Wales farming evolution and post-Brexit implications. How can future policy sustain farming multi-functionality?

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Abstract:

Since 2018, Welsh farms have experienced significant policy shifts towards sustainability through the development of the Sustainable Farming Scheme, amidst broader global changes and local challenges like Brexit. Farming and food production have historically dominated the Welsh countryside, but evolving societal needs have broadened and complicated its role. This research identified a gap in understanding how the sector would respond to Brexit-related changes, particularly linked to the impact of the future Welsh agricultural policy. The concept of multifunctionality was used to conceptualise the diverse roles and functions of agriculture and its impact on rural areas. The three research questions reflected the likely challenges faced by Welsh farming; what are likely to be the most significant challenges for Welsh farming and its sustainability? How will the future SFS scheme in Wales interact with the drivers of change at play, and impact farms' multifunctionality and are there any policy adaptations that would be needed? A review of Welsh government policies confirmed the relevance of this concept and, in partnership with the Welsh Government, highlighted the need for ex-ante evaluation. A review of available research methods provided criteria that led to the selection of a systemic concept and research method to answer the research questions. The comparative agriculture method provided a mixed method, integrated systemic approach to understand farming processes across scales and their contributions to multifunctionality. The agrarian diagnosis, the landscape-scale case-study tool to study the farming system in a given area, was implemented in 4 representative areas to explore the interplay between bio-climatic factors and socio-economic environments and diagnose past and emerging challenges such as economic pressures, market fluctuations, evolving land use patterns, and constraints within production systems. To frame socio-cultural aspects identified in this diagnosis, the concept of Social-Ecological Production Landscapes was retained. The research highlighted tensions between economic viability and sustainability, as well as the delicate balance required to maintain cultural and environmental integrity. Modelling potential future scenarios revealed the potential for government support post-Brexit to better sustain these systems. Combined with an analysis of the literature on the scheme it helped highlight that there was a need for a

comprehensive approach to policy considering all the factors shaping Welsh agriculture. This includes acknowledging historical legacies, evolving socio-economic contexts and policies, and emerging market demands. Methodologically, this study highlighted the interest of using a holistic method such as the comparative agriculture but it also meant that it suggested ideas to further improve the rigour of behavioural analysis within the agrarian diagnosis. This is thought to be an area which will require further work for this method to play a bigger role in the multifunctionality debate particularly on behavioural factors. There is a need for further work to pilot the future Welsh policy and further develop it, also adapting data collection tools in agriculture.

Author’s Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas.

Any views expressed in the thesis are these of the author and in no way represent these of the University or of any of the partners of the project.

Signed Théo Lenormand Date 01/05/2024

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List of abbreviations

AES	Agri-environment schemes
AONB	Area of Outstanding Natural Beauty
CAP	Common Agricultural Policy
DEFRA	UK Government Department for Environment, Food and Rural Affairs
DM	Dry Matter (in%)
EU	European Union
GATT	General Agreement on Tariffs and Trade
ha	hectare
MA	Millions years ago
MMB	Milk Marketing Board
NGO	Non-governmental organisation
NVZ	Nitrate Vulnerable Zone
T	Ton
UK	United Kingdom
WTO	World Trade Organisation

Lexicon

Real Term: economic value after the effect of general price inflation is considered.
Direct Payment: payment made directly to the farmer.
Coupled payment: payment linked to farm's output.
Decoupled payment: payment not linked to farm's output.
Milk Marketing Board: the Milk Marketing Board (1933-1993) was a producer-run product marketing board, its goal was to control milk production and distribution in the United Kingdom. It acted as a buyer of last resort for farmers, guaranteeing a minimum price for milk producers.

Introduction

Wales as Gerallt Lloyd Owen wrote in his poems, ascertains its nationhood with a lyrical link to its land and landscape features that fostered the Welsh culture, the "*cefn gwlad*" (the countryside) is at the heart of the culture despite a predominantly urban and formerly industrial society (Owen, n.d.). Welsh rural areas still rely heavily on farming economically. As Wales re-develops future farming policy away from the CAP framework, it focuses on "Sustainable Land Management", to guide the sector towards sustainability (Welsh Government, 2022a, 2023a).

The median Welsh farm received £11,141 from the Common Agricultural Policy income support measures in 2019 (DEFRA et al., 2023), with wide differences in terms of level of support across farms as seen in Table 1-1. Brexit or the exit of the United-Kingdom (UK) from the European Union (EU) has as a result been extensively discussed in the Welsh farming sector. The income support has focused the attention while it only covered 15,461 out the 24677 Welsh farm holdings (DEFRA et al., 2023; Welsh Government, 2020a).

Table 1-1: Scale of the income support measure for Welsh farming – analysis of CAP data (DEFRA et al., 2023)

	Value of the first pillar 2019 Payments (£)		
Maximum	427067	Number of beneficiaries	15461
3rd Quartile	18840	Total Number of farm holdings in Wales (June Survey)	24677
Median	11141		
First Quartile	4300		
Minimum	0		

Future policy support will no longer support farm income as such but likely remunerate for public goods other than food production (Welsh Government, 2020b). The challenges identified by policy makers and the research sector around economic sustainability or generation renewal raise questions for the future place of Welsh farming (Dwyer, 2018; Thomas et al., 2021). In this changing environment there is little understanding of how different farms enshrined in their specific environment could react and what would result in terms of public goods provision from multi-functionality.

The Welsh Government was keen to get an insight into the current state of farming in Wales and get some insights on likely future evolutions. The PhD was co-sponsored by the Welsh Government Land Management Reform Division to get topical information on farming in Wales.

As a result, in the first Chapter the Welsh farming sector is first introduced using literature and secondary data to pinpoint the key roles played by the diversity of farms as well as likely future challenges for them. Contrasting these characteristics with the ambitious policy goals developed by the Welsh Government, this will lead to the identification of the research questions centred around the needs of the Welsh Government. By considering the possible response of this farming diversity to the changing context and how policymaking might be adapted, it also represented the opportunity to pursue a substantive research exercise which can make an original contribution to contemporary knowledge and effective policy making.

Chapter 1. Farming in Wales and Brexit

In this first Chapter, the Welsh farming sector is introduced by highlighting the significance of this activity and the challenges it faces which are likely to be accentuated with Brexit. Comparing these elements to the Welsh Government (WG) policy plans will provide the research rationale, aim and objectives of this study, before summarising the structure of the thesis.

A. Wales and its farming sector

1. A rural nation

The countryside is often defined in opposition to urban areas, agriculturally focused and mostly associated with rural areas (Cambridge Dictionnary, 2024). But the definition of rurality itself is a subject of much debate. The UK approach, “defines areas as rural if they fall outside of settlements with more than 10,000 resident population” (DEFRA et al., 2016). Rural areas tend not to contain large settlements and have a lesser urban influence (DEFRA et al., 2016): Several additional socio-economic characteristics and social mixes would set rural areas apart, be it in terms of land use, dominant activities (agricultural, tourism) or the profile of population (often older; Woods, 2017). Infrastructure and anthropogenic features are also less dense, in the rural areas of Wales. The opposition between rural and urban have blurred over time in Europe with societal development that has transformed land use.

The revised French statistical definition “comprises all the small urban units and rural municipalities that do not belong to the predominantly urban space (urban hubs, suburban rims and multicentric municipalities)”(INSEE, 2021). This is acknowledging the shifting definition around rurality and its different facets; the INSEE approach to area classification is based on population density, a relatively traditional approach which omits agricultural features that were often part of earlier definitions (Schmitt and Goffette-Nagot, 2000). The new approach classifies the level of density matched by the autonomy or dependence of rural areas (INSEE, 2021), giving a more nuanced understanding than the UK approach, combined to the specific socio-economic profile typical of rural areas it provides a reference for what is rurality.

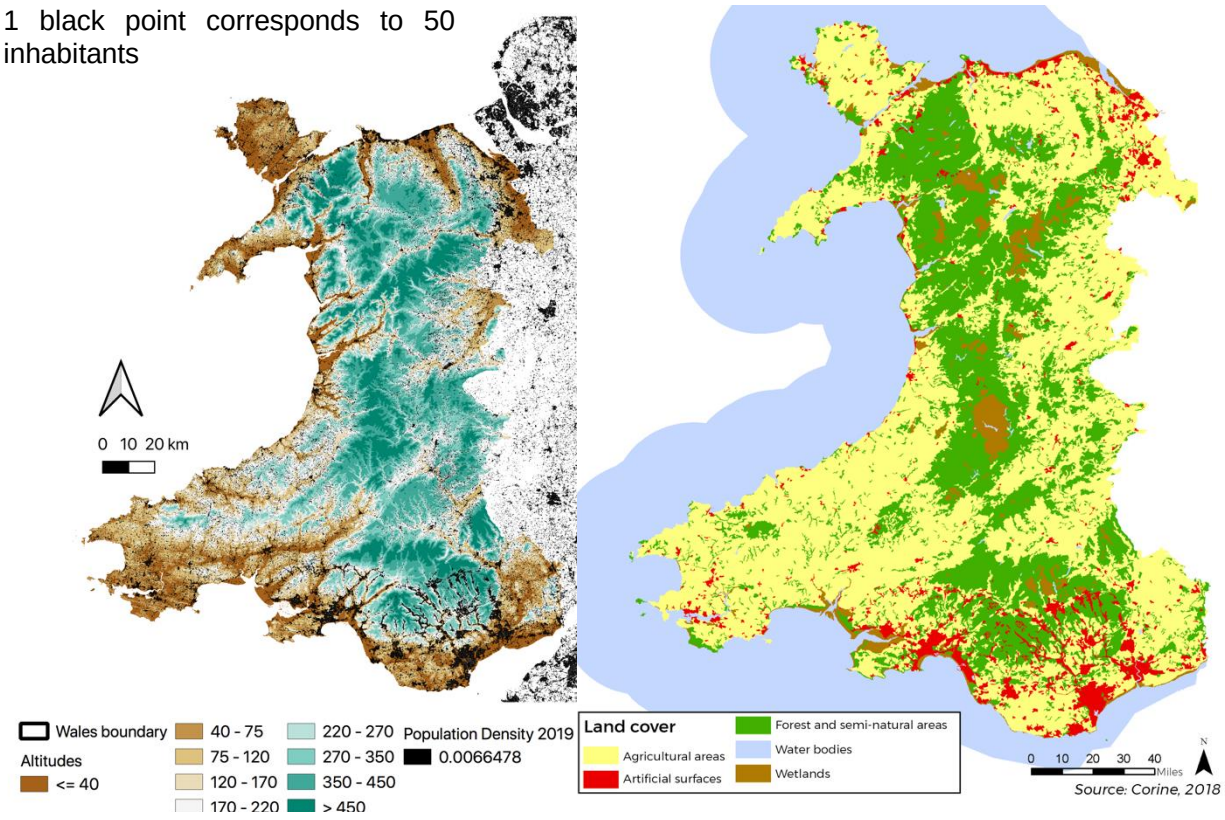


Figure 1-1: Population density of Wales and altitude (by the author from Center for International Earth Science Information Network, 2016; European Environment Agency, 2020)

Figure 1-2: Wales simplified land use (UKCEH, 2018)

The UK is the European nation with the lowest proportion of its population living in rural areas (13,4% of the population lives in sparsely populated areas) and the share of rural areas is extremely low compared to the rest of Europe (Eurostat, 2015). But Wales is more rural as shown with its lower population density (140 persons/km^2 compared to 240 for the UK) (Figure 1-1). Wales is sparsely populated apart from South-East and North-East Wales, resulting from past industrialisation and economic development processes (Davies, 1994). A statistical focus from 2008 highlighted that 65% of Wales is considered rural and 85% of Welsh land is used for agriculture or forestry as shown in Figure 1-2 (Compared to 71% in the UK)(Welsh Government, 2008).

Human settlement location in Wales is also impacted by its geography with large tracts of relatively high elevation land for the UK (30% of the surface is over 300m but only 3% of households), with narrow alluvial valleys. West and Mid Wales are more thinly

populated overall while coastal areas, and areas surrounding former industrial hotspots tend to be more populated. At the same time, the spine of Wales in terms of its semi-natural areas/wetlands (including rough grazing) is mostly managed by farming (Welsh Government, 2020a). Most of the farmed area is grass or pasture giving the idea that Wales is a pastoral nation with more sheep than inhabitants (Welsh Government, 2020a).

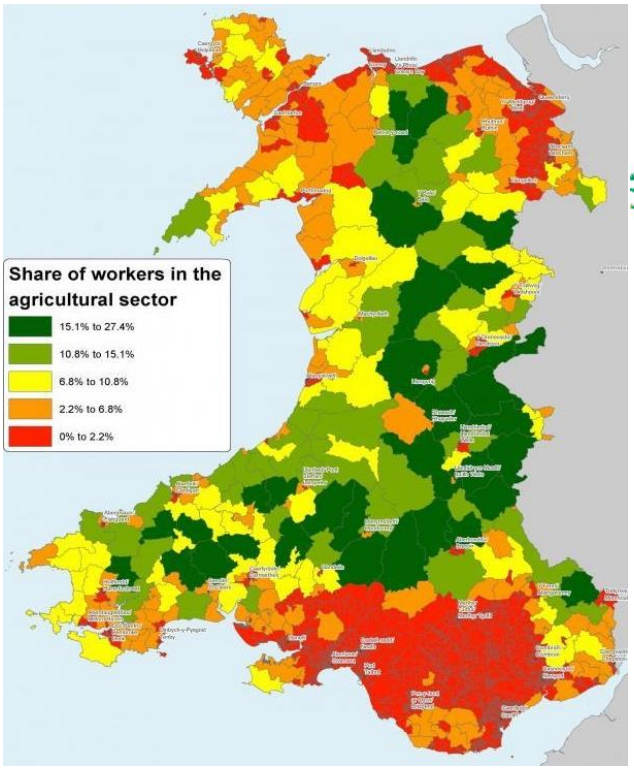


Figure 1-3: Percentage of people in the Agriculture, Energy and Fisheries work category (FUW, 2021)

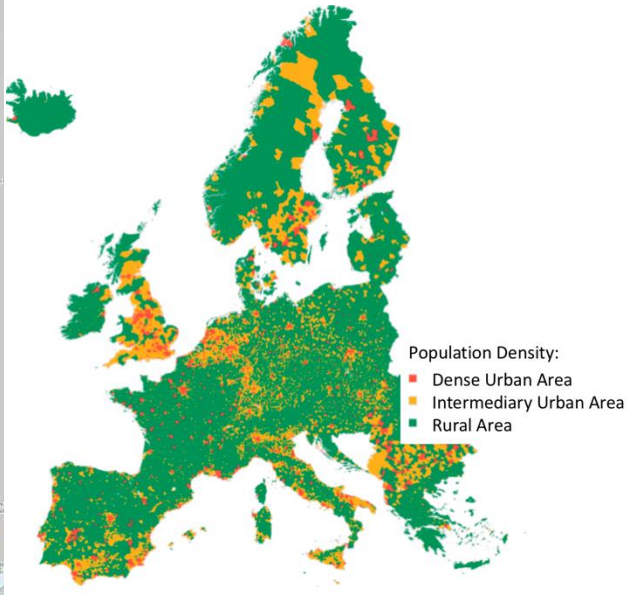


Figure 1-4: European population density and classification (Eurostat, 2015)

As shown in Figure 1-3, the importance of farming in different parts of Wales is linked how rural each part of Wales is. It is also economically significant, not by GDP contribution but for the role it plays in local communities e.g. in employment, spending or culturally (Barthélemy and Nieddu, 2003; Graves, 2022; Welsh Government and Statistics for Wales, 2021). Wales' has 1.6% of its population working in agriculture, ranking second in the UK after Northern Ireland (Welsh Government and Statistics for Wales, 2021). This is similar to other European developed countries. Agriculture's contribution to the economy in Wales is also higher than for the UK with 0.8% of Gross Value Added (Welsh Government, 2019a). Farming represents a key export of Wales

with £797m of food and drinks exports[1], mostly to the EU (£594m) in 2022. Farming is significant economically in Wales, as much at the national level as in key regions: West, Mid and North Wales tend to depend heavily on farming employment as shown in Figure 1-3, and given the demographic structure, Mid Wales is a lot more dependent on farming than coastal areas in terms of income.

Farming has an important role in Wales, as in many other European rural areas. It is the main activity shaping the landscape and remains a historically and socially significant activity (Midmore and Moore-Colyer, 2005; The Royal Society, 2023).

2. Regional variations

This section will show that the farming sector is diverse in making it significant is linked specifically to the diversity of Welsh bio-climatic conditions.

Wales has a great uniformity in terms of geology as shown in most of its bedrocks originate from the Palaeozoic era (-550 MA→-250 MA)(BGS, 2022; Cambrian Way, 2021; John, 1998). The mostly sedimentary bedrock has been deeply affected by the Hercynian and Caledonian orogenesis with a compression movement, tilting and faulting layers. This bedrock has then been gradually eroded through a process of differential erosion. More recently, geomorphological features have been reinforced during the quaternary glaciations and their melting process. The sea-level variations helped shape today's coastline and hilly areas (John, 1998; Talbot and Cosgrove, 2011). It is not so much the bedrock genesis but the subsequent differential erosion which explains the different landscapes, with one exception (Talbot and Cosgrove, 2011); some harder to erode plutonic bedrock can be found in Snowdonia, the Llyn peninsula and the Preselis (Pembrokeshire). These stand above sedimentary bedrocks (Flatrès, 1957; Goudie and Migon, 1993; Goudie, 2020).

Based on this diverse eroded Palaeozoic bedrock "semi-mountainous plateau", there is a downslope gradation in the landscape (Figure 1-1). Water does not penetrate the

[1] On a total export value of £20.5b/year for Wales (Welsh Government, 2023)

impermeable bedrock of the central areas but feeds into the talweg[2], valleys and alluvial valleys down to the sea. The bedrock hardness gradient gives a gradation in interfluve[3] size; as a shift is made from summits, they increase and widen, and the relief is smoother: the landscape changing from a plateau to large alluvial valleys or hilly areas (Flatrès, 1957). Glaciation features and deposits can usually be found with a similar downslope gradient (BGS, 2022). Soils tend to be predominantly acidic, thicker, heavier at the bottom of the valleys than on the slopes and mountain tops, with a better water carrying capacity. Some hills and alluvial valleys in specific locations (e.g. with different bedrocks – limestone, sandstone) may feature relatively free-draining loamy soils.

Wales is at the West of the UK facing the Irish Sea and that opens to the Atlantic Ocean (MetOffice, 2022) as shown in Figure 1-5. The main climatic factor is the Gulf Stream, a warm water current from the Caribbean to the West of Europe (MetOffice, 2016). The dominant winds come both from the North-West and the Arctic and from the South-West from the Atlantic. These winds loaded with water from ocean evaporation reach the coast and as they meet the coast elevation, they discharge this through rain. Wales has a temperate humid climate, relatively cold all year round with significant regional variations depending on altitude. The East of Wales is much drier than the West, particularly in summer (MetOffice, 2022). There are climatic differences across Wales that interact with the geology/geo-morphology, the combined influence of these factors is key to the determinant of this diversity of (mostly) pastoral landscapes.

[2] A talweg is the line connecting the lowest points along the length of a valley or riverbed (Derruau, 2010).

[3] An interfluve is a ridge or highland area that separates two adjacent valleys (Derruau, 2010).

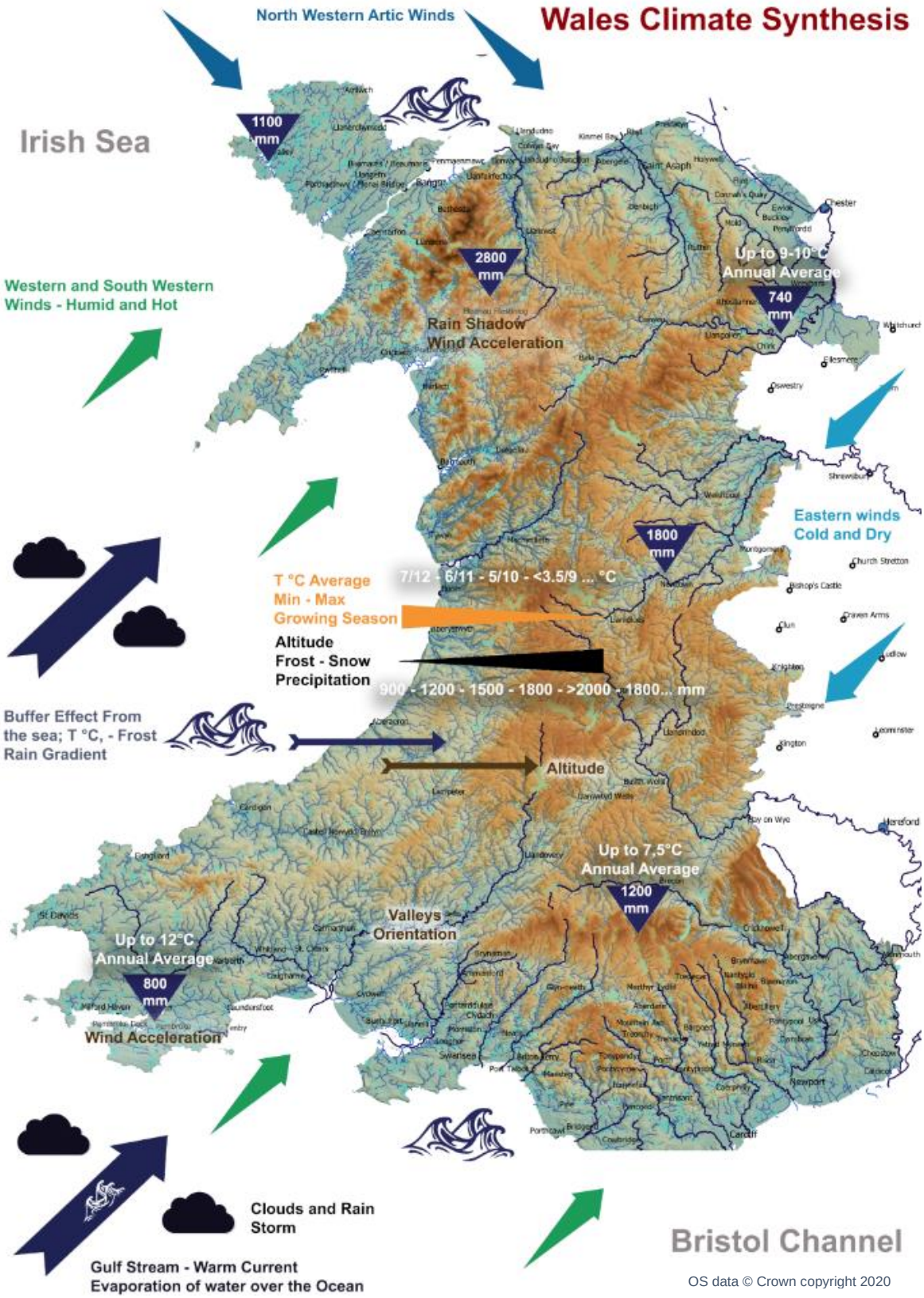


Figure 1-5: Welsh bio-climatic conditions compared to Welsh geomorphology (by the author from MetOffice, 2020;European Environment Agency, 2020; Ordnance Survey, 2020)

There is a gradation of a landscape mosaic with a climb from the vivid-green hilly lowlands and alluvial valleys to the hilly intermediate areas, going up to the upland plateau (Flatrès, 1957; Goudie and Migon, 1993; NRW, 2019). Reflecting these agro-ecological constraints, post-second World War assessments graded most Welsh soils at grades 4 to 5 (on a scale from 1 to 5) with limited possibilities in terms of their carrying capacity, growing periods, and types of crops (DataMapWales, 2019; Pembrokeshire National Park, 2017). 80% of the land is categorised as Less Favoured Area (LFA), a much higher proportion than in England and second only to Scotland, within the UK (Welsh Government, 2019a). Broadly speaking, two large landscape categories may be distinguished in Wales:, the low-altitude lowlands (<200-300m altitude, lower agro-ecological constraints) and the uplands (>200-300m altitude, higher agro-ecological constraints) widely identified in the literature[4] (Flatrès, 1957; Vigani and Dwyer, 2018; Welsh Government, 2019a).

The colonisation of Wales' natural environment took place using pastorally-focused agricultural systems suited to these agro-ecological conditions (Davies et al., 1993; Davies, 1994) This has led to the general specialisation of Welsh Agricultural systems towards grazing livestock. In turn it shaped the environment and cultural systems of land use. Welsh food originates from place-specific food-production systems; the diversified sheep breeds and their grazing patterns or specific cereal types adapted to their local environment (Davies, 1935, 1994; NSA, n.d.). Regional differences exist, for example with uplands focused on beef and sheep. The proportion of sheep increases alongside the gradient, all the while with a reduction in types of outputs (store stock instead of finished cattle, breeds used; Welsh Government, 2020a). Lowlands focus on dairy and beef (with more finishing), with higher outputs from the land (Welsh Government, 2020a). With these combined agro-ecological conditions, the course of agricultural development has been different across Wales further differentiating landscapes.

[4] The limit varies according to literature sources, on the location and on the micro-climate explaining different altitude limits

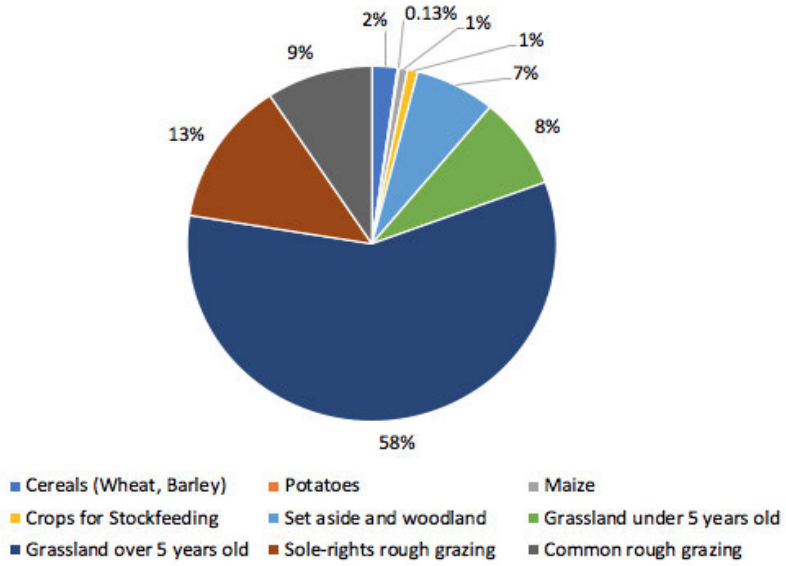


Figure 1-6: Repartition of agricultural Land use in Wales in 2019 (StatWales, 2020)

This is reflected in terms of land use as shown in Figure 1-6. Most of the land is used for livestock with just a few coastal and lowland alluvial valleys having significant areas of cropping (5% of the whole of Wales' farmed area; Welsh Government, 2020a). The dominant crops are wheat and barley, cereals and maize used as livestock feed. There is only one explicit cash-crop which represents a small share of the area: potatoes (0.13%). The main land use consists in grazing (over 84% of the farmed area); semi-permanent/semi-natural grasslands predominate with 58% of land cover, with less temporary grassland (8%). The remainder lies in rough grazing areas (21%) including rough grazing, mountain grazing, heath and moorland, including commons representing 9% of the farmed area (StatWales, 2020). Grassland and particularly rough grazing cover the majority of environmentally and culturally significant landscapes in Wales and are particularly important in terms of carbon sequestration (Vigani et al,2018).

From this diversity of landscape and farming practices originates Welsh traditional farming outputs such as store lambs and store cattle, as well as mountain-bred lambs (for breeding or meat), wool or early potatoes from lowlands (Ashby and Evans, 1944). Culturally, farming has a key role in Wales in maintaining the Welsh language, both in the past (Howell, 1946) and today (DataMapWales, 2022). It is also maintaining historically and culturally significant landscape features (NRW, 2019); stone circles, stone walls, farm buildings, hedges and the pastoral character. Less-well known is

their diverse role in Welsh culture and farming systems linked to the landscape (Kneafsey et al., 2001; Midmore and Moore-Colyer, 2005; Yarwood and Evans, 2006). This can be seen in the significant agricultural products such as artisan cheeses and other dairy produce (Graves, 2022), or distinctive meat products that may be recognised by certification (e.g. PGI Cambrian Mountain Lamb; DEFRA, 2021d). Culturally significant landscapes managed (partly) by farming have been recognised in the literature and in policy (e.g. Eryri National Park). Ecologically speaking, large parts of the open moorland in Wales have been recognised as valuable and are protected as Sites of Special Scientific Interest (SSSI), National Nature Reserves, Natura 2000 Special Protection Areas, and Special Areas of Conservation. Welsh farming has a key and diverse role in Welsh landscapes linked to the landscape diversity that can be found (DataMapWales, 2022).

B. The changing roles of Welsh farming

1. Farming system change and productivism

Farming in Wales exhibits specific regional differences and has been heavily territorialised due to agro-ecological (Davies, 1935) and also socio-economic parameters (GENUKI, 2023; Howell, 1999, 1983)[5]. The regionalised spread of agricultural improvements in relation to market-accessible outputs was another determining factor behind these changes (Ashby and Evans, 1944; Perkins, 2004).

'The land of Britain' reports from the first half of the 20th century are an useful source from which to understand its characteristics (Davies, 1939; Howell, 1946; Redford, 1940). Taking a farming system vision, farms before the Second World War were extremely self-sufficient and numerous (Ashby and Evans, 1944). The farm density in Wales was, and remains, much higher than in the UK (the average size is 48ha vs 81ha). Wales still accounts for 16% of UK's farm holdings, on only 10% of the land (DEFRA et al., 2022; StatWales, 2020). This dense farming ecosystem evidenced by

[5] e.g. although Pembrokeshire was able to grow relatively early potato crops, it required improved transport links to enable this specialist production to develop.

Grigg (1983), was then and still is mostly composed of family farms; either tenanted or owned (Butler et al., 2008). The type of systems run would be mixed (with an element of cropping) but heavily leaning towards pastoral farming. Many holdings, particularly in the uplands, were very extensive, with low land output per hectare. These reports also highlight other characteristics of traditional Welsh farming. For example, North Wales was portrayed as Welsh-speaking using the typical Welsh mixed-purpose breeds (Howell, 1946).

The Second World War was a tipping point in terms of farm change (Hodge, 2016) with a focus on increasing food production. This was done through increasing output by substituting inputs and capital for human labour and biological processes of fertility-building, but also applying technology to improve the livestock or land's production characteristics (Devienne, 2019). This led to an increased integration of Welsh farming in economic exchange and a gradual specialisation of farming. The mixed aspect of Welsh farming reduced steadily while its focus on livestock was reinforced, with regional specialisation in terms of production types (lowlands - dairying and finishing cattle, uplands - beef and sheep, store cattle; Grigg, 1983; Perkins, 2004). Regional areas also specialised further owing to their agro-ecological comparative advantage (Welsh Government, 1998). Notably uplands focused more on very long-term pastures[6] for meat production (Powys, Ceredigion), particularly with sheep while lowland areas focused on short-term pasture for meat production and dairying.

After the Second World War western Europe countries focused their agricultural policy on increasing output, by using pro-production agricultural policies. To reach this goal a focus was placed on family farms that were to implement output focused technological evolution also increasing labour productivity (Devienne, 2003). As in France the family-farm triptych combining total control of capital, labour and land was favoured, in this regard the access to land was particularly secured/regulated in the aftermath of the second world war (Cochet, 2008; Quinn et al., 2010). But in the UK, contrary to other EU countries, no structural tools were needed to reorganise

[6] Almost permanent pasture, never ploughed over 5 years

landholdings (e.g. as in France); indeed farms were already larger and more coherently organised due to distinctive factors including primogeniture. A new heavily regulated tenancy system in favour of the tenant was introduced in 1948 and strengthened in 1986, farm renting had also been enabled via County Council farms (Prince, 2012). Combined with sustained use of heavy inheritance taxes. The proportion of tenant farmers was 88% in 1908 but by 1994 had reduced to just 24% (Davies, 1939; Howell, 1946; Redford, 1940). As a result, many estates, and large traditional landowners disappeared in Wales.

2. The wider impacts of the focus on food production

This set of transformations had consequences for the role of farms in Wales' rural areas. The specialisation on farms started by gradually focusing on one type of animal and agricultural production (meat or milk) accompanied by necessary changes in land use and an increased use of inputs (Ashby and Evans, 1944). The greater uniformity of systems and practices breeds, seed types, buildings, developing through this process of specialisation can also be noted. It gave rise to new farming systems less dependent on local environmental parameters. This has been well documented in literature, albeit not specifically for Wales alone (Raum, 2020; Robinson and Sutherland, 2002). The labour productivity, the economic environment and subsidy system incentivised farmers to enlarge their farms both in acreage and output. As a result the number of farms was reduced by one third from 1945 to 2000; small farms disappeared gradually from the landscape (Welsh Government, 1998; Grigg, 1983).

Typical Welsh breeds were adapted to increased specialisation (e.g. Welsh Black cattle breed), while some disappeared, replaced by more productive ones (e.g. Castlemartin White cattle; Perkins, 2004). Sheep numbers rose steadily up to 1992 (Figure 1-8), supported by markets, subsidies, input use and land improvement, while dairy and beef numbers were at best stable despite production increases in these sectors due to a focus on efficiency and productivity (per head of livestock). The consequences of this focus were an increase in semi-permanent and permanent grassland and a reduction in unimproved rough grazing while arable crop areas reduced steadily (Welsh Government, 1998).

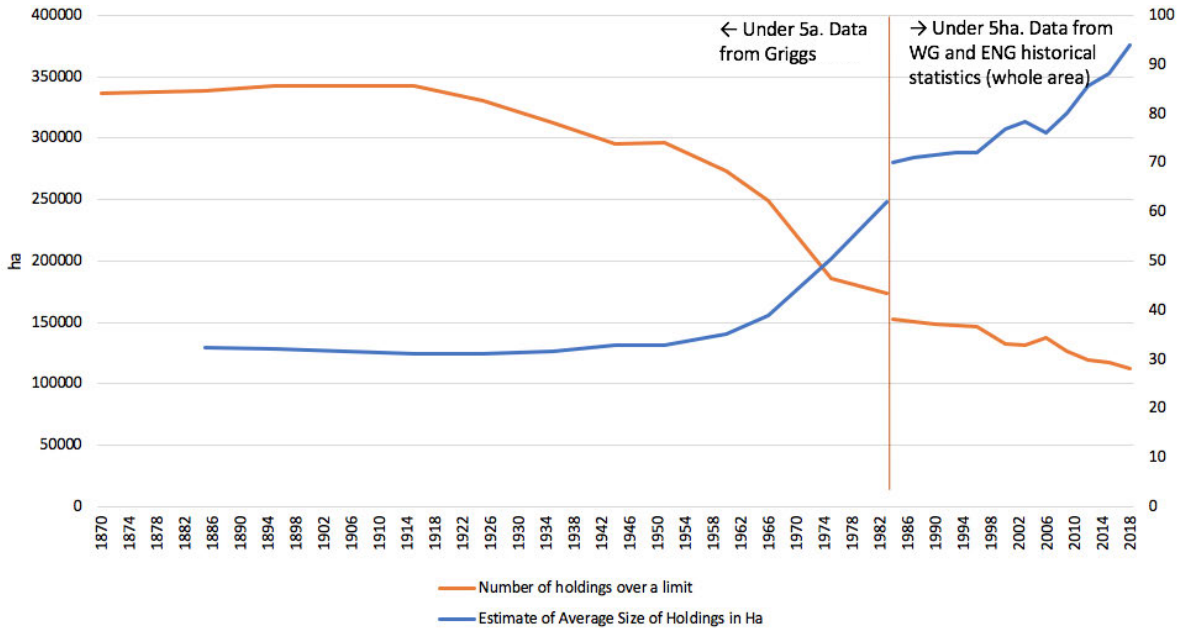


Figure 1-7: Evolution of the structure of farms in England and Wales from 1870 to 2018 (by the author based on; Welsh Government, 1998; Grigg, 1983)

These technical transformations were linked to further market integration and increases in goods and transport flows (further distance to market, commuting, business trips, tourism). It led to a reduction in locally-integrated farm management practices (Hodge, 2016) or in the ability to retain food identity (Graves, 2022). At the same time, culturally, the Welsh language reduced in importance in the daily life of the community (DataMapWales, 2022). Effectively, despite retaining some diversity the significance of farming reduced in rural areas.

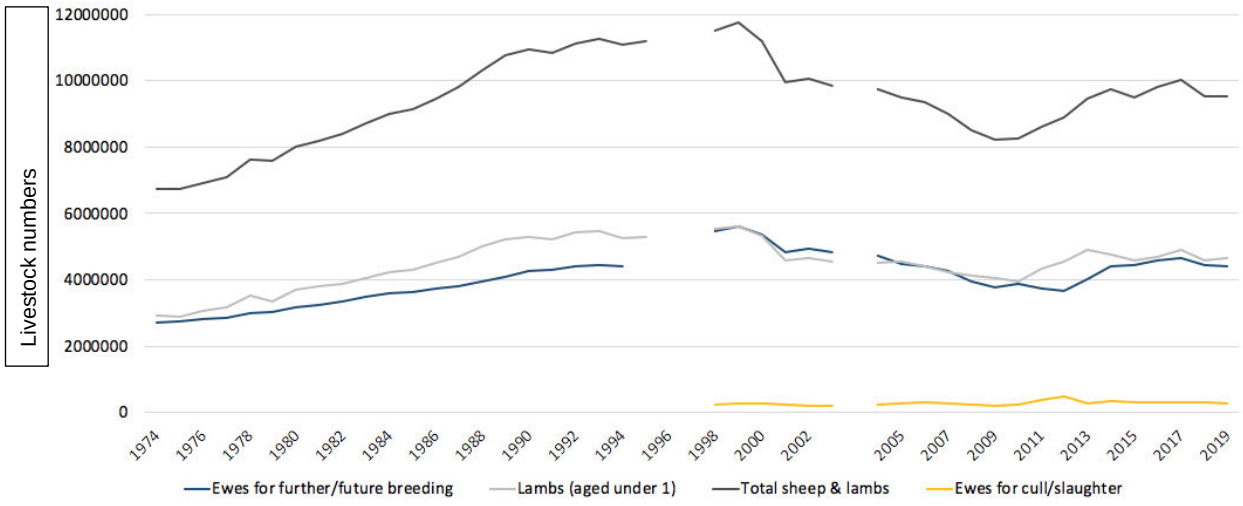


Figure 1-8: Evolution of sheep numbers in Wales from 1974 to 2019 (StatWales, 2020)

3. Post-productivism era changes

From the 1980s, a widespread liberalisation trend, influenced by a vision of a leaner state, significantly impacted farming across Europe, including the UK (Bureau et al., 2019; Dibden et al., 2009; Hodge, 2016). This change led to reduced government involvement in economic and social affairs, based on the neo-classical economic theories fashionable in this period (Boussard, 1987). Liberalization influenced by global economic trends particularly affected agriculture, traditionally a protected sector (Dibden et al., 2009; Hodge, 2016). World Trade Organisation (WTO) cycles contributed to the gradual removal of trade barriers, within a broader context of economic globalization (Bureau et al., 2019). Although not always due to decisions taken by the UK government, Britain liberalised its national food cooperatives and industry bodies from 1990, seeking to introduce greater competition for farm outputs (Empson, 1998; Glover, 2011; Savills Research, 2020).

A selection among farms had already taken place as farms were incentivized to expand and increase output or leave the industry, but they were further incentivized in this through specific capital taxation policies (Gibbard and Ravenscroft 1993), for example inheritance tax relief for farms (Butler 2015). Since 1984, active owner-occupier farmers pay no inheritance tax on farmland and benefit from a hefty rebate on other farm elements (while landlords are only exempted for 50% of the tax), allowing successors not to bear the full brunt of land value appreciation (Butler, 2015). This further consolidated existing farms and the shift in landholding to owner-occupancy. It also led to a disconnection between the price of vacant land versus that of tenanted land but also the rent value from the price of land (Gibbard and Ravenscroft, 1997; Hill, 1985; Traill, 1979). At the time the market was deemed malfunctioning due to supply shortage linked to the post-war tenant-favourable tenancy framework acting as a disincentive (CAAV 2005). The tenancy market was partially liberalized from 1995 with a broad agreement across the sector (DEFRA, 2006; Gibbard and Ravenscroft, 1997). Indeed, further farm expansion through renting was supposed to mitigate the difficult context in farming. The land tenure legislation was partially liberalised through a new flexible approach of variable-term ‘Farm Business Tenancies’, from 1995 (Gibbard and Ravenscroft, 1997). This reversed the

balance of power, with landlords able to adopt a best-price, best-time approach to renting land, with greater possibility to retain control of land at the end of each term (Savills Research, 2020).

Agricultural policy, shifted gradually away from support to food production and its negative knock-on impacts. The UK government reduced, as rapidly as possible, its EU spending through the Fontainebleau agreement as well as other related mechanisms (e.g. exchange rates and the particularity of 'green currency rates' applied only to farm policies), limiting market support and then direct payments to agriculture (D'Alfonso, 2016). The MacSharry reform of the CAP in 1992 supported the idea of a multi-functional approach to farming that could also fit with the liberalisation vision. The shift was only partial but there was more emphasis for environmental conservation, knowledge exchange and training and some rural development funding (Bazin, 2003). Finally, environmental regulations have been progressively tightened for the last 30 years; for example, with the EU Nitrates Directive (Blackstock et al., 2010; Burt et al., 2010). In the UK devolution was introduced in 1998 with a Welsh Assembly created following the 1997 vote (UK Government, 2018). Wales gained new powers to determine its own implementation of the CAP and agricultural regulations as more options were offered to EU member states via successive CAP reforms (e.g. Finney, 2021; Pouch and Trouvé, 2018). This was also linked to the vision that subsidiarity was positive, to enact better policies (Rawlings, 2022). For example, Wales tried to protect its farming ecosystems through the implementation of specific policies (Buller, 1999; Midmore and Moore-Colyer, 2005). In contrast to England, income support policies changed slowly in Wales to protect farms from rapid income change. On the environmental side, conservation schemes very similar to these developed in England from the late 1980s, payments were based on income-foregone (Marsden, 1998; Wynne-Jones, 2013). This was an EU-wide provision, highlighting the wider neo-liberal vision.

While the government control of agriculture reduced during the 20 years following 1980 (regulations of market), the focus shifted away from food production, it led to a greater role for fluctuating input and output markets. Output and some input prices

were gradually aligned to world market levels with added volatility during crises[7]. Since 2008 input prices have remained at sustained high levels after a momentary boom (Annex 6 Item 6-1).

At the same time, since the 1980s there has been a continuous increase in rural population trying to make the most of rural amenities (Hodge and Midmore, 2008; Welsh Government, 2008). Tourism gained in importance for the Welsh rural economy, with many farmers having facilities such as bed and breakfast accommodation or campsites (Velu, 2021).

Between 1980 and 1992, Welsh farming experienced divergence in structures and practices due to policies favouring environmental protection and increased market liberalisation. Livestock numbers declined (Figure 1-8) but in parallel farm efficiency and market focus increased; the rising number of lambs per ewe and higher cattle liveweight are clear indicators of this trend (Welsh Government, 2020a). Part of the sector seemed to have changed its practices towards leaner operations, with lower workforce, more permanent pasture and simpler operating practices while also trying to be more market-driven (Morris et al., 2017). An indirect result of this cost-pressure has been a smaller and ageing workforce, with generation renewal progressing very slowly (Hayden et al., 2021b; Ingram and Kirwan, 2011). Many farms adapted by adding income streams and further restructuring (Arnott, 2021; Welsh Government, 2019a). Post-2013, global markets supported UK livestock products, particularly favouring the dairy sector and specialised granivore production, these activities grew and concentrated regionally (if not in numbers of farms, then in output volume)(Welsh Government, 2020a). However, red meat farm contraction over two decades was observed, with some areas experiencing up to a 20% loss in less than 10 years (Welsh Government, 2020a). The transformations that took place after 1980s continued to change the role of Welsh farming in rural areas, with a lesser economic importance

[7] For example, the post 2000 reduced consumption trend in beef and lamb could be linked to the successive BSE and Foot & Mouth outbreaks (House of Commons, 1998; Scott et al. 2004) or the 2008 financial crisis.

and greater challenges ahead. Policies and the wider discoursed shifted to recognise their role outside of food production.

Climate change has become a crucial issue in the 21st century, with Welsh agriculture, particularly focused on ruminants, acknowledged as a significant contributor to greenhouse gas emissions (D'Angelo et al., 2020). But farmers also face the impacts of changing weather patterns and attempts at adaptation are evident (Wheeler and Lobley, 2021). However, climate disruptions, both locally (extreme weather) and broadly (supply-chain disruptions, price fluctuations), increase in frequency (Farrar and Vaze, 2000; Forest Research, 2007). Addressing climate could require further changes to Welsh farming to reduce farming's impact on greenhouse gas emissions and preserving endangered natural resources (Gerber et al., 2013). The challenge remains in defining the role of farming in fostering a sustainable society while protecting the environment although farming's place is still perceived as critical (Clark and Scanlon, 2019; Fowler et al., 2004).

4. Economics of Welsh farming

Despite these continuous adaptations the economics of Welsh farming and particularly of beef and sheep producers remain challenging and reliant on subsidies; questioning their capacity to continue to play a role in the future of Welsh landscapes.

Notwithstanding the changes, part of the sector is still reliant on farm subsidies for its survival which is shown by the Farm Business Surveys year after year (O'Regan et al., 2019). Average hill cattle and sheep farms' profit is entirely composed of subsidies and even the top third rely on the subsidies for half of their profit. Hill sheep farms are in a similar situation, but the top third still rely on subsidies for 60% of their profit. Upland beef and sheep are in a similar position but with much reduced profit levels while lowland farms in the same sectors are only marginally better. The exception in Wales would be dairy farms although subsidies still represent a third of their profits. The payments of the CAP have been distributed on hectares while access to key production factors and resources for farming and other activities is unequal (Szreter, 2021). The sector remains asset heavy and cash poor with low or negative margins (e.g. on lamb production or beef; O'Regan et al., 2019). The exception is dairy farming.

Contractual relationships with suppliers are not as developed in beef and sheep compared to milk, but even these contracts are no guarantee of a fairer price in relation to the costs of production (Competition Commission, 2008a, 2008b; Franks, 2001).

Over the last 30 years the contribution of Welsh farms to the rural economy has declined for example the amount of labour on farms (StatWales, 2020) and the number of livestock markets, food processing industries and abattoirs (HCC, 2022) have reduced. In contrast there were also positive developments, South Caernarfon Creameries, First Milk and Llaeth y Llan developed their activities (AHDB, 2020a; Food Skills Cymru, 2022). But the sector is vulnerable (with low margins) to the price fluctuation witnessed on world markets for its indexed outputs and inputs, putting further pressure on farms, particularly in terms of cashflow (FAOSTAT, 2021a; O'Regan et al., 2019). In short, Wales exports agri-food products, particularly to England and mostly in un-processed form thus capturing little added-value linked to food processing. Wales and the UK still rely on imports for other agricultural products (Annex 1).

The overall picture then is of a changing agricultural sector that moved towards productivism before reacting to a changing environment. 70 years of successive change have left Wales with a slimmed-down sector and a transformed role for agriculture. Even in the last recent decades, changes have taken place with further regional specialisation reflecting a more complex sector. Farming remains a key land-management, economic and cultural element of Wales; a large part of the sector is nevertheless fragile economically.

C. Brexit, a change of environment for farming

The Brexit process started following the June 2016 referendum. Eight years in, Brexit is not yet finalised (Annex 1 Item 1-2), and the forthcoming operating environment remains particularly uncertain for farms. A SWOT analysis was produced based on the literature on potential impacts (Annex 1 Item 1-3) from which it will be shown that this represents a step-change for Welsh farming.

1. Brexit and trade

Brexit was about divergence from the EU single market - the most comprehensive common market - which helped the UK–EU Brexit trade deal to be negotiated rapidly (Gerval, 2023). But many issues linked to UK future standards divergence are left to future negotiations in this deal (Annex 1 Item 1-2). The UK-EU Brexit agreement's validity depends on maintaining a level playing field, where standards in both the UK and the EU are aligned. If not, unilateral measures such as bans, tariffs, and quotas could be implemented until a bipartisan agreement is reached and a long-term solution established. It requires monitoring and continuous efforts to ensure alignment across numerous sectors. For example, this could be impacted by UK government aims for regulatory freedom, as indicated by Defra's consultation on GMO use in farming (DEFRA, 2021b). From an economic perspective, this deal represents regression as it reintroduces border friction and the UK is divided because Northern Ireland remains in the common market[8]. Challenges around trade in food and beverages have emerged, specifically related to the Northern Ireland border (The institute for Government, 2021). Wales ought to be consulted on trade policies but the WG does not have trade policy power.

One limit to UK divergence from the EU and the installation of trade barriers has been that the UK is not self-sufficient in food (Annex 1 Item 1-1). Production levels cover approximately 76% of food consumption but only 60% for all food: a level that has gone down steadily since its peak in the 1980s (DEFRA, 2021c). The biggest UK partner for food and beverage trade remained the EU, in 2021 (DEFRA, 2021c). The UK is self-sufficient in most livestock production but is less than 40% self-sufficient on fruit and vegetables. This is without considering sector reliance on imported inputs[9]; including fertiliser, livestock feed and phyto-sanitary products (DEFRA, 2021c).

[8] The Irish Sea border was seen as the only solution to address the Good Friday Agreement, but it has strained UK-EU relations.

[9] This reliance should also be analysed in economic terms the benefits of importing low-valued commodities like soyabean compared to importing higher value products (e.g. cheese).

Exporting agri-food products has become more challenging with Brexit (Annex 1 Item 1-3; Swinbank, 2022) and Wales exports 40% of its sheep meat production and 12,5% of its beef production to the EU (HCC, 2022). Exporters and importers must now be registered and provide pre-notification of goods, individual health certificates for each batch crossing the border, and pay VAT in the country of export (Swinbank, 2022).Certificates of origin are required to ensure the product originates from the UK. The complexity of paperwork has increased for diverse and fresh products. However, new importing and exporting paperwork and checks have been postponed, due to the UK's low self-sufficiency and long-standing links. Nevertheless, exports to the EU have decreased for food and beverage products (ONS, 2021). But there has been little evidence of changes in trade flows that could impact farms in Wales (ONS, 2021). However, obstacles for imports from the EU were still not fully implemented in 2023, as the UK government fears food shortages (Defra, 2021; Annex 1 Item 1-1**).** For example, rules of origin and Sanitary and Phyto-Sanitary checks were not yet in place (Jozepa, 2023). The Irish Sea border has posed operational challenges, and full checks are not conducted, which led to conflicts between the EU and the UK (Food Research Collaboration, 2023; The institute for Government, 2021).

Regarding post-Brexit trade deals, existing Free Trade Agreements have been rolled over with countries outside the EU, such as Japan. Only a few new deals, including Australia and New Zealand, have been concluded, removing import tariffs and quotas for agri-food products (Senedd Research, 2022a; Swinbank, 2022). This puts UK dairy and meat producers in direct competition with farmers from these countries. The economic impact of these deals is expected to be small, according to research, but modelling by DEFRA suggested that the devolved nations will bear more of the consequences than England (Gobey, 2021). The impact is likely to be negative in the long run (Senedd Research, 2022a; Annex 1 Item 1-3). Since the Ukraine-Russia conflict began, tariffs and quotas on Ukrainian imports have been waived, leading to increased competition in the poultry market (Bakker et al., 2022). This could lead to further market volatility and impact on farm incomes, Welsh farm viability and their role.

2. Brexit and state-support to agriculture in Wales

Brexit marks the end of the Common Agricultural Policy (CAP) in the UK, which had been devolved across the UK nations (Théo Lenormand, 2023). Without a common framework, agricultural policy goals and measures are expected to diverge[10] (Greer and Grant, 2023). England and Wales plan to use the liberty offered by the end of the CAP to deliver a new type of agricultural policy with different goals. But if England will focus on payment for environmental goods (DEFRA, 2020), Wales aims to uphold a holistic vision of agriculture.

The WG agricultural policy goals set out in the *Agricultural Act (Wales) 2023* aim to create a sustainable farming sector that supports both the environment and the livelihoods of farmers in Wales, linked to Wales' sustainability goals, commitments and existing policies (Annex 2 Item 2-1) are focused on four objectives under the *Sustainable Land Management* (SLM) framework (Welsh Government, 2023a):

- Sustainable Farming Practices: the goal is to support farmers in adopting sustainable practices to ensure the long-term health of the land and to produce high-quality food and other goods sustainably. This includes reducing waste, promoting animal health and welfare, and creating a supply chain that prioritizes both people and the land.
- Mitigating and Adapting to Climate Change: the policy seeks to assist farmers in mitigating and adapting to climate change by encouraging methods that reduce greenhouse gas emissions, store carbon, and enhance resilience to extreme weather events such as heatwaves and flooding.
- Maintaining Ecosystem Resilience: efforts will be made to maintain and enhance the diversity of plants and animals, as well as to carefully manage natural resources like soils, water, crops, and habitats to strengthen and flexibly manage the landscape.
- Conservation and Promotion of Welsh Culture and Language: the policy aims to conserve and enhance the countryside and cultural traditions of Wales,

[10] Within reason for equity considerations and the internal UK market

including promoting and facilitating the Welsh language. It also seeks to make green spaces more accessible to all residents of Wales.

While one of the vehicles to achieve these goals will be the future agricultural policy, The WG also plans to use its regulatory framework (Welsh Government, 2023a). The goals are broad ranging particularly compared to these retained in England (UK Government, 2020): The WG Sustainable Farming Scheme (SFS) aims to support farmers and foster a prosperous agricultural industry in line to SLM outcomes (Welsh Government, 2022a). Payments will be given for activities exceeding regulations, without incentivizing compliance, the goal is to base the SFS on public money for goods principle. It encompasses environmental, social, and economic objectives, including food production (Welsh Government, 2022a, 2023a). The policy has been developed through a process involving farmers and the agricultural, food, and environmental sectors (Welsh Government, 2019b). The SFS would operate as a five-year rolling programme. It is still unclear whether it will replace all the components of the former Rural Development Programme.

The scheme framework consists of five key characteristics (Table 1-1) each offering different tiers of actions for farms (all voluntary). The range of action is designed to appeal to all farm types with different level of ambitions. In general, the SFS offers various types of payments and support, including management payments, capital payments for tools/buildings, and technical advice. Contrary to the current policy it would not provide an income support payment, but it would aim at providing a tailored solution for each farm. The key characteristics for the farm support would be the fact that the WG aims at steering farms in a specific direction with its actions, the objectives would then be achieved as direct or knock-on benefits.

Table 1-1: List of action characteristics in the draft SFS (by the author from Welsh Government, 2022)

Action Characteristics
Resilient and productive farms
Reduce, reuse, and recycle inputs nutrients and waste
Reduce on-farm emissions and increase carbon dioxide sequestration
Protect and improve the farm ecosystem
Benefit people, animals, and places

For example, resilient and productive farms is expected to contribute to farms' profitability and limit income volatility, ensuring economic sustainability. Overall, the farming support is changing and is likely to require more efforts from farmers with potential impacts in terms of farming adaptations.

3. Short-term challenges

By observing two short-term disruptions, it will be demonstrated that they can impact farms and their choices.

The COVID-19 pandemic impacted agriculture (Annex 1 Item 1-4) significantly through government public health responses, leading to lockdowns and disruptions in food production systems. Consumption patterns adapted to stay-at-home lifestyles, affecting food retail channels, while output decreased slightly (Coleman et al., 2022; Harapko, 2023). Even with eased COVID-19 rules, labour availability issues disrupted the supply chain, impacting input provision for farms and processing (Ferragina and Zola, 2022; Ring, 2021; Stiglitz, 2021). Fluctuating global food demand prompted short-term responses, causing temporary over-production as markets adjusted to changing consumption patterns (Coleman et al., 2022; Ranta and Mulrooney, 2021). The crisis also led to rising energy costs due to limited supply prospects (Birol, 2022) and increased prices in various supply chains due to shortages (e.g. electronic components). Macro-economic and political implications included a shift away from austerity measures, with increased government involvement in economic and social aspects (Arrieta, 2022; Ferragina and Zola, 2022; Stiglitz, 2021). The pandemic underscored the vulnerability of existing supply chains to large shocks and the potential vulnerability of existing farms (Lenormand, 2021a).

The economic recovery post-COVID was swift but hindered by short-term decisions impacting agriculture. Armed conflict between major global commodities actors, particularly Russia and Ukraine (Annex 1 Item 1-5), led to worldwide consequences and sanctions against Russia. Both nations heavily export cereals and poultry, affecting global markets (Bazin and Bourdeau-Lepage, 2011; Chopra, 2023). The conflict caused short-term shortages of gas and diesel, impacting supply chains, causing shortages and price increases (Aubert et al., 2022; World Bank Data, 2022).

Rising energy prices revealed agriculture's reliance on fossil fuels, prompting farmers to reduce fertiliser usage. Increased government action was limited by rising interest rates, emphasizing prudent spending (Hoddinott et al., 2022; Xiang, 2023). Ongoing conflict in Ukraine has led to partial price reductions but stagnant or slightly decreasing farmgate prices due to reduced consumption (AHDB, 2022a, 2023a, 2023b; HCC, 2022). Despite global fluctuations, UK agriculture is affected, impacting Welsh farm economics, and influencing farmer choices. Farm incomes have been volatile as a result of these two crises (e.g. James, 2023) and highlight the fact that the challenging context around farming is likely to persist.

In summary, in this section Welsh farming, its importance and the challenges ahead were contextualised. Welsh farming in its diversity is recognised as a contributor to the social, environmental, and economic fabric of the countryside by the WG, but the significance of its role has diminished. The Welsh agricultural sector faces significant challenges because of successive crises occurring at different scales and short intervals (e.g. Tooze, 2022) with potential knock-on consequences for Welsh farming. The subsidy system, which ensures farm viability, is set to change to guide farmers towards sustainability but represents a more significant change than in England or Scotland. The WG white paper supports these sustainable practices for environmental and social reasons noting that it could lead to improved economic results (Welsh Government, 2023a). The WG finds itself in a situation where a model for greater sustainability and resilience will be attractive after successive years of crisis, fears, and risk. Brexit is still perceived as a risk with farms still leaving the industry (StatWales, 2020). Questions remain on how the future scheme will be implemented and how it will interact with long-term and short-term drivers of change in agricultural systems. Some might drive the sector towards sustainability (e.g. fertiliser price increases) while others are pushing in the other direction (e.g. reduced market prices). The future agricultural development impact on farm diversity resulting from these combined factors might not match WG ambitions for the sector.

Considering Brexit and the different potential challenges for farms helped clarify the existing analysis around Brexit and farms as well as the likely gap in the literature. The impact of Brexit on farms has first been considered mostly through the lens of the

uncertainty that it created and particularly the risk of a no-deal Brexit (Dwyer, 2018; Thomas et al., 2021; Van Berkum et al., 2016). Most of the literature on the impact of Brexit on the agri-food sectors is focused on specific consequences that Brexit could have on part of the supply chains (e.g. media treatment impact of Brexit; BBC News, 2021) or farms (e.g. horticultural labour; Nye and Wilkinson, 2022). Given the timescale, most studies or impact assessment linked to the potential implementation of future policies were only considering the macro scale and used secondary data and focused on one specific axis (e.g. on trade deal impact on UK farming). The socio-cultural sides of the impact on farms and on rural areas were not often considered and resulted in significant uncertainties (Hill and Bradley, 2019). Studies rarely managed to consider the sector-wide potential interactions between challenges faced or the likely response of farms resulting in a different role in rural areas, as perceived by the Welsh Government. Wales has had less coverage compared to England or Scotland. The research questions can help address this gap, while focusing on Wales and the challenges highlighted above:

- Among all the challenges faced by Welsh farming what are likely to be the most significant for Welsh farming and its sustainability?
- How will the future SFS scheme in Wales interact with the drivers of change at play, and impact farms' multifunctionality?
- What policy adaptations might be needed for Welsh farm policy to ensure it reaches its broad goals as set out in the Agriculture Act?

'Multifunctionality' has been coined and used in policy discussions to refer to the notion of farming delivering a range of functions for society, in addition to food production with environmental, ecological or socio-economic benefits (Knickel and Renting, 2000). WG will support farm-based scheme actions (Table 1-1) but they are expected to have a wide-knock on impact as the range of outcomes expected shows either directly (e.g. landscape condition) or indirectly result (e.g. farm viability) and at different scale (e.g. national/regional scale for Welsh language).

Chapter 2 will review in detail the concept of multifunctionality and highlight criteria that can help select a research method to answer the research questions. After this

introduction, a literature review will be conducted to guide the choice of methodology. A holistic field-based case-study assessment method has been used as the main data collection mechanism for this study. The five results chapters cover successively the main findings of the research, Chapter 3 presents the baseline evidence to discuss the historical change and economic analysis of Welsh farming in Chapter 4, 5 and 6. These chapters cover different geographical areas of Wales. Chapter 7 focuses on the potential impact of the SFS, and Chapter 8 concludes by answering the three research questions and reflecting on lessons learned and further research needs arising from this thesis.

Chapter 2. The concept of multifunctionality and Welsh farming

Chapter 1 revealed the diversity of Welsh agriculture, both regionally and within regions, with different types of farms contributing to various functions such as sustainable agriculture, landscape management, and territorial identity. The research questions are aimed at assessing the potential impact of the future WG scheme (Welsh Government, 2023a) and identify any current barriers that could prevent the achievement of the WG goals. In addition, it will be necessary to undertake a prospective analysis of the future change of this diverse “ecosystem” in order to assess how it will react to the WG offer.

Chapter 1 introduced 'multifunctionality’ as an overarching concept which could potentially provide an articulation between farming and sustainability to match the WG’s ambitions, by acknowledging the broad range of functions that farming provides to society. Chapter 2 will discuss the interest in the multifunctionality concept, before considering the research methods required to answer the research questions: assessing Welsh farming challenges and considering the potential impact on multifunctionality of future change and likely responses to the proposed new WG scheme. A literature review of approaches to evaluate multifunctionality will help determine criteria to evaluate the impact of the SFS on Welsh farming multifunctionality. The method will have to consider spatial and temporal diversity as well as the interlinkages between farming and the land, and farming and its up and downstream links in supply chains, and farming and communities, and the diverse nature of contemporary farm businesses. Finally, retaining the comparative agriculture method will be shown to be adapted to study multiple and interconnected disciplinary insights, and particularly the use of a case-study approach to capture a diverse range of local situations.

A. Multifunctionality and sustainability

In this section the concept of multifunctional farming will be discussed as a potential concept to understand the roles played by agriculture in Wales. Multifunctionality has been coined and used in policy discussions to refer to the notion of farming as delivering a range of functions for society, in addition to food production (Hawketts et al., 2017; Hediger and Knickel, 2009). In academic literature, this concept has been explored and critiqued by social scientists and geographers as well as agricultural economists - three disciplinary perspective will be used in considering its potential value for understanding Welsh agriculture. Farm multifunctionality will be defined not only as an institutional concept, a tool for governance but also a practical concept (as seen in Hawketts et al., 2017).

1. Context

As discussed in Chapter 1, agricultural policies since the Second World War had pushed for an increase in food output with increasing labour substitution by capital and other inputs. Farms had specialised gradually to one main function, food production with a negative impact on rural development and the environment (Hodge, 2016; Moore, 2010; Rackham, 1986). This led to a broad criticism of the productivist policy model with its food-producing vision of rurality (Marsden, 2003; Moore, 2010; Wilson, 2001). Environmentalism was also an important growing force, particularly in some European countries (Clark and Scanlon, 2019; Oostindie et al., 2006; Sattler et al., 2023). At the same time, in trade policy the neo-classical vision of the WTO and the GATT advocating freer trade was pushing for market forces to play a greater role in the agricultural sector (Van Huylenbroeck et al., 2007). The Cairns Group of countries in the WTO were strongly against the protectionism and heavy agricultural support by governments that characterised the post-Second World War policy paradigm in Europe (Losch, 2004; Marsden and Sonnino, 2008a).

Neoliberalist theories promoted the globalisation of agriculture, and predicted that the removal of subsidies would reduce trade distortion between countries, potentially permitting a more efficient use of agricultural resources (Potter and Burney, 2002;

Wilson, 2008). In response, critics noted that this could exacerbate the negative environmental and social consequences of industrial agriculture, through more intense international competition (Potter and Goodwin, 1998; Robinson, 2018).

The concept of “multifunctional agriculture” was first introduced in 1993 by the European Council for Agricultural Law, as a way to highlight the fact that one economic activity can play a role in delivering multiple goods and services for society, at different scales and places (Hawketts et al., 2017; Rippon, 2004). Farming, aside from food and fibre production, can provide other benefits to society: environmental, ecological, and socio-economic (OECD, 2001). Among these products there would be goods and services for which a market exists, while others would be qualified as externalities or non-market goods (Machado, 2004a). Many services linked with agricultural activity have been identified with or without direct causality (Pimbert et al., 1999; Van Huylenbroeck et al., 2007). Different functions can be joint with the food and fibre producing activity (Huang et al., 2015). The concept was popularised in the international political discussions of the late 1990s to describe a potential way to re-think agriculture and its support, but it has since continued to evolve.

2. Evolution of the concept

Debates around multifunctionality as a socially-constructed and negotiated concept seem be organised around four successive visions (Barnaud and Couix, 2020; Huang et al., 2015; Perraud, 2003)**.** The first sees agricultural multifunctionality as pluri-activity that farms are adopting. In other words, it describes a combination of agricultural and non-agricultural goods/services/income produced by farmers, akin to income diversification strategies (Barnaud and Couix, 2020). This specific definition is not heavily represented in the literature (e.g. Bartolini et al., 2014), but it is useful to understand the potential impact on rural development (Marsden and Sonnino, 2008). Pluri-activity is often perceived as an income substitution strategy away from food and fibre production.

The concept can be traced to various wider societal and political transformation processes at different scales, each representing an opposition to the productivist focus of agriculture (McCarthy, 2005). Multifunctionality has been associated with the

resolution of agriculture's problems, whereby less productive farms could be expected to deliver other societally desirable outcomes (Groot et al., 2009; Wilson, 2008, 2007). In other words, societies' expectations in terms of services that are to be delivered by rural areas have changed, food production is no longer the main activity for the majority, more and more their amenities and other functions of are gaining importance (Munton, 2009).

Multifunctionality represented a counter-argument to oppose further liberalisation of the European agricultural sector, by focusing on exceptionalism (Machado, 2004a; McCarthy, 2005). It was claimed that EU agriculture took place at a smaller scale and with an extremely diverse profile in terms of products, as compared to the agriculture of Cairns group countries which were focused on the large-scale production of commodities, i.e. a much more productivist agriculture (Hawketts et al., 2017).

The EU embraced the concept of multifunctionality for two key reasons:

- In the international arena its negations for trade liberalisation could progress by including a specific European vision in terms of its 'model of agriculture' with the concept of multifunctionality (Hawketts et al., 2017; OECD, 2008). The support for multifunctionality was political (Potter and Burney, 2002) providing a counterargument to liberalisation, thus satisfying some EU member states (Van Huylenbroeck et al., 2007).
- Domestically, it had the potential to help redirect the much-criticised CAP away from productivism (Jean, 2007; McCarthy, 2005), by identifying the multiple roles assigned to agriculture by society. Focused on a "normative" vision, i-e by providing a long list of these functions, the language was compatible with maintaining farm-focused support while addressing various environmental and socio-economic concerns (Bazin, 2003; Bohman et al., 1999).

Multifunctionality could be seen as a tool to understand local characteristics and support them adequately, in response to pressures of globalisation and processes of economic development (Daniel and Perraud, 2009; Parent, 2001; Tafani, 2011). Some authors justified policies and farm support as a way to protect naturally significant areas, and/or their culturally significant production methods, and to sustain heritage

(Bazin, 2003; MacDonald et al., 2000; Machado, 2004a). Tafani (2011) noted that a new, positive vision around territorialisation could be retained by areas that had not benefited as much from productive agriculture, trying to preserve identity. Indeed, multifunctionality has been increasingly recognised through specific landscapes and territories, as well as through tourism or geographically-identified products (e.g. PDOs recognised in 1992, in EEC policy although equivalent existed previously in other nations) (Perraud, 2003) in situations with a more limited connection to productivist agriculture (Tafani, 2011).

Following on from the discussions in an international trade context, the OECD played an instrumental role in developing a 'framework for multifunctionality' in agricultural policy assessment. Its aim was to provide an interpretation of multifunctionality that could help to limit protectionist policies (in direct opposition to the aims of other proponents of the concept), whilst recognizing the legitimacy of states seeking to recognise and acknowledge the other benefits that agriculture could or should provide (Ollikainen and Lankoski, 2009; Hawketts et al,2017). In essence, it took a neoclassically "mainstream economic approach that could be shared among countries with different trading positions" (Hawketts et al .2017, p. 18.). This resulted in a reductionist vision of multifunctionality. Its paper, OECD (2001), took a neoclassical approach to analyse the concept and its policy implications, this centred around a constrained treatment of the 'jointness' of production. With this definition of multifunctionality there is a need to prove the link between two types of product; OECD (controversially) claimed this was a "positive definition" as opposed to the EU's "normative definition" (OECD, 2001), further explaining "Joint production refers to situations where a firm produces two or more outputs that are interlinked so that an increase or decrease of the supply of one output affects the levels of the others. Three reasons for jointness are frequently distinguished: i) technical interdependencies in the production process; ii) non-allocable inputs; and/or iii) allocable inputs that are fixed at the firm level." (OECD, 2001, p. 12). The OECD argued that as a result, farming's positive environmental or social outcomes had to be proven, to subsidise these functions through agriculture, and concluded that government's involvement should be limited to non-commodity production clearly associated with some form of market failure. This vision first articulated in OECD (2001) was developed in OECD

(2008) to investigate the issue of degree of jointness through various papers. It showed that interlinkages farms' activity and resulting products (market or non-market) were difficult to identify economically, even with the development of methods for the economic valuation of ecosystem services (OECD, 2008).

Based on this vision, fears arose that some non-market goods provided by farms could end up being traded as commodities in the future after identifying a link (McCarthy, 2005; Perraud, 2003). This reductive approach was criticised in academia, as it tended to limit the interest of the concept (Barnaud and Couix, 2020). Since the mid-2000s, multifunctionality has not been prominent in EU policy discussion, although as will be demonstrated, the concept has continued to evolve in broader usage (Hawketts et al,2017). Some academics criticised that the use of the term by the EU to protect its policies had led to its loss of acceptability in the international arena, in turn leading to a focus on other concepts in the policy-making process (e.g. Bazin, 2003; Kroll, 2002).

At the same time as the OECD was producing its framework, Vaucoret et al,(2007) considered a regional case-study analysing the composite and integrative nature of multifunctionality. They concluded that it was better analysed through an integrative vision than by only considering positive externalities, as per the "functional" approach of OECD. Their work proposed a vision of multifunctionality that aligned with rural development and sustainable agriculture, putting food production and agriculture at the centre of the web of sustainable rural economies and local societies (Marsden and Sonnino, 2008). This alternative vision suggested a pragmatic balance between the benefits and the dis-benefits of farming, in multiple terms (for economy, environment and society).

Multifunctionality was later applied to a wide range of functions (Figure 2-1), with a return to a normative vision (e.g. Bernués et al., 2015; Van Huylenbroeck et al., 2007); although still based on public or policy expectations (Gaupp-Berghausen et al., 2021a; mccarthy, 2005) or derived from scientific analysis. Parents (2001) highlighted five main functions (agricultural, economic, social, cultural, and environmental) (Figure 2-1).

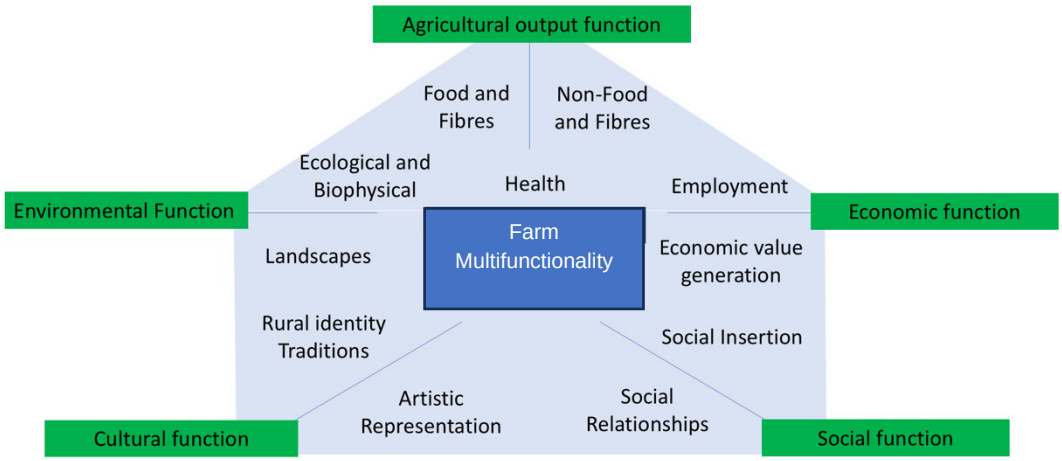


Figure 2-1: Farm multifunctionality in different categories (adaptation from Parent, 2001; Turner and Daily, 2008)

Renting et al,(2007) and McCarthy, (2005) showed that this range of functions and services could fall under the different pillars of sustainability; echoing reviews showing that multifunctionality was best understood as part of the concept of sustainable development (Bohman et al., 1999; OECD, 2001; Wilson, 2008). Guiding farms towards increased multifunctionality was seen as a development model moving away from specialised, food-focused agriculture (Parent, 2001; Wilson, 2008). Barnaux et Couix (2020) in a review of multifunctionality, noted that there could be trade-offs between the different functions, depending on the resources available. For example, if there is a consensus around the maintenance of extensive mountain farming in the policy and science arena, it could limit desertification but also negatively impact ecological state (as seen in MacDonald et al., 2000). The trade-offs were context-specific; quite often linked to a specific location, time and organisation (Aumand et al., 2005; Nowack et al., 2021).

Today, multifunctionality could therefore represent a new potential framework to develop rural areas, with agriculture as one of its backbone (Hodge and Midmore, 2008; Parent, 2001; Tafani, 2011). For example, positive change towards sustainability can be made as a result of change in land use on farms, as shown by Oostindie et al,(2006).

In summary, having reviewed multifunctionality, it is suggested that it is a useful concept with which to understand that farms produce more than food, and that this can be linked to positive or negative impacts on economic, social, and environmental goals and outcomes. Whilst the concept has had multiple definitions, its meaning and application has evolved, and it retains a strong appeal through its flexibility, its integrative nature, and its links with sustainability. The wider range of functions that are considered seems highly relevant to understand the state of Welsh farming and assess the potential results of the WG within the direct and indirect framework of action highlighted in Chapter 1. This section will discuss why evaluating the multifunctionality is likely to answer the research questions more adequately than other potential concepts.

B. Criteria to guide the selection of the research method

1. Criteria for the evaluation

The WG has defined its goals for agriculture, with an explicit commitment to environmental sustainability alongside broader goals for economic and socio-cultural value (Figure 2-2). Outcomes would be attained because of farms' adapting their practices through adoption of the SFS giving a highly systemic nature to the future scheme.

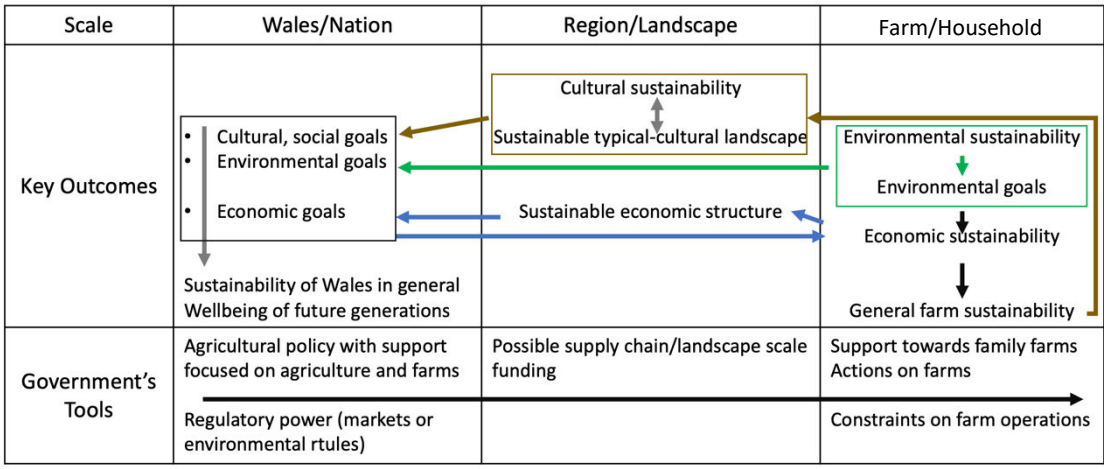


Figure 2-2: Agricultural policy framework of action: farm-centric actions and their ripple effects (by the author)

The research questions could be answered by an ex-ante evaluation to understand the potential impacts of proposed interventions before they are implemented to try to

inform policy design and suggest how to improve its efficiency (HM Treasury, 2020). An ex-ante evaluation reflects on the current situation to measure against likely future progress. It tends to focus on the mechanisms likely to deliver the policy but also making sure to understand where the future risks lie and how to control them as shown by Dwyer et al., (2008). The Magenta Book insists that the choice of the type of evaluation should focus on the mechanism of the policy intervention and its likely impact, although Knickel and Kroger, (2008) noted - as Chapter 1 did - that it only represents an influence among many others on farm multifunctionality.

