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Sustainability in Agri-Food Systems: Transformative Trajectories
toward the Post-Anthropocene

Goal frames and sustainability transitions: how cognitive lock-ins can impede crop diversification

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Abstract

Transitions towards more sustainable agricultural systems are often characterised by 'lock-ins', understood as self-reinforcing mechanisms that reproduce the status quo and impede change. While socioeconomic, technological and institutional lock-ins have been widely used to understand processes of sustainable transitions in agri-food systems, the role of so-called cognitive lock-ins is still under-investigated. In this study, we focus on how institutional settings create cognitive lock-ins in farmers' decision-making related to the adoption of sustainable agricultural practices. We apply goal framing for environmental behaviour and transition theory in explaining how socio-technical conditions may shape farmer's decision-making. Empirically, we focus on the example of diversifying crop rotations with legumes as an established strategy to increase biodiversity and soil health, and reduce agrochemical use, emissions and pollution, which still remains rare in European agriculture. We use two cases in the Atlantic pedo-climatic region, Cornwall, UK, and Gelderland, Netherlands. Using in-depth interview data with farmers and extensive supplementary secondary data, we explore how context-specific socio-technical settings interact with farmers' normative, gain-oriented and hedonic goal frames to shape the (un-)desirability of crop diversification with legumes. This creates conditions recognisable as cognitive lock-ins: the context of farmers' decision-making creates cognitive processes that drastically reduce the perceived viability of alternative agricultural practices. Our findings in this case suggest the framework developed for this study may help to identify regionally specific, as well as common, barriers and solutions to crop diversification and comparable practices that are relevant to transitions towards sustainability in agri-food systems.

Keywords Sustainability transition · Legumes · Crop diversification · Lock-in · Goal framing

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Introduction

Agricultural practices in contemporary agri-food systems are now recognised as major drivers of climate change, biodiversity loss, soil erosion, and pollution, requiring fundamental and urgent shifts to more sustainable production, distribution and consumption (Campbell et al. 2017; Davies 2017; Rockström et al. 2020). Changing agricultural practices to enhance soil health and agro-ecological diversity, while mitigating and combating climate change and ensuring fair access to affordable and nutritious diets, are only a few of the transitions widely accepted as necessary (Böhm et al. 2020; Springmann et al. 2018). Despite agreement on the need for and nature of required transitions, change is happening far too slowly (Pretty et al. 2018; Rockström et al. 2020). Self-reinforcing mechanisms that reproduce the status quo

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and impede change, so-called lock ins, have been found to delay the needed changes (Geels 2019; Magrini et al. 2016; Meynard et al. 2018). While extant literature has explored factors relevant to lock-ins, such as technologies, economic mechanisms, institutional rules, and political dynamics, the role of cognitive processes as impediments, recognised as relevant to sustainability transitions, has only partially been explored (Geels 2019; Louah et al. 2017). Given that transitions in agri-food systems are complex and non-linear processes (Geels 2011), it is relevant to also consider potential cognitive mechanisms impeding change.

The context in which we have studied cognitive lock-ins is that of crop diversification in Europe. The focus on major, high-productivity crops, large-scale production, specialisation and monocropping is known to contribute to the damaging ecological conditions in agricultural systems, and diversifying cropping systems is an essential step in achieving sustainability in the agri-food system (Davies 2017; Gurr et al. 2016; Hammond and Dubé 2012). Introducing legumes[1] in extended crop rotations, particularly, is well known to increase agro-biodiversity, reduce pests and diseases, improve soil structure and increase soil fertility through nitrogen fixation, which is known to reduce the impacts of chemical fertilisation, pollution and eutrophication associated with intensive monocultural farming (Bedoussac et al. 2015; Magrini et al. 2016; Voisin et al. 2014; Watson et al. 2017). Also, the emergent debate on "protein transitions" has added to calls for their re-introduction, to support the necessary shift to more plant-based diets which reduces the substantial greenhouse gas emissions from meat production (Manners et al. 2020; Springmann et al. 2018; Willett et al. 2019). On a policy level, the EU strategy on climate and biodiversity has increasingly focused on stimulating crop diversification and increasing the production of plant proteins (European Commission 2018, 2021b). Despite these well-known benefits and support, the use of extended crop rotations with legumes remains limited (Voisin et al. 2014; Zander et al. 2016), and factors relevant to crop diversification, also within conventional farming systems, are less studied than other sustainable practices such as organic farming, especially in the European context (Morel et al. 2020).

In this study, we explore the role of cognitive lock-ins within two parallel case studies of crop diversification, informed by literature that attempts to explain the cognitive processes relevant to the adoption of pro-environmental behaviour (Lindenberg and Steg 2007). The identification of cognitive lock-ins requires understanding of how those queried make sense of their environment. We, therefore, used in-depth interviews supported by secondary data to investigate farmers' decision-making processes related to the introduction of legumes in rotations in two farming communities, one located in Gelderland in the Netherlands, and the other located in Cornwall (UK). We then used an abductive methodological strategy to support iteration between evidence and theory (Gioia et al. 2013).

In the following, "Sustainability transitions and lock-ins" presents a brief discussion of the literature that frames our conceptual approach in "Conceptual framework". Then, we describe the methodology used for this study, followed by the related findings. We then discuss our results and the concept of cognitive lock-ins within the context of transition research. Finally, we conclude and suggest avenues for further research.

Sustainability transitions and lock-ins

Sustainability transitions are fundamental, purposive changes to fulfil societally necessary functions more sustainably (Geels et al. 2016; Vermunt et al. 2020). Transition processes include, but are not limited to, technical, political, market and cognitive dimensions (Dumont et al. 2020; Geels 2019), and literature discussing them often focusses on meso- and macro-level processes (e.g. Bui et al. 2016; Ingram 2015, 2018; Meynard et al. 2017). When one or more of these dimensions intersect and reinforce the status quo, "lock-ins" may emerge which constrain actors' choices (Magrini et al. 2016). Boonstra et al. (2016) call these "social–ecological traps": a situation in which circumstances trigger a decision-maker's behavioural response that leads to the reproduction of the structural conditions within which that decision makes sense, i.e. the status quo. Several dimensions of lock-ins have been previously considered (Geels 2019), as reported in Table 1 below.

The literature on sustainability transitions, particularly that examining agri-food systems, makes frequent use of the concept of "lock-ins", particularly when examining institutional, technical and economic dimensions (e.g. Magrini et al. 2016; Plumecocq et al. 2018; Vanloqueren and Baret 2009). Studies discuss, for example, actors' technical knowledge and experience being limited to monocultural production systems (Kuokkanen et al. 2018; Morel et al. 2020), as well as the monoculture focus in public policies and research (Magrini et al. 2016; Meynard et al. 2018; Vanloqueren and Baret 2009). Sunk cost and economies of scale related to existing technologies have also been explored (Magrini et al. 2016; Meynard et al. 2018). Kuokkanen et al. (2018) and

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[1] Legumes refer to a group of plants, including crops such as beans, peas and lentils, which have broad applications in both human consumption and animal feed due to their high protein content. They also fix nitrogen into the soil from the air through biological processes, reducing the need for nitrogen fertilisation for the next crop in rotation. For further discussion of legume benefits see e.g. Watson et al. (2017) and Bedoussac et al. (2015).

