

Appendix 3

ADDITIONAL INFORMATION ON DEFINITIONS OF SUPPORTING AND INHIBITING FACTORS

1. Supporting factors (opportunities arising from landscape changes or niche developments)

- a. Cultural preference for autonomy:** As a potentially self-sufficient livelihood, farming has long been driven by a desire to pursue an independent lifestyle, free from dependence on markets and governments (Ploeg, 2010). Traditional-ICLS practices enable this self-sufficiency and autonomy by producing all of the necessary inputs to production, as well as a diversity of food sources. While landscape changes and agricultural regime shifts have generally reduced the autonomy of individual farms, certain communities, have withstood pressures to change their systems to prioritize their autonomy due to cultural, religious, and political reasons.
- b. Targeted by climate or pollution mitigation policy:** Policies that create taxes or fines for carbon, nitrogen, or phosphorus emissions or soil erosion force farmers to internalize the costs of pollution and land degradation to society, incentivizing more environmentally responsible production (Zilberman et al., 1999). Since ICLS tend to promote soil conservation and reduce the carbon and nutrient emissions associated with agricultural production (Balbino et al., 2012; Lemaire and Franzluebbers, 2013), the introduction of taxes or fines on greenhouse gas and nitrate pollution should encourage their adoption vis-à-vis both continuous cropping and animal confinement systems. Conversely, any public policy that pays farmers for the environmental services provided by their farm will have a similar impact on ICLS adoption, albeit by shifting the burden of payment to taxpayers rather than farmers.
- c. Highly variable topography, climate, or soil:** Soil and water constraints can limit crop and forage production. This works to incentivize ICLS from two directions: livestock farmers seek out additional grazing areas (e.g., on neighboring farms) to supplement their livestock (i.e., rows between grape vines, stubble of cover and forage crops), while would-be crop farmers raise livestock in areas with topographical and soil features that are not suitable for cropping (Lacoste et al., 2018).
- d. Creation of agricultural research and development programs focused on sustainability and climate adaptation:** Federally supported research and extension directly focused on ICLS can help incentivize the adoption of these management systems (FAO, 2010). Long term agronomic and animal health research can help improve the production, animal welfare, and environmental outcomes of these systems (FAO, 2010), while economic research can help identify which systems are most efficient.
- e. Industry and civil society initiatives promoting ICLS:** ICLS is often implicitly promoted by permaculture, organic, and biodynamic civil society networks (Allen et al., 2005; Cunfer, 2004; Faust et al., 2017; Lovell et al., 2010). An additional stimulus for new-ICLS adoption comes from the rise of peasant movements calling for self-sufficiency and autonomy in reaction to globalization, such as *La Via Campesina* and *Fédération Associative pour le Développement de l'Emploi Agricole et Rural* (FEDEAR) (Dumont et al., 2016). In seeking self-sufficiency for cost-savings and autonomy, these social movements often promote more holistic and agro-ecological farm-management approaches that reduce reliance on external inputs, including types of new-ICLS (Bonaudo et al., 2014; Dumont et al., 2016).

- f. Differentiated value chains and eco- or social labels:** The possibility to market ICLS products as “local” and “green”, leading to the creation of a differentiated market in crop and livestock value chains could help incentivize adoption in regions where consumers already have strong environment or local food preferences.
- 2. Inhibiting factors (barriers arising from the agricultural regime or a lack of niche developments needed to push changes)**
- a. Lack of supply chain infrastructure or marketing opportunities:** ICLS require a diverse union of supply chain infrastructure that enable access to markets for multiple products (Gil et al., 2016). In some agricultural regions, where economies of scale have favored the specialization of agribusiness around a single product, there may be limited supply chain infrastructure or marketing channels for diverse products (Garrett et al., 2013a, 2013b).
- b. High labor prices:** Livestock production tends to be more labor intensive than cropping (at least specialized, mechanized cropping) and most forms of crop-livestock integration require greater management attention (Bell and Moore, 2012).
- c. Low prices of synthetic inputs and fuel or feed:** The lower the prices for synthetic inputs and fuel or feed, the fewer incentives farmers have to produce these products on their own farm via ICLS (Garrett et al., 2017b).
- d. Protectionist policies (e.g., insurance, subsidies):** As a more diversified form of production vis-à-vis continuous crop monocultures or single animal systems, ICLS can be an important mechanism for reducing farmers’ risk (Bowman and Zilberman, 2011; O’Donoghue et al., 2009). Therefore, policies that protect policies via price subsidies, minimum price floors, or subsidized insurance on margin or production losses will also reduce incentives for ICLS and encourage specialization.
- e. Food safety regulations restricting integration:** Policies that create restrictions and fines regarding the presence of animals or animal excrement in cropland areas will disincentivize many forms of ICLS (Garrett et al., 2017b). The impact of these food safety restrictions will depend on the types of crops they apply to (typically non-food crops and crops that are processed or intended for home consumption are excluded) and the minimum exclusion time between animal grazing or manure application and planting.
- f. Lack of ICLS farm trials/demonstration:** Demonstration farms, farm trials, and extension programs can help spread information about the potential benefits of ICLS and technical details about how to operate such systems (Gil et al., 2016). In regions where these don’t exist farmers may not have sufficient information about how to adopt ICLS.
- g. Lack of farmer networks to share knowledge on ICLS:** Farmers’ networks have proved to be influential on perceptions of specific technologies (Lubell et al., 2014; Prokopy et al., 2008). Creation of multi-actor and cross-sectoral groups can be a further step in supporting ICLS (Pigford et al., 2018), especially when these groups are supported by participatory scenario building (Ryschawy et al., 2017).