An ex-ante evaluation could highlight the different obstacles present or future to attain these outcomes to suggest a likely course of farm change if linked to an understanding of policy mechanisms (Knickel and Kroger, 2008). As goals and modes of actions will be articulated at different scales in the WG vision (Figure 2-2; Welsh Government, 2023a), the policy-driven changes to operating practices (whether it is or is not taken up by farm businesses) among the diversity of farms (Devienne et al., 2005; Van der Ploeg et al., 2009) will impact the expression of multifunctionality at different scales. The operating practices will be linked to other land use and rural economic activities. Multiple factors at different scales will have to be considered, to assess whether the goals are achieved; as agriculture and rural areas react to endogenous and exogenous factors which are applied and relevant at different scales (Boussard, 1987).

If an ex-ante evaluation tends to hold a lot of uncertainty regarding what is likely to be future course of action it is even more the case given the early stage of policy design of the SFS (in 2020) it also represents a clear break from previous policies contrary to for example past Rural Development Policies. An ex-ante evaluation is also important as it sets a baseline against which future change can be monitored (HM Treasury, 2020). Chapter 1 showed the highly uncertain nature of the economic environment and the state of policy development in 2022. In general, the detailed analysis of past trends in drivers and in farm adaptations is used in the literature to consider the likely future trends, to analyse how successfully the goals of the WG can be reached, in a prospective/foresight exercise (e.g. as in Reed et al., 2009).

The research questions and the specific mode of action of the policy show that to evaluate the success of this policy it is likely that concepts and assessments embraced will have to consider:

- These interlinked elements; economic sustainability, environmental sustainability, and culture (inc. landscapes; Reed et al., 2019).
- How past and future policies impact Wales at farm, landscape, and national levels to achieve policy outcomes (e.g. Devienne et al., 2019).
- The range of scales of application of relevant WG policies and other factors that might impact the diversity of farms (Chapter 1; Van der Ploeg et al., 2009).

2. Choice of concept and linked research methods

The future of Welsh farming hinges on its ability to navigate complex challenges to be sustainable in the future. There are two key concepts that could help evaluate the sustainability of agricultural policy to bring a cohesive, nested, and integrated understanding of its impact but also of existing challenges; "multifunctionality" and "ecosystem services."

The concept of ecosystem services focuses on the ecological benefits farms provided to humans; “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life.”(Daily et al., 1997). It is widely held that the Millennium Ecosystem Assessment helped popularise it (Millennium Ecosystem Assessment, 2005). This concept originates in ecology it has had limited take-up in political circles so far (Hawketts et al. 2017), potentially due to its slightly different focus compared to multifunctionality. Frameworks built around this concept aim at quantifying the value of provisioning services like food production and regulating services like soil health (La Notte et al., 2019; Turner and Daily, 2008). Ecosystem services frameworks often overlook the social and cultural aspects (Australian Government, 2010) crucial from the WG point of view. Another key aspect of multifunctionality is the fact that it has been identified by part of the literature as being delivered by a diversity of farms; different types of farms contributing different elements (Ickowicz et al., 2022; Knickel et al., 2004; Laughton, 2017).

The answer to the research questions will have to reflect on this diversity to understand likely future change considering “The diversity … of farm households needs to be assessed in a different way, taking into account the roles of this diversity for meeting new social and environmental purposes.” (Van der Ploeg et al., 2009). The diversity of farms, their practices, their underlying challenges, and the resulting socio-economic and cultural elements enshrined in Welsh landscapes would not be as readily captured by an ecosystem services approach. Multifunctionality encompasses the diverse benefits farms provide as demonstrated above, while linking it with farm practices. Furthermore, multifunctionality's flexibility allows it to be adapted to the specific goals of the Welsh SFS. For instance, the SFS might prioritise cultural landscape preservation alongside agricultural production. Multifunctionality could accommodate this by incorporating both aspects into the evaluation framework (Van der Ploeg et al., 2009).

While both multifunctionality and ecosystem services offer valuable insights, retaining multifunctionality as a core concept provides a more adequate framework to assess the likely impact of the SFS.

C. Methods to evaluate multifunctionality in agriculture

This section will identify a set of requirements for a research method to answer the research questions. The first step will be to highlight the potential opportunities and challenges around the evaluation of policies trying to develop multifunctionality.

1. Evaluation of policies fostering farm multifunctionality

If policies can be designed to support multifunctionality and sustainability across the territory (Berriet-Solliec et al., 2003; Dupraz et al., 2001), then it can be said that the CAP has so far failed to achieve this, despite its past multifunctional vision. O’Connor and Dunne, (2009) showed that the fragmented nature of policy measures, their diverse and overlapping goals. This creates a challenge to evaluate multifunctionality and as a result, studies often focus on only some of the sustainability axis side elements (Barnaud and Couix, 2020; Daniel and Perraud, 2009; Struillou, 2003). This might come from the siloed tools used in agriculture and environmental research that

have not lived up to the needs of a holistic concept (Gaupp-Berghausen et al., 2021). Knickel and Kroger (2008) highlighted that as a result in most studied “countries – except France and Italy – multifunctionality is not an explicit concern in policy and its evaluation” (Knickel and Kroger, 2008, p. 406) and even then, it is perceived as a tool of control and not necessarily as a tool for future decision.

The complexity of multifunctionality has limited its use in policy and policy evaluation, Knickel and Kroger (2008) showed the concept was perceived as difficult to encompass, it has been difficult to evaluate it due to the unsuitability of observation and evaluation tools and methods. At the time the authors re-iterated the interest of the concept considering the increasing focus of policies on sustainability “What has been largely neglected so far is the discussion of multifunctionality as a promising conceptual and analytical framework.” (Knickel and Kroger, 2008, p. 415).

After this brief introduction to the challenges of multifunctionality evaluation the next section will consider methods that have been used. The broad needs of an ex-ante analysis of the SFS impact on farm multifunctionality have been discussed in the previous section and set a baseline of parameters for the evaluation (e.g. scale, linkages).

2. Methods for evaluation

Ferrari and Rambonilaza, (2008) review of approaches to evaluate multifunctionality showed the challenges of linking the quantitative and the qualitative findings, but reflecting on Knickel et al., (2009) framework it was also revelatory of the siloed approach taken in multifunctionality evaluation and the limits of classic evaluation tools, like cost-benefit analysis.

The literature has extensively discussed how to evaluate and value multifunctionality (Barnaud and Couix, 2020) the latter does not link directly linked to operational processes as it tends to focus specifically on benefits (or disbenefits). Researchers have often sought to find and measure indicators that can act as a proxies, trying to ascribe a value to a specific asset or service - usually ones which does not have easily-observable market prices (Ferrari and Rambonilaza, 2008; Rossing et al., 2007).

According to Song et al., 2020, there could be four different types of valuation in multifunctionality that lead to the identification of indicators; economic, bio-physical, socio-cultural and holistic (Figure 2-3).

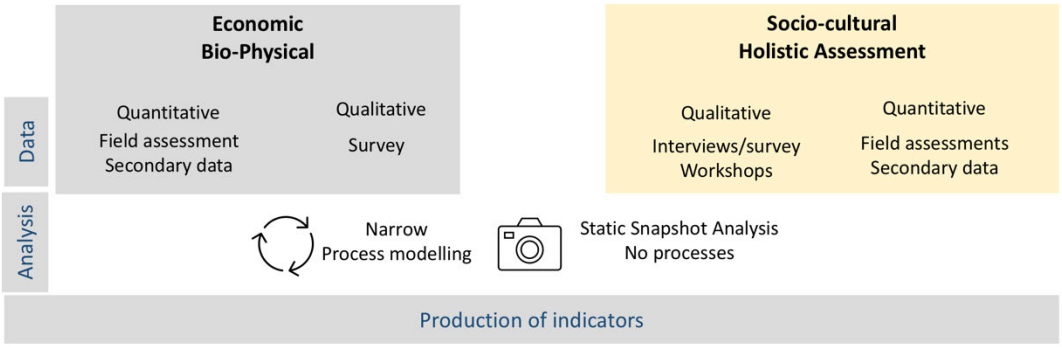


Figure 2-3: Different method to evaluate multifunctionality (by the author from the literature)

Given the origin of the multifunctionality concept, it is strongly represented in economics. In this context, its assessment is based on a range of techniques based either on the quantitative analysis of secondary data or using other approaches to examine its value (Hediger and Knickel, 2009; Madureira et al., 2007; Torres-Miralles et al., 2017; Van Huylenbroeck et al., 2007). The bio-physical valuation has also been investigated extensively with methods focusing on quantitative analysis (Barnaud and Couix, 2020; Song et al., 2020). The socio-cultural valuation of multifunctionality uses qualitative methods with factual assessments or mixed methods. Studies using this approach tend to be non-comparable (Mansfield et al., 2004; Midmore, 2000; Nowack et al., 2021). One challenge, for the study is therefore that the approaches to evaluating multifunctionality (the outcomes) are often siloed not reflecting correctly the interest of multifunctionality (Knickel and Kroger, 2008), tend to use a wide range of methods difficult to link between them(Ferrari and Rambonilaza, 2008), they are also not to operating processes (Devienne and Pillot, 2003; Tafani, 2011).

In effect, evaluating farm multifunctionality, as explored by Janssen and van Ittersum, (2007) and Rossing et al., (2007) involves assessing a farm's performance across economic, environmental, and social aspects. An evaluation of a policy focused on multifunctionality will need to provide insight into existing issues and potential improvement of the production process of multifunctional outcomes (e.g. Lovell et al., 2010; Waldhardt et al., 2010). As a result, simply estimating farm multifunctionality

outcomes is unlikely to provide answers although it continues to be a strong focus of the literature.

Holistic evaluation gradually appeared, in response to the limitations of other types of evaluation (Mastrangelo et al., 2014; Song et al., 2020; Tafani, 2011). A holistic evaluation generally combines qualitative and quantitative research with indicator-based approaches (such as proxies derived from secondary data, and specific data collection) combined in an analytical hierarchy to integrate indicators after weighting them (Song et al., 2017). Holistic approaches to multifunctionality evaluation are less frequently found in the literature due to restrictions around secondary data availability (e.g. Dwyer et al., 2008) and the lack of links between different data, the farming diversity and processes leading to its expression (Song et al., 2020; Tafani, 2011). Knickel and Kroger, (2008) suggested that future research on the evaluation of multifunctionality should aim at linking in creative ways quantitative, qualitative, discursive approaches to adapt to more holistic concepts.

Another challenge has been the multitude of approaches used to adapt to the data available and the functions identified. The indicators are often defined or restricted to the needs of actors and the means available to collect them (Song et al., 2020), for example, Rossing et al., (2007) highlighted that “farmers, policy makers or scientists propose indicators, resulting in a more or less subjective selection with limited transferability” (Rossing et al., 2007, p. 43). It therefore tries to evaluate against multifunctionality outcomes by Ferrari and Rambonilaza (2008) and Knickel et al. (2009) but with limited comparability.

A key aspect used in the assessment of multifunctional agriculture has been a reliance on typologies of farm models[11] to represent the link more easily between farm practices and multifunctionality, with a systemic approach. According to Renting et al. (2007) these models can help evaluate multifunctionality representing the links between farm processes and their outcomes; helping to assess the efficiency,

[11] Models are theoretical abstractions used to make sense of the world and organize our understanding of it… First and foremost, models describe the units, conditions, and outcomes that define inquiries.” (Alexander, 2023)

challenges but also identify the potential for improvements. For example, Vaucoret et al., (2007), did an assessment of multifunctionality which identified a typology of farming structures at a regional scale and what they were delivering. They concluded, like Laurent et al., (2003) or Barthélemy and Nieddu, (2003), that to understand changes in farming it was important to understand the link to the production process. The models in Vaucoret et al. (2007) were differentiated using a holistic vision and were sociological, practice and history based. They were not only linked to farm specialisation or performance indicators. It should be noted that the limited amount of quantitative relationships covered in the models can limit the capacity of this approach to understand future change (Rossing et al., 2007); for example management practices tend to be marginally taken into account (Allan et al., 2015; Hölting et al., 2019; Song et al., 2017). These models, often do not reflect deeply the socio-cultural functions of agriculture, focusing mainly on its economics and implications for the environment. In the reviews of approaches to evaluate multifunctional agriculture, the complexity and interrelations across different actors at different scales was identified as a challenge (Huang et al., 2015; Nowack et al., 2021; Payraudeau and van der Werf, 2005; Song et al., 2020), in systemic approaches it often led to some simplifications. This strong link of farm models with farm practices is a significant element that could help answer the research questions.

Groot et al., (2009) judged that scenario linked to potential changes if applied to a model could inform “stakeholders in two ways: by suggesting goals and possible futures (policy development) and by establishing consequences of choices through mapping change trajectories (planning).” (Groot et al., 2009, p. 157). This was also judged to help identify how different drivers interact by Knickel and Kroger (2008) and Reed et al., (2009). An example of this would be the comparison of an existing landscape to the likely future landscapes by Waldhardt et al., (2010). This could help reflect some of the existing uncertainty around the future.

One way to address those concerns is to consider the landscape implications and impacts of agriculture, the analysis on farm multifunctionality would be at a regional or landscape scale as shown in Vaucoret et al., 2007. Similar approaches in the literature were found for example, on the implementation of high nature value farming (e.g.

Antill, 2000; Gafsi et al., 2006), the consequences of production systems on multifunctionality (e.g. Wilson, 2008), or specifically farmers' understanding of multifunctionality (e.g. Barnaud and Couix, 2020; Dufour et al., 2007). These studies managed to qualitatively model different farm functions using different approaches for each type of function and related challenges. Some authors commented that a potential improvement would be to standardise the way to quantify this complex information and inter-relationships, but since then no clear framework has emerged (McCarthy, 2005; Song et al., 2020). Nevertheless, case studies enable a closer connection between -and understanding of- different aspects of multifunctionality in different landscapes, this in turn can make it easier to understand the interrelated actors and drivers in the evaluation of multifunctionality.

A case-study of farm processes and how they are linked to a landscape, particularly if they can be chosen purposively could meet the needs of the research questions and provide the potential for a holistic evaluation of policy impact on multifunctionality (e.g. Fare et al., 2017; Machado, 2004a; 2004a; Waldhardt et al., 2010). Nevertheless, Renting et al., (2009) found those would focus on some functions more than other (i.e. with more emphasis on economic and environmental elements, because they more readily suggest appropriate indicators), but that it was inherent to the nature of conceptualisations from different disciplines coming together to understand multifunctionality.

In summary, the vision of the WG in terms of actions or impact guided the review of evaluation methods to highlight further criteria for a research method. It led to identification of the need to do some modelling to do an ex-ante analysis of future scenarios. A case-study approach with primary data collection would be necessary to ensure a causal link between operating practices and different elements of multifunctionality, linked with the diversity of Welsh farms (e.g. Figure 2-4).

3. Different scales to consider

The distinction between the different levels of actions of the SFS and WG regulations and the different levels of expression of their outcomes is likely to be important to consider. Evaluating multifunctionality and how the actors behind it interact at different scale is likely to be a challenge. Groot et al., (2009) showed that multifunctionality will arise from interactions within and between hierarchical levels of characterisation and analysis (i.e. field, farm, landscape, region; Figure 2-4), and that the heterogeneity and diversity within agricultural systems in different landscapes is therefore crucial for examining it adequately.

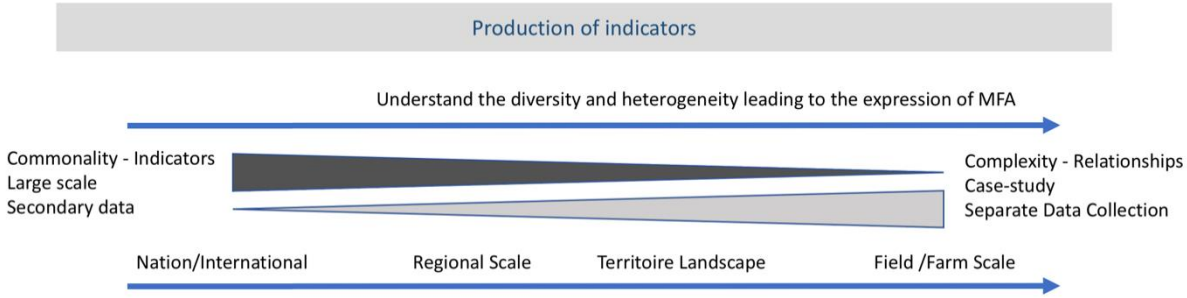


Figure 2-4: Farm multifunctionality and scales (by the author)

The expression of agricultural multifunctionality at different scales is a potential issue for practical assessments of multifunctionality (such as Machado, 2004a; Soulard, 2005; Waldhardt et al., 2010). Within the vision of multifunctionality, the joint products of the main agricultural output result from decision-making at farm scale. Farm management choices (economic, social and environmental) will result in bio-technical processes with impacts that can be witnessed directly at the field and then at the landscape scale (e.g. Le Clec'h et al., (2019), with low intensity agriculture and high nature value landscape), or indirectly at a larger scale (e.g. at the regional scale for the economy as in Knickel and Renting, (2000). Indirect links particularly at larger scale are more difficult to understand and evaluate (Allaire and Dupeuble, 2004; Groot et al., 2009; Wilson, 2008).

The farm represents the production unit resulting from a decision-making process and the initial level of agricultural multifunctionality outcome (Rapey et al., 2005; Wilson, 2007). The functions acting together will have cumulative effects, which can be positive, neutral or negative overall at different scales (Dobbs and Pretty, 2008; King et al., 2015; Rodrigues and Hanley, 2021; Wynne-Jones, 2011). Another element to

consider is the issue of temporality in delivering farming outputs. Farming processes take place at different times of the year and in activities across the farm, with trade-offs between activities (e.g. Knickel and Kroger, 2008). The drivers affecting farm decisions also operate at very different scales further reinforcing this logic of nested scales that have been demonstrated (Wilson, 2007).

The scale at which the evaluation of multifunctionality takes place can significantly influence the understanding and assessment of farming multifunctionality (Groot et al., 2009). Studies conducted by Argent, (2011), Mansfield et al., (2004) and Soulard, (2005) underscore the significance of scale in assessing the link between multifunctionality and the territorial identity of an area. The expression of multifunctional agriculture can be seen at different geographical scales (Holmes, 2006), from large-scale (e.g. Potter and Burney, 2002) to the individual field (e.g. Rapey et al., 2006) and different scales of analysis tend to reveal the different scope of functions (Figure 2-4).

Case studies can capture information and interlinkages at a local scale, but at a larger scale there is a risk that they miss key information or interrelations. To avoid this Moreau et al. (2012) used two complementary territorial holistic case-studies considering the links between farm practices, driving forces and the resulting economic and environmental impacts to generalise some of their findings. Multifunctionality expression is interconnected to land management strategies and driving factors across different scales. Focusing on the farm scale provides the direct link between practices and multifunctionality expression, it is essential to consider broader scales to capture all the interactions within agricultural systems.

In summary, the evaluation will likely require analysing Welsh farming diversity to understand its potential future changes, as well as to assess the influence of new policies and the impacts on WG goals. It must consider the interdependence between and across scales in farming activities. The specific goals of the Welsh vision for the SFS and its actions can help to identify the scales that must be included to analyse farm multifunctionality:

- The farm as the decision-making unit, impacted by factors operating at other scales
- The landscape scale, with its direct expression of multifunctionality linking economic, social, and environmental outcomes in spatially distinctive ways
- The region, or all-Wales level at which the impact of these functions might be more indirect but at which the policy is fashioned and many of the key drivers of change will operate

As has be shown, when integrating elements and scales it is essential to ensure a consistent holistic approach to multifunctionality where actors and functions at different scales are inter-related. While a case-study approach which produces farm and landscape-scale models would seem adequate, all three scales will have to be considered in the selection of the overall research method. The next section will discuss a concept and its research method which could fit many of our criteria (Figure 2-15).

D. Agrarian system and agrarian diagnosis

Kropff et al. 1997 showed that “The complexity of the problems and conflicting objectives call for systems approaches in which issues are addressed in an integrated multidisciplinary way” (Kropff et al. 1997, p. 2). Laurent et al., 2003 showed that these approaches are flexible, integrate scales and maintain interdependent links between actors and functions[12]. This section briefly considers farming system research and its interest for the evaluation before discussing the agrarian diagnosis concept as developed within the comparative agriculture approach, as an integrative systemic concept. The agrarian diagnosis, the tool to study the agrarian system, will be shown as a method that could meet the needs of the evaluation although it has not been discussed extensively in anglophone literature and it has been little used to explicitly study multifunctionality.

[12] Also highlighted by Norman, 1995 more generally on the benefits of system-based approaches. Key functional concepts are integrated in systems (Kropff et al., 1997).

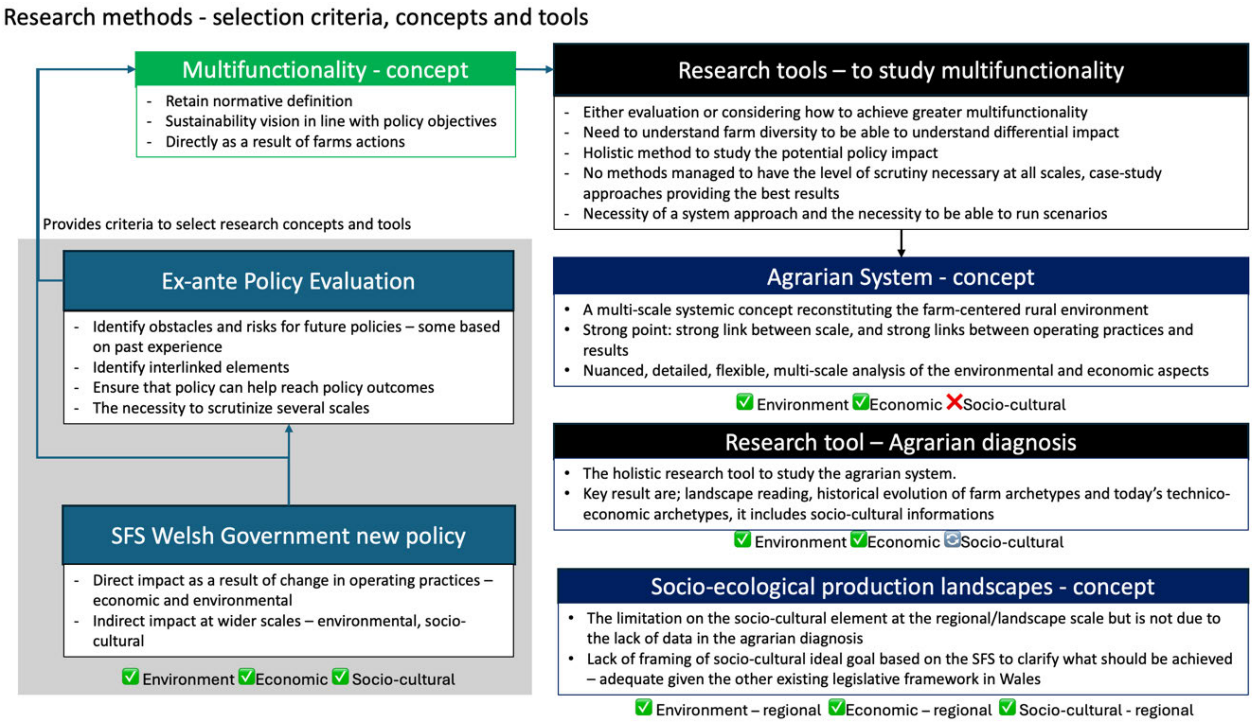


Figure 2-5: Research methods selection and selection criteria, link between the different concepts (by the author)

The diagram in Fig 2-15 captures the combined approach that was adopted to answer the research question linking the thinking from the Welsh Government policy and evaluations to the different research concept introduced. This will help clarify the link between the research method investigated in-depth and the research questions, this will be subsequently explained in more detail in the following sections.

1. Farming system research

The concept of farming system research to understand farm decision making and farming change has grown in importance in the anglophone research community. In general, the expression "farming system" usually indicates that the scope of study encompasses farms' structure, organization, and operations (Kropff et al., 1997). Its aim is to understand what farmers do, how they do it, and why they do it; in other words, to understand the logic behind the combination of activities on the farm and the reasoning and/or the constraints behind their operations (Devienne and Pillot, 2003). Farms are the centre of the analysis, but these analyses often consider only technical processes and economic viability (Kropff et al., 1997). This is particularly true in the

anglophone milieu where such approaches tend to be used mostly in development studies (Laurent et al. 2003).

On the other hand, in French-speaking agricultural research, social, economic, and political aspects are considered together by using a research and development approach, in which technical and socioeconomic change are considered inseparable (Cochet, 2015a). They consider “a social organisation of production” (Larrère, 1973) with historically differentiated units. This concept of the “agrarian system” emerged in French geographic studies in the 1960s, predating the multifunctionality concept. It was discussed in English by Cochet (2015a) but it remains a concept relatively absent from anglophone research. The idea stems from the interdependence of various elements in farming and offers an analytical perspective to provide a holistic understanding of farming within its operational environment, rooted in the principles of the "terroir school" [13]. The agrarian system attempts to combine research and development using “a systemic approach to productive processes combined with a deep understanding of their relationship to social processes throughout time.” (Cochet, 2012, p. 134). The agrarian system as a focus of analysis comprehensively captures farming processes and interacts with the broader regional and national factors. Its primary objective is to comprehend the complex practices and evolutionary patterns of farm systems with the farm considered as the centre of the decision-making.

To better clarify the specificity of the agrarian system, an introduction will be given to other systemic approaches. In their reviews of the approaches available, Laurent et al., (2003) or Darnhofer et al., (2012), highlighted different ways to model farms when

[13] The terroir is a portion of land appropriated, managed and used by the group that resides on it and draws from it their means of existence (INAO, 2006), in the Cochet, (2012) the definition is a usage focused definition further than the initial early vision of a well identified, specific area with a homogenous potential (Angles et al. 2014).

considering their combination of functions and how resources are combined in enterprises.

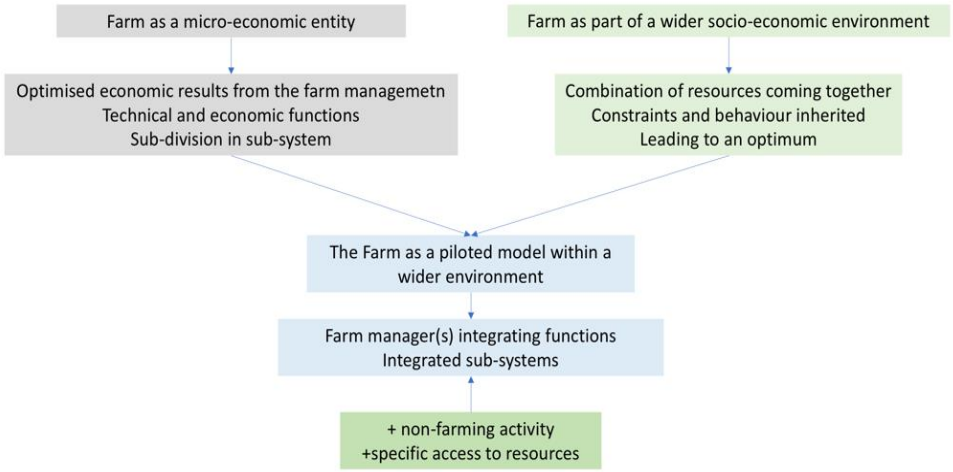


Figure 2-6: Farm model and integration, a combined vision (by the author)

The farm as a micro-economic unit (Figure 2-6) examines farm management, with production system optimisation, dividing the farm into production functions (Kropff et al., 1997), effectively sub-systems, mostly focusing on agronomic and economic systems and functions but with few environmental or social elements. This field is important as it covers the division of each part of the farm in a sub-system but it remains a relatively isolated tool (Kropff et al., 1997). The scale is relatively broad as a result, and not applied to one farm in general relying on secondary data sources, it does not lead itself to an efficient assessment of multifunctionality and remains one-dimensional (e.g. Randall, 2002; Zhichkin et al., 2022).

The second level is to understand the farm as part of a larger economic and social element with the system of production defined as a combination of resources coming together and common to a group of farms. The constraints linked to general agricultural change explain a decision-making process to reach an optimum (e.g. Rapey et al., 2005; Soulard, 2005). An integrative vision of “farmer-led decision making”[14] exists at the intersection of the two previous approaches (Figure 2-6). The farm would be best described as the farmer –the farm manager - making decisions

[14] Translation from ‘modèle piloté’ (French)

logical from their point of view (Deffontaines, 1990; Vaucoret et al., 2007), with the farm composed of integrated sub-systems while still focusing on inputs and outputs; for example, with cropping systems and livestock systems. The agrarian system integrates the holistic vision into the decision-making process on the farm (Cochet, 2012).

2. The agrarian system

The agrarian system approach considers a locally-specific use of the agro-ecosystem to answer societal needs which would be sustainable at a given time and linked to the bio-climatic factors (Dufumier, 2007). Farming systems in their diversity are included within the agrarian system that itself exists at a larger scale, as an “operational region” (Cochet, 2012). Compared to other approaches, it is unusual in considering the historic change of production within the landscape over time, to understand today’s system. The approach looks at the past, present, and future farming systems within a specific socio-economic and bioclimatic context.

The agrarian system “encompasses the agro-ecosystem and its transformations over time; production tools, labour force, and resulting artificialization (i.e. Anthropogenic impacts on the land); the social division of labour among farmers…” (Cochet, 2012, p. 130). This definition entails that the system goes from “sustainable situations to sustainable situations”, within the production factors available although acknowledging the gradual and constant farm change (Mazoyer and Roudart, 1997). Cochet described the agrarian system vision as going from one step to another through time (Cochet, 2012). The concept incorporates changes linked with agricultural crisis and agricultural revolution but also “all agrarian system evolution dynamics resulting from contradictory trends in the different parts of the system, whose evolution is partly endogenous” (De Bonneval, 1993).

In overview, the agrarian diagnosis method applied to study the agrarian system could offer an integrative approach to capture the complexities and interdependencies between people, farms and the land, something which will be necessary in the evaluation of multifunctionality in Wales.

The agrarian system integrates the diversity of farmers' different economic activities in a way that facilitates the understanding of the production process, the farm organisation, and its management practices (Cochet, 2012). A farm was shown to be integrating different functions and processes, and could be perceived as being a farmer focused model with influencing factors at different scales influencing farm decision making and thus the farms' impact at different scales (e.g. Devienne and Pillot, 2003; Wilson, 2007; Wynne-Jones, 2011). The agrarian system has different sub-systems within it, reconciling conflicts in resource use through the farm as a functional unit (Mazoyer and Roudart, 1997).

From a Bourdieusan point of view, this relates strongly with the concepts of Habitus (the deeply ingrained dispositions for example a sense of identity) and Field (where and how farmers interact with their environment) as well as the notion of capital (e.g. social capital), it's perceived as a powerful way to understand social dynamics which shape agricultural development (Sutherland and Darnhofer, 2012). This concurs with Gray, (1996) finding "that the field of farming acts like a prism, refracting the influence of outside forces onto a well-established set of endogenous social practices". Gray"s detailed analysis of individual farmers has played an important role in revealing these links. It highlighted that it is important to take a broader, more extensive view of farming to understand the development of social capital in the agricultural field, a point also made by Yarwood and Evans, (2006). The later considered also specifically the joint evolution of the bio-economic with the social capital. Comparing the agrarian system to those principles highlights that although some or most elements of these could be identified, are likely to be collected and identified, the focus is more on the bio-economic elements (Cochet, 2012).

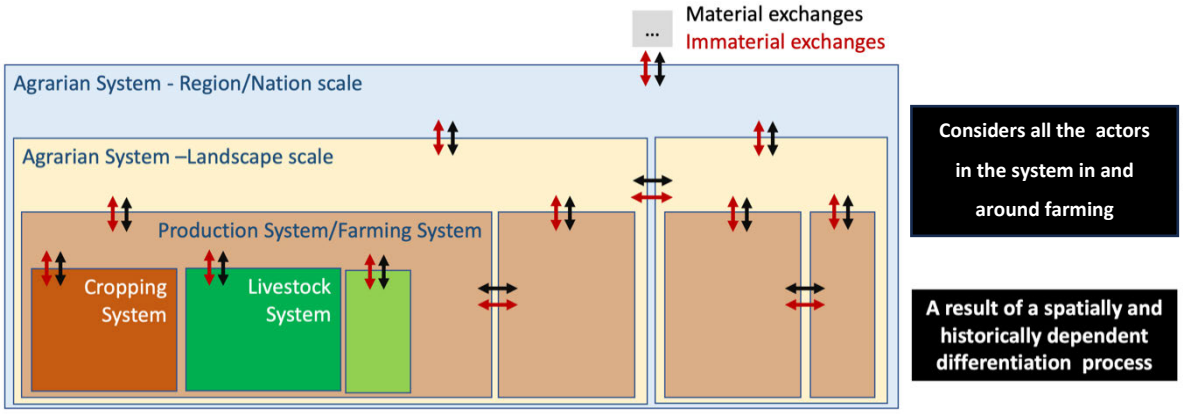


Figure 2-7: The agrarian system a nested scale analysis (adaptation from Cochet, 2012)

The agrarian system is a nested approach (Figure 2-7) with farmer holding a key role as they combine farm resources in the production process (Cochet and Devienne, 2007); for example, the different potential of different types of land determining specific fodder production choices, for livestock. Devienne and Wybrecht (2002) showed that to understand these farm-specific rationale it was necessary to understand the diversity of production systems but also their specific access to resources in a socio-economic context. Including how each of them accessed their resource and built their production systems, (although it has already been stated that individual contexts would not be described as in Soulard, 2005). The key level of analysis is the production unit—the family-owned farm, in the case of Wales. This concept articulates the nature of the production process and how it integrates with other actors' enterprises and their joint impact on the rural economy or the creation and management of landscapes (Aubron et al., 2009). These production systems are not individual farms but modelled farms representative of a specific combination of outputs from a specific access to means of production, it is therefore a specific combination of various cropping systems and livestock rearing systems (Devienne and Wybrecht, 2002). It also describes a specific socio-cultural organisation with social relationships (Figure 2-8) and significant amount of social capital which might be needed for specific operations (Devienne and Wybrecht, 2002).

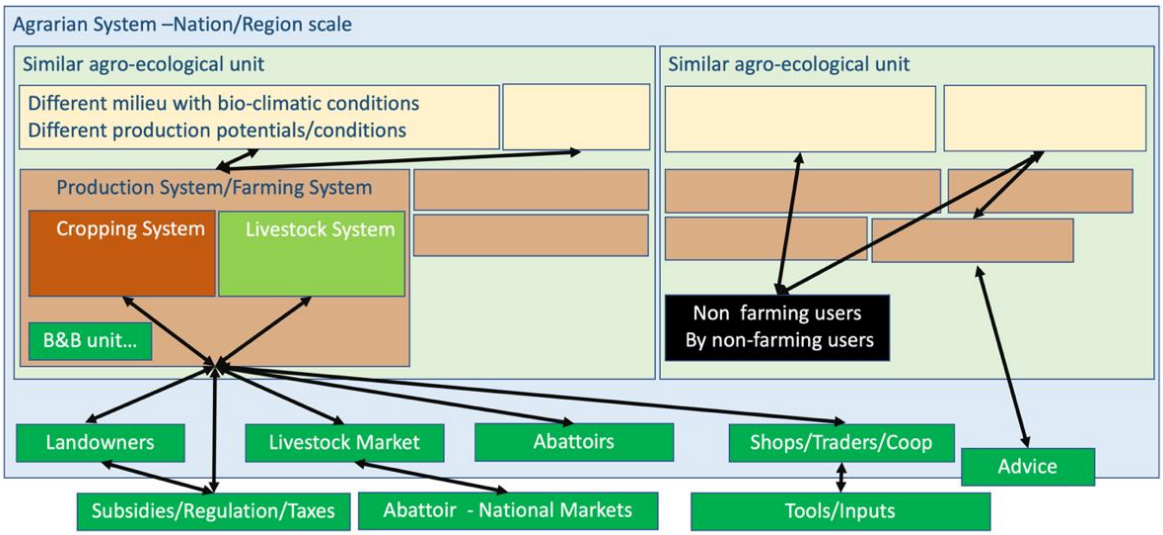


Figure 2-8: Example of a nested agrarian system (adaptation from Morsel and Garambois, 2022)

In the past, pluri-activity has been perceived as a challenge for production systems due to the complexity of its integration in the farming process (Knickel and Kroger, 2008; Marsden and Sonnino, 2008), with no specific consideration in the field of comparative agriculture. The concept of 'activity system' has been used in social science to integrate all social and economic activities in a given location, and study their combination[15] (Gasselin et al., 2014; Laurent et al., 2003). Some of the activities would be income-generating, sustaining the rest of the activity system (Gasselin et al., 2014). Based on this, it is put forward that by extension, the agrarian system can include pluri-activity in a similar manner. Where pluri-activity is present, this non-farming activity interacts with the rest of the production system, linked to resource availability (e.g. capital or labour), whether in competition or synergy (Cochet, 2015a; Gasselin et al., 2014), as illustrated in Figure 2-8.

Rossing et al. (2007) in their meta-analysis of modelling approaches to study multifunctionality questioned how to extract findings at wider scale and recommended that "the methods for upscaling should be selected such that the presence of scale-dependent processes resulting in emergent properties at higher levels of aggregation can be accounted for" (Rossing et al., 2007, p. 54). The definition of the agrarian

[15] And this taking into account the different scale with a similar piloted and resource-focused approach.

system makes it possible to add different levels of analysis (Cochet, 2015). In effect a local agrarian system, or ‘‘elemental agrarian system,’’ is relevant for issues at a landscape level (Deffontaines, 1990; Jouve, 1986) and “a broader agrarian system that groups together several local agrarian systems that are largely interdependent.” (Cochet, 2012). The largest scale of the agrarian system is the scale at which the researcher can still identify meaningful two-way relationships between components and key decision-making as shown in Figure 2-8. The initial analysis of Welsh characteristics in Chapter 1 has shown inter-landscape relationships across the whole territory of Wales; for example, via livestock trading.

3. Future scenarios and the agrarian system

In summary, this system is a resource-based and process-focused concept, but while the agrarian system could be adequate to analyse current multifunctionality and its past evolution, there is a need to evidence how the same approach could play a role to identify likely change in reaction to the WG plans and identify potential future challenges.

The agrarian system is the analytical concept that sits within the broader approach of comparative agriculture, which has at its heart a comparative approach whose goal is to describe and understand the processes behind agricultural development, going further than simply comparing regional agrarian systems (Hugonnet, 2018). The method incorporates three clearly defined elements:

- Whether the agricultural development processes and dynamics in a particular place are general or can be generalised.
- To clearly identify the characteristics of an agrarian situation by contrasting the change of the local system to the different changes operating at a much larger scale.
- To identify what is and what could be driving the agricultural development process in a direction expected by actors.

The approach to understanding Welsh farming offered by the agrarian system approach would notably study the diversity of Welsh farming and its processes,

resource access and use, and outputs. Limits and opportunities in multifunctional production would be identified in farms' decision making (Cochet et al., 2007). The diversity within the agrarian system will inform current and future trends of agricultural development (Devienne and Wybrecht, 2002). By focusing on the desired goals of the WG policies, it would be possible to assess the existing shortcomings and challenges based on the processes in the agrarian system. In other words, it opens up the potential to "formulate hypotheses on how farms may evolve in the near future and identify and prioritise the problems farmers encounter so as to shed light on the conditions under which they could modify their practices." (Devienne and Pillot, 2003 p. 1).

As plans forming part of the future environment become clearer, a forecasting exercise can consider these changing parameters and these be used in simulations (Darnhofer et al., 2005; IPCC, 2023; Rossing et al., 2007). The scenarios need to be discussed with actors in the agricultural development environment, to ensure they are plausible (Rossing et al. 2007) and as accurate as possible, to ensure that the results are credible for partners (Moreau et al., 2012). Scenario definition could be based on an approach similar to Reed et al. (2009) and Gómez-Limón and Riesgo, (2009) using both qualitative and quantitative information to identify past trends and likely future trends. The involvement of all partners in the design of new scenarios is key to increasing their acceptability, ensuring a common understanding around the project, enhancing transparency, and eventually reducing uncertainties (Martínez-Santos et al., 2008; Moreau et al., 2012). In Wales this would mean involvement with the WG, local researchers, or extension services. In turn, the sensitivity analysis; applied on key variables after applying the scenarios to the model of the agrarian system, could lead to a better understanding of potential behaviour or issues, to reach development goals (Cochet, 2015a).

The analysis of the WG goals shaping the framework for analysis unveils three key principles around farming sustainability based on farm processes:

1. The economic sustainability, viability and the structure of farms in terms of economic value generation, farm income, economic links with the community,

and the way the added-value is shared (across the agrarian system and actors), or the economic challenges for the farm (Cochet, 2015a).

2. The environmental sustainability (Caroline Harkness et al., 2021; Franks, 2022; Moreau et al., 2012) with a focus on the type of inputs necessary for the production system and the amount used to maintain the fertility of the cropping system. It also looks at yields and their sustainability in the long-term and, in the case of specific landscapes, considering what helps to maintain these.
3. The combination of enterprises will have to ensure the feasibility/acceptability of the farm in terms of workload and if it is sustainable on its own (Family farms tend to be a particularly stable structure through time and potentially across generations; Lobley et al., 2016).
4. All of the points above are expected to help sustain the socio-cultural elements of the WG vision.

The agrarian system provides an overarching concept to analyse the diversity of farms and production systems and understand the main challenges to reach the WG's goals, including in a number of scenarios (Cochet, 2015a). It would potentially provide an adequate framework for analysis that will be further considered by examining its attached research method the agrarian diagnosis.

4. The agrarian diagnosis to study a regional agrarian system

The agrarian diagnosis is the tool to study, analyse and diagnose the agrarian system at a regional scale which has been developed by the school of comparative agriculture in Paris. This method has been applied to different kind of environments by the researchers and student of AgroParisTech (Cochet, 2015a). For the description of the comparative agriculture approach, the following discourse will be based upon recent work exploring the principles of the method in Cochet, (2015a) and Cochet and Devienne, (2006). The agrarian diagnosis method is composed of three successive and interdependent steps **Error! Reference source not found.**that take place one after the other and that aim at studying the agrarian system: a landscape analysis and then two rounds of in-depth interviewing with farmers within the landscape – one

historical and the second contemporary – to understand how farming systems have evolved and to examine their current status (economics and farming science).

This specific step aims at understanding the landscape as a bio-ecological milieu resulting from agricultural land use. It entails studying the landscape through desk review (geology, geomorphology, soil science, secondary data) and field observations. Following in the steps of geographers, the study of the "milieu", the bio-climatic conditions at disposal of farmers that farming has been shaping, "further than just … food production… farmers produce shapes and colours. Within this vision, farming can be seen like an activity based on the biology which produces changing landscape forms within a set relief" (Deffontaines, 1990, p. 10).

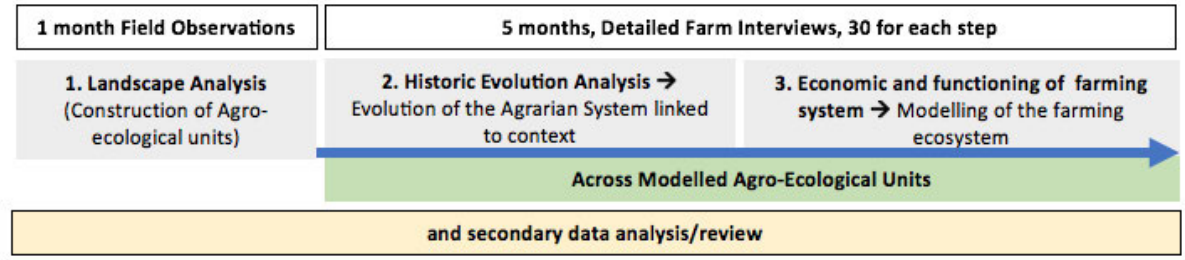


Figure 2-9: The agrarian diagnosis in a small agricultural area (Cochet and Devienne, 2006)

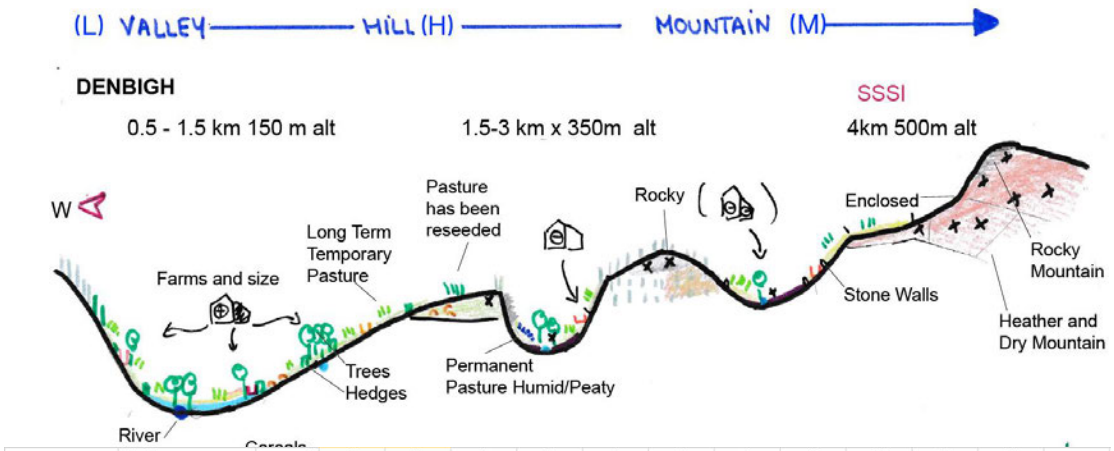
Despite the increasing artificialisation of the production environment, farmers' decision-making processes are still linked to the conditions of the milieu (Cochet, 2015a): an interaction between the landscape, the environment, and human society with farming. Cochet, (2015b) concluded that landscape observations can be linked to practices, the visual representation suggesting the way the processes take place.

a) **Landscape analysis**

The geographic analysis of the agrarian landscape to extract a typology of functional units is a well-studied discipline (e.g. Angles et al., 2014, Blanc-Pamard and Milleville, 1985). Angles et al. (2014) did a landscape analysis focusing on French regions with a Mediterranean climate producing wine and olives, the methodology highlighted the gradual refinement of the scale of study/understanding, using landscape analysis and landscape reading, starting by identifying large scale units, before going down gradually, identifying sub-classes and elements. The lower levels of analysis would

describe the bio-climatic conditions. This approach is similar to the one described by Cochet and Devienne, (2006).

The observation itself then requires knowledge particularly on the general topography and geo-morphology (Derruau, 2010), “the cultural palette” of the different land-uses and their clues - the geographical objects (Deffontaines, 2001). These combine visual observations, aerial photography, cartographic analysis, and field assessments. It is a precise analysis, through knowledge gained from secondary literature about the area and the disciplines. This analysis is coherent and integrative to relate the different levels of organisation of the productive activity to each level’s landscape typology. It is key to conduct the analysis over a long-time period (six months) to understand the temporal dynamics and analyse the differences as well as the dynamics and functions in this typology (Cochet and Devienne, 2007).



	Month	1	2	3	4	5	6	7	8	9	10	11	12
Rootcrops							Plo+ Plant + Muck					Grazed/Ha	Grazed/Harvested
Spring Barley/Oats		Grazed/Ha	Grazed/Harvested		Plo+Cul+Plant				Harvest Cu	Reseed			
									<- Muck	Kale and Rapeseed			
Prairie Temporaire				Strip(Sh)	Plo+Cul+Plant			Hay			Muck		
Improved Grassland			Lambing	Lambing							Muck		
					Start Cattle								Sheep
Humid Permanent Pasture						Start (Sh)							
Slopy Permanent Pasture					Start								
Dairy Cows	VL				Past							Hay, Corn, Roots, Cake	
Cattle	Bovins viande				Past							Hay, Corn	
MOUNTAIN	Sheep (Ewes 1x and Ewe Lambs)				Climb up							Climb down	

Figure 2-10: Examples of outputs, simplified landscape transect from Bala and a landscape use summary from the Vale of Clwyd (by the author)

The key outputs from this phase of the work would be detailed description of landscapes and sub-landscapes, their organisation and characteristics as well as agronomic potential (rotations, grass growth curves, yield, timing;

Figure 2-10). This would also help identify the appropriate study area for agrarian diagnosis, representing a coherent area for farming operations and covering the broad range of landscape that its farms have access to (Cochet, 2015a). .

“Reading the landscape” leads the researcher to formulate hypotheses linking the landscape use and the constraints on these landscapes (bio-climatic or other) that are confirmed by further contextual literature review and later validated in farm interviews. Unlike the method of Angles et al. (2014) agrarian diagnosis requires no specific interviews about the landscape. Angles et al. gained further knowledge on the functioning of the different units to understand the agrarian system but instead, hypotheses will be made on changes that took place or relationships in the landscape between actors and parts of the landscape. Angles et al. (2014), also checked hypotheses from historical analysis through interviews to explain the genesis of the landscapes, and the next step of the agrarian diagnosis also specifically considers this (Bloch, 1949; Sauter, 1985). From the landscape reading, each of these “areas with specific features”, would be a modelled agro-ecological unit with sub-units, as explained by Cochet, (2015) and represented by block-diagrams in a schematic visual representation.

The landscape study is followed by a historical analysis, made using in-depth semi-structured interviews with retired farmers who have witnessed and taken part in the agricultural transformations of recent decades. During these, both quantified (technical, economic), and qualitative (environmental, social) changes on the farm are discussed as precisely as possible and the rationales behind these are explored in detail with the farms’ former operators. This step seeks to understand farmers’ motivations and choices for each change step by step, for a thorough analysis of policy, market and technical impacts (Boussard, 1987; Brown et al., 2021). These are linked in parallel to a contextual literature review and examination of relevant secondary data sources (trends in agricultural prices, changes in policy, technical innovations…) to evidence the rationale for the transformations that are taking place locally.

b) Historic evolution analysis

There are 2 successive rounds of interviews, one to understand the historic origin of today's farming ecosystem and the other one focusing on existing farms technical and economic functioning. Although it has evolved substantially towards more standardisation, since René Dumont's first work on comparative agriculture (Cochet, 2015b), the method for historic analysis is a semi-structured interview as attached in Annex 3 Item 3-1 The questions range from understanding farmers' motivations, the broader farm ecosystem, characterising in-detail the functioning of the farming system and understanding the rationale behind farm operations. To identify causal relationships and mechanisms, the interview requires in-depth exchanges and observations (Cochet, 2015a). Secondary data can be used to facilitate the interview and contextualise some of the decisions made. The key differences of this approach, compared with ethnography, is that it follows a structured and comprehensive sampling process to select interviewees (see page 62;Devienne and Pillot, 2003) as well as requiring the quantification in some detail of the production mechanisms for each farm business, and how these have changed over time (Cochet and Devienne, 2007). As Cochet, (2015a) and other literature on the agrarian diagnosis do not detail in-depth the steps in the research method and the analysis, the following provides a detailed account of it.

The historic interviews target retired farmers, whether their farms still exist or not. Indeed, the "understanding of causal links and mechanisms leading to their disappearance as well as its consequences are extremely useful to identify differentiation mechanisms and understand how other systems have managed to evolve to become what they are today and draw hypotheses in terms of potential evolutions" (Cochet and Devienne, 2006, p. 4). Effectively, this means two things are possible, first to understand historical lock-ins and challenges that impacted farm differentiation (and might still impact future decisions). Secondly, it provides an insight into past farm reactions to policy and market changes, hinting at potential likely reactions to future change. It helps to ensure a more accurate understanding of the agrarian system by ensuring that the researcher understands its origin and its historically inherited structure (e.g. tenure), also its path-dependency.

After each historic interview, the first output is a narrative or explanatory timeline summarising a snapshot of the farming system during each distinct time-period, linked to the changes seen in moving between these periods (Figure 2-11). Some checks would be done with quantified information and scientific data (e.g. rotations) to ensure the accuracy of the information (for example, grass growth, yield, fodder quantity compared to livestock needs). In the summary, the range of information gathered is laid out in a timeline, the researcher ensures that it shows key characteristics, inflexion points in terms of evolution and the rationale for each change. Reconstructing the livestock and cropping system combined with the key structural characteristics and socio-cultural insights provides the key to understand the rationale for farm changes. Quantitative tools are used to help check the accuracy of the farming system and its evolution as identified in the interviews, based on secondary data drawn from relevant scientific sources (e:g: specialists books; Gerber et al., 2007; INRA, 2010; Soltner, 2012, 1968; Sommer and Husted, 1995).

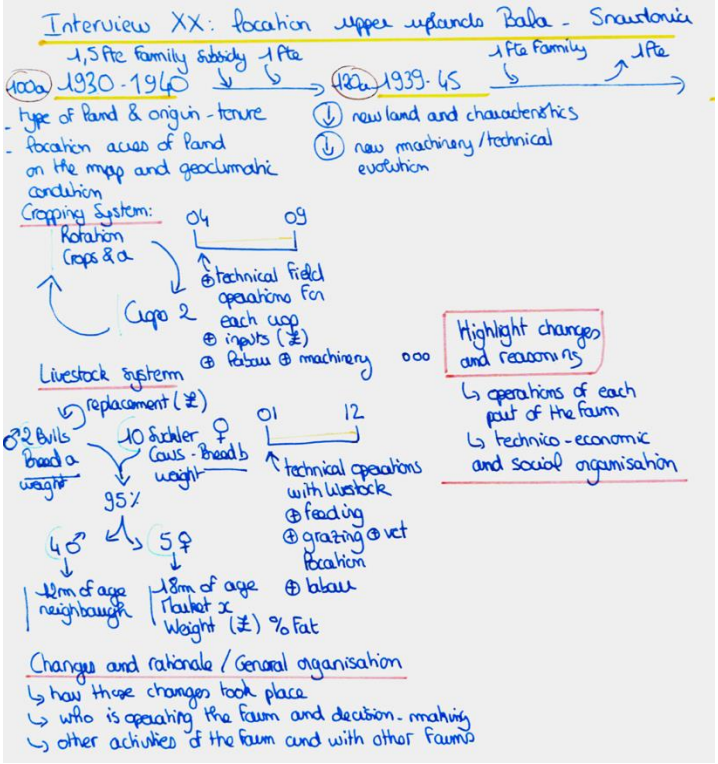


Figure 2-11: Example of a timeline representing the summary output of an historical interview (by the author)

This is an intermediate phase in which the production systems are reconstructed through time to rank “differentiation criteria” in system reconstruction (Cochet, 2015a).

The decision-making and rationale is integrated through the multiple factors including lock-ins.

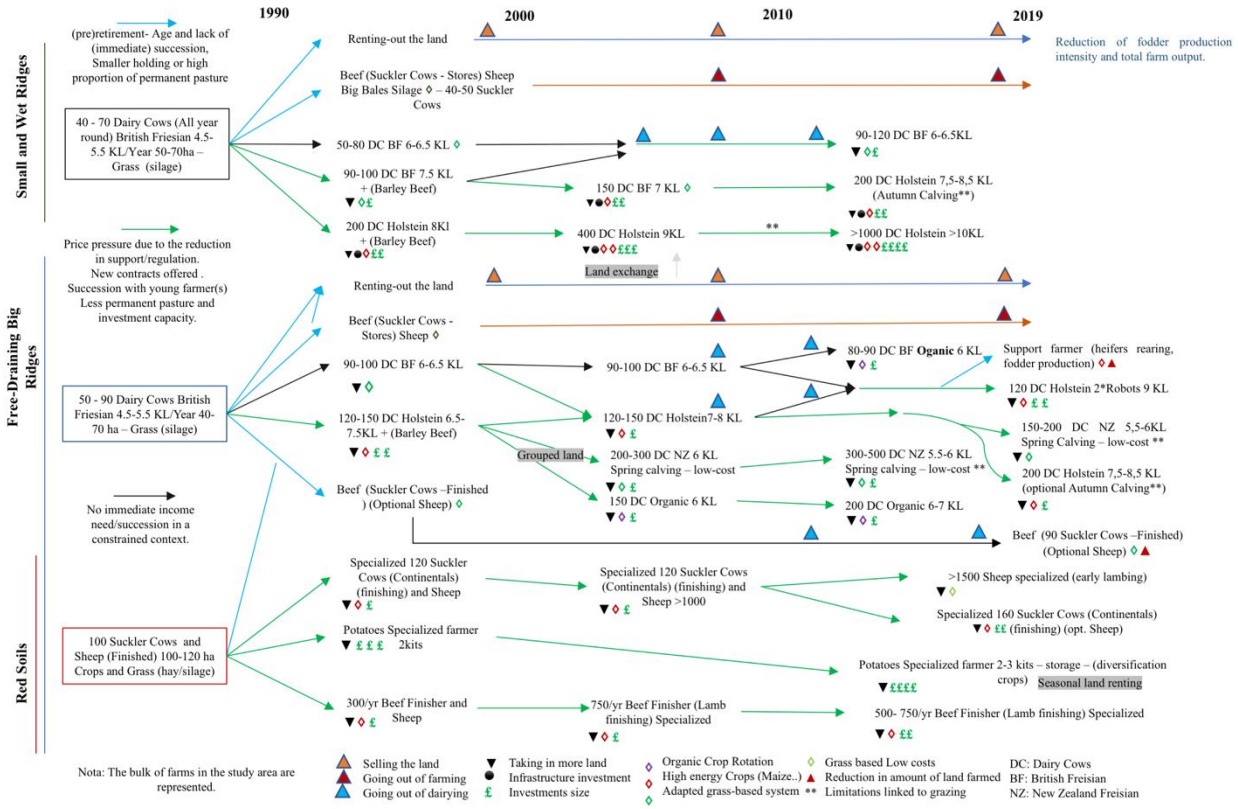


Figure 2-12: Second key output of the historical analysis, the farm differentiation pathways results from a qualitative analysis of all the historic farm interviews, this example is for Pembrokeshire (by the author)

The next output considers all the farm changes trajectories. Those are qualitatively analysed as a response to multiple drivers, in a similar manner to a decision tree approach (Darnhofer et al., 2005). Usually, this analysis groups farms in categories by type of production, structural characteristics, type of equipment, labour, geo-climatic conditions and then considers the different paths followed, depending on the different rationales and determinants, e.g. succession (Figure 2-13). This informs an understanding of production systems' differentiation across the landscape, clarifying the mechanisms that led to today's landscape (Cochet and Devienne, 2007). Today's differentiated typology of production systems is situated at the end of the timeline and is therefore linked to their historic differentiation as shown in Figure 2-12 and explained in Figure 2-13. The high level of detail required to understand the transformations taking place in relation to the bio-climatic environment explains the need to have

individual interviews and the provision of secondary data and information to facilitate it (maps, name of places, landscape units or general policy context)(Cochet, 2015b).

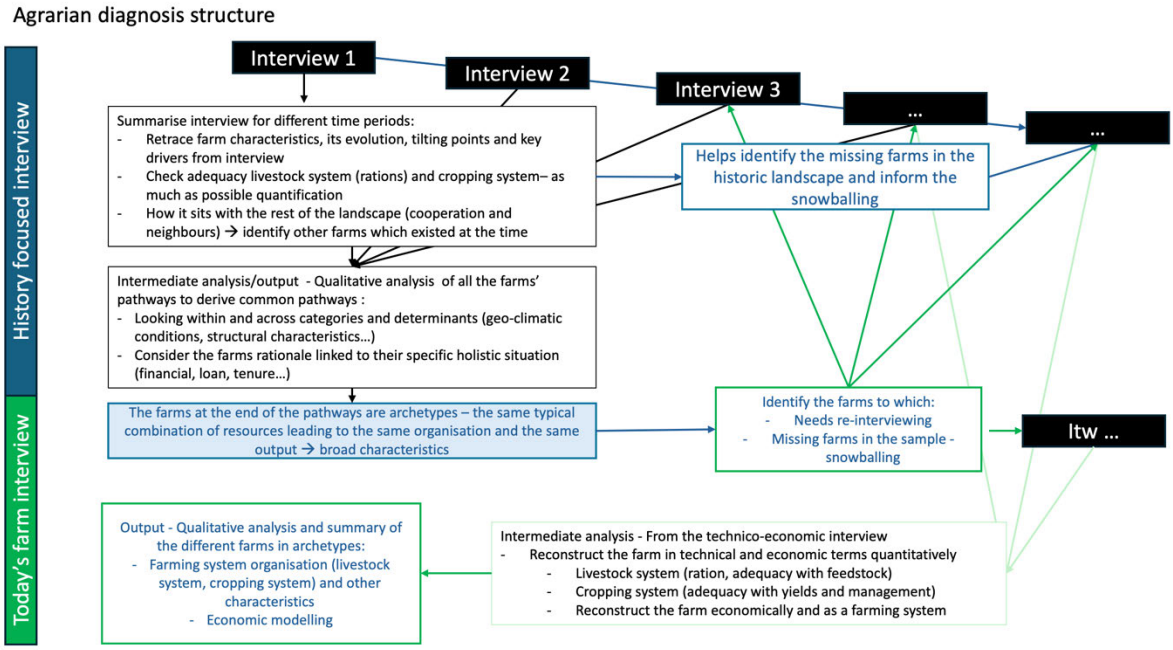


Figure 2-13: Diagram illustrating the complementarity of the 2 phases of interview in the agrarian diagnosis, structure of the research process (by the author)

In terms of sampling and the required number of interviews, a clarification is necessary compared to Cochet, 2015a. If the goal is to ensure the coverage of the agrarian system and of its different trends, a substantial number of interviews must therefore take place, to understand these dynamics covering all key determinants of the agrarian system. For example, the different agro-ecological areas or the different production types identified must be present (Figure 2-12). But within production types and landscape, the constitution of the sample to interview is gradual and based on past interviews (iterative snowballing) by identifying the missing pieces of the agrarian system 'jigsaw' at different times (Cochet et al., 2007, p. 20). All interviews will include key information on surrounding farms and how the interviewed farm compares (

Figure 2-10) helping the researcher to identify missing farms in the sample. The iterative nature of the sampling requires a gradual analysis of interviews during this phase of study, to achieve a comprehensive and representative sampling of all the farming systems within the landscape (Figure 2-11). This step usually requires approximately 20-40 interviews per study area. Some help is usually sought from

gatekeepers in recruiting participants at the beginning of the study (local partners from the agri-food sector), after which the rest of the participants are recruited by snowballing (Annex 3 Item 3-1 and Item 3-2).

c) Contemporary technical and economic interviews

The final element in the three-step diagnosis is an in-depth agronomic and economic examination of current farming businesses, based upon the characterisation of all the production systems in the landscape that were identified during the previous steps, as distinct 'archetypes' (Figure 2-13). The archetypes each represent a quantitative description of a qualitatively modelled farm (Cochet, 2015b). This third-step data collection is thus done more purposively, returning to visit some participants (Figure 2-13) and then snowballing in order to ensure that all of the different archetypes are covered. The goal is to have at least three farm interviews per distinct archetype.

Shorter interviews (1-2 hours) focus on the operation of the farm production processes, its technical and economic functioning (Annex 3 Item 3-1). While quantification is not always possible in the historic interviews it is a requirement for this second round of interviews. It is then possible to characterise the operating logic of each farm system by looking particularly at the access to production factors and linking it to economic performance. The visual representation of each archetype farming system is the end goal, providing a summary of the farming system with its different sub-systems (Figure 2-14). Several steps are taken: to prepare the relevant data beforehand for each interview, starting with the livestock system, based on livestock characteristics and needs, the level of nutrients necessary at different times during the year is extracted from the literature (add link), based on the fodder/crop nutritional value and timeliness checks are run on the size of the farm required and the type of fodder produced (e.g. item 3-4). A reconstruction of the cropping system is also done using the literature to check the validity of the interview data. Finally, on the economic side, simple modelling is used to get from the technical information and raw economic data on each output and input to produce summary values (Figure 2-15). Each interview as a result has its own economic and technical model. These interviews are then qualitatively combined (Figure 2-13) to reflect the archetypes from the historical analysis (e.g. Figure 2-14). Crucially the technical tools behind the archetypes are

similar to all the ones used for each farm interview (cropping model, livestock model, technico-economic model, visual representation).

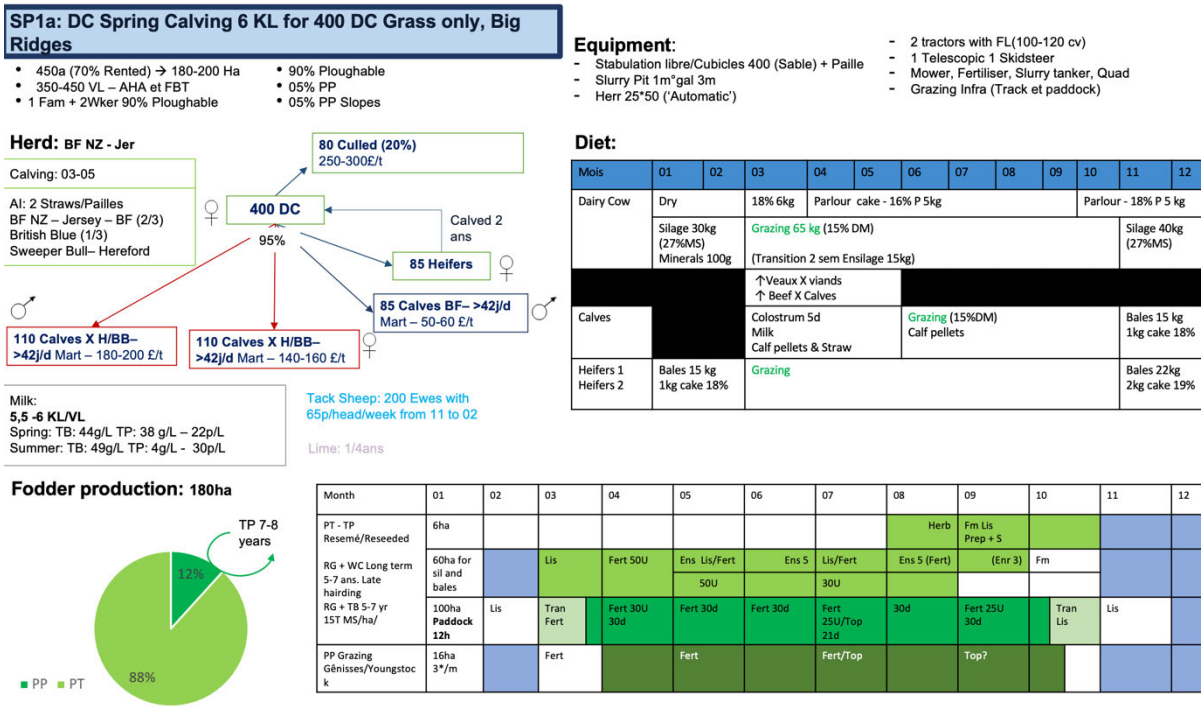


Figure 2-14: Illustrative example of the visual representation of an archetype, a production system with its different sub-systems - example from the Pembrokeshire case-study (by the author)

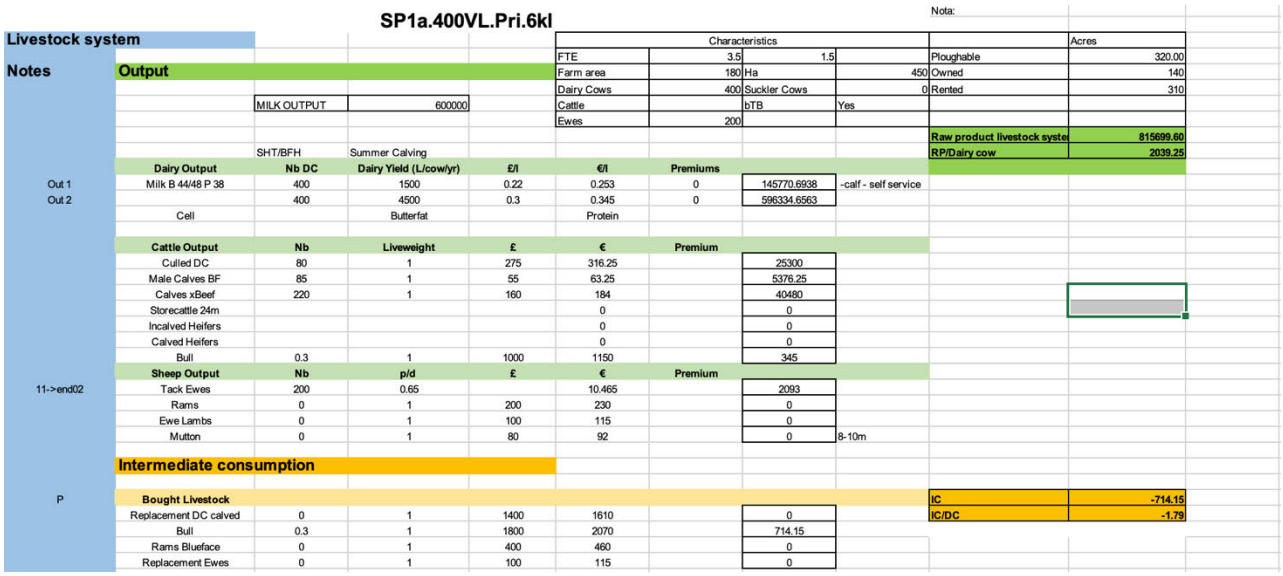


Figure 2-15: Technico-economic model to obtain the economic results, linking the farm productive processes directly to the farm operations (by the author)

All archetypes' models describe the farming over an average year while making sure to identify possible variability in operating conditions and the resilience built into the operating processes. It also hinges on the identification of operating constraints; particularly "for the most restrictive period, the number of available days (in function of soil and climate conditions), and the available equipment and labour resources allows one to identify the system's upper technical limit—that is to say, the maximum number of hectares or animals that one worker can farm with the available resources and in function of the combination practiced." (Cochet et al., 2007). It links up to the vision that historically differentiated productions systems will have from their similar access to production factors similar productions (Cochet et al., 2007). The detailed analysis of the sequencing of processes within the cropping and livestock systems can help understand the link with environmental results of the farm.

The first-hand data collection means it is possible to distinguish the economic findings from those of an aggregated and non-functional financial or business analysis (Figure 2-15). The economic approach in Cochet et al., (2007) is designed to be as close as possible to the production process while ensuring comparability; regardless of archetypes, access to production factors and their structure (e.g., share-farming, tenants…). For example, to obtain added-value, financial depreciation is not used, and instead the depreciation of the tools and equipment in the production system is estimated, relating to their actual use. This gives a stronger link between capital use and production processes than the methods used in Defra's standard FBS financial analysis (PROMAR, 2023). The production system can also include quite different sub-systems going beyond agricultural output (e.g. on-farm electricity generation) if they are related to the production sub-systems. In this case, the notion of business productivity[16] must be clarified (Cochet, 2015b), it is different from yield, and to measure it, the added-value is divided per hectare or per worker. The use of annual labour units reflects the seasonal nature of agricultural work, by counting only permanent staff and not contracted elements (Cochet 2015a).

[16] Farm productivity is a measure of how efficiently a farm converts resources (inputs) into products (outputs).

The business structure is considered in the analysis of agricultural income for the different types of farm stakeholders, farmers, managers, or investors. In Wales most farms are family farms (Chapter 1), thus given their specific economic rationale (Bartolini et al., 2014; Brown et al., 2021; Wynne-Jones, 2011) the measure of profit is the agricultural income before tax for family members, which is used as a comparison metric, as recommended by Cochet and Devienne (2006). Of particular importance to this study is the fact that each archetype also holds a brief qualitative description of the archetype's origin, logic of operating, how it links up with other systems and socio-cultural elements which could not be reflected in the other research outputs. The Figure 2-16 provides an example of what it can reflect this for a specific archetype of Bala area for which it was of particular importance.

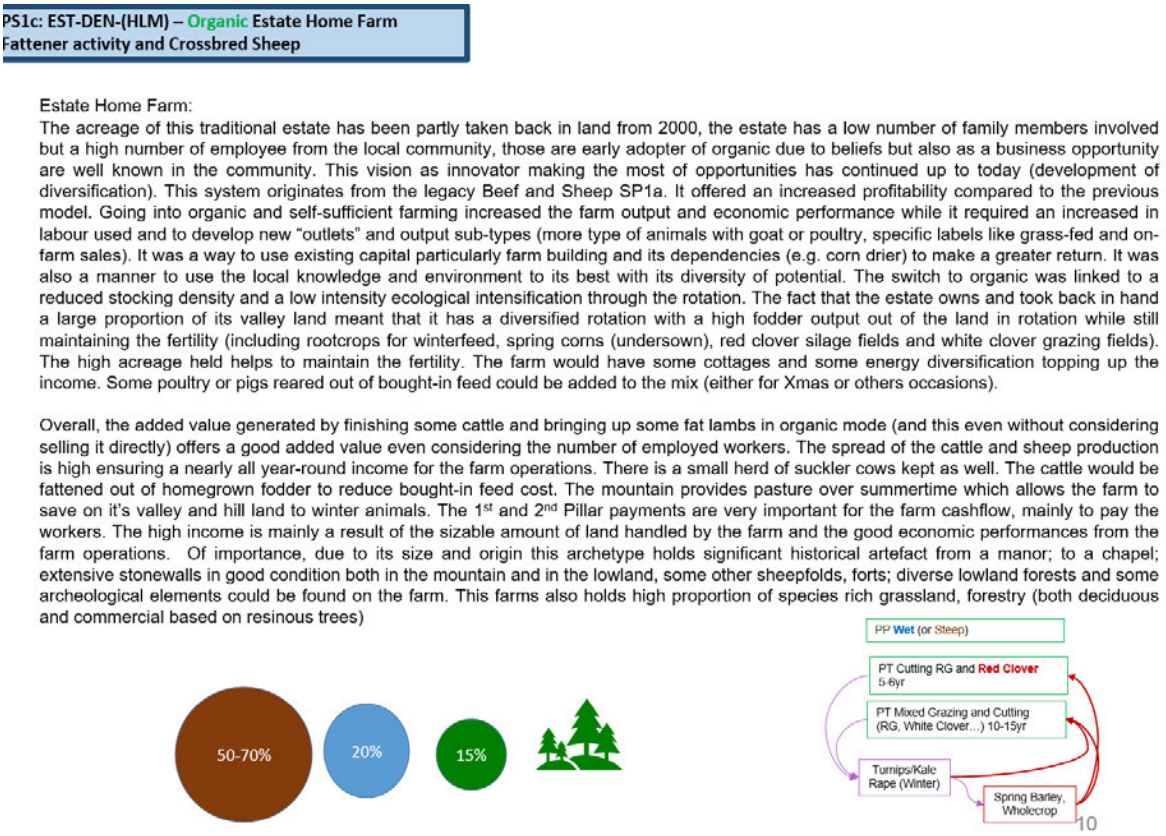


Figure 2-16: Illustrative qualitative description of a Bala case-study archetype extracted from the archetype booklet of this area (Lenormand, 2021a)

A sensitivity analysis[17] is usually done with possible scenarios of key input and output price trends/changes that can help identify challenges and rank them. It is also a crucial step to consider a sensitivity analysis linked to the range of archetype sizes. As the archetypes combine information from farms with a similar production structure, they could exist in varying scales (e.g. archetype A might be seen in a farm with 100 acres and 1FTE labour, but the same archetype could also be found on a 150 acre farm with 1.5FTE, and with a six-abreast dairy parlour). Sensitivity analysis make it possible to establish a diagnosis of the situation and formulate appropriate future change hypotheses (Cochet and Devienne, 2007). In effect, this is going further and adapting these archetypes to different contexts (e.g. policy change) owing to the fact that the path dependencies of each archetype – inherited from the past – are rigorously defined.

The result of an agrarian diagnosis in a small agricultural area is therefore a set of rigorously characterised and modelled farm archetypes, linked strongly to existing geo-climatic potential, their technical operations, their historical significance and lock-ins as well as their resulting economic performance. Working from a historically differentiated typology helps rank farm challenges and their past effects without needing to present data from individual farms and farming households (thus preserving the anonymity of interviewees). It also avoids the risk of doing a segmentation of farms based solely on today's characteristics, which might hide significantly different future pathway constraints. This approach enables a thorough and flexible diagnosis.

[17] A sensitivity analysis aims at assessing how some variables (e.g. inputs) can affect the production system

5. Agrarian system and farm multifunctionality

In conclusion, the concept of multifunctionality is an interesting and relevant concept to analyse the vision of the WG and assess the success of its future scheme (see Figure 2-5). The concept of multifunctionality was explored and represents a pragmatic way to analyse the link between food and fibre production and other outputs coming from the farm activity. After considering the interest and requirements of an ex-ante evaluation, the plans of the Welsh Government were scrutinized to understand the mechanism of this policy. From this, criteria were extracted to assess the potential impact of the SFS. This highlighted some key requirements for the research method; the need to retain a holistic, system-based approach, and the need for different scales of assessment in the evaluation method as well as system thinking, to understand the interrelations between actors. The agrarian system and its field method the agrarian diagnosis was identified as being capable to answer these demands. The role of the farm in different modelling approaches was briefly discussed and the farm was shown to be the key decision-making unit in the landscape for the analysis to answer the research questions. At the same time, the nested approach of the agrarian system could be adequate to frame farm multifunctionality at different scales, in Wales although clarifying the elements relating to socio-cultural analysis would prove helpful. The agrarian diagnosis method was described and shown to offer a holistic first-hand evaluation of multifunctionality with potential to understand future changes and the specific Welsh context at a regional scale.