Table 1 Overview of lock-ins

Dimensions of lock-in	Description
Technological	Infrastructure and (applied) know-how organised around existing technologies and practices
Economic	Existing economies of scale, sunk investments creating costs and benefits biased towards current technologies and practices
Institutional	Existing regulations, standards, and policy networks create an uneven playing field biased towards the status quo
Political	Vested interests and power relations that favour the status quo
Social	Existing alignments, relations and social capital between social groups
Cognitive	Routines and mindsets that "blind" actors to (the benefits of) other alternatives

Source: Adapted from Geels (2019)

Morel et al. (2020) discuss power imbalances in agricultural value chains with their economic and political implications.

While less prominent so far, cognitive processes are also starting to be recognised as relevant in the transition literature. For instance, Vanloqueren and Baret (2009) describe the "cognitive routines" keeping agricultural scientists focussed on using monocultures and agro-chemicals. Morel et al. (2020, p. 11) briefly mention lock-in resulting from farmers' inability "to develop systemic thinking" in their decision-making, thus preventing complex changes in practices. Similarly, Louah et al. (2017) explicitly describe cognitive lock-ins when exploring the necessity for "holistic thinking patterns" for the adoption of agro-forestry. While highlighting the relevance of cognitive processes in lock-ins, these studies do not provide a clear framework adequate to analyse cognitive lock-ins. Given that cognitive processes and their related behavioural responses in decision-makers are central to lock-ins (Boonstra et al. 2016), more attention needs to be paid to the conceptualisation of cognitive lock-ins, in order to complement our understanding of the role of structural and institutional conditions in transitions (Geels 2020; Hassink et al. 2018).

Outside of transition literature, and confirming the relevance of cognitive lock-in, farmers' decision-making has long been discussed as part of adoption processes. Here, farmers' adoption of, for example, sustainable practices is commonly linked to farm-level economic, socio-demographic and farm structure factors, such as costs and benefits, age and education, and land size and tenure, respectively (Brown et al. 2021; Jones-Garcia and Krishna 2021). Additionally, there is a growing body of studies that takes farmers' attitudinal, behavioural and (to a certain degree) cognitive variables into account (see e.g. Bartkowski and Bartke 2018; Brown et al. 2021; Dessart et al. 2019 for reviews). It has been pointed out that the different motivations driving farmers' decision-making should be considered (Han et al. 2021). We build on these streams of literature on lock-ins and farmer decision-making by providing a first conceptualisation of cognitive lock-ins within sustainability transitions.

Conceptual framework

Cognitive processes and decision-making: goal framing theory

To connect context-specific cognitive processes to behavioural change within sustainability transitions, we draw on goal framing theory (GFT) (Etienne 2011; Lindenberg and Steg 2007). GFT is often used to study pro-environmental behaviour in the agri-food sector (e.g. Djenontin et al. 2020; Lemken et al. 2017; Thøgersen and Alfinito 2020; Veisi et al. 2017). Since GFT fits our purposes of investigating and theorising the role of cognitive processes in transitions, and since it has been used in similar conditions, we found it appropriate for our study.

GFT starts from decision-makers' consideration of multiple relevant goals in their decision-making. While the *focal goal* receives most attention, decision-makers continue to attend to other goals, and the rise and fall of the importance of these *background goals* alter the salience of the focal goal (Etienne 2011; Lindenberg and Steg 2007). Background goals may reinforce or contradict the focal goal and change the order of preference among options that satisfy the focal goal (Lindenberg and Steg 2007). For example, a farmer's main goal in farm management may be to make a living, thus he or she may be guided by *gain-oriented goals*. Gain goals focus on preserving and improving one's personal resources (Etienne 2011; Lindenberg and Steg 2007). So, in the situation of buying new machinery, budget and effectiveness considerations are likely guiding. Yet, within the set of suitable options, one may select the more environmentally friendly option, thus being swayed by a normative background goal. Following *normative goals* means doing what is appropriate and contributing to collective goals (Lindenberg 2017). Farmers may also be motivated to get more enjoyment out of the everyday job activities, such that a farmer might opt for manual over mechanical weeding to create a more social work environment (a *hedonic goal*). When hedonic goals are in focus, we pursue immediate pleasure, try to avoid

negative emotions and seek to feel better in the current moment (Etienne 2011; Lindenberg and Steg 2007).

Goals need not conflict. If the most environmentally sound option is also the most profitable, gain and normative goals can strengthen each other (Lindenberg and Steg 2007). Yet, only providing financial incentives, such as subsidising an ecological focus area on a farm, can undermine the subsidy-independent sustainability of that initiative by reinforcing the salience of the gain goal frame and crowding out intrinsic motivation based on hedonic or normative frames (Steg et al. 2014). The salience and contents of goal frames are, in part, contextually determined (Foss and Lindenberg 2013; Gkargkavouzi et al. 2019; Steg et al. 2014). For example, as a farmer nears retirement, their goal frame may switch from making a living (gain -oriented) to transferring something worthwhile to their heir (normative). The possibility to influence goal frames brings us to the next aspect: the relationship between an individual decision-maker's goal frames and the contextual conditions of sustainability transitions.

Goal framing in the context of sustainability transitions

Decision-making in transitions entails a constant (re-)negotiation between goals. Once taken, decisions, then, contribute to either the reproduction or transformation of the overall system which creates interdependence between individuals' goals, the decisions they make and the institutional context to which these decisions in part contribute (Geels 2004, 2020). Institutions interact with individuals' goal frames, create incentives and disincentives for certain behaviours, and delimit decision-makers' autonomy (Lindenberg 2017; Steg et al. 2014).

These interactions between institutions and actors are shaped by power. Transitions are contested processes in which not all actors have compatible goals or the same amount of control over their actions (Geels et al. 2016; Hinrichs 2014). Relations of power mediate between institutions and individuals' goal frames and decisions. We, thus, assume that the more power an individual has, the lesser the degree to which their decisions are determined by contextual factors and the higher the degree of influence over the institutions that surround them and others. While an in-depth investigation of the effects of different degrees of power is beyond the scope of this paper, we assume that, given market concentration in processing and retail (Morel et al. 2020), farmers tend to be relatively less powerful actors in the agri-food system, and their business-related decisions are thus assumed to be highly influenced by their institutional context. Moreover, actors' definition of goals, and their hierarchical salience, is influenced by these power relations, often

embedded in the social and institutionalised norms of the given context (Lindenberg 2017).

Promotion of environmentally friendly decisions often requires hedonic and gain goals to be restrained and normative goals to be supported (Steg et al. 2014). When actors operate in institutional contexts where hedonic or gain-oriented goals are dominant, normative goals will be less relevant and achievable (Lindenberg 2017). The interplay between institutional conditions (e.g. rules, systems and regimes) and actors' goal frames is key to understanding cognitive lock-ins (Geels 2004; Hassink et al. 2018). When barriers in the institutional context are stronger than drivers promoting change, the current focal goal of decision-makers will be strengthened, their actions will gravitate around the status quo, and the institutional setting will be reproduced, creating a lock-in, as shown in Fig. 1.

However, Steg et al. (2014) explain how interventions that alter the institutional context can trigger or displace focal goal frames. Such a 'frame displacement' involves shifting the relative salience of goal frames (Etienne 2011; Lindenberg and Foss 2011). Changes at institutional and societal level can lead to changes in the wider decision-making setting in which the salience of goals that support environmental transitions increases (Steg et al. 2014) which, in turn, can lead to different outcomes that then may provoke institutional transformations. These dynamics of reproduction and transformation imply that, while individuals may adopt different practices, despite unfavourable conditions and due to their own personal goals, broader transition processes require the alignment of the institutional context and the dominant goal frame of a substantial share of decision-makers (Geels et al. 2016; Geels 2020; Kuokkanen et al. 2018). Figure 2 illustrates this process.

