g. enough water, good soil physical structure, near-pH neutral soils, mineral nutrition, plus optimised sowing densities and spatial patterns). In addition, commercially and agroecologically important common legume crop types such as faba bean, are also pollinator dependent. Work with bee pollinators, has indicated that pollinator-limitation may reduce yield in popular legume crops such as faba bean by over 20% (Cunningham and Le Feuvre, 2013). Yields are therefore at risk through the levels of terrestrial insect biodiversity-loss which have been likened to 'insect Armageddon', (Hallmann et al., 2017; van Klink et al., 2020). Interestingly, it has recently been discerned that moths often have crucial roles as plant pollinators in agroecosystems (Walton et al., 2020), though estimates of their role in closing the yield gap, for crop species including legumes types remains to be determined. Nevertheless, in the absence of evidence to the contrary (*i.e.* that moths are not important crop pollinators), then advice advocating night-time applications of pesticides to avoid affecting pollinators and other pollinating insects may be called into question.

Reenable the activities of independent legume-agronomy specialists

In many countries and regions throughout Europe publicly funded and publicly accountable agricultural extension services[5] have been eroded and/or privatised (Rivera, 2008). **Balancing the needs of commerce and the environment demands independent knowledge brokers in the**

[5] Agricultural extension services communicate the most up to date (scientific) research findings directly to agricultural practitioners. As such services are invariably supported (funded) by government agencies, they should be commercially independent of commercial entities, and focused upon improving farm profitability and the delivery of public goods, including the safeguarding of natural capital.

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form of extension services providers who are skilled in legume agronomy and crop-capacities, fully appreciative that the effective implementation of legume-based crop systems can be regenerative without losing gross financial margins.

While **organic systems** are dependent upon legumes as an essential means by which high soil fertility and good soil function are maintained, these cropping systems can still be seen as presenting a food security risk since their yields are on average lower than that of more intensive systems (Ponti et al., 2012), where environmental dependencies are substituted for high inputs of synthetic fertiliser and man-made pesticides. Yet, in systems where plant water availability is not limiting and in soils that are pH neutral, **yields from organic cropping systems can almost match and even exceed that of current-conventional approaches** (Seufert et al., 2020). Furthermore, Iannetta et al., (2016) discerned that **legume-based cropping systems (whether organic or not), were capable of being more productive than the comparator conventional[6] non-legume supported systems**. Often, this high productivity was achieved at levels of legume inclusion up to 50% (*i.e.* half of the crops throughout the whole period of the rotation being leguminous, with an equal mix of grain and forage-legume types in arable systems), and the extensive use of intercropping (Brooker et al., 2015). Collectively, such studies re-highlight the **need for more research to discern integrated legume-management approaches** to optimise nutrient-availability and (re-)cycling at farm and regional levels (Ponti et al., 2012).

Value networks (not food- and feed-chains)

The vast majority of agricultural production is centred on delivery of a **'feed system', not a 'food system'** - since most of the European farmland is used to yield commodities that are produced as industrial-scale feedstocks for production of animals (Westhoek et al., 2011), and to provide feedstock for the production of alcohol and bioenergy too.

Similarly, in discussing the role of legumes in feed- and food-supply chains, **the term 'supply chain' reinforces industrial and mechanistic- or linear-design approaches** which are driven by commercial goals and do not necessarily encompass the need to be holistic or regenerative. Such

[6] Conventional here denotes non-intensive (or not high input) systems.

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commercial objectives are often supported by government policies geared towards short-term economic efficiencies of larger-scale industrialised feed- (and food-) systems. However, **it is critical that ecological and whole-system level considerations are also ensured**, and as we have already elaborated these extend to: environmental functions, biodiversity protection; and human-wellbeing (nutritional and cultural provisions).

Additionally, food- and feed-supply chains rarely exist as a simple sequence of finite businesses, but rather they are dynamic interdependent networks, and often integrate non-commercial elements. Thus, use of the **food- and/or feed-network(s)** is a step towards a more scientifically accurate or realistic description. In addition, **the increasing significance of personal food values is determining food choice behaviours that affect the structure and natured of food- and feed-networks**. Traditionally, such values were largely determined by expectations of: taste; nutritional value; expense; preparation-time and/or ease; and the fulfilment of cultural and social needs. However, the significance of values which used to be less prominent are increasing and these may factors extend to : environmental sustainability, including reducing food waste; biodiversity protection; ethics *e.g.* human and animal welfare; provenance; and, personal safety and well-being (*e.g.* agri-toxin free production). Personal food values therefore reflect the interaction of numerous influences such as: culture, socioeconomics and -politics, food safety regulations, cropped system, food technologies, and marketing preferences. Moreover, the personal food values of consumers is affecting how food is produced, transported, processed and marketed, Therefore, which, and/or extent to which, such **personal food-choice values are accommodated, and the impact of their accommodation, could be recognised formally as functional indicators of the extent to which food-systems are be sustainable.** We suggest here that 'foundation food choice values' are those which help safe-guard: human health and wellbeing; the environment; biodiversity; plus, food-culture and -literacy. However, conventional food choice has a strong cultural and socio-economic basis, and entrenched behaviours have been learned over a lifetime. Such habits are notoriously recalcitrant to change, and require constant, consistent, and concerted actions if they are to be altered, (Nestle et al., 1998), and no less so for legume-based foods.

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Reinforcing understanding of 'legumes for health'

Even where there is awareness, **the public's understanding of the potential of legumes for positive impact on health appears to be limited** and conceived mainly in concepts of being 'natural' or as 'whole' foods with high nutritional provisioning. Despite this, such understanding and any resulting personally motivated sustainable consumption is a positive thing, and one which also offers another 'pivot-point' to drive food system change towards a more sustainable state. One such example of a place for legumes in food systems, is to help avoid obesity. Beyond social stigma and threats to personal wellbeing, **obesity has emerged as a major economic burden across Europe** (Müller-Riemenschneider, 2008) and globally (Organisation for Economic Co-operation and Development (OECD), 2019; Swinburn et al., 2019). Also, the **link between obesity and agricultural policies** is recognised (Abarca-Gómez et al., 2017), and the available evidence does lead to the conclusion **that legumes, and in particular pulses when consumed as food, may help combat obesity** [7] (Marinangeli and Jones, 2012) Also, to help redress the impacts of diabetes and cardiovascular disorders, which also place negative economic impacts via high (and increasing) health care costs and lost economic productivity due to sub-optimal well-being and illness (Saha et al., 2010). Therefore, there is also a need to improve positive legume-based consumption choices that curtail the impacts of over- and malnutrition, the so called 'double-burden' (Popkin et al., 2019; Swinburn et al., 2019), and this may be best achieved via more effective interventions and policies.

Ignorance is not bliss: the marginalisation of legumes

Food literacy voids are compounded in various ways as the presence of legumes and complexity of their provisions are often overshadowed by overly simplified marketing or 'commercial-communication' strategies. It may seem pedantic but consider the term '*grass fed beef*', which is employed as a unique selling point to convey to consumers the impression that the meat product is raised in a more-natural and -wholesome manner. Yet grass-plus-legume fed cattle, raised on feed-self-sufficient extensive pastures can feature as one of the most environmentally friendly and nutritious forms of beef which can be consumed (Daley et al., 2010). Nevertheless, the fact remains that usually the product is not simply 'grass fed', but 'legume-grass fed', so: '***why is the legume component marginalised in this way?'***. Also: that the benefits provided by legume are

[7] Only as part of a well-balanced calorie-controlled diet, and active lifestyle. Though also because the plant protein should replace at least a proportion of the (red) meat in the diet.

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ascribed to the grass component (only): ***does this amount to 'appropriation', or 'mis-appropriation' of food values?*** Whatever the answer to these questions are, we can be sure that **this simple-marketing choice appears as a legume-education opportunity lost.** It may also be argued that this marketing choice is more purposeful, and the intention is to raise the profile of the meat-protein product over the legume-protein from which it is (also) derived. ***Is the marginalisation of legumes in marketing a common phenomenon?*** Certainly, historically legumes have been the subject of, 'food discrimination', and are often described as 'poor man's meat' - despite their superior nutritional and health provisions (Iqbal et al., 2006). Today, also legumes feature as the subjects of new discriminatory (post-truth) narratives.