ADDITIONAL INFORMATION ON RANKINGS OF SUPPORTING AND INHIBITING FACTORS

We used a combination of our expert knowledge and additional literature review of each case to develop the qualitative rankings that are presented below (and summarized in Table 1).

1. Traditional-ICLS persistence

a. Amish farms in United States

Supporting factor - Cultural preference for autonomy - Very high

Supporting factor - Industry or civil society networks promoting ICLS - High

Inhibiting factor - Lack of ICLS farm trials/demonstration - Low

Inhibiting factor - Lack of farmers' knowledge networks on ICLS - Low

The religious/cultural beliefs of Amish farming groups include controls on new technologies that would threaten their Christian values (Brock and Barham, 2015). For some orders this includes an avoidance of modern technology (e.g., synthetic inputs, heavy machinery) and a refusal of government assistance, such as subsidized insurance (Stinner et al., 1989). Amish tradition encourages “The purposeful stability of cultural practices and ideas with controlled introductions of new forms,” (Parker, 2013). These traditions helped lock-in traditional-ICLS as a preferred model of farming. Given that most Old Order Amish farmers are surrounded by other farmers pursuing the same practices, there is no shortage of successful demonstration farms.

Supporting factor - Targeted by climate or pollution mitigation policy - Low

Supporting factor - Creation of agricultural R&D programs focused on sustainability and climate adaptation - Low

Inhibiting factor - Low prices of synthetic inputs and fuel - Low

Inhibiting factor - Protectionist policies (e.g., insurance, subsidies) - Low

Old Order Amish farmers tend to be influenced more by tradition and their cultural model of good stewardship, rather than external policies and research or market prices (Parker, 2013). The emphasis on autonomy and control over ideas is associated with a rejection of government interference/support. Since religious views explicitly prohibit the use of synthetic inputs, the overall low prices of these inputs in the US would not play a large role in the broader choice to pursue ICLS.

Inhibiting factor - Food safety regulations restricting integration - Moderate

The Food Safety Modernization Act of 2011 provides standards for the safe production and harvesting of food crops. This Act has the potential to impact certain forms of ICLS adoption through rules limiting the presence of animals and use of animal excrement on cropland. While these regulations provide potential benefits for public health, they could discourage the integration of animals into cropping systems. Yet, foods destined for home consumption and foods that will be processed before consumption are exempt from the policy. This limits their impact on Amish farming systems.

Supporting factor - Highly variable topography, climate, or soil - Moderate

Ohio has the largest Amish settlement in the world and a majority of this group reside in Sugar Creek, Ohio (Parker et al., 2009). This region is characterized by a high degree of variability in topography, geology and soil, and ecosystems. Yet, this variability is not necessarily high within individual farms, and given the cultural considerations above, not the major driver of ICLS persistence.

Supporting factor - Differentiated value chains and eco- or social labels - Moderate

Inhibiting factor - Lack of supply chain infrastructure or marketing opportunities - Moderate

Amish farmers have found a strong and stable niche in marketing their products via organic dairies, either via cooperatives or directly trading to individual cheese brands (Brock and Barham, 2015).

High cost of labor - Low

Traditional Old Order Amish discontinue education after primary school as labor is directed at the farming unit. Furthermore, labor is fairly abundant (Parker et al., 2009) - population growth in Amish communities has led to high increased migration out of existing regions.

b. Family farms (smallholders*) in Brazil

*In Brazil family farms are defined as farms under a certain size that primarily rely on household labor.