Data and methodology

Research context and methodological strategy

The context in which we investigated cognitive lock-ins is that of crop diversification with legumes. While once commonly part of farmers' rotations, legume production in Europe is low and decreasing (Watson et al. 2017; Zander et al. 2016). According to the latest available data, legumes covered only about 1.3% of agricultural land in the EU in 2016 (DG Agriculture and Rural Development 2018, 2021). In Europe, farmers are reported to be reluctant to re-introduce legumes due to the pressure to stick to monoculture-oriented practices, now embedded in established policy, subsidy and regulatory regimes, indicating the presence of lock-ins (Magrini et al. 2016; Meynard et al. 2018; Voisin et al. 2014; Zander et al. 2016). Additionally, the adoption of legumes broaches several dimensions of the agri-food

Fig. 1 Institutions, goal frames and lock-ins, adapted from Geels (2020), Lindenberg (2017), and Steg et al. (2014)
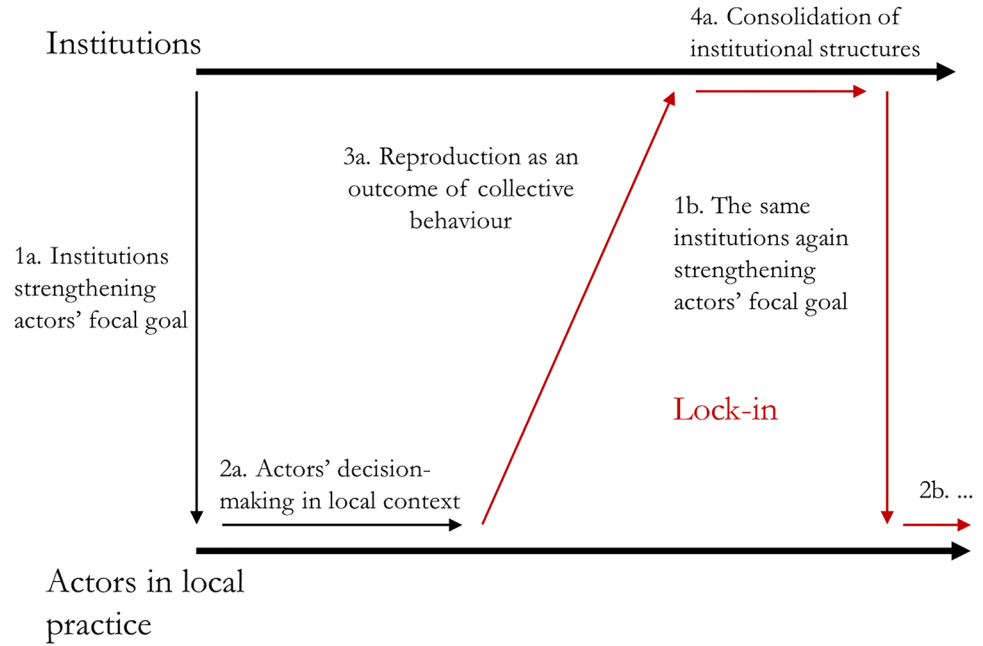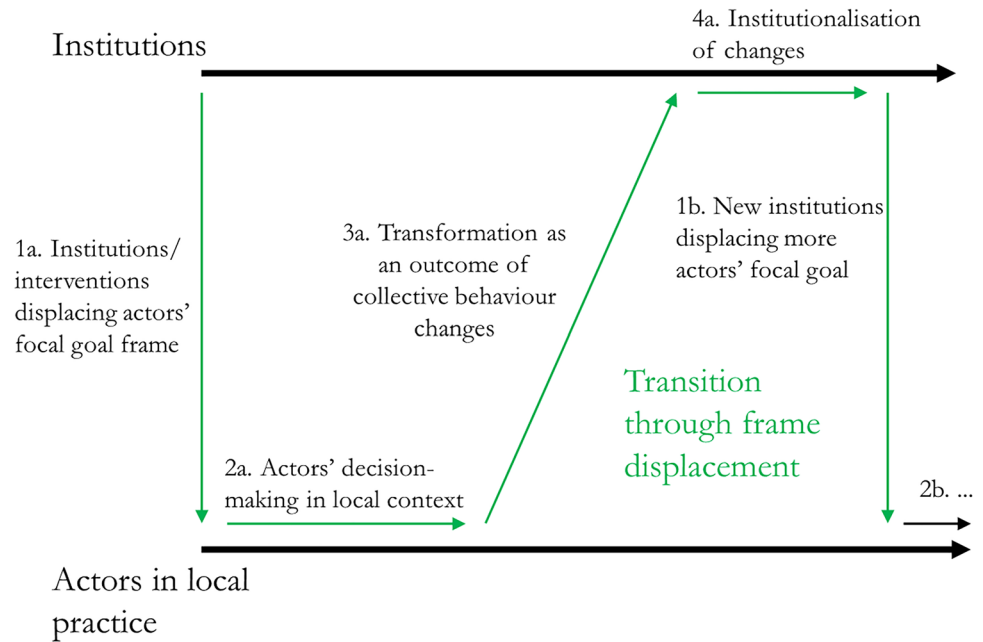

Fig. 2 Institutions, goal frames and transitions, adapted from Geels (2020), Lindenberg (2017), and Steg et al. (2014)

system such as climate, agronomy, markets and value chains, as well as policies and trade (Magrini et al. 2016; Morel et al. 2020). This inserts complexity into a farmer's decision-making process, which makes it a useful case within which to investigate cognitive lock-ins.

Our efforts to conceptualise cognitive lock-ins are based on rich case studies (Eisenhardt and Graebner 2007). The research team had the opportunity to conduct field work in two farming communities located in the Atlantic pedo-climatic region, both affected by low adoption rates of legumes despite the presence of public support for their adoption.

However, these communities also differ on a few significant characteristics, such as regional and local social norms and institutional setting, as well as structures and dynamics in the agricultural and market systems. The farming community, located in the region of Gelderland in the Netherlands is embedded in an export-oriented agricultural sector, is well connected to domestic urban centres, and supported by very active agricultural research and innovation organisations (CBS 2016; European Commission 2020; Food Valley 2021). The farming community in Cornwall, UK, on the other hand, is more socioeconomically disadvantaged, more

remote, has poorer infrastructure, and a far more domestically oriented agricultural sector (Cornwall Council 2017; DEFRA 2018a). Both areas were easy to access and data sources required for triangulation were readily available, which provided extensive opportunities for our efforts to build sound empirical cases. At the time of primary data collection, the purpose was to understand what explained the low adoption of legumes in crop rotation in farmers' own terms. Once data were collected, the research team developed an interpretive framework by iteratively moving between our initial frames (presented in Sect. 3) and the evidence found in our cases. In our analysis, we started from transition literature (e.g. Geels 2004, 2011) and, guided by our empirical data, extended our framework with coding informed by GFT.[2]

Data collection and analysis

Our primary data comes from semi-structured interviews held with farmers in 2019.[3] We decided that it was appropriate to interview farmers since, while some in our sample may be bound by production agreements for certain crops, they declared considerable freedom when it came to crop selection. Farmers in the two farming communities were identified through the co-authors' professional networks and snowball sampling, in which we deliberately sampled for heterogeneity as is appropriate in exploratory research (Eisenhardt and Graebner 2007). We conducted ten interviews with farmers from Gelderland and seven interviews with farmers in Cornwall. As less supplementary data were available for the Cornish case, three additional expert interviews were conducted, two of which were also former farmers. Additional interviews in the Dutch case were used to support the design of our data collection instruments. Secondary data, such as official statistics, government reports, and scientific literature were used to situate the farmers' responses in the context of local agriculture in general and grain legume production in particular. All interviews were held in the farmer's native language, recorded and analysed in Atlas.ti.[4] First, in vivo coding highlighted all relevant information related to inclusion of legumes in rotation.