Examining the food service sectors (Hamann et al., 2018), **the potential of legumes is also largely unrecognised and marginalised, even downgraded, at key 'pinch-points' or 'bottle-necks' in the network structure**. **This scenario is also replicated in many wholesalers** which fail to classify legumes and legume-based products in their own categories (Hamann et al., 2018), and rather classify them in a hidden form within categories such as vegetables of one form or another, and even 'meat substitutes'. This final classification is especially interesting since it offers legumes a positive route to market as adjuncts in meat-based processed products, which represent the main portion of the protein-food market.

Nevertheless, **the characterisation of legumes as 'meat substitutes' or adjuncts reverts legumes to continued anonymity** and expert reports, such as those led by the Intergovernmental Panel on Climate Change (IPCC) 5th (IPCC, 2013) and Special Report on Climate Change and Land Use (IPCC, 2019) the EAT-Lancet Commission (Willett et al., 2019), have been explicit regarding the necessity to reduce meat consumption (rather than increase legume consumption) on the basis of environmental- and personal-health factors.

Nevertheless, legume-based products which aim to reduce meat consumption by mimicking meat must be excellent imitators. A reality is that until recently, legume-based meat-alternative products have been of rather poor organoleptic quality and consumed by only a small number of people with sufficient ethical drive. Consequently, for most consumers such products often represent a poor substitute for the real, tastier, and often more affordable meat that they are trying to mimic.

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However, if legume-based (convenience) foods can be manufactured, and when allied to added marketing on eco-credentials and potential health benefits, they should become the products of choice.

Soybean: a legume that is difficult to ignore

The ethical and environmental risks of continuing to use the grain of one main legume crop, soybean, imported to Europe mainly from deforested rainforest and cerrado regions of South America has been widely recognised and popularised by the activities of large global NGOs such as WWF (Machado, 2016). Some companies are taking measures to ensure that soybean sources are either sustainable or excluded from value networks altogether. Consequently, increasing grain legume protein self-sufficiency in Europe via large-scale transnational soybean production, is an aim originally embodied in the European Soy Declaration (2017), but rejected by several non-governmental organisations including La Via Campesina (International Peasants Movement; Duminicioiu, 2017) and Friends of the Earth (Ruralis et al., 2018)[8]. This initiative was allied to a series of public and expert consultations which culminated in development of the EUs 'Plant Protein Plan' (EC, 2018; November 22nd), and their acknowledgement only 8 days later that, "*EU efforts - should instead focus their efforts on infrastructure for processing of plant proteins for food*" (Clément et al., 2018).

Legume diversity should feature in national and regional initiatives

The launch of the EU Plant Protein Plan follows on from an initiative originally realised by Germany, a dedicated and strategic national and regional plan to help promote the cultivation of pulses in Germany (BEML, 2016). These intentions appear well founded as a basis of sustainable economic development as the area sown to legumes is projected to increase 67% to 2.5 million ha by 2030: driven, by consumer-, environmental-, personal- and animal-health concerns; and demanding, the

[8] Linked to this rejection is a recognition that low cost imported soybean from what was biodiverse land underpins the commercial success of most livestock and meat production units. This occurs despite that fact that European grown legumes grains of various species can replace soybean in the diet of almost all livestock. The issue is therefore one of cost, as soybean alternatives mean great value network complexity, longer production times and more expensive production costs. Furthermore, if the European meat producers were restrained from using imported soya, they would need to make this transition in a price-protected market (i.e. from meat raised in a soy-unrestricted environments). However, if meat does become more expensive consumers will look for and accept more affordable (and ethical) alternatives.

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development of alternative production systems *e.g.* local, organic, GM-free or other certified products (EC, 2019). **Critical to capitalising on these sustainable economic development opportunities, is that all value network actors need to be equipped via strategic support to deliver the necessary underpinning awareness, knowledge, skills, and capacities.**

Allied to this, it is also critical that there is regional or national recognition of the carbon foot-print reduction that may be accrued by legume production compared to other non-legume grain commodities. 'carbon credit' (payments) may be provided for legume based cropping systems and downstream value networks, similarly proportional carbon taxes should be incurred for negative carbon footprint balances. This carbon-based suite of measures would allow the balanced weighting of taxes and credits to transform food- and feed-value networks. Towards such ends, **Helm (2019) identified three core principles to realise transition to more responsible commercial norms namely:** 1, public money (taxes, such a common agricultural payments) are used for delivery of public goods (not simply a payment for agricultural land ownership or production); 2, that 'polluters' such as those degrading soil carbon stocks, or net producers of GHGs, pay for such environmental impacts; and 3, that where direct environmental damage occurs the financial cost must be more than compensated for.

Ensuring equitable access to legume and legume-based food products

Whatever regional and national plans are decided and implemented, we return in this circular treatise to reconsider the starting element, which is the wellbeing of the environment whose state is diminished by unnatural geochemical cycling and biodiversity loss. These two negative features which have come to characterise the Holocene, and to define the new proposed geological era of the 'Anthropocene (Crutzen, 2006).

The real cost of food products that include potentially detrimental environmental and health impacts are not captured in the price of those products, with the arguable exception of alcohol which is taxed heavily in many European countries (Anderson and Baumberg, 2006) - but most of the revenues do not go back into repairing the environment or health consequences of these products. With few exceptions, inexpensive (and popular or common) food products do not confer **the environmental and health-cost savings of more sustainable products.** Additionally, marketed on

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their higher environmental-sustainability and ethical credentials are sold at premium prices, which may not be justified by the cost of production and probably reflects a high demand for those products from more affluent consumers (Reisch et al., 2013). This *may* be a necessary short-term consequence in transition towards such foods commanding a stronger market share, since establishment costs of innovation, production at scale and marketing to gain consumer acceptance must first be recouped. In the longer-term, cost reduction of legume-based foods would be expected. By comparison, such market-establishment costs have long been dispensed with in the meat industry. There is a strong argument here that the price of meat and meat-based products must reflect the cost of production and consumption. This will help create fair space for these new legume-based products and the environmental- and human-health messages they convey. Nevertheless, we emphasise still that **ensuring access of societies poorest consumers to the most sustainable food-choices should also be assured by civilised societies** and this could be a defining feature of legumes - in helping to realise food sovereignty[9] and food literacy (Vidgen and Gallegos, 2014) in practice.

[9] *A term initially conceived by members of Via Campesina (the peasant farmers movement in 1996) and describes that: producers, distributors, and consumers should control capacities and policies for food, locally. This is to ensure that value chains providing food operate ethically with respect for the environmental and biodiversity, whilst also ensuring all people have access to affordable nutritious and culturally appropriate food. This structure is opposed to the current paradigm, where small number of large corporate entities define a global food system based on profitability, and consumption choices are dictated to mainly passive consumers.*

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Pathways to impact

This report should be read in parallel with the 'Activity Plan – Year IV' for the final year of the TRUE-Project, and it should also be noted that this report supersedes some of the information given in the activity due to delays associated with the impact of COVID-19.

Project publications

The TRUE-Project can already boast a significant impact as summarised in the WP1 (Knowledge Exchange and Communication) 'scientific, practice and policy publications' (years 1, 2 and 3)

Project publications are collated on the TRUE website which is kept regularly updated. Here readers can find all: peer-reviewed scientific articles, policy briefs, publicly available Deliverables including the 'TRUE Toolbox for Transdisciplinary Research', LIN workshop reports, and a selection of presentations (as pdfs) made at various events. With respect to the latter, it was acknowledged that we should endeavour to have at least some key presentations available in short voice-to-video (V2V) formats and these resources will be generated for the next General Assembly, and made available publicly in due course.

Thus, and towards avoiding a siloed approach within discreet value network stakeholder groups, the TRUE-Project has fully embodied the **Open Science** approach, and this includes ensuring that all **public Deliverables** (even prior to approval), are released immediately after submission (with full reference and DOI) to the EC-REA (Research Executive Agency) via a range of platforms including: a **TRUE-Project 'Community' on Zenodo, ResearchGate** and **TRUE-website Blog** where **Case Study (CS) narratives** also commonly feature.

Case study summary narratives

The TRUE-Project embodies a suite of 24 Case Studies (CSs) which are formally acknowledged in the Grant Agreement, though there are also several others which are also embodied with WP activities too. Capitalising on the insights and innovations with **the CSs are an integral component of TRUE and its impact and legacy plan**.