Supporting factor - Cultural preference for autonomy - Moderate

Generally speaking, small “peasant” farmers are thought to have a high preference for autonomy (Ploeg, 2010). Yet smallholder autonomy in Brazil has also developed out of a “lack of options”. That is farmers cannot necessarily rely on the government for support and have to be self-sufficient.

Supporting factor - Targeted by climate or pollution mitigation policy - Moderate

Brazil implemented many aggressive climate change policies in Brazil during the 2000s (see “Pastures and Croplands in Brazil”). However, in practice, family farmers are much less targeted by these policies than large farmers.

Supporting factor - Highly variable topography, climate, or soil - Moderate

Even small farms in Brazil can be fairly large (depending on the region), so there can be large variety of soil types within a single geography. However, outside of the mountainous regions in Minas Gerais there is not normally substantial variation in topography within single farms.

Supporting factor - Creation of agricultural R&D programs focused on sustainability and climate adaptation - Low

Supporting factor - Industry or civil society networks promoting ICLS - Low

Inhibiting factor - Lack of ICLS farm trials/demonstration - Moderate

Inhibiting factor - Lack of farmers' knowledge networks on ICLS - Low

Despite large R&D efforts for new-ICLS adoption in Brazil, including cooperation with agribusinesses to support new-ICLS technologies (see “Pastures and Croplands in Brazil”), federal research and extension programs often fail to reach small and medium farmers (Cortner et al., 2019). Additionally smallholders are not likely to interact with major agribusinesses (Garrett et al., 2017a). Nevertheless, traditional forms of ICLS have persisted and are socially embedded, so there is general community knowledge about how to pursue these types of systems.

Supporting factor - Differentiated value chains and eco- or social labels - Low

Inhibiting factor - Lack of supply chain infrastructure or marketing opportunities - High

Inhibiting factor - Low prices of synthetic inputs and fuel - Low

Many agricultural regions have limited agribusiness infrastructure (Garrett et al., 2013b), which constrain farmers' ability to adopt newer forms of ICLS (Gil et al., 2016). Because of these infrastructure limitations, the prices of synthetic inputs are higher in more remote regions where smallholders typically reside. Additionally, these inputs tend to be financially out of reach for smallholders who have little cash or credit available. There are very few channels for marketing higher value crops or niche products that could support smallholders in leveraging their traditional-ICLS systems toward differentiated value chains (Garrett et al., 2017a).

Inhibiting factor - High cost of labor - Low

As mentioned above, in Brazil family farms are defined as farms under a certain size that primarily household labor. Thus, relative to their size, labor tends to be abundant and low cost (since off-farm job opportunities are low) (Garrett et al., 2017a).

Inhibiting factor - Protectionist policies (e.g., insurance, subsidies) - Low

Family farmers are required to purchase coverage through the Insurance for Family Farmers (SEAF) program when they access subsidized loans through the Program for Strengthening Family Agriculture. However, currently this program reaches less than 1% of farmers (Canal do Produtor, 2012; IBGE, 2006).

Inhibiting factor - Food safety regulations restricting integration - Low

Food safety laws in Brazil are geared toward processing facilities and complying with the sanitary and phytosanitary regulations of importing countries (Salay and Caswell, 1998). Brazil does not have restrictions on the use of animal grazing or manure in food crop areas (Garrett et al., 2017b).

2. New-ICLS reemergence

a. Pastures and croplands in Brazil

Supporting factor - Cultural preference for autonomy - Moderate

Farmers in Brazil tend to be open to government support in the sense that they receive substantial subsidies via low interest loans and are willing to engage in complex agribusiness markets (Garrett et al., 2013b). However, many farmers are averse to government interventions that constrain their behaviors or encourage them to adopt more pro-environmental behaviors (Cortner et al., 2019).

Supporting factor - Targeted by climate or pollution mitigation policy - High

In Brazil, new-ICLS is being promoted by the government's Low Carbon Agriculture (ABC) Plan and increasing restrictions on native vegetation clearing that are linked to Brazil's broader international commitment to reduce national greenhouse gas emissions (Gil et al., 2016). The ABC program provides subsidized loans for adoption of integrated systems to combat soil degradation and recuperate pastures through the introduction of crop species, thereby shortening the cattle life cycle and reducing emissions per unit of food produced (Observatorio ABC, 2016). Restrictions on forest clearing have incentivized the adoption of ICLS to increase productivity on the existing land area (Cortner et al., 2019; Garrett et al., 2018).