Based on the description above the below is a reflection on the strengths, weaknesses and opportunities of this concept and its research method. Among the strengths, this package offers a systemic approach and considers well the different scales of analysis although at this stage uncertainties remain on how to synthetise results at the all-Wales scale. The method of analysis and the tools of analysis provided fit well the identified requirements of an ex-ante analysis of the impact of the new Welsh Agricultural Policy; it considers the policy and other challenges impacts on a farms' ecosystem in a bio-climatic context, from this it can help identify risks for the future policy. It identifies past and today's farm evolution drivers by reconstituting the operation of the farming system, considering operating constraints as well as future

change constraints that shape adaptation to future policies. For this the high level of detail is invaluable. Finally, by understanding in-depth today's concept with its detailed operating practices it means that is possible to provide insights on potential futures .Based on the review of other methods to study multifunctionality, the agrarian diagnosis method enables a comparatively strong causal link between farm-decision making, farm geo-climatic conditions and the farms' functions at different scale (Machado, 2004; Hugonnet, 2018). Nevertheless, the treatment of the different functions necessary to understand the potential impact is unequal: it was shown by discussing the steps of the analysis the strong emphasis on the technico-economic side, whereas environmental and socio-cultural aspects are not as central to the method. Additionally, the method is extremely farm-centric. However, as the WG estimated that the environmental and socio-cultural benefits were likely often delivered indirectly by changes in farms' operating practices, the agrarian system approach could remain valid. Based on the interview schedule and the indicative summary of the interview (see item 3-1 and figure 2-10), there is a significant amount of socio-cultural insights collected which do not necessarily feed through directly in the agrarian diagnosis outputs. It is integrated as one factor contributing to the wider course of evolution of farms. It is suggested that while for technical and economic data, it is easier to understand the target of the SFS and translate it into desirable characteristics of a production system, as was often done on multifunctionality, this is not as much the case for socio-cultural elements. The agrarian system with its focus on the farm as a piloted system, could be lacking in economic and environmental adequacy to assess accurately the goals of the SFS at the regional or national scale. Therefore an additional concept was sought to enable this broader perspective.

The Socio-Ecological Production Landscapes concept describes landscapes characterised by a co-evolution between people and their nature environment (Saito et al., 2020). In other words, it is a sustainable landscape including strong socio-cultural links, this concept and the requirements for it to be considered as such could provide a blueprint which matches the WG wider legislative framework around farm sustainability (Welsh Government, 2020; Wellbeing of future generation act; Welsh Government, 2023). It would go further in providing a holistic framing to issues of sustainability at the regional scale than the comparative agriculture approach does.

Comparative agriculture analysis is a novel but potentially accurate representation of farms ‘economic impact reflective of the economic productive process, with an added challenge of a relative lack of comparability against more traditional financial analysis like the FBS. To effectively draw hypotheses on future agricultural development the agrarian diagnosis findings require further modelling to reflect the potential changes made to adopt the SFS and the potential issues arising, for which a high level of detail in archetypes is needed (Soulard, 2003;).

This review shows that the agrarian diagnosis, although giving deeply specific results to each small agricultural area, was likely to address the gap in the evaluation of agricultural policies targeting farm multifunctionality as highlighted in Knickel and Kroger (2008). It would provide a good research concept and research method particularly if supplemented by a concept of a “sustainable goal” to reach. It provides a framework to understand and analyse farm multifunctionality linked to its processes. For example, the economic element is directly linked to the farm operations and diversification. Although a case-study, several agrarian diagnoses spread across Wales can be adapted to understand the whole of Welsh farm diversity, informing on multifunctionality evolution and key challenges.. Further exploration will be conducted of the limitations and opportunities around this research method in Chapters 3 and 8. The next chapter will discuss the validity of this assumption and then select case-study areas of the agrarian diagnosis to gain and discuss how to gain an understanding at the Welsh scale before moving towards the results of the research.

Chapter 3. Choice and description of case-study areas in Wales

The agrarian diagnosis can provide a holistic and systemic understanding of case-study areas through fieldwork and data collection, while the comparative agriculture provides the integrative tools to enable work at an all-Wales scale. It is important to consider if this will adequately answer the needs highlighted in Chapter 1, particularly considering the identified limitations of case-study fieldworks mentioned in Chapter 2. In this chapter an informed and purposive selection of study areas will be highlighted as the preferred manner to reduce risks linked to a case-study approach. The practical implementation of the research method during the fieldwork will be discussed. Furthermore, the results on landscape and early historical differentiation will be briefly presented to represent the basis upon which to take a thematic approach in answering the research questions results in following chapters.

A. Overcoming the limits of a case-study approach

The agrarian system concept has been used at the small 'agricultural area' scale, particularly in areas that have some degree of homogeneity but also a common logic from the perspective of the ecosystem, it also offers a direct visualisation of the dynamics behind agricultural development and links farm practices to farm multifunctionality (Cochet, 2015a). Chapter 2 showed that the agrarian diagnosis, the tool to research the agrarian system could represent an appropriate method to understand farm multifunctionality in relation to the WG goals.

But, how to ensure that what is observed at the local scale, and the consequences in terms of evolution of the multifunctionality in these case study landscapes, is representative of Wales as a whole? How to ensure that it does not generate too much information, and ensure the validity of its findings for the whole of Wales, in respect of farm processes or potential evolution of farming systems? Those are common criticism of case-study approaches that were highlighted in Chapter 2. The next section will cover how combining case-studies could help link the key scales of the agrarian system to answer the research questions.

1. Selection of case-study areas

Hugonnet, (2018) gave a good account of potential routes to follow, building on the work of Pélissier and Sautter, (1970). These researchers faced similar problems: they were studying different “terroirs”, and trying to analyse agrarian systems at a small or very small scale of agricultural area and they questioned their findings in regard of their geographic anchoring. To find a way to up-scale these findings, two approaches were identified by Hugonnet. One was a quantitative approach, multiplying the number of “terroirs” studied to find common points between them, and building large regional groups with similar agrarian structure. Another approach is a purposive sampling of the “terroirs” to study, selecting case-studies that are designed to be characteristic and broadly representative of main regions/territories at a larger scale (e.g. Rossing et al., 2017) In this case the purposive sampling has to be meaningful at the scale at which the relevant research questions are put forward (in this case, the whole of Wales); covering the range of conditions of Welsh agricultural development and thereby to answer the research questions (e.g. Hugonnet, 2018). The purposive sampling approach is easier to implement than a fully comprehensive approach, within a limited timeframe, and considering the methodological requirements of agrarian diagnosis.

The following section will discuss the purposive selection of case-study areas in Wales linked to the policy change and particularly its goals (i.e. what it is interested in) and mechanisms (i.e. The tools) as discussed in Chapter 2.

An initial regional analysis of Wales took place to identify potential agrarian systems and case-study areas at regional scale, by mapping the different areas and trends apparent across Wales (as done in Hugonnet, 2018). While Chapter 1 already discussed broad regional units this section will specifically aim at understanding post-Brexit challenges for farming and possible future changes. This would mean either identifying the diversity of existing trend currently but also the future diversity of trends taking place; identify the regions where farm changes are expected to occur, will likely to be the strongest, or where there is already a strong agricultural development dynamic. Then, by comparing the dynamics, functions, and changes in each case-study area it will be possible to draw conclusions at the Welsh scale, by comparing

how, when facing a similar macro-economic and policy environment, these areas have evolved and may evolve differently in the future (Hugonnet, 2018).

2. Linking the study to policy development and evaluation

For this study, a co-funding partnership was built with the policy arm of the WG, when the post-Brexit farm policy in Wales was still in early stages of development (Welsh Government, 2020b, 2019b). This meant that the findings and outputs from the case-study analyses could inform policy development discussions and highlight further issues for investigation and consideration (as suggested by Dwyer, 2021). In addition, by combining the insights from case studies with higher-level analysis of markets and other trends, the work could provide insight on future change that could be used to test out different scheme options and models (e.g. as seen with the ERAMMP modelling; Thomas et al., 2021).

The study was supported by a diverse supervisory team with a wide range of methodological expertise, knowledge of local policy and Agri-ecosystem practice, and inclusion of both researchers and policymakers. The primary supervisors at University of Gloucestershire were Janet Dwyer and Chris Short, an agricultural economist and a geographer both with long experience of policy analysis and evaluation in this field. The second supervisors included Sophie Devienne, expert in comparative agriculture; Keith Watts from the WG Future Farming Team, and Prysor Williams, an expert in agronomy and Welsh agricultural practitioner. This would enable the policy implications and challenges emerging from study design and accumulating findings to be shared, discussed, and refined, increasing the relevance of the work to its WG sponsors. Half-yearly presentations of emerging findings were also made to Keith, other WG policy team members and the wider policy development group that they had assembled, enabling wider stakeholder input to this process.

Farmer participants in case study areas who contributed information were also fed back the results of the study (including topical analysis), as were other key gatekeepers, most notably Glenda Thomas from FWAG Cymru. In addition, a personal

research blog was also created online, to record the steps taken and share the research, from its inception to its results[18].

In summary, the method of comparative agriculture, with its systemic approach and its typified agrarian diagnosis tools, combined with a purposive selection of study areas could help upscale and generalise findings from the studies of small agricultural area agrarian systems, to facilitate the understanding of Welsh farming multifunctionality and possible changes in the future. This vision was developed in an open and interactive partnership with the supervisory team and the expanding network of practitioners and stakeholders across Wales, enabling cumulative feedback into the subsequent elements of the study. Given the specific vision of the WG, this approach and method would have potential for a wider impact than Wales. It has potential relevance as a method for regional or national policy analysis which provides territorial sensitivity and offers scope for stakeholder engagement, throughout.

B. Selection of case-study areas

The SFS policy's comprehensive implementation requires an understanding of its impact on diverse farms and landscapes. Thus, to initiate the approach, specific regional units in Wales were identified, to select study areas. This is achieved through the analysis of bio-climatic conditions, land use, and multifunctionality expression within these units. A second step in the selection process involves anticipating future dynamics, including Brexit's effects on multifunctionality expression. These insights guide the selection of case-study areas, ensuring an informed sampling (Hugonnet, 2018).

1. Research to identify the regional units

After the brief introduction of Chapter 1, regional units in Wales were identified through an initial analysis. This involved a week-long field study across Wales to make a broad landscape analysis. Out of these observations came block-diagrams of typical

[18] https://theolenormand.mystrikingly.com/

landscape organisation and broad characteristics in terms of large-scale landscape change – focusing on regional units that might represent similar types of landscape and land use (Cochet, 2015a).

This initial landscape grouping was combined with an analysis of secondary data (geophysical, ecological and socio-economic) and a literature review (Cochet and Devienne, 2007). Geology maps were analysed (BGS, 2022; Talbot and Cosgrove, 2011) to understand links with the geomorphology and relief (Derruau, 2010; Goudie and Migon, 1993; Goudie, 2020), soil types (DataMapWales, 2019; Keay and Hannam, 2020) and habitat types (DataMapWales, 2017). An important step was the study of topographical maps from Ordnance Survey to make the link between topography and human activities. All map resources were downloaded from Digimaps and WG datasets in 2020 to superpose them using QGIS 3.2 software,.

Observations were compared to these used to produce the National Landscape Character Areas (NRW, 2019), although the scale of analysis retained was often larger (e.g. 50km^2 compared to a valley), as functional organisation was considered as well as the combination of some landscapes[19]. This step was supported through online-sourced and library contextual literature.

It is necessary not only to understand current broad regional land use but also the dynamics that will be impacted by Brexit and policy changes; thus, an attempt was made to understand recent regional changes since 2000. Using WG surveys and small area agricultural statistics, trends from 2002 to 2018 were mapped and compared using QGIS and Microsoft Excel (Welsh Government, 2020a). These findings were then compared with SFS scheme priorities, and likely change from Brexit as indicated in the literature (Van Berkum et al., 2016; Vigani and Dwyer, 2018) and in discussions with the WG (Welsh Government, 2019b). WG's own ERAAMP land use change modelling and relevant reports were also considered(Thomas et al., 2021).

19 For example, the Vale of Clwyd unit in our analysis (Figure 3-2) straddles two NCLA areas; National Landscape Character - NCLA 10 Denbigh Moor, 2013; National Landscape Character - NCLA 12 Clwydian Range, 2013 (NRW, 2019)

This combined analysis led to the identification of key dynamics within different regional units across Wales, and areas of potential future change under Brexit and subsequent policy shifts. These insights informed the selection of case-study areas. These interlinked steps informed further discussion on the case-study areas that could be representative of Wales' main regional units to understand the range of challenges linked to Brexit.

2. Identification of regional units in Wales

The key factors around Wales' geology and climate were briefly covered in Chapter 1 leading to different bio-climatic conditions in Wales. A summary is provided in the annexes of the determinants of this diversity (Annex 4 Item 4-1 and Annex 4 Item 4-2). Instead, the analysis will focus on the two key units that can be identified uplands and lowlands and their respective characteristics after combining these bio-climatic factors. (Welsh Government, 2020c).

In upland territories, as elevation increases, growing conditions deteriorate significantly (Figure 3-1). Various factors such as soil types, operating conditions, species diversity, and the length of the growing season progressively decline as one climbs higher. The flow of water in these regions follows a centrifugal pattern, starting from impermeable rocky mountains and moving towards softer bedrocks and faults (Derruau, 2010). Soil development is slower, resulting in thinner soils, especially in comparison to valleys (Rudeforth et al., 1972). The most favourable soil types and conditions are typically found in alluvial valleys and on slopes. The landscapes in these areas are predominantly pastoral, ranging from permanent pastures to temporary ones, and further up, to rough grazing areas and mountainous plateaux. This diversity is reflected in the main habitat classes of Wales, encompassing heather moorlands, blanket bogs, and tree plantations (Welsh Government, 2020c).

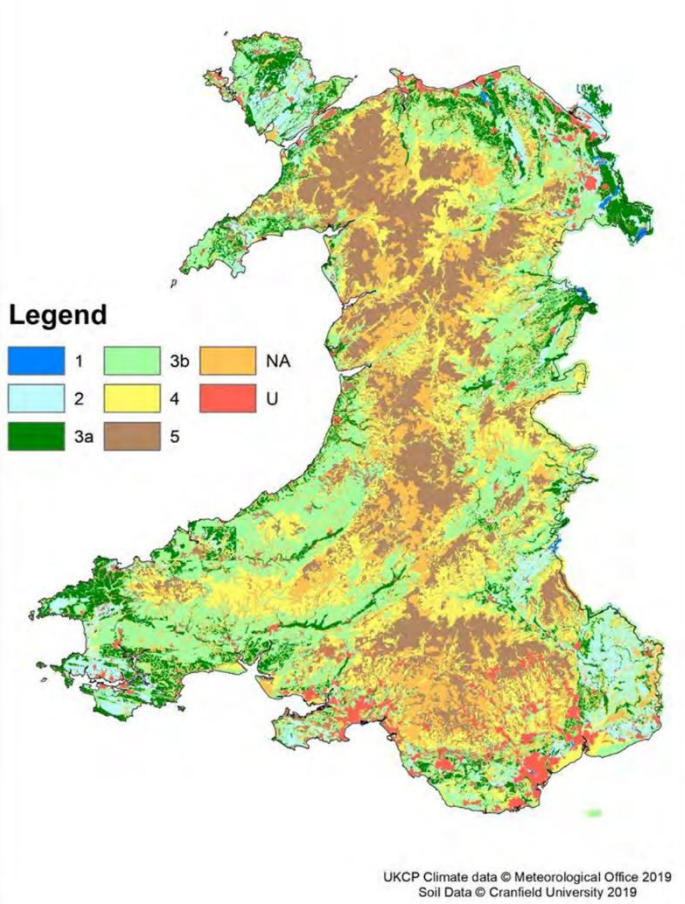


Figure 3-1: Predictive Agricultural Land Classification in Wales (Keay and Hannam, 2020) Legend: 1 is the best and most versatile soil, U stands for urban and NA for non-agricultural

Conversely, lowlands serve as natural sinks, exhibiting a centripetal organization where watercourses concentrate in areas with softer bedrocks. In these regions, areas around rivers, floodplains, valley floors, and coastal plains present higher constraints for agricultural production in respect of drainage. However, on slopes or rolling hills, these constraints related to drainage are less prominent. Lowland hills can have a cap of rough grazing. The smooth relief of the lowlands sharply contrasts with the rugged uplands. These lowland landscapes are more uniform locally concerning bio-climatic conditions, predominantly dominated by a pastoral landscape featuring temporary and semi-permanent pastures. In limited areas of Wales, different types of land use are observed, with more extensive cultivation of crops such as potatoes or cereals (Welsh Government, 2019a).

3. Definition of regional units

From the previous analysis, key regional units were identified (Figure 3-2) which will be described briefly, before considering the importance of agriculture and the dynamics observed, in each. Delineating large regional units based on relief, agriculture, and anthropic organization, seven units within Wales were identified. When describing recent changes, 2002 statistical results at the small agricultural area scale will be compared to 2018 (Welsh Government, 2020a).

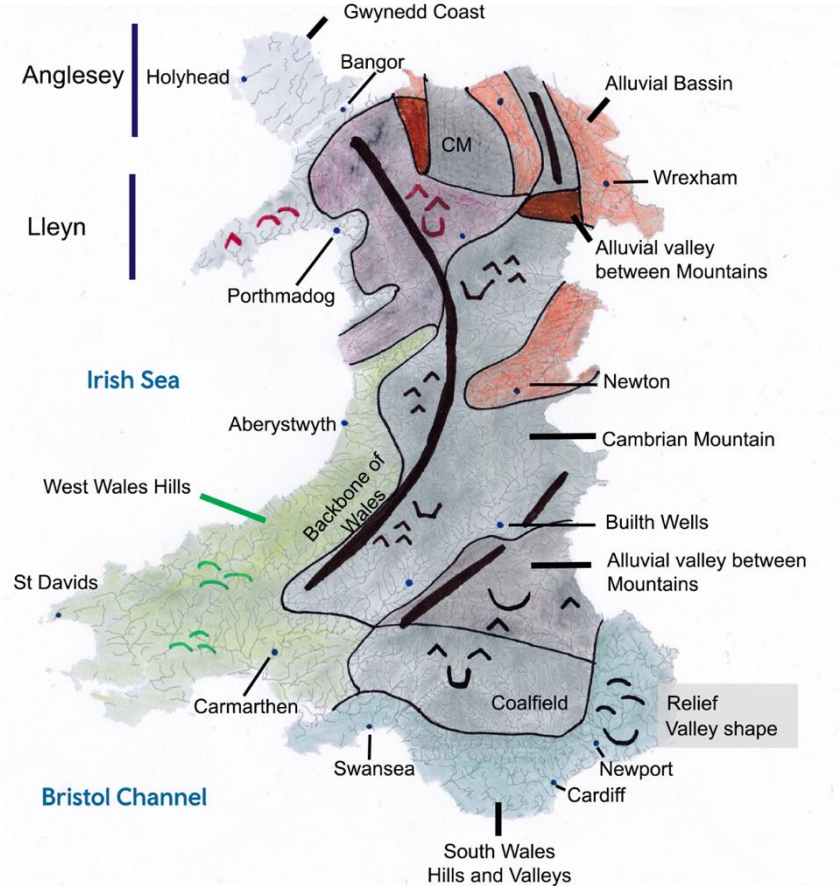


Figure 3-2: Map of regional units identified in Wales (by the author; European Environment Agency, 2020)

A description of these will be briefly covered, including upland areas and the key agricultural trends which have been highlighted in Annex 9. Two different contexts can be highlighted in the uplands in terms of changes (Figure 3-2;Table 3-1) from the more detailed analysis (Annex 4 Item 4-3). The first context is in the upper uplands (e.g. Snowdonia) specialised on beef and sheep farming and farm numbers remaining stable. In other areas with a lesser proportion of mountain land, more farm structural

change with strong differentiation on poultry and dairy can be witnessed (e.g. Cambrian mountains).

In lowlands regional unit (Table 3-2; Figure 3-2), two key different contexts can be identified from the more detailed analysis (Annex 4 Item 4-4). The first can be found in dairy focused lowlands that are relatively homogenous like the West Wales lowlands these tend to further specialise, particularly on dairy, other areas have a stronger beef and sheep focus with even stronger specialisation. The landscape in these tends to be more heterogenous with different pressures as a result (e.g. valleys in between hills or close to urban areas).

This description and analysis led to the identification of seven units within Wales that could be grouped further linked to structural changes taking place, geography, and farm specialisation.

Table 3-1: Characteristics and trends of the key upland regional units (by the author from fieldwork and secondary literature)

Uplands- Annex 4 Item 4-3		
Regional unit	Characteristics	Trends
North West Wales Mountains – Snowdonia (Eryri)	Permanent pastures, extensive rough grazing areas (over 50%), and craggy mountains with bogs and acid grasslands. Gradient of beef and sheep production. Low production potential.	Snowdonia's land use has remained relatively stable since 2002, with minimal decline in stocking rates. While the area has experienced a decrease in sheep farms, the decline has been comparatively lower than that of cattle farms. High level of tourism, few food processing industry.
Cambrian Mountains	Rough grazing ranges from over 50% to over 25%, indicating central blocks of mountain rough grazing linked with the plateau relief. Grassland covers over 90% of the area, with semi-improved grassland prevalent, especially on the West side, exceeding 50 to 60% in many cases. Gradient of beef and sheep production. Higher production potential.	Decrease in farm numbers, especially in suckler cows, with a loss of 10-20% of farms, particularly in the hills from 2002 to 2018. The stocking density has dropped, with more than 1 Breeding Ewe lost per hectare. Increase in poultry farming, especially in Mid Wales and development of spring calving dairy units in the North of this regional unit, which were previously beef and sheep farms. The farms are orientated towards English markets. There is a strong diversification of farms on tourism.
The Dissected Plateau and Mountains of South Wales	The Brecon Beacons/Black Mountains area characterized by expansive, lush alluvial valleys featuring both temporary and semi-permanent pastures, alongside limited crop cultivation such as maize, fodder crops, and barley. These valleys are surrounded by rough grazing hills consisting of marshy grassland and poor acid grassland. The South Wales Coalfield is oriented in a North-South direction. These valleys exhibit U-shaped valleys, interspersed with hills featuring permanent grassland on their sides and in secondary valleys. Rough open grazing can be found on the top, characterized by boggy terrain and acid grassland. The production potential is lower than in the Brecon Beacons area. Farms are focused on beef and sheep production.	Farming dynamics in both these areas mirror these of the Cambrian Mountains, with an overall reduction in stock numbers, particularly in beef and sheep, although these regions already had a less significant agricultural sector as early as 1945. Small scale horticulture plays a slightly more substantial role in the valleys. These regions are home to some processing units, including abattoirs and substantial local-scale processors, often connected to the high local population (eFoodChainMap, 2020).

Table 3-2: Characteristics and trends of the key lowlands regional units (by the author from fieldwork and secondary literature)

Lowlands - Annex 4 Item 4-4		
Regional unit	Characteristics	Trends
West Wales Coastal lowlands and Plateau	The predominant land cover includes temporary grassland (up to 50% near the coast), semi-permanent grassland, and permanent grassland. Grassland occupies approximately 85% of the area, dropping to under 75% in the southern regions where there's more cropping diversity, including maize, potatoes, and cereals. Rough grazing covers less than 10% of the area. There is a small share of DA land, mostly at higher altitudes or on substrates with heavier soils. Dairy farming is particularly strong, with over 15% of farms (and up to 30%) dedicated to dairy production. There is some beef and sheep farming at higher production levels than in the lowlands.	The region has experienced a smaller drop in sheep and cattle numbers in recent years compared to the Cambrian Mountains. However, the region has experienced a significant reduction in farm numbers, ranging from -8% to -25%, coupled with no decrease in farmed areas, indicating farm enlargement. There is a strong diversification of farms on tourism.
North Wales Coast lowlands	With over 90% grassland (primarily semi-permanent pasture) and under 20% rough grazing, it resembles West Wales in production potential and trends. However, it experiences colder temperatures and more pronounced seasonal precipitation patterns. While not as dominant in dairy, it has a higher proportion of sheep and beef farming. This region is closely linked to surrounding uplands.	Farm numbers have dropped more strongly than in West Wales, for beef and sheep but also on dairy.
East Wales Sediment Basins	In Eastern Wales, the landscape comprises large sediment basins with alluvial valleys, flanked by rising hills and some semi-mountainous regions. As a result, an area of high production potential (e.g. like the West Wales valleys) is surrounded by lower production potential areas (e.g. similar to Cambrian Mountains). Livestock farming takes precedence, with a significant emphasis on dairy production (over 15% of farms). Despite the strong dairy focus, beef and sheep farming are significant, especially in beef finishing (with low suckler cow numbers and less than 60% of farms raising sheep). Poultry farms can also be found. These regions are strongly linked with neighbouring areas across the Welsh border. Pressures and links with urban areas exist (housing…).	These areas have experienced lower farm losses, ranging from -2% to -5% from 2002 to 2018, especially in terms of beef farms and dairying, distinguishing them from West Wales.
South Wales Coastal lowlands	The South Wales Coastal lowlands, marked by diverse substrates, display gently rolling terrain and occasional coastal plains. It shares similarities with the West Wales unit but faces challenges from the South Wales conurbation. It has a high productive potential (lambs per ewe > 1). There are diverse productions, including cereals, is prevalent, with a shifting focus towards dairy in the East. Pressures and links with urban areas exist.	The beef and sheep sector is gradually contracting, as in the South Wales Mountains area.

4. Policy goals and sector changes in Wales' regions

In this section, the goals of the WG will be considered against some of the trends that have been witnessed across Wales in the regional units. This will help refine the choice of case-study areas but also suggest avenue for themes of analysis. In Annex 1 Item 1-6 the market challenges and trends witnessed in the meat and the dairy sector were explored (Chapter 1).

a) **A decrease in the number of Welsh Farms**

Welsh Government goals (Welsh Government, 2022a):
• Preserve family farms to maintain and ensure socio-cultural aspect around farming – traditional family farm. • Towards economic and environmental sustainability of the sector

The agricultural landscape in Wales is predominantly composed of small and very small farms, totalling 6,700 and 14,500 respectively (Welsh Government, 2020a; Bradley et al., 2021). The decline in traditional beef and sheep systems, particularly in upland areas like Snowdonia and the Cambrian region, has raised concerns about the socio-economic sustainability of these areas (Dwyer, 2018; Vigani et al., 2021).

Linked to this vision around multifunctionality delivery, the traditional mixed grazing livestock systems in Wales, especially in the uplands, are evolving (Midmore and Moore-Colyer, 2005; Morse and Lenormand, 2021). There is a notable shift away from these practices in most upland areas, although the pace of change varies, particularly between Snowdonia and the Cambrian area, in the latter the pace of change is quicker (Welsh Government, 2020a). This decline in traditional production is mirrored by the rise of poultry units. In the North of the Central Wales Mountains area, there's a shift towards laying hens, while in the South of the Central Wales Mountains, poultry meat units are becoming more common[20].

Although some literature has explored this trend, the scale, location, and drivers remain undocumented, and their environmental and socio-economic impacts are understudied (Williams, 2011; Wynne-Finch, 2012). The lower stocking density in

[20] Landscape observations and analysis of the statistics (Welsh Government, 2020a)

terms of both breeding ewes and suckler cows, coupled with an increase in the number of lambs per ewe, particularly in the Cambrian Mountains compared to Snowdonia, suggests a possible intensification of production. This aspect is crucial in discussions seeking to understand the new developments in dairying[21] (Gerardin and Joseph-Oudin, 2017).

b) Expected development of horticulture and dairying

Welsh Government goals (Welsh Government, 2022a):
• Brexit is expected to have some positive impact on some products • The expectation that there is a need to develop horticulture in Wales

In the lowlands, there is a noticeable shift towards regional specialisation in milk production, on fewer farms and within smaller areas like Pembrokeshire, South of the West Wales unit, and alluvial basins. This concentration raises concerns about environmental sustainability and the underlying mechanisms, as well as socio-cultural impact, especially given the Brexit context (Welsh Government, 2020; Dwyer, 2018). Dairying, perceived as a sector that could benefit from Brexit, is experiencing increased concentration and intensification, evident from the rise in Maize usage in these areas (Welsh Government, 2020).

Brexit has been seen as a potential catalyst for positive change, particularly in the development of horticulture. While limited areas in Wales currently engage in horticultural activities, there are expectations of growth, particularly in regions with fertile soils, such as the South of South Wales and the anticipated expansion in the Vale of Clwyd[22] (Dwyer, 2018).

c) Land use change modelling

From the WG's perspective, concerns have arisen regarding potential Brexit-induced land use changes, as highlighted in the ERAMMP model (Thomas et al., 2021), different scenarios depict varying impacts (Figure 3-3):

[21] Also, from discussions with the WG
[22] Mentioned in discussions with the WG

- EU Deal Scenario: under a favorable EU deal, there might be a shift from sheep farming to non-agricultural use in mountainous areas. lowlands could witness a transition from diverse grazing systems to dairying.
- No Deal Scenario: in a no-deal situation, significant land use change risks emerge. lowlands might shift towards dairying across Wales, with a substantial move from sheep production to beef in hillside areas.
- Multiple Trade Deal Scenario: in the context of multiple trade deals, substantial land use change from sheep and occasionally dairying to non-agricultural use, especially in uplands, becomes a possibility.

Additionally, there is a growing emphasis on tree planting (Chapter 1), but this raises concerns about potential impacts[23]. The Environmental Impact Assessment statistics indicate increased demand for woodland plantations, especially in the Mid Wales Mountains area (FUW, 2022a). The development of poultry units and horticulture income, as highlighted in reports, adds another scale to the evolving agricultural landscape. Dairy farms, poultry units, and pig farms also face challenges in liberalized trade scenarios, necessitating a deep understanding of the dynamics, particularly in dairy-focused areas (Jelliffe et al., 2023; Shrestha et al., 2023; Swinbank, 2022).

The proposed implementation of the SFS scheme raises questions about its impact on Welsh farms, for example with the Brexit *ex-ante* integrated impact assessment (Figure 3-3). This approach, while conservative in its modelling, shows the potential negative effects for the WG goals. This led to many reactions (Financial Times, 2022; Garside and Wyn, 2021) and some of the literature finds that it would not be perceived as a good example of land-sharing (e.g. Hardaker et al., 2021). Multifunctional land-use is questioned in its implementation at a potentially challenging time.

[23] As it happened before for example with the Clocaenog forest in North Wales (Forestry Commission, 1952)

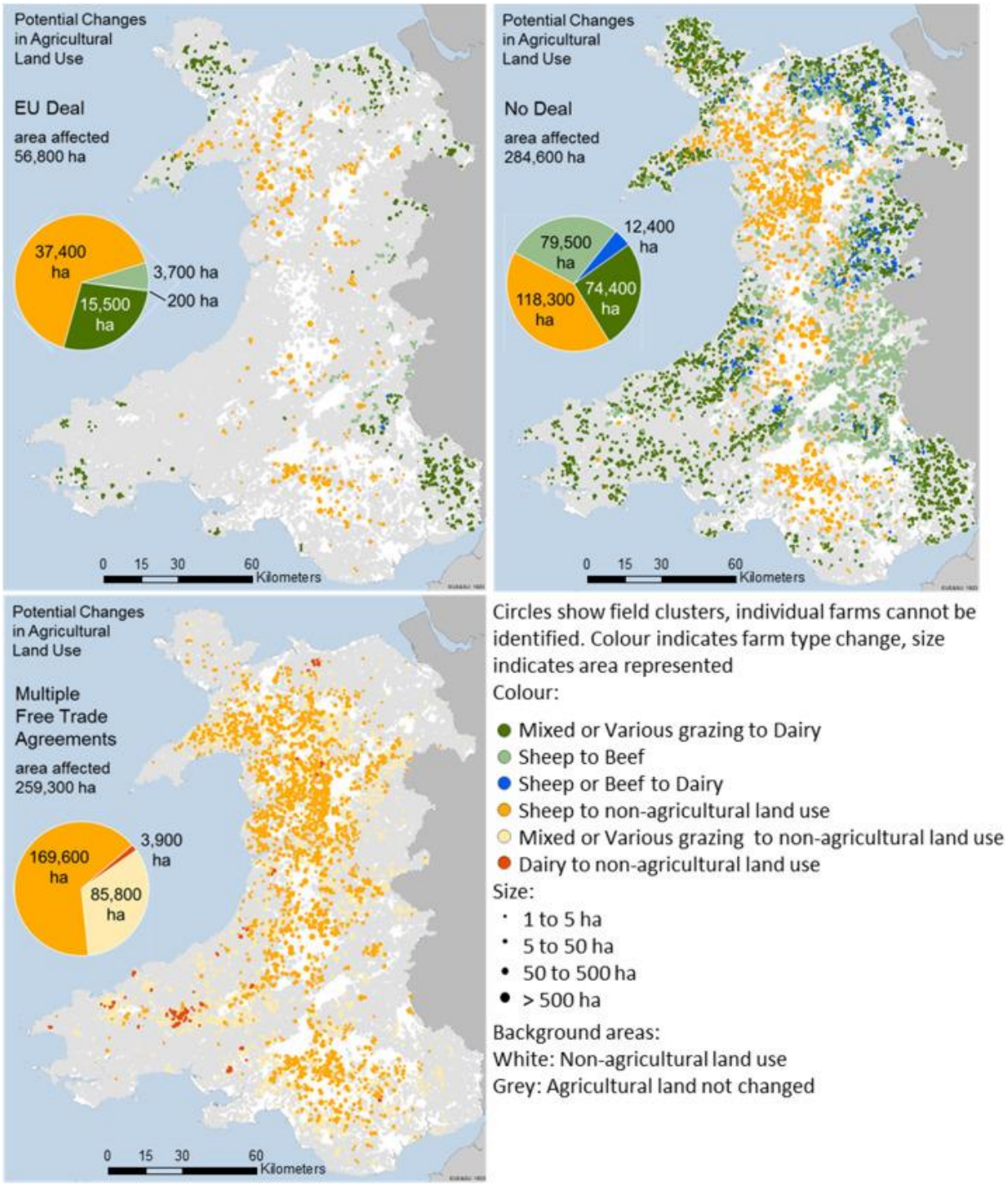


Figure 3-3: Potential agricultural land use change in Wales (From Thomas et al. 2021, ERAMMP modelling)

Legend: There are three Brexit trade scenarios. Farms that have potential for land conversion and are geographically close to each other have been combined into circles proportional to their combined area, such that individual farms cannot be identified. Grey areas are agricultural land not changing under a scenario

Welsh agriculture stands at a juncture, with all sectors vulnerable to Brexit-related changes and affected by the implementation of the SFS scheme. Socio-culturally significant systems and sectors could face dramatic shifts, impacting multifunctionality expression (FUW, 2022b; Hardaker et al., 2021; Thomas et al., 2021; Van Berkum et al., 2016; Welsh Government, 2022a, 2022b).

In summary, this analysis, the broad regional characterization, and supply chain elements provide a guide in how to tailor the analysis of the diversity of farm multifunctionality in Wales. Key considerations from the subsequent discussion of WG policy goals and sector evolution also guide the selection of regional areas and case studies, these can be summarized as follows.

- An interest in horticulture development: considering the potential for horticulture development (at a large scale), it would have to take place on specific soils that can be found in the alluvial valleys (Vale of Clwyd) or In South Wales (Pembrokeshire, with the potatoes).
- Some worries around upland farming evolution: upland areas are of interest due to varied agricultural development trends, especially in the Mid Wales and North-West Wales units. Significant shifts, including new farming types beyond traditional beef and sheep, necessitate a detailed assessment of changes in beef breeding, finishing, and their impact on socio-cultural multifunctionality expression. This could be addressed by selecting a case study in the Cambrian Mountains Area (Rhayader) and another in North-West Wales (Bala).
- Dairy Farming Transition: dairy farming is anticipated to undergo substantial change, although the exact impact on concentration, development dynamics, and their repercussions on multifunctionality expression remain unclear. Different changes and linkages in West Wales and coastal areas compared to alluvial basins add complexity to the sector's transformation. This could be addressed by studying an area of South-West Wales (Pembrokeshire) and North-West Wales (Bala).

Focusing on four areas: Bala, Rhayader, Vale of Clwyd and South Pembrokeshire; is expected to provide the necessary insights to answer the research questions.

C. Research method in the case studies

To address the research goals, an in-depth study was undertaken of three distinct areas: South Pembrokeshire, Bala and the Vale of Clwyd. A lighter touch approach was taken to analyse the Cambrian Mountains due to the overlap with Bala and the Vale of Clwyd area that will be evidenced below (Annex 4 Item 4-3 and Item 4-4). Complementary investigations were then made in other landscapes, to test the representativeness of these four-core case-study areas. The study involved alternating phases of fieldwork, data analysis, literature review, and secondary data analysis, as it moved from one case study area to another and finally into the development of the comparative analysis. The study timeline was collaboratively determined by the WG and other supervisors (Annex 3 Item 3-4).

Ethical clearance was obtained from the University of Gloucestershire on July 16, 2020[24], with the university serving as the data controller. The project adhered to the ethical guidelines outlined in the University of Gloucestershire Research Ethics Handbook of Principles and Procedures. The research was undertaken during and after the COVID-19 pandemic. The work was therefore undertaken as described in Table 3-4 depending on the level of COVID restrictions.

The study would take place as described in Table 3-3 and Table 3-5. The data collection was planned to take approximately six months for the four main study areas. An analysis of the scale of the work is provided in the different case-study areas, in Table 3-5.

[24] The research in Pembrokeshire, was under ethical clearance from AgroParisTech

Table 3-3: Case-study areas and type of fieldwork:

South Pembrokeshire	91 farms; 45 historical interviews, 66 technical-economic, includes 40 where the 2 interviews were done). 25 where the farm had disappeared. Discussions with 5 farming stakeholders (4 farmers). Multiple interviewees were present for large farms with diverse activities (7 farms) and half of the historic interviews.
Bala Upper Dee Vale	61 farms; 45 historic interviews, 51 technical-economic and 35 where the 2 interviews could be done, 10 where the farm had disappeared. 20 interviews took place remotely. Discussions with 5 farming stakeholders (3 farmers). Multiple interviews were done for large farms with diverse activities (4 farms 8 participants) and half of the historic interviews
Vale of Clwyd	65 interviews; 45 historic interviews, 45 technical-economic and 25 where the 2 interviews could be done, 20 where the farm had disappeared). 10 interviews took place remotely. Discussions with 5 farming stakeholders (3 farmers). Multiple interviewees were done (5 farms 11 participants) and half of the historic interviews
Cambrian Mountains	10 interviews covering both the historical and the technical-economic element - 1 farming stakeholder- 2 interview where multiple interviewees were present
Other areas and general landscape reading	5 days general landscape reading – start of the PhD 2 days of landscape reading *2 (Flintshire, Anglesey) 2 days of landscape reading with 1 event (interaction)*4 (Llyn Peninsula, Brecon Beacons, Coalfield valleys, Vale of Glamorgan) Discussions with 5 farming stakeholders (all farmers).
Stakeholders met as part of these interviews – all stakeholders except landowners were interviewed as farmers – see interview schedule – by stakeholder this research describes people with another role than farmer but in the industry	
Large scale private landowners	2 large landowners
Farming unions	4 from FUW and NFU
Farming support organisation	3 Farming connect, 2 NFFN, 1 RSPB, 1 FWAG Cymru, 1 bank
Involved in food processing activity	2 Dairy/Potatoes

Table 3-4: Fieldwork conducted and impact of COVID regulation (by the author)

Covid-19 assumptions	Restrictions	Limited restrictions	Low level of restriction
Welsh Government guidelines were followed as well as that of the University of Gloucestershire	No meeting face to face were allowed	Meeting face to face were allowed outside. Either a face to face or remote interview was offered to participants.	Meetings are held outside but possible inside with FFP2 mask on. Either a face to face or remote interview was offered to participants.
Landscape reading	This step could proceed except during full lockdown, very low risk. Can be intensified to contextualise interviews further.		
Interviews	All interviews could take place remotely using telephone or preferably zoom/skype.	Interviews in person were possible. Physical distancing rules of the WG were followed.	
Feedback meetings	For the briefings and seminars/workshops with WG policy makers and stakeholders, meetings will be held online via Zoom/MS Teams/Skype. Feedback presentation to farmers will be held in a digital form.		

Table 3-5: Steps in the implementation of the agrarian diagnosis case-study (by the author)

Steps in the study from gatekeepers to interviews	
Start	In each of the study areas gatekeepers from existing organisations were contacted – Farming Connect, FWAG Cymru, farming unions; first by raising awareness on the work conducted, secondly, they would decide whether they would help the study by providing contacts and insight in study areas (documents, advice on delimitation of study areas). Participant's stakeholders/farmers will be first contacted over the phone, email, or social networks (twitter).
1	A first introductory telephone call/email where the researcher explains the research would be sent. The farmer will be sent a participant interview sheet, interviews topics and notices (digitally or by post), as made available in Annex 3 Item 3-2 and Item 3-3. The personal website of the researcher was also used to present the research process in an attractive way and present past research outputs.
2	An interview can then be arranged, the informed consent form will be sent, completed, and returned (digitally or by post). The interview can take place once the consent form is received. The researcher will again seek the interviewee approval as well as checking that he or she feels sufficiently informed and conscious of how the data will be used and handled.
3	The interview is recorded by taking notes, the interview is conversational. At the end of the interview, participants were asked whether there is any information that they feel should be removed. Participants were reminded orally that they can ask their data to be removed within 30 days by asking the researcher or/and his supervisors.
4	The interview schedule is often constrained by the farming activities and peak times, the interviews are scheduled at farmer's convenience. The workload can be harmonized week on week due to the necessary transcription of the notes taken. After the interview the researcher will keep locked the note taking. The anonymised paper notes of the modelled farms obtained will be kept locked and the link with the landscape is possible thanks to the typification of the landscape that took place beforehand. The anonymised paper notes will not refer to any identifying element. The modelling of farms archetypes does not mimic any individual farms and is a typified farming system representing a group of farms that have similar use of inputs and outputs. Economic calculations will only be done on the modelled farms.
5	The participants potentially provide the researcher contact to other potential participants, snowballing. The participants have up to 30 days to retract from the study.
End	At the end of the study of each case-study areas the participants will be informed of the result, with a report on the case-study, a summary and eventual analysis, presentations that took place. While for Pembrokeshire it was possible to hold a feedback meeting, this was not the case for other areas due to COVID restrictions. During the PhD the feedback took the form of messages sent at the end of the research on each case-study (SMS/Emails) with links to content produced on the website: with summary reports, full reports, videos, research articles…

D. Case-study areas landscape description

In this section the main points from the earlier strategic analysis of Welsh regions are linked to the four case-study areas (Figure 3-4). This will highlight high-level findings of the first step of the agrarian diagnosis: landscape analysis, a more complete analysis can be found in Annex 4.

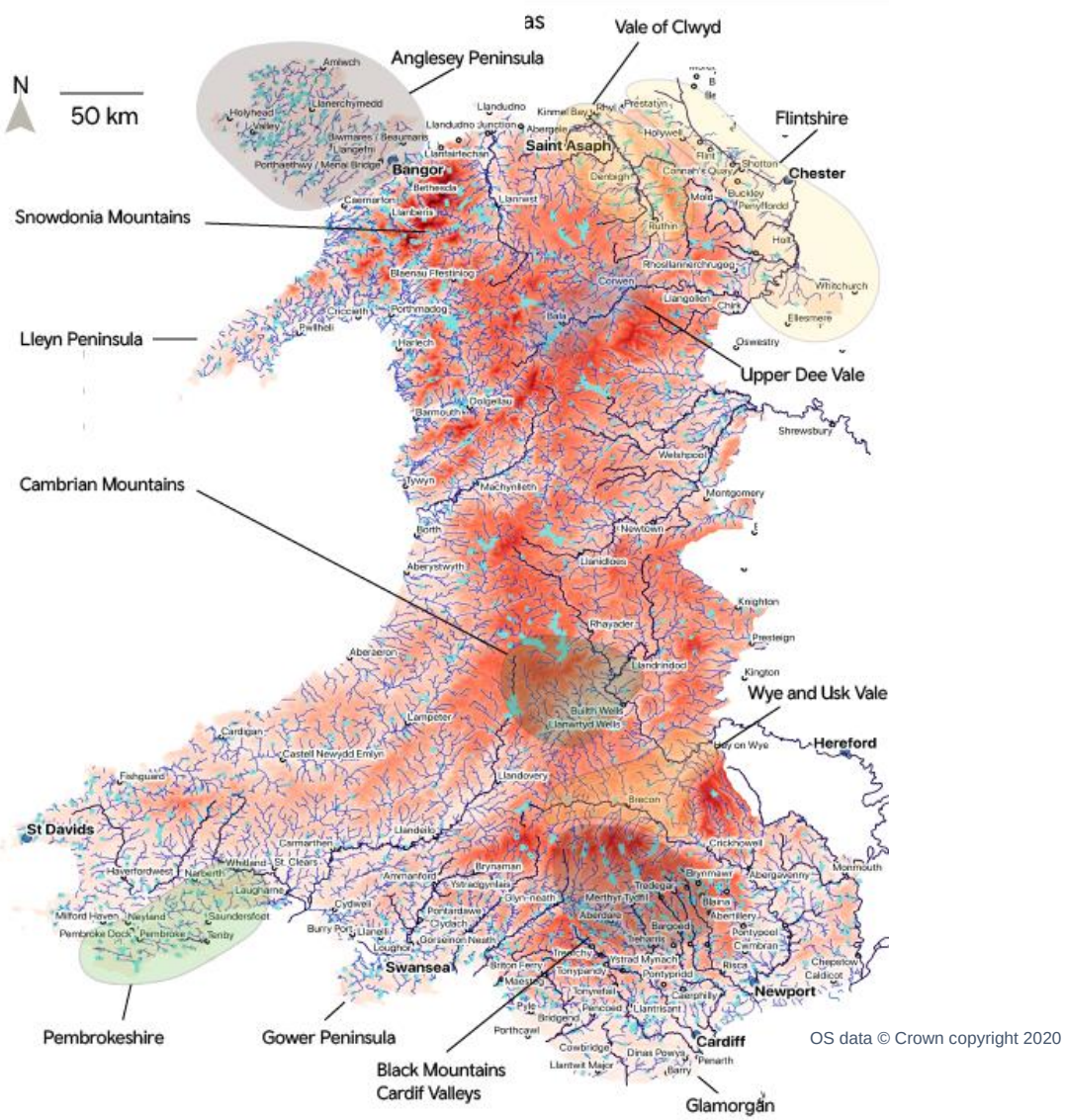


Figure 3-4: Location of case-study areas (by the author from European Environment Agency, 2020; Ordnance Survey, 2020)

1. West Wales Hills and South Wales region: South-Pembrokeshire

The range of landscape is typical of West Wales (Annex 4 Item 4-5), and bio-climatic conditions on some parts of the landscape are very similar to South Wales, with limited urbanisation and a dense farming community. It is a dairy powerhouse, but also a range of horticultural crops typical of Wales (e.g. potato). A range of beef and sheep systems can be found with some cattle finishing taking place. It provides a diversified picture of the trends taking place in Wales lowlands without adjacent uplands. Additionally, a strong reduction in farm numbers questions the dynamics/trends, even before Brexit, and the role of lowlands in multifunctionality expression, in the future.

2. North West Wales: Bala and the Upper Dee Vale area

This area (Annex 4 Item 4-7) has an inner diversity of context that represents well different typical landscapes of Snowdonia's particular upland territories. This is a landscape both traditional in its structure and offering some new opportunities for development in the uplands and Hills. It is representative of the altitude gradient found in Upland territories with mosaic upland, lush alluvial valleys, some glacier valleys with the typical U-shaped forms, smooth climbing valley sides with hills and towering above them peat hills, the wide-open moors with the dramatic landscape linked to Snowdonia. Some forestry is located on steep hillsides or tops. The area around Bala is not isolated but it is nestled between Snowdonia National Park and the North of Cambrian mountains. The trends in terms of stocking changes are in line with the rest of the North-West Wales mountains. With its relatively wide alluvial valley it features some new development of spring calving dairy farms, as well as some new poultry farms, focused on egg production.

3. The Vale of Clwyd

The Vale of Clwyd study area complement the upland areas and lowland study areas as it is organised around a small alluvial valley (Annex 4 Item 4-6). This is a prosperous lowland alluvial valley with soft permeable substrate bordered by rolling lowlands and

hills on the West, rather harder to erode and impermeable; and the Clwyd range in the East - a steep escarpment. This cuesta acts as a physical barrier preventing access to the smoothly descending other side. The Clwyd range is an AONB and borders grade 2 land, among the best soils in Wales that could be seen as potentially good for horticulture. Farming is articulated around dairying, beef and sheep farming. The Vale of Clwyd is a typical alluvial basin and features a milk area in its middle with a diversity of production. In the heart of the vale the number of breeding ewes and dairy cows is falling sharply but the farmed area and the number of suckler cows and fattening cattle remained at similar levels. The average stocking rate decreased slightly from 2002 to 2018. It is a landscape waiting for further development of farming with a potential to switch partly to horticultural crops. To the West, the area of hills has faced among the highest rates of reduction in suckler cow and sheep farms while not developing poultry so heavily.

4. Cambrian Mountains area

To complement the Upper Dee (Bala) area, another upland area was chosen (Annex 4 Item 4-8) that can help understand the specific challenges linked to Mid Wales. The landscape is complementary to Snowdonia with a plateau and hilly plateau relief. This landscape is not as thin a mosaic compared to what can be found around Snowdonia. The area is nearly entirely under grassland and has numerous poultry farms (and now pig farms). This is the area of Wales that suffered the most losses from 2002 to 2018 in terms of number of active farms. The landscape is split between farming the valleys, the hills, and the forest. There is a very big open moorland for farmers: a very different organisation compared to Bala, with less of a mosaic and larger blocks.

5. Synthesis landscape description

Wales offers a diversity of pastoral landscape with different levels of bocage mosaic as well as the mountain land. Key comparative elements were highlighted from the landscape analysis that can help understand the landscape’s impact on production to continue the area grouping that took place earlier. Two categories of landscape units were identified in lowlands as seen in Table 3-6; with small and large ridges, but three

distinct altitudinal layers in uplands (Table 3-7). These types can help structure the historical analysis of farming systems' change and when farm economics in results chapters is considered.

Table 3-6: Landscape units in lowlands – broad characteristics (by the author)

Landscape units in lowlands case-studies	**Large ridges/Core of the alluvial valley/Coastal/Big smooth hills** "Bocage landscape"	**Small and steep hills/Small ridges/Steep valleys** "Bocage landscape"
Characteristics	Longer grass growth Easier access to field Lower proportion of permanent pasture and forestry Bigger fields	Shorter grass growth Lower access to field and cropping possibilities Higher proportion of permanent pasture and forestry Smaller and steeper fields.
Key variations across areas compared to the "standard" landscape	Red soils on big ridges, more free-draining and close to the coast.	Steeper fields in some conditions with limited hayfields, drier and more dangerous for livestock.

Table 3-7: Landscape units in uplands – broad characteristics (by the author)

Landscape units in uplands case-studies – Altitudinal layers	**Alluvial valley L** "Bocage landscape"	**Climbing hills or slope H** "Bocage landscape, brown topped"	**Mountain M** "Open Grazing" with some in-bye and forestry
Characteristics	Longer grass growth Easier access to field Lower proportion of permanent pasture and forestry Bigger fields	Shorter grass growth Lower access to field and cropping possibilities Higher proportion of permanent pasture and forestry Smaller fields and steeper (with wet parts).	Shorter vegetation growth. More restricted access. Higher proportion of rough grazing and forestry. Larger grazing blocks.
Key variations across areas compared to the "standard" landscape	Size of the alluvial valley and floodplain.	Steeper fields in some conditions with limited hayfields. Slopes or hills for the climb up and different relief due to underlying geology.	Different amounts of mountain converted to pasture in the landscape[25]. Different types of moorland due to underlying geology.

In the uplands three distinct landscape units can be identified linked to the altitude, the relief, and the land cover.

The distinction between uplands and lowlands is not always clear, particularly in the detailed landscape analysis covered in Annex 4 Item 4-5. Most of Wales' uplands are

[25] Often termed as reclaimed

characterised by the presence of “high altitude” rough grazing or mountain ground and lowlands by low-lying territories (hills or valleys). However, there is a distinct split between high upland areas - with a proportion of rough grazing/ mountain of over 30%, and high relief differences- and intermediate uplands areas with closer to 15% of more dispersed rough grazing with a smoother relief (Annex 4 Item 4-9; Lloyd and Dyfri Jones, 1980). This split is not representative of the formal split within the LFA designation, as most hill farms would be in Severely Disadvantaged Areas and some Disadvantaged Areas would be in lowlands (Annex 4 Item 4-10). Nevertheless, many of the intermediate uplands are not in agro-ecological hardship with good production potential. These areas which would be classified as hill farming as determined in UK policy almost a century ago[26], have a relative disadvantage in agro-ecological terms compared to lowlands, but they are also diverse as highlighted in the analysis, this will help nuance the dichotomy between uplands and lowlands in answering the research questions. This represents intermediate hills complementing lowlands and uplands with a structure usually similar to uplands (Table 3-7) but with a smaller mountain area. This simplification will help structure the analysis to link it to deep production potential differences and thus potential land uses.

The development of the early agrarian systems will now briefly be highlighted in the case-study areas, this discussion will help set the scene for the forthcoming results chapters.

[26] i.e. with a relative disadvantage compared to lowlands in respect of their farming potential (Bazin, 1992), but which today is commonly linked to the EU definition of Less Favoured Areas (LFAs) that were redefined as ‘Areas of Natural Constraint’ (ANCs), after 2013

E. Early farming change in Wales and the UK

Different periods were distinguished using a literature review and secondary data analysis to describe agricultural policy and economic tools as summarised in Annex 5 Item 5-3. This early historical analysis is not directly providing an answer to the research questions, but as highlighted in Chapter 2 it will help clarify the origin of the diversity of farms to then answer the research questions. First, the origin of the Welsh agrarian system will be briefly covered up to the end of the Second World War.

1. The origin of the structure of UK farming

The historical development of the UK's landholding system can be traced back to feudalism, where the obligations of peasants gradually transformed into landlord-tenant relationships (Thirsk, 1987). This change was significantly influenced by the industrial and agricultural revolutions, leading to the reorganization of farming systems and field boundaries under the direction of landowners (Clark, 2002; Dwyer and Hodge, 2016; Hodge, 2016). This context resulted in a diverse range of farm types (Howell, 1999, 1983).

- Large farms, either home farmed by the estates with salaried workforce or tenant farmers with large amount of capital (potentially over 40-60ha, 6% of farms; Zayed and Philip, 2019), with the largest home blocks and on top of the large ridges/best parts of the landscape.

- Mid-size Farms, with a mix of family workers and salaried workforce with intermediate amount of capital (over 8ha, 38% of farms; DEFRA et al., 2022; Grigg, 1983; Zayed and Philip, Loft, 2019)

- Smallholders, with only family workers, possibly even only working part-time on the farm and selling their workforce to other farms (often under 8ha, 48% of farms; Zayed and Philip, 2019)

In upland areas, farm types were more differentiated due to very different agro-ecological factors, larger farms have access to multiple landscape units, while smallholders had limited access to only some units (Annex 5 Item 5-2).

The early 20th century brought significant changes to the UK's farming. The First World War incentivized farms to increase food production, with temporary government grants and market price regulations (Clark, 2004; Hodge, 2016; Rackham, 1986). A significant change compared to the libertarian turn taken in 1870's. Farms strategically positioned (distance from the market or agro-ecological factors offering the potential to produce cash crops/niche products) transitioned to owner-occupiers. However, the 1920s posed significant challenges due to a global agricultural depression, the shift towards more owner-occupier nevertheless continued due to the impact of rising death duties on traditional landowners (Annex 6 Item 6-1 and Annex 5 Item 5-3). Perishable products like fresh milk and niche items retained profitability but outside from this, difficult times economically prompted shifts in farming practices and a move toward more pastoral farming compared to 1870 (Annex 6 Item 6-1 and Annex 5 Item 5-3)

Even with the pastoral/grazing livestock focus farms were producing their own food and selling their mostly their surpluses with little inputs[27]. All farms were mixed farms (with a mix of livestock and crops) relying on different productions and outputs (inc. some processed) to offer a stable output and a regular production spanning through several months (dual purpose cows and milk/butter, pigs, sheep, beef cattle…). The regional differentiation among farms was primarily driven by their comparative advantages but broad characteristics can also be identified from Annex 5 Item 5-2:

- It was shaped by agro-ecological factors. Varied grass growth patterns on different landscapes necessitated strategic decisions, such as opting for more dairy cows or finishing cattle in favorable conditions.
- Access to inputs and markets were important, with transportation costs, even with railways, proving significant, especially for areas distant from population centers. This disparity in costs and travel time affected perishable products like eggs, chicken, milk, and potatoes.

[27] Apart from seeds and some feedstuff

- Agricultural development, including infrastructure and equipment, alongside socio-economic factors, and land improvement efforts, further influenced farm specialisation.
- Tenure status and additional income sources also impacted farm development strategies.

Larger, well-positioned farms with superior fertility and infrastructure exhibited greater economic integration and specialized in specific production types. These factors highlight the nuanced dynamics of regional farm specialisation.

2. A gradual focus on productivism

The development of the productivism took place in two phases, one before the Second World War and the second after. The development of policies in relation to the socio-economic and historical context as well as technical development and their adoption have been studied extensively by the literature, the key elements will be briefly summarised and its phases to link it to the analysis of case-study areas transformations, those changes are covered in detail in annexes.

a) **Technical changes**

The 20th-century agricultural revolution, driven by technological advancements, had three phases, as described in Annex 5 Item 5-1**.** The initial phase from 1920 in Wales, focused on motorization, employing tractors for efficient ploughing and field operations, leading to increased acreage for fodder crops and improved livestock fodder production. Innovations such as bucket vacuums in new buildings streamlined milking chores and allowed for larger herds. The transition from haystacks to haybarns enhanced management and improved fodder quality. Farmers also embraced advanced grazing techniques and purchased inputs to boost efficiency.

The second phase, from 1945 witnessed the widespread adoption of tractors, lorries, and cars, revolutionising farming practices and providing farmers with increased mobility to access inputs, outputs, and services (Annex 5 Item 5-1**)**. Veterinary sciences played a pivotal role in minimizing farm losses. Despite the potential

advantages, the adoption of innovations was mor complex in uplands due to cost considerations and bio-climatic conditions. The sector experienced significant transformations, with a focus on efficiency, specialisation, and technological advancements. Labour productivity increased significantly as a result but less so in uplands and marginal areas.

b) Context and policy change after 1930

From the 1930s, the United Kingdom responded to economic challenges on agriculture by implementing substantial measures to support its agricultural sector (Annex 5 Item 5-3). Legislative acts such as the *Import Duties Act* of 1932 and the Agricultural Marketing Act imposed import tariffs and regulated markets for livestock and various agricultural commodities on a sector that had been liberalised. For example, the Milk Marketing Board played a crucial role in establishing a standardized national price for fresh milk, this strategy led to a decrease in net imports of targeted agricultural products and the formation of monopolistic structures and farmer cooperatives (Empson, 1998; Franks, 2001).

Subsidy schemes played a role in supporting land and farm improvements, covering areas like drainage, livestock enhancements, and farm building refurbishments. The Milk Marketing Board significantly contributed to these enhancements, and the interventionist approach extended support across diverse agricultural productions to ensure fairness for producers (Empson, 1998; Franks, 2001).

c) Context and policy change 1939-1945

The Second World War marked a pivotal moment for farms as they played a crucial role in addressing the U-boat blockade that posed a threat to British food security[28] (Annex 5 Item 5-3). In response, the government implemented rationing and price controls, and farmers were subject to comprehensive market control, including

[28] Rationing only ended in 1954

guaranteed prices and mandated farm management plans. The centralized organization of the food supply involved rationing and streamlined food processing.

During this period, farmers had to adhere to instructions from local committees regarding crop rotations and farming system design. Agricultural improvements were accelerated, with significant premiums incentivizing arable production[29] and the reclamation/reseeding of hillsides. Although these measures were applied to all farms, uplands experienced lower returns and did not benefit as much from pre-war changes in their production mix.

The war era also witnessed the implementation of systematic milk collection through Marketing Boards, aiming to control food distribution and provide it at a reasonable price to the population (Empson, 1998). Medium and large-sized farms with high production potential were provided with tractors to address labour constraints. The "Land Army" and prisoners of war played significant roles in time-consuming cultivation operations, particularly in lowlands.

The changes faced by the study areas are covered in Annex 5 Item 5-2. Despite some transformations most of the changes were endogenous and preserved broadly the agrarian community, the landscape, and the productive processes of the study areas. It resulted in an intensification of production often using slightly more inputs; for example, expanding areas in rotations, reclaiming areas from the mountain or increased livestock densities. The case-study areas were more integrated with surrounding areas, already they would be even more focused on some key outputs (like milk for lowlands and store animals for uplands).

d) Context and policy after the Second World War

This is discussed in more detail in Annex 5 Item 5-1. After the post-Second World War, Western trade policies, influenced by the General Agreement on Tariffs and Trade (GATT), prioritised trade liberalisation while safeguarding heavily protected

[29] Premiums were provided for improvements, particularly going towards arable production, to return permanent grassland (£10/a) deemed suitable for cultivation (e.g. permanent grassland near livestock farms) with subsidies to reclaim/reseed hillsides (Hodge, 2016).

agricultural sectors. In the UK, following a Keynesian economic framework, the farming sector was nationalised during the war to ensure food security. Post-war Agricultural Acts guaranteed prices and outlets for agricultural products, with notable policies such as deficiency payments and innovative schemes like the Hill Farm Compensatory Allowance to help farmers in the uplands. The *Agriculture Holding Act* of 1948 provided tenancy security, contributing to a rise in owner-occupied farms. These offered a protected environment for farmers to increase the food production for Britain. Forestry acts post-war strengthened the Forestry Commission's role as the forestry resource manager, and the *National Parks and Access to the Countryside Act* 1949 focused on landscape conservation.

The agricultural policy then saw continuous improvements and a further focus on production increase. A notable shift occurred in the 1960s as the UK government viewed agriculture as a potential export industry. Upon entering the European Economic Community, the UK adapted its agricultural policy to integrate improved supply and demand control tools through Marketing Boards. Farm development plans from 1970 offered subsidies to enhance productivity and encouraged specialisation, field adaptations, and the adoption of new techniques. Early retirement plans aimed to facilitate the exit of less efficient or smaller farms from the sector, reflecting a nuanced approach balancing research of productivity gains and support of farmers' interests.

3. Impact of the productivism era on the agrarian system

The transformations of farming systems had remained limited in terms of operating logic before 1945 (Annex 5 Item 5-2). But the set of transformation incentivised by the productivism era had a differentiated impact on the farm ecosystem. It has been shown that there were three broad size of farms which have different access to production resources, therefore resulting in differences across regions that could result in different dynamics found in agrarian systems (Annex 5 Item 5-3).

In summary, this chapter helped explore the hypothesis that the comparative agriculture and a combination of case-studies of its tool the agrarian diagnosis could represent a research method to provide answers to the research questions at the

Welsh scale. Successive sections briefly articulated the rationale behind the selection of the case-study areas. The implementation of the agrarian diagnosis in those case-study areas was described before presenting first findings on the bio-climatic conditions and a brief analysis of the early policy and agrarian context in Wales. This showed that there were already different trends of agricultural development in Wales across areas up to 1980 although the changes were relatively homogenous within each area.

In the next chapters, recent farm developments will be studied using the three broad types of farms, the three landscape types and the five key agro-ecological units in our four case-study areas. Today's farms' challenges will be linked to their diversity and their historical development pathways. Chapter 4 will cover lowlands and Chapter 5 will cover intermediate and upper uplands. Chapter 4 and 5 will focus on the results of the agrarian diagnosis with an investigation of farms' past and present-day challenges through their evolution but will also consider the technico-economic performance of archetypes. Together, these chapters focus on the economic and environmental elements of present-day multifunctionality in Welsh farming.

Chapter 4. Farm differentiation in the lowlands

The changes in Welsh farming prior to the 1980s led to a gradual reduction in the range of farm activities, focusing all development of the farm business on one function: food production. Farms grew more homogenous, larger and more specialised. But from the 1980s onwards, the policy environment changed in response to a growing realisation that the focus on agricultural production had some unfortunate knock-on consequences. This period marked the start of a new period of agricultural development where food production-focused drivers were gradually overlain with conflicting and emerging visions for reduced subsidy spending, liberalisation of the sector; a more multi-functional agriculture; and environmental conservation. Welsh lowland areas were the first to be hit significantly by these new policies due to their focus on milk, which was one of the first areas reformed: upland policies were preserved for a longer time period. The main trends will be highlighted in the agrarian systems' differentiation, and its consequences for multi-functional agriculture in Wales by analysing technical changes and their socio-economic implications during this second main phase of change at the farm scale. This chapter focuses on the historical, environmental and technical-economic element from the agrarian diagnosis in the 2-lowland case-studies. Those 2 steps are directly linked to the 2 steps in interviews described in chapter 2 and 3. While the historical analysis is based on changes observed in the Pembrokeshire case study area, further observations in the lowland areas of the Vale of Clwyd add some additional elements.

A. Farming changes 1945 to 1980

Before developing the more recent analysis of farm differentiation, the varied agro-ecological conditions in lowland areas as well as the type of farms and their evolution since 1945 will be presented below.

1. Different landscapes and different types of farms

Two main agro-ecological units were identified to describe the Welsh lowland territories: large ridges - big rolling hills with better cropping and growing conditions; and small and steep hills (Annex 4 Item 4-5). In terms of farm types, three key farm sizes are identified after 1945, summarized in Table 4-1. At that time most farm enterprises were heavily focused on own household consumption.

Table 4-1: Indicative table of the state of the production mix in lowland case study area (by the author)

	Farm characteristics
Smallholding	<15ha, 2FTE labour <10 Shorthorn cows – for dairy and calves 30-40 ewes Welsh- for wool, and store lambs Rotation 1 in 10 years – cereals, green and fodder crops Rest for household consumption – adoption of mechanization – use of inputs Little infrastructure
Mid-size family farm	20-60ha, 3-5 FTE labour <20 cows – Dairy, calves, and strong stores (sold at 24 months) 50-100 ewes – for wool, also finished lambs Pigs and chickens Rotation 1 in 10 years – cereals, green and fodder crops (Early potatoes or Christmas poultry) Rest for household consumption – adoption of mechanization – use of inputs Medium sized blocks of land
Large	Over 60-80ha, over 6 FTE labour Over 30 shorthorn cows 100-200 ewes – for wool, also finished lambs Pigs and chicken but mainly OC Rotation 1 in 10 years – cereals, green and fodder crops Rest for household consumption – adoption of mechanization – use of inputs Better access to blocks of land suitable for large herds
	For own consumption: pigs (bacon), chickens, potatoes… *Lowland farms had a higher proportion of farms owned*

Small farms in lowlands relied on dairy (dual-purpose beef and milk) and beef store cattle, some 20-30 sheep, and a few acres of cereals: these three enterprises generated each a third of the farm's output value in terms of surplus for sale; the rest would be for own consumption. As size increased, farms over 40ha required more labour that would often be from cottages/smallholdings (with little land of their own); these kept 10 to 15 cows and retained all their beef calves. Larger farms had been much more affected by the 1870s agricultural price decline. They produced 2 or 3-year-old cattle to be sold as stores. By contrast, large farms would have more cows - up to 20-30 - and a more specialised approach in terms of main outputs sold. Farms

would also have small woodlands and hedges (at least around the farm) to provide wood as fuel.

2. Changes from 1945 to 1980

After 1945, the 20th century agricultural revolution was implemented in full, facilitated by sustained policy support as summarised in Chapter 1 (Annex 5 Item 5-1; Item 5-2; Item 5-3). This levelled up most farms in the landscape into specialised grass-based farms, including these on the less favourable small ridges and the more productive big ridges. Almost all farms' resources were focused on milk production, with labour productivity gains driven by mechanization. Farms gradually ceased their other enterprises. Most farms had not expanded in acreage, but fodder productivity gains allowed growth in production and incomes, and many farmers were able to buy their land: e.g. by 1986, most farmers in Pembrokeshire owned their farm (over 90%; Welsh Government, 1998) and all labour was from the family, except during peak working times. The only farms that did not specialize in dairying were these with ample supplies of the best soil; red soil on big ridges which could grow early potatoes as well as feed wheat, to fatten beef cattle rapidly with the use of demanding breeds. Potato farming had previously fallen into decline due to price pressures (volatile prices and an expensive crop to manage; Annex 5 Item 5-1)(Lloyd et al., 2008; Sykes and Hardaker, 1962). All these transformations are covered in more detail in Annex 7 Item 7-4.

Two key goals had been successfully pursued: increasing both food production[30] and farm productivity. In the rest of Europe, agricultural policy and market drivers also triggered a significant labour decline, whereas in the UK the proportion of these employed in farming was already quite low, because of industrial expansion and rural exodus in previous centuries (Bowers, 1985). Nevertheless, the sector reduced gradually in economic importance (down to 1.2% of UK GDP by 1990; 0.5-0.6% by 2005). Farm numbers also reduced but many of these who remained in agriculture could attain a broad standard of living equivalent to other sectors but this had knock-

[30] In order to meet more of UK domestic needs while maintaining existing trade commitments, this reached up to 85% of domestic types of food consumption in 1985 (DEFRA, 2021c).

on consequences of food-focused agri-policy for UK landscapes and the environment (Bowers and Cheshire, 1983; Hodge, 2016; Rackham, 1986), leading to significant damage to wildlife and other natural resources. Continuing an agro-industrial trend which began as early as the 1920s (Rooth, 1985; Woods, 2007a), the 20th century agricultural revolution also led to a greater integration of UK producers into global supply chains (Empson, 1998), with the emergence and establishment of very large-scale food processing and retail companies in the UK and Europe (e.g. Agri-Dutch Unilever; Proctor and Gamble; etc.).

B. Farming changes 1980s-2020s

As in chapter 3, secondary data and insights from the literature on agricultural technical change, market trends or policy change which could not be fully articulated in this chapter were made available in annexes. A summary is provided for each period to facilitate the subsequent presentation of the fieldwork's findings. A summary of the pathway analysis was provided in Item 8-1 for Pembrokeshire and Item 8-4 for the Vale of Clwyd.

1. Evolution of policies and markets

Prior to EEC accession in 1973 some domestic outputs were already in surplus, and market support costs had increased (deficiency payments to farmers on key commodities), putting UK agricultural policy, and market support under increased scrutiny in the UK (Annex 8 Item 8-9). This gave rise to several widely-read analyses of its failings (Body, 1984; Bowers and Cheshire, 1983; Campbell, 1985). From the 1980s onwards, pressure gradually increased to reform the CAP, particularly due to the cost of the policy and its perceived negative impact on environment (Bowers and Cheshire, 1983; Hodge, 2016; Jacquet, 1993). This pressure led to a gradual tightening of farm support in the 1980s, also spurred by the negotiation of the Fontainebleau agreement which enabled the UK to 'claw back' a share of its net contribution to the EU budget, annually, based on the difference between contributions and expenditures (D'Alfonso, 2016).

a) Changes from 1980s to 2000s

The change in policies and markets is covered in detail in Annex Item 8-9 and Item 8-10 but the main elements are summarised below. During the 1980s the CAP introduced production regulation through quotas and later, 'set-aside' (payments to take land out of production) for the main agricultural products, notably milk in 1984 (Barthélemy and David, 1999). The MacSharry reform in 1992 supported the idea of a multi-functional approach to farming, and in the subsequent decade the policy developed the components of what became its 'second pillar' of the Agenda 2000 reforms, with subsidies supporting environmental measures (agri-environmental management, restoration and investment aids) and grants for a range of rural development activities (Bazin, 2003; Buller, 1999; Dobbs and Pretty, 2008; Jacquet, 1993). The market measures of the 'first pillar' were transformed through successive guaranteed price cuts with the introduction of direct payments as compensation. In Wales, the earliest agri-environment schemes were the Environmentally Sensitive Areas, introduced from 1987 (Buller, 1999; Wynne-Jones, 2014). By 1998, farm output prices were aligned to fluctuating world market levels. Across the UK, its agricultural marketing monopolies were broken up during this period (e.g. Meat and Livestock Commission, Milk Marketing Board; Bourgeois and Pouch, 1993; Finney, 2021; Pouch and Trouvé, 2018). Agricultural regulations were tightened, most notably in the form of an initial and then an expanded implementation of the EU Nitrates Directive (first implementation 1994, expanded from 2002; Beck et al., 2007; Burt et al., 2010; Wynne-Jones, 2013).

From the value of subsidy support level obtained from fieldwork[31], but also comparing the subsidy received to the price level resulting from market deregulation in each product (e.g. Pouch and Trouvé, 2018) and the cost of new regulation (e.g. Finney, 2021; Hodge, 2007; Prince et al., 2022; Wynne-Jones, 2013), dairy farms received a relatively low level of support compared to that offered to beef and sheep producers. Incidentally, this also meant that combined with the broader CAP changes towards

[31] And compared to past values of farm support in CAP payment data (DEFRA, 2020) but also specific support scheme

environmental support (Boatman et al., 2008; Dobbs and Pretty, 2008; Rose, 2011) the level of subsidy was increasing in uplands but diminishing in lowlands. Based on fieldwork and the literature, further reforms would maintain this gradual change towards less coupled, more environmentally focused support (e.g Ciaian et al., 2018).

b) Changes from 2000s to 2020s

The change of policy and socio-economic context was introduced in Chapter 1 and is discussed in detail in Annex 8 Item 8-10 but the main points of the analysis are summarised below. Under UK devolution legislation passed in 1998, Wales gained new powers to determine its own agricultural policy. This was important as more options were offered to EU member states in respect of how CAP was implemented, in the Agenda 2000 reforms. At first, Wales kept its implementation of first pillar subsidy partially linked to farm output, using historical reference levels (Boinon et al., 2003) to calculate a decoupled Basic Payment Scheme (Bouyssiere and Buczinski, 2015; Chambre d'Agriculture Normandie, 2015; European Commission, 2016). From 2015, a Wales-wide, flat-rate decoupled Single Payment Scheme was gradually introduced, with a redistributive element which favoured smaller holdings, taking into account the end of LFA subsidies (Farmers Weekly, 2002). Full decoupling was finally attained in 2019 (Townsend Chartered Surveyors, 2020), with payments subject to cross-compliance conditions (Hart, 2015). This process was less radical than that followed in England, where full decoupling and the move to a flat-rate payment were complete by 2012 ensuring more farm income farm stability particularly for beef and sheep producers.

Under the CAP agri-environment schemes, Tir Gofal was launched in 1999 and Glas-Tir in 2012[32]. Glas-Tir, focused mostly on the management or creation of environmental and historic features through five-year contracts including annual payments (management) and environmental grants (investment support)(Fieldwork; Welsh Government, 2016; Rose, 2011; Wynne-Jones, 2013). The WG also developed

[32] A pilot scheme, Tir Cymen, ran successfully in three specific target areas of Wales in the period 1994-98.

a broader business support approach for farming, with investment grants and public-funded advisory bodies Farming Connect and Menter y Busnes offering a variety of services, including one-to-one advice and business development groups (Hindle et al., 2021). While the overall level of CAP funding to farms reduced from the 1980s onwards (European Commission, 2018), it was undertaken in steps as shown in Figure 4-1: simplified evolution of farming environment in Wales from before 1990 to 2019 (by the author from a literature review), with some sectors prioritised.