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Summary reports synthesising insights from across the CSs have been initiated and are developed into the first iteration of short reports in TRUEs second (confidential) Periodic (36 month) Technical Report to the EU. This is the first step toward an easily understood **plain English 'map' of the CS transition paths**, the foundation which drives the interest in legumes, the opportunities realised, the barriers which have been overcome and which remain. These CS narratives have also captured how indicators of their success relate to specific sustainable development goals (SDGs). It is also expected that the **CS narratives should also elucidate the development of commercialisation 'blueprints'** (in partnership with all other WPs). This process of s**ummarising the CS narratives will culminate in the** scheduled Deliverable (D) of the **TRUE-Ebook** (WP2, D17). The eBook will also include summary highlights of the systematic review on the optimisation of production and value network development for grain legumes used as (only) food (using common bean) as a model.

Legume Innovation Network (LIN) workshops

LIN workshops are also critical elements of TRUE, as they are the hubs around which the multiactor approach is delivered in a face-to-face and transdisciplinary format. These were held in every year of the project in three different pedoclimatic regions (Atlantic/Boreal, Continental and Mediterranean), such that by the project end-date a total of nine region-specific workshops will have been delivered. Each of the **LIN workshops were designed strategically, to have a different focus.** For example, spanning various grain- and forage-legume types, plus value network sectors. In addition, the workshop content and outputs (*e.g.* PowerPoint® and poster presentations, data collected during break-out group discussions *etc*), of each LIN are formalised in separate extensive reports which are freely available on-line. These reports include delegates information (where data sharing permissions were approved). In addition to the nine regional workshops there is also a final **Combined-LIN** and Legacy-LIN workshop to be held as detailed below).

The TRUE-SAB and -ISAB

The TRUE-Project partners comprises an equal balance of academic and non-academic partners, the latter extending beyond commercial (for profit) entities to include non-governmental organisations (NGOs), farm networks (*e.g.* FdM and AK), consumer groups (*e.g.* SF) and registered charities (JHI, though not included in the SAB to help ensure independence from project

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coordination). In addition, a similar breadth of linked stakeholders has been achieved via individuals who have engaged with the project through the LIN workshops. As such, the impact and legacy plan described here builds upon feedback received from the Stakeholders Advisory Board (SAB) (Löhrich et al., 2020), reports of the Legume Innovation Network (LIN) workshops and informal repots of the TRUE-ISAB (Intercontinental Scientific Advisory Board) too, beneficiaries and LIN delegates. It is not practical for the TRUE-Project to act upon all the recommendations made and some have been identified as strategic priorities, and some examples are shown below.

- During the final year of the project, specific opportunities should be promoted in workshops such as LINs and/or General Assemblies to discuss and reflect upon potential 'science-to-business' (S2B), 'science-to-society' (S2S) and science-to-policy (S2P) disharmony, and *vice versa.* This will be pursued through a final face-to-face **Transdisciplinary Reflection Workshop**.

The final TRUE General Assembly (GA) (Dundee, Scotland UK, Jan. 2021), should be used as an opportunity to discuss and reflect upon potential '*science-to-business*' (S2B), '*science-to-society*' (S2S) and '*science-to-policy*' (S2P) disharmony, and *vice versa*. Towards understanding and resolving this, the **Transdisciplinary-Reflection Workshop** was planned to take place at the next GA (University of Hohenheim, Stuttgart Germany), in the last week of June 2020. However, due to the impact of COVID-19, this workshop will be rescheduled until late 2020 in the hope that the intended face-to-face event may be realised. However, as the workshop is realised, it is hoped that the outputs will be of utility to others innovating in this legume-based arena.

- Continue to ensure that all scientific results are communicated in a manner which is specifically tailored for recipient groups of potential end-users (beyond academic stakeholders). This is being addressed through newsletters and Blog posts, though we will develop **plain-language summaries** for peer-reviewed articles and WP outputs. These may also be featured in the **E-book**.

- Accommodate greater discussion and practical translation of insights from CSs, and with a view to developing improved mechanisms for translation of scientific findings to greater uptake (*i.e.*

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encouraging behaviour or cultural change). CS partners should also look to identifying a targeted list of potential end-users of their insights. This can be addressed in the planned CS narratives which are planned (also or the **E-book**).

- Develop a strategy whereby existing stakeholder networks may be used to help circulate TRUE-Project outputs more effectively. This may be achieved via a strategic approach with **other linked-projects and project networks as well as the TRUE legacy 'European-LIN' ('E-LIN').**

- Dissemination of all project outputs should be communicated to all partners more regularly and immediately upon submission. A new platform for more regular internal emails between partners has been implemented by UHOH. This dedicated email-based platform (i.e. project-only mailing-list) remains to be fully and freely exploited by partners, and it may be that active efforts need enacted to encourage regular content/outputs are highlighted.

'Plain-language' (English) summaries and 'common-format' reporting

The Open Access scientific peer-reviewed papers published from TRUE are highlighted on the project web page should also be released as short reports in 'plain- language'. If drafts should be translated into the different languages by co-authors (including English), and for the following outputs or activities. These could be delivered via the **TRUE-website (TRUE-Blog)**, though perhaps also as extra **Practice Abstracts**.

Practice Abstracts serve as one 'common format' component of as initiative aimed to improve the communication of project methodologies and results. While these have been submitted to the EC-REA and will feature on an EU based platform at some future date, in the last year of the project TRUE's practice abstracts should also feature on the project website, Zenodo and ResearchGate. As well as being uploaded to the TRUE data repository for later upload to other longer-term publicly accessible data-repositories too. Going forward, it appears that making the EC's Practice Abstract database fully searchable remains a challenge and resolving this would also help project impact.

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Making best use of social media

TRUE is also active on social media, though effort here could be intensified. Nevertheless, social media is routinely used to advertise the availability of these reports immediately after each is uploaded. This activity includes notification *via* Twitter (**@TrueLegumes**) and Facebook (**@transition paths to sustainable legume-based systems in Europe**). In the last years of the project, and as other reports emerge after the project end-date (Marsh 31st 2021), the intensified effort should be geared to ensure that Tweets (in particular) highlighting Deliverables and peer-reviewed article and mainstream press reports, and that these Tweets are targeted to species EU agencies including **@CORDIS_EU** and other EU based agencies including: **@EU_Commission**; **EUScienceInnov**; **@EU_Env**; **@EU_Health**; **@EU_ClimateAction**; and organisations such as **@ipbes, @FAOKnowledge, @COPACOGECA, @via_campesina**. The TRUE-Project (WP1) has produced a guide (available internally) conveying recommended protocols and avenues for project communications and it may be that dedicated and brief practice abstracts detailing such social media targets would be beneficial. This could be allied to an end of project collective social media campaign from all project partners and linked stakeholders including parallel projects.

Legacy activities and capacities

IP and innovation impact summary (to date)

In addition to the academic outputs and impacts, examples of significant commercial impact have begun to emerge from the project, and these are summarised in Table 1 below.

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Partner(s)	Commercial Products		Intellectual Property								
	Primary	Secondary	Know How	Trademark	CA/NDA[10]	Patent[11]	Licenced	Material Transfered	TRL (1st Product)	Description	Inventors
ADL/HUTTON	Pulse-based (barley) beer FabaBean IPA CoolBeans®)	Spent barley-pulse grains as premium animal (hen) feed	X	X	X				9	Optimised methods for brewing of pulses	Black, Iannetta et al.,
ADL/HUTTON	Neutral Spirit (used for gin, Nadar)	Pot-ale as (bovine) feed		X					9	Optimised methods for distilling pulses &	Black, Iannetta et al.,
ADL/HUTTON	Isolation of protein for food from pot-ale[12]	Solid material as feed	X			X			6-7	Protein isolates from pot-ale liquid – for specialist food products	Black, Iannetta et al., [13]
HUTTON/PGRO	Molecular Diagnostics: for rhizobia of pea, bean, lentil and *Lathyrus*		X	X			X		6-7	Assess symbiotic and non-symbiotic rhizobia from soil DNA	Iannetta et al.,
PGRO/HUTTON	'Elite' rhizobia for rhizobia of pea, bean, lentil and *Lathyrus*		X	X				X	9	Isolation and screen methods. Elite strains shared[14]	Iannetta et al.,
PGRO/HUTTON	Methods to identify rhizobial strains with improved on-seed shelf-life		X	X					6-7	Methods to identify elite strains, and liquid formulations	Iannetta et al.,

[10] Confidentiality Agreement (CA), or Non-Disclosure Agreement (NDA).
[11] (X) indicates Patent possibility.
[12] Liquid (and ca 10 5 solid) 'waste' material (co-product) from distilling (pulses).
[13] Property of Horizon Proteins Ltd. (Edinburgh, Scotland UK).
[14] To Legume Technology Ltd (UK).