Supporting factor - Highly variable topography, climate, or soil - Moderate

There is a large variety of soil types within a single farm. However, outside of the mountainous regions in Brazil there is not substantial variation in topography in the major agricultural regions.

Supporting factor - Creation of agricultural R&D programs focused on sustainability and climate adaptation - High

Supporting factor - Industry or civil society networks promoting ICLS - Moderate

Inhibiting factor - Lack of ICLS farm trials/demonstration - Moderate

Inhibiting factor - Lack of farmers' knowledge networks on ICLS - Moderate

Since the 1980s, the Brazilian Agricultural Research Corporation (Embrapa) has been doing research on ICLS in beef cattle systems as a mechanism to restore degraded pastures. In the early 1990s, six existing Embrapa state research units in the North region were transformed in Agroforestry Research Centers. This restructuring process strengthened R&D on agroforestry and integrated crop, livestock, and forestry systems in deforested areas (Flores, 1991). Federal research on ICLS increased substantially during the 2000s and resulted in the development of ICLS farm trials and demonstration site (Embrapa, 2016). Recent research has shown that ICLS adoption is significantly higher near these

sites (Gil et al., 2016). These efforts have included cooperation with agribusinesses to support new-ICLS technologies (i.e., the “Rede-ILPF” [ICLS-Network], <https://www.embrapa.br/web/rede-ilpf/rede-ilpf>). Yet, the engagement of retailers is only starting and few farmer associations have ICLS on their agenda. In a study of ICLS adopters and non-adopters the Brazilian Amazon, most adopters had high awareness of the technical aspects and benefits of ICLS, and were well connected to social groups supporting these systems. Yet, non-adopters were less well connected and cited a lack of information as one barrier to adoption (Cortner et al., 2019).

Inhibiting factor - Lack of supply chain infrastructure or marketing opportunities - High
Inhibiting factor - Low prices of synthetic inputs and fuel - Moderate

Many agricultural regions have limited agribusiness infrastructure (Garrett et al., 2013b), which constrains farmers’ ability to adopt newer forms of ICLS (Gil et al., 2016). Because of these infrastructure limitations, the prices of synthetic inputs in Brazil are higher in more remote regions.

Supporting factor - Differentiated value chains and eco- or social labels - Low

There are very few channels for marketing higher value crops or niche products (Garrett et al., 2017a). One exception is the higher meat grading for cattle that have higher fat content, which can be linked to ICLS (Cortner et al., 2019).

Inhibiting factor - High cost of labor - Moderate

While wages are not as high as developed countries, they are increasing and labor trained to work with machinery or advanced livestock management tends to be scarce. Farmers’ perceive skilled labor scarcity as a major barrier to adopting ICLS (Cortner et al., 2019).

Inhibiting factor - Protectionist policies (e.g., insurance, subsidies) - Low

In 2011, all public and private mechanisms for mitigating risks in agriculture were accessed by 1.55 million farmers, covering 18% of the agricultural area in Brazil (MBAgro, 2012).

Inhibiting factor - Food safety regulations restricting integration - Low

Food safety laws in Brazil are geared toward processing facilities and complying with the sanitary and phytosanitary regulations of importing countries (Salay and Caswell, 1998). Brazil does not have restrictions on the use of animal grazing or manure in food crop areas (Garrett et al., 2017b).

b. Non-Pastoral areas in Australia

Supporting factor - Cultural preference for autonomy - High

The concept of autonomy is more commonly expressed as “self-reliance” in the Australian literature and is highly valued as an objective of farming (Waters et al., 2009). Indeed, much of the agricultural policy is built around the concept of farmer self-reliance - that is, policy interventions should not create dependency, but rather leave farmers in charge of their own destiny (Kiem, 2013).

Supporting factor - Targeted by climate or pollution mitigation policy - Moderate

In 2011 Australia passed the Carbon Credits Act (C2017C00076). This policy provides carbon credits to farmers and land managers through eligible carbon abatement activities which store or reduce greenhouse gas (GHG) emissions on land. This could include ICLS practices.

Supporting factor - Highly variable topography, climate, or soil - High

In Australia farms are very large. Landscape heterogeneity has been a major impetus for adoption of new-ICLS (Bell and Moore, 2012), leading to the incorporation of livestock areas to take advantage of topographical and soil features that are not suitable for cropping (Lacoste et al., 2018).