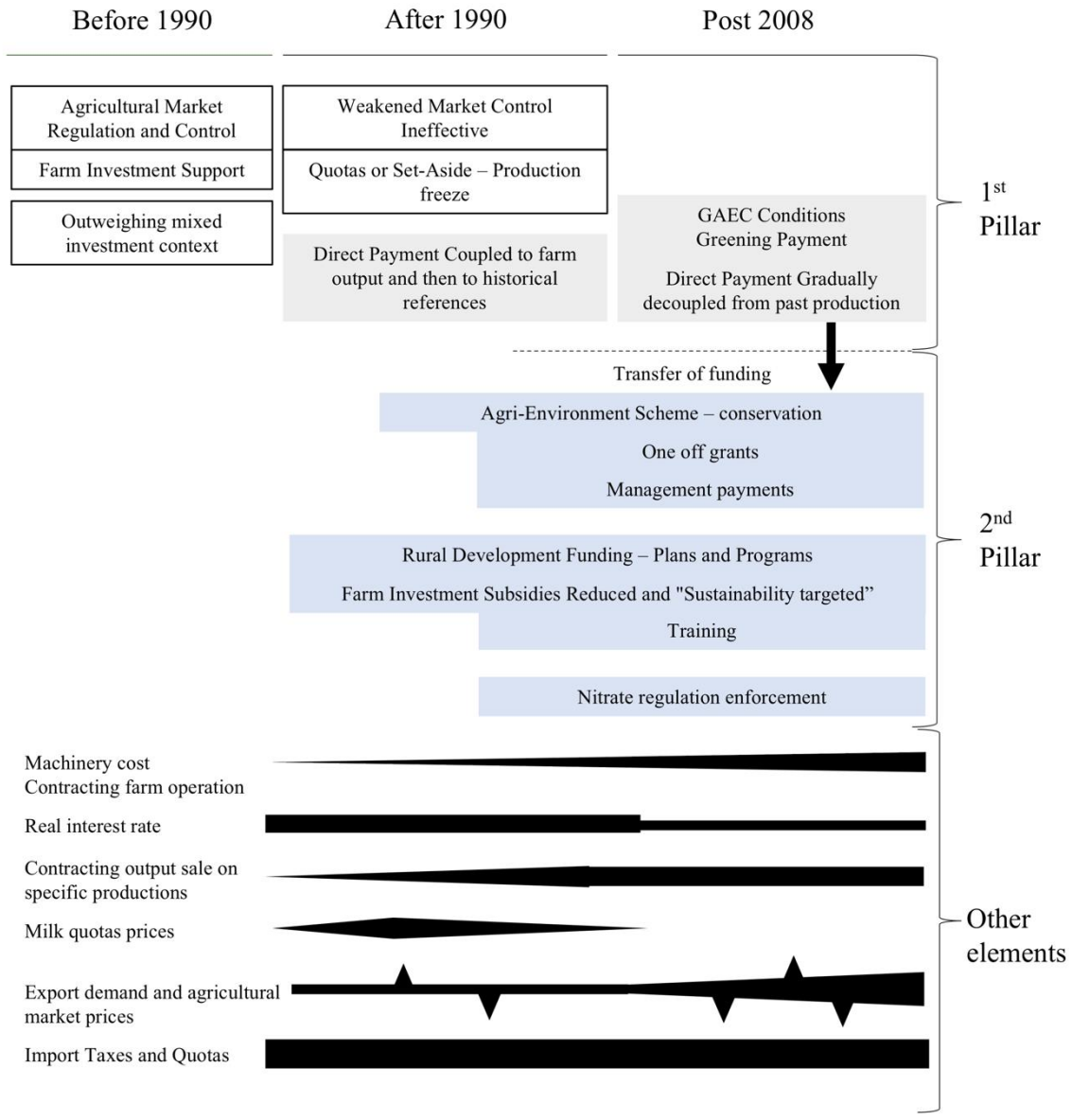


Figure 4-1: simplified evolution of farming environment in Wales from before 1990 to 2019 (by the author from a literature review)

In Wales, beef and sheep farms and then particularly extensive beef and sheep farms (especially in the uplands), were afforded more policy support than other sectors

(Bazin, 1992; CJC Consulting, 2003; European Court of Auditors, 2011).This resulted from a combined influence of first and second pillar payments and their evolution: subsidy payments reduced more steeply in lowland areas than in upland areas as they moved to the flat-rate system, while agri-environment payments proved more popular in the uplands (DEFRA et al., 2023).

2. From 1980, a first phase of farm differentiation and expansion

The context as illustrated in Figure 4-1: simplified evolution of farming environment in Wales from before 1990 to 2019 (by the author from a literature review) was particularly challenging from 1990 to 2000; as milk price fell steadily against the high price of quotas (Figure 4-2). The cost-price squeeze situation for milk was mirrored in beef production, despite more sustained policy support.

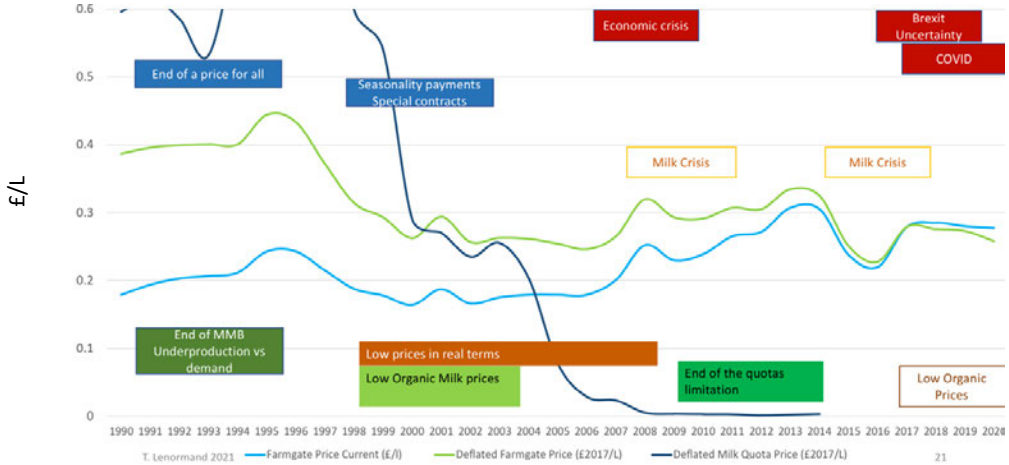


Figure 4-2: Farmgate fresh milk price and quote prices between 1990 and 2017 (by the author from FAOSTAT, 2021 and Townsends Chartered Surveyor, 2016)
Legend: In real and current terms (£/L)

New “disruptive” equipment (herringbone parlour, self-propelled harvester…) and increased fodder production options (winter cereals, maize silage, Italian ryegrass) became available although they were costly to implement and only applicable the best parts of the landscape (Annex 8 Item 8-9). On the other hand, small labour and fodder productivity gains were made possible for every farm via contracting (e.g. self-propelled harvester, third cut of baled silage…), and adoption of high-yielding Holsteins. As a result of these opportunities and constraints a selection and differentiation took place among existing farms, that was mirrored in other UK dairying

areas (Rohé, 2018). While 2008 did not match the exact above policy changes in Figure 4-1, it refers to a gradual combined change of context ranging from the price of inputs, interest rates, demand for agricultural output and environmental regulations with a more supportive context after 2008 than before while subsidy support changed more gradually.

Table 4-2: Drivers of change in Pembrokeshire farming: from interviews, complemented by literature analysis (by the author; Annex 6 and Annex 8)

Global economic and investment context	The global economic environment changed enormously over the course of the 20th and beginning of the 21st centuries. The real interest rate (comparing the Bank of England interest rate and the inflation rate indicates the cost of borrowing capital and two phases are distinguished (Savills Research, n.d.). From 1990 to 2008 real interest rates were high: but from 2008 to 2020 lowered offering a much more favourable investment context. Banks would lend to these farmers with enough collateral (i.e. owning assets) or with high added-value and relatively low risk business plans (Annex 6 Item 6-5).
Agricultural input prices	Most inputs used in farming are imported, with costs based on world market prices. These increased steadily (in real terms) over the last three decades (i.e. doubling for petrol-derived products, 1990-2019) and with high volatility (most notably, the financial crisis of 2008). Feed, fuel and derived N-fertiliser prices stepped up from 2008. (FAOSTAT 2021; Annex 6 Item 6-4).
Agricultural output farmgate prices	Although most Welsh products were destined for the EU, agricultural farmgate prices gradually mirrored world markets, meaning reduced prices and increased volatility. Export bans and declining consumption of meat increased nervousness (due to BSE and the 2001 Foot and Mouth outbreak; Beck et al., n.d.; Bennett and Jones, 1999). A high sterling exchange rate further pushed UK prices down until 2008 (Savills Research, 2020), after which they gently increased in real terms for most livestock products, as developing-country demand began to pick up (FAOSTAT, 2021; World Bank Data, 2018; Annex 6 Item 6-3 and Annex 8 Item 8-9)
Quotas on agricultural products and subsidy entitlements	Tradeable quotas on agricultural products were never used for meat but were initially very costly to buy for milk, until 2005 (Barthelemy, 2001; Barthélemy and David, 1999; Townsend Chartered Surveyors, 2016; Figure 4-2). By then, UK milk production had reduced substantially and was below the total UK quota, which made it gradually worthless (Townsend Chartered Surveyors, 2016). In 1992, the Milk Marketing Board (MMB) monopoly was liberalised, ending a 'one price for all' policy and giving way to direct processing contracts with variable bonuses or cuts and stringent milk specifications (Fieldwork; Franks, 2001). Small dairy farms tended to receive the lowest prices (Fieldwork; Franks, 2001).
Liberalisation of the land market	Tenancy legislation previously in favour of the tenant farmer (under the Agricultural Holdings Act 1960) was liberalised through new flexible Farm Business Tenancies (FBT), from 1995 (Gibbard and Ravenscroft, 1997; Hill, 1985). This reversed the balance of power, with landlords able to adopt shorter terms, a best-price approach to renting land, and retention of control (Savills Research, 2020).
Emergence and promotion of new farming system tools	The agricultural industry adopted technical changes gradually increasing labour productivity and output volume. New infrastructure and machinery tended to enable capital substitution for labour (e.g. milking robots, GPS-guided tractors…; Annex 8 Item 8-9).

Farmers nearing retirement without a clear succession plan exited dairy farming, often aided by government programmes or selling/leasing their quotas. Depending on farm size and age, some shifted to beef production, raising cattle for slaughter on larger plots or rearing young cattle on smaller areas. This led to a notable drop in output for these farms due to simplified farming practices and land management. These leaving agriculture entirely were able to lease out their land to larger, more profitable farmers through flexible agreements like Farm Business Tenancies (FBTs) or (annual/short-term) grazing agreements (Table 4-2).

Dairy companies favoured sourcing milk from a reduced number of larger farms, providing them with higher prices via newly established direct contracts, aligning purchased milk with their specific product requirements. Expanding within this framework was challenging, it required investment-heavy approaches reliant on high inputs. The primary tactic involved rearing more cows and producing barley-fed bull beef – on which there was no limit-, facilitated by increased input use, expensive feed, and improved productivity.

Dairy farms with limited investment capacity, such as these already mortgaged and lacking successors, pursued income maximisation with little investment. This involved small expansions, opportunistic leasing of land, taking additional silage cuts and gradually outsourcing cropping, thus enhancing labour productivity despite financial constraints. Expansion on smaller ridges was more challenging, due to unfavourable bio-climatic conditions, necessitating a larger acreage to accommodate increased herd sizes, which limited growth. Across all lowland landscape types, management was simplified: rotating stock was eschewed in favour of mob grazing based on field size. Expansion relied on increased input purchases, as little land was available on the market -and if it was fast expanding farms would outbid other farms-.

The BSE and foot and mouth crises led to changes on beef and sheep farms. Cattle needed faster fattening (under 30-36 months) amid a depressed beef market due to export bans. Pressure to enhance labour productivity and livestock gains through increased inputs led to farm specialisation. The under-36-month rule favoured specialised finisher farms. Sheep farms adjusted to earlier lambing and increased their enterprise by purchasing some feed, to make the most of more lucrative market prices

(e.g. the Easter market). Farms sought to maximize animal numbers due to subsidy regulations.

During this phase in Pembrokeshire, there was a resurgence in potato cultivation. In the mid-1990s, local farmers established the Puffin Produce cooperative, aiming at lucrative contract markets such as chippers and supermarkets. There were few farmers on red soil capable of irrigation and affording the upfront costs for expensive equipment. This equipment would be fit for 200ha potato crop on a five-year rotation (standard practice for disease control) it compelled these farmers to lease substantial seasonal land (at a high price), with an input-intensive and high-output operation, despite market uncertainties and volatility. Farms taking it up would be large farms.

Around the turn of the 21st century (Figure 4-1: simplified evolution of farming environment in Wales from before 1990 to 2019 (by the author from a literature review)), the operating environment began to improve; contracting emerged, and quota prices experienced a decline. A policy shift away from subsidies tied to stocking rates in 2005 triggered a need to find alternative means of sustaining farm incomes, even more given low milk prices. Consequently, all barley beef units ceased before 2008. Simultaneously, the UK's stricter nitrate regulations enforcement in 2002-2003, coupled with renewed specialisation in dairy herds, necessitated investments for most farms. Farms that had not increased size or yield by this period faced challenges as, after 2005, direct subsidy payments were fixed based on historical reference periods.

Small dairy farms, typically housing around 90-100 dairy cows, which had previously experienced gradual increases in both yield and cow numbers, sought significant growth with the adoption of the post-1992 support package. They saw a trend of specialisation and simplification, facilitated by the departure of numerous neighbouring farms from the sector, enabling expansion.

Other farms lacking investment capacity pursued more conservative expansion strategies, either moderately increasing scale by acquiring land and intensifying input use (including a third cut of silage) or opting out of dairying.

Farms that had already undergone substantial expansion continued post-2005 towards herds of 150-250 dairy cows, which is the operational limit of the herringbone parlour. Most dairy farms had good historical reference levels for the new CAP first pillar support introduced after 2000, as they had comparatively high milk yields per animal and had tried to keep as many animals as possible in a limited environment for growth. Due to their high fodder production and high outputs, subsidies per acre went down by approximately 30%-40% on most farms after full decoupling began in 2013, except on small, extensive early beef and sheep holdings.

Agri-Environmental Schemes (AES) were not taken up by most Pembrokeshire farms as they were not a target area and managed few outstanding features. CAP second pillar support in this area went mostly towards investment grants (e.g. hedges, farm tracks…). Which improved the farms' infrastructure. The amount of subsidy per Pembrokeshire farm declined in this period, despite continuing amalgamations (DEFRA et al., 2023). The number of dairy farms in Dyfed (including Pembrokeshire) declined from around 2500 (1995) to 1200 (2008) (Welsh Government, 2020a, 1998).

3. From 2008, a second phase of farm expansion and differentiation

After the financial crisis of 2008, farms continued specialising in response to volatile agricultural markets. Depressed milk prices and rising costs of feed, amidst oil price spikes, created financial strain. Despite this, reduced constraints on farm expansion and investment offered growth opportunities at low interest rates.

Livestock-based markets saw some demand recovery post-2010, but prices remained low. Dairy firms began offering different prices based on farm size, milk production patterns, and quality, aiming to better match their pool of producers to their processing equipment and markets. To sustain income, with tighter margins and reduced subsidies, dairy farms made the most of these changing demands.

New farming methods aimed at reduced input and labour use with an IT revolution in dairying boosted labour productivity via technology (robots, GPS-based systems). Some farms specialized solely in dairy, outsourcing crop management or buying

silage. Cereal wholecrop silage, a new method, offered high-energy feed suited to Pembrokeshire conditions including on small ridges.

Farms that expanded in the 1990s-early 2000s faced challenges to meet the interest costs on their resulting loans. To cope, they had to continually raise cow numbers and milk production, embracing IT to boost labour productivity, and emphasizing husbandry. However, as herds and cow yields increased, incorporating grazing into cows' routines became progressively difficult: typically, these were herds over 500 cows, yielding over 9,000L/year/cow.

Smaller farms in a comparable position could adopt the new I.T equipment in a 1-1.5 FTE-sized farming system, maintaining herds under 200 dairy cows, with some continued grazing.

The remaining dairy farms operated at slightly lower scale (200-250 dairy cows), in terms of labour and productivity. Limited investment capacity restricted major expansion, with these farms yielding 7,500-8,500L/year/cow. They combined whole crop silage and grass use, relying on increased external resources. Milk prices were maximized via contracts based on autumn calving or stringent milk specifications, year-round. These farms' carrying capacity depended on their available grazing platform, leading some to adopt autumn calving to alleviate summer grazing pressure or reduce the grazing regime. Larger ridge farms typically had more accessible grazing area.

Most farms had moved away from short rotational grazing as herds grew, so grazing pattern was not linked to an efficient use of the grass growth cycle. A way to use less input to reduce cost and grow more own fodder was to return to more grass-based and home-fed systems.

- Spring calving herds situated on big ridges have thus emerged, capitalizing on their ample grazing areas. These systems are characterized by low yields coupled with remarkably high labour productivity and simplified herd management. Cow numbers typically range from 90 to 250 dairy cows for longstanding "legacy" family farms, but some herds can reach up to 500,

especially in entrepreneurial holdings: large pre-existing farms (owned or under stable tenure) or newly-formed via estate amalgamations. They often include "new entrants" engaged in share-farming or with Farm Business Tenancies (FBT).

- Since 2005, organic farming has seen an increase, spurred by a new incentive scheme. Farms on big ridges have adopted diverse rotations to maintain soil fertility, catering to fewer, lower-yielding dairy cows. Farms with sufficient land could convert to organic farming with larger cow numbers, thus offering these smaller farms access to higher-value production at low cost. However, managing the conversion could pose challenges for farms with more limited land, as it requires additional acreage to maintain fertility under longer rotations.

For beef and sheep enterprises, among the farms that dropped out of dairying, a range of store cattle producers and fatteners has developed. Renewed trends in beef enterprises include calf-rearing (bought in from dairy farms) for fattening, or sale as stores. As the beef market slowly recovered from the impacts of diseases in the 2010s, more farmers on small ridges moved into fattening using maize or whole-crop silage. A wide range of input and output profiles exist among beef and sheep units, depending mainly on the age of the farmer(s) and their land tenure. The differentiation trends are summarised in Annex 8 Item 8-9.

After retiring, a growing number rent out their land while maintaining their status as farmers. Some growing crops and rearing heifers for bigger dairy farms have also appeared out of former dairy farms, since 2010. A few sheep farms are also present in the landscape, while potato farms have increased in size but with no change in numbers.

Thus, over the course of 30 years, the number of active farms has more than halved (from 2,500 to 1,000 dairy farms over 1995-2018; Welsh Government, 2020a, 1998) as farms have roughly doubled their dairy herd size. The number of farm workers has reduced with the substitution of capital for labour.

In summary, the number of farms has fallen sharply as farms were forced to specialize and expand to survive, in a competitive environment. Most farms in the Pembrokeshire

case-study area remain grass-focused, in an overwhelmingly green landscape (>90-95%, and closer to 97% pasture cover in winter) still providing the bulk of dairy cow diets. But there is much more diversity among farms and between farming systems than in the 1980s. The change is represented in the landscape with different levels of production on pastures. While some fields are increasingly included in input-heavy rotations, others have gone the opposite way. This can also be said of many other system components: dairy cows, grass seeds etc. Nevertheless, farms are working as an interlinked ecosystem, trading goods to make a profit out of this good quality land.

4. Vale of Clwyd

In the Vale of Clwyd, lowland areas (alluvial valley and hills) are surrounded by mountainous hills. The adoption of specialised farming has been more recent compared to areas like Pembrokeshire, particularly on dairy farms. The findings of the pathway analysis are summarised in Annex 8 Item 8-4.

a) **From 1980 a slower differentiation and expansion**

As market conditions became more challenging in the late 1980s, quotas hit hard the many dairy farms that just had expanded despite high interest rates. The dynamics described in Pembrokeshire could be found albeit at lower scale in terms of farm size. More farms remained in beef and sheep (sometimes abandoning dairy specialisation). Some farms that were mixed (livestock and crops) were also hit by set-aside rules. As a result, beef and sheep enterprises remained a stronger feature than in Pembrokeshire, including on dairy farms as many farms had spare hill land (inc. mountain grade land) but also due to the slightly different grass growth profile[33].

Contrary to Pembrokeshire, at the ending of the MMB Vale dairy farmers mainly joined a cooperative, reducing the need to differentiate at first. The collapse of the co-operative later in the 2000s put producers in a difficult position, except a few larger ones that had differentiated their contracts.

[33] Higher bulk growth but not capable to graze cows as early

Further, limits to expansion came from the landholding. Given the high density of farms in this area, even with the new productivity package (particularly high energy crops), the limited grazing area available to each holding limited herd size (usually a maximum of 100-150). Even with cheap inputs, farms with some land in the best part of the valley would still grow some corn, in contrast to Pembrokeshire. The land market of the Vale also changed in the 1980s-1990s. As in Pembrokeshire, farmers retired, and their farms were sold or rented out altogether. New residential buyers purchased small lots with houses, and re-let the land, at least partially (c. 10-30ha plots). Land expansion would tend to be spread-out making it more challenging to graze, with competition for the best land on the lowland sites. The price of farmland in the Vale was approximately 30-50% higher than in Pembrokeshire.

b) From 2010, a later differentiation and specialisation

The “late” expansion in the Vale, due to a combination of factors, reduced the pace of immediate possible further change in the 2000s compared to Pembrokeshire, with more pressure on land but also greater agronomic potential. There was increased possibility to grow cereal crops, particularly as it allowed some farms to have a higher level of autonomy. Likewise, a higher degree of autonomy was possible over some machinery (e.g. silage-making) than was the case in Pembrokeshire: these two factors tend to explain a lower average size.

The reduction in lowland farm numbers has been similar in the two regions, albeit later in the Vale of Clwyd. This, combined with a landholding profile not particularly well adapted to grazing large herds (more dispersed due the smaller starting size of farms, except on former estate ‘home farms’) has led to smaller farms persisting, and for these that increase their farm size, a higher proportion of high-yielding herds reliant on high-energy crops.

Herds over 500 dairy cows have only developed since the 2010s in the Vale, based on former estate ‘home farms’. Average dairy farms are smaller than in Pembrokeshire although they have a similar range of differentiation (organic, spring calving…). More small farms can be found with herds of 40-60 cows, but the median dairy farm would

have 100-150. Sheep or beef might still complement a dairy enterprise due to the specific holding situation (e.g. proximity to mountains, dispersed landholdings).

As in Pembrokeshire, there is a mix of specialist and converted beef and sheep farms, and most of the farms in the core produce either fat animals or strong stores (grown quickly). More farms grow energy crops: these see higher daily weight gains. Among recent trends in the Vale of Clwyd there is a rapid development in dairying: most dairy farms apart from these on "alternate paths"[34] are differentiating, moving towards more specialised systems (e.g. autumn calving, heifers reared somewhere else…) to deal with their more limited grazing areas. Recent trends in the Vale of Clwyd are not dissimilar to Pembrokeshire but show a different dynamic.

C. Summary of farm archetypes identified

The resulting archetypes of the historical differentiation process can be found in the figures below in the key case-study areas from the lowland area case-studies (Figure 4-3;Figure 4-4). Those archetypes have been described in more detail in intermediate publications (Lenormand, 2019; Lenormand and Dwyer, 2022).

Type of farm	Landscape	Number of archetypes	Size of farm	Milk production pattern	Other element to consider
Dairy	Small ridge Grass and potentially wholecrop (for higher yielding)	1	<60-120DC small	All year round. - 6KL	- Diversification selling on the farm - Type of crops on the farms - Milking equipment - Keeping its beef calves for rearing - More demanding fodder (either grown or bought-in
		2	200-250DC intermediate	All year round – 8.5KL Autumn calving – 7.5KL	
	Large ridge - Grass, wholecrop, maize	2	<60-120DC small	All year round -9KL All year round – Organic – 6KL	
		3	200-500DC intermediate	All year round – 8KL Spring Calving herds -6KL All year round – Organic- 7KL	
	Small & large ridge - Grass, wholecrop, maize	2	>500-2000DC large	All year round - >9KL	
Support farmers	Small & large ridge	2	15-50ha	Active support farmer – rearing heifers producing fodder Renting out the land	- Link with the lead farm
Beef and sheep	Small ridge - Grass, fodder crops	2	Small - 100 head of cattle	Storecattle rearing – 3weeks old to 24m old storecattle Cattle rearing and fattening – 6m old to 30m old fat	- Can be part-time farm/ semi-retired
	Small ridge - Grass and potentially some fodder crop	2	Small - 35-40 SC 200-400 Ewes	Organic farm- 12m old storecattle light Conventional – 12m old storecattle heavy	
		1	Intermediate – around 100SC or storecattle rearing 100 head/year	Finishing storecattle – 20-22m old sold at 24-28m fat cattle	
	Large ridge - Grass, fodder crops and	2	Large – 100-180 SC large Or 50 SC with >700 heads of sheep	Organic farm – 28m old fat Non-organic farm – 28-30m old fat (heavier)	- Some farms might have a sheep rearing activity as well
Potato farming	Large ridge	1	150-350ha	Specialist potato farm renting land in - Might have an annex activity Supplying Puffin Produce Different numbers of equipment	

Figure 4-3: range of archetypes identified in the Pembrokeshire case-study area (by the author)

[34] E.g. Organic farming, adding diversifications activity like milk vending machines, ice-cream parlours…

Type of farm	Landscape	Number of archetypes	Size of farm	Milk production pattern	Other element to consider
Dairy	Small ridge (potentially hill land) - Grass, fodder crops and potentially cereals (for higher yielding)	2	<60-120DC small	All year round. – 6-7KL (inc. Organic 5.5KL)	- Some farms with secondary activity - Beef for larger farms and sheep for those with hill land
		2	200-250DC intermediate	All year round – 8.5KL Autumn calving – 8.5KL	
	Large ridge - Grass, fodder crops and potentially cereals, wholecrop, maize (for higher yielding)	2	<60-120DC small	All year round -9KL All year round – Organic – 6KL	
		3	200-500DC intermediate	All year round – 8KL Autum Calving – 8.5KL – Flying herds Spring Calving -5.5 to 6KL (inc. Organic 4.5KL) - sharefarming	
Other	Small ridge - Very small farms - Grass	2	<20ha	Breeder with 10SC and 80 Ewes Smallholding producing meat boxes and rearing calves on the bottle	
Support farmers	Small & large ridge	2	15-50ha	Active support farmer – rearing heifers producing fodder Renting out the land Breeder	- Link with the lead farm - Might have some sheep as well for heifers rearing
Beef and sheep	Small ridge - Grass, fodder crops, cereals for finishers	2	Small - 100 head of cattle and 400-700 ewes	Storecattle rearing – 3weeks old to 24m old storecattle SC and cattle rearing – as strong stores 18m old or finished if possible to grow cereals	- Can be part-time farm/ semi-retired
	Small ridge - Grass and potentially some fodder crop	2	Sheep specialist 0-40 cattle and >1000 ewes	Predominantly with mountain/hill land Storecattle 18m old and late lambs compared to other farms	
	Large ridge - Grass, fodder crops and cereals	1	Large – >100 SC large with >1000 ewes	With suckler cows, lambs finished early Finishing storelambs	- Might be a different cattle operation with similar land use
Poultry farming	Small ridge	1	Used to be beef and sheep now 600-800 Ewes	100k broilers	

Figure 4-4: range of archetypes identified in the Vale of Clwyd case-study area (by the author)

D. Economic analysis

In this part, the lowland farming ecosystem is analysed economically to illustrate the logic behind farm differentiation and the different strategies, but also their limitations. The economic analysis of farm performance will first be covered, with the intention of demonstrating- through economic performance - farm differentiation is linked to a range of factors, including bio-climatic conditions (big and small ridges). The literature on farm types' economic performance will also be nuanced, due to the diversity in production system (e.g. in terms of outputs or inputs); for example trying to go further than the economic types and descriptions as seen in the Farm Business Survey (O'Regan et al., 2019; PROMAR, 2023). The economic performance of a limited number of modelled 'archetype' farms derived from real systems identified in the fieldwork will be analysed, as described in Chapter 2 with the specific terms below (Figure 4-5).

To clarify the below analysis, the following definition will be retained in relation to archetypes' performance: raw product means the value of the farm's output, intermediate consumption means the value of all intermediate inputs used to produce

output, purchased/used on a regular basis (i.e. bought-in feed or fertiliser, but not buildings) (Figure 4-5), capital depreciation represents the yearly cost of farm infrastructure and added-value is the difference between raw product and costs: the economic value created by on-farm production. All monetary values are in £2018 and based on an average year.

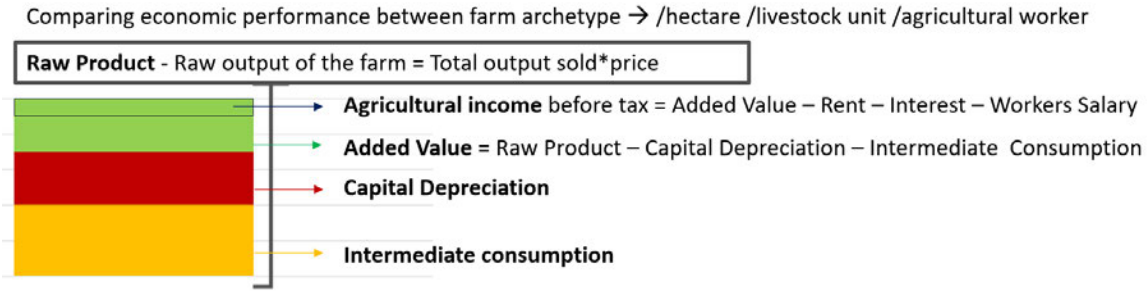


Figure 4-5: Comparing economic performance between farm archetypes (by the author)

1. Economic analysis

a) **Economic performance**

Dairy farms are predominantly on big ridges, despite having high levels of intermediate consumption and capital depreciation, have high added-value per animal, per worker (Figure 4-6) and per hectare (Figure 4-7). Dairy system added-value does not necessarily represent a higher proportion of the farm's raw product[35] compared to beef farms because of high costs (ranging from 20 to 42%). Farms on big ridges tend to have lower inputs costs and higher added-value.

Beef systems' are largely located on small ridges and their added-value is lower and can even be negative (e.g. some breeder archetypes, unable to finish cattle). Their intermediate consumption is much lower than dairy archetypes, with lower raw product. As such, the added-value proportion of the raw product can be as good as dairy farms (up to 28%, but mostly around 15%). The exception would be farms that specialise in finishing cattle, these can often be found on large ridges.

[35] The value of the farm's output

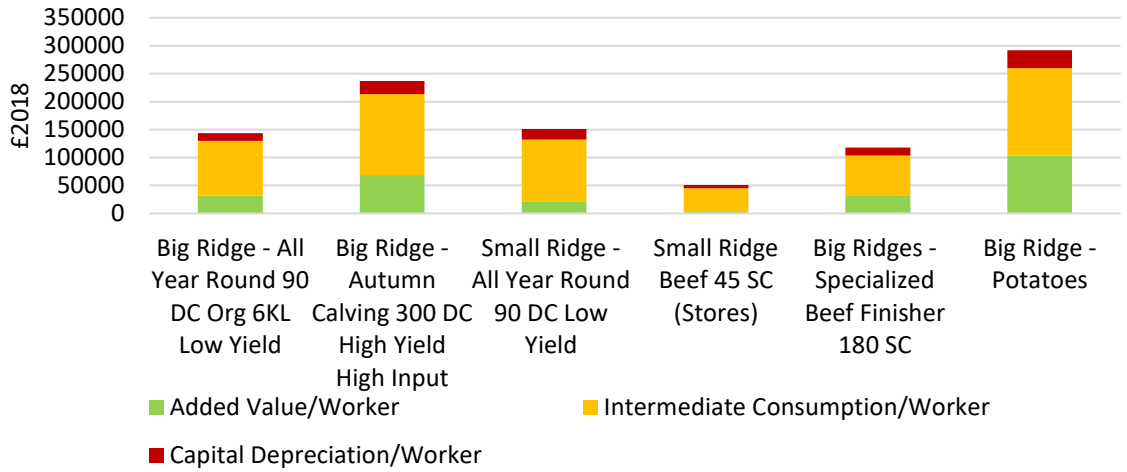


Figure 4-6: Raw product decomposition per worker on a range of modelled pbs production system, in £2018.
Legend: DC: dairy cows, SC: suckler cows

Beef producers that fatten animals gain twice as much added-value per hectare than the ones producing stores even if they use an increased proportion of inputs. In general, capital depreciation tends to be higher on dairy farms than beef farms, apart from these archetypes that have remained small. Potato farms are on big ridges and have a high added-value but their market is very volatile (Annex 6 Item 6-3), even in a cooperative, price variations of 30% per year are observed and their costs are high compared to other farms (per hectare, and absolute). Added-value is over £300/ha on all dairy systems and over £100/ha on beef, but it can go over £1,200/ha for potatoes and some dairy farms. High added-value systems require more resources this puts more pressure on land.

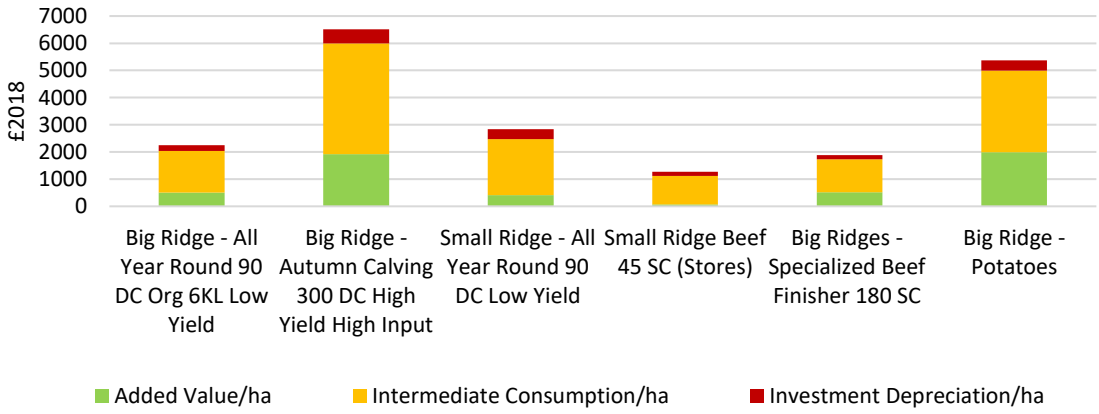


Figure 4-7: Raw product decomposition per hectare on a range of modelled pbs production system in £2018.

Archetypes have a range of sizes and represent the labour productivity potentially attainable within the boundaries of this production system, particularly its upper and lower limits (in this operating structure, with a set system). Dairy farms tend in general to have higher labour productivity, then beef farms. Increasing the size of the farm generates more economic value, but less for smaller dairy or beef farms, as shown in Figure 4-8. An example of differences between landscapes can be seen by comparing two dairy farms (shades of red) with relatively similar yields; the type of system determines the impact (e.g. high inputs, less grazing, calving pattern). The type of output (e.g. producing stores or finished stock, and the level of added-value that can be generated per animal, or poor milk price contract due to a less interesting contract to size) and the labour productivity allowed by the tools/systems in place are more significant (the type of dairy parlour on small farms noted in purple, vs larger ones in red). But the environment and its bio-physical limits result in greater path-dependency. For example, the range of potential size for some archetypes is quite narrow (in green or red) due to constraints (e.g. size of the grazing platform, maximum capacity of the parlour, economic sustainability). It is larger when the system is more flexible, in its implementation (e.g. an average dairy farm of 200 cows).

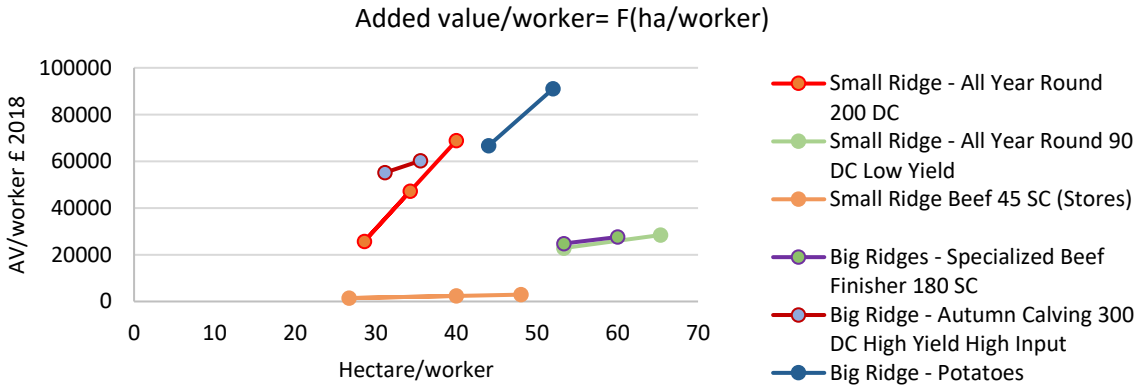


Figure 4-8: Evolution of the added-value per worker in function of the area/worker

For some of the archetypes, in their size range there is little output-based logic in increasing the size of the farm within a given system (e.g. beef systems and small dairy farms). If most have at least a small incentive to increase farm size, mid to large dairy farms or potato farms have a clear incentive (Figure 4-7). Systems that have a high raw product per worker also have high costs linked to past investment loans that they need to repay through high production (e.g. wagon mixer, rotary parlour, robot

milking or new potato equipment). This links to the relative rate of capital depreciation. High input, high output farms offer the highest proportion of added-value for example very large dairy farms compete with potato farming in offering the highest added-value and as well in terms of land required.

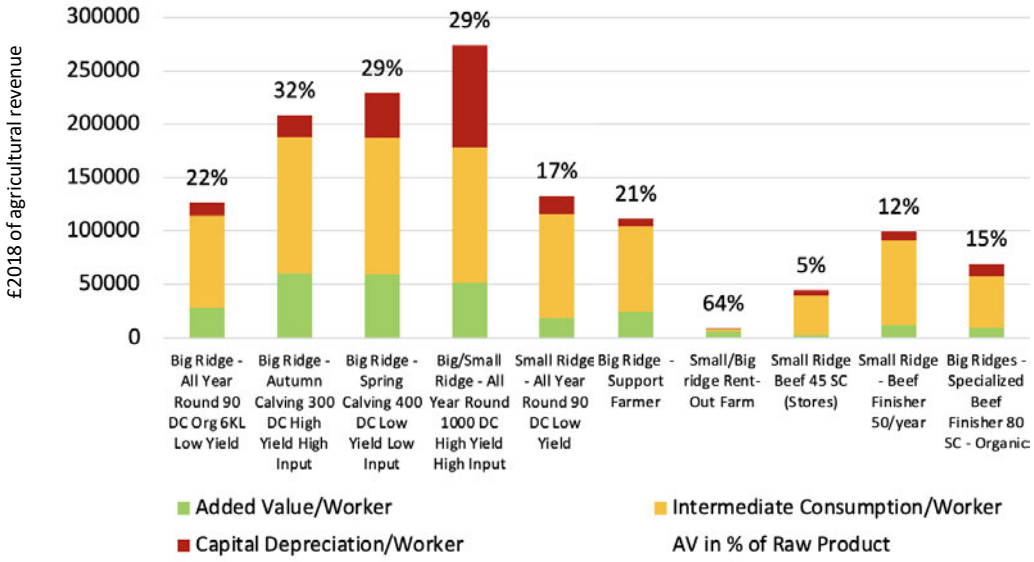


Figure 4-9: Raw product decomposition per worker on a range of modelled Pembrokeshire production system, in £2018.
Legend: DC dairy cows; SC suckler cows; AV in added-value.

However, adapting farm management to limit input use, increase labour productivity, and/or increase the self-sufficiency of the farm are strategies that can attain similar levels of added-value at lower cost, for example as shown by the low-input, low-output farming system with 400 dairy cows on big ridges. Cutting costs may not be sufficient - particularly for some beef and sheep farms that produce low value outputs like store cattle or have a low number of animals, particularly on small ridges (typical of pre-retirement or part-time systems). Other systems carrying less risk than traditional agricultural enterprises would be support farmers or these who rent-out their land (but manage some of the operations), which can return higher added-value than some beef systems. There is little added-value in the latter, but they retain the highest proportion of raw product, while the support farms can reach a level of added-value similar to one that is finishing cattle. Some farmers choose to produce highly valuable goods to get a higher added-value, such as 30-month slow-reared beef, or specific types of milk (autumn milk or organic) to increase the raw product. This is a differentiation pattern

often linked to the available bio-climatic conditions (e.g. small organic dairy farms need to be on big ridges).

The production of stores, although less economically profitable and riskier in an area where bTB[36] can constrain farm operations and exchanges, is part of a system where they are then finished on another farm with access to better agro-ecological conditions, sometimes using other products (e.g. waste potatoes). With their more extensive use of the land, they can also rent some out to potato farms.

In the Vale of Clwyd, similar broad trends were observed in the differences between farm systems (Figure 4-10), but the farms there also tend to have a higher output (per worker and per hectare, with higher stocking density) than Pembrokeshire, as a result of the farm differentiation process. This leads to higher added-values with a higher proportion of added-value in the raw product, despite higher intermediate consumption compared to farms in Pembrokeshire (which is usually over 50% of raw product), due to their lower reliance on contracting and bought-in feed.

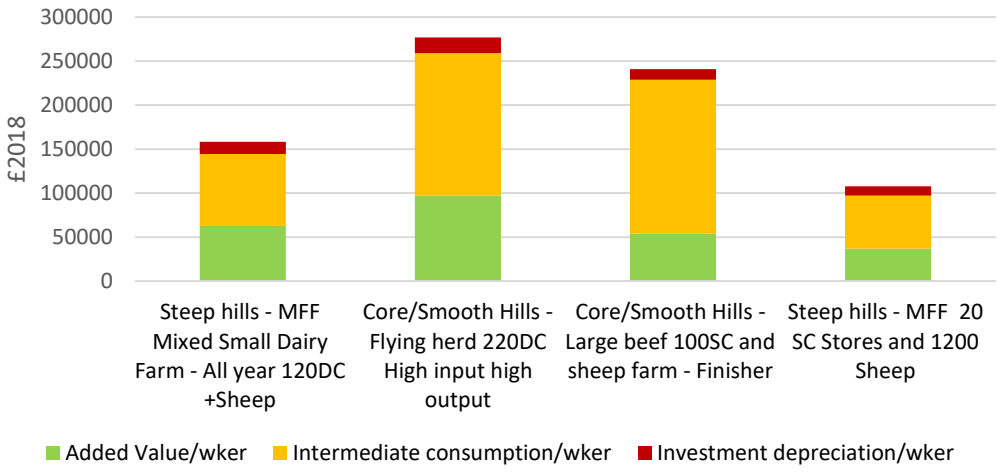


Figure 4-10: Raw product decomposition per worker on a range of modelled Vale of Clwyd production system, in £2018.
Legend: DC dairy cows; SC suckler cows; MFF mid-size family farm

There are some mixed farms, e.g. dairy and sheep, with a better economic performance than Pembrokeshire small dairy farms for example making the most of their land. More specialised autumn calving systems can be found with “flying herds”

[36] as discussed in McCulloch and Reiss, 2017

– replacements are not reared on the home farm, and they have an extremely high output with marked specialisation and high labour productivity, using their limited area and resources as efficiently as possible. Milk prices were higher in the Vale of Clwyd compared to Pembrokeshire which explains part of the difference - linked to the cooperative model, but also due to higher solids in the milk (better quality). The latter can be linked to grass growth patterns. For beef, the results seem to point towards a higher labour productivity, with slightly higher outputs and lower costs linked to higher self-sufficiency (home-grown cereals, tight grazing techniques and with fodder crops), than in Pembrokeshire.

b) Agricultural income

The above exercise will be repeated but this time focusing on farm's agricultural revenue and how it can be linked to farm differentiation and differentiating factors. As described in Chapter 2 the following analysis will consider archetypes' agricultural income before tax (Added-value: Salaries - Interest - Rent + Subsidies), a comparison of different farms is made regardless of business structure. Agricultural revenue is examined per FTE family member working on the farm, also comparing incomes to the UK living wage (around £20,000) and median income (£32,000).

Differences in enterprise strategies lead to different agricultural incomes, even if differentials between farms seem more modest compared to the former figures (Figure 4-11). They relate to the relative weight of loan interest payments, rents and salaries, as key resources that have enabled the expansion of specialized farms.

There is a gradation in terms of income per family worker across the farm archetypes in Pembrokeshire, primarily linked to the type of production: dairy and potato farms return higher agricultural income than beef and sheep or support farms. The only beef and sheep farms that can match some of the dairy farms' income are these specialised in finishing. Support farmers can have higher income than other beef and sheep farms, and larger beef farms tend to have higher income.

Beef and sheep farms depend overwhelmingly on farm subsidies to survive, even specialized farms (subsidies represent 75% - 100% of agricultural revenue). In the dairy sector, the smaller the farm, the more it depends on subsidies. Larger farms and these with potatoes have very low dependence. Organic farms also tend to depend more on subsidies for their income.

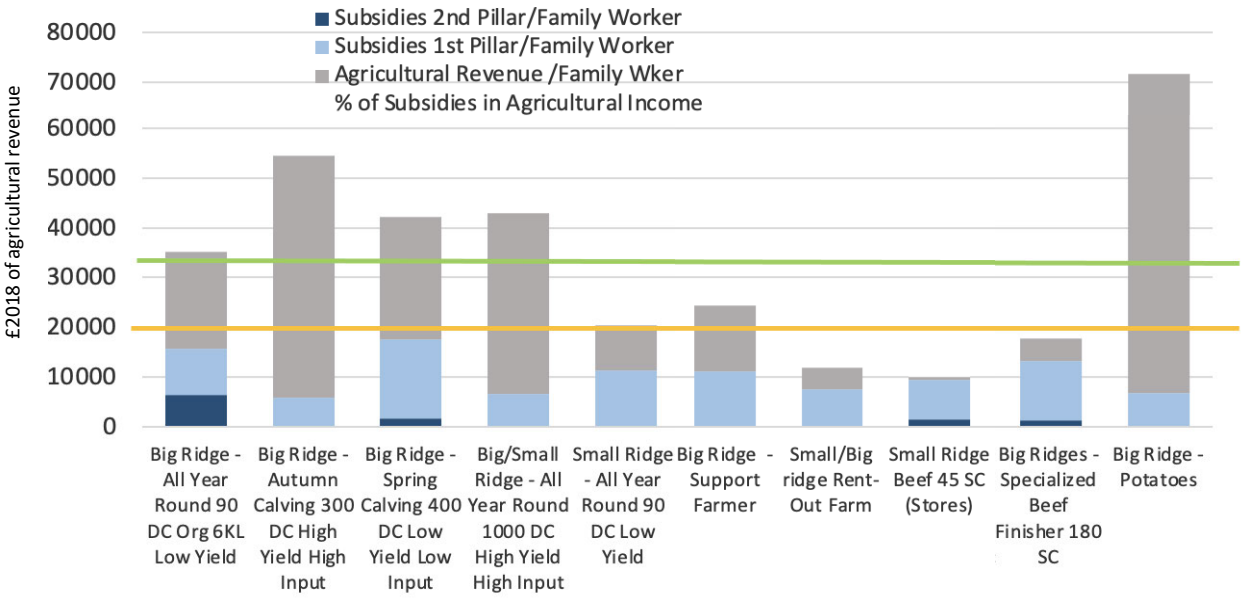


Figure 4-11: Annual agricultural income per family worker on a range of Pembrokeshire's production systems (modelled) with the cap share in the revenue in £2018.
Legend: DC dairy cows; SC suckler cows; Green line - median wage Orange line – living wage

Among dairy farms, farm incomes are over the median wage (Figure 4-11), only one farm falls below: the smallest farm. But the income of dairy farms tends to be lower on small ridges due to path-dependency linked to bio-climatic conditions: they could not convert to organic to gain a higher income. More differentiated and versatile farming systems are on big ridges, reaching without much economy of scale the income of bigger farms on the small ridges. Specialised systems over 200 cows and with specific milk contracts have a low reliance on subsidy payments and support a high number of family workers.

Beef and sheep farms have lower results, though finishers have higher incomes and depend less on subsidies, except if organic. Renting-out land limits risk-exposure compared to selling beef stores but returns a similar level of income. Farmers renting out their land and some with beef and sheep enterprises can have agricultural

revenues below the living wage, particularly in the small ridges area. These renting-out rely heavily on their tenants financially, but their income mostly complements a retirement pension or other job.

With economies of scale and a subsidy system paying per hectare, bigger farms tend to have bigger agricultural revenues per family worker. There are some exceptions due either to a high added-value niche, or the amount of land rented by the farm, and/or farms that have a high historical cost, for example with high interest rates for investments made before 2008; like the 1,000-dairy cows farm.

Farm incomes in the Vale of Clwyd tend to be higher due to a higher reliance on family labour, higher feedstuff autonomy and higher milk prices (Figure 4-12). Average agricultural revenue per family worker for dairy farms with over 100 cows does not rely much on subsidies to get over the median wage threshold, in contrast to Pembrokeshire. Broad trends between farm types and sizes are similar, small farms have a low income, but it is supported by other income streams.

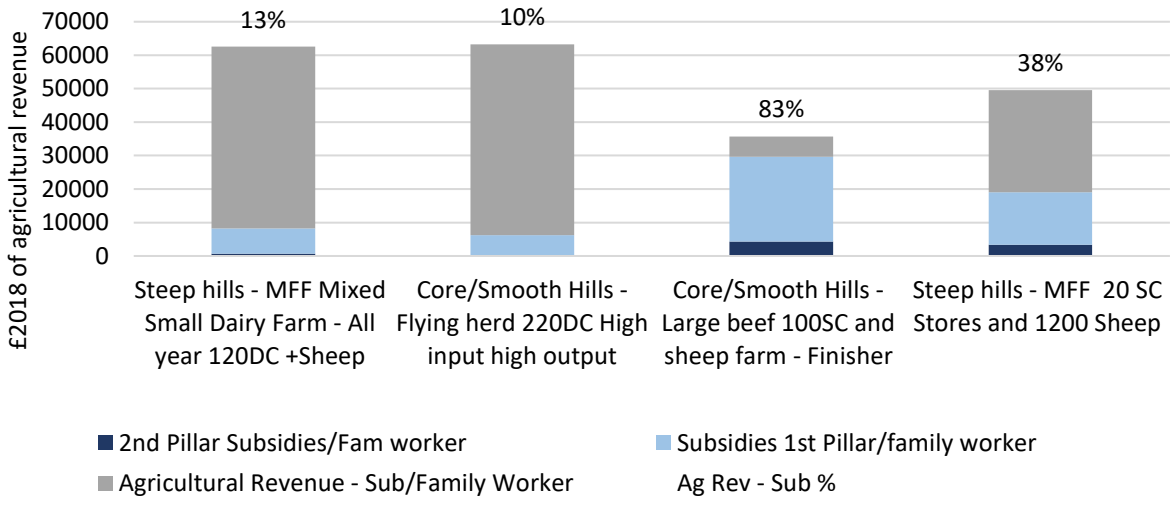


Figure 4-12: Agricultural income per family worker on a range of modelled Vale of Clwyd production system, in £2018
Legend: DC: dairy cows; MFF mid-size family farm

In conclusion, the economic impact of farms' differentiation was demonstrated - linked to key parameters covered in the historical analysis; from geo-physical to path-dependency of farms, that lock them into different pathways of change, in and across study areas (e.g. as seen in Darnhofer et al., 2005). The economic performance of farm production models/types was detailed and nuancing the findings of Wales wide economic analysis of farm performance (McNally, 2001; O'Regan et al., 2019), with a more detailed view of some production types. Even within an area or a production type there is a very high diversity likely to react differently in the face of Brexit.

2. Farm models to examine the effects of market volatility on farm income

In the approach, it was intended to understand farms by linking economic performance to operational constraints. However, to fully understand some strategies and their economic consequences a modelling analysis is necessary, since increased volatility on output/input markets has been a feature of the last decade. This will provide valuable insight to nuance the good economic performance of some farms. For the analysis, limits to high and low prices are retained, representative of past market conditions as shown by literature and fieldwork (Table 4-3). The impact of a range of prices within these limits is then considered, on a selection of archetypes from the Pembrokeshire case study.

Table 4-3: Volatility analysis range of prices retained (by the author)

High prices	Low prices
Input: Feedstuff: 135% Fuel: 135%	**Input:** Feedstuff: 85% Fuel: 85%
Output: Milk: 100% - 27 pence/litre* Sheep: 100% - £90/lamb* Beef: 100% - £900/Store*	**Output:** Milk: 95% - 25.6 pence/litre* Sheep: 90% - £81/lamb* Beef: 89% - £801/Store*
Market conditions selected as gathered from literature and interviews. Average price given by farmers depending on their product characteristics, in interviews. *Prices are purely indicative and do not reflect output pricing in the archetypes	

Analysis of how input price variations affect farms' performance.

These graphs show the sensitivity of the economic performance of production systems to changes in the price of bought-in inputs; how big a shock it would be if input prices increase.

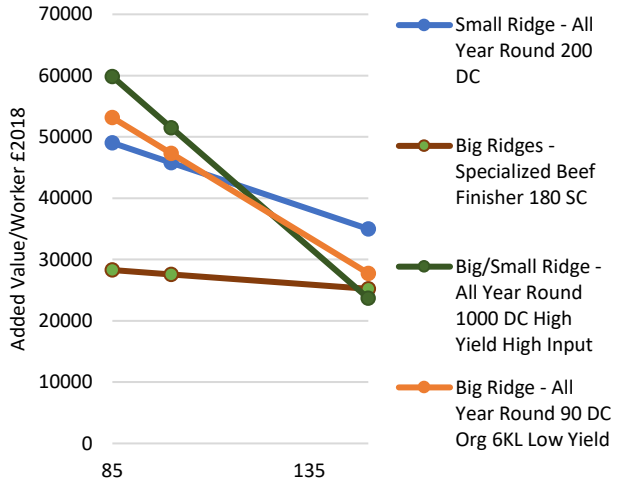


Figure 4-13: Added-value per worker depending on the evolution of feedstuff prices Legend: DC dairy cow ; SC suckler cow; Org organic

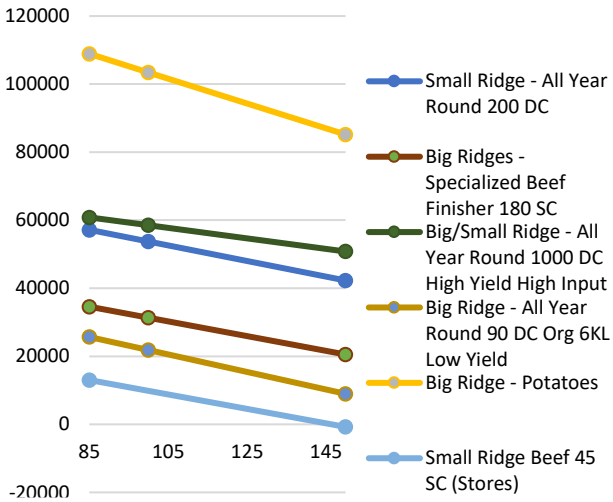


Figure 4-14: Added-value per worker depending on the evolution of fuel/fertiliser prices

The scale of the impact of inputs price rise is larger with fuel or fertiliser (Figure 4-13) than on feedstuff (Figure 4-14), with higher added-value variation for all archetypes. Potato farms have the highest added-value drop, closely followed by high input livestock farms; the impact per worker is not necessarily smaller on more "extensive" farms such as the suckler cow archetype. Organic farms or farms growing their own fodder can still have high fuel consumption, due to field operations that negatively impact their added-value if the fuel price rises. But low usage of bought-in feedstuff per animal means farms fare better (the beef farm, blue dairy farm). On the other hand, there is a lower short-term risk for large dairy farms[37] because many operations are externalised with a contracted price (inc. livestock rearing with flying herds) it explains the fact that they react better than some beef and sheep systems with less input use.

[37] Although the stickiness of inputs prices due to prices being fixed for some inputs might limit this, in this case, the rise of inputs price is limited to reflect this compared to short-term shocks that can be witnessed in markets.

Maintaining production standards in comparison with larger farms (e.g. 90 cows dairy farm) in poor landscape conditions can require higher spend on feedstuff.

The above argument opens a nuanced discussion on the impact of inputs price rise with differentiated impact for farm systems included in terms of timeframe.

a) Sensitivity analysis to output price variations.

The economic performance is not as impacted by output price variations (Figure 4-15), it falls by £10,000-20,000/Family Worker in most systems, which still represents a substantial reduction.

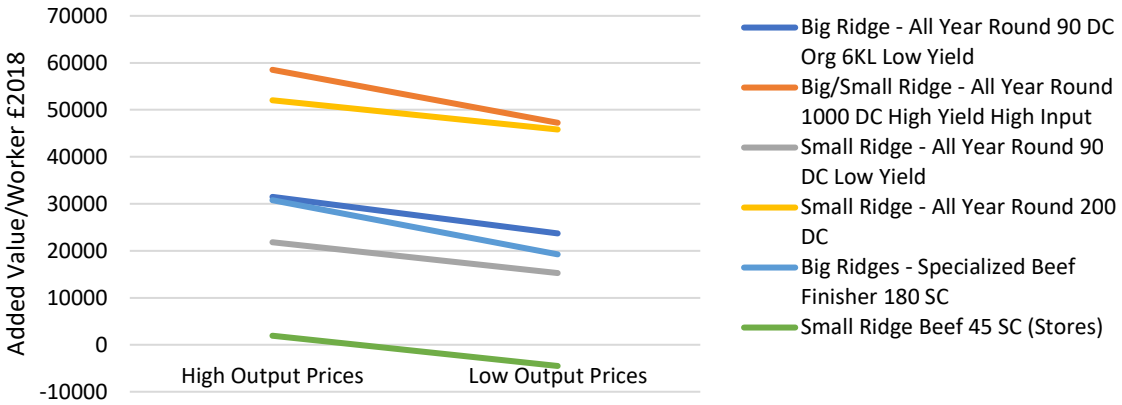


Figure 4-15: Evolution of the added-value per worker on a range of modelled farm archetype (Pembrokeshire) in function of the change in farmgate output prices
Legend: DC dairy cow; SC Suckler cow

The drop is linked to three things; how much output is produced (e.g. the more output the strongest the sensitivity e.g. 180 suckler cow farm), the margin on the product (e.g. the organic farm not dropping as much as the high output farm) but also the variability on output prices (which differs between productions with stronger drops on beef than milk). The strongest impact would be on high output farms selling large amounts of produce but with relatively low margins per unit of product. For most systems, the impact would be immediate with limited opportunity to buffer this price drops in the short-term. A buffering strategy would combine several productions which can help reduce the impact of these changes like on the 200-cow farm on small ridges which also kept some stores.

b) Subsidy payments act as a buffer

Looking at the agricultural income (Annex 8 Item 8-8) without CAP support, it is noted that the current support represents a buffer in times of crisis, limiting the income risk of farming activity. Annex 8 Item 8-8 demonstrates that the volatility in outputs and inputs prices could impact more significantly small farms, beef and sheep farms and organic dairy producers, as their income is lower and would require them to think about further changes. While CAP subsidies are often said to be important for the economic viability of farms (NFU Cymru, 2024; O'Regan et al., 2019) argue that they are not necessarily targeted at those in most need. In the case of Pembrokeshire, on a total of 263 farms within four postcodes[38] inside the case-study area, a simple distributional analysis of CAP data (DEFRA et al., 2023) demonstrated that just 20 farms claim 27% of subsidy payments, questioning the equity of the existing system that has been in place for 13 years (Figure 4-16).

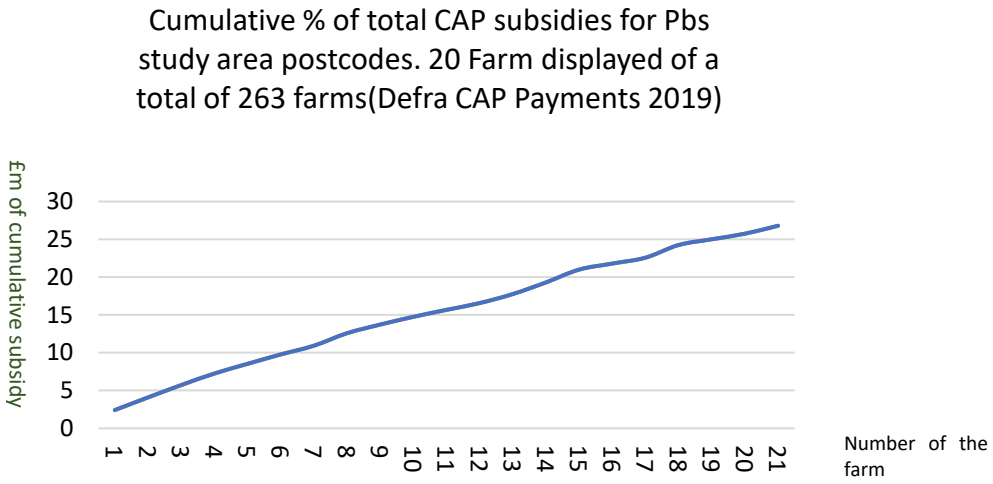


Figure 4-16: Analysis of the structure of subsidy distribution from 2019 CAP data (by the author; DEFRA et al., 2023)

When considering the level of subsidy per family workers on the archetypes and comparing it across farms the findings remain similar, subsidy payments are important for farm incomes but do not necessarily suffice to bring some farms up to the living wage threshold (Figure 4-12). The annual funding of £4.3m is focused mainly on the

[38] Postcodes: SA71, SA70, SA68 and SA67

first pillar (84%) direct payments, and half of the 263 supported farms are over the maximum ceiling for receipt of the redistributive payment. Of the Second pillar payments, 1/6 is targeted at organic farms, Glastir management payments are virtually nil, while targeted investment support represents the majority. This effectively shows that while the organic scheme has been of interest, Glastir has gained little traction in lowland areas, with low payments compared to the added-value that can be generated. The payments per hectare remain below the added-value generation of most production systems in Pembrokeshire except for some low output low input beef systems the SFS, given the constraints in terms of outputs it has therefore had very limited take-up. In the literature, there have been reports showing the capitalisation of subsidy payment in rent and land value, further limiting the interest of the current decoupled direct payment system (Ciaian et al., 2021, 2018).

E. Discussion and conclusion

The case studies represent typical Welsh lowland landscapes evolving from a relatively homogenous farm structure in the 1980s; the emergence of very different, yet complementary farms are observed, that now work together in a landscape (Figure 4-17). This is particularly notable in terms of land use intensity, with wide differences across the area which explain that some farms can spare land for others.

The case studies show that there is no uniform ‘Welsh model of agriculture’, as stated in Morgan et al., (2010) and there are many different strategies that lead to a diversity of economic parameters. The existing links in the farm ecosystem between specialized farms, in different types of landscape (Figure 4-17), were demonstrated. Welsh lowlands are green, grass-focused areas but have some of the best farmland in Wales. From this comes a diversity of complementary enterprises and farming systems. Although dairy and potato farming are the real economic performers in this farming community, many other systems retain important agricultural capital, but their annual economic performance is not enough on its own to enable continued full-time farming, except for the most specialized farms, fattening beef, or rearing calves. This strongly nuanced the current rationale on beef and sheep farms’ economic performance (DEFRA, ONS, 2021; Lloyd and Dyfri Jones, 1980). But inside high performing

categories like dairying there is also a diversity of systems and economic performance, these integrate farm's constraint but also show (as in beef and sheep) a diversity of farm economic rationale which is partially acknowledged by the literature (DEFRA, 2018; Gasson et al., 1988; Lobley and Baker, 2012).

The diagnosis shows how contemporary farm structures come directly from past patterns interacting with agricultural market trends and other opportunities and validates the interest of the methodology. Farms are a very complex socio-economic activity, a livelihood enshrined in a landscape, operating in a market economy, and continuously evolving (Figure 4-17). Very similar economic results or income levels can hide very different functioning, strategies, and pathways of change, including lock-in from historic loans, and path-dependency which narrows the range of future options. Examining a specific agricultural landscape offers an interesting scale at which to study the process and drivers of farm change and consider its economic and environmental consequences.

Finally, volatility in terms of economic performance is linked not only to the amount of outputs sold. Many farm systems are more vulnerable to input price changes than output price variations, except for large producers where some parts of the production system have been externalised to other actors[39]. The output "specifications" and the "margin" of the farm in the production process play a key role. Farms at risk can be clearly identified, as well as the rationale behind their income generating strategies to remain sustainable. The end of CAP subsidies could represent a step change for many of these farms, particularly if it is combined with low output prices as farm income would drop to unsustainable levels. The current subsidy mechanism is, nevertheless, not necessarily the best way to support the farms that have been identified as most at risk as it tends to reinforce inequalities.

[39] e.g. Replacement stock rearing

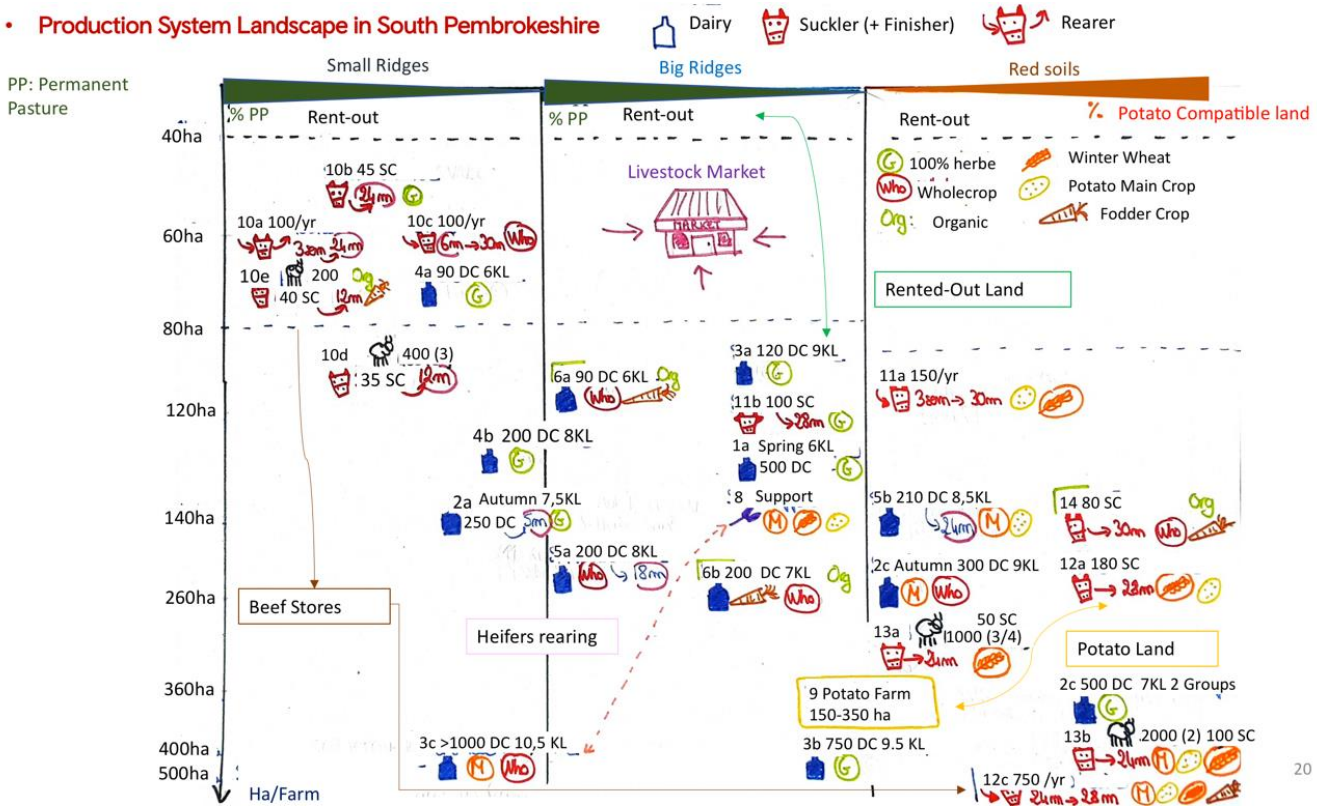


Figure 4-17: Production system landscape in Pembrokeshire, three landscape units with cooperating farms in the case-study area
Legend: DC dairy cows; SC suckler cows; m: month old

It has been demonstrated above that high output (high inputs) strategies were not the only determinant of a robust and prolonged economic performance. Small farms and beef and sheep farms were more hampered by low margins/prices and the immediate impact of inputs/outputs price volatility and as a result could (Annex 8 Item 8-8) and needed subsidy support to be viable. If these systems disappear, this could have a knock-on consequence on the whole agrarian system due to the interconnected nature of farming systems[40] (Figure 4-17).

[40] As they exchange inputs and outputs

Chapter 5. Farm differentiation in the uplands, divergence between upper uplands and intermediate uplands

While recent markets and policy changes had a major combined effect on both lowlands and uplands in Wales, today's agrarian systems were initiated in the 1990s and 2000s. In this chapter, following a similar structure to Chapter 4, farm differentiation in the uplands is covered, up to 2010. Then from 2010, the intermediate uplands and the upper uplands are analysed separately, where the first has strongly differentiated away from beef and sheep. As in chapter 4, the main trends will be highlighted in the agrarian systems' differentiation, and its consequences for multi-functional agriculture in Wales by analysing technical changes and their socio-economic impacts.. This chapter focuses on the historical, environmental and technical-economic element from the agrarian diagnoses in the uplands case-studies. While the historical analysis is based on changes observed in the Bala case study area, further observations in the upland areas of the Cambrian Mountain area and the Vale of Clwyd add some key insights. Path dependency has had a major impact on future environmental conditions, as the agrarian system is switching from beef and sheep towards higher added-value products.

A. Upland farming changes from 1945 to 2000

The broad post-war shift in policy towards productivism included significant provision to develop production in the uplands. Key policies included the Hill Farm Payments, introduced to reflect the lower production potential in these regions (Bowen and Martin, 2016; House of commons, 1964). These changes are covered in more detail in Annex 8 Item 8-9.

Subsidies encouraging farm improvement were more important for farms in upland Wales with the reclamation of mountain land (which was ploughed, re-seeded, and fenced) and the subsidies for improved drainage (Welsh Office Agriculture Department, 1985). These policies, accompanied by a significant R&D effort and on-farm facilitation (e.g. Angell, 2007) helped increase the fodder production in these

areas, maintaining a profile of grass growth and complementary agro-ecological practices suited to breeding livestock.

Upland farms received two key signals from the market between 1945 and 1980. Firstly, a lucrative milk price was offered with the MMB after milk cooperatives were created (Annex 8 Item 8-9). Because these were farmer-owned, farmers were initially encouraged to keep milking. But then after the 1960s, there was a more supportive context for developing beef and sheep production in the uplands, combined with specific technical advances (Annex 8 Item 8-9). For many middle-sized family farms and smallholdings, it was also a time of opportunity to buy their own farms, thus limiting their capacity to invest even in a supportive market for farmers.

1. Phase 1: 1945-1980s

The fieldwork interviews showed that the post-war drive for food production profoundly changed upland farms in Bala, from semi-subsistence, mixed farms to specialized[41] and relatively homogenous beef and sheep holdings (a few dairy holdings, only, survived mainly in the valley) (Annex 7 Item 7-5). This was the biggest wave of change ever seen in this landscape. Upland areas were included more intensively in the UK food production network. Table 5-1 covers the broad types of farming systems that could be found in upland areas at the end of the Second World War. Based on this classification, an attempt will be made to understand farms' response to the productivist era in Bala and the Welsh uplands, in general.

Hill farms used government subsidies for drainage and de-stoning, particularly around the homestead, increasing their proportion of hayfields and reducing the number of fields with poor accessibility, ensuring adequate fodder provision for more demanding and numerous livestock. mountain land and hillsides were reclaimed, and the grass around the homestead improved from 1970 on, with lime and fertiliser. This phased introduction created the conditions for steadily increasing output.

[41] Dropping side agricultural activities (e.g. pig rearing) or linked activities (e.g. milk round)

Most farms in the uplands would make complementary use of the resources of the three different bio-climatic altitudinal layers in the landscape, which are well -suited to breeding beef and sheep operations, producing store stock (Annex 9 Item 9-2; Mansfield, 2005). With the 20th century agricultural revolution, technical improvement meant that it was possible to increase the number of livestock (by a factor of 2 or 3) on a constant acreage (e.g. in Canévet, 1991).

Table 5-1: Indicative table of the state of the production mix in different study areas

	Upper uplands	Intermediate uplands
Uplands have a lower level of farm ownership in general than lowlands		
Smallholdings	20-24ha with or without Rough Grazing 2FTE family labour only On hills 5-6 cows Welsh Blacks – for meat, stores (calves) 45-55 ewes Welsh - for wool Rotation 1 in 20 years for some parts of the land – cereals (oats), green crops Mostly for own consumption Little adoption of mechanisation	16-20ha 2FTE family labour only Either on hills or on low parts 7-8 cows Herefords/Welsh Blacks – for meat, stores (calves), milking 40-50 ewes Welsh - for wool Rotation 1 in 15 years – cereals (oats or barley), green crops Mostly for own consumption Little adoption of mechanisation
mid-size family farm	50-70ha with Rough Grazing 2-5 FTE family labour mainly On hills (H) with access to rough grazing (M) 10-15 cows – for meat, stores (calves to 12m) 150-300 ewes - for wool, stores Rotation 1 in 20 years – cereals (oats), green crops Partial adoption of mechanisation – Moderate use of inputs	40-60ha 2-4 FTE family labour mainly Either on hills or on low parts 15-20 cows – for meat, stores (6-12m), milking 150-250 ewes – for wool, stores Rotation 1 in 15 years – cereals (oats or barley), green crops Partial adoption of mechanisation – Moderate use of inputs
Large	The only type of farms that might be spread over all three agro-ecological units (HLM) Over 120ha and some additional rough grazing Over 6-7 FTE (Family labour and hired-in) Over 30 cows – for meat, stores (12 or 24 months) 300-500 ewes – for wool, stores Rotation 1 in 20-25 years – cereals (oats, barley), green crops Adoption of mechanisation – use of inputs	
Farms would also produce for their own consumption: Pig (weaners), Chickens… The share of the farm's raw product consumed on the farm is inversely proportional to their size		

Farms specialised in meat breeding production, mostly reducing their labour needs. These changes were made possible by an increase in fodder production and increased input use; the landscape shifted from brownish to a more vivid green as reclamation took place first on rough grazing hillsides and then on the fringes of open moorland (inc. commons), with very long-lasting grazing mixes.

In general, because of environment transformation it was possible to implement beef and sheep breeding in a specific technical package[42], to produce cattle stores and a mix of finished and store lambs. Continental breeds of cattle and meatier sheep breeds would be gradually favoured (wherever possible) over the low maintenance but smaller Welsh Mountain Sheep and Welsh Black cattle.

Improvements to production could be used to increase farm output; lambing date could be brought forward to March and farms could produce heavier and more lambs. Breeding ewe flock renewal focused on selecting bigger animals and the sires used would be partly continental types. Farms gradually focused on producing fat lambs, leaving the farm in the summer at 34-35 kg liveweight. Continental breeds of cattle or continental bulls were introduced with bigger, more demanding store stock sold at 18-24 months (meaning an increased fodder demand but reduced shed space). Nevertheless, there were only limited hayfields and limited winter fodder production.

In general, the rougher the grazing and the lower the number of hay fields on the farm, the more improvements were needed. The lower the production potential, the higher the proportion of sheep (with no possibility to take up continental breeds…). Side enterprises would also disappear from farms, through this process of improvement and productivity growth.

Large farms followed this path with a focus on grass growth (but also a possibility to keep a bit of cereal cropping) and mechanising as much as much as possible, limiting their paid work but also their infrastructure investment. They would not make clamp silage, as on dairy farms.

Owner-occupied mid-size family farms in the lower parts of the uplands could implement gradually, and in full, dairy specialisation like in some lowlands farms on small ridges. Due to their more limited investment capacity, they maintained an

[42] Set of combined technical innovations in the cropping system or livestock system representing a significant increase in farm output or in efficiency

element of mixed farming at first. They would nevertheless be larger than some lowland farms in acreage.

Other smallholding farms in similar landscapes retained dairying for as long as possible, with limited adaptation of equipment, until the end of bulk tank collection, similarly to what happened in lowland areas. In these areas, the more numerous the hayfields and the richer the landscape, the better the fodder production and the more likely that farms would keep dairy production.

Some mid-size family farms and smallholdings with rough grazing needing a regular income would still maintain dairy production (e.g. repaying the loan needed to buy the farm) but never implemented a full dairy package (due to limited hayfields and investment capacity) and then ceased dairying when the bulk tank became necessary under new legislation. Most farms, particularly these with rough grazing, specialised into beef and sheep.

For example, in Snowdonia, the hills and mountains required a lot more improvement to make them ploughable or manageable with mechanised tools, due to shallow/rocky soils or too much deep peat. Any landscape improvement would be slower and cost more. The hayfield area in these farms would be highly limited, with climate constraints. Nevertheless, the mid-size farms would have a similar trajectory to these away from Snowdonia, but they would have a lower proportion of improved breeds.

For the most mountainous farms, these with the highest proportion of mountain land, improvements were impossible and growth in size was the only route to increase farm income. With the limitation of fixed labour productivity, these farms specialised in sheep only.

Differences between farms would be linked to how improved the farm could be, and its mix of improved versus traditional stock. There was a gradient across agro-ecological scale in terms of adoption of improved breeds of sheep and cattle. Upper upland farms, with a high proportion of mountain land, remained with traditional breeds. Upland farms with less mountain land could mix a traditional flock and an improved “commercial” flock, with a continental cattle herd, the proportion of each

depending on the proportion of rough grazing/high altitude grazing. Grazing management and timings for open moorland use did not change in terms of use, with a focus on usage during spring/summer, except for mountain farms (e.g. Annex 9 Item 9-2).

Smallholdings without rough grazing could not keep enough beef and sheep cattle to ensure a sustainable income and did not have the financial capacity to expand. When retiring, their land was bought by other farms expanding from the later 1970s onwards, responding to the input/output price squeeze.