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HUTTON	Novel faba bean type		X		X	6-7	Early-flowering dwarf faba bean variety	Iannetta et al.,
HUTTON	Baked whole faba bean product	X	X		X	6.7	Improved nutrition and sustainability credentials	Iannetta et al.,
IGV	Shaped & textured extrudates for food and feed	X		X		6-7	Optimised methods for food & feed products from legume isolates	IGV
STC	Prototype PA[15] machinery developed	X	X	(X)		5 -6	PAT-assisted strip-tilled living mulch production systems	Manterra Ltd.[16]
JSI *et al.,*	"Pathfinder" DSS[17]	X				5-6	On-line sustainable food-/feed system assessment tool	Debeljak et al.,
FdM	Vegetarian 'acorn sausage' [18]	X	X			9	Food product successfully launched	Sendim & Silva et al.,
UCP/IGV/AWI	Food Products[19]	X		X		6 -7	New products/production processes for plant-based foods improved nutrition profiles.	UCP/IGV/AWI
AWI/IGV/UCP	Aquaculture feed products	X		X		6 -7	New products and production processes for fish and shellfish	AWI/IGV/UCP

[15] Precision Agriculture.
[16] Sub-contractor.
[17] Decision Support System.
[18] Acorn, chickpea, carrot (24, 13, 12 %, respectively).
[19] For example: Lentil pancakes ("*Plantcakes*"), Faba-bean based donuts ("*BBDonuts*").

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TRUE data repository

WP2 (CSs) is coordinating the collation and storage of data and methodologies from across all TRUE-Project WP and CS activities. The information is being gathered in a secure (available online) data-repository, based in a secure encrypted data-server based at JHI. The data comprises a library of Standard Operating Procedures (SOPs) (i.e. material and methods) covering techniques such as: agronomy and agronomic approaches; assessment of yield and yield qualities; measuring BNF; rhizobial culture and characterisation; soil and plant nutritional status; Green House Gas (GHG) emissions; plus legume breeding (and grafting), approaches for example. In addition, data gathered using the SOPs is also captured alongside the associated descriptive information (*i.e.* metadata). The metadata describes experiments which gave rise to the datasets, as well as the data itself. The information is checked before storage to ensure information is captured in a routine and systematic manner, and that the information complies with aims of being 'FAIR' (findable, accessible, interoperable, and reusable). Towards that end, datasets are fully documented using standardised metadata repository templates (called Metadata Entry Forms, or' MEFs'). There are standardised SOP forms too. All such information is stored in the TRUE data-repository and accessible only to project partners who have registered to access the repository. This restriction is in place for a period of 6 months after project end (*i.e.* until 30th Sept 2021[20]). After this date, and since TRUE has undertaken to participate in the Open Research Data Pilot (ORDP; OpenAIRE), the SOPS, MEFs and associate data will be transferred to an Open Access Repository such as Zenodo (www.zenodo.org). The Table 2 below list numbers of SOPs and MEF currently gathered.

[20] Unless the project is extended by up to 6 months due to the impact of COVID-19, in which case the end-date will be 6 months later than this.

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Table 2. Summary of beneficiaries' contributions to the TRUE database during the 2nd reporting period (for more details, *cf.* **Error! Reference source not found.**).

N°.	Partner	SOPs	MEFs[21]
1	**JHI**	4	-
2	**CU**	2	-
3	**STC**	16	3
4	**SRUC**	1	1
5	**KEFRI**	1	1
6	**UCP**	2	8
7	**UHOH**	1	1
8	**AUA**	28	7
9	**IFAU**	2	3
15	**IGV**	3	2
17	**AK**	2	1
18	**AWI**	1	2
20	**ADL**	3	2
21	**TEAG**	1	1
22	**FDM**	-	-
23	**EUR**	1	1
24	**SOL**	1	1
25	**PIRED[22]**	1	2
	Total	**70**	**36**

t is therefore hoped that this information will also contribute significantly to TRUEs legacy, and it may be that collaboration with the EUREKA project may help impact in this regard. Since the aim of EUREKA aims to connect all multi-actor projects, their findings, and data in a common modular data

[21] As an indicator of anticipated raw datasets which are anticipated.
[22] This partner was previously known as REDEA.

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system or 'knowledge repository', termed 'FarmBook'. In addition, the impact of the TRUE data may also be improved via interaction with other facilitative projects such as Project Booster.

Collaboration with other relevant (EU funded) projects

Collaboration with coordinators of existing and relevant H2020 research projects has been initiated, and this includes the five projects LegValue, DIVERFarming, DIVERSify, Remix and DIVERImpacts, with DIVERSImpacts (Coordinator Antoine Messéan, INRA), coordinating this collective as the **'Crop Diversification Cluster' (CDC)**. The CDC's aim is to establish complementary information flows and joint activities. Several meetings have been held and formal Minutes documented. In this period, this interaction has including a face-to-face planning meeting in Budapest ahead of the *European Conference on Crop Diversification* (September 18th – 21st 2019).

This CDC meeting itself led to the formation of several working groups including on topics such as 'monitoring tools', 'policy' and 'communications.' Several joint KE proposal were tabled including one to the EC for IT support (the '**Dissemination Booster'**). TRUE is now also in contact with **META Group** as the Coordinator of a newly funded project called **IMPACT BOOSTER**, this includes commissions routed to them via the 'Dissemination Booster' initiative. A second CDC bid to the **American Association for the Advancement of Science (AAAS)**, was successful and the CDC will be represented in a parallel session at the next (2021) annual meeting of the AAAS.

The first 'European Conference on Crop Diversification' co-organised by the founder-projects gathered over 200 delegates and a summary report can be found here. TRUE was highly represented taking a co-lead role in the organising committee and editing abstracts for the book of proceedings. Numerous representations were made by TRUE with poster and oral presentations – and some TRUE WP-Leaders chairing some sessions. Challenges remain for the cluster including strengthening co-development of the cluster with industry stakeholders from across the value network.

TRUE WP Leaders have also interacted actively with other EU projects such as Legumes Translated (workshops). Also, LIAISON, a 'research and innovation' project which aims to help unlock the potential of "working in partnership for innovation" in agriculture, forestry and rural business. TRUE partners engaged with personal face-to-face interviews, completion of on-line questionnaires and

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(non-beneficiary) stakeholder interviews linked to TRUE activities and workshops. We have dialogue with the Bridge2Food project and recently established contact willingness to collaborate with the EUREKA Project, facilitate and support thematic networks.

The project partners are aware that there are many more projects which have a strong legume-component, whether funded by the EU or national funding agencies. For example, Protein2Food, TomRes, FoodProFuture, and projects supported via the first call from SusCrop-ERA Net (Co-fund on sustainable crop production), including ProFaba and LegumeGap or Leg4Life. While the existence of such projects is highlighted on the TRUE-Project webpages (here) , drawing together the vast array of outputs from across the demand a dedicated project focus which includes the development of a legume-specific DIH (Digital Innovation Hub). It may be that such a development could be scoped as an extension of the Legacy E-LIN provision, though it is anticipated that would demand a multi-actor transnational approach and dedicated funding.

Development of new legume-based projects

New projects have also emerged from new partnerships developed among beneficiaries with projects submitted to the EC, and nationally. These include project proposals focusing on: sustainable food systems (in Africa; Sustainable Food Systems) (**EC H2020 SFS (Sustainable Food Systems**); optimising a role for cover crops in the circular bioeconomy (**Marie Curie - Initial Training Network**); and realising dynamic value networks and smart-marketing for underutilised crop species more generally; dissemination of practical measures from long-term experimental platforms for implementation of legume-based cropping-systems and value networks (**ERA-Net**). **Nationally, project proposals which have also emerged** from the TRUE-Project include those focusing upon: development of business blueprints for more effective marketing of legume-based low carbon foods; the nature of legumes and their potential role in improving soil- *and* gut-health; establishing and linking digital platforms for optimised pulse production and food-processing and -retailing. While these proposals were presented to national funding agencies: some of these proposals have also included TRUE beneficiaries from other countries as associate partners. In addition, TRUE beneficiaries have been external advisors to other projects led by scientists and stakeholders external to the project: for example highly commercial projects such as the development of high-premium pulse based feeds to reduce antibiotic dependency; also, initiatives

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to realise more sustainable (intercropped based) production of common beans in North Macedonia (funded **World Food System Centre**).