Supporting factor - Creation of agricultural R&D programs focused on sustainability and climate adaptation - High

Supporting factor - Industry or civil society networks promoting ICLS - Moderate

Inhibiting factor - Lack of ICLS farm trials/demonstration - Moderate

Inhibiting factor - Lack of farmers’ knowledge networks on ICLS - Moderate

The Grain and Graze program aimed to increase integration of beef and sheep with crop production by improving the profits, reducing environmental impacts, and building social capital in ICLS via the adoption of best management practices (Price and Hacker, 2009). A major objective was to improve “whole-farm knowledge” and promote researcher-to-farmer knowledge networks via annual research and extension forums (Hacker et al., 2009). The program is credited with the adoption of new-ICLS practices by 3200 farmers over five years despite unfavorable climatic conditions (Price and Hacker, 2009). Nevertheless, knowledge gaps and extension remain an important challenge for scaling up ICLS (Price, 2009).

Supporting factor - Differentiated value chains and eco- or social labels - Low

The development of value chains for more sustainable food products has been slow to take off in Australia due to consumer skepticism (Bhaskaran et al., 2006). While international markets for sustainable product are growing, most of the beef exported from Australia is still sent to commodity markets that differentiate only on meat grade (Lawrence, 2002).

Inhibiting factor - Lack of supply chain infrastructure or marketing opportunities - Moderate

Most of the grains produced via ICLS are intended to overcome seasonal forage production shortfalls and are consumed locally rather than marketed (Hacker et al., 2009). Further development of cropping systems could be constrained by limited infrastructure.

Inhibiting factor - Low prices of synthetic inputs and fuel - High

Low and declining input prices have favored cropping over ICLS systems in Australia (Bell and Moore, 2012).

Inhibiting factor - High cost of labor - High

Studies of Australian farms have shown that labor costs for integrated systems are significantly higher than specialized cropping systems and a likely factor inhibiting adoption/encouraging retirement of new-ICLS (Bell and Moore, 2012).

Inhibiting factor - Protectionist policies (e.g., insurance, subsidies) - Low

Australia dismantled most supports for farmers in the 1970s. Most industries receive little assistance and it is mainly in the form of adjustment assistance, R&D support, drought relief and tax concessions (Productivity Commission, 2005).

Inhibiting factor - Food safety regulations restricting integration - Low

None of Australia's food safety policies prohibit the presence or use of animals or manure on cropland area.

c. Non-Pastoral areas in New Zealand

Supporting factor - Cultural preference for autonomy - High

In a 2002 survey 88% of New Zealand dairy farmers stated autonomy or "being one's own boss" was their primary motivation for farming (Pangborn, 2009). Additionally, the economic reforms in the 1970s have nearly completely deregulated farming, leaving them as economic entrepreneurs (Stock and Forney, 2014).

Supporting factor - Targeted by climate or pollution mitigation policy - Moderate

The Resource Management Act (RMA) of 1991 (Public law No 69) stipulates that the use of land must be consistent with "national environmental standards, regional rules, or district rules". The RMA and other environmental regulations are administered by Regional Councils, who are tasked with issuing permits for resource consents (activities that may influence environmental quality, including agriculture). The 2014 National Policy Statement for Freshwater Management reinforces the responsibilities of regional councils for dealing with these issues, clarifying their responsibility under the RMA for decision-making and management planning. The policy statement emphasizes responsible use of water resources with respect to climate change, prohibits the over-allocation of water, and charges Regional Councils with mitigating adverse effects. The most significant aspect of the regulation was to establish a minimal acceptable condition for freshwater across a variety of contaminant parameters. Regional Councils with particularly acute water quality issues have already or are currently implementing regional policies related to nitrogen management through cap and trade programs.

Supporting factor - Highly variable topography, climate, or soil - Moderate-High

Given the rolling topography of many of the agricultural regions, there is substantial variation in climate and soils in New Zealand farming systems. Soil and water constraints limit forage production, creating incentives for beef and sheep farmers to seek out additional grazing areas to supplement their livestock (i.e., rows between grape vines, stubble of cover and forage crops). In some regions, however, this variation serves as a barrier for ICLS because the soil type and water accessibility are insufficient for cropping systems (Garrett et al., 2017b; Minneé et al., 2009).