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[2] An attempt to apply the transitions theory's own institutional theory base (Geels 2004, 2020) based on Scott (1995) as the analytical framework for this study failed due to the difficulty to empirically distinguish between cultural-cognitive and normative rules. Additionally, the overarching dominance of financial motivation that emerged from the empirical data could not be sufficiently captured in the three categories offered by this approach.

[3] This means that at the time of the interviews the UK had not yet left the European Union.

[4] Analysis was also done in the native language to avoid the data losses associated with translation prior to analysis.

In vivo codes were then summarised into descriptive categories. Finally, these descriptive categories were matched with goal frames.

Data sources

In this section, we briefly describe the sample of farmers and list the additional sources of data consulted. To support comparability, we imposed restrictions on our interviewee selection. Firstly, arable farming had to be a core activity of the farm business. On the included mixed crop–livestock farms, at least 30% of land had to be used for arable farming. Secondly, to exclude hobby farmers, we determined that income had to be drawn from the farming business. All but one interviewee were full-time farmers and fully depended on their farming income. The one exception is a Cornish farmer who draws income from his arable crops, but has other additional sources of income.

The Gelderland sample included eight strictly arable farms and two mixed farms who also reared livestock. Farm sizes ranged between 35 and 200 hectares. The most commonly grown crops in the sample were sugar beet, maize, summer grain and potatoes, of which sugar beet, grains and potatoes are also the most common crops in Dutch arable farming (Voskuilen 2020). Currently or previously grown legumes included field beans, peas, green beans, soybeans and broad beans.

In the Cornwall sample, three farmers were strictly arable and four were mixed farms, ranging between 53 and 560 ha. The most common crops among the interviewed Cornish farmers were: barley, wheat, oats, forage maize and oil seed rape. This is in line with the most common crops in in the UK and Cornwall, where 66% of arable land is used to grow cereals (DEFRA 2018b; National Farmers Union 2014). The only legume that appeared in this part of the sample were beans, though others such as lupines were also discussed.

All but one interviewee sold their arable crops off-farm. The exception was one Cornish farmer who uses his arable production on-farm as livestock feed, and only sells in case of overproduction. In both cases, we made sure to include farmers that are currently using legumes in their rotation, farmers that previously used legumes but stopped, and farmers that have never grown legumes on their farm. All interviewed farmers were male. Table 2 below shows an overview of all data sources consulted. The appendix provides an overview of farmers.

Findings

In this section, we start by presenting the main goal frames identified. We then discuss how these different goal frames relate to the institutional setting to create cognitive lock-ins.

Table 2 Overview of data sources

Category	Gelderland, NL	Cornwall, UK
Farmer interviews	Current legume production (2) Previous legume production (5) No legume production (3)	Current legume production (2) Previous legume production (2) No legume production (3)
Expert interviews and supplementary material	Exploratory interviews with legume-growing farmer CEO of organic vegetable and legume food processing company Participatory observation at lupin supply chain event	Farm advisor on diversification[5] Expert on Cornish agriculture and rural development[3] Expert on Cornish rural resource management and farm household behaviour
Policy documents and government sources	Policy documents (5) Central Statistics Bureau Netherlands (6) EU policy documents and data (7)	Department for Environment, Food and Rural Affairs (6) Cornwall Council (4)
Other secondary data	Academic papers (8) Research reports (9) Industry reports (3)	

[5]This expert was previously a farmer himself and thus added his own experience of farming in the region.

Table 3 Normative goals—overview of emerging themes

First-order codes	Exemplary quotes
Theme 1: Providing soil health and environmental benefits	
Preserving/promoting soil health (NL/UK)	We cannot carry on farming the way we are farming, traditionally the soils are knackered—UK Farmer g I strive to get as much balance into the soil as possible. Then peas, beans, grass and spelt fit a lot better—NL Farmer A
Provide environmental benefits (NL/UK)	[It] is the environmentally right thing to be doing, is growing pollinators—UK Farmer c You had a crop that produced pollen in an open flowering way that was attractive to pollinators such as bees—UK Farmer d
Theme 2: Supporting the local/place-based economy	
First-order codes	Exemplary quotes
Improve non-GMO varieties for local conditions (NL)	It is interesting to help bring non-GMO soy to another level—NL Farmer I
Local production more environmentally friendly (UK)	I think we should look also to the environment instead of getting all the stuff from South America—UK Farmer b With all the protein beans imported from the amazon and rain forest […] I do think we should be encouraged as an industry to grow our own protein—UK Farmer b
Theme 3: Preserving traditions and social relations	
First-order codes	Exemplary quotes
Trust in the buyer that proposes crop (NL)	I was getting along with him well and you just think, let's try it—NL Farmer H
Legumes not an "established" crop (UK)	I think it's an element of education. In the last 50, 60 years, which is all of my generation, probably most of my father's generation, who will remember the old school way of farming—UK Farmer f

Goal frames in decision-making processes for farm diversification

Within the themes consistently nominated by farmers as important, we identified normative, gain-oriented and hedonic goals, as emerging from farmers' expressed motivations and decision-making relevant to the introduction of crop diversification. The first set of findings revolves around **normative goals** (Table 3), summarised into three emerging themes: providing soil health and environmental benefits (theme 1), supporting the local economy (theme 2), and preserving traditions and social relations (theme 3). These demonstrate recognition of collective goals that go beyond the farmers' personal benefit. Farmers link their motivations to adopt legumes in crop rotation to the recognition of potential collective benefits. This *process of recognition* extends to the social and economic dimensions of how they make sense of their practices.