In the last year of the project, there will be an even stronger strategic approach to pursue new insight via a suite of EC-based opportunities, including: **Operational Groups** (*e.g.* for the brewing and or distilling of pulses and biorefining of co-products for food-, feed-, -industrial chemicals and bioactives and/or -energy; **Focus Groups** (*e.g.* implementing intercropping: value network focused approaches); **Innovation Partnerships** (*e.g.* to realise implementation of legume-based value networks to aid delivery of good-food policies); **Thematic Networks** (*e.g.* have still to be established via 'smart' DoT (digitisation of things) approach for legume-based.

LEGVALUE & TRUE end-of-projects showcase[23]

The LEGVALUE- and TRUE-Projects are collaborating closely with the aim to jointly deliver three legacy tools and structures in Brussels over three days from April 13th to the 15th 2021. The delivery of the events are currently conceived as follows[24].

DAY 1 - Tuesday 13th of April: the projects will hold a joint **Policy-Dialogue Workshop**, in a final single project LIN'[25], and there a suite of at least **four Policy Briefs will be presented.** These Policy Briefs will summarise the findings on policies and shall describe specific recommendations towards different value network components as key leverage points to help direct for legume-based food system transformation.

At the Policy-Dialogue Workshop, **the concept of a single legacy European-LIN (ELIN) will be introduced** and TRUE-consortium partners and legume-focus stakeholders will also be asked to sign a **Co-Ownership Declaration**, describing how they can best contribute to the ELIN. To help

[23] Please note that this proposed itinerary below may be subject to change.
[24] This itinerary may be subject to change, especially in response to the ongoing impacts of the COVID-19 pandemic.
[25] Over the course of the TRUE-Project LINs have operated independently as pedoclimatic focused networks across Atlantic/Boreal, Continental, or Mediterranean zones. However, the final TRUE-LIN, will be 'combined' in a single workshop focused on the elaboration of a 'policy-mixes' to enable legume-based farm-to-form networks in Europe.

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disseminate the information presented local press will be invited to the Dialogue too, and pre-arranged press-releases distributed nationally by project beneficiaries.

DAY 2 - Wednesday the 14th of April 2021: a joint TRUE-LEGVALUE-Conference will take place in collaboration with TRUE. The conference will see **legacy E-LIN, formally established with a membership, and view to appointing elected stakeholders to the ELIN Organising Committee (on day 3 of the programme).** Further details on the ELIN and its implementation are provided in the next section below.

Day 3 - Thursday the 15th of April 2021: TRUE-WP8 (Transition Design) will see more detailed science-based talks of the TRUE and LegValue projects including the **introduction of a new tool for experts designing sustainable food systems**. The tool represents the state of the art for its type, since **it incorporates sustainable development indicators for all 'three pillars of sustainability'** (society, economy and environment), **and which the value network** from product to consumer. The DSS is a model whose structure is informed by experts, and by its launch date will have been validated using live commercial legume-based value networks. The DSS also boasts a user-friendly based interface. It is also anticipated that the first meeting of the newly formed European LIN will also be held, with the aim of establishing an organising committee, constitution and the initiation of a network development strategy.

The legacy European-LIN and its implementation

Despite the potential benefits of European grown legumes to benefit the environment, health and the economy, **the world of legume research, innovation and trade remains small compared to many other crop types.** This is with special reference to grain legume crops, which remain dwarfed by interests in cereals and oilseeds. The significantly smaller grain legume-cropped area reflecting relatively low current commercial values and investments. Nevertheless, the TRUE- and LEGVALUE-projects were jointly empowered by the EC-REA to identify routes (or 'transition paths') by which legume-supported food and feed value networks could be enabled across Europe. **TRUE and LEGVALUE are therefore drawing upon their complementary research and innovation**

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programmes[26] which incorporate industry stakeholders to realise jointly a legacy E-LIN. The ELIN is geared to form new legume-based business and innovation networks - linking researchers and research bodies, industry with industry, industry with researchers and everyone with policy makers, brokers, and consultants, throughout Europe and wider afield.

Therefore, **the legacy E-LIN is a valuable joint opportunity to connect networks of legume-focused businesses and promote awareness of new insights and enable innovation.** And in addition to offering services that help realise commercially competitive production and consumption of legumes and legume-based products. The challenges facing legumes should be overcome more-easily, with potential partners finding resources for mutual benefit, helping one another in an industry that is currently at a low level.

While the E-LIN will initially be formed by those who formed the concept (LEGVALUE and TRUE partners), it will have to be formally organised and these stakeholders will be elected at a specific session of the LEGVALUE Conference. Thereafter, the ELIN will evolve to meet the needs of those who form the network. **The E-LIN should retain an enduring focus on innovation and issues spanning the legume value networks and should be guided, by a founding constitution that ensures a wide membership base** that embraces all aspects of:

- input and production, commodity processing and food technologies;
- trading markets, retailing plus new and emerging markets:
- cultural aspect including 'sustainable consumption' (Mason and Lang, 2017)
- and environmental impacts; and
- socioeconomics, governance, and policy-development.

An established Digital Innovation Hub (DIH) for Agriculture and food production (https://itc-cluster.com/dih-agrifood/**), will be used to host registered ELIN members.** Membership will be free, and the LIN is not exclusive, as partners of all forms will be welcomed by their common interest – to help realise sustainable legume-supported agri-food systems. **ELIN partners should register**

[26] The TRUE-Project is largely focussed on innovations with legumes beyond the farm gate, whereas the LEGVALUE-project has more-concentrated efforts on studies at production level, and values along the supply chain.

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as members using this link - https://mapping.dih-agrifood.com/, and **registering members should ensure they use the specific terms "Legume" and "Legume-innovation-network" is the "Key Words" section of the registration process.**

DIHs are encouraged by the EC as one-stop shops that help companies become more competitive in their business and production processes, products, or services – and ultimately using digital technologies. It is predicted, if the countries which comprise the European Union are to remain competitive internationally, the value networks, and legume-based value networks among them, are encouraged to exploit DIHs. The selected approach builds on the network of European Digital Innovation Hubs and will ensure that the ELIN can link to other relevant DIH-based networks. It is envisaged that ELIN events will be organised and developed (perhaps bi-annually) to take place in different EU countries to ensure continued Europe-wide networking, and to accommodate special foci on the specific opportunities and barriers to legume uptake within each host country, and/or region. Though **we emphasise that conversations are being initiated to explore the possibility that the legacy European LIN established by TRUE and LegVALUE be achieved in partnership with the International Legume Society** www.legumesociety.org/.

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Closing remarks: legume impact in a dynamic world

We now reflect on contextual aspects raised in the Introduction, and highlight the following points.

Limited reaction to reactive nitrogen

There is an urgent need to implement mechanisms to address the largely invisible threat of reactive nitrogen, and the reality that **new and modified markets can be created with impressive speed if there is a suitable policy change.** This has been seen most recently in the response of governments globally to the threat of plastics. Yet, the less visual threat of reactive nitrogen is generally treated with less urgency, though the recent '*Launch of the UN Global Campaign on Sustainable Nitrogen Management*', calls for more-coordinated and strategic action. A critical feature here is that government policies will (should) operate to safeguard the wellbeing of natural- and human-capital. This would see the role of government as distinct from that of commercial enterprises which (without regulation), cannot be expected operate with environmental- and human-health in mind. As such, **developing environmental and social-policy frameworks within which enterprises must operate are critical to realise truly sustainable systems.**

Legumes as subjects of food-appropriation and/or -discrimination

The empowerment of EU-grown legumes should be acknowledged and encompassed more fully within EU policy position documents such as the European Commission's 'Development of plant proteins in the EU', plus Green Deal and Farm-to-Fork initiatives – since legumes have a key-stone role to play combating climate and eutrophication, as well as the obesity epidemic and hidden hunger. Such **inclusion should clearly define the pivotal role legumes and their good management** in sustainable nitrogen planning plus nutritional provision for food, feed, and the maintenance of optimised soil function.