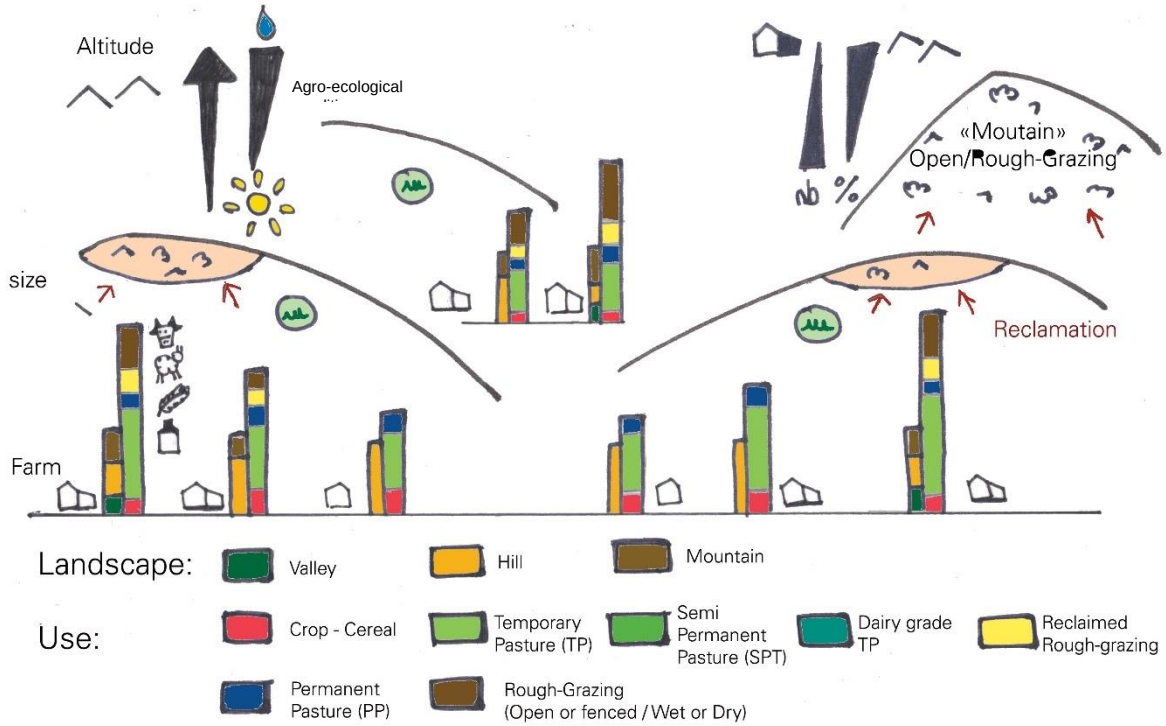


Figure 5-1: Land use in upland Wales 1945 to 1970 (by the author)

In summary, landscape management was simplified and homogenised with grass re-seeding on the ploughable areas and the use of bought-in seed (Figure 5-1). Fertiliser, feedstuff, and re-seeding were the key to increased output and improved land productivity. Most farms opted for an endogenous expansion, reclaiming some of their land and improving livestock management (Vet, feedstuff…). Farms were mostly specialised in beef and sheep with relatively similar systems, the biggest differences would be linked to land productivity and the type of animals produced. However, exceptions existed at both ends of the scale, with some farms in the lower uplands (staying in dairy) and these with a lot of mountain land (sheep only). While not

fundamentally different from trends noted in the wider literature, these findings tend to highlight the gradient found in uplands. It was also clarified that in most regions of upland Wales, the reduction in terms of farm numbers was limited at this stage.

2. Phase 2: 1980s to 2010

1980s represented a significant change due to the technical advances available to upland farms that could further increase their labour productivity (Annex 8 Item 8-9) and increase output, harvesting more from the farm ecosystem. The area of hayfield on each farm was a constraining parameter that had limited farms' expansion as it provided the winter feed for cattle and/or sheep. The new technologies would enable these farms to increase their livestock numbers per labour unit. In contrast to dairy farms, beef and sheep systems were not as impacted by change in markets and policy context, as policy support was better for beef and sheep production in the UK from the 1980s to 2000s[43].

a) **Changes on farms with land in the valley and the hills**

With high-priced milk quotas, the decrease in real milk prices and the end of the MMB (Chapter 4; Finney, 2021) drastically reduced the number of dairy farms in the uplands. Dairying disappeared in the Bala area after 2000 as milking equipment had to be renewed, and the income provided was not sufficient.

1985 marked a breakthrough for upland farmers with a productivity leap derived from big bale silage and quad bikes (Annex 8 Item 8-9). The access to this combination was dependent on having the capacity to invest and adopt improved breeds, as described for the lowlands. The previous tendency to reclaim land further and further up the mountain reduced gradually, as a result. Farms increased their herds and flocks

[43] There was a comparative advantage for beef and sheep farms in terms of policy support (as discussed in Chapter 4); the lack of quotas (and as a result lack of cost to access the right to produce), the strong value of livestock headage payments (NAO, 2000; Scottish Executive, 2003), the lack of subsidy rights on young male cattle (House of Commons, 2001; House of commons, 1964), put them in a comparatively better position than dairy farms. Although not highlighted as such in the literature it was found to be accurate in the field by considering the levels of support per livestock unit. Arable farming was not a possibility in uplands of our study areas.

while remaining mostly with the same enterprises, as dictated by the bio-climatic conditions of each farm (**Error! Reference source not found.**).

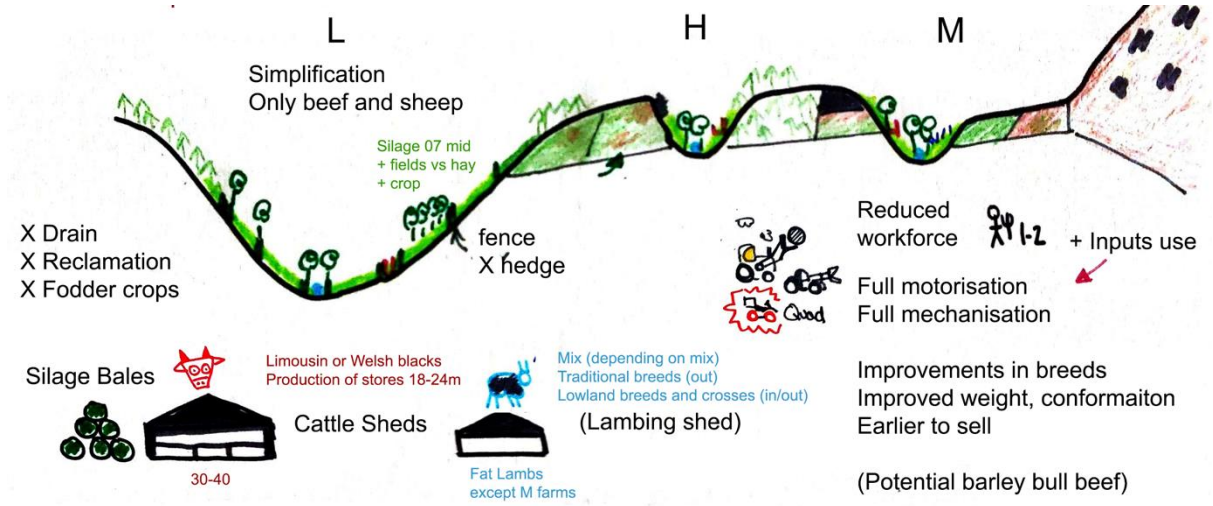


Figure 5-2: Evolution of the agrarian system in Bala after 1985 (by the author)
Legend: L valley; H hill; M mountain

As a direct continuation of the trends described since 1945, by 1990 most farms were homogeneous in their performance (in labour productivity, and the tools used), with 1.5 or 2 people handling 30-40 suckler cows (to produce 12-to-18-month stores) and 400-800 breeding ewes, on different sized farms. Farms with more mountain land would have a higher share of sheep and would not have applied all the new techniques on all their acreage. The management of livestock could be split into two broad categories, depending on the hill animals and valley animals (Annex 9 Item 9-2 and Item 9-3) with complementarity between areas operated by the farm (**Error! Reference source not found.**).

Over the last 30 years since 1990, the intensification drive in upland Wales has been partially and gently reversed. A new farm support environment of decoupled aids and incentives for environmental management (Chapter 4.B), combined with more challenging food market conditions, has encouraged farmers to adopt different options to safeguard their livelihoods. Before 2010, conditions favoured farms that were able to increase their outputs and these with conservation habitats, the last decade has favoured farms with conservation habitats and a big extent of land, now that the Single Farm Payment has moved to a flat rate per hectare. As such the support moved from away from high producing farms; these often located on lower parts of the landscape

(Valley and hill on **Error! Reference source not found.**; examples in Figure 5-3) and which had the capacity to invest with the family labour to make it worthwhile in a difficult context. It started supporting more and more the higher mountains and moorland (Hill and mountain on **Error! Reference source not found.**). This is a key factor in explaining farm differentiation in the uplands.

As in the lowlands, as the value of direct market support fell with reduced output prices through the 1990s and 2000s, some farms (both small and intermediate) went out of farming or reduced numbers (for example focusing on sheep), renting-out part or all of their land. The last step would have been to sell the holdings as blocks of land, providing for the expansion of other neighbouring farms.

There was a higher production focus among farms located in the valley or on the low hills. For example, mid-size family farms with 3-4 family workers and 1-2 staff would increase their activity to maintain their income from both beef and sheep. Options included keeping 100 head of heavily subsidised barley bull beef (finished at 14-16 months – both from their own calves and bought-in; House of commons, 1993; Scottish Government, 2003); increasing the suckler herd from 30 or 40 up to 100 cows, or the flock from 500 up to 1500-2000 breeding ewes, with partial adoption of more demanding mules and terminal sires such as Texel but also lambing inside before March with de-synchronization of ewes[44]. Fed with bought-in feedstuff, using fertilisers and renting land on short-term leases or buying some, this strategy represented an 'exogenous' expansion, based on importing production factors. Early lambing inside enabled higher lambing rates (170%) associated with the sale of heavier lambs (37-39 kg) to markets and abattoirs from the end of May. This then freed some ground to buy in store lambs to fatten. These farmers would go far away to secure the extent of land necessary, across North Wales. They could also use tools typical of dairy production to increase labour productivity and total output, e.g. Total Mixed Ration feeding, or cubicle sheds. Another possibility was to keep even more ewes and

[44] Through the use of special hormonal implants there was the possibility to lamb the ewe earlier by intentionally staggering its oestrus cycles for better breeding and lambing management. This technique became available from the 1990s.

increase income but with slightly less manpower, lambing at the homestead and sending them to be kept away on a different farm (on tack). This practice only declined from 2005 onwards, with subsidy decoupling.

Other intermediate sized farms not as pressured for an income with less family labour (1-2 persons) or without capital (i.e. renting their land, or already having a mortgage) chose more gradual growth, adopting the new tools and buying land close to the homestead, increasing their herd from 30 to 40 or 50 suckler cows, producing stores and with 1000-1200 ewes, mostly Welsh Mountain (lambing rate 120-130%). The lambing would be mid-March, and lambs would only go a bit earlier to market with only slightly higher prices, as a result (Annex 9 Item 9-3).

Another strategy, on smaller and rented farms would be to implement the package on their homestead with 20-30 sucklers and 800 ewes (producing lambs early and fast-growing) and combining it with a barley bull beef unit generating more income at the cost of increased input use, but providing the funds to gradually buy more land, to grow the business. Other farms where there was no or little income pressure, with a shrinking family workforce, might decide not to grow but instead just increase labour productivity with various technical improvements. However, smaller farms struggled: these with younger farmers or secure succession could follow the models above with investment but incurring a high level of debt. For farmers close to retirement, the easier option was increasing inputs to move towards cross-bred ewes and lambing inside in makeshift sheds to increase productivity.

b) **Changes on more mountain farms**

Low input and low output strategies were mostly taken by large upland farms with hill and mountain land - they did not have to increase their landholdings and could grow stock numbers based on existing land, potentially reaching up to 100 suckler cows. They would also lamb more sheep inside and start using terminal sires, but lambing dates would not move forward and lamb weight at slaughter remained lower. This required only a modest increase in inputs compared to other farms. These heavily reliant on mountain land could not go far in crossbreeding with their ewes.

On Snowdonia, there was no complete adoption of the new technologies. Adaptation was possible at least for part of the flock, moving it towards hill-like management. Every farm with mountain land could gradually benefit from new payments (first ESAs in few locations then Tir Goval and Glastir; Dobbs and Pretty, 2004; Rose, 2011) linked to conservation agreements to reduce "overstocking[45]" that had been necessary to allow farmers with mountain land to make a viable income. This move generally benefited the mountain landscape as it was not grazed bare in the best places anymore. More importantly, conservation agreements stopped the trend of land reclamation and enclosure. A reduction in ewe numbers took place through agreements made on a case-by-case basis, for each farm.

On Snowdonia pure open moorland/mountain farms, reductions would be low in summer/spring (April to October) but around a quarter to a third of the sheep flock would be taken off over winter (e.g. from 900-1200 to 500-900 ewes for average mountain farms; smaller mountain users would see reductions from 500 to 300). These farms would winter away more of their animals and buy in slightly less winter feed (Annex 9 Item 9-2). On farms that were not pure mountain farms there was no farm-wide reduction in ewe numbers, but ewes were taken off the open moor for three months, and stocking was reduced in the other months, under these agreements. They did not affect the land that had already been enclosed or reclaimed previously. These farms would resort to a combination of wintering away, bigger fodder crops and bought-in feed, to maintain their ewe numbers. By switching part of the flock to crossbreeds they would stop sending the entire flock onto the mountain, instead splitting the flock in two (of mountain, low weight lambs and hill, higher weight). For all these farms, the conservation agreements compensated natural handicaps but also limited their room for manoeuvre by locking-in part of the management of the farm.

45 Effectively, overstocking would be keeping too high a stocking rate through the year, compared to the environment's carrying capacity (grazing without damaging the vegetation)

In summary, before 2005-2010, low input costs and direct subsidies on livestock more than counterbalanced the impact of new agri-environmental policies[46] and poor market conditions. Further beef and sheep production growth continued on upland farms in Wales. Nevertheless, with gradual decoupling most farms that had adequate agro-ecological conditions started to move towards a market-focused approach, particularly in sheep. The farms that maximised subsidies and capitalised more were under intense income pressure, and thus intensified proportionally more than other farms. The rate of loss of farms was limited, with relatively high agricultural support overall for beef and sheep.

In Powys, similar strategies were broadly witnessed among farms. The greater proportion of hill farms, often smaller, in this landscape led to a greater intensification to maintain income on landlocked farms. Farms tended to be also more often tenanted, which limited what they could implement on the farms. The higher density of farms led to a greater reduction in farm numbers as smaller farms struggled to maintain income. Farms in the Elan valley presented a picture very similar to the pure mountain farms in Bala.

B. Intermediate hill farms, changes since 2010

1. Context

Considering the challenges faced by Scottish hill farmers, Slee et al. (2014), described a “squeezed middle” of farms. This was the term used to describe farms on the margins of upland areas where land is more productive than on the mountains, but still less good and versatile than in lowland areas. The most recent data available shows that it is also true for Welsh hill farming (Welsh Government, 2020). Some factors are common to Scotland, and some are specific to the much more populated and productive Welsh hills. In addition to the ones highlighted previously (Chapter 1):

46 Alongside the roll-out of agri-environmental schemes in Wales, the introduction of tighter environmental regulations (notably the NVZ revisions in 2005) was an important factor requiring many farms to make new investments in manure storage and handling and limiting further herd expansion in the most affected areas.

tourism or power generation; others have developed more recently: e.g. tree-planting for carbon offsetting (FUW, 2022a; Garside and Wyn, 2021) or new residents (Pinto-Correia et al., 2014).

While beef and sheep systems had benefited from a supportive subsidy system until 2013 (with first pillar payment based on historical reference), the move to a Wales-wide flat rate first pillar payment and the development of the second pillar meant that farms that had maximised their subsidies linked to production and had a limited amount of land would lose out (Figure 5-3).

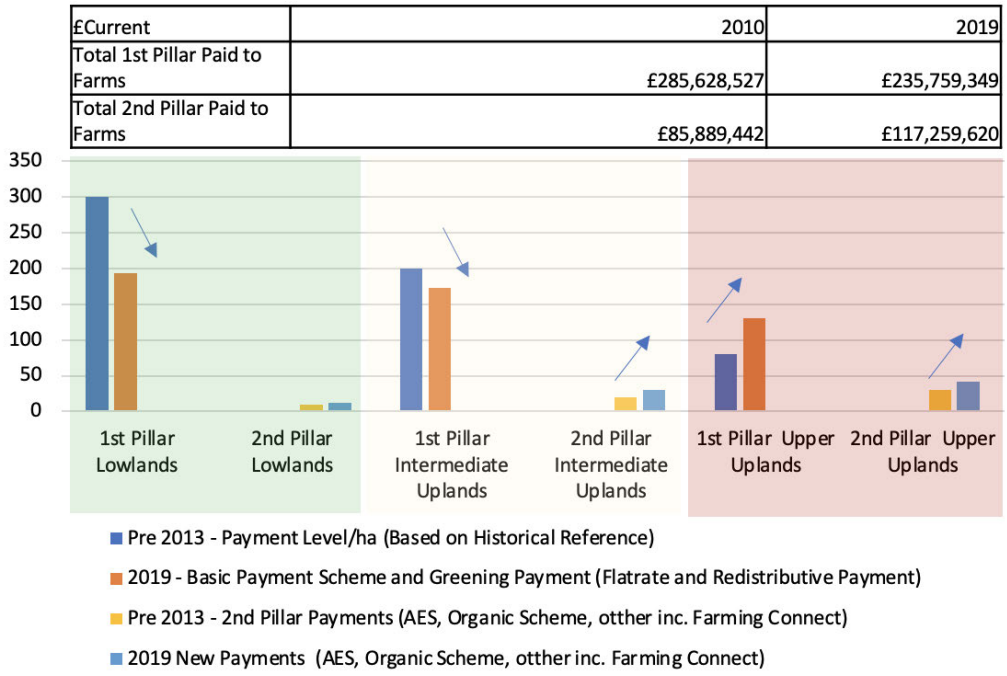


Figure 5-3: Total farm CAP funding evolution in each landscape (by the author from fieldwork and analysis of DEFRA et al. 2023)

Lowland and intermediate uplands farms lost funding that was directed towards upland farms, but intermediate uplands farms had less opportunity to develop in the same way as the lowlands and less opportunities to capture second pillar funding than upper uplands. Farming statistics show that from 2013, these hill farms that had intensified their production were the most impacted by the changes around farming (Welsh Government, 2020a).

The size and the profile of the intermediate farms is as the term suggests, with some access to mountain land but this only represents a limited proportion of their acreage

(<10-15%). The “squeezed middle” describes how they are slightly disadvantaged compared to lowlands, but not as limited as mountain farms.

Table 5-2: Three main types of farms in 2010 in intermediate uplands

Hill Farms	Bala/Vale of Clwyd (Upper parts)
Large Farms	Access to the mountain and possibly to lowlands, on top of the hills. >300ha Family and hired in labour (2-3 FTE)
Medium-sized Family Farms	Access to the mountain – with some rented land - 75-200ha Family labour (1.5-2 FTE)
Smallholdings	No access to open grazing – with some rented land - 25-30ha Family labour (<1FTE)

As noted in the literature, intermediate systems tend to still have a strong social capital value and are key to the social, environmental, and economic mesh constitutive of the Welsh uplands (Vigani and Dwyer, 2018). Despite this, their treatment in past policies has been mostly focused on agricultural activity (Reed et al., 2009). They have relatively constrained production potential but at the same time feature fewer areas that are recognised as priority habitats.

As summarised in Table 5-3, a range of new opportunities became available not so much from newly developing technologies and policies, but more from market changes. The end of dairy quotas and increased demand in milk and meat markets also played key roles. The government incentives for farms to generate electricity and the development of diversification opportunities in general (

Table 5-4) represented a key change of context. Crucially, the capacity to borrow at lower cost made any farm project easier, particularly if the land was used as collateral.

Table 5-3: Summary of main market trends for farming systems in hill farming areas from 2013 to 2022 (by author from secondary data)

Context for enterprises	Dairy (AHDB, 2020b)	Beef (FAOSTAT, 2021a)	Sheep Meat (FAOSTAT, 2021a)	Poultry (FAOSTAT, 2021a)	Egg Prices (Annex 6 Item 6-8)
Policy changes	No quotas on production.	End of high subsidy support. Difficulty to access AES			
Output prices	Increasing	Very gradual increase	Very gradual increase	Very limited price increases	Very limited price increases
Demand	Increase	Demand increasing	Demand increasing	Demand increasing	Demand increasing on free-range
Input prices	Volatile but remaining relatively high since 2008 (Analysis of FAOSTAT, 2021b data)				
Investment conditions	Lower cost of borrowing capital with quantitative easing policy from 2008 (Savills Research, 2020), particularly with first pillar payments used as security.				
Land market	High flexibility, opportunities for landowners and enterprising tenants (Chapter 4; Lenormand et al. 2021b). Low supply and high demand in lowland areas (Chapter 4).				

Table 5-4: Summary of other activities available in hill farming areas from 2013-2022 (by author from secondary data)

Other types of activity	Electricity generation (Energy Saving Trust, 2022)	Demand for tourism in rural areas and rural residential buyers (Velu, 2021)	Local food demand (Food Policy Alliance Cymru, 2021)
Context	Incentive to produce electricity by secure and high prices with Feed-in-tariffs (2012-2019). Consumer and business demand for green energy.	Growing demand from consumers	Growing demand from consumers

2. Differentiation of farms

In this section, the appearance of a twin-track model will be highlighted as well as the role played by farm diversity as was described for Welsh lowlands in Chapter 4. The pathway analysis for these two areas can be found in Item 8-1, Item 8-4 and Item 8-5.

a) **Changes on large farms**

On large beef and sheep farms in hill areas the impact of subsidy changes was limited, and beneficial if they held mountain land. But the continuing poor economics of beef and sheep (O'Regan et al., 2019), particularly for stores and light animals, meant that new income options were sought, including tourism and conversion to organic. New income possibilities were also available like electricity generation - mostly hydro-electricity, wind generation or Combined Heat and Power (CHP) - making the most of the feed-in tariffs. This was easier to implement on large farms with woodlands/plantations and a larger landholding (e.g. with a drop in altitude, for hydroelectricity). Nevertheless, this was costly to implement and as a result, owners could adopt it more easily by using their land as collateral, particularly if they had not expanded too much prior to 2008 when interest rates were high.

Owner-occupier farms with large numbers of family workers with less mountain land and high-cost loans to service were the most likely to remain fully in beef and sheep, possibly finishing cattle and growing more of their own fodder but reducing the suckler herd. The strategy to increase the size of the holding was still retained by some, but it was often coupled with diversification into other products. Often, the stocking density reduced with less management activity (in terms of livestock rotation etc.) for time-saving measures.

Large farms with little mountain and a good grazing platform[47], gradually and increasingly moved into spring calving dairy systems from 2013. The land would be "relatively" smooth and still be adapted to small and nimble dairy cows, following the example of New Zealand. These farms focused on producing milk cheaply from grass with a high labour productivity and a technical package framed around low-cost operation designed for as much grazing as possible, matching the production of milk to the grass growth cycle (Figure 5-4).

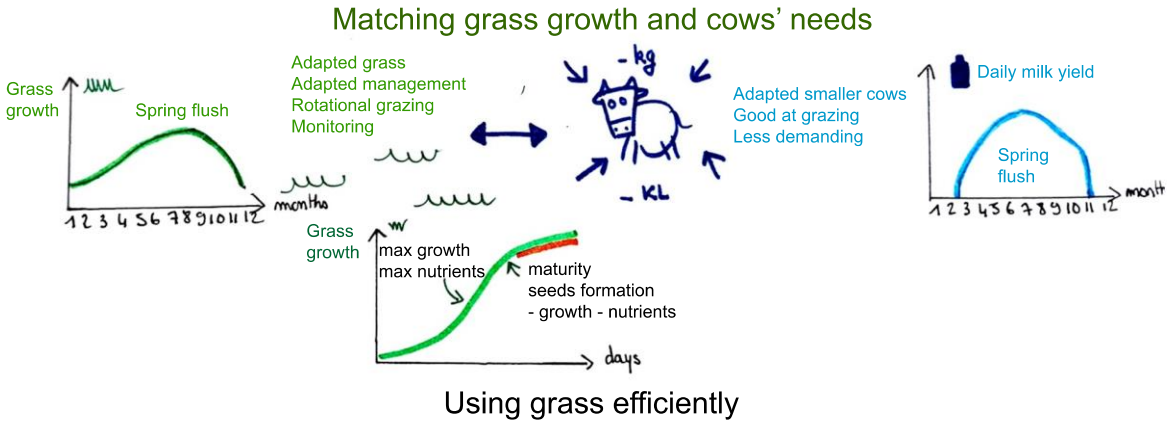


Figure 5-4: Agronomic logic of the dairy spring calving system (by the author)

Although first implemented in the lowlands in the 1950s, this grass-based system (Béranger et al., 2002) is also suited to hills. With small and light cows, an intensive and efficient management of grassland combined with tracks to access the fields, early growth, and productive rye-grass pasture (sometimes mixed with other perennials), these characteristics fit well the gentler parts of the intermediate uplands.

The economics return are good and they can make do with a very basic farm layout due to the low yield of the cows (6,000l/year/ dairy cow maximum, high butterfat and protein percentage in the milk). However, herd numbers must be relatively high to compensate for lower yields. In the uplands they often use no-till grass renewal techniques.

[47] Land grouped together to allow cows to graze around the farm where the milking parlour is, additionally it is also necessary to have good grass growing potential for the farm

The infrastructure available on large farms would often need less adaptation for dairy cows (Annex 9 Item 9-1). In many cases the mountain land and rough hill grazing far away from the homestead would be managed using a now separate, sheep-only system, though the dairy land might be used for wintering sheep. This development of low input dairying has gained pace and started to attract large family farms with few family workers.

Initially adopted by farms of large traditional landowners, the development of these systems relies partly on share-farm[48] structures that have now developed, using profit-sharing models to match land more easily, built capital, working capital and labour (Williams, 2011; Wynne Fynch, 2013). They also offer a pathway for new entrants into farming (as shown in Rona, 2011). With time other types of landowners, sometimes retired farmers, turned to these models but their structure varies widely between farms (Annex 9 Item 9-1). More recent upgrades tended to be less favourable for the 'new farmers' in the partnership, due to these farms being less easily adapted than these which were first to convert. Already within large farms category, a differentiation of farms can be observed but also some interdependence, with farms intensifying and others extensifying their land-use.

b) Changes on mid-sized family farms

(1) Beef and sheep

Farmers that had increased production usually benefited from the 2005 Welsh CAP adaptation and gradually changed their farming systems, as they lost 10-20% of their subsidy payment from 2013 onwards, particularly if they did not have any rough grazing. These farms represent 60-65% of active farms in these areas.

[48] Sharefarming or Joint-venture in the UK is an agricultural arrangement where a landowner grants a tenant the use of land in exchange for a portion of the output produced, enabling farmers to access land without purchasing it outright and landowners to benefit from their land without direct management.

Medium-sized farms with 1 to 3 family workers represented the largest proportion of farms (50-60%), many farms had to arrange succession[49] while the economics of beef and sheep remained relatively difficult, particularly for these that struggled, due to the limited capacity of their land (fodder production, timewise…) to match market demands while limiting their inputs use[50]. Farms with young farmers would tend to favour a more market-focused product with earlier lambing (partially indoors), bigger sires and crosses/mules ewes thus producing a heavier, well-conformed lamb sent rapidly to the market. For cattle, market orientation would mean further uptake of continental breeds of cattle to produce fat animals or large stores, sales date would tried to be matched to markets highest prices (Figure 5-5; Annex 9 Item 9-3). This could mean selling finished or store stock in autumn or spring when prices would be higher for both (Figure 5-5).

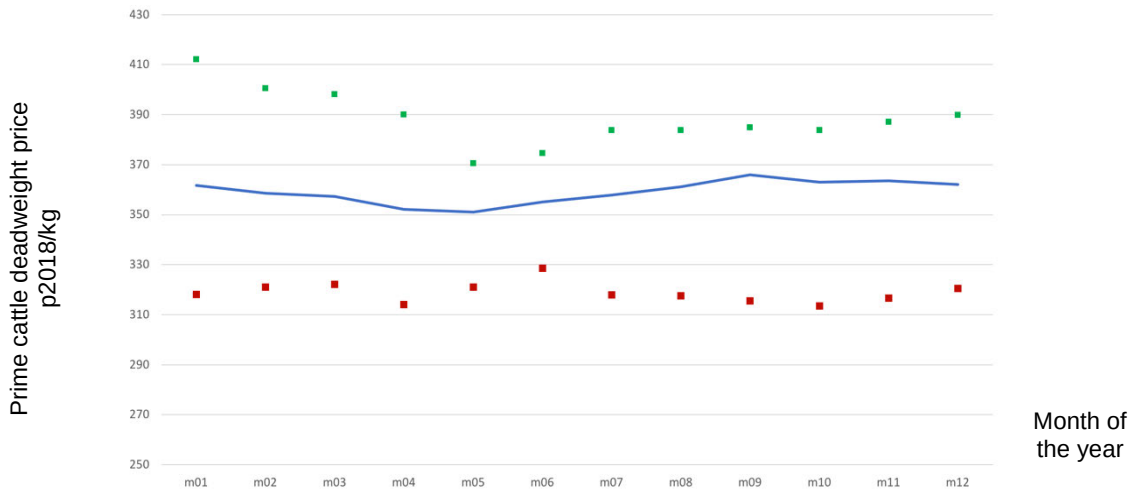


Figure 5-5: All prime cattle deadweight real farmgate monthly average price (including min and max) from 2014 to 2021 in p2018/kg (by the author from AHDB, 2022a)

To attain these gains without buying more feedstuffs a series of adaption of the fodder production system it was necessary to make higher quality silage/haylage for supporting beef cattle growth over the winter months, implement rotational grazing techniques and adopt more nutritious grass mixes with a higher proportion of dairy type seeds (ryegrass high yield, high sugar). Having access to dry parts of the valley

[49] Farmers born in 1940-1950 would be reaching retirement age, they would have been taking over the farms that had effectively survived/specialised from the 1970s.
[50] As these had increased significantly in price (Annex 6 Item 6-4)

and the hills was better as farms could do two cuts of grass with these grass mixes (in July and later in September).

Producing fodder crops for winter feeding, often incentivised by successive second pillar schemes (Glastir and Tir Gofal but also Farming Connect), that could be grazed during winter[51] helped add some diversity into hill farming systems. Cereal growing in the hills, on less steep fields was also incentivised on a small scale in the driest and less steep parts (Valley and hills). This could help farms trying to achieve outputs better tailored to market demands. These farms would be more self-sufficient in terms of fodder; they aim to reduce input use while increasing production (Figure 5-6). Farms going further in this direction would manage to improve their added-value and if located close to settlements, they would add family workers or side-activities building from the system; like selling some of their meat locally or adding horticultural production (and with the support of RDP grants; European Commission, 2016;Marsden and Sonnino, 2008).

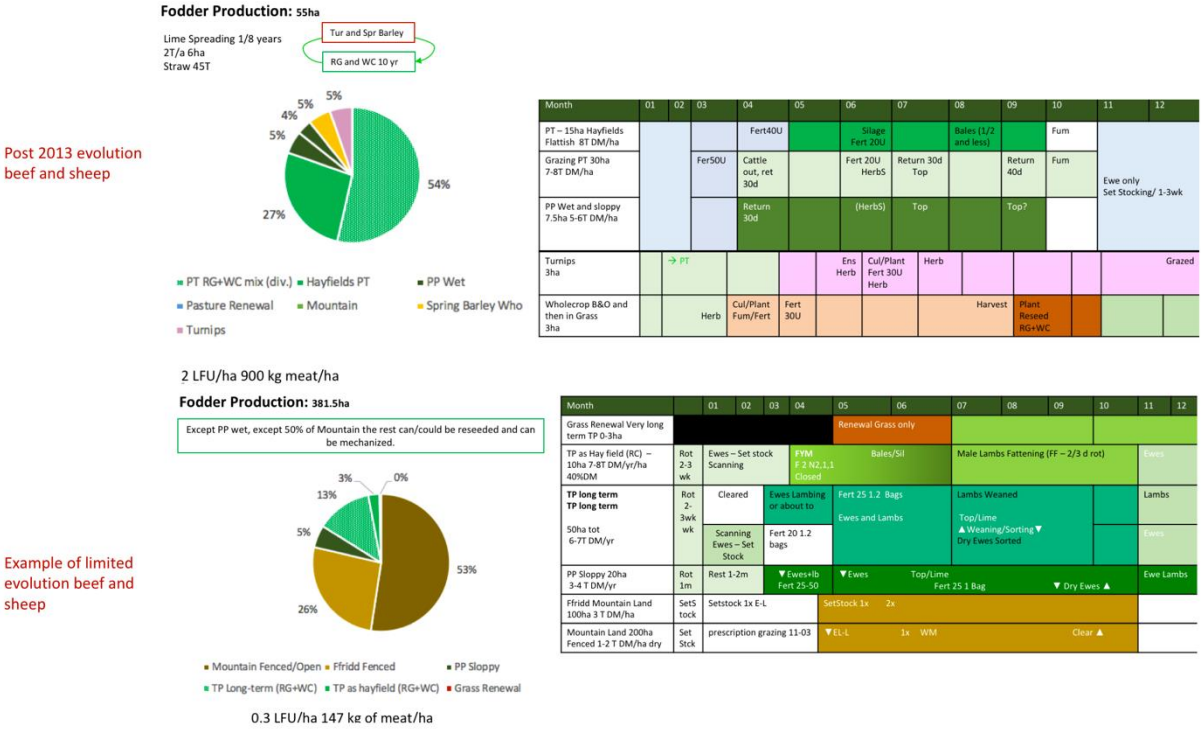


Figure 5-6: Two different archetypes of beef and sheep farms

[51] With a rationing system using a fence moved forward, controlling how much is eaten everyday – and limiting vet risks in some cases

Having mountain/open-grazing land was a determining factor in retaining more traditionally oriented beef and sheep farming systems, but complementary activities might be needed to support succession: for example, a high added-value system not dependent on land (e.g. poultry). Having established family members on the farm that would not draw on the income could be helpful (e.g. just retired). These elements are reliant on the farm's capacity to borrow and are thus less accessible to rented farms.

Without heavy investment, further expansion could be sought by adopting only some of the changes of more ambitious farm types. For example, using rotational grazing on some fields to finish lambs at heavier weights (Figure 5-6). The development of part-time campsites has been a trend supplementing farm incomes at relatively low-cost. Also, renewable electricity generation was taken up but on a much smaller scale than on large farms, rarely hydro-electricity and wind turbines but most often solar panels placed in farm fields, it was only possible for these who have long-term control of land.

It was found that the change towards a more demanding land use would not be compatible with a tourism activity, mostly due to the lack of family workforce but also the location of these farms.

(2) Retirement and support-farming

The fieldwork has demonstrated that the change in subsidy payment on first pillar was challenging for intermediate uplands farms. Many 1-1.5 FTE farms without planned succession started renting out their land, pre-retiring, sometimes letting it to new spring calving dairy farms units, with a developing market for renting or downsizing while planting trees[52]. Also, rented farms were taken back in hand by landowners as secured multi-generational tenancies (AHA 1986) have come to an end, to be re-let at higher prices (in relation to expected higher possible prospects) or incorporated into developing spring calving dairy units. Some might have been downscaled to smallholdings, as part of the farm is removed. For example, as in lowlands (Chapter

[52] With policy support for example the small woodland scheme (Welsh Government, 2022c)

4) the land could be sold separately from the farm holding: if split, it would give a higher sale price or rental value. For farms buying the land, using subsidies as collateral, a slow growth strategy could be followed, for market-focused beef and sheep producers.

In the lowlands, the change in policy and market context emphasised in Chapter 4, has fuelled a continuing development of dairying (Figure 5-7). It means that these lowland farms have gradually looked uphill for fodder, as well as for potential rearers for their dairy heifers. Operating parts of the farming system of lowland dairy farms under contract has been an interesting prospect for some upland producers (Figure 5-7). Rearing heifers through contract can be a secure income offering good returns, while these heifers tend to have more modest requirements in terms of fodder quality and quantity, it is possible to supplement it with bought-in feed. Different levels of risk are linked to different levels of integration with the dairy farms.

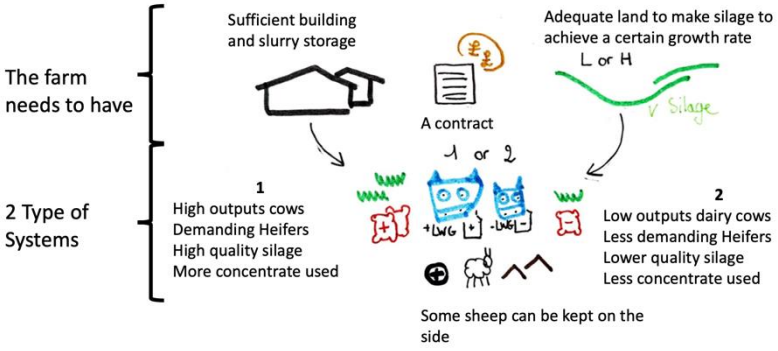


Figure 5-7: Support farmers in dairying, rearing heifers for dairy farms (by the author)

These systems might still have some sheep, particularly if they hold mountain land. The decisive factor would be the infrastructure available and the ability to get access to land on which it would be possible to produce good quality dairy grade silage or haylage sustaining the growth of dairy heifers (Figure 5-7). In turn, the level of income risk would potentially reduce drastically while generating a higher added-value. The rapid development of spring calving dairy systems has further incentivized this move and they are targeting farms higher up than lowland dairy farms, their heifers have lower requirements in terms of silage or grazing (Annex 6 Item 6-9).

(3) Poultry farming

Another significant option available to upland farmers has been poultry units. Historically in study areas no farms specialised in it. But with the gradual increase in consumer preference for UK eggs and poultry-meat, there has been a need for new units (e.g. DEFRA, 2023; "Hybu Cig Cymru," 2022). Production has been planned by the integrated supply chains for these products, most of all for free-range poultry which has seen the greatest growth and attracts a price premium (DEFRA, 2023a; Godley and Williams, 2007). Looking for pools of livestock-knowledgeable farmers was one factor - as in Brittany (Canévet, 1991) - but poultry contract-economics improved after 2008-2010, with price now adjusted according to the cost of production (Fieldwork). The relaxing of borrowing conditions in this period meant that poultry was a more attractive option for farms looking for extra income. Most farms taking up poultry would be mid-size, owning their land or with sufficient collateral (well-established tenanted farms) and with additional manpower (upper thresholds or more than the 1-3 family FTE). There were also clear pre-requisites (Figure 5-8), regarding location-specific or other factors (e.g. having some electricity generation). Planning restrictions including some linked to the neighbouring AONB or National Park limited which farms could move into poultry. Laying hens have been more popular in the North, as there was no nearby abattoir/processors, laying units were cheaper/more often offered than broiler units (due to their smaller size) and the labour required was higher.

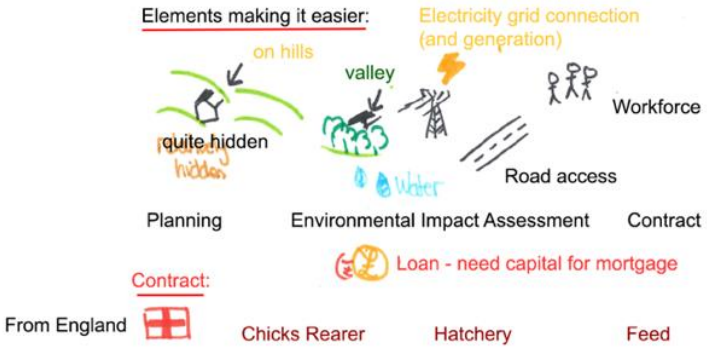


Figure 5-8: Poultry farming in Wales logic behind the development of the industry (by the author)

Poultry units (Figure 5-8) can require more land or other people to take manure but can easily increase their landholding, given the profits generated. Poultry farms tend to develop gradually, building up one shed after another, limiting risk and adapting the rest of the farm gradually. It represents a change impacting the local economy, as the processing and supply-chain actors are not located in Wales' rural areas. This production is highly technological and has a result creates a technological and financial lock-in for farmers, as can be shown in Figure 5-9.



Figure 5-9: Poultry Farming technological and financial lock-in (from Fieldwork by the author)

Rearing poultry in Wales while importing the feedstuff from England, represents a transfer of fertility and nutrients, with the muck from the poultry is spread at home. In turn, potential yields would increase (potentially fostering further mixed farming with crops), to finish cattle or have heavier lambs (with rotational grazing). However, this is found wherever farms had spare family workers and with some amount of hill land, otherwise it led to a simplification in management of the farm to accommodate the poultry unit (end of rotational grazing, end of cattle rearing).

c) Changes on smallholdings

Smallholdings also faced a reduction in CAP subsidy, this led to some retirement on farms with reduced income prospects. As farmers grew older, farms without clear succession were rented-out to other farms or sold, including for residential and tourism use. On smallholdings with succession, the farm would not support a full-time family worker, so part-time farmers would simplify their farming system (e.g. reduced livestock, less rotational grazing). Younger smallholders seized the opportunity to adopt small hen units (eggs marketed locally); locally selling meat; developing a small horticulture activity or setting-up a micro-dairy on the farm (Annex 9 Item 9-4).

For smallholders who rented out or simplified their management, they would have decreasing or no agricultural output. For these who diversify further, this required knowledge, a local side-job to support the nascent activity, or some external financial backing. Such systems could be associated with higher rental value, should the farms be re-let.

d) Changes in the Cambrian Mountains

Integrated poultry and pork units are the prime differentiation of this area, in response to subsidy reductions. Sustained demand for broilers/free-range meat has meant that profitable contracts have been offered to farmers, as they tend to be closer to processing centres of the industry (based in Herefordshire). Pork finishing units represent a more recent development.

The development of inputs-substitution on these units could be achieved by using muck in place of fertiliser, but also with a rotation incorporating more cereals and fodder crops. Increases in grass production could enable changes like farms in North Wales, with rotational grazing and an increased number of silage cuts. It also enabled these farms to continue growing and retain labour on the farm. Agro-ecological conditions makes grazing more challenging than in North Wales but there is a lower risk for hay harvests, comparatively favouring beef and sheep compared to dairy. The dairy sector is near absent from the Cambrian study area, in contrast to Bala. Dairying can be found further to the East, out of the study area, where grass starts growing earlier with warmer climatic conditions.

Considering the changes that this area has faced in the last two decades highlights the course of agrarian development in Welsh upland areas more generally, where market drivers have now become more dominant than subsidy drivers, for hill farms. There has been a sustained loss of 20% of farms in the area overall. The area is characterised by strongly self-sufficient and/or low labour farms enabling them to reach sustainable levels of income. Nevertheless, for the 30% of farms that are part-time or on the verge of retirement, their economic sustainability is in question in the future.

e) Land use change trends

There has been a net reduction in the number of active farms, and strong amalgamation. The pace of differentiation has been rapid: half of these farms changed significantly in less than 10 years, with landscape-scale changes (Figure 5-10) and different development paths (Annex 9 Item 9-5). The use of the environment was split between these decreasing output, sometimes with encroachment and degradation of vegetation (e.g. Pakeman et al., 1996), sometimes reducing inputs but with management maintaining an open sward; and these with increased levels of output and management, sometimes with increased inputs due to development of dairying and poultry. A dual track model of farm development was thus observed. Key to these fast-changing trends has been a focus on economic income maximisation among many actors, while others chose changes that were easy to implement on the farm and compatible with the "life-cycle", such as where a farm has limited investment capacity or ability to adapt the farming system (e.g. if tenanted, or with agro-ecological constraints).

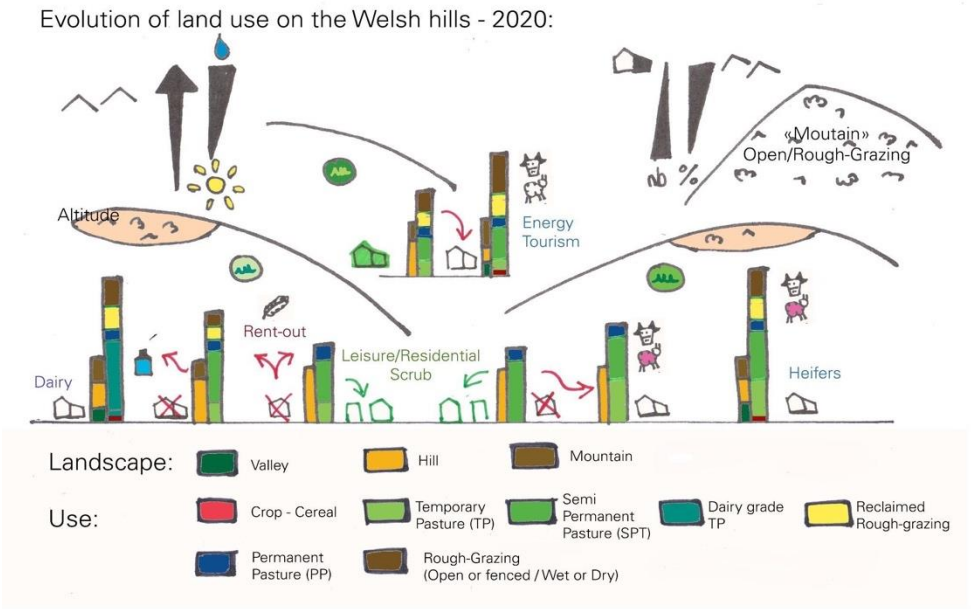


Figure 5-10: Landscape of the intermediate uplands in 2020

The role of knowledge exchange during this period has moved away from supply-chain actors, as RDP-funded advice from Farming Connect and farmer networks (reinforced by social networks) were taken up by a new generation. These sources advise farms to consider a range of solutions, focused on different market opportunities.

C. Upper uplands farming changes from 2010

In the uplands at relatively high altitudes, farms have faced the challenge of trying to balance their available opportunities to maintain income. Their production potential per ha is lower due to bio-climatic constraints but they have larger acreages and extensive rough grazing/mountain areas. As a result, the WG's decision to rebalance subsidy support away from a historic reference level (which paid more per hectare on more productive land) to a flat-rate area payment did not affect these areas as much as the more productive areas (Chapter 5.A); most farms in the upper uplands were net beneficiaries of this subsidy change.

The context surrounding farms on higher ground was similar to the description given for all uplands (Section A). As is demonstrated in Table 5-5, the following narrative will be summarised across-the three main farm categories. These farms were often partly in planning-restricted areas (e.g. National Parks or AONB) and due to their mountain areas had a more limited lee-way to adapt their farming systems due to the higher proportion of environmentally sensitive land (as demonstrated in B.2).

Table 5-5: Three main types of farms in 2010 in upper uplands

Upper hill Farms	Bala/Vale of Clwyd (upper parts)
Large Farms with a high proportion of mountain land	Access to the mountain and possibly to valleys, on top of the hills. >400ha Family and hired in labour (2-3 FTE). Land in SSSI/National Parks/AONB. 60-100 suckler cows, 2,000-3,000 ewes (1/2 Welsh Traditional Breeds)
Medium-sized Family Farms with a high proportion of mountain land	Access to the mountain – with some rented land - 75-200ha Family labour (1.5-2 FTE). Land in SSSI/National Parks/AONB. 30-40 suckler cows 1000-1,200 ewes (1/2 Welsh Traditional Breeds)
Medium-sized family farm based on mountain land	No access to open grazing – with some rented land - 75-200ha. Family labour (1FTE). Land in SSSI/National Parks/AONB. 0-20 suckler cows 700-1,200 ewes (Mostly Welsh traditional breeds)

1. Differentiation of farms

The main differentiation trends will be discussed based on the Bala case-study area before enriching it with findings from the Cambrian Mountains area. The pathway analysis for these two areas can be found in Annex 8 Item 8-1 and Item 8-4.

a) **Changes on large farms**

It is noted that large farms (with access to all distinct levels of altitude, and some good valley land; Table 5-5) that had expanded in the past reduced their input use after 2010 by 20-30% and looked at how much livestock they could reasonably carry. They kept an element of fodder growing, sometimes with a bit more finishing and associated high energy fodder production, with a rotation on the valley and hillside fields, much like farms in the intermediate uplands. These with a system of around 100 sucklers and 1,000-1,500 ewes would be gaining some subsidies from the second pillar and potentially the first. They therefore moved their lambing for all their flock to March – instead some of the ewes could be lambing earlier- to better match grass growth and animal needs, abandoning de-synchronisation, and retained beef and sheep because their scale of operation made it still sufficiently income-generating. They could potentially diversify into houses to rent or renewable electricity generation (e.g. anaerobic digester or CHP unit), subject to planning consent being forthcoming.

These who had gradually accumulated more land and particularly mountain land[53] were able to benefit from the shift in subsidy payment towards a flat rate. They had to have two flocks for two different environments and manage with different lambing dates, needs and outputs. The mountain flock could nevertheless provide part of the breeding stock for the crossbred flock. These farms would also see their subsidy payment increase.

Some farms with more limited mountain land could see a slight drop in subsidy payment due to the policy change, with a low family workforce and/or capital decided

[53] Which was comparatively cheap in the 1990s-2000s due to its poor production potential

to convert to organic (triggered partly by the availability of transition and maintenance grants). To keep the same number of animals in such a system, the acreage of hill and valley land would need to be multiplied by two. This switch often took place on rented farms that had never been able to benefit fully from previous output increases. Conversion to organic was an “easy step” for estate home farms with a large amount of land that could be taken back in-hand. Having access to the lower-lying areas of land meant being able to add more high-energy intensive crops and fodder crops into the system as seen in intermediate uplands. Other than this, these systems would remain traditional in their management of grazing or of their livestock (Figure 5-11;Annex 9 Item 9-2).

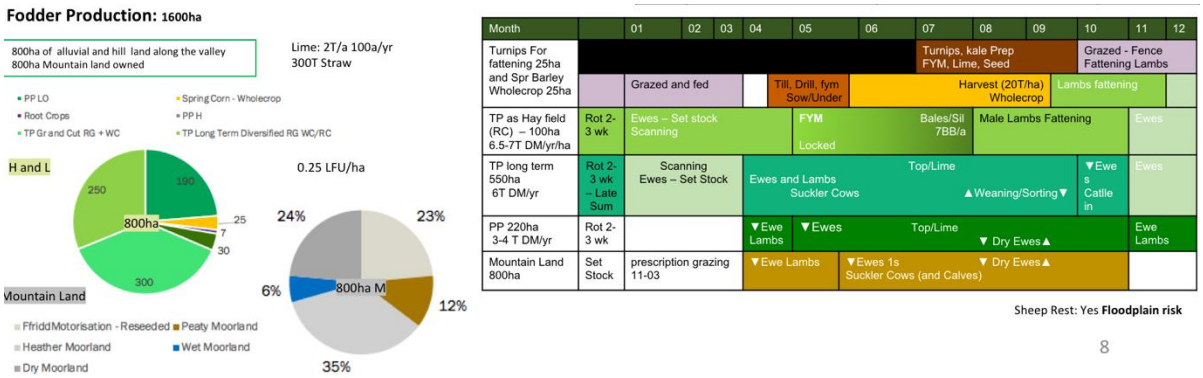


Figure 5-11: Management of a large organic archetype in upper uplands

b) **Changes on mid-sized farms**

As in intermediate uplands, mid-size family farms under 100-200ha with low mountainous area were in a tight spot with some reduction in subsidy payment. If there was no successor, they would either gradually simplify (extensify) their management before retiring and renting-out. If there was a successor some steps could be taken to add diversifications activity compatible with the area or go part-time. The key difference to intermediate uplands would be the increased use of “Uplands breeds” for beef and sheep with a later lambing date and less output potential.

Medium-sized farms continued to expand gradually through time, building up their landholding and livestock numbers with the added security/cost of subsidy entitlements. In the last decade, facing high input costs, farms adopted more self-sufficient and “efficient” systems but did not have as much leeway as farms on the

intermediate uplands, which limited the size of their crossbred flocks (and the crops they could adopt). Their adoption of fodder crops would be more limited than intermediate uplands farms linked to long-term pasture renewal and AES scheme options, being based predominantly on grass (Figure 5-12).

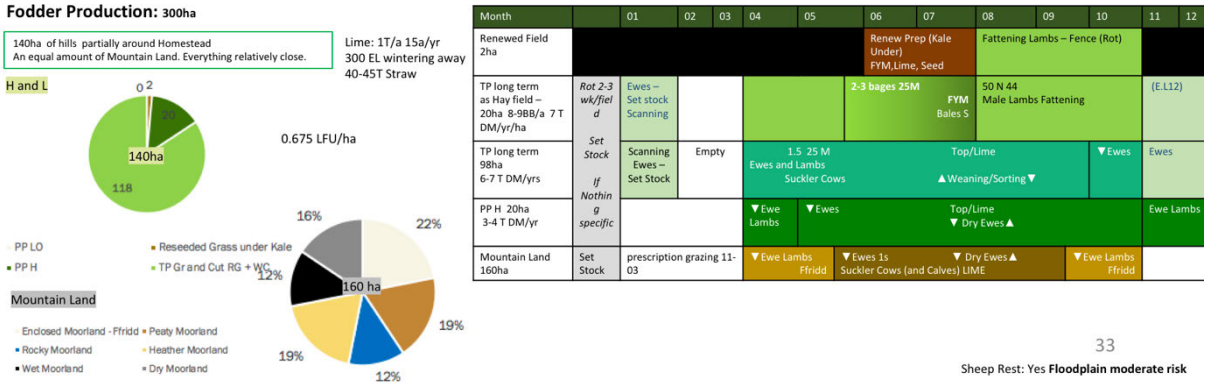


Figure 5-12: Land management on a mid-size family farm with a traditional management and mountain land

Rearing heifers would be a possible option, as in intermediate uplands, but it would entail much less grazing and having some dedicated silage land, that would have to be rented-in in the valley.

Farms on Snowdonia mountains with the most mountain land and poorer hill land tended to be these with the highest proportion of traditional breeds (often 100%) and the most extensive systems. They benefited from subsidy re-distribution with their high proportion of mountain land, producing Welsh black (or crossed) stores and some Welsh Mountains lighter/later lambs that have a lower market value. The stocking density further reduced on those systems although their stock numbers have not dropped. With a new higher income thanks to fully decoupled flat-rate subsidies, they have often invested in small lowland farms (in areas such as Denbigh, or Corwen) to have more grass available to limit their input cost further or rent-out land to out-winter their ewes. These farms struggle to manage their specific habitats sustainably with traditional breeds that have “improved” through time. Lambing percentages have increased even for Welsh mountain flocks, and their average size has gone up. The challenges with these specific habitats will be analysed - their evolution and needs - in Chapter 6.

While diversification options have expanded in general, on the higher farms they have been more limited. The transformation of these farms has also been more limited in their adaptation to market conditions, due to bio-climatic conditions.

c) Changes on smallholdings

Smallholders had disappeared step by step earlier than in the intermediate uplands, as early as the 2000s, if they had not increased size, they would not have survived except in a part-time farming fashion or by diversifying their enterprises (e.g. Annex 9 Item 9-4).

d) Changes in the Cambrian Mountains

In the Cambrian mountains landscape, fewer farmers than in North Wales went into organic farming (even with mountain land). This is explained by the different land holding pattern, with fewer large farms and the lower proportion of hill land in general. The lower and later grass growth profile also has an impact as it makes it more challenging to adopt an organic system. In the area most farms with hill land also pursued a drive towards further input use efficiency and more self-sufficient production systems, while maintaining production; by re-introducing crops and fodder crops in the rotation, incentivised by second pillar subsidies and a reduction in first pillar subsidy. Beef and sheep farms had in general a slightly different farming system, lambing later due to the later grass growth and with more suckler cows and livestock compared to North Wales farms (50-60 sucklers and 700-900 ewes). The proportion of upland flock would be smaller. The development of agri-environment schemes benefited these farms but less so than in Snowdonia as they tended to be tenanted.

In the Cambrians, the 2000s rather than the 1990s marked the diversification of farming systems into campsites or caravan parks, found mostly in the hills. By contrast, part-time working was also retained, as contracting was also sought by farming systems in nearby Herefordshire. Renewable electricity generation was not as popular in the Cambrians area as in Bala, due to a lack of forestry associated with large farms, and generally poorer national grid connections.

It is also intended to highlight a differentiation through marketing of traditional beef and sheep products: in this case, large and mid-size farms, with the adaptation of limited farming systems, all of which benefiting from a slight uplift in output prices. The Cambrian Mountains Lamb Protected geographical indication (Defra, 2021a) aims to offer a premium for specific mountain lamb conformation, maybe the most identifiable Welsh agricultural product. These are Welsh lambs of under 32kg liveweight from Welsh breeds, slowly grown over more than 16 weeks and coming from a denominated area, which tends not to fit the expectation of general live market buyers. The company Dunbia has partnered with an association of 18 farmers to develop a scheme looking at ways to add value; usually with mountain land that had limited the evolution of their farming systems towards a purely market focus. The Protected geographical indication (PGI) specification gives an idea of the kind of production practices that make it unique. The premium stands at 25p/kg Deadweight of which only part goes back to the farmers (via remuneration of their producer organisation).

The development of the PGI is a positive step aiming to add value to farm outputs, but it does not fully fit mountain farms, as they cannot benefit directly from a premium on finished lambs, and their buyers only want lambs to finish, much later in the year (10-12). If Welsh breeds are further improved, the lambs would easily overshoot the deadweight threshold. As a result, it calls for a change of direction in terms of breeding and maybe increased use of the moorland/mountain for farms that have had to abide by conservation agreements. The number of producers is relatively low for now, with low volumes limiting the impact of this new PGI.

To conclude, the general trajectory on upper uplands was one of livestock density reduction and a relative extensification of farm management. Diversification as well as differentiation options were more limited, so the broad beef and sheep orientation of these landscapes remained, the land-use as such has not changed significantly.

D. Summary of farm archetypes identified

The resulting archetypes from the historical differentiation process can be found in the figures below in the key case-study areas from the uplands area case-studies (Figure 5-13;

Figure 5-14), the findings for the vale of Clwyd can be found in Annex 8 Item 8-5. These archetypes have been described in more detail in intermediate publications (Lenormand, 2023, 2021).

Figure 5-13: range of archetypes identified in the Bala case-study area (by the author)

Type of farm	Landscape	Number of archetypes	Size of farm	Key informations on the archetype production systems Lambs all sold fat except stated otherwise	Other element to consider
Dairy	Valley – Grass, fodder crops	1	<100DC small	All year round. – 6-7KL	- Some farms with sheep with they own hill land
		1	400-500DC	Spring calving – 5-5.5KL	
Support farmers	Hill or valley	1	20-50ha	Active support farmer – rearing heifers producing fodder Renting out the land Breeder	- Might have some sheep as well for heifers rearing
Beef and sheep	Valleys - Grass and potentially some fodder crops	2	Small - <80 head of cattle and <600 ewes	Storecattle rearing – 3weeks old to 18m old storecattle Or SC and cattle rearing – as strong stores 12m old or finished if possible to grow cereals Lowland ewes	- Diversification types (inc. BnB, energy generation)
	Hills – Grass and potentially some fodder crops	2	50 SC and >1000 ewes	With some hill/mountain land Storecattle 18m old and late lambs compared to other farms Mountain ewes and lowland ewes	
	Valley and hills - Grass and potentially some fodder crop or wholecrop	1	Large – >60SC large with >1000 ewes	With suckler cows, finishing some cattle crossbred ewes and lambs finished early – can be organic	- Might be a different cattle operation with similar land use
	Mountain land - Grass	2	Sheep specialist SC and sheep	400-1000 mountain ewes, highest proportion of mountain land producing store lambs 20-50 SC and 500-1000 mountain ewes with some hill land, producing 12-18m old storecattle	- Possibility to have some rented-in land in the valley
Poultry farming	Hill – Grass and fodder crops	2	Small scale <6K hens Large scale 32K/16K hens	Accompanied sheep rearing (<300 on small farms, >500 on larger farmers) On the biggest farms there would also be some storecattle being reared – with eggs	

Figure 5-14: range of archetypes identified in the Cambrian case-study area (by the author)

Type of farm	Landscape	Number of archetypes	Size of farm	Key informations on the archetype production systems Lambs all sold fat except stated otherwise	Other element to consider
Would have some support farmers and some small beef and sheep farms as well as some mountain farm but we focused on the archetypes where the differences are more significant.					
Beef and sheep	Hill with Mountain - Grass and potentially some fodder crop or corn (for those fattening)	1	50-70 SC and >900 ewes	With some hill/mountain land -storecattle 18m old and late lambs compared to other farms. Mix of lowland and mountain ewes. Some farms finishing their storecattle at 24m old with corn being grown	- Diversification types (inc. BnB, energy generation)
	Valley and hills - Grass and potentially some fodder crop or corn (for those fattening)	1	40 SC and >600 ewes	With suckler cows, finishing some cattle crossbred ewes and lambs finished early – can be organic	
Broiler farm	Hill with Mountain - Grass and potentially some fodder crop or corn	1	50/100K Broilers with beef and sheep	70 suckler cows and 1200 Ewes mix of lowland and mountain, selling finished cattle	
Pig farm	Hill with Mountain – Grass, fodder crops and corn	1	Pig unit 1000 pork	45 suckler cows 700 ewes mix of lowland and mountain, selling finished cattle	

E. Economic analysis

The economic results derive from economic analysis of the 'archetype' farming systems as described in the method, as shown in Chapter 4[54]. First, the economic analysis of farm performance will be covered, and an analysis will be undertaken through economic performance of farm differentiation linked to a range of factors and particularly bio-climatic conditions. It will be demonstrated that these are more significant in uplands by comparing upper and lower uplands. It will be demonstrated that there is no uniformity behind beef and sheep production despite some common factors. The economic performance of 16 archetypes is scrutinized (Table 5-6), they represent the range of farming systems resulting from the differentiation described above, including both "traditional systems" (some in upper parts of the uplands which could not respond to new opportunities), and these arising in the intermediate uplands. Six of the archetypes have small-scale electricity generation.

1. Economic performance

a) **Upper uplands and "traditional" beef and sheep systems**

These beef and sheep enterprises in the uplands are often those where adaptations in terms of investment and product differentiation are more limited. These archetypes represent in general up to 70% of systems in upland areas. Most of the beef farms have suckler cows and are rearing some stores to 18 months old, with low inputs and relatively low output. Some are organic. All farms have relatively similar outputs and labour productivity (Figure 4-6). The main differences are linked to the amount and type of land held, as well as its management and how that links to the different outputs.

[54] The farm's Raw Product is the value of the farm's output. Intermediate consumption is the value of all intermediate inputs used to produce the output. Capital depreciation represents the annualized cost of farm infrastructure. Added-value is the difference between the output and the costs, it represents the economic value created because of on-farm production. All monetary values are in £2018 and based on an average year.

Table 5-6: Description of farming archetypes studied in the economic analysis (by the author)

Spring calving dairy 500 cows- yielding 5,500 Litres/cow/year- large share farming - Intermediate uplands
Spring calving dairy 400 cows -5,500 Litres/cow/year- large family farm share farming – Intermediate uplands
Spring calving dairy 200cows -6,000 Litres/cow/year- mid-size family farm – Intermediate uplands
Rearing dairy heifers and sheep (rough grazing), and renewable electricity - mid-size family farm - Intermediate uplands
Beef finisher and sheep (mix) - Strip of land - Large farm family operated and electricity (export) – uplands (upper and intermediate)
Organic beef and sheep (mix) and electricity (export) - Strip of land - Large farm family operated – uplands (upper and intermediate)
Laying hens, sheep finisher and ewes (lowland) and electricity (hydroelectricity)- mid-size family farm – uplands (upper and intermediate)
Broilers and sheep (lowland) and electricity (solar panels) - mid-size family farm –Intermediate uplands
SMH local food beef and sheep (lowland) – Intermediate uplands
Sheep only hill (mix) - Split - Large Farm split in two – Upper uplands
Sheep smallholding family farm - Intermediate uplands
Rent-out farm smallholding family farm – Intermediate uplands
Hens eggs sold locally and sheep (lowland) and electricity - Smallholding family farm - Intermediate uplands

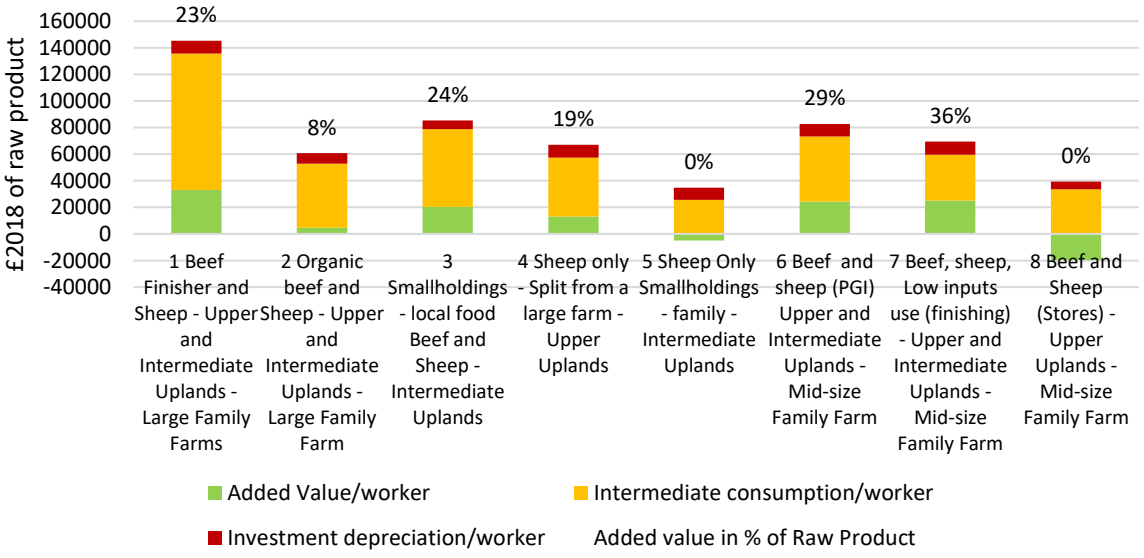


Figure 5-15: Raw product decomposition per worker on a range of archetypes, in £2018

In Figure 5-15 there are key differences depending on the orientation of farms. Some are common with lowlands, finishing cattle and sheep uses more inputs but returns a higher added-value. But in the uplands, the systems with the lowest added-value and intermediate consumption, are either very extensive farms with mostly mountain land or smallholdings, their added-value can be negative. Mountain-only farms, which can be organic, tend to have a lower output due to the hardy breeds, and low weight of the sheep/animals they sell, the bio-climatic conditions limit labour productivity. Other efforts to improve the added-value are noticeable, for example selling PGI lambs or looking towards finishing using an autonomous approach (producing own high-energy fodder like barley), returns higher added-value and has reduced input use, compared to other finishers. All these examples highlight the great diversity of economic performance in the uplands linked to the diversity of beef and sheep system often linked to bio-climatic conditions of farms' landholding.

b) **Difference in terms of opportunities**

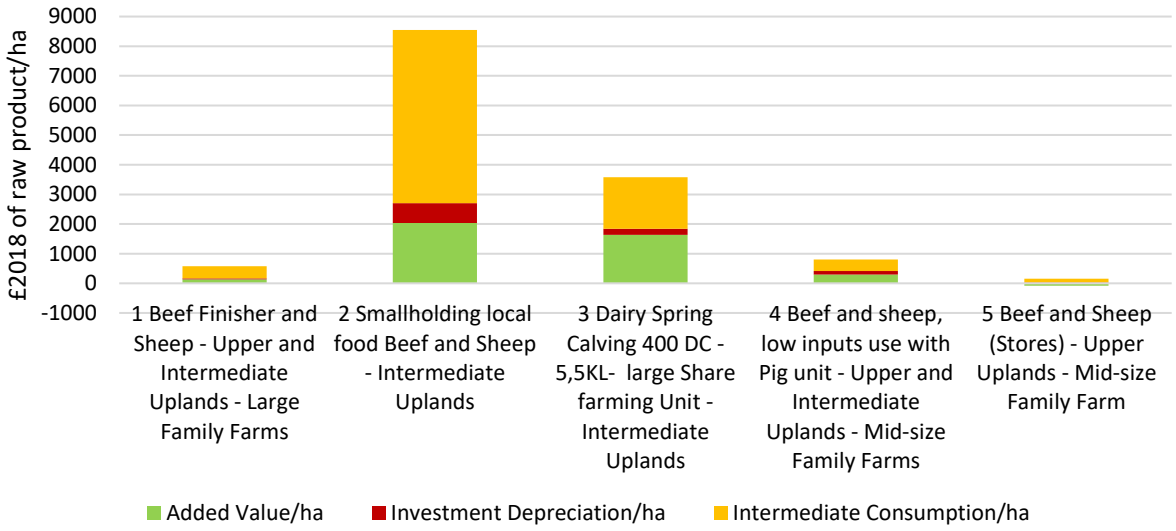
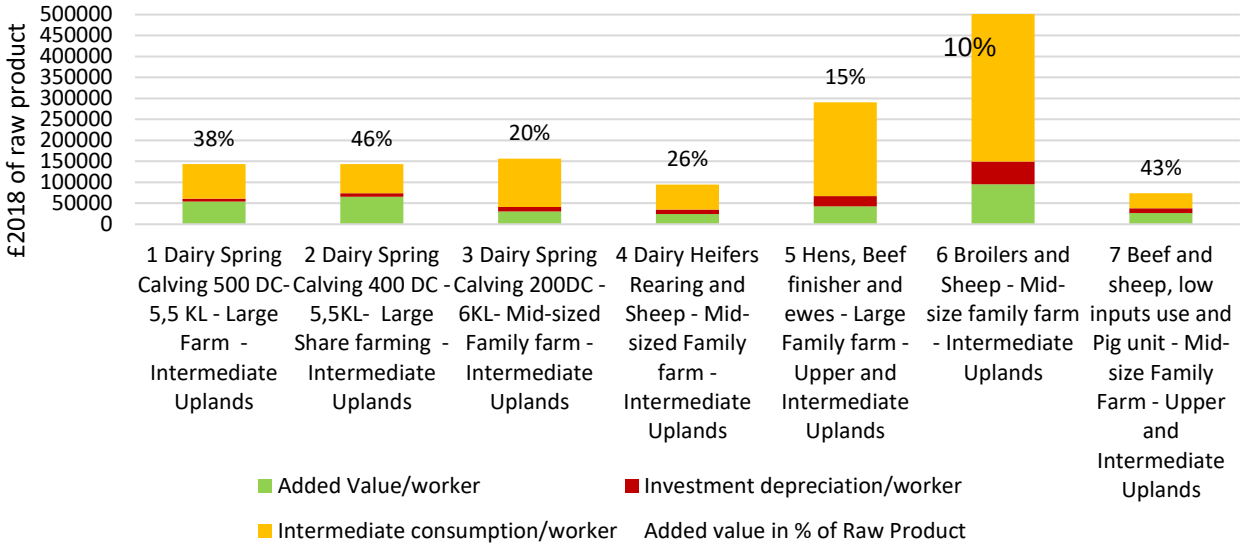


Figure 5-16: Raw product decomposition per hectare on a range of archetypes, in £2018

In general, beef and sheep systems (1,5) tend to return a lower added-value generation per hectare than newer differentiation (2,3,4), despite lower costs and inputs use (Figure 5-16). This reflects their small raw product, due to the low value of their output. It varies across archetypes depending on systems in place conditioned by bio-climatic conditions and how extensive the production (e.g. (1) Large farm with valley land compared to (5) store producer). Spring calving dairy farms, despite their

higher intermediate consumption and capital depreciation[55] have a high added-value per hectare, although under what is achieved in lowlands.

The smallholding in beef and sheep has a higher added-value per hectare than all



other systems per hectare, with different land management and significant input use with its calf rearing activity (intermediate consumption over £5,840/ha) due to the small acreage. The inputs usage, therefore, represents an opportunity to limit the impact of bio-climatic conditions (e.g. like on poultry farming).

c) Intermediate hills differentiation

All spring calving dairy systems generate high levels of added-value per worker, but some differences exist (Figure 5-17), linked to economies of scale (due to the relatively low output price) and the time when it was set up (the later, the more costly). Rearing dairy heifers gives a higher economic generation per hectare than beef and sheep farms, at the cost of a more limited increased in inputs use than dairy farms.

Figure 5-17: Raw product decomposition per worker on a range of modelled upland production system, in £2018.

[55] Although the capital depreciation and intermediate consumption of these systems remain lower than lowland dairy systems.

It is noted that farms with broilers and laying hen units all return higher added-value per worker, though with vastly increased intermediate consumption and capital depreciation, and reduced level of added-value vs total output (10-15%). The laying hens archetype has much more land and workers and therefore has a lower labour productivity than the other poultry systems, while retaining good added-value. Finally, adding a pig finishing unit seems only marginally different to rearing heifers, in terms of economic impact. As this is coupled to a more self-sufficient farming approach, it returns higher added-value and overall lower levels of inputs, in all the systems.

2. Agricultural income

a) **Upper uplands and "traditional" beef and sheep systems**

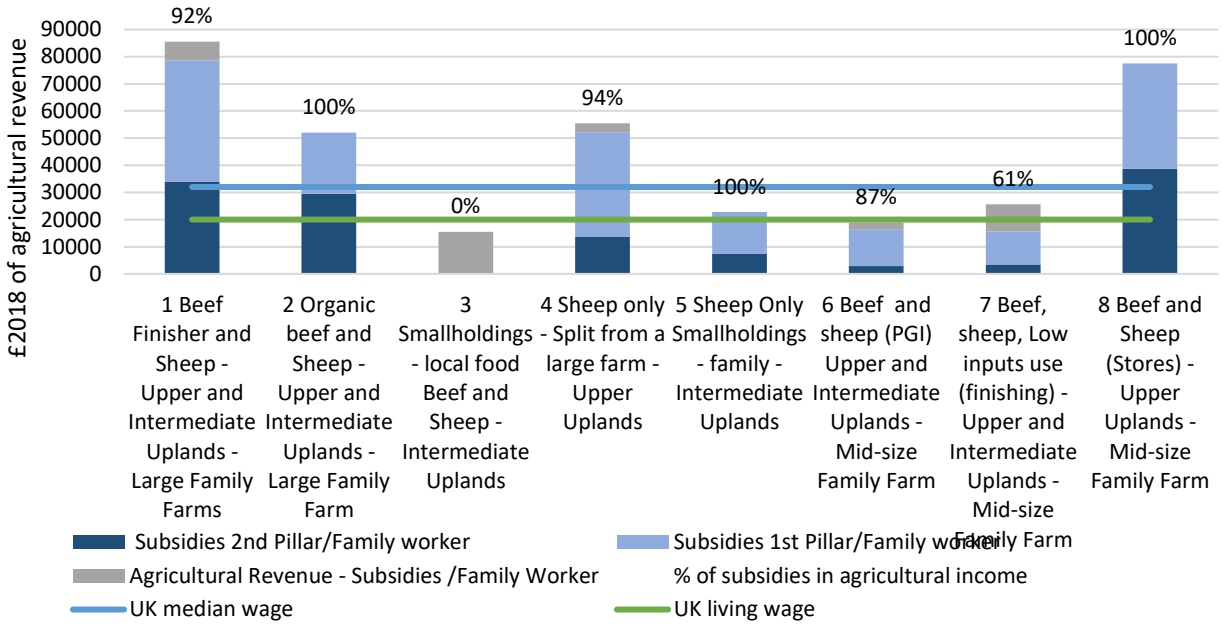


Figure 5-18: Annual agricultural income per family worker on a range of upper uplands production systems in £2018.

The levels of agricultural income per family worker (Figure 5-18) are very different compared to the added-value generation, as subsidy payments are based on acreage. As a result, as farms tend to have significantly different sizes in the uplands compared to lowlands, it causes bigger income differences than in the lowlands. Agricultural incomes depend significantly on subsidies, especially more extensive archetypes (e.g. mountain farm, sheep only hill). Added-value generation is not synonymous with high agricultural income, but finishing cattle and being more inputs-savvy or looking for

other market outlets seem good strategies to limit subsidy reliance (e.g. 3 a smallholding selling locally). Farm incomes are not high for hill farms with beef and sheep that do not have a lot of land (3, 5, 6, 7), even considering adaptation strategies, many earn around or below the living wage threshold. Farm diversification into energy generation helps relatively little in all cases, apart from reducing intermediate consumption slightly (1, 2, 6, 7). These systems over the median wage tend to be these that are heavily supported by subsidies. Access to agri-environment schemes has been unequal in terms of farm payments, benefiting larger farms and not necessarily matched by the number of workers. Renting-out the farm to high added-value farms appears a logical choice, economically speaking, compared to working part-time on it, particularly if subsidies are attached, given the low additional income achievable by keeping beef and sheep.

b) Intermediate hills differentiation

The spread in agricultural revenue per family worker (pre-tax) is more limited than that for added-value per hectare (Figure 5-19), but there is a much-reduced reliance on subsidy for farm incomes linked to newly developed production systems. Systems with dairy and/or poultry enterprises rarely have access to agri-environment subsidy (except the laying hens archetype which also has mountain land). Without subsidies, these systems still return an income over the median wage. The split of estate/large farms into a sheep holding (very simple with high labour productivity) and a dairy holding[56] returns a higher income than keeping the two farms together, particularly if they have access to agri-environment subsidies.

Heifer rearing has a higher dependence on subsidy but much less so than beef and sheep systems, with a higher income than most. Adding a pig finishing unit and combining it with a higher self-sufficiency would give a similar income profile.