Supporting factor - Creation of agricultural R&D programs focused on sustainability and climate adaptation - Moderate

Supporting factor - Industry or civil society networks promoting ICLS - Moderate

Inhibiting factor - Lack of ICLS farm trials/demonstration - High

Inhibiting factor - Lack of farmers' knowledge networks on ICLS - Low

There is some focus within New Zealand Crown Research Institutes (CRIs), to conduct research on ICLS. Plant and Food work on integrating sheep into vineyards, while AgResearch works on crop, forage, pasture, and sheep/beef and dairy integration. The New Zealand Agriculture Greenhouse Gas Research Center pursues a research agenda of reducing greenhouse gas emissions across sectors by partnering with the industry group DairyNZ and the CRI AgResearch to conduct analysis of integrated systems (NZAGRC, 2016). The Sustainable Farming Fund invests up to \$8 million per year in research and extension programs led directly by farmers to fill gaps in industry-funded research by opening a grass-roots award mechanism focused on sustainability to farmers. Several of the funded projects in SFF's portfolio are explicitly directed toward integration (MPI, 2015). Despite all this funding there are still few ICLS specific farm trails.

Supporting factor - Differentiated value chains and eco- or social labels - Moderate

Inhibiting factor - Lack of supply chain infrastructure or marketing opportunities - Low

Due to the small size of New Zealand and the presence of both crop and livestock farming throughout all major production regions, supply chain infrastructure for marketing conventional ICLS products is not a major issue. However, given the small population size and large distance to international markets, reaching differentiated markets can be somewhat of a challenge. Still, grass-fed lamb labels and integrated sheep-viticulture systems have made their way onto labels and differentiated markets (Niles et al., 2018). More generally New Zealand has been working on branding its wine in terms of environmental sustainability.

Inhibiting factor - Low prices of synthetic inputs and fuel - Moderate

New Zealand has no tariff on fertilizer imports and a 5% tariff on imported animal feeds (New Zealand Ministry for Foreign Affairs and Trade (MFAT), 2012). However, five separate biosecurity acts and standards regulate the import of animal feeds, including the Import Health Standard, Animal Products Act (1999), Agricultural Compounds and Veterinary Medicines Act (2011), Biosecurity (Ruminant Protein) Regulations (1999), and the Biosecurity Act (1993). These acts make it relatively expensive to import feed or feed components (New Zealand Government, 2015). Fonterra, the largest dairy company in the world, and virtual monopoly in New Zealand, encouraged farmers to keep palm kernel rations (an imported feed source) at 3kg per animal per day in 2015 (Fonterra, 2015). Nevertheless, fertilizer and feed imports (particularly for dairy) are high in New Zealand and have continued to increase since policy reforms in the 1980s (MacLeod and Moller, 2006).

Inhibiting factor - High cost of labor - High

Labor is frequently mentioned as a limiting factor for New Zealand agriculture, as they rely heavily on seasonal migration for labor intensive agricultural industries. Labor savings are cited as one of the major benefits of adopting ICLS (Niles et al., 2018).

Inhibiting factor - Protectionist policies (e.g., insurance, subsidies) - Low

Farmers in New Zealand receive no support through minimum prices or direct payments (MacLeod and Moller, 2006) - all agricultural subsidies were removed in 1984. As a result, New Zealand has the lowest support for agriculture of any OECD country (producer supports are estimated at 0.7% of gross farm receipts) (Organisation for Economic Development (OECD), 2016). Crop insurance in New Zealand is voluntary and unsubsidized. These factors require farmers to manage their own risks, often by diversifying production (Evans et al., 1996).

Inhibiting factor - Food safety regulations restricting integration - Low

None of New Zealand's Food Safety acts prohibit the presence or use of animals or manure on cropland area (Ministry for Primary Industries, 2016).

d. Agroecological farms in France**Supporting factor - Cultural preference for autonomy - High**

Recent studies have highlighted the autonomy as a major motivation for ICLS in France, especially limiting reliance on external markets for crop inputs and livestock feed (Coquil et al., 2014; Ryschawy et al., 2013). This autonomy is not necessarily limited to the farm level, but also may be supported via territorial synergies, e.g. exchanges within groups of 10-15 neighboring farmers (Moraine et al., 2017; Ryschawy et al., 2017).

Supporting factor - Targeted by climate or pollution mitigation policy - High

ICLS and other forms of agro-ecological farming systems have been promoted via the Agro-ecological Plan launched in 2012 by the French Ministry of agriculture. A specific program called 4/1000 was implemented to encourage carbon storage in soils through agroecological practices (4/1000 pertains to a target of growing soil carbon by 0.4% per year). Self-sufficiency and in particular ICLS were particularly encouraged at farm or collective levels through this policy and through the European Commission. At the collective level, funding was given to groups of farmers engaged in agro-ecological activities, including territorial-ICLS (alim'agri, 2017)

Supporting factor - Highly variable topography, climate, or soil - Moderate

In France traditional-ICLS and new-ICLS tend to occur in less-favored areas where crops cannot be grown (e.g., steep slopes or wetlands), or where cropping is less profitable (Ryschawy et al., 2013; Schiere et al., 2002).