The second set of findings relate to gain-oriented goals (see Table 4 below). This set of goals emphasises farmers' frames that are directly associated with benefits for their farm business and themselves. Our findings highlight five main conceptual themes. First, a set of farmers' gain-related goals emerges in association with the mitigation

Table 4 Gain-oriented goals—overview of emerging themes

First-order codes	Exemplary quotes
Theme 4: Dealing with agro-ecological and climate-related risks	
Vulnerability to wet climate conditions (NL/UK)	You got to be cuckoo to grow combining peas in Cornwall because we're just too wet—UK Farmer d
	The dependency on the weather makes the pea harvest very risky—NL Farmer E
Lack of adequate seed varieties for local climate (NL/UK)	I know they have tried to grow soya in the UK […] but I think the problem is having the right varieties. – UK Expert h
	[The growing period of] the variety was way too short. […] if the pulses are ripe and you touch them, they fall […] and the harvest is lost—NL Farmer C
	You actually have to harvest in August, this [growing period] lasts till October. With the rain and the cold, it does not work—NL Farmer I
Pest and disease management (UK)	[Y]ou got a massive weed problem then, and you got real chocolate spot diseases around here so […] that was useless—UK Farmer b
Machinery (NL/UK)	Then you got the damage that you do to your combine because peas in Cornwall in a wet climate are as flat as that table—UK Farmer d
	If you have your own machinery, you're not going to experiment with something else so quickly—NL Farmer G
	Technically, it would be easy since I can use my own combine—NL Farmer I
Theme 5: Optimising use of subsidies and policy/regulatory support systems	
First-order codes	Exemplary quotes
Subsidies were strong motivation while they lasted (NL/UK)	After the subsidy period it was better to grow grain, because in the end it is about money—NL Farmer B
	We were growing it for the subsidy that was on it at the time—UK Farmer d
Regulations banning planting of GMO soy (NL)	Because we are not allowed to plant GMO here, it takes more time and effort in weed management compared to abroad—NL Farmer J
Regulations on pest and disease control limit access to subsidies (UK)	So, the political masters said: 'you take that away because we believe the NGOs are all good people and will stop you horrible farmers putting sprays on your pulses—UK Farmer d (sarcastically)
Theme 6: Avoiding threats from import competition in the feed market	
First order codes	Exemplary quotes
Low prices due to global competition (NL/UK)	Certainly in Western Europe, we are not going to be able to compete with the cost and production of soya that is coming in from the States and South America—UK Farmer d
	[Legumes] disappeared 20 years ago from the farm because they could get it cheaper from abroad. So there were no more buyers—NL Farmer D
Low demand due to lack of continuous supply (UK)	The truth is, the mills, […] they don't want 2 or 300 tonnes of beans, cause they can't just keep changing things over and over. […] It is easier for them to take soya—UK Farmer b
Market uncertainty (NL)	I don't want to be dependent on the whims of the world market—NL Farmer A
Value distribution along the chain (UK)	You sell to a middle [who] will use the excuse of logistics. This is me being a little bit cynical. There is a problem in the system, not the logistics. […] There is a big bit in the middle going missing—UK Farmer f
Theme 7: Creating opportunities for local cooperation in the feed market	
First order codes	Exemplary quotes
Protein crop for on-farm livestock (NL/UK)	[With the beans] we hence got a regular source of protein that we know. We haven't got to rely on the world market or what the price of soya is—UK Farmer c
Direct cooperation with livestock farmers (NL/UK)	[…] it is increasingly happening I think, where your arable producers have discussions with local livestock producers. To ask what feed they need, rather than the market for their crops being global, they are thinking more local—UK Expert i

Table 4 (continued)

First-order codes	Exemplary quotes
Create local brands (UK)	You don't have to compete with [imports]. If the public will pay the price for identity preserved, GMO free, European produced soya—UK Farmer d
	"[I]f consumers are saying, I want to know where my food is coming from, I want my food to help pollinators or I want my food to have a positive effect on the environment […] as a result that is […] what the farmer grows."—UK Farmer g
Theme 8: Creating economic advantages by integrating food/seed supply chains	
First-order codes	Exemplary quotes
Demand and good prices but with high standards (NL)	Vegetable crops, where quality is very important, a dry period can be a real problem—NL Farmer E
	Niche markets pay more but they also ask more of you—NL Farmer A
Low risk, labour input and investment, secure outlet (NL)	[With this contract] I have not invested anything besides my land lease, a bit of weeding and making a seedbed—NL Farmer A
Timely payments (NL)	As soon as the peas are gone, 6 weeks later I have my money, that is very fast— NL Farmer A
Geographic distance to buyers can be prohibitive (NL)	The buyers do not come here, it is too far away. I would like to grow products for the canned industry, but all buyers are located below the big rivers and the polder [region in NL]—NL Farmer C

and avoidance of risks related to agro-ecological and climate-related conditions (theme 4). This socio-ecological dimension captures the struggles to diversify in an uncertain environment, where a lack of socio-technical solutions is coupled with increased uncertainty due to climate change. The second set of themes associated with gain-oriented goals refers to costs and benefits derived from policy and regulatory instruments and support systems (theme 5). Finally, three sets of themes directly relate to market conditions, namely avoiding import competition in the feed market (theme 6), creating opportunities from local cooperation in the feed market (theme 7), and creating economic advantages by integrating into food/seed supply chains (theme 8). While legumes have the potential to add economic benefits by increasing soil fertility and reducing costs of fertilisation, they also come with what this frame recognises as the salient risk of not being easily and profitably marketable. Despite these conditions, farmers still saw opportunities to overcome these challenges using entrepreneurial logics specific to their local circumstance. For instance, in more isolated Cornwall, where almost all grown legumes enter the feed market, farmers were inclined to cooperate directly with local livestock farmers. In Gelderland, instead, increased integration into food supply chains, along with the associated support measures, was perceived as a prospective solution.

The last set of themes relates to hedonic goals. Farmers demonstrated a direct association between their sense of well-being and the adoption of legumes. A more diversified farm was, at times, associated with a change in lifestyle perceived either as a discomfort (theme 9), or with the joy of experimentation, the excitement it brings, as well as the aesthetic value of a diversified farm landscape (theme 10). Table 5 provides the overview of hedonic goals.

Situating goal frames and cognitive lock-ins

We used secondary data to triangulate our primary findings, identifying systemic and contextual factors in each institutional setting relevant to each goal type. We then identified where misalignments between salient goal frames and the institutional context were consistent with the production of cognitive lock-in.

Overall, normative goals seem to align with expressed collective goals in the institutional context, as indicated in policy documents for both regions, the national and European context. However, the exception is the preservation of traditions which aligns, rather, with historical prioritisation of food security as a collective goal, resulting in policies focussed on industrialised production of cereals, which marginalised legumes (Magrini et al. 2016; Zander et al. 2016). While policies change, individuals' perceptions and practices may do so more slowly, leading to a *'historic misalignment trap'* in which current and historically rooted normative goals are in conflict. For gain-oriented goals, the institutional context does not appear to be aligned with the adoption of legumes. Farmers reported underinvestment in seed development, resulting in a lack of locally adapted varieties. This, in turn, produced low demand for seeds, justifying continued underinvestment. Despite policy makers' expressed support for local protein production, their policies support imports. As for entrepreneurial solutions, partially adequate institutional support was reported in the form of

Table 5 Hedonic goals—overview of emerging themes

First-order codes	Exemplary quotes
Theme 9: Dealing with the struggles of changing lifestyles	
Change/taking risks is uncomfortable (NL/UK)	I like a simple life, I like to be able to block crop things […] [Growing beans], it's making life difficult. It's making life hard work."—UK Farmer d
	Technically I would participate in such trials […] but on the other hand it costs a whole lot of effort. […] Not much is known, it is like pioneering—NL Farmer J
Theme 10: Enjoying experimentation	
First-order codes	Exemplary quotes
Joy of experimentation (NL)	It was a nice crop, a different crop, simply less boring—UK Farmer B
	I always particularly enjoy trying new things, even if it just brings the same money—NL Farmer H
Beauty of crop and its attraction to insects (NL)	Just the joy to look at it, walking through the field, the humming of all the insects—NL Farmer A

labelling options and changes in consumer demand. In the end, these *misaligned incentives* reinforce gain goals that discourage adoption. For hedonic goals, there appears to be a lack of risk management instruments to overcome the *discomfort of change* and enable the desired level of experimentation for the given circumstances. While this discomfort persists, adoption is not attractive. However, hedonic goals were not particularly prominent in farmers' deliberations in interviews so they may be less relevant in decision-making. An overview of the identified lock-ins per goal type and the associated conditions in the institutional context is given in Table 6.