[56] One of the dairy holdings in Figure 5-19 (1,2 or 3) combined to the archetype 4 with only sheep in Figure 5-23

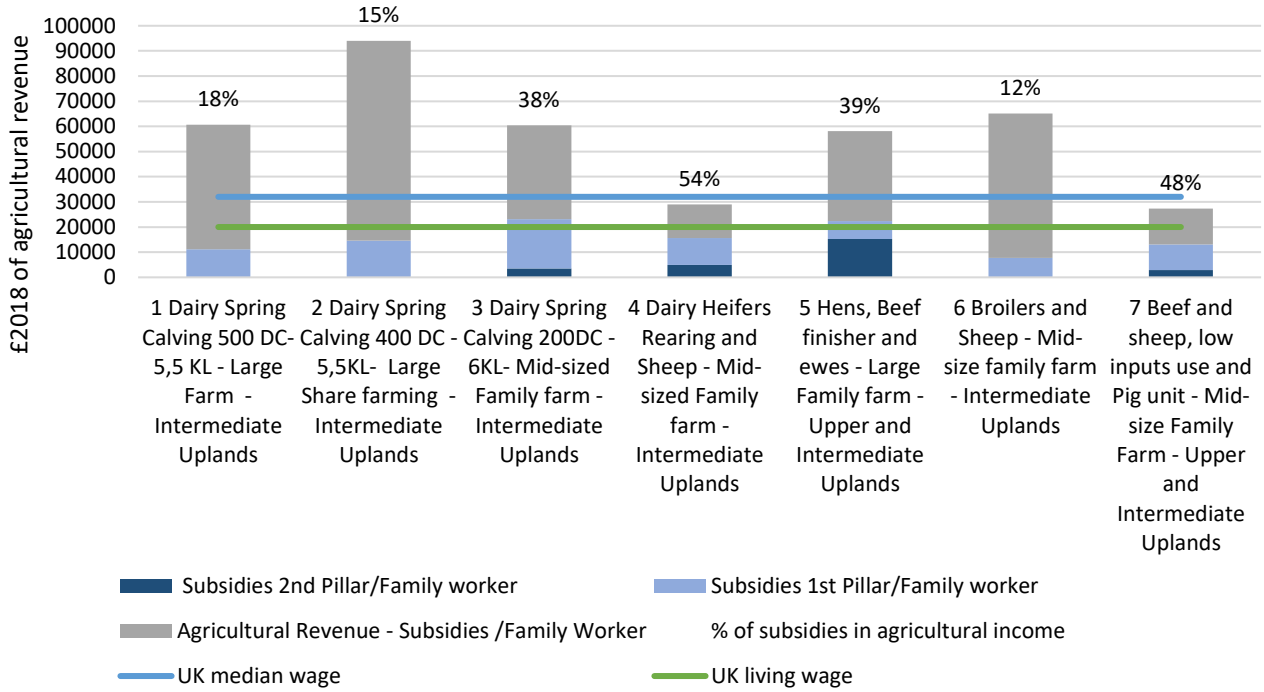


Figure 5-19: Annual agricultural income per family worker on a range of intermediate upland production systems in £2018

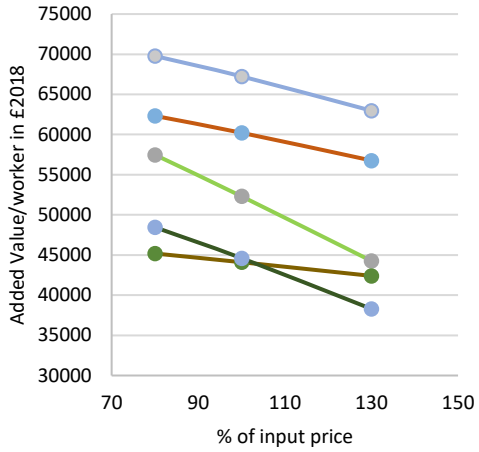
Separately, the case of share-farming systems is considered as all partners need to be paid proportionately to their share in the enterprise (e.g. owner of cattle, land…). Archetypes 1 and 3 have a lower agricultural revenue than archetype 2 before separating between partners, but once split, the manager's share is worth £47,000/manager, this is lower than if the system was family owned (50% share of results for two managers).

3. Sensitivity tests

A similar approach is taken with sensitivity testing to that conducted in Chapter 4. The analysis considers a reduced number of archetypes from uplands for ease of representation, while retaining a range of the differentiation strategies identified.

The sensitivity of farms to input use in terms of added-value per worker is higher for high added-value production systems (Figure 5-21 and Figure 5-21). The impact of feedstuff price change is felt more strongly for hens and dairy farms than beef and sheep systems as they are using higher amounts. The mountain sheep-only archetype also shows a high impact, but feedstuff is its key inputs to compensate some of its bio-

climatic conditions while it is not impacted as much by fuel price change with its low level of motor vehicle use. High fertiliser and fuel users would be impacted more strongly by fuel price change. The organic farm is impacted as well, as it is spread out with higher motor costs. A high inputs price context can be very challenging for all farming systems.



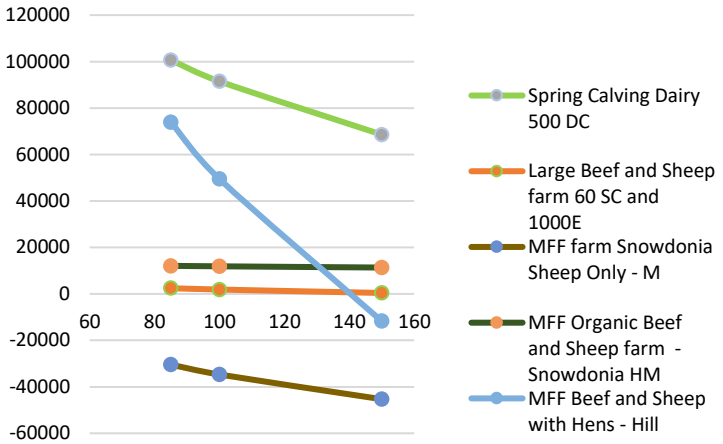


Figure 5-21: Added-value per worker in £2018 depending on the evolution of fuel/fertiliser prices
Legend: MFF means mid-size family farm, M means mountain land and H hill land

Figure 5-21: Added-value per worker in £2018 depending on the evolution of feedstuff prices

The potential falls in terms of income drop are limited (Figure 5-22) given the level of prices in the last five years. Output price variations impact more high output farms than beef and sheep farms. Bad years are disastrous for beef and sheep but manageable for high added-value archetypes. If the spring calving system was share-farmed the low added-value in bad years could lead to extremely low remuneration of the managers as they would get approximately 50% of the total revenue. Share Farming renders these systems slightly more fragile in the face of future disruption or crisis, and it also complicates decision-making, but the partners are involved together so the risk is shared.

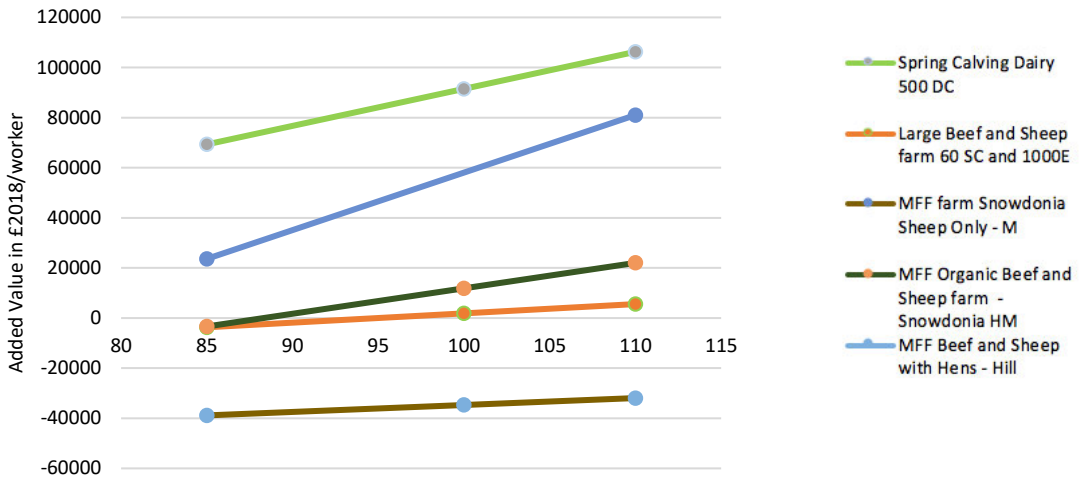


Figure 5-22: Evolution of the added-value per worker in £2018 on a range of modelled farm archetypes (uplands) as a function of the change of farmgate output prices.
Legend: MFF mid-size family farms; M mountain land; H hill land

Considering agricultural income per family worker in high and low scenario for inputs, outputs and subsidies (Annex 9 Item 9-7, Item 9-8 and Item 9-9), shows the significant role of subsidy and the fact that the current support (labelled high subsidies) represents a more important buffer in times of crisis for uplands than it did in lowlands (Annex 9 Item 9-10). The results show that these who would struggle the most to deal with a crisis would be small and intermediate beef and sheep farms, organic farms, intermediate uplands are likely to be more impacted and to look for alternative options. All the models that result from new differentiation options fare well whatever the future scenario, except perhaps the smallest farms for which it can be assume that they would grow gradually in size. As in Chapter 4 what follows is a simple distributional analysis of subsidy payment to nuance this argument around the role of subsidy payments.

An analysis of CAP payment data (Figure 5-23) with a similar method to Chapter 4 shows that upland areas with large areas of open moorland, tend to be more unequal in terms of the distribution of support. For example, 20 farms (8% of claimants) claim 27% of all CAP subsidies in the area, including 9% by three large estates. The situation is similar on second pillar payments: 30 farms claim more than 50% of these payments. Intermediate hills have not adopted the Glastir scheme widely as it represented high constraints and complexity (with the necessary involvement of advisory services) for limited gains (Wilson et al., 2017).

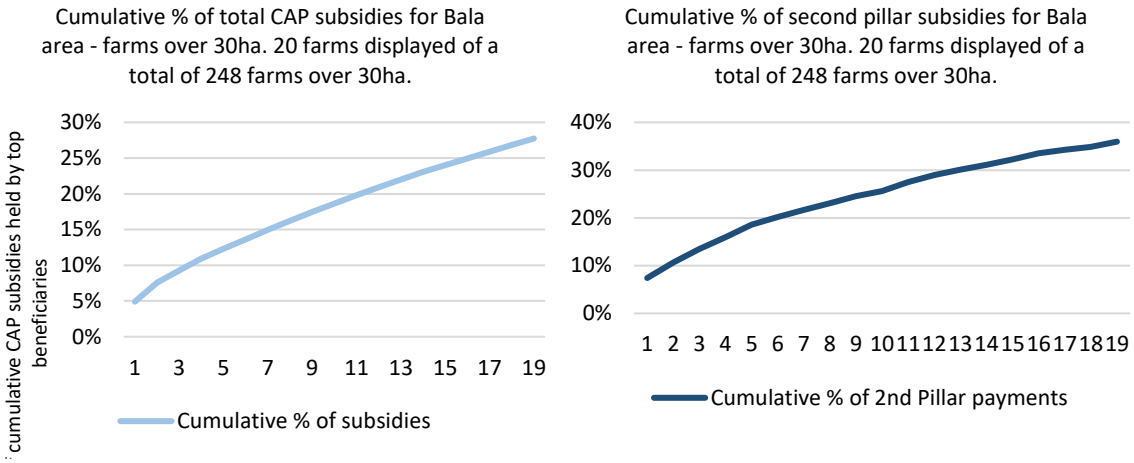


Figure 5-23: Analysis of the structure of subsidy distribution from 2019 CAP data in Bala area (postcodes LL21 and LL23) (by the author from DEFRA et al., 2023)

These farms can return very high level of incomes for their farmers/landowners, the largest farms in the area, the most extensive estate farms returned very high incomes per family worker (more than £100,000). The findings on the role of subsidy are similar to what was found in Chapter 4 and serve to reinforce the understanding of potential margins that exist in the current system.

F. Discussion and conclusion

Low intensity beef and sheep grazing systems remain important in managing existing hill landscapes (Midmore and Moore-Colyer, 2005; Vigani et al., 2021; Vigani and Dwyer, 2018), they have dominated the study areas for decades with varying levels of intensity of landscape use. It was demonstrated that typical Welsh upland landscapes went from a relatively homogenous farm structure in the 1980s focused on beef and sheep to differentiated productions working together in and across landscapes. The beef and sheep systems of intermediate uplands have differentiated more than in the upper uplands faced by more significant economic shortfalls. The place of beef and sheep grazing farming system has therefore reduced. The overall stocking density might have diminished but within areas there are more differences between the land use intensity of different systems. The upper uplands are highly constrained by bio-climatic conditions and have tried to diversify their activity more strongly on tourism or energy generation; they have been the key beneficiaries of the 2013 CAP reform system changes on these farms has been more limited.

There is a gradient of beef and sheep production strongly correlated to the bio-climatic conditions available but as well to socio-economic context. It has also been demonstrated that some beef and sheep system can be rewarding economically for farmers when past choices were validated based on today's economic performance. The vision on beef and sheep upland farms' economics was nuanced by showing the diversity of farm systems behind similar economic performance (DEFRA and ONS, 2021; Lloyd and Dyfri Jones, 1980). In many cases, rather than bad husbandry, their low returns are more a problem of receiving low prices for farm outputs.

The development of upland dairying had not been identified previously and is of concern for environmental reasons as it creates a simplified framework of management. It is profitable and would support more workers and results in increased income for landowners. For people without farms, spring calving systems with share farming allow them to overcome several barriers to new entrants (Williams, 2015). The development of poultry farming has been a stopgap to limit people leaving the land when traditional outputs were not remunerative; but it also has potential negative environmental consequences. Both these changes render the farms that choose them locked into a pathway of further specialisation. These systems are currently driving the economic change of the intermediate uplands not the least as they are bankrolling other holdings through rents or heifer contract-rearing. All those farms have a strong commitment to the farm and a given production pathway.

In summary, the differentials in economics support the analysis of the drivers of farming change, where farms have considerably differentiated in 10 years under a "two-track model"; either focusing on agricultural market drivers or looking at options that lead to reduced land-use intensity based on other revenue streams. Farms with high mountain areas and these intermediate uplands areas have different dynamics of differentiation depending on socio-economic as well as bio-climatic factors. In intermediate uplands areas, the analysis demonstrates that market-focused approaches have been more and more important since 2003. Like in lowlands the interconnectedness of resulting production systems was highlighted. Finally, while some systems might not return a high agricultural income, it takes time to build income-generating elements such as a customer base for local products, or to trial innovations,

while also continuing with general planning, e.g. land or livestock improvement (boundaries, soil quality…). All these developments are enshrined in a long-term sense of culture and belonging, linked to sustained use of the landscape. While subsidies are important for the economic sustainability of farms in the uplands, similar challenges as in the lowlands were highlighted. The following chapter will focus on the wider economic, cultural, and environmental impact at the landscape scale to bring together the challenges around sustainability.

Chapter 6. Socio-economic and cultural significance of production systems

Past chapters focused on farm differentiation processes and their consequences in lowlands and uplands from an economic and environmental point of view. This chapter will focus on the socio-economic and cultural significance of Welsh farming in different landscapes using the concept of Social-Ecological Production Landscapes (SEPLs), as first identified by the International Partnership for the Satoyama Initiative (IPSI), launched in Nagoya in 2010. It will also consider the wider sustainability of farms and landscapes, from this perspective. The IPSI approach can help complement the analysis of farm multifunctionality gained from the use of the comparative agriculture approach and its methods, as presented in chapters 4 and 5. It provides a critical framework of analysis for sustainable agrarian systems in regions across the spectrum of sustainability with rich insights on the interaction between socio-cultural function, the environment and the economics. It is also a vision of sustainability which is compatible with the WG objectives discussed in Chapter 1. Lenormand and Morse, (2022) discussed the SEPL concept and how it can be applied to North Wales in their conference paper reflecting on the combined experience of a geographer and agri-economist. This chapter is based on the findings from their respective case-studies, and uses IPSI and SEPLs principles to examine how far Welsh landscapes are from the WG vision of sustainability, which includes socio-cultural, as well as economic and environmental, dimensions. To conclude the chapter, an overall multifunctionality matrix is produced for all farms and landscapes examined in the case studies for this thesis.

A. Social Ecological Production Landscapes and Welsh Government goals

Satoyama is a Japanese term that describes the concept of very longstanding harmonious relationships between people and nature, linked to indigenous knowledge applied through land management. The Satoyama Initiative defines a social-ecological production landscape as an area where diverse habitats interact dynamically, fostering a harmonious relationship between people and nature (IPSI Secretariat, 2015, p. 3).

This relationship sustains biodiversity while meeting human needs for livelihood, survival, and well-being sustainably (IPSI Secretariat, 2015, p. 3). SEPLs describe such landscapes characterised by co-evolution between people and their natural environments. Saito et al. (2020) concluded that their sustainable management is vital to ensure community and environmental wellbeing and to establish resilient ecosystems. Landscapes which have been sustainably managed in this way over a long period of time are described as 'cultural landscapes' by UNESCO (2008). The human-landscape relationship identified in the Satoyama concept also links to the "agrarian system" (Cochet, 2012), in landscapes where agricultural production has been the main output.

This concept provides clear criteria of what a sustainable landscape should look like when considering the three pillars of sustainability (economic, environmental and social). In SEPLs, agriculture is multifunctional because it jointly produces food along with environmental and socio-cultural benefits. Given that the concept applies to whole landscapes, it can be used as a benchmark for the landscapes of Wales to assess their multifunctionality and sustainability. By considering how far Welsh landscapes are from these criteria it is possible to assess the extent to which they meet a definition of sustainability, as it is conceived by the WG.

Conceptual Framework of the Satoyama Initiative (Adapted from IPSI Secretariat 2015 by the authors)

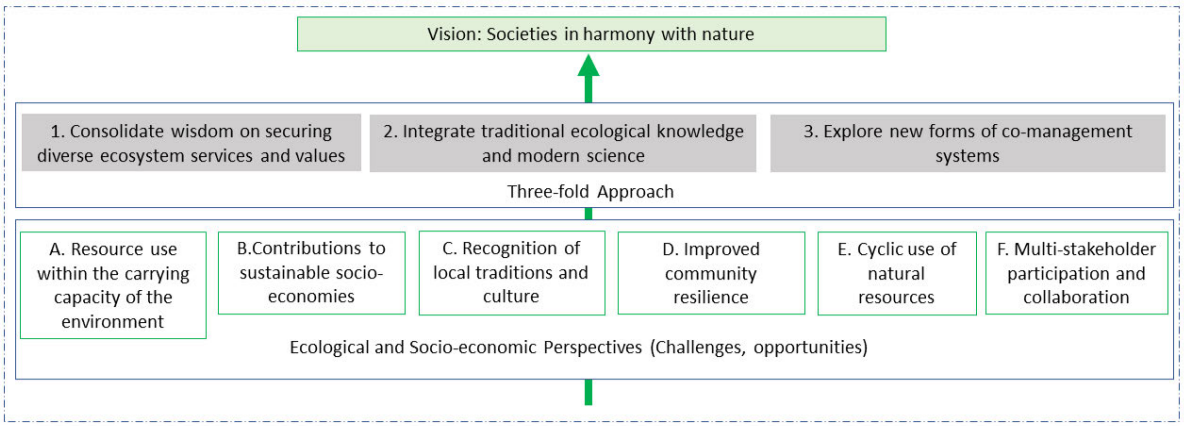


Figure 6-1: The Satoyama Initiative's approach to reach their vision of a society in harmony with nature (adaptation from Lenormand and Morse, 2022 of Nishi et al. 2021).

The use of this concept is extremely relevant in the study as Wales adopts policies with goals that are synergistic with the Satoyama Initiative's goals. The *Wellbeing of*

Future Generations (Wales) Act 2015 provides a sustainability framework for all future Welsh policies' to work within (Welsh Government, 2015). For example, the development of the *Sustainable Farming Scheme* (SFS) will have to ensure that the land is managed in a sustainable and resilient manner by farms, which should help conserve and enhance the countryside and cultural resources (Welsh Government, 2022a). "Keeping farmers farming" is perceived as ensuring that the land is managed by those who know it best. The Satoyama Initiative identified six ecological and socio-economic characteristics or perspectives representing the foundations of this concept (Figure 6-1). Lenormand and Morse (2022) highlighted the three-fold processes approach that can further these foundations to reach the ideal represented by SEPLs (Figure 6-1). These elements represent the basis of sustainable landscapes, environmentally, economically, and culturally. We now analyse whether case-study areas in Wales have displayed key characteristics of SEPLs, also how their provision has changed up to today, and what is the impact of current trends of farm differentiation (Midmore and Radmore, 2005, Morgan et al. 2010).

Based on the three processes approach, and using the six perspectives of IPSI, three key characteristics were highlighted by Lenormand and Morse (2022):

- Environmental: the co-evolution of farms with their environment (integrating modern science and traditional knowledge), resulting in sustainable environments for nature and natural resources
- Socio-cultural: recognising and celebrating/affirming the significance of local production and strong socio-cultural connections to the land and its management
- Economic: achieving sustainable enterprises and viable, vital local economies

The following analysis will build on these 3 key criteria.

B. Wales as a territory of SEPLs

It will be demonstrated that in Wales, much of the farmed countryside could be considered a SEPL, as it has developed through a co-evolution between people and nature, over centuries. However, Wales has been gradually integrated into economic

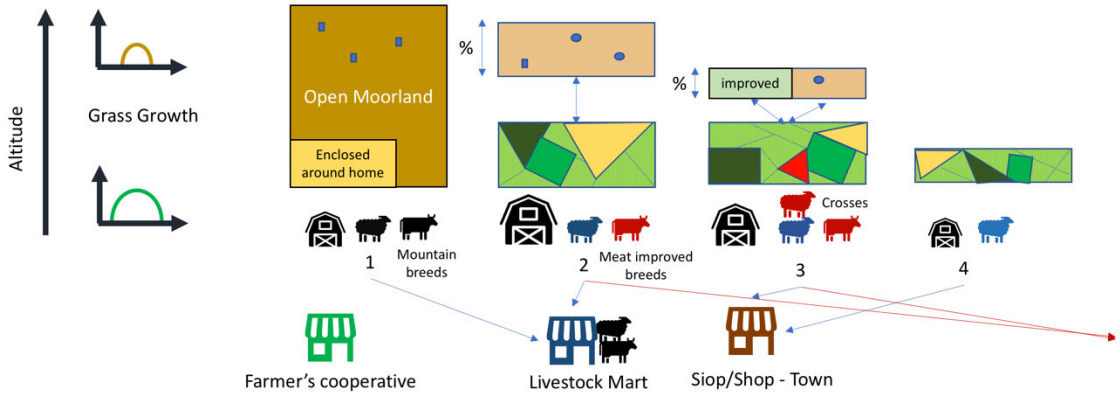
development through farming but also through other economic activities as demonstrated before leading to a growing importance of exogenous factors in its regions.

1. A co-evolution of farms with the environment

The landscape analysis described in chapter 3 highlighted the role of farming in shaping case-study landscapes , linking the land management and the landscape but the historical analysis of farm differentiation also summarised consequences at the landscape scale (Chapter 4). Different agro-ecological conditions offer different potentials for production and diversification that farms have adapted to, through their farming systems. Certain farms in the case study areas were constrained to maintain farming systems closer to their landscape potential, due to agro-ecological constraints or landscape/environmental designations (Figure 6-2), while others were able to intensify or diversify to meet the demands of different markets. For example, in the Vale of Clwyd, farms in the valley were able to take advantage of their position with better agricultural land and a mild micro-climate to sustain a higher level of feedstuff self-sufficiency. In turn, this advantage generated economic benefit when competing on markets or facing economic/policy changes. Upland farms such as those found in Snowdonia, particularly in the upper hills - i.e. with more open moorland - were unable to adapt as readily, given their range of environmental conditions, often including more extreme situations that constrained farm operations (weather, soils…)(Figure 6-2).

Transformation towards increased food production, and more intensive food production detached from the land's potential, that took place after the second world war, and supported by farming policies, has had an impact on the landscape. In particular, a reduction in permanent pasture or rough grazing was seen, including "Ffridd" land (intermediate, enclosed land that can vary in condition), with increased stocking densities across Wales overall, but less so on the uppermost Upland areas. The carrying-capacity of the environment has been increased artificially, however, some of these increases may not require inputs per.se in the long-term like drainage. While some of these changes have been reversed since 1992 both in the uplands and lowlands, market-driven volume-focused farm differentiation is taking place in study

areas alongside other streams of differentiation (as covered in Chapters 4 and 5 and earlier sections in this chapter).



Collaboration in the past	Gathering and Harvests (hay making and corn)			Harvests (or paid)
End Collaboration?	For harvest: Yes Gathering: No - Contracted			Yes
Local Livestock Market Participation	Yes	(Possibly)	No – Direct	Yes
Reclamation of Open mountain in the past Improvements to the land/Inputs use	No Extremely little	Yes – Some Some	Yes – Some Some	No Some
Reduced Mountain use in recent years	Reduced stocking density as per CAP agreement			
Subsidy dependance	> 100%	70%	40%	20% (Part-time)

Figure 6-2: An example of SEPLs in 2020s, North-Wales uplands and its farming system, an agrarian vision, different scales, different systems (by the author)

Based on the historical and landscape analysis, it can be estimated that the co-evolution of farms and environment persists but is heavily influenced by past and present artificialisation of the environment, notably by input use (Figure 6-2). The links between the environment carrying capacity and agricultural output remains stronger in uplands than in lowlands where input use has been more sustained. In uplands it led to significant changes as well (e.g. reclamation) but bio-climatic conditions impact more significantly production systems (Figure 6-2).

2. Cultural connections - local products significance

There is a diversity of ecosystems across Wales, interviews and observations highlight the fact that local farmers adapt to the environment and surrounding areas and develop a specific, differentiated farming system. Farms in Wales have significantly differentiated their production systems and their output are often linked to bio-climatic conditions and to specific methods of production; these are partially recognised in the literature (Beynon et al., 2012; Graves, 2022; Yarwood and Evans, 2006). Examples found in case-study areas will be highlighted. In the past, most areas of Wales had their own specific breeds adapted to the local bio-climatic condition and specific

production mix, some regions have maintained these links more strongly than others. In the case of mountain grazing, adapting the livestock to the rigours of the environment will simultaneously help it to make a living (via markets and subsidies).

Ruminant grazing remains the main land use in Wales as there are strong bio-climatic drivers for doing so, but the specificities of some of the case-study regions' outputs have been demonstrated. Meat based product promotion has focused on the so-called" Welsh way" of environmentally-focused farming on grass, but this is no different than lamb produced in many other nations (e.g. New Zealand) with similar climatic conditions (HCC, 2020; Welsh Government, 2020b, 2020d). Welsh lamb and Welsh beef PGIs have failed to offer a significant premium to producers as the determinants of the product are not linked enough with the specific Welsh context, and most production systems have departed from using traditional Welsh breeds.

On the other hand, a group of farmers in the Cambrian mountains has collaborated to secure higher prices for their specific, slow-growing, lean lamb of the Welsh Mountain sheep breed which would otherwise fetch a low price in the open market, with the Cambrian Mountains Lamb PGI[57](DEFRA, 2021c). This lamb would be a "mountain lamb" grown in harmony with the local growing season and the landscape's potential. In this case, it is suggested that this approach could yield benefits for the landscape recognition and economically for the supply-chain. Additional research would be necessary to link specific elements of the produce of the most "traditional" upland management systems to its particular organoleptic properties (Fisher et al., 2000) and thereby to build a stronger case for it.

One other significant example of locally specific products that have known diverse fortunes is the range of Welsh cheeses (Graves, 2022) or the early potatoes of Pembrokeshire. This crop was developed in the 1930s, grown early only on fast-drying red-soil that can be found around the coast: it could then be harvested by gangs from local communities and shipped rapidly to South Wales' wholesale markets. The long

[57] Certain specific products have Protected Geographical Indications (PGI) to recognize their value and try to set them aside from commodity markets.

rotation with grass and cereals was adequate to a crop with limited inputs. While this crop later disappeared after the area specialised in dairying, since the mid-1990s it has been reintroduced again in the region.

Dairy systems have lost most of their local production significance in case-study areas, with only marginal differences mostly linked to the timing of the production and the quality of the milk. 1-2 farm per area had on farm mik-selling machine or ice-cream prduction but there were no specific on-farm production of cheese or of any products linked with the landscape as can be found with some PDOs (Maye et al., 2016).

3. Cultural connections - a tradition of co-management

As highlighted in previous sections, cooperation and co-management have been at the heart of farming activities in Wales but these practices are now less common. A well-known example would be the management of common land in North Wales, which has been practised for centuries (Short, 2008). Co-management of upland landscapes by groups of local actors is common across the UK (Joye, 2021; Short, 2008; Thébault, 2021). Many family farms in North Wales engage in co-management; it is often required in mountainous areas, for example, the vast mountain commons without boundaries grazed by stock from different farms. Interviewees in Bala and the Cambrian Mountains areas explained that they were part of a group of farmers who farmed and gathered the livestock on the mountain each year together (inc. shearing and lambing). There is a clear attachment to this tradition among such farmers (Jones et al., 2021).

Historically, haymaking and crop harvesting would have been community-uniting moments in uplands and lowlands, to provide the labour required to quickly get the crop in, one field after another (Annex 7; Phillips, 2016). This would have required a wider group than the farming community, possibly using labour from nearby towns (e.g. suggested in the Vale of Clwyd). This was also true during the potato harvest in Pembrokeshire. Rules around the order in which to do the operations existed, but this effectively linked together the agrarian systems. Finally, at difficult times or when the community faced a challenge, common solutions have been investigated and

implemented - for example, to eradicate or control animal diseases (e.g. rules around bTB in Pembrokeshire in 2023-2024 or sheep diseases)(Davies, 1935).

In the Vale of Clwyd, the research identified that compared to South Pembrokeshire, a higher proportion of milk cooperative buyers (Arla and Calon Wen) led to differences in terms of farm evolution, with more family farms surviving as a result. However in Pembrokeshire, Puffin produce was a successful cooperative spearheading marketing efforts behind the re-development of potato production. And in the Cambrian mountains, the Cambrian Mountains Lamb PGI has a specific association to support it and a premium contract with Dunbia (the major meat processor). The development of necessary supply-chain links and the structure to support them is resource-consuming, but nevertheless offered a strengthened market position to the farms that adopted it with better contracts or market prices in the long-run.

The differentiation of farming systems and the development of specialised high-volume farming systems with significant mechanisation has reduced farmer to farmer working relationships; however, input, contract and marketing cooperatives remain key to these rural communities (Chapter 4 and 5). More modern forms of interdependence between farms in and across case-study areas has also been highlighted; for example, farmers rearing heifers in intermediate uplands working with dairy farms in the Vale of Clwyd. Livestock markets have also been shown to play a central role in bringing farmers and land managers together in hub towns (such as Bala or Ruthin) which connect territories and people (Nye et al., 2020). It also connects farming systems across study areas, for example by store cattle going to finishers. Such markets play an important role in ensuring the complementary use of resources in livestock production systems and provide a bridge to finish upland-produced stores in the lowlands (Ashby and Evans, 1944). This type of link survives to today and examples have broadened to embrace areas further afield, like England for Poultry farms. The Cambrian Mountains Area still represents today a pool of farmers and farm contractors that are brought in seasonally in Herefordshire to support cropping systems at specific times (sowing, harvest…).

Market pressures, amalgamation and the scale of farms have limited the time available for co-management. Nevertheless, these ties remain stronger in the upper uplands.

Contractors, often drawn from farming families, are also part of these communities and link people together. Both in Wales and in other countries, increasing the size of the farm is seen as a way not to work alone (one of the factors cited behind the development of spring calving dairy farms in the intermediate uplands), offering more flexibility in one's personal life.

Within our case study areas, some land use change in the past was singular and driven by external demands. In the 20th century, the Forestry Commission planted significant areas with commercial forest species, such as Clocaenog Forest (Forestry Commission, 1952) or other areas around Bala. There has also been the development of water reservoirs in case-study areas; such as llyn Celyn (with the drowning of Capel Celyn village; (Atkins, 2018). Farmers impacted by these transformations more than 50 years after remembered unhappily how the changes had taken place and their impact on their farms (Fieldwork). On the other hand, almost all of the changes that have taken place incentivising increased agricultural output have been voluntarily adopted in all case-study areas (Fieldwork).

4. Cultural connections - overview

Morse and Lenormand, (2022) discussed the key cultural connections that exist in North Wales landscapes, for example the sense of belonging of study participants. However, it has been demonstrated that societal expectations of the services to be provided by rural areas have changed (Nishi et al. 2021; Slee et al. 2014) with resulting impact on farms and landscapes. Recently, the narrative in Wales has turned towards a debate on the "sheep-wrecked uplands" and the potential to return these areas to a wilder state (Monbiot, 2022) or to respond to afforestation pressures and incentives linked to climate change and climate policies. But in our case study areas, all interviewed farmers and participants from the farming community want to stand up for their landscapes and livelihoods, resisting the external pressures which translate for example into some retired farmers offering preferential rates to attract young farmers into their area. Farmers markets or local shows (e.g. sheepdog shows) are further important social opportunities (e.g. Nye et al., 2021).

Within this vision the family farm is a vital part of Wales SEPLs, and the Welsh language and Wales' landscapes are inextricably intertwined. This is reflected in field names (Figure 6-3; William, 1980), buildings, practices (e.g. hedge laying; Figure 6-3) and other landscape features (e.g. stone walls) which have evolved slowly over centuries, and it reflects a distinctly Welsh sense of place (Figure 6-3).



Figure 6-3: Cultural significance of landscape feature results from human/landscape co-evolution (by the author; Geoff National Library of Wales, 1952)

Farms tend to have a high temporal permanence in general, with their specific rationale limiting short-term economic-based decision making (Hayden et al., 2021a; Wynne-Jones, 2011). Generational transfer of knowledge on family farms in Wales is a key mechanism by which knowledge links to co-management but also the specific landscape management. Specific determinants of sustainability identified are the long-time frame study and a potential acceptability of non-profit-maximising solutions as sen in other studies (Busck, 2002; Singh et al., 2016; Wynne-Jones, 2011).

To conclude, the relationship between nature and humans has been partially lost, with artificialised enterprises. In uplands landscape current production systems retain a stronger link with the carrying capacity of the environment but also the determinants of Welsh agriculture specialism (mountain breeds…). Farms, farmers cooperation, co-management and social links underpin these elements. Welsh landscapes have features typical of SEPLs, but the link is not as robust in lowlands, compared to uplands and particularly upper uplands. The challenges faced by these SEPLs will be considered in the next section based on the key principles highlighted in section A.

C. Challenges and opportunities for Welsh SEPLs

1. The link between farming and the environment



Extensive upland farms can be organic (low input use) with rough grazing
Output: light livestock and/or storecattle/storelambs Income sources: AES subsidies and organic support Opportunities: better recognition through marketing
Inputs use: low – within the carrying capacity of the land High level of adequation between livestock and environment to further develop.
Low level of added-value per worker but low inputs use

Figure 6-4: An opportunity to develop existing known co-evolution (by the author)

Traditional breeds are an asset by being more suited to specific environment, they have been highly retained by upper uplands farmers (both for breeding stock and due to bio-climatic constraints). Welsh mountain sheep could be outwintered in Snowdonia contrary to other more demanding sheep. Their body type or behaviour had adapted to the environment, the North and South Welsh mountain did not have the same characteristics. But even the hardy breeds are a result of a gradual breeding, as a result prolificity (of ewes, particularly), and the scale conformation (and thus value) of livestock carcasses have increased out of proportion to the degree of landscape improvement (e.g. with Welsh mountain ewes going from 50kg to 60-65kg). In turn, the landscape is perceived as even more of a constraint upon the farming system; the low-nutrition moorland is now insufficient for the ewes that are mountain grazing, at all times. It creates rigidity in terms of reduced adequacy of the agricultural system for the land, requiring the identification of a new system of sustainable management, for the future. New opportunities exist with fieldwork highlight new production systems re-creating a link of co-evolution with the landscape, with agro-ecological, self-sufficient and some organic systems looking for novel approaches to evolve their economic production alongside their environment (e.g. micro-dairy, specific breed of cattle).


Agro-ecological, agro-forestry, low input use and sometimes organic production systems
Output: diversification of marketing channels, short-supply chain possibly along other outputs.
Inputs use: low – within the carrying capacity of the land High level of adequation between the livestock, the crop, and the environment at disposal. Gradual implementation of required adaptations; Trial new possibilities. Might reflect on past breeds and agricultural practices (e.g. fodder crops)
High added-value per worker but low inputs use –

Figure 6-5: A development of a new co-evolution (by the author)

The level of modification of landscapes using imported inputs from outside the study areas is high, but less than it was in 1992 in the upper upland areas. Since the CAP reforms of 1990s, there has been a relative return to systems co-evolving with nature (Figure 6-6). Additionally, the new differentiation trends have increased the level of demands on the environment in many cases, using systems that result not from co-evolution but from adaptation of a ready-made 'technical package' introduced into the environment.

The development of technological systems on part of a farm has sometimes resulted in knock-on consequences on ruminant, either restricting the flock size and animals' type to fence them on mountain (e.g. a Welsh mountain flock to manage the land under environmental restrictions) and hill areas while the best parts of the farms are dedicated to a high added-value production system or simplifying them managements removing the rotational grazing.

The gap between the least and most productive parts of the farm has increased, with specialisation of areas according to the type of livestock that can effectively make use of them, leading to more complex and differentiated stocking patterns and practices. Through the differentiation that took place in lowlands and uplands a new landscape mosaic was created, with extremely different levels of land use intensity (both economically and in agronomic terms) in each area. But the mosaic within the landscape itself does not necessarily reflect co-evolutions and a sustainable land use.



Standardised high added-value systems with high input use
Output: commodity supply-chains
Inputs use: high – not within the carrying capacity of the land Low level of adequation between the livestock, the crop, and the environment at disposal. This level will be higher for spring calving dairy or heifers and lower for poultry. Transformation of production systems not linked to local capacity
High added-value per worker and high input use

Figure 6-6: The implementation of existing technological package (by the author)

Climate change is also of significant concern (S. M. Howden et al., 2007; Keay and Hannam, 2020; Lenormand, 2021b), and this is reflected in the changing priorities of land managers and owners. In case study areas, farmers were concerned about extreme weather events and broader change in weather patterns at different scales. For example, extreme weather events included: a drought with local impacts on forage available for animals over the summer (e.g. in 2022), damage to pastures during wet and long winters (e.g. in 2018), and cold spells during late March/April time (UK 2017). The fast-changing general weather patterns, with wetter and warmer winters and longer dry spells during summer, have an impact on vegetation growth throughout the year. Combined with past changes in agricultural policies, the evolving land management practices and climate change have been changing the condition of Welsh semi-natural habitats. Some species are dominating others, and this might also be linked to the reduced management on some parts of the landscape (e.g. Molinia on the mountain, bracken on the hillside; Fieldwork). Most of all, the newly developing forms of specialised farming are identified as having a negative impact on nitrate pollution and surface water quality, with increased of some type of livestock (Senedd Research, 2019). Flooding is also an increasingly pressing issue in North Wales, linked to climate change particularly along the alluvial valleys of case-study areas (Keay and Hannam, 2020; Lenormand, 2021).

As the UK seeks to decarbonize, there is also growing pressure on the farming sector to reduce its greenhouse gas emissions, and a growing interest in what more can be done to store carbon (Manzoor et al., 2021). These issues are likely to affect the landscape mosaic and economic activities in these upland areas and may also present challenges to their sociocultural heritage.

2. Economics challenges and opportunities

Economic pressures and market-related challenges impacting farms in Wales were covered in previous chapters. It is now intended to better understand the local impact on the economy of the different farming systems. The following analysis uses data from six farm archetypes from four agrarian-diagnosis areas, to understand the differences between production types – comparing agro-ecological and more vertically-integrated systems. Outputs and inputs are distinguished depending on whether they would involve local spending (i.e. only one step removed from the farm in the supply-chain, e.g. cattle sold at the local livestock mart, straw from neighbouring lowland farms) or to more distant links in the supply chain (e.g. cleaning or veterinary products…).

Traditional beef and sheep farms tend to have a higher proportion of output sold locally (Table 6-1), potentially up to 88% if all goes through local marts, but selling to abattoirs can limit this proportion (since abattoirs will be more distant). For the vertically integrated supply chain farm archetypes (producing dairy products and/or eggs), these have a much lower proportion of outputs sold locally. To understand the impact of these differentiation trends on Welsh supply chains, a comparison is made of the values per labour unit and hectare. It is observed that the local output is higher for any system that is not resulting from newly differentiated systems, except finished cattle sold in livestock markets.

Table 6-1: Analysis of farm output on a range of archetypes from the Vale of Clwyd (by the author)

Value in £2018	Dairy system high input high output[58]	Dairy system small	Spring calving dairy	Beef and sheep finishing (abattoir)	Beef and sheep finishing (self-sufficiency and mart)	Beef and sheep with eggs
Estimate output sold locally	63300	82050	100150	63352	185223	39202
Estimate output sold	584100	279000	616000	584100	26281	890566
Estimate % output sold locally	10%	23%	14%	10%	88%	4%
Local output/labour unit	25320	32820	20030	42235	97486	19601
Local output/ha	281	586	200	317	617	131

Another challenge is the volatility of returns which is already seen with existing beef and sheep systems, but specialised dairy farming systems reinforce this trend with stronger peak market times, locally (e.g. for spring or autumn calves sold to markets…). Output values can be higher with the new systems, but these are mostly going towards the rest of the supply-chain, meaning that the impact on returns to farms in Wales would be more limited. The development of locally focused developments in dairying (e.g. milk vending machines on-farm, allowing direct sales) or meat (e.g. smallholdings selling locally) are so far limited in scale and value, but they do have a positive impact.

It was then considered more specifically how production factors and based on this which system had the most significant contribution to Wales' wider rural economy, as well as a share of capital depreciation (Figure 6-7). Considering farm input use, approximately 40% of inputs have a dominant local origin except for these of the poultry archetype (only 16%;Table 6-2). The amount spent locally by newly evolved systems is high but not necessarily significantly higher than high-autonomy beef and sheep systems. These tend to have the highest proportion of local spending (54%).

[58] High level of agricultural outputs, often per hectare as well as per worker

Reducing feedstuff or fertiliser use on high-autonomy farms required an increased use of contractors within the local economy.

Table 6-2: Analysis of farm production factor uses on a range of archetypes from the Vale of Clwyd (by the author)

£2018	Dairy system high input high output	Dairy System small	Spring calving dairy	Beef and sheep finishing (abattoir)	Beef and sheep finishing (self-sufficient and mart)	Beef and sheep with eggs
Estimate local spending	-207951	-100335	-214697	-43723	-122556	-112942
Estimate supply-chain spending	-341570	-159235	-296744	-66439	-104783	-603014
Estimate local spending % inputs	38%	39%	42%	40%	54%	16%
Estimate local spending/labour unit	-83181	-40134	-42939	-29149	-64503	-56471
Estimate local spending/ha	-924	-717	-429	-219	-409	-376
Estimate supply-chain spending/labour unit	-136628	-63694	-59349	-44293	-55149	-301507
Estimate supply-chain spending/ha	-1518	-1137	-593	-332	-349	-2010

The greater efficiency of the spring calving dairy systems can be seen with lower local spending (per hectare and worker) than other high added-value developments, on a par with some beef and sheep farms or a much smaller dairy farm. Other high added-value systems would tend to require a lot more inputs from the wider supply-chain: this is particularly the case for the hen unit. This tends to nuance findings from the economic analysis.

Considering how the production factors are split further in all key production factor is helpful to further understand differences between farm types (Figure 6-7). Any of the high added-value archetypes tend to have high supply-chain spending further away, and a comparatively lower proportion of local elements. It is only because of wages that spring calving archetypes have relatively high local spending, their input use is predominantly from further away. Capital depreciation is also higher from the supply-chain inputs, reflecting their need of specific elements (e.g. technological tools which form part of the 'production package'). The archetype with the hen unit shows the highest need of supply-chain sourced inputs, compared to local elements. The

structure of the autonomous beef and sheep farm is notable with a strong local focus in all categories.

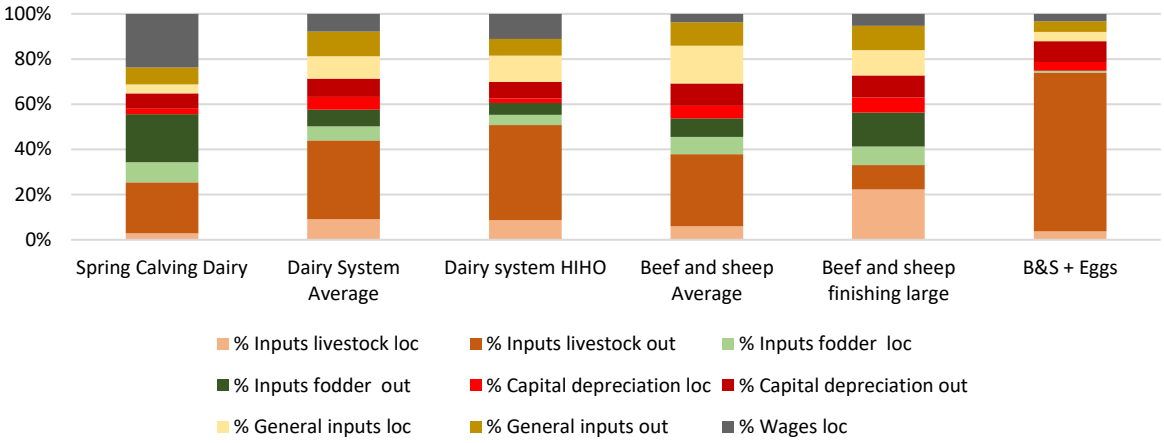
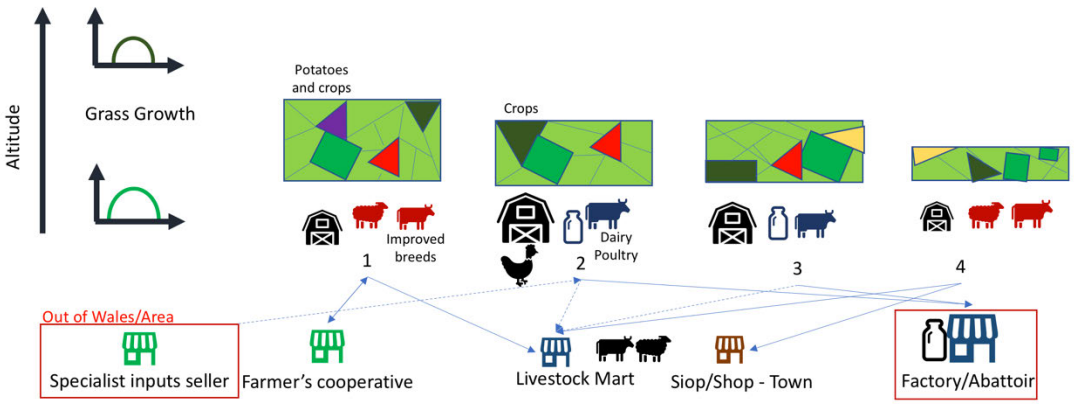


Figure 6-7: Split in terms of production factor origin for a range of systems from the Vale of Clwyd
Legend: Loc sourced locally; Out sourced from further away; HIHO high input high output; B&S + Eggs beef and sheep with eggs

The capital depreciation contribution to the local economy of these new systems is limited in time and could be inhibited by a lack of further development. For example, a change in the investment context would limit the creation of spring calving/Integrated livestock units that tend to build infrastructure all together, rather than phasing the work over a period of years, as would be more common among more traditional farms.

While farming systems of the 1945 would be operated economically at a local scale and use limited quantity of inputs, concentrating the added-value generation from farming into rural areas (Figure 6-2 compared to Figure 6-8). The focus on commodity supply-chain, market-based approaches and economies of scale have led to an increase in size of actors of the industry, broadening their catchment area. Farm specialisation has led farms to be linked more specifically to specific actors of the supply-chain (output or input) seldom located in their area. Many tools/inputs used are not developed for farms specifically in study areas but standard products seeds, fertilisers, or feedstuff.



Collaboration in the past	Harvests (hay making and corn)		Harvests (or paid)
End Collaboration?	For harvest: Yes, except some groups of farms for silage		Yes
Local Livestock Market Participation Inputs	Yes Mostly local	Partial for secondary outputs Through specialised companies	No – Direct abattoir/supplier Mostly local
Artificialisation of land use Improvements to the land/Inputs use	Yes Yes - Intermediate	Yes – Some Yes - High	Yes - Some Yes – Intermediate

Figure 6-8: An example of SEPLs in 2020s, North-Wales lowlands and its farming system, an agrarian vision, different scales, different systems (by the author)

In summary, this analysis suggests that most of the new differentiation types appearing in Wales are unlikely to have as positive an impact on the wider territory, with more autonomous/less input heavy type of farms likely to have a significant positive impact on the local economy. The development of high added-value systems combined to AES schemes on protected landscapes tend to silo the management of environment.

3. Challenges and opportunities for socio-cultural links

With a reduction in the number of farms in the past, in case-study areas, such common practices, such as gathering for shearing, are deeply significant in rural areas' and came through in historical interviews. Even the conversion to other production type, pre-retiring or diversifying can have this effect as the management will differ significantly and often have a reduced significance linked to the environment. When a family farm is removed and its land no longer farmed, the stable management driven by decades of experiential, direct knowledge accumulation and transfer is lost, along with the farm's contribution to the rural community to which it belonged. Some farmers try to address this selecting who they might rent/sell their land. These challenges are likely to be more common in the future as the proportion of farmers approaching

retirement age is high (Welsh Government, 2019a) and many that were met did not necessarily have successors in their family.

Another unique value of these SEPLs - placed under pressure – should be noted: the Welsh language. North Welsh farming is as a stronghold of the Welsh language, particularly in North Wales, given the ambitious goals in terms of the number of Welsh speakers and the locally-specific link with Welsh in many landscapes (e.g. Eryri) this has been identified as a priority (Welsh Government, 2022a). Farmers interviewed in case study areas mentioned a feeling of lack of proper consideration by the devolved institutions for Wales' rural areas of the value of the Welsh language: one recent example was cited of an important live Q&A session on the SFS which had been conducted entirely in English, without translation (see Welsh Government, 2022a).

D. Multifunctionality in Welsh landscapes

To summarise the findings of these 3 result chapters on Welsh multifunctionality and understand the potential broader consequences for case-study areas and Wales, a matrix of multifunctionality was produced considering the performance of farm archetypes on a range of criteria in. It also considered the likely evolution of those archetypes in the future in Figure 6-9 and 6-10. The findings highlight the role played for beef and sheep farms in Wales for economic and environmental sustainability, including the maintenance of outstanding features (environmental and historical). While newly developing farm differentiation offers a higher on-farm economic performance they could reduce the farm involvement at the regional scale and reduce environmental sustainability. In particular; the economic contribution to the regional economy could be more limited and time specific with the exception of increased salaried employment. The farms as they specialise on other outputs would not necessarily remain involved in the landscape co-management. Of particular interest is the impact of output or input price crisis on the economic sustainability of farms; in that case a beef and sheep unit with a specialised diversification would still be likely to struggle economically, dairy systems would be negatively impacted but would have more room to adapt their farming system.

Figure 6-9: multifunctionality matrix at the landscape scale (by the author from fieldwork)

Landscape	Dominant type of farm	Economic sustainability – family farm	Economic sustainability –region	Cultural significance of the farming system	Maintenance of culturally significant landscape features	Contribution to societal link at the local scale and social culture	Adverse environmental impact – inputs use	Adverse environmental impact – ecosystem management
Upper uplands	B&S farms with mountain land	Low overall without support	Intermediate to low	High	Often	High	Low	Low
Intermediate uplands - Cambrian	B&S farm – store and fat	Intermediate without support – switch to new differentiations likely	Intermediate	Intermediate to high	Some	Intermediate	Low to intermediate – increasing	Low to intermediate
Intermediate uplands – North Wales	B&S farm – store cattle producer, more cattle	Intermediate without support – switch to new differentiations likely	Intermediate	Intermediate to high	Some	Intermediate	Low to Intermediate - increasing	Low to intermediate
Lowland – South Wales	Dairy farms	High to intermediate	Intermediate	Intermediate	Few	Intermediate to low	High	Intermediate
Lowland – close to town	B&S and smallholdings	Intermediate to low	Intermediate	Intermediate to low	Few	Intermediate	Low to Intermediate	Intermediate
Lowland - North Wales	Dairy farms and B&S finishing cattle	High to intermediate	Low	Intermediate to low	Some	No	Intermediate to high	Intermediate

Figure 6-10: multifunctionality matrix for the main farm archetypes identified (by the author)

Landscape	Type of farm	Economic sustainability – family farm	Economic sustainability – region	Cultural significance of the farming system	Maintenance of culturally significant landscape features	Contribution to societal link at the local scale and social culture	Adverse environmental impact – inputs use	Adverse environmental impact – ecosystem management	Likely future of the farm
All	Semi-retiring & non-ag	Low within 5-10 years	Low	Intermediate	Low to high	Low to high	Low	Low to high	Retirement, non ag users
Mountain	B&S farms with mountain land	Low without support	Intermediate	High	Yes	Yes	Low	Low	Economically challenged without subsidy – risk retirement if no succession or transition to more economically rewarding
Lowland/ Hill	B&S farms lowland profile - store producer	Low without support	Intermediate	Intermediate to high	Some	Yes	Low	Low	
Lowland/ Hill	B&S farms – finisher	Low to intermediate without support	Intermediate	Intermediate to high	Some	Yes	Low to intermediate	Intermediate	
Lowland/ Uplands	B&S farm organic	Low without support	Intermediate	Intermediate to high	Some	Yes	Low	Intermediate	
Lowland/ Hill	B&S autonomous	Intermediate	Intermediate	Intermediate to high	No	Yes	Low to intermediate	Intermediate	Could continue
All	Renting-out the farms	Low within 5-10 years	Low	Low	No	No	Depends on the land use by other farm		Retirement
All	Support farmers crop growing or heifers rearing	Intermediate	Intermediate	Low	No	Yes	Intermediate	Intermediate	Could continue, could develop or retire
Small/Large ridge	Dairy farms – Small and mid-size and organic	Intermediate except during crisis	High for employment and building.	Intermediate	Some	Yes	Intermediate to high	Intermediate	
All	New development dairy farms - Autumn/High yielding/Very large	High except in crisis	High for employment and building.	Low	No	Yes	Very high	High	Would develop
All	New development dairy farms- Spring calving	High except in crisis	High for employment and building.	Low	No	Yes	Intermediate to high	High	
Pig farm	B&S farms with pigs	Intermediate	High	Intermediate (small pig activity)	Some	Yes	Intermediate to high	Intermediate	Could develop
Hill	B&S farms with broilers	High except in crisis	High for employment and building.	Low to intermediate	Some	Yes – except broilers	Very high	High	Would develop
Hill/Small ridges	B&S farms with hens	High except in crisis	High for employment and building.	Low to intermediate	Some	Yes – except hens	Very high	Intermediate to high	

A short-term and medium-term challenge remains the cohort of near-retiring farmers which have varying contributions to multifunctionality but could also catalyse changes in the Welsh regions towards more or less sustainability depending on what this land would be used for after their retirement. It could have significant adverse environmental impact. This finding is also pertinent for most beef and sheep farms as shown by Figure 6-10.

In conclusion, the challenges and opportunities facing Wales regions have been examined, and particularly its upper uplands, and how, within the Satoyama Initiative's approach, they may be considered as SEPLs. It was found that most Welsh landscapes can be judged to have SEPL characteristics as a whole. The SEPL concept provided a set of criteria to analyse holistically farming landscapes and the implications of recent farm changes while helping summarise the findings of this work on Welsh farming multifunctionality. Traditionally, farmers have worked alongside nature, engaging in socioeconomic activities which contribute to rural communities and Welsh culture. Many individuals farming the land have an intimate knowledge of their land and can provide environmental, social, and economic improvements while upholding cultural traditions. There are already production systems and initiatives linking strongly with Sayotama initiative principles, but recent evolutions driven by economic factors have tended to favour the development of production systems that had a negative impact, not only environmentally but also potentially on the sustainability of farms' contribution to the local economy. Potential opportunities and risk for multifunctionality were highlighted and linked to different enterprises. The next chapter will analyse the details of the future support available for land managers and the likely impact of Brexit and of its future potential impacts.

Chapter 7. Assessing the prospects of the Sustainable Farming Scheme in Wales

The agrarian system differentiation since 2013 has led to more challenges to reach sustainability shown in Chapters 4,5 and 6. Chapter 6 helped identify the current Welsh farming multifunctionality at the farm and at the regional scale and where there were opportunities or risks. This chapter will assess whether the SFS as a policy can be successful in its goals. A first step will discuss the policy plans and their structure, this will involve looking at SFS composition and its design, comparing it to existing policy mechanisms. Following this, a forward-looking analysis will build on the past chapters and the in-depth analysis of existing archetypes' operations, their capacity for change and multifunctionality, it will consider the potential changes required on farms by the future WG scheme and what would be the results of those on farms. It will therefore enable an analysis of how individual archetypes' multifunctionality and performance is likely to change, enabling us to draw conclusions at the regional and Welsh scale in Chapter 8. A third step will focus on the impact of short-term challenges, specifically the risks of farms going out of business if faced with the current inflationary context or low payment rates. Effectively, this will provide a summary of likely changes in the middle-term, indeed, longer terms changes on farms are unlikely to be specifically described given the origin of the findings and the uncertainty surrounding potential future farm development we can formulate agricultural development hypothesis but not give a definite answer (Cochet, 2015a). Plans to develop regulatory policy tools will also be discussed. Finally, this chapter will be concluded by combining these different analyses and contrasting them with other policy developments, considering whether it will be enough to ensure a high level of multifunctionality and a high level of sustainability. The analysis will be based on plans publisheded in 2022 in the Sustainable Farming Scheme draft (Welsh Government, 2022a).

A. The Sustainable Farming Scheme

1. General scheme structure

The SFS scheme aims to deliver a wide range of objectives which makes it quite challenging to design. It must support farmers in a range of contexts, and it aims to help create a sustainable sector, including one providing viable incomes. However, the SFS is not aimed at all farms but only these over 3ha, which limits the potential impact on horticulture, intensive indoor livestock, and very small farms. Horticulture was a sector that the WG has been keen to develop but it is only supported via investment grants at the moment (Welsh Government, 2024).

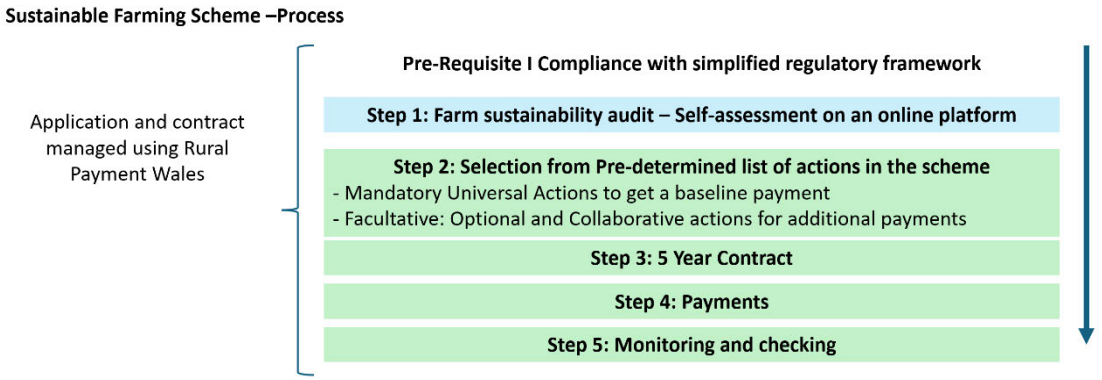


Figure 7-1: General structure of the future Sustainable Farming Scheme in Wales (by the author from documents from the Welsh Government 2022 proposal)

The first step will be doing a sustainability audit of the farm on their own, farmers will be able to apply to the SFS on their own using an online portal of Rural Payment Wales (RPW) (Figure 7-1). Steps 1 and 2 of the application process require farmers to provide data about their farms to enable a 'sustainability audit' of all the farm economically and environmentally, which then requires them to choose some management options from a pre-determined list. It is recognized that some farmer training might be required to help them to do the audit, and it is likely that many of these audits will be undertaken by advisors[59], particularly if they are complex. The RPW portal will be updated to

[59] This could imply costs for the farmers

accommodate its use on a smartphone and provide a simplified ‘dashboard’ to present the results of the audit.

The SFS offers (as in the previous second pillar agri-environment schemes in Wales) a tailored solution for every farm. The scheme seems to try to rely as much as possible on existing elements of the Welsh policy framework, most notably the Farming Connect advisory service (operated by a contractor), the RPW agency, and many options relate to existing support/measures in existing policy, but also potentially in the contract length (5 years) and structure. As in existing schemes, there will be some monitoring and checking against the contracts signed but moving towards digital/online monitoring and applications will offer cost reductions for the WG, to enable more funding for other parts of the SFS.

Most SFS options will be paid on a per-hectare basis or by the specific cost of the option as in pre-existing AES in Wales, with more details announced in 2023 (Welsh Government, 2022). The SFS payment rates are described as including factors beyond a ‘cost incurred and income foregone’ model’ (such as currently applies to Welsh AES)(Welsh Government, 2023b). This change is intended to recognise the wider social value provided by the outcomes that SFS will deliver. The payments and support can be of different kinds: management payments (per hectare); capital payments for equipment or buildings; also, payments for technical advice. Little has been said about how the funding will be split between the option types, or how specific support for ‘collaborative actions’ will work (will it be a competitive process in which applications are scored, ranked and funded up to a maximum scheme budget)(Welsh Government, 2022a).

All actions within the SFS are organised under five key characteristics (e.g. Resilient and productive farms; Table 1-1), each of which has action-groups (e.g. Diversify, differentiate, specialise for added-value), with different farm-based actions in it. Any farmer willing to enter the SFS must adopt all 12 actions labelled as universal to receive a baseline payment. This universal tier within the SFS will be a pre-requisite for any farmer to access the upper layers/actions of the SFS. The upper layers of the SFS are named optional and collaborative actions, as well as advice they can be complementary to, or separate from, the universal actions (Table 7-1).

Table 7-1: Example of the nested and tiered approach with actions in the SFS structure (by the author from Welsh Government, 2022)

Action types: Action-group:	Universal mandatory action	Optional action	Collaborative actions	Advice
Minimise the risk of catching and spreading disease P23-24	Set of standard biosecurity measures in place.	Reward for having 3m wide fence and hedges on farm boundaries to limit contact between stock	Work with industry to introduce a procedure that demonstrate livestock comes from safe units	Farming Connect will provide advice on how to limit the spread of disease

The composition of the action list has been analysed against the key themes of action that were in the SFS, targeting different sides of agricultural sustainability (Annex 2 Item 2-2). Looking at the balance between them, ecosystem protection represents more than half of the total available actions and half of the universal actions (Annex 2 Item 2-2). It has the highest number of optional and collaborative actions as it tends to be more place specific. This split would tend to suggest a strong environmental direction of the programme.

Table 7-2: List of action streams and split in terms of action types in the draft SFS (by the author from Welsh Government, 2022).

Action types: Key characteristics:	Universal mandatory action	Optional Action	Collaborative Actions	Advice
Resilient and productive farms	2	5	2	3
Reduce, reuse, and recycle inputs nutrients and water	2	6	2	6
Reduce on farm emission and increase the carbon dioxide sequestration	3	5	2	3
Protect and improve the farm ecosystem	6	10	8	10
Benefit people, animal, and places…	2	4	2	2

The options listed for the SFS were then classified according to whether it was likely to deliver against the SFS's social, economic and/or environmental goals (Annex 2 Item 2-2). On that basis, it was noted that the options' impacts are almost equally shared, with 18 actions delivering social benefits, 23 delivering environmental benefits and 26 delivering economic benefits, showing a potentially more balanced vision.

2. SFS development

The WG has engaged to deliver co-design and piloting its future scheme as shown (Figure 7-2) and said that it was keen to engage with the whole farming sector to have a scheme "accessible to all". The development of the replacement of CAP policies started in 2018 with the launch of the first "Brexit and our Land" consultation in which the Sustainable Land Management objective arose (Welsh Government, 2019b). The

replacement was supposed to be developed by a process of co-design. The *Agriculture (Wales) Act* was shared as a white paper and open to responses (Welsh Government, 2020b). It set the basis to give Wales the power to develop and implement its future agricultural policy. It provided clear indications on the broad principles and objectives of future policies. The *Agriculture (Wales) Act* later went through the Senedd. Just before, in July 2022, the broad structure of the SFS became clearer with the first SFS consultation on its structure. It took place in two parts: a written part with a survey/form and questions covering successively the objectives/outcomes/scheme design of the SFS; its structure; its characteristics and proposed actions; and its processes (Annex 2 Item 2-3). While the outcomes/objectives had been well covered in 2020, the other points represented novelties. After this part, a round of 26 co-design workshops took place in 2023 to gather feedback on the SFSs; looking at the actions, the processes and some covering areas that were identified as challenging; and some of the Universal Actions (Lyon et al., 2023). Overall, most of the engagement was conducted in English and Welsh but some elements were not (e.g. some types of workshops, and video information). A new phase of consultation is taking place in 2024 and the SFS scheme is then supposed to move to a piloting phase (Figure 7-2;Welsh Government, 2022a).

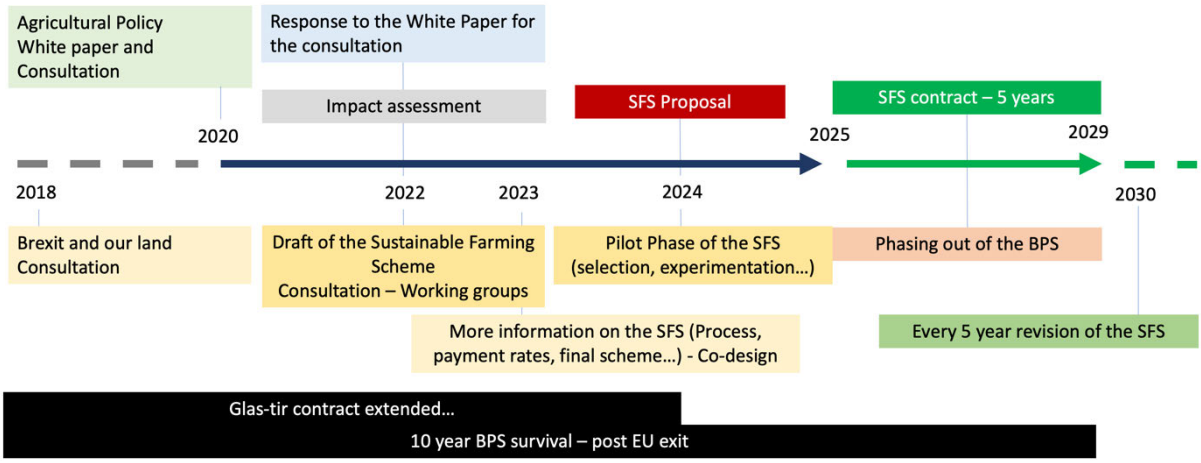


Figure 7-2: Timeline of the development of the replacement Agricultural Policy in Wales (by the author, from available information in 2023)

With colleagues at CCRI, responses were continuously provided to questions where the findings of the research could be useful. With A. Morse and L. Beaman a workshop was organised to discuss the SFS after the first plans were circulated. The Sustainable Farming Scheme workshop was held on 26th October 2022, organised through the

Economic and Social Research Council's Festival of Social Science. Representatives from organisations across the farming sector in Wales, from environmental NGOs, and academia attended the online event which comprised a panel session and a workshop, to discuss the current proposals. LB, TL, and AM collated the feedback from these discussions chaired by Prof. J. Dwyer.

The WG has already started to pilot part of this scheme and is engaging in a gradual transition from the CAP support system, but the scale of the transformations needed is significant. The transition will take place from 2025 to 2029 with a gradual phasing out of the BPS. Wales compared to England is taking a more gradual approach to the transition to the new policy (Figure 7-2).

3. Responses to the SFS plans

To understand the challenges ahead and the fears/opportunities that might exist, the challenges highlighted were built upon by the workshop as well as the co-design exercise findings (Lyon et al., 2023). Further insight is drawn based on secondary literature and the comparative agriculture findings covered in previous chapters.

In the workshop the message was broadly positive but clear concerns were highlighted around the future. The SFS incorporation of all three pillars of sustainable development received positive feedback, with attendees appreciating its recognition of the interconnectedness between farming, the natural environment, and Welsh culture. This was less the case in the wider co-design exercise which concluded, despite differing opinions on implementation, that participants recognised the importance of sustainability principles underpinning the future scheme.

a) **Farm-Specific considerations:**

First, some challenges identified at the farm-scale will be covered.

(1) Support for scheme actions

In the workshop competing demands for land were acknowledged, a theme which was also covered in previous result chapters, participants emphasized the necessity for a

practical and pragmatic approach to the SFS's implementation. Tailoring actions to specific areas and allowing flexibility for local designs were recommended. The co-design participants had broadly similar feelings, while farmers supported several actions within the SFS, particularly these related to improving soil health, hedge management, renewable energy options, animal health and welfare, and farmer health and safety, others were deemed challenging or unclear.

In the co-design, farmers, sought a system for earned recognition and payment for these already undertaking actions. They emphasized the need for clarity on how existing efforts would be rewarded. Many identified the need to balance what is needed to do to get access to a similar level of funding to what people do under the CAP framework, notably if they had limited capacity to go further. Global and political events, the challenging context around agricultural outputs and inputs, the increasing volatility of prices for produce were mentioned as they are happening in parallel to the change in support.

(2) Clarity on scheme objectives and structure

The participants expressed stress due to the lack of clarity in the SFS. They called for broad indications on funding, tier/action splits, and expressed apprehension about strict thresholds. A locally tailored, farmer/land manager-centric scheme with clear communication was suggested. Clarity on certain objectives, especially these related to the Universal action requiring a minimum figure of tree and hedge planting, was deemed essential to avoid hindering farm productivity. Attendees stressed the need for the SFS documents to focus on illustrating the benefits of different options for farm businesses.

The co-design exercise found that farmers appreciated the different tiers of actions within the SFS, expressing positivity towards both optional and collaborative actions. But they also found that there was a lack of clarity on SFS’s objectives; participants expressed confusion around certain objectives, particularly some of the universal actions. Clarity on scheme objectives and decision-making processes was deemed essential. Participants to the co-design exercise linked the complex scheme to

concerns about the additional pressure the SFS could add to farmers' already challenging jobs, emphasizing the potential impact on mental health.

(3) Food Production vs Environment

In the two instances, concerns were raised regarding the balance between food production and the SFS's environmental goals. Participants emphasized the importance of aligning food production with environmental management and sought a clear understanding of Wales' food production ambitions in tandem with the SFS's objectives. Food production was perceived as the key income generating activity, explaining part of these reactions (as well as a key part of farm's identity).

From the analysis of the SFS menu of actions, some noteworthy gaps were identified in coverage, by comparison with previous approaches to public goods delivery by farms. Firstly, there is no mention of organic farming, or of any young farmers scheme to help encourage a younger generation into farming. Organic farming is identified as a more environmentally sustainable option than many of the SFS elements (Rigby and Cáceres, 2001), so it would seem sensible to have included it among SFS options.

Overall, key considerations were identified among farmers for balancing productivity and production with environmental goals, ensuring clarity and accessibility, and providing adequate support for successful implementation. The themes of climate mitigation or adaptation were not mentioned as objectives which could a problem in the future (e.g. as shown by Harkness et al., 2021).

(4) Accessibility concerns

Among the key headline figures from the SFS draft document was a requirement for a minimum of 10% tree cover and 10% 'ecological interest area' on the farm, to enter the Universal tier and thus to enter the SFS. This immediately proved a controversial element for most farming unions and farmers (FUW, 2022b; NFU Cymru, 2022). Other than these, there were no specific numbers included in the WG communication on the proposals for SFS. Even these 10% figures were ill-defined as it was not clear what they were encompassing; for example, would the area be calculated by reference to the cover of foliage or trunks in the ground? From the farm's perspective, it would

mean restrictions, in terms of agricultural use (e.g. fencing-out livestock), which could be seen as more like land sparing.

In the workshop, ensuring accessibility to the SFS's universal layers was deemed crucial. A transition maximising initial entry, consideration of regulatory baselines, and local designs were recommended, something that was perceived as lacking. Past experiences and the economic feasibility of the SFS were identified as factors influencing uptake.

Challenges related to the 10% tree cover requirement, as a universal action, were extensively discussed in the workshop and the co-design exercise, especially for tenant farmers. Concerns included uncertainties about tenancies, potential problems with tree planting, and the need for site-specific considerations also came top of the list. These concerns were echoed by farming unions (FUW, 2022b; NFU Cymru, 2022) but also to some extent by environmental NGOs (RPSB, 2024); the latter focusing their criticism on the risk of indiscriminate tree planting (Nature Friendly Farming Network, 2023). Improved communication regarding tree planting goals was emphasized. Tenant farmers faced barriers in their tenancy agreements, impacting their participation in the SFS. For example, it was discovered from the fieldwork that Landlords might not accept the change(s) of land-use linked with scheme expectations.

There was also a broad agreement that the length of scheme agreements might also prevent tenants signing if it overruns the length of their tenancy. In the case of a farm with tenanted land the agreement would not be on all the farm area as a result. Collaboration between landlords and tenants was seen as essential for the success of long-term options. The 10% "ecological interest area" was not as debated as the tree coverage requirement, it was perceived as less challenging.

(5) Financial considerations

In the two exercises financial considerations, including payment rates, administrative ease, and support for specific farm types, were discussed extensively and clarity sought. In the co-design, participants were concerned about the level of support the

SFS would provide to the agricultural industry, both in terms of monetary support and assistance for food production. They wanted assurance that funding would not be compromised by additional consultant costs.

In the workshop, pilot schemes were recommended to demonstrate benefits and encourage uptake. Support for the next generation of farmers and anticipation of the necessary ecological and agricultural skills were emphasized for the SFS's success.

Current funding for farm policy was only ring-fenced in Westminster by the UK government until 2025. More broadly funding settlement for Welsh agricultural policy will be awarded every year, its case debated against other WG priorities. The Welsh Government will need to make a reliable and efficient case (in terms of proven ability to deliver) for the SFS to the UK Treasury as well as to its own Members of the Senedd. It is unclear if the funding will be sufficient to match the level of payment ambitions held by Welsh farmers (Welsh Government, 2022a).

b) Wider consideration:

Participants also identified some challenges at the wider scale.

(1) Readiness of industry and supply-chain

There are several challenges around potential bottlenecks, identified in the workshop and in the co-design exercise: guidance, training, and assistance were highlighted as crucial elements, especially related to Farming Connect or RPW. Given the complexity and scale of the SFS, these two organisations might not have the resources to handle it as designed today. From the fieldwork, it is judged that Farming Connect has so far had a limited role in working on ecological conservation, whereas for this scheme the skills and knowledge building needed are huge. A key element will be working with existing organizations that would have the capacity to help. However, even if it uses existing RPW administration tools, the development timeline for such an online service could be slow, requiring additional compatibility with previous systems, during the transition period.

Concerns were expressed about the availability of a specialized workforce and the anticipated demand for advice during the SFS's delivery. But fears were also expressed about the availability of other production factors at given times; the amount of equipment and material, contractor's hours, seeds, seedlings, and plants could be significant and if not phased, could risk holding up implementation and uptake. A risk was also identified around a potential boom and bust cycle for these similar elements linked to the SFS's life. It can be noted that this could limit the interest to develop bespoke solutions/advice/supply-chains for Wales in the longer-term.

The analysis of themes and actions demonstrated that there is a risk of a lack of joined-up approach around the research or education components to support the WG vision. Clear evidence is likely to be required to understand how to design the policy for multiple goals.

(2) Concerns around data collection

Regarding the data that will be collected from farms who undertake the audit when they come into the SFS, as noted above, the industry and academia could use this anonymized data for research purposes. But in the co-design exercise, most farmers showed they wanted clarity on what it would be used for and showed a relative lack of trust of the WG on the subject.

If farmers must agree to this element of SFS, it is likely to be crucial for them to gain some return from it; either through benchmarking, gaining new market information, or benefiting from independent research produced from its analysis, or through its use to design new software that would be available for SFS farmers to use. In the co-design exercise, the lack of potential benefits coming out of this exercise was raised, and the risks around a one size fits all approach, plus the lack of time to complete it were other factors mentioned.

In conclusion, while farmers showed overall support for the SFS's principles and actions, concerns related to clarity, recognition of existing efforts, flexibility, industry support, resource readiness, and mental health implications. These need careful consideration for the successful development and implementation of the Sustainable

Farming Scheme. A key concern of participants was the balance between the requirements to participate in the SFS (amount of work, time, prescription, use of the land) compared to its impact on their viability; the rewards of participating compared to the CAP, the overall impact on the economic side and other aspects of farm viability (amount of work, remuneration...). The SFS is an innovative policy, and its scale and the work required to develop it are significant.

B. Case-study implementation of the Sustainable Farming Scheme

In this part, a prospective analysis will be done building on the past chapters and the in-depth analysis of existing archetypes, it will consider the potential changes required on farms by the SFS and what would be the results on archetypes' operations and economic performance. The impact for multifunctionality including at a regional scale will be covered in Chapter 8.

The newly developed SFS will be implemented in a challenging context, and it was shown that its uptake by farmers is likely to be dependent on the relative amount of work compared to the reward. To examine the likely impact of entering the SFS on farms in Wales, a range of different farm archetypes were chosen from the four study areas in order to analyse their possible uptake of the SFS, but also to consider their necessary adaptations and the consequences of these for the business, in the medium-term. The archetypes represent a diversity of Welsh farming systems all originating from my fieldwork, these also represent the different differentiation challenges described in previous result chapters. Their broad characteristics are discussed in Table 7-3.