Supporting factor - Creation of agricultural R&D programs focused on sustainability and climate adaptation - Moderate

The European Commission has launched a European Innovation Partnership (EIP) Focus Group of experts to build state of the art ICLS (EIP-AGRI, 2017). Operational Groups have been funding field projects across Europe where research, advising, marketing and farmers are brought together to develop agro-ecological forms of ICLS and new skills for farmers (EIP-AGRI, 2017).

Supporting factor - Industry or civil society networks promoting ICLS - Low

Most industry marketing channels remain highly focused on either the crop or livestock sector independently (EIP-AGRI, 2017). Civil society is generally not informed of the challenges of ICLS and more concerned by animal welfare, quality labels or local food chains (Dumont et al., 2016).

Supporting factor - Differentiated value chains and eco- or social labels - Moderate

In specific areas, there are well-established quality-label products ensuring remuneration to farmers for products based on locally-sourced feeds, good image, and contributions to territorial vitality, but those are mostly linked to livestock products and not ICLS specifically (Beudou et al., 2017). The recent consumer interest in decreasing food waste could be seen as an opportunity for ICLS (Dumont et al., 2016).

Inhibiting factor - Lack of supply chain infrastructure or marketing opportunities - High

Agglomeration economies have favored the regional concentration of supply chain infrastructure for certain crops or livestock (Gaigne, 2012). In general, there is a lack of marketing options for livestock by-products (wool, manure, ...).

Inhibiting factor - Low prices of synthetic inputs and fuel - High

Inhibiting factor - High cost of labor - High

The labor supply available in agriculture across Europe has shrunk over recent decades and there has also been a loss of skills and motivation to manage both crops and livestock (Peyraud et al., 2014). In France, the large decrease of ICLS has been linked explicitly to the lack of workforce to manage both crop and livestock and the high cost of labor relative to input and fuel costs (Ryschawy et al., 2013; Veysset et al., 2005).

Inhibiting factor - Protectionist policies (e.g., insurance, subsidies) - High

Livestock has suffered from strong competition with crops as a result of protectionist policies. Since 1970 the 1st pillar of CAP has provided high subsidies for crops, which has led to a general process of specialization and modernization of local agriculture (Veysset et al., 2005).

Inhibiting factor - Food safety regulations restricting integration - Moderate

Food safety regulations are not limiting ICLS at the farm level directly, but they are limiting the recycling of waste between farms for animal feed or manure use (Dumont et al., 2018). Specific regulations around direct sales of products between farmers are limiting the development of ICLS beyond farm level in France (Ryschawy et al., 2018).

Inhibiting factor - Lack of ICLS farm trials/demonstration - High

Research and advising have been mostly focused on either crop or livestock management (EIP-AGRI, 2017). There are few examples of farm demonstrations for ICLS. At INRA (French National Institute for Research in Agronomy), only three demonstration farms are considering ICLS. In general, advising systems are implementing trials on specific crops and not considering the effects of crop-livestock integration.

Inhibiting factor - Lack of farmers' knowledge networks on ICLS - Moderate

A lack of farmers' skills to manage ICLS has been underlined by the EIP Focus Group around ICLS (EIP-AGRI, 2017). Still, some farmers' knowledge networks that were not focusing on ICLS are now considering these systems in their discussions, such as groups around conservation agriculture or livestock feed autonomy through pasture use

e. Carbon farming in the United States

Supporting factor - Cultural preference for autonomy - High

The value of autonomy in American agriculture is linked to Jeffersonian agrarian values and the concept "rugged individualism" (Sullivan et al., 1996). In a survey of both conventional and organic crop farmers in the US, independence was listed as the major benefit of being a farmer (whereas low financial return was listed as the biggest drawback) (Sullivan et al., 1996). Even in the hog industry, independence has been shown to be an important driver of behavior - farmers will avoid contractual arrangements that could reduce risk to maintain autonomy (Key, 2005).