Modern- and smart-marketing approaches for home-grown legumes need to be identified and adopted, and probably by professional (as opposed to academic) contractors. Such approaches would from an important component of any blueprint for improved 'innovation landscapes' (where all stakeholders may harmonise their objectives). Since, while the expectations of what constitutes a sustainable food system are likely to be similar, the objectives of the disparate stakeholders'

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groups will differ. That is, the behavioural basis for the choices made by producers, processors, retailers, and consumers need to be understood and managed in a collaborative manner to try and help ensure more sustainable outcomes - including facilitating greater uptake of home-grown legumes and legume-based products. For example, how consumer groups are categorised (*i.e.* separated) or amalgamated can make the difference between a more-profitable transition, or not. For example, many food industry stakeholders, including public- and private catering-services, have co-operated to embrace the vegan movement, and increasingly at the expense of the vegetarian category. As such, collectives adopt the vegan (and free-from) options in a single product category, or service offering. **However, no single mechanism for success is anticipated in the implementation of behaviour change,** since needs and expectations will vary across regions with different pedoclimates (which determines what is available), and as a function of historic and future aspirations of food-cultures. Additionally, regional expectations will all need to be harmonised with expectations and capacities at national and international (trade) levels. It may be that: ***regional authorities should invest in a professional modern-marketing taskforce to best realise the strong economic development potential that has emerged for legumes and legume-based products?***

Legumes are pivotal for efficient circular bioeconomies

The role of legumes as 'bio-based' commodities which are central to helping realise the circular (biorefining) economy has not been widely recognised. Trees are widely recognised and utilised as a defining biorefining feedstock and many tree-focused industries have emerged (e.g. '*Paper Province*'; '*LignoCity*'). Were more legume-focused industries to be established, legumes could become a defining feedstock for these systems too – especially if this were realised on marginal land which is not suitable for food production. Bio- or eco-technology pipelines for the commercialisation of wood and wood-based products have been created. If legumes are to be mainstreamed in the same way, such facilitative commercialisation pipelines could be important drivers. Such capacities are common in certain spheres, including for other crops (e.g. soybean and wheat). ***Why not work towards realising a 'legume-commercialisation pipeline' as a large-scale (EU funded) research facility?*** This could be implemented as an economic-development or -investment opportunity to prime legume-based bioprocessing industries.

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Regional capacities and -policies for legumes

Ensuring that the environmental, cultural, nutritional, and economic benefits of legumes are realised locally **will demand the baselining of regional and national capacities for the cultivation, storage, processing and retailing of legumes in all their forms.** Creating an inventory of this form is standard professional practice in advance of any intended management (or transition-path) changes. What is often found is that a transition path cannot be taken, or its intended impact will be compromised, until capacities are first established. This may not be simply a matter of establishing industrial capacities, but also including cultural or behaviour shifts for example in consumption habits. For such shifts to be effective, a sound evidence base is necessary to provide the 'emotivation'[27] (Apter, 2001), or 'nudges' for change (Hansen and Jespersen, 2013). Even with the social and industrial baseline capacities established, **policymakers will face the issue of satisfying regional and national needs, in a global-trade environment food system debate**. This debate has several facets, including whether to ensure that the potential to be self-sufficient in nutritional provision can be quickly realised when necessity may demand it. The debate was recently a focus of *Nature Food* (2020), since the relative balance and potential of local- and global-food systems present both opportunities or benefits, and risks. This is demonstrated in the wake of the food shortages and supply-network failures realised in (at least) the UK by the impact of COVID-19 (Garnett et al., 2020; Power et al., 2020).

Such food systems shocks aside, it is clear that **transition can be achieved in a transformative or revolutionary fashion by marginal gains in key areas of the value networks**, and specifically by: **1, increasing production efficiency** and not necessarily legume yields *per se*, though this could be welcome); **2, reducing food and feed losses** post-harvest; and, **3, more-sustainable consumption**, especially reduced consumption of imported grain-fed meat, and great consumption of (locally grown) pulses. Transition in any one of these areas of the value network could reduce the area of agricultural land required globally for food production by around 1/5th (Alexander et al., 2019), or

[27] The mental states of 'understanding' and 'emotion' are (usually) connected and the term 'emotivation' serves as a basis to recognise this and by-which poor choices may be understood and better managed. This approach has potential to understand the behavioural basis of the poor dietary choices which characterise modern ultrahigh-processed food consumption. This also relates to the formalisation of 'blue prints' discussed above (here, here and here), to support legume-focused transition.

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equally free this land area for accommodation of legumes – or more if the three interventions are adopted collectively.

Legumes to mitigate the rapid impact of pandemics and natural disasters

The 2020 COVID-19 crisis has served to highlight the risks of pandemics, or the serious risk to (human) life globally which is posed by pathogens, *i.e.* biological entities. Despite simulations of such a pandemic occurring (in the UK; Scally et al., 2020), many countries were not prepared and/or failed to react appropriately within the expected time frame. Therefore, ***can lessons be learned in preparation for the next pandemic and/or natural (or geophysical) hazard that will also impact on the (global) food system?*** The role of legume-based feed- and food-systems that are resilient to disruption should be included in the planning for eventualities.

Abiotic risks should also be considered. More localised events that could impact food security might include a tsunami, especially where food is either not stored or not stored well. This would all extend to small volcanic events. However: ***what if a volcanic eruption large enough to rapidly realise very severe climate impacts globally?*** (Oppenheimer, 2003). It is assumed that such impacts will impact most severely where populations are poorest. However, with such an interdependent global food system, where most (if not all) countries are significantly food-import dependant, the negative effects will not be localised. Since international distribution may become physically impossible and/or prohibited for reasons of national (food) security. In this way, densely populated developed regions of the world will very quickly become food insecure. This raises a series questions around that unrealistic expectation that, '*a country can quickly become food self-sufficient*'. However, ***how quickly may a country become food self-sufficient if the need arose? What regional and or national capacities would be necessary to achieve this? What threshold of import dependency is tolerable for different foods?*** Ensuring resilience to natural and anthropogenic disasters will demand that foresight is reinforced with investment to realise and implement the pre-prepared mitigation measures.

Legumes and the promises of synthetic food: the case of 'clean meat'

During the TRUE-Project questions have also emerged regarding food-technology advancements, including the potential threat brought by synthetic proteins (so-called 'clean-meat'), as the

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businesses concerned claim they are close to commercial reality. If fully realised: ***what is the place of legumes in future food-systems where 'clean-meat' technology may be applied?*** Proponents of the technology suggest that protein derived and supplied in this way- could decouple land-use from food production. However, 'clean-meat' technology is energy demanding and land-use requirements are only marginally lower than the land area required (and including feed requirements) for poultry producing meat and eggs (Alexander et al., 2017). Furthermore, Alexander et al., (2017) also suggest that a selection of targeted small changes in consumer behaviour would be more likely to achieve sustainable diets.

Let us assume that the energy to produce 'clean-meat' can be acquired from renewable energy sources. There then remains the goals of attaining the necessary food-safety- *and* nutritional standards, such that the clean-commodities are also 'substantially equivalent[28] to the conventional products they aim to supersede. Therefore, significant technical challenges remain and include: the use of animal-derived and synthetic materials; uncertainties regarding the governance, political - and socio-economic aspects will shape any regulatory systems that may emerge (Stephens et al., 2018). Additionally, **there are powerful vested interests which seek to oppose and/or possess the production of legume-based products at large-scales. The primary motivation for such activity is that of self-interest, and that has little to do with the environment, health, well-being, or environmental sustainability.** Instead, such interests have everything to do with continuity of their existing profitability and they will work hard to supress and/or possess the competition and appropriate the standards and value of disruptive newcomers. This phenomenon may be characterised as the "*illusion of diversity*" (Prof. Phil Howard, Michigan State University, USA), though it has also been shown to have significant socio-economic and environmental impacts. It has been most-notably recorded for the seed industry where a small number of agrochemical sales companies vie for ownership of the world seed suppliers, including new companies in the arena (Howard, 2009). Ownership of the USA's soft drinks industry also serves to highlight that three companies own all business that that account for 89% of sales there (Howard, 2010). It has also been witnessed for companies which have emerged to serve the popular craft-beer markets which has emerged in developed countries across the work (Howard, 2014).

[28] The mention of 'equivalence' is also significant, since legumes offer important non-nutritionals as well as nutritionals to maintain wellbeing; this is not simply a 'protein provision story'.