Discussion

In this section, we reflect on the potential role of cognitive lock-ins in sustainability transitions. While previous work has established the role of lock-ins generally (Geels 2019; Magrini et al. 2016), results of our study show the relevance of cognitive lock-ins, specifically, for our understanding of sustainability transitions. By integrating GFT to conceptualise cognitive lock-ins as an interplay between individual-level behaviours and contextual factors, particularly societal norms, regulations, policies and standards, we have been able to identify key relations between cognitive lock-ins and transition pathways. First, confirming existing findings, dominant gain-oriented pathways appear to hamper transition opportunities, keeping farmers in what we defined as the 'incentive misalignment trap' (see Table 6 above). While normative goals, related to environmental protection, and hedonic ones, related to enjoying experimentation, are favouring transitions, they are outmatched by goals formed in the gain frame, which seems to be embedded in and re-enforced by current institutional conditions. As indicated, crop rotation with legumes is known to enhance soil health, increase fertility, and reduce crop losses from pests and diseases, and thus may actually reduce long-term costs. Paradoxically, the dominance of a gain-oriented goal frame, in combination with adoption of legumes being associated with normative background goals, may in fact impede farmers' recognition of crop diversification practices as a potential financial gain. Figure 3 shows this cognitive lock-in, reinforcing the dominant gain frame and reproducing current practices. This implies that if we fail to recognise the dynamic of this cognitive lock-in, possible efforts to only target normative frames to encourage legume adoption, e.g. by emphasising positive environmental effects without further changes, is unlikely to have an effect, and may even further entrench the incentive misalignment trap.

Our analysis also identified two alternative mechanisms for inducing transition using the concept of cognitive lock-ins. For instance, a re-alignment of financial incentives with adoption of legumes, through a reintroduction of subsidies, may compensate for low prices or the extra effort required for finding suitable outlets. Historically, subsidies were found to shift practice indicating improved alignment of gain, normative (and hedonic) goals. However, the framework also explains why subsidies only work while in place: their use triggers and strengthens the gain-oriented goal frame, as illustrated in Fig. 4, and they do little to address the underlying relations of power that delimit farmers' options (Morel et al. 2020). Our results on farmers' responses to subsidies and their current experimentation with other crops are consistent with that of flexible optimisation: they grow what makes financial sense, with a bias in favour of normative and hedonic goals as long as impacts on gain goals are negligible. Still, analysing the dynamics of cognitive lock-ins indicates that, by buying into the immediate response of farmers to non-sustainable financial incentives, policy makers may reinforce the short-term gain goal frame whose priority suppresses the relevance of the normative goals needed for long-term adoption without subsidies. This could actually hamper long-term sustainability transitions.

Table 6 Types of goals and related lock-ins

	Systemic or contextual conditions	Exemplary secondary data support
Normative goals: historic misalignment trap	Normative goals align with public recognition of soil health and environmental issues, as well as support for local economy Misalignment on preserving traditions: goals align with historic focus on mass production for food security, not the current promotion of sustainable production	*Dutch national protein strategy is motivated by both environmental reasons, as well as to support the local economy and to move away from legume imports (*Schouten 2020) *The Cornwall Council (2019) acknowledges the region's issues with soil management and carbon emissions* *There is an overall European push to tackle the plant protein deficiency in European agriculture (*European Commission 2018; Häusling 2011) *Historic prioritisation of cereals in EU policies lead to the marginalisation of legumes (*Magrini et al. 2016; Zander et al. 2016)
Gain-oriented goals: incentive misalignment trap	Incentives reinforce misaligned gain goals Underinvestment in local breeding programmes leads to low adoption which leads to underinvestment Lack of (previously effective) subsidies, subsidies strengthen gain goals Unfavourable import policies Possibility to label local production at EU level, but lack of collective action for implementation in Cornwall Consumer demand is changing in the Netherlands but as of yet insufficient	*History of low investment into research on seed varieties at EU level (*Magrini et al. 2016). *Available varieties were not sufficiently adapted to the Dutch cold (*Nederlandse Akkerbouw Vakbond 2019; Prins et al. 2018) *Adoption rates were substantially higher during periods of subsidies (*Voskuilen 2020; Watson et al. 2017) *International trade agreements set by the EU (e.g. the GATT and the Blair House Agreement), allow the import of protein crops on a duty-free basis (*Häusling 2011) *Added value for local production is supported through labelling options (*European Commission 2021a), *but local cooperation in Cornwall is still lacking and not actively encouraged (expert interviews)* *Consumer demand for plant proteins and meat replacements on the rise in the Netherlands (*Aiking and Boer 2020; Tziva et al. 2020), *protein production in Cornwall is almost exclusively for the feed market (expert interviews)*
Hedonic goals: disregard of discomfort trap	Discomfort of behavioural change not recognised or compensated which leads to continued discomfort	*40% of English farmers indicated a lack of appropriate risk management tools (*DEFRA 2019) *More transparent legume markets are needed to develop risk management tools (*European Commission 2018)