Table 7-3: List of farm archetypes retained to assess their interest in the SFS, the required transformations and economic performance (by the author)

System	Landscape types and size	Pre-requisites for scheme entry
A valley spring calving dairy herd with 500 dairy cows mostly flying herd (that could be a joint-venture, a nuance of share farming), a result of the development of spring calving dairy farms – large farm	190ha Vale of Clwyd Core / Steep hill	Not compliant Biodiversity No Tree cover No NVZ Average
A hill dairy heifer rearing farm with some sheep (that is linked to a lowland dairy farm) – Medium sized Family Farm	280ha Bala 3 landscapes Snowdonia L / H / M	Compliant Biodiversity Yes Tree cover Yes NVZ ok
A beef breeding to finisher with some sheep holding a strip of land (bottom of the valley to top of the hills – rough grazing) – Estate type, large home-style farm	850ha Vale of Clwyd Core / Steep hills / M	Compliant Biodiversity Yes Tree cover Yes NVZ ok
An organic beef and sheep farm holding all the different categories of land but with a high and rough mountain profile. – Medium sized Family Farm	338ha Bala 2 landscapes Snowdonia H / M	Compliant Biodiversity Yes Tree cover Yes NVZ ok
A beef and sheep farm with a large hen unit (£32,000) with access to mountain land– Large Medium sized Family Farm	300ha Bala 3 landscapes not Snowdonia H / L / M	Compliant Biodiversity Yes Tree cover Yes NVZ ok
A smallholding with beef and sheep selling locally but also rearing some calves to top up its income – Tenanted smallholding	5ha Vale of Clwyd Core or large hills	Not compliant Biodiversity Yes Tree cover No NVZ regulation Average
A smallholding with sheep and a small hens shed selling locally – Tenanted smallholding	40ha Bala H or L	Not compliant Biodiversity No Tree cover No NVZ regulation ok
A family dairy farm of 200 dairy cows based on grass mostly – Medium sized Family Farm	120ha Pembrokeshire Large ridges	Not compliant Biodiversity No Tree cover No NVZ regulation Average
A family beef finishing farm with a 100 head with a high level of autonomy – Medium sized Family Farm	52ha Pembrokeshire Small ridges	Not compliant Biodiversity No Tree cover No NVZ regulation ok
A potato farm, large home-style farm	130ha +130ha(annual)Pembrokeshire Large ridges	Not compliant Biodiversity No Tree cover Yes NVZ regulation ok
A small valley organic dairy farm with 90 dairy cows with a mixed rotation and already autonomous – Medium sized Family Farm	70ha Vale of Clwyd Core or large hills / Steep hills	Compliant Biodiversity Yes Tree cover Possibly NVZ regulation ok

1. Sustainable Farming Scheme accessibility

At first, a case-by-case assessment was carried out as to whether these farm archetypes would fit the SFS pre-requisites for the universal layer without changes (e.g. 10% tree cover and biodiversity area; Table 7-3) including in terms of nitrates[60]. These show that larger farms in the sample would have less difficulty to enter the SFS, while others would have to adapt more heavily, but entry into the SFS would still be possible. More specifically, on the tree planting requirement, which was heavily discussed above, the evidence suggests that large and mid-size farms would not struggle to achieve these 10% land use requirements, notably farms in the upper uplands, and these with lower added-value enterprises. It would be more challenging for lowland and intermediate uplands farms with high added-value enterprises. Small and some mid-size holdings could also be significantly impacted by this requirement, in all parts of Wales.

However, the impact is highly dependent on the specific terms and conditions of the measures. For example, if agroforestry could be considered as eligible tree areas, this would reduce the potential negative income implications of the 10% trees requirement. The WG claimed that farms already had an average of 6.5% tree cover on their holdings, but this is not split evenly across holdings and landscapes (Welsh Government, 2023c).

2. Changes needed on farms

Looking at theories of adaptation and transformation of farming systems; it was shown that farms can display a greater vulnerability while enacting transformations (Dardonville et al., 2020; Darnhofer et al., 2010; Möhring et al., 2022), the risks associated could make evolutions as incremental as possible (Dessart et al., 2019), even if other methods exist it is useful to highlight some barriers and challenges (Hadarits et al., 2017; Nettle and Paine, 2009; Panda, 2018). A more stable situation

[60] As such abiding by the Nitrate Vulnerable Zone regulation and its farm nitrate limits will be a pre-requisite as well due to the structure of the SFS application see Figure 7-1.

could be envisaged for farming systems in the medium-term after 5-10 years in the SFS, adapting towards farm resilience[61] (Howden et al., 2007), so the scale of immediate benefits would be limited. The results of these adaptations would be seen in the longer term (Howden et al., 2007; Vermeulen et al., 2018). To analyse whether joining the SFS would be worth it in the medium-term, the necessary transformations will be implemented regardless of the need for the SFS.

Action plans were then designed for each archetype, to enable them to enter the SFS (Annex 10 Item 10-1), taking an incremental approach. All farms are operated with a constant workforce without any major labour productivity gains in the first five years of the SFS. Given the level of detail available on the SFS at the time of this analysis, it was not possible to consider all the adaptations required by the SFS actions as might have been done at a later date (e.g. Moxey and Thomson, 2023). The analysis of the WG policy documents showed that the SFS was likely to target a reduction in input use. In this exercise, behavioural preferences were not considered as limiting for each archetype, archetype is seen as a bio-economic model where the researcher intents to adapt to a new policy and a new context with limited changes to the system (Janssen and van Ittersum, 2007). It remains a theoretical exercise demonstrating the maximum level of adaption compatible with a given archetype with minimal changes to the production factor and a change of the farm's policy environment as seen for example in Shrestha et al., (2023). In some specific cases the changes made to the models will reflect potential shifts which could happen to fit into the Welsh Government scheme although they do not reflect the the behaviour of farm decision-makers (Grashof-Bokdam et al., 2017; Martínez-Valderrama et al., 2021). In turn, the economic and environmental impact of those changes on archetypes can help inform the likely behaviour of actors (Grashof-Bokdam et al., 2017). This is likely to be only valid in the short to medium-term as a result of the scale of the changes.

A first step would be to adapt the farm to fit in the universal layer (Annex 10 Item 10-1). The extra needs in terms of land are considered to meet the new regulatory context

[61] interpreted both economically and by reference to coping with extreme weather events

(evolution of NVZ rules) and the requirements of the universal layer (e.g. more land for the spring calving dairy system with 500 cows, to compensate for the 10% tree planting/biodiversity requirement). As was seen with farmers' response to the Wales NVZ rules (Fieldwork), farmers are likely to seek to buy or rent land simply to meet the requirement, generating no new environmental assets. Management was then adapted for example on permanent pastures to meet the biodiversity requirements (Welsh Government, 2022a).

Archetypes are transformed by way of implementing input substitution/reduction, starting with the livestock and cropping systems: a reduction of fertiliser/feedstuff by 10% at least, in each system (per ha/livestock) and adapting the rest of the system as a result, by first reducing the yield or the number of livestock (e.g. reducing by 5% the weight of finished beef cattle), then using rotational grazing, making changes in the rotation to introduce legumes and cereals (Annex 10 Item 10-1). Some adaptations would improve efficiency around livestock breeding (e.g. hardier breeds) and cropping systems (e.g. selection of different seed-mixes for pasture renewal with an increased clover/legume component).

- On high-output farms, the mix of products sold was adapted- a pre-requisite to scheme entry and input use reductions-, for example in potatoes; producers would now sell part of their crop locally (e.g. potatoes sold at £1/kg and 10-30kg/day) and selling at a higher price a share of what was considered as waste previously, as a result of changing standards (e.g. 'wonky potato' in retail stores), in which case this change would be agreed with buyers.
- A third step was to consider the area and features available on each farm for optional actions. Some were common on nearly all farms, e.g. hedges, grazing infrastructure or items that would be environmentally sensitive (e.g. mountain).
- Some knock-on assumptions were also chosen to accurately model the agrarian system. It is expected that with the new scheme 'renting-out farmers' will not be able to operate anymore, this will trigger an increase (by 5-15%) in rent, incorporating part of the subsidy payment depending on the location and linked to market parameters (Chapter 4: farms renting land previously with precarious leases can now get the subsidy).

It was observed that the operating constraints are likely to be the minimum for large and low input farms, some would have very little to adapt to enter the SFS scheme and could enter most of the area into optional payments. On the other hand, for higher input, higher output farms substantial adaptations would be necessary. There are also more opportunities to adapt on lowland farms than on upland farms, given the labour per hectare available and the versatility of the land. The highest input consumers but less technologically-specific could achieve a higher amount of transformation (e.g. Poultry cannot be adapted, because such systems are partially integrated within the supply chain and producers operate to fixed specifications, under contract).

A sensitivity analysis will now be conducted, assessing the future farming support in different likely economic environments: a reference environment; a future scheme environment, a high input cost environment, and finally a high output price situation.

3. Assumptions in the SFS modelling

Assumptions for the sensitivity analysis are as follows:

- Some general assumptions regarding the economic and market context: that the investment context will remain favourable in the short-term with low real interest rates (Bank of England, 2022)
- The current trends in milk and meat markets will continue, in terms of price and volume, with a low reduction in demand and supply (AHDB, 2023c, 2023a, 2022b).
- On market prices, it is assumed that low input prices will occur when prices are low and that high prices would concur with high input prices (mirroring trends on commodity markets and sellers' pricing strategies - from fieldwork and secondary analysis; (FAOSTAT, 2021b).

For ease of representation all economic values will be in £2018. Two different price scenarios were detailed in Table 7-4 based on previous market trends.

Table 7-4: Market scenarios retained (by the author from fieldwork and secondary analysis: FAOSTAT, 2021b; AHDB, 2023a, 2023b, 2022)

High prices	Low prices
Milk: 126% - 38 pence/litre* Sheep: 130% - 95 £/lamb* Beef:120 % - 1200 £/Store* Hens/Poultry: 115% Input costs: 130% Average price given by farmers depending on their product characteristics, in interviews.	Milk: 95% - 26 pence/litre* Sheep: 90% - £79/lamb* Beef: 90% - £950/Store* Hens/Poultry: 100% Input costs: 100% Market conditions selected as gathered from literature and interviews.
*Prices are purely indicative and do not reflect output pricing in the archetypes – prices do not represent top of the curve but more sustained levels **All prices would be converted to £2019 afterwards The reference price at 100% would be the medium-term prices (2-3 years) received by farm (collected during fieldwork and cross examined against market prices)	

The assumption was taken that the level of funding and the split between landscapes will remain similar to 2020 CAP funding given the information available in the SFS draft and the policy statements/FAQ (Welsh Government, 2023b, 2022a), the time-horizon is 5-10 years, the duration of 1-2 rounds of the SFS. The scheme budget would remain similar to 2020 CAP budget minus new administration and transaction costs. For example, based on the available literature on administration and transaction costs[62] the transaction cost was estimated to be at 10% of total scheme budget for the universal layer and at 20% for the upper layers, reducing by a similar amount the payments to farms. The amount of funding was split between the different tools, based on an extrapolation of the proportion of land in different tiers of the SFS combined to broad potential payment rates (Figure 7-3). The proportion of land in each tier of the SFS was adapted based on field observations, and the broad payment rates were based on previous analysis that were then adapted to match the funding envelope (Lenormand et al., 2021a) . It was possible to maintain payments for the Universal layer at a similar level as in Lenormand et al. (2021): £125/ha accompanied with a similar structure to today's BPS, such that the acreage payment is supplemented by a redistributive payment paid on all farms under 54ha (also £125/ha).

[62] Despite the use of existing tools, it is likely that the SFS will be more complex to administer than the current BPS, conversely the structure of the universal layer is likely to be closer to existing AECM in terms of costs (e.g. range of 10 -20% in Rørstad et al., 2007) even allowing for the impact of digitalisation.

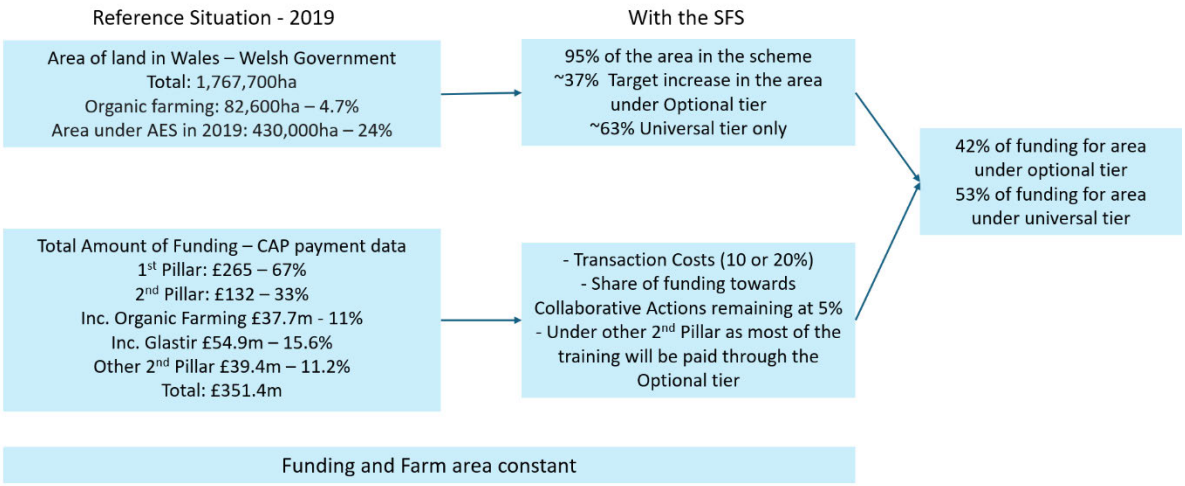


Figure 7-3: Calculations of the amount of funding and payment rates linked to the assumption retained (by the author using data from DEFRA et al., 2023; StatWales, 2020)

The optional payments were modelled, not as a flat-rate acreage rate but as a farm-specific amount to better reflect the action-based vision behind the SFS. Therefore, the optional payments are specific to each archetype, to represent the options retained. It considered: farm features to maintain through management (environmental, historic), the additional management that could take place on holdings (habitat creation, water condition improvement) and payments for capital work that could take place (Welsh Government, 2022a). This analysis reflected the amount of family labour available on the farm (inc. at different times of the year), as a result the value will vary as shown in Table 7-5. The impact of the collective options on farm archetypes was not considered, as the available details are too limited. The assumptions around the SFS have been summarised in Table 7-5.

Table 7-5: Subsidy scenario around the Sustainable Farming Scheme (by the author)

Key hypotheses	Funding constant by comparison with funding up to 2025 Net additional transaction cost, 10% for the Universal and 20% for the optional scheme 20% of the farm will be tree-planted/covered or identified as of high ecological value
Universal payments	+ £125$_{2019}$/ha, and double this rate on the first 54ha
Optional payments	Basic: + £30-100$_{2019}$/ha as a management payment, depending on each archetype. More ambitious: + £200-1200$_{2019}$/ha as a management payment, depending on each archetype.

Four different scenarios were identified to test on the farm archetypes mentioned above:

- Reference High: CAP Reference Policy (i.e. no change to existing policies) under a situation of high market Prices
- Reference Low: CAP Reference Policy under a situation of low market Prices
- SFS High: new policy, i.e. the SFS as proposed by WG, under high prices
- SFS Low: new policy, i.e. the SFS as proposed by WG, under low prices

Two approximate thresholds are used as a benchmark against which to assess the agricultural income per family worker: the living wage, and the median wage in the UK (£20,000 and £32,000 respectively).

4. Economic analysis

a) **Economic performance**

In the reference situation, the level of dependence on intermediate consumption of all modelled production systems tends to be high (Figure 7-4): seldom under 50% of the archetypes' output value, for each scenario. Dependence is higher in the low-price scenario compared to the high price scenario, 10% more for high input systems and 3-5% for others.

Intermediate consumption in adapted production systems (Figure 7-4) tends to be lower or similar in the scenario with SFS, compared to the reference scenario, shifting the farms towards more self-sufficient production systems. Intermediate consumption

thus represents a reduced share of the Raw Product. The share of the farm's output spent on intermediate consumption with SFS decreases in every case except for organic farms and laying hen producers, from 10% for high input systems to 3-5% for low input systems or where there is little margin (NB. organic farms are already self-sufficient).

As a result, the impact of input price volatility is reduced under SFS, by comparison with the reference scenarios. The difference between the high and low-price scenarios reduces for this metric, showing reduced reliance on volatile inputs (e.g. seeds substituted as feedstuffs). This also happens in high input, "high yield" systems, that were not previously self-sufficient (e.g. dairy or beef finishers).

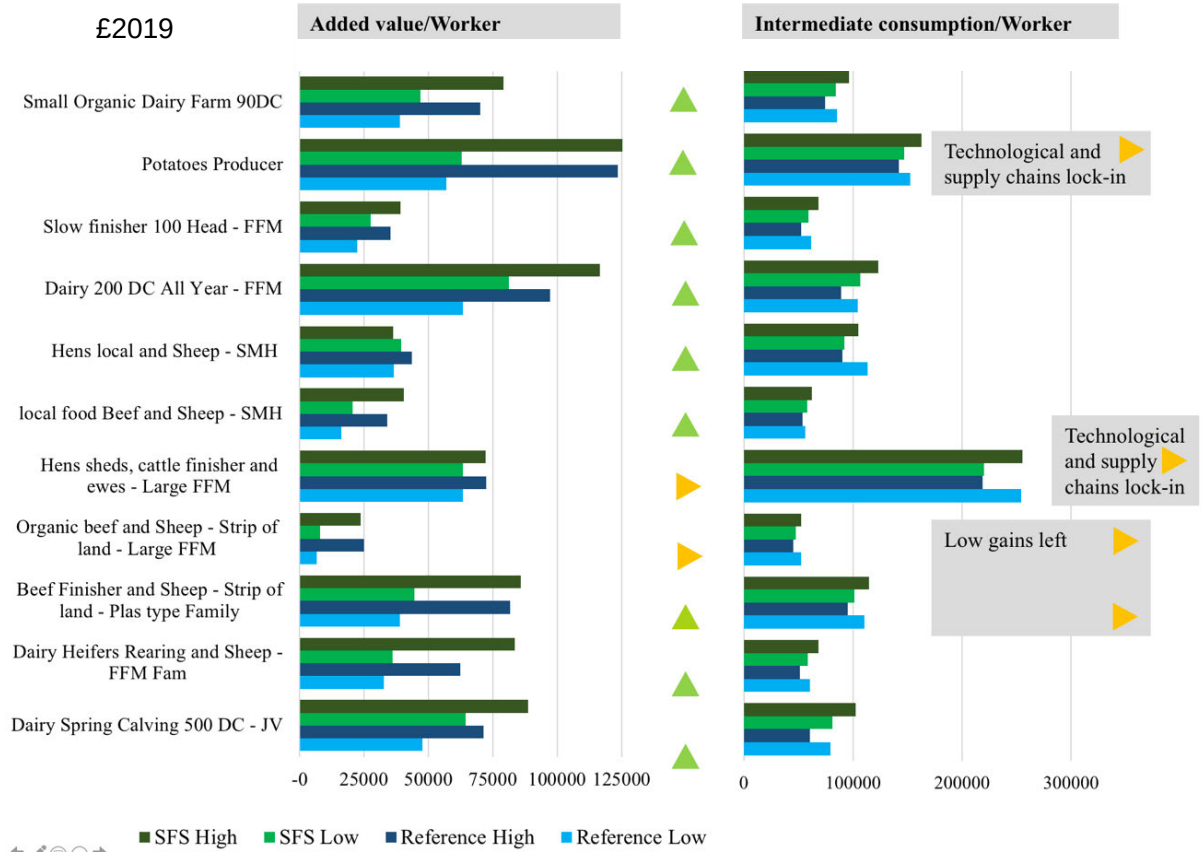


Figure 7-4: Comparison of the added value/worker and evolution of the farm subsidy payment in £2019 in different scenarios
Legend: FFM mid-size family farm; DC dairy cow; SMH smallholding; JV joint venture

The SFS has a lesser impact on the already self-sufficient[63] slow finisher, or on organic dairy farms. SFS benefits are low for farms that had already adapted to increase their environmental value. High input, highly specific systems that cannot switch to other inputs easily also show a smaller impact from SFS (e.g. laying hens that represent a technological lock-in, or potatoes, despite significant adaptation). The added-value[64] per worker in the reference situation (Figure 7-4) represents under 39% of the farm's raw product for all archetypes except high value-added enterprises. The low price scenario 2 has a greater impact on added-values, with added-value falling by 7% for low input systems and by 15-18% for high input systems. In all cases except the already self-sufficient farms (that had a strategy in place), the added-value of being in SFS tends to be higher than under the reference scenarios. An important caveat is that archetypes rely heavily on family labour, and only high added-value production systems require paid workers (more than 1 FTE), this limited the additional labour cost of SFS changes. The most radical system transformations from joining SFS result in greatest benefits, although this may take time to implement. For example, the 200 DC dairy farm would probably take a phased approach to SFS entry, working on the yield, its contract, and grazing options, before moving towards more significant land-use change; over five years at least. The already self-sufficient farms will have limited further gains from joining SFS.

The results of SFS modelling are therefore positive: the SFS improves economic performance even in the low added-value production systems, with gains of 5-15% for high input enterprises and 3-5% for low input systems. Supply chain constraints or technological lock-ins can prevent some farms adapting and realising significant gains. For example, poultry farms in vertically-integrated production systems cannot easily substitute home-produced food for their highly technological units and livestock; while

[63] By self-sufficient this research qualifies the low reliance on bought-in inputs for feedstuff and fertiliser (Devienne and Garambois, 2022)

[64] As covered in previous chapters, the added-value shows the different level of labour productivity of the economic activity of farming and the added-value is a measure of economic efficiency compared to input use, regardless of access to production factors (e.g. land) or subsidies

dairy farms with supply contracts that specify acceptable levels of fat and protein, or the production profile, may also struggle to adapt.

Overall, as demonstrated in previous chapters the archetypes are more sensitive to output price change than input price change as a result of low margins in the sector that are reflected by the low-price scenario. High prices for output in scenario 1 generate more economic value. It also demonstrates the volatility of operating conditions and economic results on farms, with low prices challenging all farms. High added-value systems, which are often also higher input systems (with higher environmental impact; see Chapter 4 and 5) can still return a higher added-value and are more robust economically.

b) **Subsidy Payment**

To provide scope for analysis, the universal layer of the SFS is compared to the level of former first pillar CAP funding, while the optional layer is compared to the second pillar. Farms would not experience big differences in subsidy payments with this SFS scheme modelling (Figure 7-5). The main losers in terms of subsidy would be large, extensive farms with a low complement of workers. There would only be low gains for most small and mid-size farms, due to their limited ability to commit to both scheme actions and to the capital elements of the SFS (which can be particularly interesting for seasonally heavy archetypes, like potato farming or spring calving).

Considering the universal element of the funding, as it is now fully decoupled from landholding and linked to specific SFS management actions, farms can retain their subsidy payments, albeit rents have increased which feeds through into farm income. Farms in this case would be high added-value farms compensating for the drop in universal payment compared to the BPS, and increased rent. These who lose more subsidy payment are large farms in low added-value enterprises.

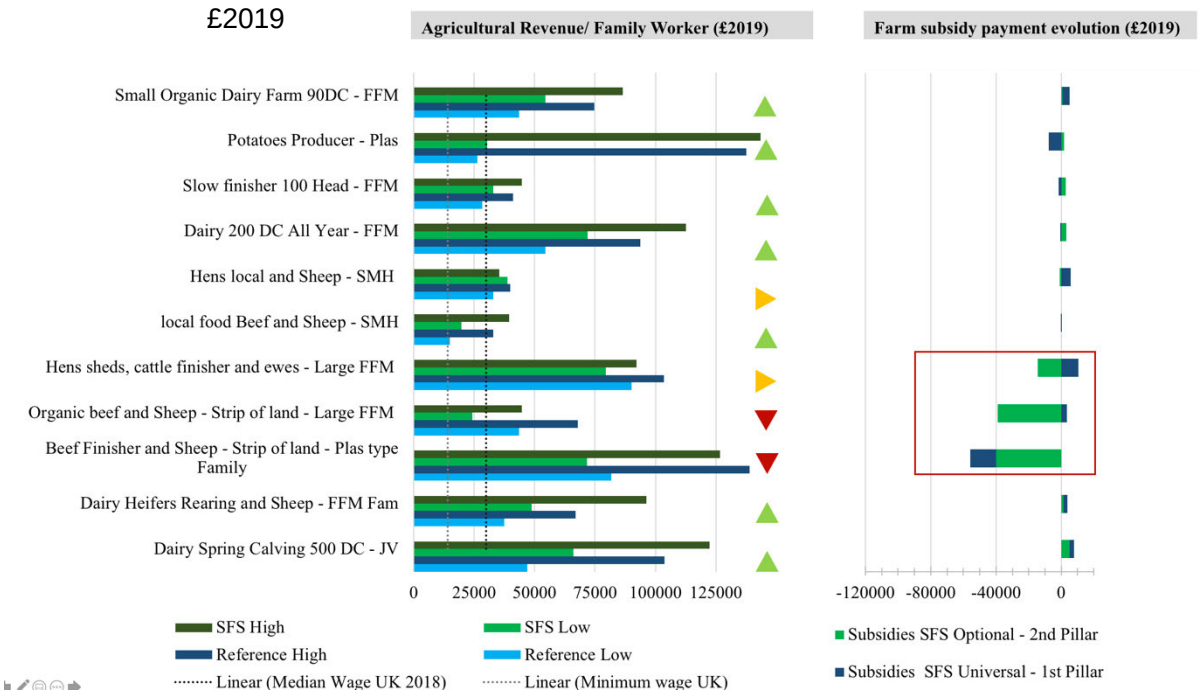


Figure 7-5: Comparison of the agricultural revenue/family worker and of subsidy payment in £2019 in different scenarios on farm archetypes
Legend: FFM mid-size family farm; DC dairy cow; SMH smallholding; JV joint venture

In optional payment, there is a significant reduction for large farms that previously had Glastir or Organic payments. SFS payments are based on practices and management actions with a rationale around the cost of the elements and capacity to do some work. These low-staffed extensive systems with already a high productivity per worker are limited in terms of possible options under SFS. Small organic farms would only have a small loss, because of its capacity to commit to more management options requiring more labour.

c) Agricultural income

The impact of the SFS on agricultural revenue is limited, most modelled farms benefit from it, with reduced volatility (from input-use reduction) and increased income (Figure 7-5). This is very often linked more strongly to input-use reduction, with a knock-on increase in terms of added-value. The losers remain organic farms and very large farms with lots of mountain land due to the redistributive element of the action-based payment, which questions its environmental knock-on impact (e.g. Fowler et al., 2004; Rigby and Cáceres, 2001). Transition payments were extremely useful during organic farming conversion, and they are phased-out, as well.

The reference situation (Figure 7-5) represents a situation of low prices with lower incomes per family worker while the high prices scenario helps reflect farm incomes volatility. Most stable farm incomes are these supported by integrated indoor laying hens (12-17% swings in income compared to the reference), while other high input high output systems have 70-90% swings, and low input low output systems have 40-70% swings. With the SFS most farm incomes increase, particularly for dairy farming systems or farms rearing dairy heifers, even with their reduced production. Potato farming also sees increased income, with more significant changes to the system performance. Steps towards self-sufficient systems are an important element in improving the economics, even in a difficult environment where farm outputs are still seen as “commodities” by reducing reliance on at least on one element explaining farm income volatility.

The reliance on subsidies for agricultural income (Figure 7-5) is lower on nearly all farms under the SFS scenarios, although virtually no change is observed for small farms. Less positive results occur on technologically locked-in poultry farms with small margins and slightly higher costs with SFS, or large, extensive farms that simply have not enough margin to reduce their costs anymore. The share of subsidy in agricultural income is traditionally around 10-30% for high output systems but it can increase by as much as 10-20 points during crisis. For low output systems it will go up by 30-40 points from an already high level (over 50%) and as high as 80% in one case: a beef and sheep farm with mountain land. Farm incomes drop under £20,000 for a smallholding, in the low-price reference scenario.

The choice of SFS design in this analysis also had the benefit of reducing subsidy payment imbalance from a 22-x multiplier to a 10-x multiplier per family worker on the sample. Nevertheless, it is recognised that in this case, it created additional hardship for high multifunctionality organic farms and large extensive mountain farms. The low value of extensive farms’ output was identified combined to the fact that many farms could not commit to more labour-intensive measures and rewarding measures, with their lack of resources. The more changes take place, the more benefits there would be in terms of economic and environmental gains, but often it will require a supply-chain wide approach to accompany the changes or validate them. For example

changes to potato size and heterogeneity has implications for the marketing, processing equipment and contracts between actors with in-turn knock-on consequences for inputs use (Fielwork).

d) Multifunctionality impact

This section will summarise the key potential impact of the SFS on multifunctionality by reflecting on farms' economic performance, the changes that took place and the socio-cultural importance explored in Chapter 6. From an all-Wales point of view , input substitution is beneficial, despite the necessary increase in seed, contractor bills, machinery and possibly tree imports, required to get to this point (Chapter 6). This applies for all elements that could be produced partly in Wales with the potential to increase (in proportion) the added-value captured in the agri-food sector (Chapter 5). The economic resilience of farms, their grounding in the local supply-chain would be improved, there would also be a significant stream of a capital investments due to the changes taken forward benefiting the local area with similar or increased employment, the reliance on imported inputs would be reduced. The economic impact of modelled change is therefore broadly positive across archetypes and likely to be positive as the regional scale. On the most demanding archetypes whose production is based on the land (dairy, crops, finishing cattle), the negative environmental impact due to inputs would significantly reduce and the management of the land would be more sustainable. The farms with poultry units are the ones where the lowest level of potential improvements given the technological lock-ins. Culturally, the above assessment highlights the risks for culturally integrated farms (mainly beef and sheep and small dairy farms) despite some improvements to their economic resilience. The lowest level of additional benefits in terms of multifunctionality would be expected to be found on upper uplands and uplands as their multifunctionality is already high and their economic gains would be limited. The highest level of benefits would be expected in the lowlands, environmentally and economically.

What this work has demonstrated is the value for many farms in Wales of taking a phased approach to the adoption of SFS to improve multifunctionality. This analysis acknowledged that the labour available is limited on farms. Thus, initially incentivising input reduction could deliver economic benefits for nearly all farms, giving them more

breathing room before they turn to other elements in the SFS. Furthermore, focusing on a desired typical farm change (e.g. input reduction) would help farms to design and coordinate the policy tools more effectively (universal actions/optional actions/advice). A phased approach, with a continuous improvement from individual farms taking place over time, could be imagined. For example, input use will only be reduced by a certain degree without further sector-wide transformation in Wales, for example to cut fossil-fuel consumption and reduce farms' reliance on imported machinery and feed. However, added-value only increases due to adaptation of inputs, and agricultural income can still be low, in low-price market conditions (Figure 7-4). But there are possible options to increase the raw product value and limit its volatility. These include differentiating products, for example with organic certification or PDO labelling; or diversifying income sources (including developing short supply chains). These will increase added-value for the farm and increase socio-cultural connections with wider multifunctionality benefits, but they are place and time-specific (Yakovleva, 2007).

C. Potential impact of market pressures

While the impact of the SFS on farms has been considered, it is now intended to assess whether it would create a farming sector that would better be able to deal with short and medium-term market economic pressures which are increasingly likely. In the shorter-term -as highlighted in Chapter 1- the coronavirus and the Russo-Ukrainian War have led to supply chain issues, fear of shortages, high volumes of monetary inflation, high market volatility for many agricultural commodities and key agricultural inputs (Aubert et al., 2022; Bank of England, 2022; Chopra, 2023; Lenormand and Dwyer, 2022). These immediate challenges pose a risk as they can be difficult to negotiate when already anchored in path-dependent factors that constrain and limit farming system change (Chapter 4 and 5). The following section will consider farms' economic performance as in Chapter 4 and 5.

1. Potential impact on the SFS and assumptions

Since 2020 there has been a considerable monetary inflation followed by various supply-chain challenges and a more general macro-economic inflation. The value of

the WG agricultural policy funding has thus been reduced by 21% in real terms since 2018 (CPI change from 2018-2023; AHDB, 2022b; ONS, 2023a). As the funding remains constant and inflationary pressures remain high, the leverage of the SFS will be much diminished from the start of its implementation. Commitments from the WG were to focus on supporting Welsh farmers, hence it is expected that the supply-chain and accompanying measures might be the first to be cut.

Positives and negatives can be seen from this situation, i.e. further incentives to reduce input use to accelerate the uptake of the SFS. But will farms be able to survive immediate shocks? Since 2020, no specific policy instruments have been introduced.

Scenarios were adapted to consider how farm archetypes would be impacted in a short-term context (1-3 years); with higher input prices, rising interest rates as well as limited increase in output prices due to a contraction in food demand for specific products, locally and worldwide. In that scenario the subsidy payment was reduced because of combined budgetary pressures and real-term funding reduction with inflation; in a 20% reduction. This context described in Table 7-6, is compared it to a reference situation from 2019 in terms of prices.

Table 7-6: Different price change scenarios applied to archetypes (by the author)

Reference scenario - £2019 prices	Inflation scenario - £2019 prices
Output prices: Milk: 100% - 27.36 pence/l Sheep: 100% - £84/lamb Beef: 100% - £1055/store Potato: 100% - £150/T Hens/Poultry: 100% **Production factors:** Fertiliser and fuel: 100% - £270/T Feedstuff: 100% - £125/T Rent: 100% £100/a Hired-in labour: 100% - £40,000 cost Interest rate: 100% Baseline of 2% interest rate Subsidy budget: 100% - £120/ha for SFS	**Output prices:** Milk: 120% - £32pence/l Sheep: 116% - £97.44/lamb Beef: 116% - £1223/store Potato: 115% - £172.5/T Hens/Poultry: 116% **Production factors:** Fertiliser and fuel: 170% - £459/T Feedstuff: 130% - £163/T Rent: 120% - £120/a Hired-in labour: 120% - £48,000 cost Interest rate: 200% Subsidy budget: 80% £96/ha for SFS
Prices and costs are archetype-specific; illustrative estimates are provided of price levels. Price change has been limited to reflect the stickiness of contract prices for inputs and outputs in agriculture.	

In the inflation scenario, input prices rise faster than output prices which tend to stagnate or go down slightly. It was also decided to run the inflation context in a case

where the SFS was substituted for the current subsidy system. Apart from the subsidy reduction, this is a more realistic comparison to the situation faced by farms today.

Four different scenarios were considered to test on the farm archetypes as follows:

- Reference: CAP Reference Policy (i.e. no change to existing policies) under a situation of reference Prices
- Inflation: CAP Reference Policy with the market prices of the inflation scenario
- Reference with SFS: New policy, i.e. the SFS as proposed by WG and with the assumptions above, under reference prices
- Inflation with SFS: New policy and with the assumptions above, plus the inflation market prices

2. Economic performance of archetypes

On the added-value per worker the picture is not as challenging as might be expected, high added-value systems manage to increase their added-value, but this is not the case for low added-value archetypes (Figure 7-6). Self-sufficient production systems are in a better position with gains for all systems with the SFS, except for these already highlighted in the previous analysis of price impacts (organic).

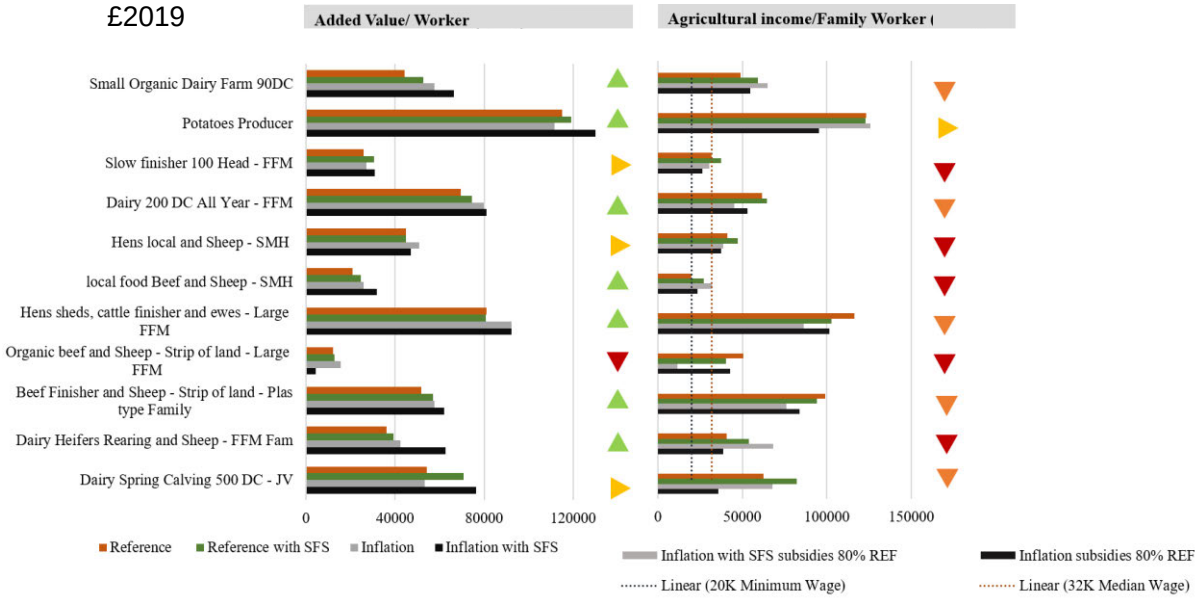


Figure 7-6: Added-value per worker and agricultural income per family worker for a range of modelled farming system in £2019
Legend: FFM mid-size family farm; DC dairy cow; SMH smallholding; JV joint venture

But farm income falls in all cases in the inflation scenario as shown in Figure 7-6 while before with high market prices, higher incomes were mostly witnessed. With these shorter-term scenarios, the types that suffer the most would be these with heavy investments and requiring a high quantity of production factors, dairy farms, potato farming. In this case, archetypes that are self-sufficient fare better, reinforcing the argument articulated around the SFS. Another factor is the reduction in subsidy payment combined with the redistributive element, hitting low added-value and extensive farms. Spring calving systems, particularly the ones that have developed more recently in less favourable conditions (Chapter 5), could face a difficult situation as the archetype is near its economic sustainability threshold. They tend to have more costly access to production factors than early-developed ones. Due to the large-scale of investment made in one episode, these are likely to be destabilised by higher interest rates. This is not an issue for farms with poultry units. Some beef and sheep farms could see their income drop under the sustainability threshold or the living wage threshold as a result of inflation. The SFS even with reduced funds could still help. The modest scale, local beef and sheep producers are the only ones that see a modest total revenue increase, linked mostly to low input costs, and low reliance on both subsidy and commodity supply-chains.

It is noted that the interpretation of SFS implementation tends to help reduce the fall in overall subsidy and thus the impact of the wider economic context for farms (grey bar; Figure 7-6), albeit doubts can be raised about the possible speed of implementation on farms. The transition into the SFS could be unaffordable for some farms, despite the prospect of later gains. This would be particularly where payments are too low to support the farm through its transition, when farms spend time/money for little return or they face crisis conditions (Darnhofer et al., 2005; Lamine and Marsden, 2023). The design retained and the payment cut would endanger extensive low added-value farms further -inc. organic ones-. In conditions where funding is limited, choices might have to be made in targeting the funding further. A suggestion would be to make sure that during the transition into the SFS the farm could call on additional support (as was done in the organic scheme), from the government investing in farms for later returns. In its 2023 plans the WG considers a stability payment during the transitory phase (Welsh Government, 2022a). Another element of

interest would be counter-cyclical payments, made from a crisis fund into which farmers pay in, yearly, this represents the majority of payments in the US (Economic Research Service, 2023). Finally, to escape the commodity trap, efforts could be made to develop differentiated markets.

Based on the above analysis, it appears that there would still be benefits to phase-in the SFS with an initial focus on input reduction.

3. Tenanted farms and the SFS

The impact of short-term market pressures and the SFS on tenanted farms was considered (Annex 10 item 10-2) in a similar fashion to the previous approach with other archetypes. Tenanted farms, particularly uplands beef and sheep operations, are more impacted as a rent increases in scenarios with inflation. These uplands farm can see their farm income fall below the sustainability thresholds but dairy or poultry farms are in a better position even at a small scale. Some loans can become costly to repay/finance on farmer's owned farms in a context of inflation. Based on the analysis, operational flexibility and cashflow could represent the key challenges for these farms, as securing funding and adapting to regulatory changes without landlord agreement is difficult.

Tenanted beef and sheep farms guardian of the SEPLs (Chapter 6) face limitations in adding value due to rented land and rent increases may become unsustainable without changes in production, this could be problematic in the Elan valley or on some farms in Bala. The type of tenancy plays a crucial role in bargaining power and accommodation of the SFS, with Agricultural Holdings Act (AHA) tenants having more leverage compared to Farm Business Tenancy (FBT) tenants (Lenormand et al. 2021b). But there is no specific provision for the SFS in existing standard tenancy agreements and code of practice. Establishing a standardized framework for SFS implementation on tenanted land is a key taking of this analysis to address potential disputes and ensuring fair distribution of funding. However, without clear land-use frameworks, there's a risk of land exiting agriculture, as some landowners may find it more appealing to take land back into their own hands (See below).

4. Tree-planting on farms

Tree-planting on farms has been a controversial theme of discussion following the WG decisions to include tree-planting requirements. While this target was built-in in the modelling, the analysis went further reflecting on the economic consequences (Annex 10 Item 10-3) using the existing Woodland Creation Scheme (WCS)(Welsh Government, 2022c). It was assumed that it would remain an incentive for farms to cover the expenses to create and manage new woodlands (up to 2ha/p.a). Three payment scenarios were examined, with differing levels ranging from £235/ha to £615/ha focused around the current £410/ha. Payments levels were compared to the added-value across different archetypes and it indicated that high-value producers are unlikely to participate apart from using some of their marginal land, sometimes at the detriment of the environment (Annex 10 Item 10-3).Considering agricultural income, interest in tree planting is even higher among low-value systems, particularly for extensive beef and sheep farms even if the funding needs to be shared with a landlord. The lower levels of high added-value archetypes could also find it interesting (e.g. heifer rearing). Additionally, some farms may find it opportune, particularly if high economic performance is not land-dependent (e.g. poultry), or if there are agreements with landlords. Despite economic concerns, tree planting could provide supplementary income, especially for retiring farmers. Regarding carbon markets, some uncertainty remains around the status of new woodlands but more broadly businesses are buying land to offset carbon (e.g. FUW, 2022a, 2022c), potentially competing with agricultural production or the SFS at prices per year. The analysis underscores the importance of a coherent land-use policy/framework to align with future needs.

Requiring a proportion of farm area for tree planting or biodiversity management could be achievable but requires funding, effort, and time to adapt farms. Effective communication and facilitation, possibly through in-person engagement, could increase uptake, as seen with similar initiatives (Breyer et al., 2022; Morse, 2022). In 2023 the WG has also clarified some of the exemptions that might apply and the timings which could make it easier (Welsh Government, 2023c).

D. Additional regulations and their interaction with the SFS

The analysis has so far focused on the new policy support being developed by the WG, the WG has also meant to introduce new regulation to deal with some farms' environmental performance. A potential extension of regulation is highlighted: the Nitrate Vulnerable Zones (NVZs) introduced in the 1990s under the EU Nitrates Directive, which had a significant impact on some farms in the historical analysis (Chapter 4). This section will explore the potential role of this regulation and its probable impact in relation to WG goals.

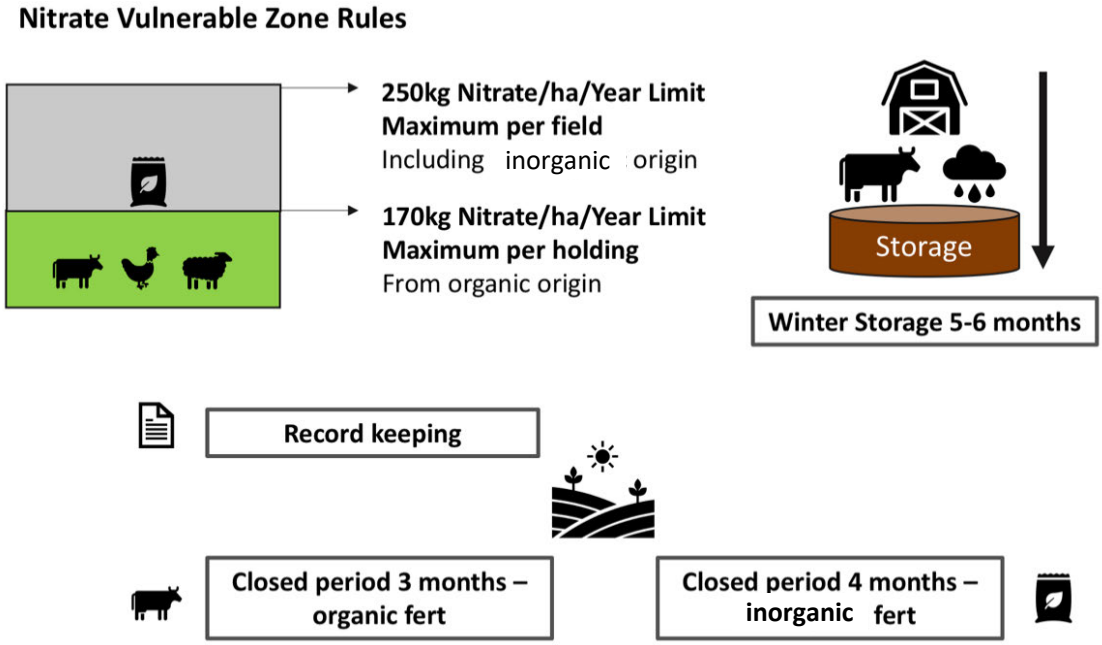


Figure 7-7: Nitrate Vulnerable Zone plans (by the author from literature review)

The EU Nitrates Directive was implemented gradually (Fieldwork;Burt et al., 2010; Macgregor and Warren, 2006;Senedd Research, 2012). It aimed to correct one externality of agricultural development. The designation of NVZs is part of the nitrate directive aimed at tackling water pollution problems due to leaching (Figure 7-7). Within NVZs, nitrogen-applications to farmland are limited to 170kg of nitrogen/ha limit from animal origin and 250kg of nitrogen /ha overall. However, farms with more than 80% of grassland had a derogation and could apply up to 250kg of nitrogen/ha from animal origin (Welsh Government, 2014).

In addition, an action programme has to be developed, ensuring compliance with conditions affecting the management of farmyards, and slurry and silage storage.

Farms had to produce records of expected agricultural management with sufficient storage requirements, longer rotations between applications and observing some other restrictions such as not spreading on frozen ground or sensitive habitats. In Wales the Action Programme took a “country-wide” approach (Farming Connect, 2023; UK Soil Observatory, 2023). In view of accumulating evidence on nutrient enrichment across Wales, the Welsh Government plans to move from a hitherto clearly defined NVZ area applying in a few specific areas (UK Soil Observatory, 2023) to the whole of Wales from 2021 onwards (Farming Connect, 2023). The plans involve clear steps to apply stronger requirements for all farms.

1. Consequences of the policy change

For farm archetypes studied, the level of Nitrogen from organic origin loadings was considered, based on the regulation’s standards, the amount of land where the farm would spread its manure (e.g. they might not be able to spread the manure everywhere, due to tenancy requirements; Fieldwork) and the total nitrogen loading (inc. inorganic fertiliser). Considering these factors, three different implications for the Nitrogen loadings on farms were identified.

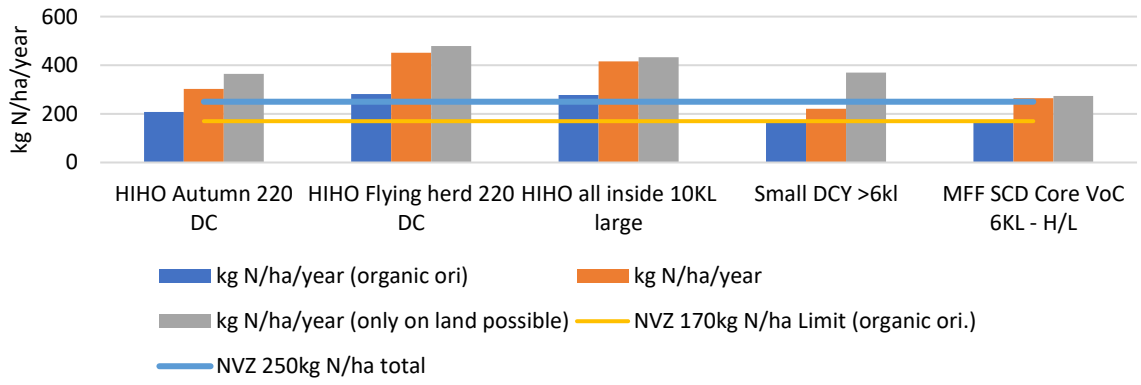


Figure 7-8: Nitrogen loadings on a selection of dairy archetypes from Pembrokeshire and Vale of Clwyd
Legend: HIHO High Output High Input; DC dairy cows; HL hill and valley

Farms most challenged by the NVZ rule introduction will be the high input, high output farms (Figure 7-8) but it also represents a challenge for smaller dairy farms and low input systems (spring calving dairy). Flying herds would be particularly badly impacted, more so than 1,000 cow high-input, high-output dairy farms. If a more specific risk assessment is considered in terms of areas where it is possible to spread manure, many other farms could be impacted, for example, a small dairy farm with too much steep land. Most of these apart from small 1-1.5 FTE dairy archetypes would be compliant with the NVZ infrastructure requirements. There are higher nutrients loading linked to the development of high-input and output dairy spring systems.

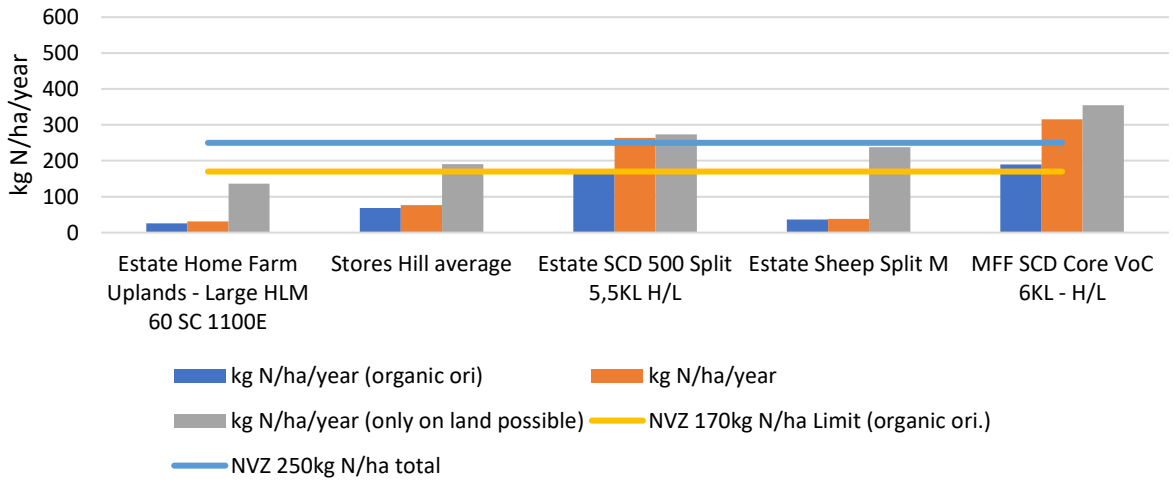


Figure 7-9: Nitrogen loadings on a selection of spring calving dairy archetypes from Pembrokeshire and Vale of Clwyd
Legend: HLM: hill valley mountain; B&S beef and sheep; SC suckler cows; E ewes; MFF mid-size family farm; Organic ori Organic origin

The development of spring calving dairy systems will not run into problems (Figure 7-9) in the uplands and is likely to be compatible with the rules in lowlands (Figure 7-8). In the case where for the purposes of the regulation it can be attached with the mountain/hill land that is not suitable for grazing, the impact would be even less. Most uplands beef and sheep farms would not struggle to be under the limits. Nevertheless, overall nutrient loadings increase due to the development of spring calving dairy in uplands.

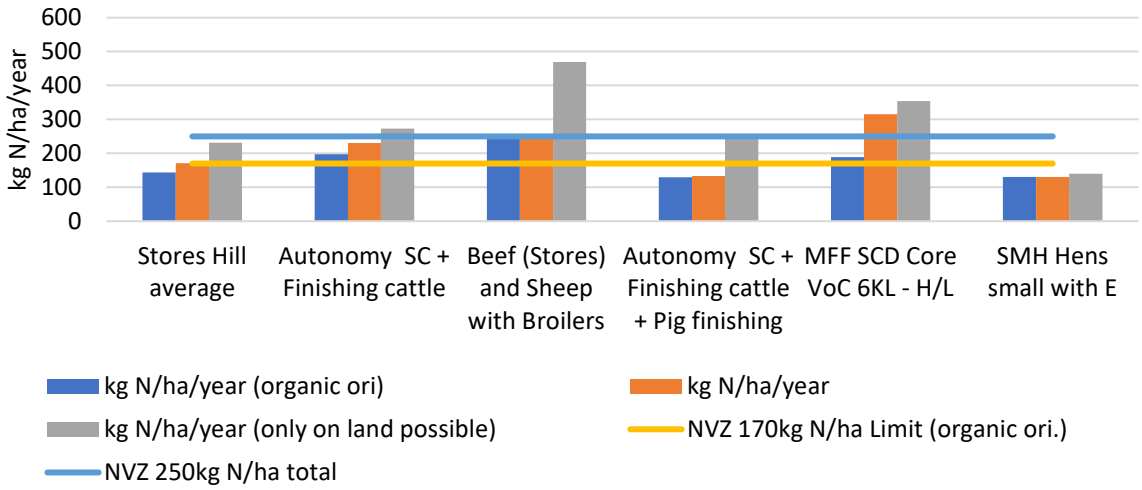


Figure 7-10: Nitrogen loadings on a selection of differentiated uplands archetypes from Vale of Clwyd and Bala, with mountain land
Legend: HLM: hill valley mountain; B&S beef and sheep; SC suckler cows; E ewes; MFF mid-size family farm; Organic ori Organic origin

All farms considered in the uplands with large landholding (Figure 7-10) would be compliant with the new rules regardless of their differentiation, but it is noted that newly differentiated systems would have higher nutrient loadings than traditional beef and sheep farms. The broader infrastructure compliance for the farmyard and buildings could be a significant issue on smaller beef and sheep farms[65]. Differentiated systems representative of intermediate uplands with less land could struggle to comply with the new restrictions, particularly if they are hill farms finishing stock, or keeping poultry. Their nutrient levels would be as high as low-input, low-output dairy farms. Smaller poultry farms would not have an issue in adapting if they do not increase their livestock numbers. One issue for the uplands is nevertheless the much higher loadings on the limited amount of land on which machinery can be used combined to the more challenging climate, reduced vegetation growth and thinner soils. In other words, the increased loadings are unlikely to benefit the farm's fodder production.

[65] Where farms are supposed to capture all rainwater effluent

2. Likely consequences

The speed and scale of the implementation of the all-Wales NVZ requires a quick and immediate response on non-compliant farms (Macgregor and Warren, 2006). In 2004 when NVZ rules were enforced more strictly in the small ridges area of the Pembrokeshire case study, some farms needed to adapt their infrastructure. At that time, farms that wanted to avoid the extra paperwork and the infrastructure adaptations, made a choice to move away from cattle or to retire altogether. When the burden of new paperwork was the only issue, some "linked their holding" with a non-compliant one, therefore becoming contractors on neighbours' land[66].

Given the uncertain market environment, it is likely that farms would tailor their facilities as tightly as possible to limit costs in a competitive environment, in turn this would lead to slurry/muck spreading particularly around the closing/starting dates for spreading[67]. The NVZ implementation has pushed high-added-value, nutrient rich farms to limit their nutrient loadings by renting or buying more land or rearing-out some animals on other farms (Fieldwork). Many farms would look rapidly for a workable mix of land, some to spread and some to keep the loadings low (as an 'insurance' tactic). Some adaptation can also take place to reduce animal yields to make the most of the different standard livestock N-values[68].

Reflecting on farm potential changes, the NVZ expansion across Wales might reduce the number of small dairy farms (fewer than 120 dairy cows and without investment in the last 10 years) and cattle smallholders for whom the required adaptation (additional infrastructure and more land) would be of limited interest, under current market conditions -especially if they are nearing retirement-. Generally, the land available for manure-spreading can be found on the hills or on land released by retiring farms; farms negatively impacted will be found in lowlands and intermediate uplands; impacting the Welsh SEPLs. The implementation of the NVZ

[66] For the large livestock farmers
[67] In potentially inadequate conditions
[68] Different cow yields and animal types are associated to different levels of slurry and organic N production (Welsh Government, 2014)

rules, combined with the current context, could lead to land-use change with some negative environmental externalities. For example, some rugged hill land has been bought and will be managed by dairy farms more intensively[69]. The Pembrokeshire case-study area is in a more difficult position with limited opportunity to expand uphill, unlike the Vale of Clwyd. It is likely that there will be stronger pressures on the land market, with a continuation of existing trends. This competition for access to land is likely to further select farming systems to favour these with high added-value production and high capital accumulation (Lenormand et al., 2021b).

3. Is an all-Wales NVZ an appropriate approach?

It is concerning that these adaptations might not lead to better use of animal manure and greater sustainability, as many parts of modern farms can be miles away from the homestead (Beaudoin et al., 2012; Pochon, 2022; Senedd Research, 2019). Often the land closest to the homestead (at least in lowlands) would receive the heaviest applications of manure: with a high moisture content as it is highly inefficient to move it around (Espagnol et al., 2019).

The Welsh Government is seeking sustainability with the SFS in a world where resources are becoming scarcer (Espagnol et al., 2019; Griffon, 2013). Animal manure is seen primarily as a risk, rather than an opportunity to move towards sustainability, given the focus of current policy (NRW, 2023; Senedd Research, 2019). In the last decades, economies of scale have been a way to cope with volatile prices and narrow margins (Chapter 4 and 5). The problem is endemic to a process of specialisation, and also regional specialisation of farms, in livestock farming and with poor nutrient usage (e.g. Pochon, 2022); involving the import of farms input to sustain a high density of livestock, and a lateral transfer of fertility from feedstuffs/ fertiliser production. The manure produced on the farm does not necessarily match the needs of the fodder produced at a given time in the local area (e.g. Maize crops; Griffon, 2013; Pochon, 2022).

[69] In respect of inputs and outputs/ha

Increasing environmental pressure from other nutrients in Wales has also been mentioned but has been dealt with differently (e.g. Phosphates), through planning and environmental impact assessment (Limiting farm expansion in terms of livestock numbers; evidenced from fieldwork). This integrates the spatial impact of other land-uses and nutrient producers (inc. human beings), in the approach. The NVZ, by design, is very focused on nitrogen emissions but it is not a systemic measure and its interaction with impacts on the land market is poor in respect of how its outcomes further select between farms, in the landscape. This limited regulation of agriculture interacting with unregulated land markets seems likely to lead to outcomes that conflict with SFS goals (causing a reduction in farm numbers, with farms focusing more on high-output strategies).

E. Relevance of the SFS objectives

It is now intended to highlight a significant risk for the SFS: a disconnect between its goals of achieving the sector's sustainability and the preservation of the Welsh agricultural sector. First, a review of the WG's commitment to support Welsh farming and food production is considered. The risks of greater competition and constrained demand are compared – something which could further pressure farm incomes - and this is then correlated with the SFS objectives.

1. Trends in the agri-food sector and SFS goals

The recent trends that have taken place have tended to gradually put farmers and the WG goals in a more difficult position. These trends are discussed in more detail in Annex 10 Item 10-4. Post-Brexit trade negotiations opened the UK domestic market to more competition particularly from country competing with Welsh agricultural produces, while EU exports faced challenges, the EU is the main export destination for Welsh agriculture products. The competitive advantage and production mix of Welsh Agriculture is very similar to New Zealand, except this nation tends to have lower costs; the Welsh Way of producing is not so specific (HCC, 2020). From 2010 to 2020, the UK experienced a gradual decline in its food export balance, relying more on imports, except for dairy products, one of the productions where Wales has

developed its production. At the same time the UK diversified its agri-food imports away from the EU. Overall, the medium-term outlook for Welsh products points at reduced prospects for exports and increased domestic competition (Annex 10 Item 10-4).

Recent events such as Brexit and crises like COVID and Ukraine exacerbated supply chain fears with inputs price increases (Annex 10 Item 10-4). Food prices have increased significantly in the last years with rises in food insecurity, it affected key Welsh farming products like milk and red meat. Consumption trends have adapted in consequence, the stagnation in food spending, combined with inflation and pandemic-related issues, has been mirrored by heightened input costs. However, farmgate price increases did not match cost increases, leading to challenges for producers, potentially resulting in further concentration and specialisation in farming practices, negatively affecting Welsh family farms. The future challenges for Welsh farming and the WG have grown more prominent and point towards a continuation of existing trends, while increasing food production is unlikely to tackle food insecurity.

2. Sustainable Farming Scheme objectives

The challenges highlighted above question the current Welsh Government policy focus, indeed the SFS design constrains accessibility; the size limit, the type of farming systems targeted are conservative, but this is not represented in debates. Current trends in terms of farm production are likely to persist and as a result could prevent the SFS from achieving its goals, including reaching food security[70]. Part of the opposition to the current scheme revolves about the perceived opposition between the food security objectives and the strong environmental focus (NFU Cymru, 2024). The SFS document did not mention climate change in its operation which could be a significant omission (e.g. Short et al., 2020).

[70] Definition retained by WG: “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” (World Food Summit, 1996)

The SFS will only represent one part of the farms' operating environment. Interactions with unregulated markets or other policies around regulations have not been analysed in depth. Successive policy documents included no plans to seek reform in the agri-food supply-chain, to increase the rate of return to producers. No government initiative is mentioned along these lines, although it could be promoted through the collaborative layer of the SFS (i.e. increasing producers' bargaining power through collaboration). In respect of the returns to producers, supply-chains in the UK are deemed unsustainable, with risks for food security (Lang et al., 2020; Yakovleva, 2007), suggesting that this could legitimately be a focus for policy action in Wales. A return to the principles of agro-ecology could signal a desired change of direction, delivering wider benefits (Albanito et al., 2022; Van der Ploeg et al., 2019; Wezel et al., 2009). Modelling by IDDRI highlighted a potential route to reach Welsh agricultural sector sustainability (Poux et al., 2021) based on agro-ecology and some key principles identified in previous chapters; with farms adapting their farming systems to lower reliance on inputs, increase farming system resilience and differentiate their production (including marketing channels). This could also link to a relative reduction in nutrient imbalances at regional level due to a relative reduction in specialisation, between Welsh regions. Additionally, Poux et al. (2021) found that it reduced GHG and led to other environmental benefits.

Considering the relative reversal of specialisation in agri-food systems would require more significant changes, after initial gains coupled to input reduction. A clear challenge would be that today's farms tend to be already specialised and large, requiring significant expertise. It is suggested that promoting land sharing between different land uses at a farm scale, to bring co-benefits. Small units within farms are possible - using a part of a larger farm in a partnership/tenancy to support a more diverse range of products. As well as helping to develop these products in which Wales is least self-sufficient (Figure 7-11), it could have the potential to reduce isolation (RABI, 2021), and provide further land-sharing opportunities and agronomic system benefits (e.g. shade during drought or exchange of manure/labour between farms, to save costs), bringing different knowledge together (e.g. beef and sheep integrated management and horticultural/fruit expertise). It was also shown that relying more on short/very-short supply-chains to deliver to communities could have a bigger economic

impact (Chapter 6). As seen in Chapter 5, smallholdings can return a high level of added-value per hectare while spending significant amounts in the local community.

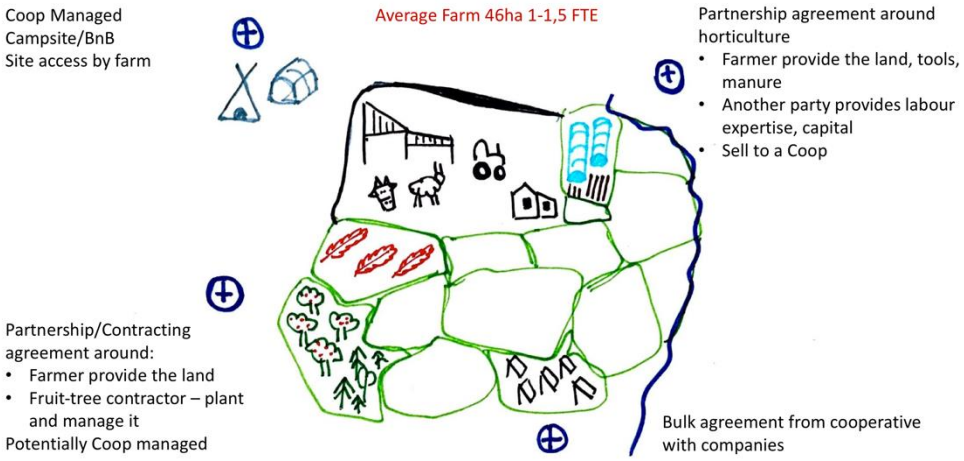


Figure 7-11: Illustrative example of the integration of more functions on farms (by the author)

This model has the benefit of acknowledging the highly specialised structure of the different elements in running a farm (e.g. rules around livestock…), and it is also compatible with joint-venture approaches. Crucially it integrates more functions on one farm, rather than specialising a whole holding. Reterritorialisation examples and local-scale initiatives have been developed previously with PDO giving a potential blue-print (Maye et al., 2016).

In summary, while the SFS's broad structure follows agro-ecology principles, the wide range of actions and (as drawn from the reading in 2023) their compartmentalised nature tends to limit the clarity of the message. A coherent list of universal actions, more than the optional actions, could be the driver of beneficial changes. The messaging around agricultural policy and the SFS could be adapted to avoid conflicting statements and goals that would not be achievable with the SFS.

F. The SFS in 2024 and potential change

The SFS has been presented as it was in 2022 but since then some changes have taken place. There has nevertheless been no headline change, and the new policy has triggered protests (NFU Cymru, 2024) in parallel to the last round of co-design with farmers. The economic impact assessment of the SFS demonstrated that the labour on farms was likely to drop by 5,500 while livestock units could drop by 122,000 (Moxey and Thomson et al. 2023).

1. Farm interest in the SFS

Three universal actions/rules have been identified by farmers as being challenging; the data collection and farm diagnosis, the 10% requirement for tree cover, and the 10% requirement for area managed as habitat (NFU Cymru, 2024; FUW, 2024). For example, farming unions highlight that universal payments should be available to everyone. While some of this negative reaction is probably due to poor communication and a polarisation in the debate between farming and the environment; these nevertheless constitute concerns which have been investigated.

Given the further guidance published in 2024 (Welsh Government, 2023d), it is judged that significant clarifications have been made; for example, to adapt to shorter tenancies, shorter lengths of SFS agreement are being considered. The WG gave further insights on the tree cover requirements and exemptions from the rule. Nevertheless, the permanent land use change required is not received well by the farming community (NFU Cymru, 2024). Clearer communication combined to a gradual implementation of the requirement, would be possible. The analysis conducted demonstrated that some tenanted farms could struggle to adapt to the SFS structure even with the suggested adaptations, particularly these with high added-value enterprises and these with short-term tenancies.

Concerning the audit that will be required to enter the SFS, the feeling that it will not benefit farmers remains (NFU Cymru, 2024). There is already an asymmetry in the food supply-chain in terms of public and easily available information (Minarelli et al., 2017); with other stakeholders in the supply chain clearly sharing much less

information than farmers. There is a risk that the SFS could reinforce this. The level of data collection is now criticized as being inadequate for specialized and place-specific systems (NFU Cymru, 2024). At a time when the wider supply-chain might require evidencing these benefits to the consumer, it might be interesting to promote a joined-up approach (WWF, 2021) and for example pilot some rewards based on initiatives which make these links.

As discussed previously, the funding for agriculture has reduced, as it is no longer set at the European level but requires discussion and competes against other priorities at the UK and the Welsh levels. For example, in 2023 £37m of agricultural subsidies' funding was redirected towards other budgets in Wales (approx. 10.4% of the 2019 budget; BBC Wales, 2020), but before then some funding had already been lost at the UK level in 2020 (approx. 26% of the 2019 budget, BBC Wales, 2023, 2020; Evans, 2020). Combined with the impact of inflation, the budget will be able to buy less. The vision from farming unions that all farms should be able to enter the SFS (FUW, 2024; NFU Cymru, 2024) would result in a dilution of funding, it would also likely result in going away from the ambition of the universal layer (Orford, 2022).

The WG has not yet provided information on payment rates, promising to give them in 2025 when the SFS starts. The SFS impact assessment (Moxey and Thomson, 2023) provided different indicative payment rates for their modelling, the payments were made only on the specific acreage under universal actions requirements rather than a whole farm payment, as in the modelling of this chapter. They give SFS payment rates of £222/ha semi-natural, £283/ha woodland, £42/ha for other areas, this represents at best £98.8m of funding (or under half of the total 2020 Welsh CAP first pillar receipts). The remaining funding would be used to fund the collaborative and optional layers of the SFS. These levels of funding were obtained using the assumption that the uptake would be 100%.

At the same time the goal remains to pay rates above income foregone with an additional ‘social value’ payment (FUW, 2024), but the modelling of the impact assessment highlighted that:

- The costs to comply would be higher than the assumed SFS Universal payments for most large farms and 25% of smaller farms. This raises the question of what capping has been retained in the modelling (FUW, 2023).
- Falls in Farm Business Income were likely even if the payment was increased to a similar level as the BPS. This showed that communication on payment levels was probably not adequate.

For example, it is unlikely that all areas would be included in the payment: common land as such might be excluded from the universal payment (NFU Cymru, 2022). As a result, even if the farm is eligible there are concerns around which areas are going to be included for payments. It is noted that the findings of who would lose out are broadly in line with the above economic analysis (e.g. about large farms). In the two modelling approaches questions are raised on how to effectively represent the permanent change of land use in conversion to trees; this was a major fear of farmers, especially in the face of uncertainty around future funding and payment rates.

The modelling of this chapter has some key differences with the Moxey and Thomson approach.

- First, given the level of detail available at the time it is likely that fewer costs/complexities have been added to the modelling of this chapter.
- Secondly, while a funding assumption was the starting point to get payment rates (based on a commitment at the time; European Commission, 2023) the work from Moxey and Thomson chose to build up from a range of payment rates. The level of the ‘poor funding’ scenario was likely to have been a bit higher than that term implies.
- Thirdly, the payment methodology was simpler and applied at the farm scale (although with an element of capping/redistribution). A choice was also made that not all Welsh farms would enter the SFS (90% uptake, vs 100%).

For example, while the payments for tree planting were considered to be at least at a similar level as in the WCS, Moxey and Thomson, (2023) used it as a upper threshold at £420/ha: the more limited tree-planting with payments under £415/ha was used by the analysis of this chapter leading to more positive findings.

Based on Moxey and Thomson, (2023), if the Universal Payment were due to be set at £98.8m representing 42% of 2019 CAP first pillar spend and 62% of this chapter's payment rates, it can be deduced that the optional and collaborative payments are likely to represent £122.2m. This would constitute a similar amount to current second pillar funding, but 70% of this chapter's modelled payment level. The universal payment would be falling at £74.4/ha (whole farm), but with this chapter's modelling and the sample of farms the only system dropping under the £32,000 (median wage) would a mid-size beef finisher. There would nevertheless be some drops in income, particularly for largest farms that rely significantly on subsidies. The income drops compared to the reference situation would not be generalised given the gains reaped from input use reduction and input substitution strategy, the only farms losing out compared to the reference situation are the ones that already lost some income (e.g. beef finishers, hens…). It is concluded that compared to the modelling done by Moxey and Thomson, (2023), the simpler approach focusing on input use reduction has smoothed the impact of the reduction in funding.

Based on the above, it is noted that it will be difficult for the WG to build consensus on the scale of the SFS. Their recent impact assessment modelling showed that the amount of work required was likely to be greater than the reward offered. The level of payments with a reduced level of funding are likely to be of limited interest, below the level of added-value generated by medium to high added-value farming systems. The concerns around accessibility remain significant, particularly if the rewards are limited.

2. An ambitious scheme

Despite these shortcomings, the SFS remains an innovative policy compared to other approaches. In the current agricultural transition in the UK devolved nations, policy choices have been iterative in their approach, building on existing support mechanisms. England has been the outlier among them, taking a strong environmental approach, while Scotland (Moxey et al., 2021; Scottish Government, 2022) and Northern Ireland (DAERA, 2023) have remained closely aligned with the CAP framework with adaptations, particularly to drive more environmentally friendly practices.

In England, the largest difference compared to the CAP framework is the ending of direct payments supporting farm incomes. Environmental Land Management (ELM) aims at rewarding the production of environmental goods (AHDB, 2022d; DEFRA, 2020; Short, et al., 2022). However, the Sustainable Farming Incentive - the base layer of ELMs - is paying approximately 40% of what CAP first pillar payments did and is very similar to EU's eco-schemes, the 'mid-tier' Countryside Stewardship plus approach is an evolution of existing agri-environment scheme, while productivity and other investment grants have been part of the agriculture toolkit in this form since at least 1973 (AHDB, 2022d; DEFRA, 2020). The schemes in place continue to focus on the main types of farming in England (e.g. linked to options or levels of payments) but structural changes were expected to take place as the sectors' farms adapt to the lack of income support; this was expected to impact beef and sheep farms most, due to their reliance on direct payment subsidies (DEFRA, 2018).

The Welsh approach has been more holistic and innovative, with support on offer across the spectrum of sustainability and a stronger structure to support the sector (including business support, collaborative payments) but as a result the overall messaging is less clear. The Welsh approach also differs in structure by adopting one vehicle to deliver all results, but as pointed out earlier the collaborative and optional layers have more objectives linked to the environment and rural development. The WG has taken into account the need for a longer transition (2025-2029; Welsh Government, 2022), with a stability payment to help farms adapt, making a less brutal

change than the BPS staged removal in England. The development of English policies has been very iterative, payment rates have changed (NFU, 2023), many test and trials have taken place and objectives have been tweaked; England now has a broad commitment to maintain its share of domestic food production (DEFRA and Prime Minister's Office, 2023). Wales has gone further in signalling a need for land use change, but the focus of the debate on antagonising points has not helped to find a way forward (Welsh Government, 2023c).

All the main UK policy mixes retain grants and acreage payments with rules and prescriptions: the Welsh policy is no different. The structure of policies across Europe remains constrained by the imperative to align them with WTO standards or the structure around the development of policies (e.g. Green Book; UK Government, 2022). Furthermore, in many European countries there is a relative lack of new development for the accompanying measures of agricultural policies; filling skill gaps (Sims et al., 2022) and adapting the land market; these were instrumental to implement the post Second World War agricultural vision (Canévet, 1991). All policies now share the need to balance the need for increased sustainability, the perceived need to maintain food production (particularly in existing sectors) and economic results (e.g. in the EU with the green deal; Bremmer et al., 2021; Paarlberg, 2022).

In the current state of the SFS, many elements have been clarified but given the objectives retained by the WG, the path to attain would require greater clarity around what is needed (e.g. food security, environment), including mentioning adjustments that would be necessary and a joined-up approach across all policy tools. A clear strategy, for example based on input use reduction would be easier to implement than the current complex approach and deliver benefits across the objectives, although this might require some dietary change and change in production types. The time before the SFS starts operating is short, much needs to be clarified or discussed and the SFS has fewer means than it was supposed to have, making it less likely to succeed.

To conclude, the SFS is trying to deal with political and funding challenges for Wales, its orientation is positive, integrative, and certainly innovative when comparing it to other schemes existing in the UK. Like most schemes in European countries, it focuses on farms with limited action on supply-chains, which represents its largest

limitation in terms of holistic thinking. The SFS tries to use as many proven elements as possible to make the SFS cost-efficient. And while farms are facing a challenging context, the WG is taking a more careful approach to the transition to the future scheme, compared to England.

Given the political status of Wales, the fact that the supply-chain of Welsh farming is integrated, and that the macro-economic context worsens its prospects, it is likely the SFS might not have the time to yield results before political and funding deadlines. The SFS as it is designed might have significant bottlenecks that will struggle to be resolved if the sector is not engaged in it holistically and for the long-term (boom and bust cycle). Being aware of existing lock-ins' impact; both technological and via the supply-chain, linked to the contraction of the sector; will be crucial to this exercise (Chapter 5; Aubert et al., 2021). It could lead to a gradual implementation of ambitions that are more within reach, in the SFS.

This chapter by considering potential impact of the scheme on farms whose multifunctionality has been summarised in chapter 6 provides insight on potential changes in resulting farm multifunctionality. The modelling suggests that although the impact would be positive for most farm's multifunctionality there would real losers: SEPLs-based large extensive farms and beef and sheep farms (Chapter 6; FUW, 2022; RSPB, 2023) which make a unique contribution in terms of multifunctionality on the environmental, cultural and social-link axis. Another element is the impact on contractors of the SFS in terms of operating and additional needs. It was demonstrated that the information published since has likely reinforced the points made. In chapter 8, these findings on the SFS will be summarised at the regional level.

Chapter 8. Discussion and conclusion

While it has been showed that the potential of the SFS was far from negligible to improve farm multifunctionality, the scale of challenges that it needs to solve is significant. As a result of the SFS's indirect delivery of goals, the analysis conducted has been focusing on an assessment of how farm multifunctionality was likely to change to understand Welsh farming and look at potential impact of post-Brexit change (Chapter 2). This purposive research gave rise to a three-pronged approach looking at the past change of agrarian systems, followed by today's context, and a subsequent analysis of the potential future at the farm level. The analysis highlighted close interlinkages between the different scales and elements of what was conceptualised as the agrarian system. While past chapters considered successively the different key regional units of Wales and the archetypes in them, this Chapter will attempt to provide answers to the likely trends and changes at the level of Wales as a whole. This chapter will also reflect on the use of the multifunctionality concept in this work and particularly the use of the agrarian diagnosis to as a research tool.