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Nevertheless, legumes fulfil important social and cultural functions: ***can a synthetic product satisfy consumers' expectations for natural and complex provisions of wholefood?*** We speculate, or conclude, that 'clean-meat' uptake is unlikely to be rapid judging by current response rates and concerns of consumers to the existing products. **Whatever the future holds in this regard, legume-based systems should be aware of such new technologies and expand alongside them.**

Legumes in a post-truth world

The implementation of more sustainable legume-based food- and feed-systems must be realised in a post-truth world. That is, a world where scientific evidence, and especially environmental and agroecological evidence, can be ignored by the ill-informed including politicians' and their supporting public. Of course, this phenomenon has been recurring for centuries, though now with digital technologies, and mass-media, 'fact checks' can at least be offered. However, in the same way that healthy food choices are often not chosen, so too are uncomfortable truths regarding ecological diets are also avoided – and despite the evidence, behavioural change cannot be easily achieved.

The theme touched upon in the introduction that legumes may be marginalised or downgraded, can be witnessed in public and trade media narratives too. For example, consider perspectives realised from scientific peer-reviewed reports including the phylogenomic study of Griesmann et al., (2018), who reported evidence indicating that the capacity for biological nitrogen fixation may have been gained and lost by numerous different plant types over the course of evolution. This was interpreted in the trade (technology) press as evidence indicating that this capacity (biological nitrogen fixation by legumes) is an evolutionary dead-end. The justification being that plant fitness is compromised by the high energetic demands of biological nitrogen fixation (Ditig, 2018). Yet this author makes no reference to that fact that the family Fabaceae is the third-largest land plant family comprising over 19,000 species and which exhibit a diverse range of psychological types having adapted to a wide variety of pedoclimatic environments globally (Christenhusz and Byng, 2016).

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Any response to false or ill-informed narratives must be constructive and ensure that the significance of findings is established by holistic dialogue. Additionally, that new or alternative food system strategies are developed and implemented collectively - by a diversity of actors from across society and food-value networks (Lubchenco et al., 2017). Scientists (who can), should highlight the successes of scientific endeavour and challenge false narratives. However, it is also imperative that such effort is underpinned by a modification of scientific reward structures and training, to ensure independence and to establish the inter-and trans-disciplinary skill-base which is necessary to meet the current- and future-needs of food systems locally, and globally.

Defending the need for sustainable value networks

Linked to the last comment regarding post-truth, is a note regarding informal comments made on several occasions from a variety of TRUE-Project knowledge exchange events, which are that the public, '*do not care about ethical food production and consumption*'. However, while consumers can be characterised by multiple criteria, a very large proportion of the population simply desires food which is tasty, culturally acceptable, and affordable. So it is that expression of concern pertaining to ethical treatment of the environment, biodiversity, farmers and farmworkers is strongly linked to socio-economic status. That is, consumers with less money to spend on food do not have the luxury of being able to purchase products which are more expensive, sustainable, and/or ethical. In addition, such consumers may lack the knowledge and/or capacities to cook more sustainable food choices. However, it does not mean that such consumers care less about food. Linked to this, is the argument that inexpensive meat is seen as a public service to society's less affluent consumers. **This anathema should cease, and the high cost of inexpensive imported grain-feed meat should cease, since the true cost of such products are not captured in the product price.** Politicians have this in their grasp and taxation at the point of consumption is impractical. However, a penalty or reward for carbon emitted or sequestered at point of consumption is seen as practical means to realise more sustainable food choices for all consumers, including farm animal consumer. **Taxation or reward at point of production will encourage greater national protein self-sufficiency via cultivation of home-grown legume-based feed.**

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The level of production and consumption of legumes grown locally, will probably only reflect the nature and strength or "pull" from a downstream (local) legume value-network. Since the commercial market value for legumes is now being realised, value networks are responding proactively to public concerns (Hamann et al., 2019). Nevertheless, overarching questions for any **concerned citizen** wishing to realise consumption patterns which encourage regenerative-agricultural practices and value networks might be: '***what food choices will support the most sustainable value networks from farm-to-fork locally, and globally?'*;** and, '***how may I be assured that my food choices are actually safeguarding what I value?'*** (questions adapted from Vasconcelos et al., 2019).

To summarise, claims that consumers, '*do not care about the food they eat*'. Or, '*are most concerned about social-status or convenience of a product*' (than the health and environmental aspects) does not seem borne out by evidence. **We argue that consumers are aware that they, '*are* what they eat', and furthermore that they, '*are* what they eat ate'.** Any appearance of 'not caring' is more likely to have been a function of the fact that **there is no convenient and/or practical means by which consumers may demonstrate their care.** In addition, it may also be that such 'don't care' claims are a strategy of post-truth narrators, who wish to maintain the 'broken food system' *status quo* that serves their own self-interest and places the burden of responsibility upon the consumers – as opposed to encouraging governments to coordinate efforts globally. Nevertheless, **consumers expect stakeholders based throughout the food and feed value networks to exercise corporate social responsibility.** Moreover, it is likely that those companies which gain from these expectations will be those which can achieve the affordable products for mass uptake *and* which also satisfy improved environmental, ethical and personal-health expectations of consumers (Golob et al., 2008). **Consumers *must* be able to make sustainable food choices with ease** (Schmidt-Traub, 2019), **and at a cost which is affordable to all members of the public, regardless of their socio-economic positions.**

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Legumes and the 'Precautionary Principle'[29]

It has been suggested here that well-managed legume-based cropping systems and value networks are realised locally, as a ubiquitous feature to help achieve economic, environmental *and* human-wellbeing. And in this context. the Precautionary Principle is enshrined in International Law including the 'Treaty on European Union' (1992), having emerged for environmental protection, and now extending to the implementation of policies which safeguard and human-health too (Foster et al., 2000; O'Riordan, 2013). Therefore, it seems appropriate to ask the question: ***does damage of natural- and human[30] -capital incurred as a failure to realise legume-based food-systems regionally (or nationally) amount to a non-compliance with the Precautionary Principle?***

Future iterations of this impact and legacy plan

The next and final iteration of this Impact and Legacy Plan will elaborate on the topic areas covered above, with additional topics as knowledge evolves. The second version will also draw upon TRUE-Project Deliverable reports and peer-reviewed articles more strongly. Not least since this report is also a co-operative and multidisciplinary output, and its breadth and style aims to stimulate discussion as well as serve as a practical summary of the TRUE-Project's deliberations and activities. It is also hoped that it is an accurate reflection of the complexities involved regarding the restoration of sustainable legume-based food systems in Europe, and so globally.

[29] The 'precautionary principle' is a means by which we may manage the introduction of new technologies, innovations or products that have potential to cause harm. The potential harm appears due to the lack of detailed scientific knowledge on the impact of the new entity. Consequently, the approach encourages the acquisition of knowledge regarding the potential risks, and a managed implementation of new entities if they are to be introduced. The precautionary principle has its opponents, the main rhetoric of which is that the principle is a barrier to progress.

[30] For example, through forfeited potential health benefits of legume-based foods. Also, moral, and ethical implications in terms of neglected alternatives to unsustainable forms of meat production.

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Annex I: Background to the TRUE-Project

Executive Summary

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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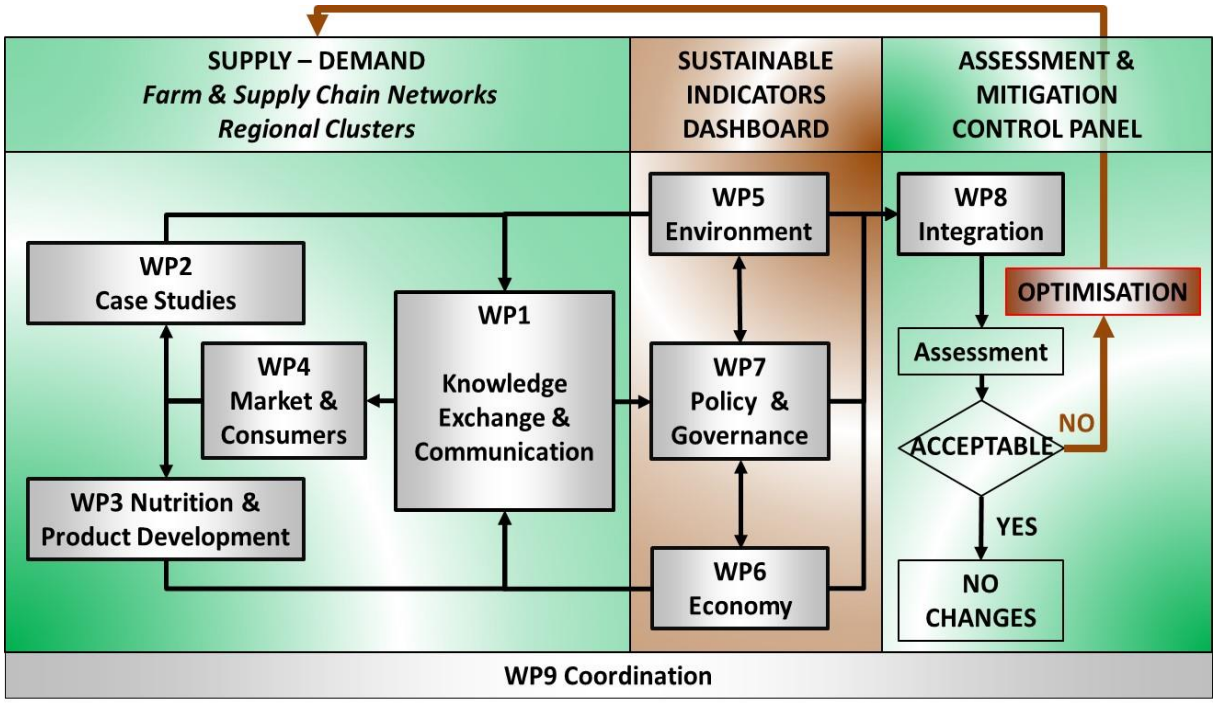
Work Package Structure