Fig. 3 Cognitive lock-in on gain goals: the incentive misalignment trap, inspired by Geels (2020), Lindenberg (2017) and Steg et al. (2014)
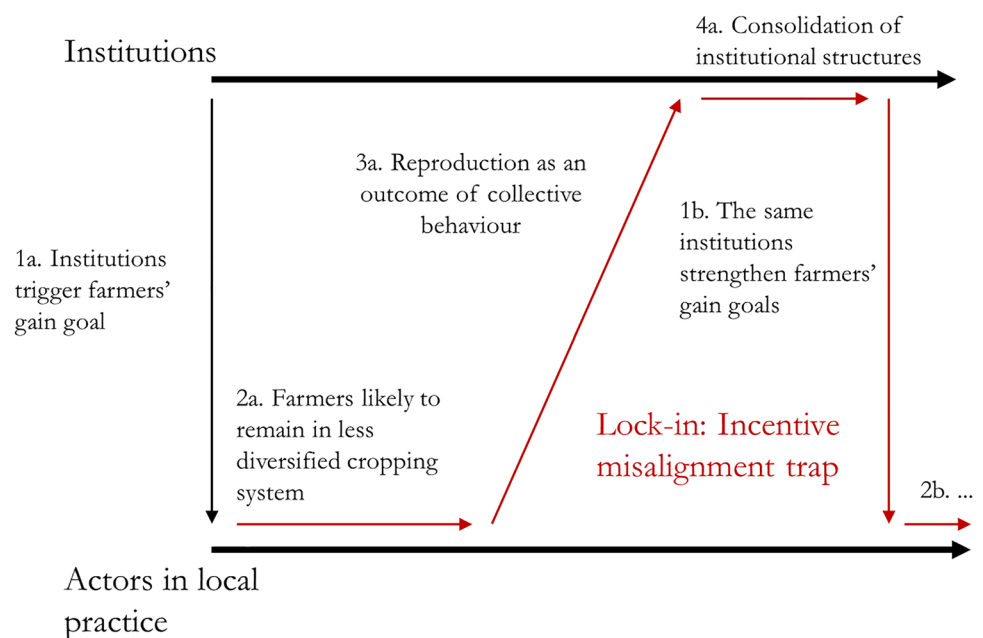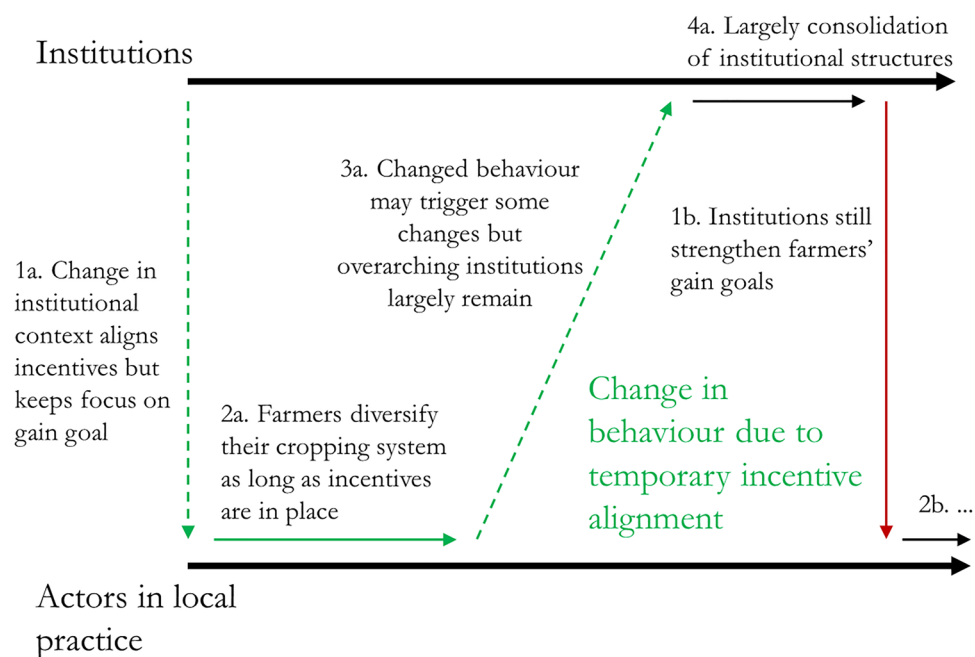
Fig. 4 Transition pathway on gain goals: incentive alignment, inspired by Geels (2020), Lindenberg (2017) and Steg et al. (2014)

Institutions

4a. Largely consolidation of institutional structures

3a. Changed behaviour may trigger some changes but overarching institutions largely remain

1b. Institutions still strengthen farmers' gain goals

1a. Change in institutional context aligns incentives but keeps focus on gain goal

Change in behaviour due to temporary incentive alignment

2a. Farmers diversify their cropping system as long as incentives are in place

2b. …

Actors in local practice

The naturalisation of gain motivations and the 'crowding out' of normative motivations has been discussed in relation to several environmental behaviours such as energy conservation and deposit refunds for reusable packaging (Baum and Gross 2017).

In the absence of a permanent shift of financial incentives, a long-term, lasting adoption of legumes without continued financial support would need a shift away from the gain-oriented goal frame towards a normative goal frame. Clear societal recognition of ecological values, in this case for legumes, and related shifts in markets and consumers preferences may be essential to increase the salience of normative goal frames in farmers' decision-making. In certain innovation niches pushing for change, these alternative goals are usually the guiding ones (Feola 2020; Koretskaya and Feola 2020). Such broader considerations of normative goals would also support the quest for soil health and soil life, as Krzywoszynska (2019) discusses for English farming. Baum and Gross (2017) also point to the importance of maintaining normative motivations in policy making, e.g. by reminding actors of past environmental behaviour and strengthening self-identification as environmentally motivated, as essential to trigger sustained changes in behaviour. While not as prominent in our study, emphasising hedonic goals and reducing emphasis on economic ones could also be an additional strategy to foster adoption by farmers, as suggested by Walder et al. (2019).

Placing normative values at the centre has been argued to be a necessary condition for fundamental sustainability transitions (Nightingale et al. 2020). Yet, as we have illustrated

using cognitive lock-ins, if the starting point is the incentive misalignment trap, only focussing on the normative frame will likely be ineffective. To counter this, Steg et al. (2014) suggest explicitly linking financial interventions, such as subsidies, to normative goals, e.g. by stressing their environmental benefits, in order to trigger a frame displacement. Such an approach would target other goal frames supporting the adoption of legumes, as well as making their adoption painless for farmers' gain goals. If a frame displacement takes place for a sufficient share of actors, and thus changes what most actors consider pertinent to their decision-making, it may even shift some of the relevant power relations and allow for a transformation of the institutional setting. As illustrated in Fig. 5, it could turn a vicious cycle into a virtuous one. Thus, while our findings support previous calls for public investments, for example in legume research or subsidies (e.g. Magrini et al. 2016; Zander et al. 2016), they also point to the need for a further consideration of individuals' goal frames and decision-making which was revealed by the cognitive lock-in analysis.

Farmers' decision-making on adopting practices, and thus supporting sustainability transitions, is known to be driven by a variety of factors and motivations (Brown et al. 2021; Dessart et al. 2019; Jones-Garcia and Krishna 2021), and scholars have come to recognise the complexity of farmers' motivations (e.g. Marr and Howley 2019). Thus, cognitive processes do not singularly determine the outcome of farmers' decision-making. Nonetheless, the study of cognitive lock-ins adds to our understanding of sustainability transitions and enables us to more carefully consider the
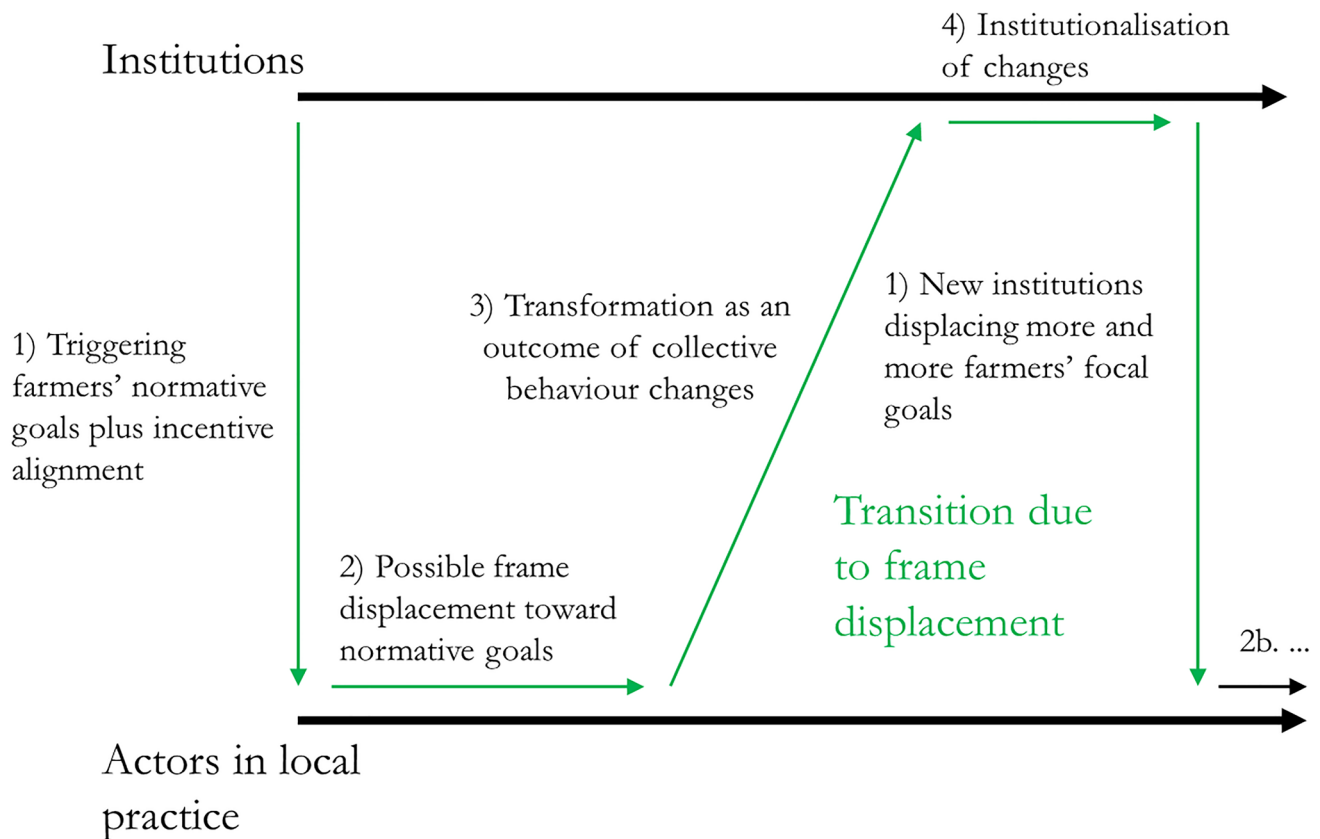
Fig. 5 Transition pathway on normative and gain goals, inspired by Geels (2020), Lindenberg (2017) and Steg et al. (2014)