Inhibiting factor - Protectionist policies (e.g., insurance, subsidies) - High

Farmers receive very high levels of support, though the type of support they receive has shifted substantially over time from price supports to income supports based on current production (after 1965), to income supports based on historical production (after 1990), to insurance for yield and revenue losses (after 2014) (Dimitri et al., 2005; Garrett et al., 2017b). Uptake of insurance programs is fairly widespread (Farrin et al., 2016; USDA, 2013). In areas where there are no available crop insurance options, the Noninsured Crop Assistance Program provides coverage for losses due to weather.

Supporting factor - Targeted by climate or pollution mitigation policy - Moderate

The Clean Water Act aims to mitigate the pollution of water through the approval of discharge permits (33 U.S.C. §1251; 1972), many of which are required of Confined Animal Feeding Operations (CAFOs) if they propose to discharge to water. The Safe Drinking Water Act protects underground sources of drinking water by regulating how farms handle both liquid waste and wastewater and requires regular sampling of drinking water to identify microbial contamination (42 U.S.C. §300f; 1974). However, farmers are often provided with exemptions to these rules

and violations are rarely enforced (Dowd et al., 2008). Since 1990 the US Farm Bill has included additional environmental considerations, including the Environmental Benefits Index (EBI), which helps prioritize land for conservation across multiple environmental attributes, and the Environmental Quality Incentives Program (EQIP), which provides financial and technical assistance for investments in environmental protection. The 2014 Farm Bill's Conservation Stewardship Program (CSP) and EQIP both provide payments to farmers for several ICLS related behaviors such as not burning crop residue, intensive rotational grazing, transition to organic cropping systems, and nutrient and feed management. There is currently no climate policy addressing agriculture.

Supporting factor - Highly variable topography, climate, or soil - Low

We consider biophysical and climate variability to be of low importance since to date it is not mentioned in any of the US literature as a motivation for ICLS adoption.

Supporting factor - Creation of agricultural R&D programs focused on sustainability and climate adaptation - Moderate

Inhibiting factor - Lack of ICLS farm trials/demonstration - High

Inhibiting factor - Lack of farmers' knowledge networks on ICLS - High

Agricultural research is mainly supported through the Farm Bill and the National Institute of Food and Agriculture (NIFA). NIFA funds several programs that are salient to ICLS, including programs on sustainable agriculture, organic agriculture, soil health, manure and nutrient management, and risk management education (NIFA, 2016). Recently NIFA has developed several grant programs that support research on ICLS (NIFA, 2015; USDA, 2015). Nevertheless, allocations to ICLS comprise only 15% of the \$135 million in agricultural research funding that is provided by the 2014 Farm Bill per year (NIFA, 2015; USDA, 2015). Farm trials and demonstrations are rare, but do occur at some NIFA-funded Land Grant colleges (see Garrett et al., 2017b for specifics).

Supporting factor - Industry or civil society networks promoting ICLS - Moderate

In the US ICLS has been promoted via permaculture, organic, and biodynamic civil society networks, e.g. "Soil Carbon Cowboys" (Allen et al., 2005; Cunfer, 2004; Faust et al., 2017; Lovell et al., 2010).

Supporting factor - Differentiated value chains and eco- or social labels - High

Consumer markets for local and sustainable products (e.g., high end retailers, farmers markets, etc.) have grown substantially in recent decades (Dimitri and Greene, 2000). Besides differentiation via organic and biodynamic labels, more specific marketing opportunities have been identified for grass-fed livestock (Gwin, 2009) and integrated sheep-viticulture (Ryschawy et al., In Review).

Inhibiting factor - Lack of supply chain infrastructure or marketing opportunities - Moderate

Limited meat processing infrastructure, specifically for small livestock, has been noted as a challenge for ICLS in the US (Hilimire, 2011).

Inhibiting factor - Low prices of synthetic inputs and fuel - High

Inhibiting factor - High cost of labor - Moderate

Low prices of fertilizers and fuel explain structural changes in US agriculture, including less diversification (Dimitri et al., 2005). Specialization in the US has also been fostered via mechanization, which helped reduce the costs of labor (Sulc and Tracy, 2007). Nevertheless, the US has greater abundance to cheap agricultural labor relative to many other regions due to seasonal migration from Mexico.

Inhibiting factor - Food safety regulations restricting integration - High

The Food Safety Modernization Act of 2011 provides standards for the safe production and harvesting of food crops and has the potential to impact certain forms of ICLS adoption through rules related to the presence of animals and use of animal excrement on cropland that produces food for human consumption. While these regulations provide potential benefits for public health, they could discourage the integration of animals into non-organic food crops and tree fruit systems. Foods destined for home consumption are exempt from the policy.

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