Flow of information and knowledge in TRUE, from definition of the 24 case studies (left), quantification of sustainability (centre) and synthesis and decision support (right).



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Project Partners

Nº.	Participant organisation name (and acronym)	Country	Organisation Type
1 (C*)	The James Hutton Institute (JHI)	UK	RTO
2	Coventry University (CU)	UK	University
3	Stockbridge Technology Centre (STC)	UK	SME
4	Scotland's Rural College (SRUC)	UK	HEI
5	Kenya Forestry Research Institute (KEFRI)	Kenya	RTO
6	Universidade Catolica Portuguesa (UCP)	Portugal	University
7	Universitaet Hohenheim (UHOH)	Germany	University
8	Agricultural University of Athens (AUA)	Greece	University
9	IFAU APS (IFAU)	Denmark	SME
10	Regionalna Razvojna Agencija Medimurje (REDEA)	Croatia	Development Agency
11	Bangor University (BU)	UK	University
12	Trinity College Dublin (TCD)	Ireland	University
13	Processors and Growers Research Organisation (PGRO)	UK	SME
14	Institut Jozef Stefan (JSI)	Slovenia	HEI
15	IGV Institut Fur Getreideverarbeitung Gmbh (IGV)	Germany	Commercial SME
16	ESSRG Kft (ESSRG)	Hungary	SME
17	Agri Kulti Kft (AK)	Hungary	SME
18	Alfred-Wegener-Institut (AWI)	Germany	RTO
19	Slow Food Deutschland e.V. (SF)	Germany	Social Enterprise
20	Arbikie Distilling Ltd (ADL)	UK	SME
21	Agriculture And Food Development Authority (TEAG)	Ireland	RTO
22	Sociedade Agrícola do Freixo do Meio, Lda (FDM)	Portugal	SME
23	Eurest -Sociedade Europeia De Restaurantes Lda (EUR)	Portugal	Commercial Enterprise
24	Solintagro SL (SOL)	Spain	SME
25	Public Institution Development of the Međimurje County (PIRED)	Croatia	Development Agency

*Coordinating institution

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Objectives

Objective 1: Facilitate knowledge exchange (UHOH, WP1)
- *Develop a blueprint for co-production of knowledge*

Objective 2: Identify factors that contribute to successful transitions (AUA, WP2)
- *Relevant and meaningful Sustainable Development Indicators (SDIs)*

Objective 3: Develop novel food and non-food uses (UCP, WP3)
- *Develop appropriate food and feed products for regions/cropping systems*

Objective 4: Investigate international markets and trade (IFAU, WP4)
- *Publish guidelines of legume consumption for employment and economic growth*
- *EU infrastructure-map for processing and trading*

Objective 5: Inventory data on environmental intensity of production (TCD, WP5)
- Life Cycle Analyses (LCA) -novel legumes rotations and diet change

Objective 6: Economic performance - different cropping systems (SRUC & UHOH, WP6)
- *Accounting yield and price risks of legume-based cropping systems*

Objective 7: Enable policies, legislation, and regulatory systems (ESSRG, WP7)
- *EU-policy linkages (on nutrition) to inform product development/uptake*

Objective 8: Develop decision support tools: growers to policy makers (JSI, WP8)
- *User friendly decision support tools to harmonise sustainability pillars*

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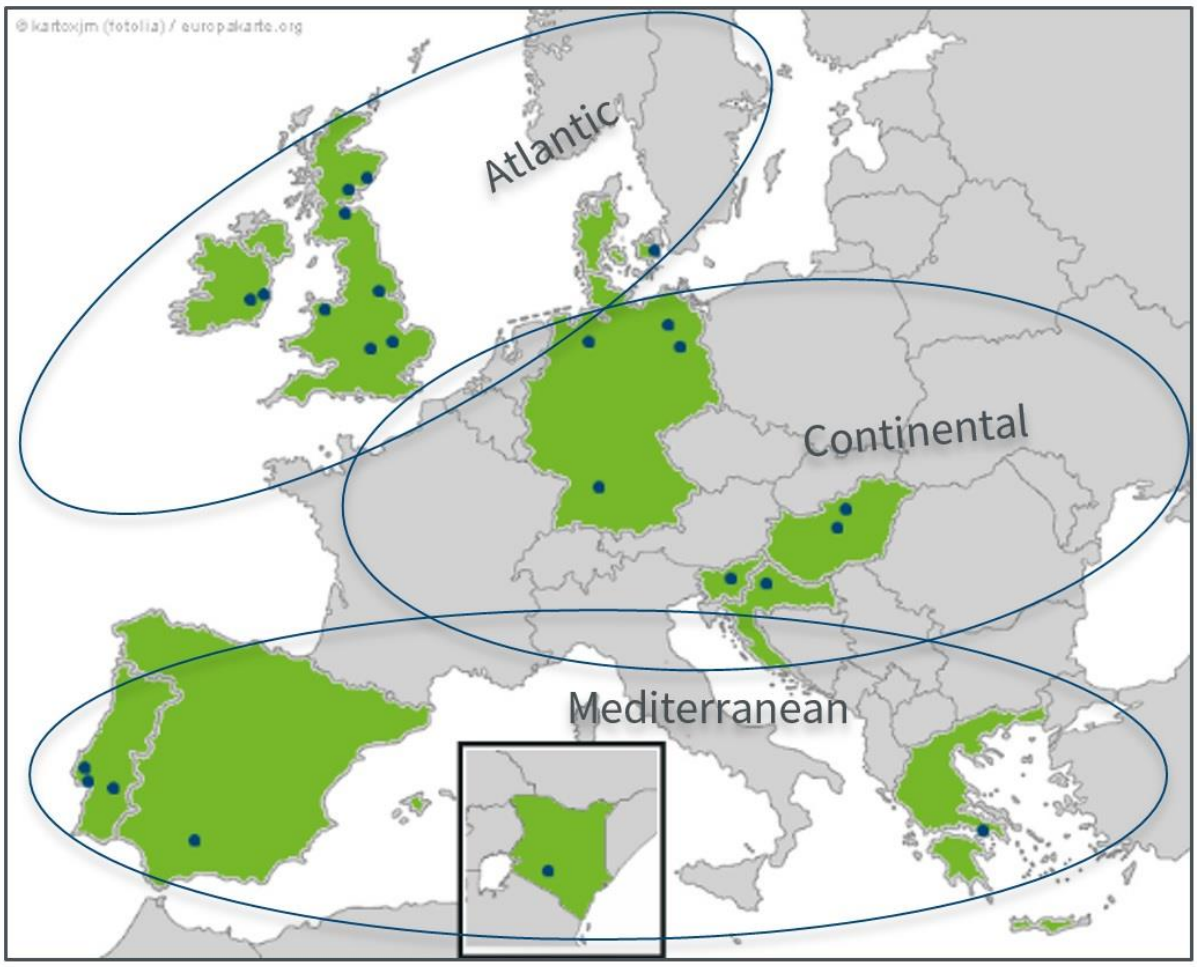
Legume Innovation Networks



Knowledge Exchange and Communication (WP1) events include three TRUE European Legume Innovation Networks (ELINs) and these engage multi-stakeholders in a series of focused workshops. The ELINs span three major pedoclimatic regions of Europe, illustrated above within the ellipsoids for Continental, Mediterranean and Atlantic zones.

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