role of individuals in transition processes. Further, it is widely recognised that lock-ins can be multi-dimensional and interrelated (e.g. Kuokkanen et al. 2018; Meynard et al. 2018; Voisin et al. 2014). We must thus assume that, while the relative salience of different lock-in mechanisms may be context-specific, cognitive lock-ins likely play a role in maintaining the status quo.

Conclusions

The approach presented in this study starts from the well-accepted position that farmers' decisions are driven by a wide range of factors (e.g. Bartkowski and Bartke 2018; Dessart et al. 2019; Sok et al. 2021). Using GFT permitted us to find that these different drivers and motivations can interact to create cognitive lock-ins that reproduce the status quo. Recognition of this complexity is necessary for understanding farmers' behaviour (Baum and Gross 2017; Baur 2020), and thus sustainability transitions in agriculture. Broader approaches to the study of decision-making that go beyond simple economic incentives have already been strongly recommended (Bartkowski and Bartke 2018; Baum

and Gross 2017; Brown et al. 2021). More generally, this study supports the advice that policies' interactions with farmers' goals need to be taken into account when designing interventions, to maintain internal drivers that support desirables behaviours (Baum and Gross 2017; Brown et al. 2021). The analysis of cognitive lock-ins can be instrumental in such an approach as it allows for the recognition of local specificities and may avoid some of the de-contextualisation of farmers' decisions that has been cautioned in studies on practice adoption (Jones-Garcia and Krishna 2021). This local contextualisation is particularly important as separate policies with singular objectives in the same locale can trigger different, competing goals in the same decision-making process, despite the best intentions of farmers and policymakers (Baur 2020).

In our empirical context, we found that gain-oriented goal frames seem to be dominant in farmers' reported decision-making. Rooted in the institutional context, the 'incentive misalignment trap' seems to be taken for granted by farmers so, when they exercise the agency so often celebrated in studies of innovation, they turn to local solutions. While legumes are desirable for hedonic and normative reasons, those goal-frames are easily

overwhelmed by the perceived risks and lack of profitability found in the gain frame. Similarly, Suvanto et al. (2020) claim that, even if profitable, the riskiness of legumes and similar crops may entice only the most entrepreneurial farmers which is not enough to precipitate the broad uptake that is needed. Institutions aiming to alter practice by reinforcing a gain frame through subsidies may fail to directly produce the sustained changes required. Subsidies may need to be accompanied by normative framings, investments in research on seed development, financial instruments to mitigate risks and the creation of markets in which less subsidised European legumes can actually compete.

Looking ahead, scholars have previously assigned different (salient) goals to different groups of farmers (e.g. Reimer et al. 2012; Thompson et al. 2015). It is thus advisable to investigate whether different cognitive lock-in mechanisms emerge in different categories of farmers, as well as in other agri-food actors more generally. It would, then, be reasonable to conduct studies that attempt to understand the variables relevant to trade-offs between normative and gain goals over short and long-term timeframes, as well as the specific role of power relations within and beyond these trade-offs. Further, while the limited reported salience of hedonic goals

may not be surprising, given that the decision to adopt sustainable practices is usually presented as a business decision (Dessart et al. 2019), future applications may want to look at the interactions of institutions with hedonic goals more intensively as hedonic goals may be both more tacit and less easily articulated. Finally, the farmers we interviewed knew the benefits of legumes. Their demonstrated knowledge is not compatible with the knowledge deficit often cited as a barrier to adoption (e.g. Meynard et al. 2018; Zimmer et al. 2016). Further studies should, therefore, test such broadly held assumptions.

Appendix

Farmer overview

The table below provides an overview of the rotation farmers reported for their most important plot, as described in the interview guide. Other crops may have been present on other plots.

See Table 7.

Table 7 Overview of interviewed farmers

Farmer	Farm size	Experience with legumes	Current rotation	Arable vs. mixed
Gelderland, Netherlands				
A	35 ha	Yes	Grass clover, spelled, field bean, partially peas and partially green beans, grass seed	Mixed (organic)
B	118 ha	No	Sugar beet, wheat, potato, corn	Arable
C	150 ha	Yes	Sugar beet, wheat, winter rapeseed, wheat	Arable
D	200 ha	Yes	Wheat, sugar beet, onion, potato (consumption)	Arable
E	90 ha	No	Corn, barley, potato (starch), sugar beet	Arable
F	120 ha	Yes	Onion, potato (starch), winter wheat, corn, sugar beet	Arable
G	70 ha	No	Sugar beet, corn, potato (experiment), corn	Arable
H	200 ha	No	Lily, gladiolus, potato (consumption), grassland (for 5 years)	Mixed
I	35 ha	Yes	Summer grain (wheat–barley), potato (starch), corn, sugar beet	Arable
J	75 ha	No	Potato (consumption), sugar beet, corn/barley	Arable
Cornwall, UK				
a	Not given	Yes	Barley, beans, forage maize, oats, wheat, oil seed rape, cover crop	Arable
b	560 ha	Yes	Barley, beans, forage maize, oats, wheat, oil seed rape, grass, stubble turnips	Mixed
c	113 ha	Yes	Barley, forage maize, oats, oil seed rape, wheat	Mixed
d	200 ha	No	Barley, oats, oil seed rape, wheat	Mixed
e	200 ha	Yes	Barley, forage maize, oats, cabbages, potatoes	Mixed
f	400 ha	No	Barley, wheat, potatoes, daffodils, Spanish bluebells	Arable
g	53 ha	No	Hemp, borage, calendula, sunflower, roses	Arable

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