A. Research questions answers

1. Key challenges and drivers for Welsh farming's future evolution

Research questions answered
• *Among all the challenges faced by Welsh farming what is likely to be the most significant for Welsh farming and its multifunctionality?* • *How will the future SFS scheme in Wales interact with the drivers of change at play, and impact farms' multifunctionality?*

In Chapter 4, 5 and 6, the range of challenges faced by Welsh farming was demonstrated, it was clear that farm multifunctionality had reduced because of changes which took place on farms over the last 45 years. Contrasting case-study areas have reacted differently to the change of their operating context; a twin-track model of agricultural development has emerged in each case-study area which negatively impact multifunctionality by compartmentalising benefits. This tends to lead farming to develop differently in areas with different comparative advantage, following either a market focused approach on agricultural "commodity" output or an approach

integrating other factors like alternative income earning opportunities (inc. selling food to local supply-chain) and personal preference (Figure 8-1).

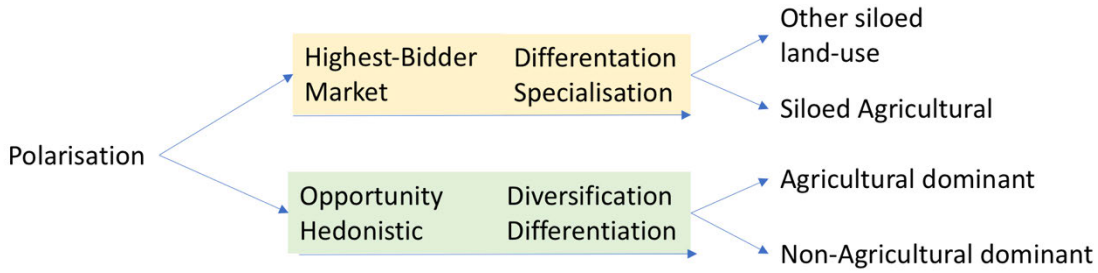


Figure 8-1: Polarisation of the farming sector in Wales (by the author)

While the intensification of agricultural practices has been well covered by the literature and agrarian studies (e.g. Allan et al., 2015; Burt et al., 2010; Hodge, 2016; Rønningen et al., 2021), such a grouping in terms of farms' underlying orientation has seldom been used. It is insightful to describe the trends observed, both in farm differentiation and in the land market (Lenormand et al., 2021b). These two diverging strands are not acknowledged in available data sources or in policy making, due to their countervailing effects (Welsh Government, 2020a). The latest June survey statistics tend to show a more and more efficient sector, with fewer unproductive animals (e.g. higher numbers of lambs per ewe, and fewer suckler cows) and a focus on high added-value production (e.g. with more dairy cows or poultry)(Moxey and Thomson, 2023). The highest-bidder, differentiation/specialisation route does not offer sustainable land-use and limits the multifunctionality of the agrarian system, particularly environmentally, with localised high input use, high nitrogen loading, and high demand for the land. While this dual system has been identified previously (Bon Pote, 2021; Espagnol et al., 2019; Giller et al., 2021; Richard, 2018), few acknowledge the cooperation among a "farm ecosystem" which can increase the overall multifunctionality (e.g. farm producing storecattle for finishers), which is a significant finding of this study. Furthermore, methodological progress was made on the twin-track model of economies of scale, compared to economies of scope, as seen in De Roest et al., 2018 by considering other income opportunities and on-farm strategies.

Brexit or any other change of context represents another shock and is likely to lead to more challenging conditions for farming communities in Wales. A likely impact of post-Brexit scenarios seems to be a further polarisation of the landscape, with a growing share used by higher added-value production systems with lower multifunctionality resulting from higher land-use intensity and environmental impact (

Figure 6-10). At the same time, some land will leave the agricultural sector or will see management strongly reduced, as a result of reorientation of economic activities, often taking an approach other than purely income-maximising (Wynne-Jones, 2011), this could result in a negative multifunctional impact (

Figure 6-10). In the light of further farm structural change and amalgamation of holdings, it seems likely that these areas will be used by some of the anticipated increase in new land uses. The literature and data (e.g. FUW, 2022a; Manzoor et al., 2021; Thomas et al., 2021) show that afforestation could gradually gather pace in Wales although this is likely to potentially impact negatively multifunctionality if done at a large scale. However, these trends were not witnessed in North Wales: likely because the strong differentiation witnessed makes afforestation a less competitive option, which is not as much the case in the Cambrian Mountains. All these trends have negative consequences for landscapes that have been identified as strong SEPLs. But Chapter 7 showed that there could be positive impact for multifunctionality with limited economic impact of adopting land-sharing approach with for example on-farm tree planting approaches.

This twin-track model has appeared because of combined drivers, and summarised below is the likely future ranking of farms' drivers of change in key areas representative of Wales. The analysis found that the potential for take-up of the future Sustainable Farming Scheme (Table 8-2 with Chapter 7 assumptions) was likely to be low where high added-value productions are present. In other words, the reward of the SFS payment is not high enough and not secure enough to justify the compromises required to agricultural output (and land use), even more as farms are often linked. This is not the case for farms where other income opportunities are available, even if significant effort is still needed to enter the SFS. In the intermediate uplands, the future changes is likely to depend on the influence of high added-value production in the area: the higher it is, the lower the interest in the SFS. In the upper uplands it is likely that uptake will be high given the better 'fit' of farms to the SFS's requirements (e.g. in terms of their forestry/wooded area) although significant economic sustainability risks exist.

Table 8-1: Hierarchy of on Welsh farms' drivers of change in characteristic areas depending on regional orientation (by the author)
Legend: Ag agricultural

Region	Characteristics: areas away from population centres and tourist hotspots	Characteristics: areas close to population centres and tourist hotspots
Upper uplands	Under 60% of income from ag origin: • Subsidy support	Under 60% of income from ag origin: • Subsidy support • Other income opportunities

	• Market for agricultural inputs and outputs • Other income opportunities	• Market for agricultural inputs and outputs
Intermediate uplands – Not integrated with lowlands	Over 60% of income from ag origin: • Ag inputs and outputs markets & regulations • Subsidy support • Other income opportunities	Over 60% of income from ag origin: • Other income opportunities • Subsidy support • Ag inputs and outputs markets & regulations
Intermediate uplands – Integrated with lowlands	Over 60% of income from ag origin: • Market and Regulations, closely aligned with lowlands' specialisation • Subsidy support	Under 60% of income from ag origin: • Other income opportunities • Subsidy support in parallel with Ag inputs and outputs markets & regulations (aligned)
Lowlands	Over 60% of income from ag origin: • Ag inputs and outputs markets & regulations • Subsidy support • Other income opportunities	Under 60% of income from ag origin: • Other income opportunities • Subsidy support • Ag inputs and outputs markets & regulations
By over 60% of income from ag origin, consideration is given to farms whose main incomes come from food and fibre production activities. Usually, these farms would have specialised their agricultural output on relative "commodity product". By under 60% of income from ag origin, consideration is given to farms whose income might come from other sources. The 60% is an estimated limit to reflect the distinction between the two-track model of agriculture		

Table 8-2: Likely uptake and impact of the future Welsh Government scheme (by the author)

	Interest in the SFS – Potential impact	Likely agrarian development
Upper uplands	High take-up. Difficult to access for smaller and tenanted farms. Insufficient support for upper uplands farmers.	High uptake but this would not be sufficient for farm survival. Small impact on existing trends
Intermediate uplands – Not integrated with lowlands	High take-up. Difficult to access for smaller and tenanted farms. Interesting for low added-value systems.	
Intermediate uplands – Integrated with lowlands	Medium to low take-up. Difficult to access for smaller and tenanted farms. Low interest for high output farms. Of interest for Lower Farming Focus farms.	Low uptake likely and low impact on current trend of agricultural development.
Lowlands	Medium to low take-up. Low impact. Difficult to access. Low interest for high output farms. Of interest for Lower Farming Focus farms.	

The scheme - as modelled in Chapter 7 –had the benefit of correcting some imbalances, in terms of the total farm subsidies paid to larger sized farms by the payment structure, effectively capping the income as a function of farm size and labour availability; indeed, the modelled universal payment was capped and had a

redistributive element while the optional payments were in function of labour availability on farms.

Despite the requirement for 20% of the acreage under trees or environmentally focused management, the SFS offered improvements in terms of economic performance and agricultural revenue combined to a focus on input reduction. Large extensive farms and beef and sheep farms often managing significant Welsh SEPLs landscapes (Chapter 6; FUW, 2022; RSPB, 2023). There would be a significant shortfall for organic farms that rely on organic subsidies and produce “standard” products with little premium (beef and sheep). Finally, the SFS will struggle to match the financial interest offered by other options (within funding assumptions), even if it could deliver for the wider community by supporting agro-ecology.

The SFS is an ambitious scheme in respect of its objectives, but the approach seems to require significant effort from farmers to enter the SFS, and the multifaceted ambitions of the SFS represent a real challenge and do not provide a clear framework for action now (Chapter 7). For lowland areas and linked intermediate uplands, it is likely that the expanded NVZ regulations or the impact of bTB will have a stronger impact on farm changes than the SFS by constraining their potential development (Table 8-3). They would also create a competitive disadvantage for producers, compared to farms across the borders or competing foreign farms[71].

The profile of Welsh farming has changed significantly with an increased focus on a limited set of products, with regional and farm specialisation (Chapter 4, 5 and 6). There are market-driven, and regulation-driven “technological” systems implemented throughout Wales, in high added-value production systems. These are also well integrated within supply-chains. Given the inter-linkages in an agrarian high output producers can exist thanks to the low output or retired ones, within a particular landscape.

[71] With increasing competition likely (Boatman et al., 2008)

While the likely consequences of policy developments were examined in depth, it is important to situate these within a broader context that includes numerous private actors with their set of behavioural constraints and some potentially binding environmental targets. The Sustainable Farming Scheme (SFS) offers a vision for achieving environmental sustainability, yet different visions have emerged across Wales to meet these goals as the interviews have shown. Many of these initiatives originate from within the supply chain, such as efforts to assess and reduce farm emissions through dairy farm audits, trials with feed additives, and efficiency and monitoring pilots for beef and sheep farms (e.g., Morrisons' pilot farms). Others are led by university departments or upstream inputs providers (e.g. seedmixes). These measures may align with or conflict with government policies, potentially reinforcing a twin-track model that locks archetypes into specific technological and contractual frameworks (e.g. breed type to match a certain additive or indoor system). Moreover, different actors often promote varying measures or metrics, leading to inconsistent implementation, reporting and a confusing landscape for end users. For example, recommendations might evolve over time or suggest divergent solutions for similar farming systems (regenerative farming with solutions incompatible sometimes with high-technology precision farming).

Environmentally, farmers face dual pressures: the adverse effects of climate change, as discussed in Chapter 6 (e.g., WWF, 2021), and the biodiversity crisis, which negatively impacts operations, particularly in upland and mountainous areas. However, farming practices themselves often exacerbate these environmental challenges (IWA, 2021; Reidsma et al., 2006; Robinson and Sutherland, 2002). It is also crucial to acknowledge that policies and economic forces beyond the agricultural sector significantly influence potential farming changes. For instance, agricultural land and buildings can be purchased by non-agricultural actors who are unaffected by farming specific contexts. These dynamics, although only partially addressed in this work, are closely linked to the persistence of the twin-track model. Finally, while dietary changes are often cited in the literature as potential drivers of farm transformation, current global market trends in livestock product consumption suggest that demand is unlikely to decrease significantly in the near term. Consequently, these trends are

unlikely to disrupt the market and opportunities to expand fruit and vegetable production remain extremely limited including in the SFS plan.

Regarding the impact of situations which would be deemed non business as usual, the sensitivity analysis in Chapter 4, 5 and 7 highlighted the fact that while a unfavourable change in market conditions was more likely to hit hard high added value production systems it meant that all beef and sheep systems were struggling even more due to their limited added value generation to start with, their income per family member was more likely to drop under the £20K threshold. On the other hand, when prices were favourable, high added value systems tended to benefit more with higher income per family member. Chapter 7 covered the likely impact if a reduction in the SFS funding as well as the potential change in market conditions (positive for farmers as well as negative), it showed the benefits of a SFS scheme focused on reducing inputs use in all conditions except for technologically locked in systems and environmentally constrained farming systems, in uplands area (low output low input). These findings highlighted the potential of the SFS even in extreme scenarios.

In effect, what is suggested within the current course of action is that the SFS might not adequately support “the most sustainable farms” and at the same time, it does not represent a big enough reward for high output farms to change their behaviour. Effectively, the likely evolution, shown in Table 8-3 is a continuation of existing trends in all study areas. Continuing uncertainty is likely to lead to the exit of low profit farms whose land would be taken by high added-value producers. The other route would be for farms to adopt the high added-value production systems, or to diversify/make the most of other opportunities, continuing the twin-track model. To conclude; given the current context we can highlight that the Welsh farming sector could change differently compared to what we described under the influence on the drivers described above.

Table 8-3: Synthesis of the likely evolution (by the author)

Agricultural Landscape type in Wales	Characteristics: areas away from population centres and tourist hotspots	Characteristics: areas close to population centres and tourist hotspots
Upper uplands	Lower farming focus, selection among farms with limited amalgamation, measures to improve efficiency, reduced number of animals, diversification of farm income. Farms bought for other uses inc. by lowland farms.	
Intermediate uplands – Not integrated with lowlands	Further selection of farms, these remaining increase efficiency and amalgamate. Farms are bought for other uses inc. by lowland farms.	Similar but increased diversification of farm income and more farms are bought for other uses.
Intermediate uplands – Integrated with lowlands	Further selection of farms, these remaining either move towards high added-value productions, increase efficiency or/and amalgamate. Farms bought/contracted by lowland farms.	
Lowlands	Further selection of farms, these remaining either develop high added-value productions, increase efficiency or/and amalgamate. Most non high added-value production farms are integrated farms with high added-value production.	Similar but increase in farm bought for other uses and higher reduction in farm number.
By strong farming focus, we mean farms whose main incomes derive from food and fibre production activities or support schemes. Usually, these farms have specialised agricultural output. By lower farming focus, we are considering farms whose income might come largely from other sources than the farm itself .		

It was found that the relative farming focus, or the proportion of agricultural output and the proportion of high added value productions in the business is likely to best reflect the likelihood of pursuing further farm specialisation and expansion. But this would also be influenced by the closeness to population centres and tourist hotspots, as those areas are likely to lose full-time farmers and land-managers with other opportunities available outside of farming (Table 8-3). As such; in those areas farming is likely to diversify further and the SFS would have a limited impact on them (Figure 8-2). This would effectively mirror current change. Depending on the availability of other income streams or the existence of environmentally constrained areas (e.g. the coastal areas, or the Elan valley in the Cambrian Mountains) there may be some systems diversifying and relying heavily on the SFS. The areas where high added-value farm types dominate will not lose as many farmers, but there will be some level of restructuring reducing the number of holdings as well; pockets of diversification can also be found. The speed of the changes could be significant, considering the high proportion of retired or pre-retired farmers (close to retirement, having reduced their farming activity0) in each area: from 30 to 60% of farmers, based on estimates (in line with Bradley, 2021; Government, 2019). Although not all those farms would exit the industry, succession is still a major issue to help predict future change. Based on

findings from Chapter 4 and Chapter 5; if the context is not supportive for farms; there could be a higher exit out of farming.

The economic impact assessment suggested 11% job losses as well as a 10.8% reduction in livestock units in Wales (Moxey and Thomson, 2023). But the loss of jobs in the industry from 2012 to 2022 stood at 8,500 FTE (-14.6%) while the number of livestock units on farms increased (Welsh Government, 2023e). These results suggest that more livestock units do not translate into stable farm numbers or agricultural jobs, and that the previous income buffer of CAP support was not necessarily an adequate measure to ensure farms' survival; findings concurring with this work.

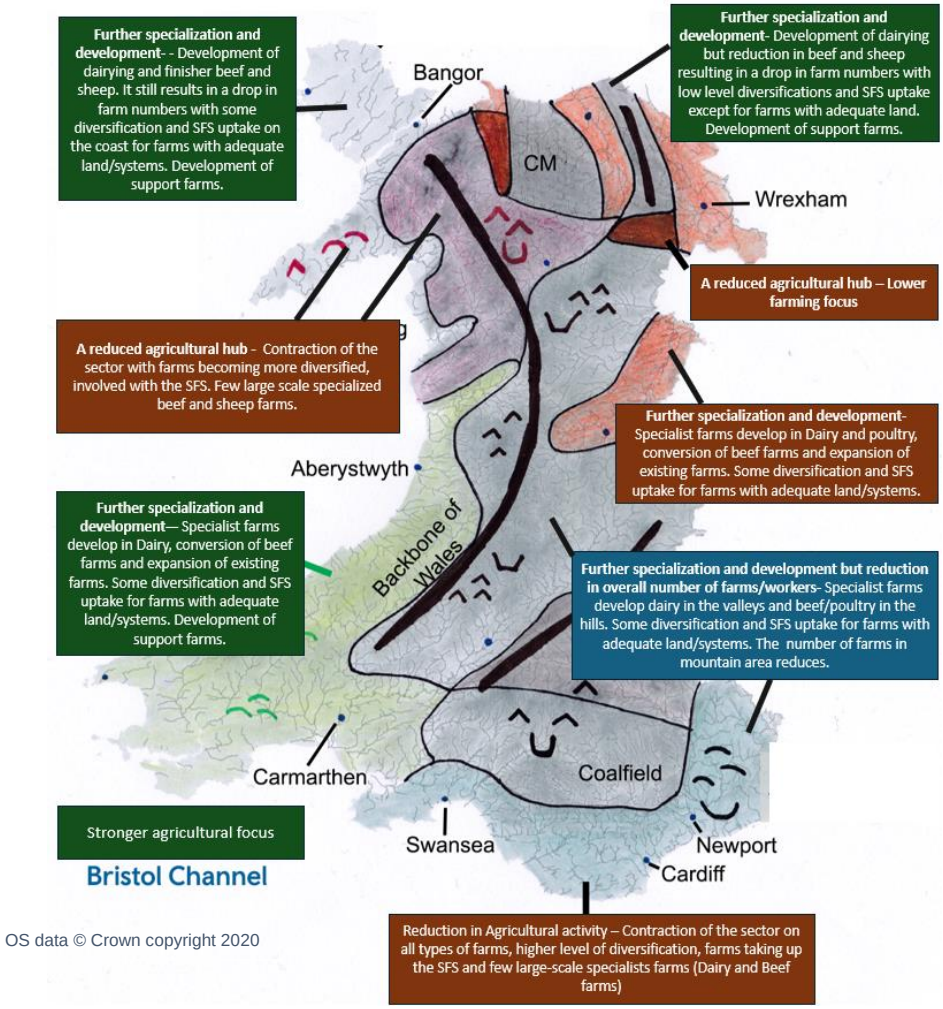


Figure 8-2: Map of the likely agrarian system evolution in Wales with the current assumptions (by the author; Ordnance Survey, 2020)

The Figure 8-2 summarises the likely impact of the SFS and wider element, lowlands will likely further specialise on milk and finishing cattle with specialisation and integration of farmers (heifer farms, fodder producers…). Their localised (negative)

environmental impact would remain high and probably have an impact on neighbouring areas, with farms buying land uphill to meet NVZ standards by example. Upper uplands cannot evolve in this direction and would therefore have to make the SFS work for them or find some alternative options: more significant losses in environmental management and local knowledge would be seen in these areas if the number of land manager reduces further. In the intermediate uplands, farms are likely to focus on high added-value production, an extension of the lowlands' model of change as seen Chapter 5.

2. Suggestions of policy adaptations

Research questions answered
• *What policy adaptations might be needed for Welsh farm policy to ensure it reaches some of its broad goals from the agriculture bill?*

In Chapters 4-7 some suggestions for policy adaptation to better drive the Welsh Farming Sector towards increased multifunctionality and sustainability were made but these findings will be brought together and developed in this section

Given the political status of Wales as a devolved UK nation, the fact that the supply-chains of Welsh farming are part of UK and global supply-chains, and that the macro-economic context worsens its prospects, it is likely that without a phased implementation and clearer goals (e.g. input substitution), the SFS may not have time to yield tangible results before the relevant political and funding deadlines. But a phased implementation and clearer goals (e.g. input substitution) were shown as being capable of delivering some benefits. A simpler Universal layer which sets a mid-term vision for the sector's evolution (e.g. on input use reduction; Devaraju et al., 2022; Lungarska et al., 2022.; Prudhomme et al., 2022) could be a positive step if the consequences are communicated clearly, avoiding setting conflicting goals and clarifying the mode of actions.

The WG may wish to ensure that the Sustainable Farming Scheme, and the wider regulatory and market policy context within which it sits, are more sensitive to the pressures upon intermediate uplands farms which often face trade-offs between production and conservation. The holistic Welsh policy approach might need to understand the challenges associated with these landscapes and seek to maintain a

coherent and multi-functional mix of farm enterprises and related land management, to ensure the sustainability of the upland landscape, retaining jobs and farming communities and the cultural and social values that these embody, without triggering or increasing a twin-track change in the landscape.

A joined-up approach to policymaking would have the potential to signal the way ahead for the sector. A joined-up approach to the SFS goals would mean matching structural tools to the support-scheme. Nudging, research, facilitating, educating, subsidising, accounting and tax rules, regulating (e.g. Simmonds and Vallgårda, 2021) are tools that can play a part in pursuing the SFS ambitious vision. For example, the list of streams and sub streams (Annex 2 Item 2-2) gives an idea of the range of options envisaged by the SFS, and taking a multi-functional view, not much is missing. But this range will also be complex to develop and require specific expertise in all categories (e.g. historic environment…), for policymakers, advisors and farmers. It could require significant efforts (e.g. developing the tree standard and then developing the hedge one). It is recommended that it be based as much as possible on existing sustainability standards (e.g. LEAF, 2022) and making sure that these also dovetail with main farming standards requirements (e.g. Red Tractor…). For example, the analysis of the SFS documentations suggested that further research or additional research support might be needed. Specific fields of concern would be breeding traditional animals; developing plant varieties; and conducting economic analyses. While the concerns of participants were highlighted - around the skills needed to adapt - the training facilities (both initial and further education) might also need to evolve to support an adequate research and workforce training (e.g. number of staff). An adaptation of the curriculum in agricultural colleges could also be necessary to better reflect the desired changes in farming practices.

Even if the WG does not have all the tools and funding that might be necessary, this research suggests that there are still some opportunities to adapt policies around farming, for example:

- It would be positive to consider the development and evolution of other regulations, like the Nitrate Vulnerable Zone regulation within the SFS (setting

a limit in Nitrogen loadings on farms to avoid run-offs). For example, it is not clear whether the areas planted with trees will be included in the area to measure the Nitrogen loading of farms NVZ. Amending Nitrate Vulnerable Zones to ensure they more accurately represent the risks of nutrient leaching on the soils rather than taking a standard prescription approach could also be beneficial (Chapter 7). Although short-term adaptations exist (e.g. slurry covers) it is suggested that a more specific systemic approach – for example as has been done in the past in France with system-based AECM measures (Luthon, 2019; Morsel and Garambois, 2022; Thoyer et al., 2014); driving farming system change with a farm-wide scheme based on rotational requirements and adopting specific practices – could be more effective.

- In Lenormand et al., (2021) it was demonstrated that the land market reform had been a driving force of farms' differentiation by creating a dual land market; a high cost one with low constraints for farms and a cheaper market with more requirements for the tenants. There is a need to fill a governance gap to help integrate the multiple functions in land-sharing potentially linking it with the SFS' development (e.g. rules around what is good agricultural management…). Reflecting on the adaptation of property rights could be crucial to better support sustainable land-use, taking into acount public good delivery in property rights and their status (e.g. taking into account communities when land use change takes place)(De Boon et al., 2024; Lenormand et al., 2021b; Roberts, 2024).
- Exploring the interest of changes on the demand-side with fertilisers (e.g. Pigouvian tax to reflect negative externalities, capping maximum use) to promote a change (Lungarska et al., 2022; Poux et al., 2021). It is also recommended that pathways be considered to increase Fruit and Vegetables production (e.g. sub-tenancies on farms) in Wales but also mechanism for this to translate in increased consumption (e.g. supporting behavioural changes) this would have several positive knock-on consequences (Garnett, 2006; Marshall et al., 2020; Yip et al., 2019)

The SFS as it is designed today is likely to face significant bottlenecks in achieving successful adoption and implementation. This research suggests to clarify and simplify the current plans with stakeholders, showing the evidence supporting SFS choices

while at the same time taking the sector on a learning curve (e.g. in research, education) to adopt all the elements that will enable the necessary change (e.g. De Boon et al., 2024; Morse, 2022). Acknowledging the impact of existing lock-ins identified in previous chapters is likely to be an important step; both technological (e.g. poultry, contractors) and in supply-chains, which are linked to the structure of the sector (Chapter 5; Aubert et al., 2021; De Herde et al., 2019; Hackfort, 2023). Such a continuing co-design process could lead to a gradual identification of what is within reach of the SFS to achieve and what a joined-up approach could look like, to achieve a step-change towards greater sustainability. This learning curve would also be crucial to explain and convince the sector about the anticipated benefits from each step taken by the programme.

It is suggested that the WG clarify policy goals and modes of action; for example, around food security, ranking priorities would help identify a gradual approach for the actual farm supports, e.g. reducing farms' carbon emissions and adapting to climate change. From the research Annex 11 reflected that WG communication would benefit from being worded adequately and tactically, for example, starting with a simple set of broad goals before highlighting the measures and rewards associated, as well as their potential benefits. The 10% area under tree cover was announced in 2022 without any accompanying rules or funding commitments (Welsh Government, 2022a). This was a risk discussed in Chapter 7 and it backfired. Highlighting the benefits of agro-forestry or trees in hedges before exploring/discussing these rules and any exemptions or timelines would have probably avoided the current political deadlock with farming organisations. From experience in the field the development of precise glossaries for policymakers to use is suggested to ensure that the wording is precise, field-specific, and as neutral as possible (Annex 11).

While the WG has tried to provide greater certainty to its farmers, compared to DEFRA in England, the ambition and scale of the SFS makes it seem like a big commitment, for limited rewards. At the same time, farms face great uncertainty concerning agricultural input and output prices and the stability payment is perceived as similar to DEFRA's gradual BPS withdrawal (even though it should mean less dramatic cuts in support).

Two courses of action are suggested:

- The first one is, rather than talking about a stability payment, to talk about counter-cyclical payments, which are not considered as direct support within WTO rules if seen as subsidies to crop insurance (Bucheli et al., 2023; Meuwissen et al., 2018). In a changing world likely to be more impacted by climate change, this would be a potential avenue for the WG. Limiting the maximum level of compensation (per ha or per worker) would have the benefits of avoiding current side-effect risks, of production intensification (Dalhaus et al., 2023).
- Secondly, the lack of clarity of the current SFS vision was highlighted, but DEFRA's SFI has been relatively well perceived by part of the farming community (CLA, 2024; Guyomard et al., 2023; NFU, 2024). On the other hand, Chapter 7 has shown that the most ambitious environmental behaviour or multifunctionality provision was likely not to be rewarded as well with the current SFS; they currently receive higher level of funding. The 2-tier structure of the SFS could be clarified,
    - A first tier with simple action-based measures to improve farm sustainability (with the step-by-step change in goalposts), accompanied by training/advice and investment support if needed, this would give access to the counter-cyclical insurance as well as to a payment structure similar to what has been discussed (redistributive, capped…).
    - A second tier could either comprise more ambitious farm-specific actions to further drive sustainability or a facilitated programme of AES agreed for specific areas with stakeholders. Chapter 6 findings demonstrated that there might be benefits in adapting AES agreements (or for example moving to a result-based approach in some specific places; Dwyer et al., 2024; Jones et al., 2021) and building in much-needed derogations (Short et al., 2020) it would be possible to ensure an adequate and responsive management of fragile environments in light of a changing climate.

In conclusion, the key to the future of the SFS success is likely to be the balance between the reward offered compared to the cost of adaptations that need to be made, for farms to enter. Preserving the strong socio-economic ecosystem of farms in the intermediate and upper uplands is likely to be important as well as steering them towards sustainability in order to ensure that farms multifunctionality can increase. The SFS, working alongside new regulations will compete with strong agricultural production drivers, particularly in the intermediate uplands where they represent strong agricultural development drivers, and with potential alternative market drivers in the upper uplands (e.g. carbon, water, renewable energies), all of which could encourage negative trends in respect of achieving the government's stated goals. Other producers that are likely to need the SFS are environmentally friendly farms that do not currently generate a sufficient income from farming; for which the proposed version of the SFS is not rewarding enough to enable them to survive. And whilst the most competitive and input-intensive systems in the lowlands are unlikely to be attracted into SFS, regulations alone may continue to lock them into business models that work against longer-term resilience and multifunctionality. If the course of the whole sector needs to be steered towards a more sustainable horizon, it is likely that some adaptation to the SFS offer would be necessary and worthwhile. Among key suggestions brought to together based on the research two stand-out: to simplify the universal layer and ensure good advisory support to applicants; to offer continued, bespoke support for organic farming; and to provide earlier and more detailed information, also enhanced funding, for the phased roll-out of optional and collaborative layers, to provide more confidence at this challenging time for the sector (Angell, 2007; DEFRA, 2023b). The more limited control on parameters leading to the delivery of expected benefits from farm action is not only a challenge for Wales but also more broadly for developed countries. In contemporary agricultural policy, the research has demonstrated that a joined-up approach bringing all existing tools in a cohesive framework of action is more likely to deliver on agricultural sustainability. It is particularly challenging when goals to achieve environmentally are legally bindings and ambitious.

B. Reflections on the research method adopted

Key challenges faced during the research journey are reflected upon in this section, first around the practical implementation of the research method before moving to the impact of the case-studies and the concept of multifunctionality.

1. Agrarian diagnosis method and multifunctionality

In the previous sections some of the challenges faced using the agrarian diagnosis and comparative agriculture as a research method were highlighted. This section will reflect on the use of the research method and its adequacy to evaluate farm multifunctionality. It will also highlight the key contributions from this research on multifunctionality.

a) **Assessment of multifunctionality**

The multifunctionality concept was useful as a first step to guide the selection of the research method, as the concept adequately reflected the WG's policy plans at different scales (Chapter 2). In practice the research method, the agrarian diagnosis was very farm-centric, as Chapter 4 and 5 acknowledged; there were strong environmental and economic links at the farm and regional scale but a relative lack of framing of socio-cultural information or behavioural elements to guide hypothesis validation for likely future change. That's why in Chapter 6 the research used the SEPLs concept as a frame of reference, it provided a set of criteria to analyse the socio-cultural data available within agrarian diagnosis interview, it was then possible to summarise which farm types where likely to be contributing the most to farm multifunctionality and draw conclusions at the regional scale. This 2-step approach in terms of research theme analysis and from the archetypes to the region, offered a possibility to draw findings based on a wider definition of multifunctionality. While there were some examples of systemic multifunctionality assessments taking an integrative view of the different functions in the literature (Groot et al., 2009; Parra-Lopez et al., 2009; Renting et al., 2009; Rossing et al., 2007), this stepped approach is a novelty and ensured a high level of scrutiny of the environmental and economic functions while

drawing some integrative conclusions at the farm and regional level which were not found commonly, with particularly nuanced insights across farm types and regions..

The agrarian diagnosis, by articulating the productive processes behind multifunctionality and the diversity of farms, provided potential routes to achieve the WG goals (e.g. an input reduction strategy for farms). Two key findings showed the value of this approach compared to studies based on secondary data: it was possible to highlight the risk due to interlinked production systems within a landscape; and to identify the newly differentiating production systems in Welsh agriculture which have hitherto received little policy attention. Case-study approaches often face reproducibility issues as findings are location-specific (Bitsch, 2000). This work challenges this vision as it has been proven that some trends identified in these case-study areas are evident at a wider scale (Cochet, 2015a)(e.g. the twin-track model of the farming sector). While the direct results from this work are not quantified for Wales as a whole, the basis of this thesis could be easily used to rigorously sift significant trends from broader media and secondary data sources, whilst also identifying region-specific factors. The agrarian diagnosis findings in the field of multifunctionality were validated using other data sources and particularly maps built using GIS software (combining existing datasets see Annex 4 Item 4-1 and Item 4-9), particularly during the landscape reading. Comparing the comparative agriculture findings to the outputs of other framework case-study methods in a similar area could have been insightful to reflect further on the agrarian diagnosis (e.g. as seen in Moreau et al., 2012).

In Chapter 2, it was shown that typologies of farms are a tool that is used extensively to assess multifunctionality (Darnhofer et al., 2005; Guiomar et al., 2018; Jouve, 1986; Nyambo et al., 2019; Zantsi et al., 2021), the archetypes coming out of the agrarian diagnosis were comparatively more defined (in respect of both agronomy and economics), as functioning archetypes. Fewer case-studies and archetypes could have been used but that would not have given such depth to the challenges identified, e.g. around the appearance of spring calving dairy farms or poultry farming within these landscapes, assessing their specific socio-economic structure and impacts (Chapter 5). But crucially, the agrarian diagnosis remains relatively deterministic in its approach with a limited focus on behavioural insights in the process to obtain today’s

archetype while the literature on farm changes has emphasized their key role since 1973, in terms of goals, values or preferences (Hill and Bradley, 2024). For example; although Cochet, 2012, linked the agrarian diagnosis approach to anthropology and more specifically to the definition around agrarian studies (Cochet, 2015a, p. 2) which examine the social, economic, and political dimensions of agriculture and particularly the importance of understanding agrarian transformations in historical and global contexts (Sarker, 2017). Although Chapter 3, 4 and 5 highlight the way the agrarian diagnosis considered these elements, as a frame for farm evolution (in an exogenus manner), similarly to what was found on socio-cultural aspects, some elements on behavioural insights can be found in the agrarian diagnosis interview data but does not have the same rigour as existing approaches in the literature on its framing. For example, the agrarian diagnosis would ask why a farmer might have gone towards organic farming compared to Mills et al. 2015 which explored the potential take up a range of AES options considering farms; willingness to adopt, ability to adopt and engagement. In the agrarian diagnosis it meant that the analysis was guided through identified sub-categories of behaviour those matching with farm types.

Particularly for recent transformations of farms interviewed, the agrarian diagnosis could profile the behaviour and values of farm operators by adding specific questions to the research method. It is not believed that it would significantly alter results, as each archetypes created did feature relatively homogenous farmers motivations due to the agrarian system imperfect framing of social dynamics and social capital. For example, the organic upland archetypes, were often held by precursors which were able and willing as well as engaged with their specific community, they had a positive attitude towards the adoption of scheme changes and taking up available opportunities. They held strong beliefs and while strongly connected with their communities their belief could be different. Those elements, part of the qualitative description of each archetype but not systematically organised were used to provide some insights into potential future changes. On the other hand, the focus on the farm income per family worker helped rationalise potential economic needs from the family unit. Of particular importance the focus on formulating hypothesis for future change was influenced by those factors but were also linked to the analysis of historical changes which helped ensured the accuracy of those. The agrarian diagnosis could

by using the existing data produce a rigorous farmer classification based on the analysis of socio-economic, cultural and behavioural element which could prove helpful to explain differences for the evolution of an archetype which might seem homogenous. This would improve the link between the agrarian diagnosis and social science methods with a more rigorous framing of outputs. Linke to this, a recommendation for the agrarian diagnosis method is to structure more strongly the interviews of the agrarian diagnosis as was done in this study (Annex 3 Item 3-1), we also suggest amending the method to make the interview more goal oriented by highlighting outputs, intermediate outputs and their format as done for example through Annex 3Item 3-1: Question list guiding the interview to understand a farming system this would help ensure that behavioural insights are captured.

In the evaluation of multifunctionality, standards were set to reflect adequately which types of farm change could be detrimental; for example, judging that agro-ecological and mixed farming were positive for multifunctionality (Garambois and Devienne, 2012; Ryschawy et al., 2012; Wagner et al., 2023), that poultry farms represented a challenge for the environment (Gerber et al., 2007; Godley and Williams, 2007; Gržinić et al., 2023) and animal welfare. Another example was the use of the SEPL concept to reflect the combined socio-economic, cultural, and environmental contribution of farms at a landscape scale. These judgments were linked to WG policy design; for example, on the economic side (seeking the survival of farms and relevant thresholds of employment and income; looking to added-value generation for a positive contribution, etc.), and on the agronomic side, considering the levels of nutrient loading on farms and its environmental implications. It has been demonstrated there is a clear articulation between farm processes and their multifunctionality (e.g. for environment or landscape, for the family and for employees) at the farm and the landscape scale, in turn generating an assessment of potential environmental, social and economic impacts at the national scale. The link shown by Gafsi et al., (2006), Hediger and Knickel, (2009) or Huang et al., (2015) between multifunctionality and sustainability was developed in this research. The interlinkages between the concept of multifunctionality and that of ‘social-ecological production landscapes’ in Chapter 6 discussion and analysis was identified and discussed.

b) Ex-ante evaluation

In Chapter 2, basing ourselves ion the criteria of an ex-ante evaluation 3 separate elements were considered as key to represent the scheme, the uncertainty and the risk surrounding an ex-ante evaluation:

- These interlinked elements; economic sustainability, environmental sustainability, and culture (inc. landscapes; Reed et al., 2019).
- The range of scales of application of relevant WG policies and other factors that might impact the diversity of farms (Chapter 1; Van der Ploeg et al., 2009).
- How past and future policies impact Wales at farm, landscape, and national levels to achieve policy outcomes (e.g. Devienne et al., 2019).

The insights provided by the agrarian diagnosis approach have validated the attempt at doing an ex-ante evaluation of a scheme using the concept of multifunctionality linking quantitative and qualitative findings. The interlinked economic, environmental and socio-cultural elements were brought together in Chapter 6, Chapter 4, 5. It helped highlight the impact of past policies on farm multifunctionality while chapter 7 and 8 considered the potential future impacts at different scale and where the SFS would be most relevant. Holistic, typified, farm-centric case-studies could be developed further, as this could be adequate to adapt evaluations to the government's broader goals and challenges highlighted by Knickel and Kroger, (2008). It provided strong links between farm practices and resulting impacts with a high level of granularity but also a high quantity of data which required time-consuming analysis which can be problematic in the case of time-sensitive assessments. The sensitivity analysis provided some insights into the level of uncertainty surrounding future contexts, but Chapter 7 showed that differing interpretations of policy documents could impact the result of scheme ex-ante evaluation modelling. A downside of the approach followed was the heavy focus on bio-economic analysis at the farm level which was required by the agrarian diagnosis to gain the necessary insights at the other scale of analysis (Cochet, 2015a). The analysis nevertheless highlighted risks and opportunities for the future scheme in its current form but also within the future environment. The chapters which considered the past and present agricultural ecosystem informed this risk analysis and were crucial to identify likely future evolution. Based on these steps and as described in the

comparative agriculture method the research suggested agricultural development hypothesis and in this case resulting multifunctionality impact (Cochet, 2015a; Hugonnet, 2018).

Another step which could have been insightful and was recommended by some of the literature on evaluations would have been to return to visit interviewees to discuss these hypothesis of potential farm changes discussed in Chapter 7 depending on the SFS potential changes (Coderoni et al., 2021; Little et al., 2024; Madureira et al., 2007). As it is the hypothesis have as a result a more limited significance. This was not done due to time-constraints, the timings of this step of the research would have also clashed with debates and the co-design exercise around the SFS universal debate which could have been challenging to do given the opposition (Welsh Government, 2023d). This would have required a more rigorous assessment of behavioural factors, for example as done in Chivers et al. 2022b and Mills et al. 2015 on bTB vaccinations options. At this stage of the research other methods could have been brought in to ensure the accuracy of the research findings for example, ranking the importance of likely driver of changes or the reaction to specific scenario (Brown and Castellazzi, 2014; Chivers et al., 2022b; Coderoni et al., 2021; Farmar-Bowers and Lane, 2009; Singh et al., 2016). Although of particular importance, there was limited time to implement these specific steps given the exhaustiveness of the analysis pursued across scale; times and the heavy focus on bio-economic factors, which were often perceived as determining strongly future evolution (Cochet, 2015a). No such study of behavioural factors across exhaustive and large case-studies combined to a deep understanding of bio-economic, historic and sociological elements has been found in the literature; the samples are smaller and are often focused on specific landscapes/farm-types and a specific policy issue (Blackstock et al., 2010; Dessart et al., 2019; Mills et al., 2017; Morse, 2021). Further steps could have considered the knock-on consequences of those changes (e.g. serious games) with potential alternatives for policy adaptation or discussions of necessary compromises required; with interviewee and policymakers (Brown and Castellazzi, 2014). This could have been pursued more effectively if policy plans had been more focused as such the broad approach of the SFS at the time the fieldwork took place was limiting, this was

often the case in discrete choice experiments considering the appeal of policy changes (e:g: Madureira et al., 2007; Schulze et al., 2024).

2. Partnership with the Welsh Government

The partnership that led to the PhD being possible provided some key insights for the research at strategic times, for example to help choose case-study areas at a time when policymaking was still in development, or to help refine the hypotheses to assess the future scheme. It is noted that many findings shared had not been much highlighted to policymakers before; for example, the concepts of technological lock-ins or the development of spring calving dairy systems. However, limited frequency of discussions and the lack of clearance or a clear secondment structure probably led to limited feedback and integration of the research processes within the key policymaking decisions. Reflecting on other partnerships (e.g. other students secured direct policy secondments), there often was a clear deliverable which was supervised closely by each organisation, through to the point of editing (e.g. Hafferty, 2022; Morse, 2021). Also, these commissions/partnerships were more specific and on a shorter timeframe (six months to one year), which may be more in-line with the pace of policy-thinking, than a full PhD. However, given the broad nature of this commission, a shorter timescale was not a possibility[72]. Covid as has been discussed delayed the research process which of course might have reduced the interest and the potential impact in the exploratory research, which is usually done at the early stage of the policy design. COVID-19 with the lack of in-person meetings from the very start of the PhD prevented informal discussions and the development of relationships; so as better to understand the needs, and challenges within the WG.

In other words, and in-line with my subsequent experience in DEFRA and similar feedback from other researchers working in policy, I believe that although my longer-term and broader research has proved useful to policymakers, further integrating the research process (possibly with a secondment or internship) and ensuring regular commissions would have facilitated a more significant impact. Something of interest

[72] The role was after all to analyse the likely results of an uncertain event over a 3-year period.

could have been to discuss writing potential factsheets on specific topics, in a specific format that would have been useful to policymakers. It is likely that the lack of integration prevented some exchanges of more significant insights and steers. In other words, the PhD structure was possibly a bit late to deliver at an adequate time for policy makers, the structure retained could have been adapted.

3. Adaptation to COVID

The agrarian diagnosis method was adapted to the COVID context, as COVID rules spanned part of the PhD fieldwork from March 2020 (as shown in Chapter 3). Moving to a hybrid method of research the research to proceed during COVID, but it meant that the data gathering phases took longer than expected, as it was less easy to snowball and recruit new participants than first anticipated. Retired farmers were the hardest category to reach. In the Pembrokeshire case-study where COVID was not an issue, the total number of participants was much higher compared to other case-studies (91 interviews in five months compared to around 60 in in at least seven months). It was also felt that it required further work to reach stakeholders who were less put forward by the community (e.g. as shown in Hurley et al., 2022). More broadly linked to this, the fieldwork was hit by a general 'stakeholder fatigue' due to a perceived lack of results and impact (Fieldwork; Hurley et al., 2022) but also usual long lead in time to show impact (Fieldwork). A PhD where impacts can be perceived as intangible can make it more difficult to attract participants. By ensuring that existing results were shared as soon as possible and that new results were made available as soon as possible or participating as much as possible in impactful opportunities (e.g. WG consultations), the research design attempted to counteract this feeling. Future research should endeavour to share results by post in addition to the usual media routes (e.g. older participants) and -if possible- in-person feedback.

I had to adapt my interview method, over the phone, by familiarising myself with the area beforehand to make the most of the discussion. Interviews over the phone were shorter due to participants' fatigue, with the necessity to prepare[73]. I have covered

[73] Looking at CAP Payment data, analysing the geology, satellite photos or landscape maps…

some of these risks and opportunities in Chapter 3. The research method is intensive in data and interviews and in the COVID period it required more effort to maintain the quality of the data to ensure an accurate analysis. Nevertheless, given the systemic vision behind the method, it was possible to quality assure all interviews by cross-checking the economic and agricultural science perspectives (and if necessary, ask the interviewee for clarification). In retrospect, the PhD project was only marginally adjusted compared to the experience of other PhD students at the University of Gloucestershire (Chivers et al., 2022a; Hafferty, 2022; Rahman et al., 2021); but the research questions, the scope of the study and even the number of participants were constrained by the agrarian diagnosis research method, as the requirement to achieve a high coverage in terms of interviewees in a limited area, in a limited timeframe, was more challenging due to Covid. There were also more limited options to network and improve the research design with fellow researchers, although steps were taken to engage more deeply in online conferences, as a result.

Trust in different institutions was also a problem: farmers often mentioned feeling at odds with the WG orientations or some aspect of farming debate polarisation (e.g. as seen in Davies, 2023; FRC, 2023.; Michael and Matt, 2009). To ensure the necessary range of farms could be interviewed, different facilitating organisations were contacted (Chapter 2).

C. Future steps for this field of research

After reflecting on the PhD research journey, this section will now consider what possible future research could be taken forward to further assess the impact of the SFS on Welsh farming and its multifunctionality. This will first discuss a driver that has been under-researched but plays an important part on driving farm changes: the land market. I will then suggest potential routes of research to improve data collection tools. Finally, the need to effectively pilot reactions to the SFS will be discussed, as well as the suggestions made regarding its adaptation.

1. The land market and farm succession

Land, recognised as one of the fundamental production factors in agriculture (Cochet et al., 2007), has played a pivotal role in shaping farming practices and structures throughout history (Hodge, 2016), from market organisation (Gibbard and Ravenscroft, 2019) to property rights (Roberts, 2018). The post-war era witnessed a concerted effort to boost agricultural production by promoting family farms and implementing tenant-friendly tenure frameworks (Hodge, 2007). However, concerns over land scarcity and high prices emerged (CAAV, 2005; Savills Research, 2020, n.d.), particularly in Wales, where a dense network of small family farms prevailed. The 1980s ushered in a period of liberalisation in the UK, with successive governments adopting more landlord-favourable tenancy laws to address land supply shortages (Lenormand et al., 2021b). Despite these policy changes, the impact of the liberalised land market on farm change and sustainability remains under-researched, with Brexit as a new challenge in the agricultural property landscape (Hodge, 2016; Morse and Lenormand, 2021).

The liberalisation of the land market in the UK may have had significant implications for farm structural change. Subsidy decoupling and policy shifts have contributed to rising land prices, driven by agricultural subsidies along traditional supply-demand dynamics (Ciaian et al., 2018; Savills Research, 2020). While farm consolidation and specialisation have occurred, access to land has become increasingly constrained (CAAV, 2021a), particularly for newcomers to the industry; which could constrain the future sustainability of the sector (Sutherland, 2023, 2014; Zagata and Sutherland, 2015). Competition for land now involves a diverse range of stakeholders, including large corporations, financial investors, NGOs, and philanthropists, each with distinct objectives for land use (Dwyer and Hodge, 1996; Munton, 2009; Sutherland, 2012). Despite this complexity, existing literature tends to overlook the nuanced dynamics of the land market, focusing instead on broad supply-demand analyses (Střeleček et al., 2010).

The evolving land market poses challenges for future agricultural policies: firstly tenants' access to future schemes has been in the spotlight (Kay, 2022; NFU Cymru,

2024); secondly, although the WG's Sustainable Farming Scheme aims to promote economic, social, and environmental sustainability, the role of the land market in shaping farm change is not considered. Access to land, a critical barrier to entry in farming, has not been officially recognized as a policy issue, despite evidence suggesting its importance (LANTRA, 2022; Welsh Government, 2019b). The absence of comprehensive research on the impact of the ‘liberalized’ land market hampers policymakers' ability to develop targeted interventions to address farm viability and sustainability (Zagata, 2017).

Moving forward, there is a pressing need for new empirical research to better understand the complex dynamics of the land market and its implications for farm viability and sustainability. By bridging the gap in both academia and policymaking on this key topic, stakeholders could work towards fostering a more resilient and inclusive agricultural sector in Wales.

The challenge of farmer retirement and succession in Wales is pressing, with implications for the viability of Welsh agriculture. Williams, (2015) notes a worrying gap between new entrants and retiring farmers, highlighting the urgency of succession planning. Retirement involves a gradual exit, often with uncertain succession plans, that is especially challenging for small farms (Fieldwork; Rona, 2011). Succession planning is crucial not only for economic reasons but also to preserve Wales' farming culture and communities (as seen in Baker, 2012). Access to land is a major hurdle for new entrants due to the fragmented tenancy market (Williams, 2015; CAAV, 2021a, 2021b), and succession planning complexities include production factors and new regulations (Ingram and Kirwan, 2011).

The evolving agricultural workforce further complicates succession, with a gap arising between knowledge as provided in agricultural education, and that gained from traditional farming practices (Nye et al., 2020). Aspirations among potential successors may not align with the realities of small family farming, contributing to a dwindling pool of individuals willing to take on agricultural enterprises (Laughton, 2017). Addressing these challenges is critical for the future of Welsh agriculture, ensuring that socio-ecological production landscapes delivering multifunctionality can still be supported. The WG has removed specific new entrants support from its future

policy agenda. I would suggest that research to demonstrate the potential impact of a stronger policy focus on new entrants would be very worthwhile, in the case of Wales.

In conclusion, investigating the challenges created by the land market dynamics, property rights, farmer retirements, farm successions, and access to labour in Wales requires further research to understand to better understand the gaps in respect of what will be needed to truly address the WG goals for farming. Combining different land uses in one nation can lead to challenges, all the more given conflicting time and market pressures, they sometimes end up being competitive and exclusive (House et al., 2010; Manzoor et al., 2021), a manner to arbitrate is by using mechanisms of the land market and property rights (and obligations attached) (e.g. as seen in Munton, 1995; Quinn et al., 2010).

2. Developing legacy tools to monitor the agricultural sector

The research showed that the current statistical tools missed key trends of agricultural development that have impacted farms ecosystems and farm diversification in Wales. Both the Farm Business Survey (FBS) and June survey only captured changes as the emergence of spring-calving dairy systems and the growth in poultry units on livestock farms in a limited manner (O'Regan et al., 2019; Welsh Government, 2020a). Significant insights were brought to light by considering part-time farmers and early developing systems, these farm development trends represent a challenge to existing data collection to effectively monitor farming change. A few suggestions are offered, here, to address these challenges.

Capturing better the potential of livestock kept on a farm could be helpful, current surveys estimate cropping farms' output, this could be achieved for livestock farms as well (European Commission, 2020; Welsh Government, 2020a). For example, considering the different types of animals could be interesting, a Texel ewe is not as demanding as a Welsh Mountain ewe, two lambs produced do not have the same economic potential or cultural significance (Beynon et al., 2012). Similar livestock numbers might hide significantly different evolutions: a 60 dairy cow farm might have

a yield of 5000l/year/cow or 10,000l/year/cow. Statistics available do not inform accurately on the production process and how farms differentiate. Every analysis of the farming sector relies on these elements, and this could make a significant impact. Although there are clear time and financial constraints for farm surveys, this could be done efficiently while maintaining comparability with past data. Considering some options could be a worthwhile exercise. Building on this, it is likely that producing some typical farms, reflecting the existing farm diversity within the statistics, and representing different levels of production could be a fruitful exercise (e.g. developing the approach seen in O'Regan et al., 2019 with broad environmental conditions and the level of performance).

It will be increasingly important to capture diversification activities on farms in future, including forestry (as is done for crops) as these elements are likely to be the focus of many discussions, especially if a land use framework is necessary. Linked to exploratory work on the land market, Lenormand et al. (2021b) noted the relative lack of data on the tenanted status of farm, and this thesis showed the fact that it was likely to be highly relevant to understand farm changes. Understanding the tenure security or the type of farm structure is extremely relevant to the type of public goods that could be expected.

Economically, reviewing the current Farm Business Survey (FBS) in a similar spirit could yield results. The FBS represents a unique opportunity where with limited effort, it would be possible to better understand farm differences, connected farm processes, land uses and their economic results. For instance, instead of asking for the raw product of milk sold, asking for the litres and the price. Similarly, moving one step closer to a practical farm process for machinery and equipment usage would be helpful. No research has been done on the steps that could be taken at limited cost to reflect the differing strategies in terms of income/capital maximisation in general, for example for tax purposes, which might help explain capital expenditure (Fieldwork). The FBS in Wales only includes 539 farms in 2020, it captures farms that are above 1

S.O[74]; it remains a small sample compared to the 25,000 farms in Wales. Including small farms, at least in a small sub-sample, could reflect dynamic sectors and innovative approaches. Finally, including other agriculture and forestry land uses as well as farm diversification strategies in broader detail is likely to be another important factor to consider in the future. In Wales the FBS population represents approximately 10,000 farms covering 93% of the sector's standard output, but it remains far removed from the 24,500 total farm number (Welsh Government and Statistics for Wales, 2023).

The WG did some research on small farms to better understand their motivations and the benefits coming from them; this effort could be further developed. Part-time farmers represent 55% of farmers approximately and the average farm is smaller than in England; in Wales they control a lot of land (Bradley, 2021, p. 5). It has been highlighted that small farms can play a significant economic role (Aragón et al., 2022; Guiomar et al., 2018; Lécole, 2021; Lécole and Thoyer, 2022). Effectively, there is still a gap in the data collection on a rolling basis for this significant side of Welsh Agriculture.

A further area of research would be to develop the understanding around farming's multiplier effects, and particularly what is contributed by agriculture that is not captured adequately by existing statistics. (Welsh Government, 2019). Improving these surveys and their participation whilst better explaining their value to the farmer will be an area of progress for governments and researchers alike.

3. Piloting the SFS and policy options

The Sustainable Farming Scheme and the proposals to amend it have not been assessed in practice or put forward to farmers and policy makers; there has been no time to get back to farmers to test the suggestions made on the SFS design. Future research should aim at assessing the value of these proposals; a first step could be to assess the challenges and opportunities to the SFS, particularly its uptake, as without uptake it is unlikely that the SFS will have an impact. In previous research, an

[74] Or £25,000 of average monetary value of the agricultural output at farm-gate price

investigation was carried out with colleagues on the reaction of farmers to potential future scenarios for bovine tuberculosis vaccination in cattle and badgers, with a social-science approach (Chivers et al., 2022b; Maye et al., 2023) A similar approach could be used, based on the Easy, Attractive, Social, Timely (EAST) framework to obtain behavioural insights guiding policy, with points that are likely to influence stakeholders (Service et al., 2015). This could identify what would be a workable compromise by highlighting key elements that might hold back scheme uptake. If this approach is taken it is likely that it would show that the tree planting measure was not perceived as easy or that the rewards anticipated were unlikely to be worth the compromise in farmers' eyes. This could also create a new dialogue on the subject giving leads for ambitious policy adaptations (Chivers et al., 2022b). This work could provide significant results to test what farmers and land managers would be likely to adopt.

An under-researched area in the current scheme development but also more broadly in policy discussions has been the potential role of collectives in future schemes. Not only collaboration could deliver potential economic benefits for example by selling products together (DEFRA, 2021a; Maye et al., 2016), creating and maintaining complex environment (Morse, 2022) it can also help drive the agro-ecological transitions (Lécole and Moraine, 2021). While in this thesis, the individual has been at the forefront of the analysis, the crucial role that collectives of farmers already play was identified in the Welsh countryside (Short, 2008; Urbanc et al., 2023). Research on the subject could be taken forward by investigating how collectives feel could deliver more for their territory building on existing programmes to develop them, combine them and integrate them in the SFS; the facilitation fund (Breyer et al., 2022), the LEADER program (Konečný, 2019) or the work made on payment by results in environmentally significant locations (Ciarán et al., 2020; Jones et al., 2021). Combining these elements to design an adequate collaborative layer of the Sustainable Farming Scheme could help empower communities with positive results.

Conclusion:

To conclude, the concept of multifunctionality proved adequate to guide the selection of a research method which provided a clear understanding of farming in Wales and assess whether the future Welsh agricultural policy would be successful. The research questions aimed to assess if the WG scheme was likely to help achieve the goals that were given to it. It is unlikely that the SFS as presented in 2022-2023 will be a strong influence steering farms towards greater sustainability. In areas with high added-value agricultural enterprise, these were likely to represent the most significant influence. Areas close to urban areas or tourist areas have more farms with non-farming activities that are likely to be more significant in influencing farming change. Worryingly, a clear gap exists in the current support plans of the WG, in respect of several types of farms that already deliver high multifunctionality (e.g. organic farms, mixed intermediate and more extensive farms with low added-value). This gap could lead to a significant contraction in overall farm numbers across Wales, as suggested by Moxey and Thomson, (2023), although this chapter does not suggest that the reduction will be as significant as almost 22% of Welsh farms, given the other income-generating opportunities available to existing farms. Potential avenues for the adaptation of WG policy to better meet its own goals for agriculture were suggested. The main suggestion was to adapt the SFS into a simpler two-tier policy, where the universal layer could focus on a simpler and shorter range of outcomes from which clear benefits could be demonstrated, also making sure rewards are adequate for the level of management required. The second key suggestion was that a more joined-up approach across all policy tools available to the WG (regulation, taxation, incentives, property rights, etc.) would signal a clearer pathway towards sustainability in all these aspects.

The SFS could deliver some benefits, but in its current form and in the current market context which is driving sector evolution in directions which will not lead to more multifunctionality, it risks facilitating a contraction of the Welsh farming sector. This would take place via a twin-track pathway of large and high added-value farms with low social and environmental benefits, versus small (economically) and non-commercial ones which provide public goods but little added-value. This is a broader

issue: in the EU as well, current agricultural policies are not deemed sufficient to steer the sector towards sustainability (Théo Lenormand, 2023; Matthews, 2018) and have been met with opposition from farmers (Alcock, 2024); who often criticise a lack of balance between the rewards offered and the conflicting demands placed upon them (e.g. as seen in Alcock, 2024; Collas et al., 2023; Slee et al., 2014; Turck et al., 2023). Further research is likely to be needed to supplement this work and increase understanding of farming systems and the issues preventing Welsh agriculture from reaching sustainability and higher multifunctionality. Critically, improving data collection to reflect the changes that the sector is going through, should be a priority. Understanding land market impacts is another area that could enable a better joined-up approach in policy. Piloting and analysing the potential of the SFS and its adaptation will also be valuable. If these challenges can be addressed, the SFS could be a successful, systemic policy delivering an increase in multifunctionality and signalling a clear course towards sustainability with rapid results and limited (or no) farm losses, it could represent a timely blueprint for other developed nations. This research highlighted the potential key role of systematic and rigorous holistic case-study analysis to analyse the impact of policy changes on agricultural development.

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Annexes

Annex 1: Review of challenges linked to Brexit

Item 1-1: UK and Wales food production and reliance on import (by the author from literature and secondary data)

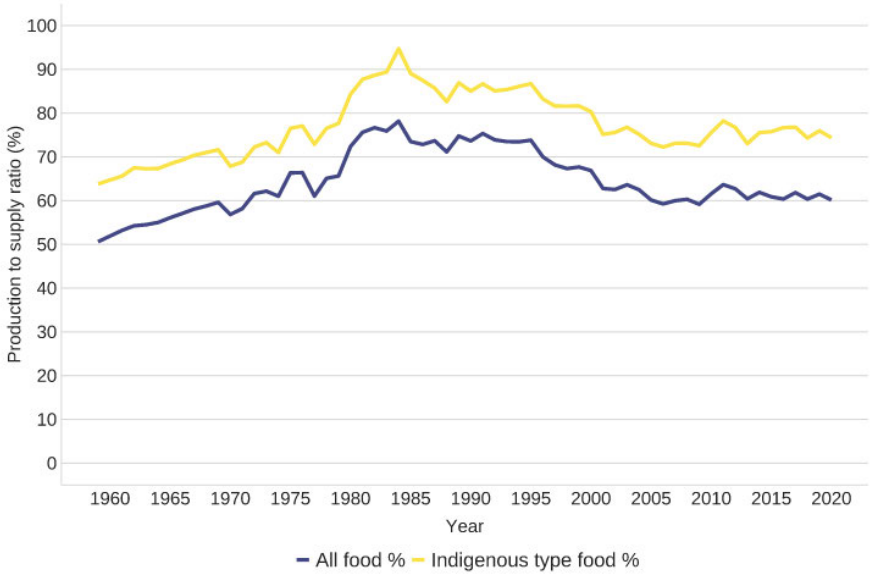
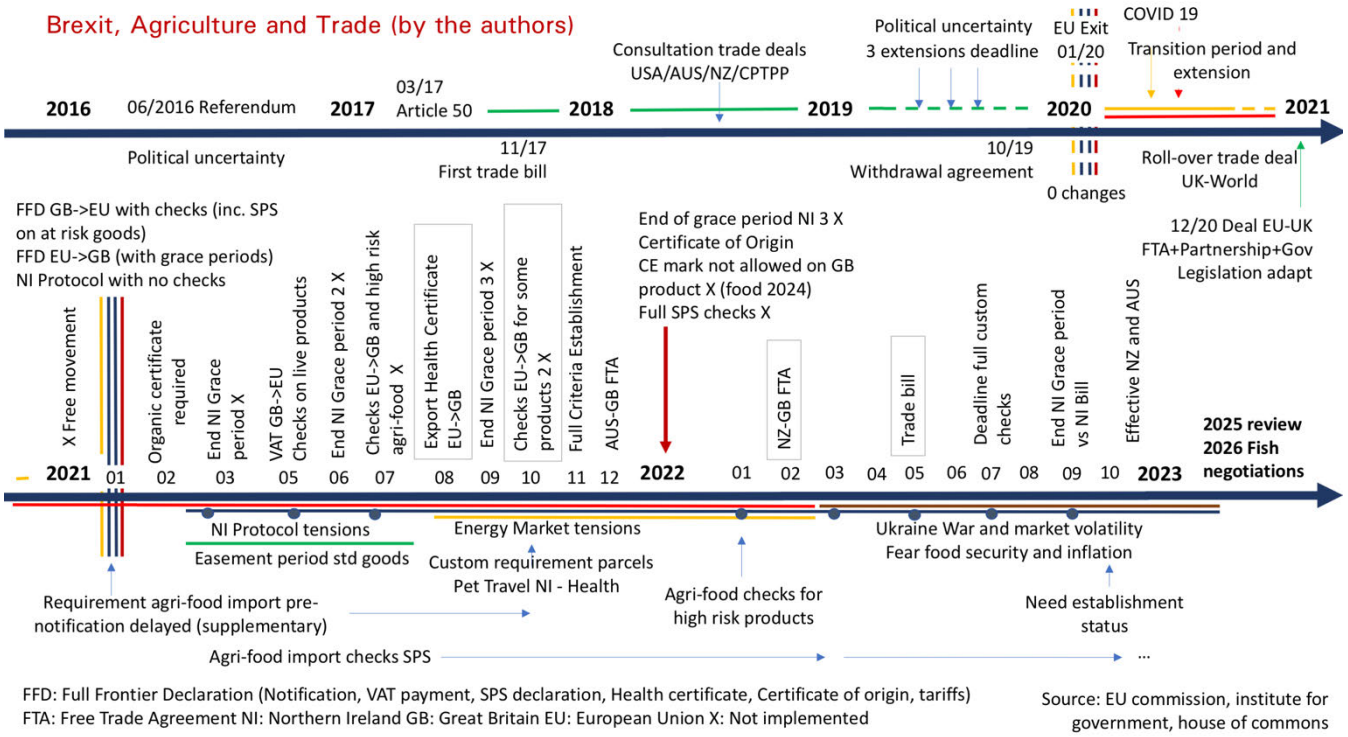


Figure A 1: UK food production to supply ratio (Defra Agriculture in the UK, 2020)

The focus on food production in the past did not particularly benefit overall food security in Wales. The Defra Food Security Report (2021) highlights a sector that provided at most 93% of UK indigenous food (78% total) but has now gone down to 75% (60% total; DEFRA, 2021) . The UK is particularly self-sufficient in meat products, with Wales exporting a large proportion of them, but less so in fruit and vegetables. Fertiliser and pesticides that bolster local food production tend also to be mostly imported. Even though their use has gone down, they remain at relatively high levels compared to the 1970s and since 2005 no reduction has been witnessed (DEFRA, 2021c). Horticultural and vegetable production are only a marginal part of total production in Wales (StatWales, 2020). The agricultural sector's past focus on food production has only been partly successful in improving food security. For example, the profile of production does not align with nutritional recommendations (Dimbleby and et al., 2021).

Item 1-2: An updated timeline of the UK-EU relationship will be added by the final publication (by the author from The Institute for Government, 2021; Walker, n.d.)



FFD: Full Frontier Declaration (Notification, VAT payment, SPS declaration, Health certificate, Certificate of origin, tariffs)
FTA: Free Trade Agreement NI: Northern Ireland GB: Great Britain EU: European Union X: Not implemented

Source: EU commission, institute for government, house of commons

Item 1-3: SWOT analysis around UK trade and agricultural policy (by the author from literature)

Strengths	**Weaknesses**
0 tariff on all goods (EU-UK FTA) Similar Sanitary standards for now (EU-UK FTA) Continuous recognition of Designations of origins The UK agri-food sector answers local demands (Defra, 2021) UK agri-food producer have concentrated in the last couple years with productivity gains (fieldwork). Green box WTO for future policies	SPS checks and increased paperwork for agri-food products one way (EU-UK FTA) UK government vets spending on agricultural policy of devolved nations Difficulty to source alternative agri-food supply channel on production of which the UK relies on (Defra, 2021) Removal of UK quota/tariffs on competing countries in terms of agri-food productions Reduced weight of devolved state in the UK parliament and government in the future
Opportunities	**Threats**
Opportunities to export high added-value agri-food product. Possible import substitution (Dwyer, 2018) Possibility to implement innovative policies or have different policy goals (Welsh Government) Policy subsidiarity (Defra ELMs) or use co-development tools to design more adapted schemes (Welsh Government) Strong agricultural commodity market (low productions) with a sustained outlook limiting pressures from imports (AHDB market outlooks 2022).	Risk to UK food security and increased cost for consumer once full border control are in place from EU to UK (UK government, 2022) (Appendix 2) Risk of competition and price undercutting by other nations with competitive advantage/subsidies Risk of structural adjustment as a response among farms (Dwyer, 2018) Risk that the UK government will reduce agricultural spending in the next parliament

Item 1-4: Impact of the COVID crisis on farming (by the author from the literature)

Covid19 started impacting agriculture through the public health response of governments. Lockdowns had a significant impact on food production systems[75]. During the initial months, consumption patterns adjusted to the new stay-at-home lifestyle, prompting food retail channels to adapt. Lockdowns tended to maintain the needs in terms of consumption, while output decreased slightly (Coleman et al., 2022; Harapko, 2023). Even with the relaxation of COVID-19 rules, labour availability issues disrupted the supply chain, impacting the input provision for farms and processing (Guilbert et al., 2022; Ring, 2021)[76]. Fluctuating global food demand prompted short-term responses (Coleman et al., 2022; Ranta and Mulrooney, 2021). The food markets and supply chains tried to adapt to changing consumption patterns, leading to temporary over-production (Lenormand and Dwyer, 2022). For example, the milk sector in Wales faced short-term challenges (price, milk collection) but in general, dominant demand market trends rapidly resumed, resulting in increased prices (AHDB, 2022c, 2022b; HCC, 2021). The cost of energy had already started to rise because of limited prospects for additional supply – partly due to capacity cuts during the height of the pandemic (Birol, 2022). Other supply-chains witnessed gradual price increases because of shortages (e.g. electronic components).
This crisis also had profound macroeconomic and political implications, marking a shift from the austerity measures prevalent in public life since 2008 (Arrieta, 2022). Governments in the West increased their involvement in the economic and social aspects of their countries (Stiglitz, 2021). Quantitative easing measures implemented by central banks in developed countries since 2008 were reinforced to prevent a widespread financial crash (Ferragina and Zola, 2022). The pandemic changed the political vision as interventionist policy by governments was rekindled (Stiglitz, 2021). The pandemic highlighted the vulnerability of existing supply-chains to large shocks and the potential vulnerability of existing farms (e.g. Lenormand, 2021).

[75] These effects were monitored effects in the author's blog in the market news section (Lenormand, 2020)
[76] Exacerbated by Brexit

Item 1-5: Impact of the Ukraine crisis on farming (by the author from the literature)

The economic recovery from COVID was quick (Bank of England, 2022) but hampered by COVID19-related short-term decisions (e.g. on energy prices). Agriculture has faced the consequence of an armed conflict between two major actors in global commodities markets. The consequences have been deep and far-reaching across the world as sanctions have been enacted against Russia.

Since the 1990s both Ukraine and Russia have developed their market economy and transformed their farming very much following the doctrine of comparative advantage (Bazin and Bourdeau-Lepage, 2011). These countries export cereals – mostly to the middle-east, Asia and Africa - as well as poultry to Europe (Mathieu, 2022).

Table A 1 : Share of World exports in % for countries involved in the Ukrainian conflict (by the author from secondary data: Mathieu, 2022; USDA, 2022)

Share of 2018 World exports in %	Russia	Ukraine
Wheat	22.7	8.5
Maize	3.3	14.6
Oilseed Rape	1.5	11.2
Sunflower Oil	17.4	46.2
Oilseed Rape Oil	6.7	2.0
Share of 2020 World exports in %		
Fertiliser grade ammonia	Ukraine, Belarus and Russia	45
Potash		40
Share of 2020 Oil Consumption in %		
Total Oil	Russia	11
Total Gas		17

Both large nations possess significant fossil resources, such as fuel and metals, although these resources are primarily unprocessed (USDA, 2022; see above). Due to the conflict short-term shortages of gas and diesel[77] emerged. The supply chain has had to readjust to this new challenge, leading to shortages and increases in prices (FAOSTAT, 2023; World Bank Data, 2022).

[77] Vital inputs for agriculture

Table A 2: Prices evolution for a range of agricultural inputs and outputs (by the author from secondary data; USDA, 2022; FAOSTAT, 2022; World Bank Data, 2022)

Product	5 Year Average*	Early 2022*	Estimate spring 2022*
Red Diesel	60p/l	80p/l	+30-100%
Fertiliser	280£/T	647£/T	+30-100%
Wheat	150£/T	220£/T	+30-100%
Oil Seed Rape	320£/T	580£/T	+30-40%
Milk	27p/l	33p/l	+10-15%
Beef	350p/kg	405p/kg	+10-15%
Lamb	430p/kg	600p/kg	+10%

The energy price rise highlighted the sector's heavy reliance on fossil fuels, particularly for fertilisers (see above). As a result, farmers tried to reduce their fertiliser usage due to rising energy costs. This inflationary context prompted increased government action but rising interest rates (done by central banks to mitigate the inflation) limited government borrowing capacity. Financial markets became more volatile, emphasizing the importance of prudent public spending management and a return to government financial heterodoxy and spending control (Hoddinott et al., 2022; Munchau, 2022).

The ongoing conflict in Ukraine has no immediate resolution, but sourcing replacement commodities has alleviated fears of shortages, leading to partial price reductions (. Retail prices in the UK's food sector have increased, but this has not fully translated along the supply chain as supermarkets aim to contain reduced consumption and protect their market position (e.g. Glover, 2011). Currently, farmgate prices for farmers are stagnant or slightly decreasing, due to reduced consumption (AHDB, 2023c, 2023a; HCC, 2023). Western nations shared common responses to the economic challenges posed by both COVID-19 and the Ukraine conflict. Crucially, in the EU and UK, food production and farming have not received significant additional support, and subsidies have declined in real terms. Despite predominantly being consumed domestically, UK agricultural output and inputs are still tied to global price fluctuations (HCC, 2023) with a direct impact on Welsh farm economics.

Item 1-6: Potential impact of Brexit on supply chains and Welsh farms (by the author)

- Dairy the main income generator in Wales:

Wales faces a challenge in its dairy industry with 298,000 dairy cows producing 1.8 million litres of milk but lacking sufficient processing capacity. Most of the milk is exported, primarily to the EU, which accounts for 75% of the UK's dairy imports, including butter, certified designation cheese, and some fresh milk (Bakker et al., 2022; DEFRA, 2021d). Dairy production in Wales focuses on liquid milk, cheese (mozzarella, cheddar), and fresh dairy products. While 55% of the production is processed in Wales, 36% is exported as butter powder, skimmed milk powder, and milk concentrate (Gooderham, 2021).

The Welsh dairy industry has experienced significant changes since the introduction of milk quotas in 1984 and the subsequent privatization of the MMB. This led to adaptations by farmers through new milk contracts tailored to supply chain needs (AHDB, 2023c; Finney, 2021). Although there have been some supply-chain developments in Pembrokeshire, Ceredigion, and North Wales, dairy farms are often distant from processing plants (See below; AHDB, 2020). Brexit has added complexity, with EU firms like ARLA and Müller having partial control over the Welsh dairy sector. The British market is highly specialized, with specific farm milk specifications and limited transfers between processors, tailored to supply chain requirements. Brexit and market fluctuations have created uncertainties, impacting dairy farming trends in Wales. Price fluctuations in inputs and outputs, varying across processors and responding to different markets, further complicate the industry landscape (AHDB, 2022a). The research aims to comprehend this diversity in organizational structures and operating models within the Welsh dairy sector.

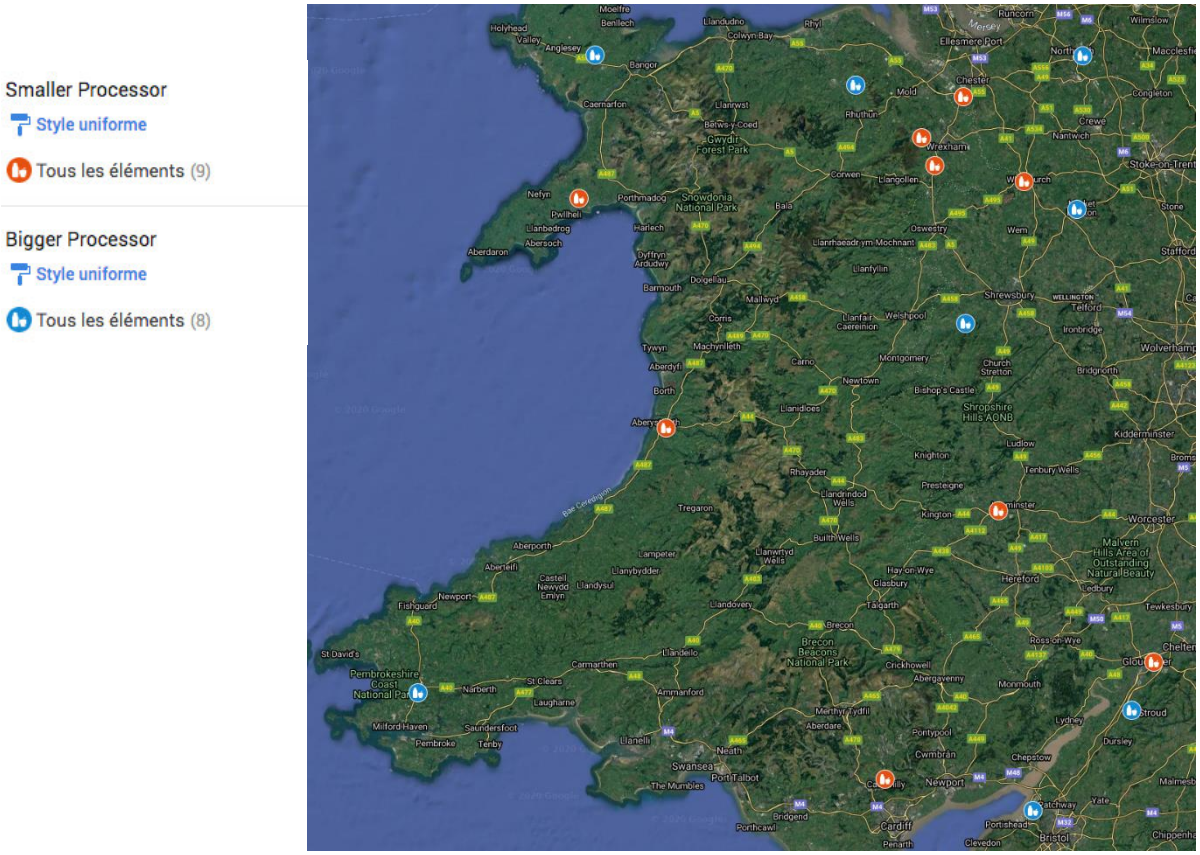


Figure A 2: MyMaps repertory of Dairy Processing Units in Wales (by the author from AHDB, 2020)

- Meat production the largest land use in Wales:

The Welsh meat sector exhibits high specialisation and concentration, with ABP and Dunbia serving as the primary meat processors (Fieldwork). The number of abattoirs has significantly reduced. Livestock markets now share farm output with contracted suppliers, catering to dedicated supply chain products, including organic and Morrison's products (HCC, 2022).

In the beef market, the UK is 89% self-sufficient and exports a significant share of its production to the EU, which constituted 90% of its exports (HCC, 2022). The cattle market can be divided into two segments: fat beef for slaughter with some direct contracts and a crucial store market for young animals of varying ages. Livestock markets play a pivotal role by balancing growth among farms with different agro-ecological and finishing potential. The two major trading seasons for both beef and stores are spring and autumn. Beef production is distinguished by the valuation of

carcass parts, with minced meat differing from the more valuable sections of the carcass.

Regarding lamb, the market primarily targets exports, with 95% of lamb being exported to the EU (HCC, 2022). Lamb production is tailored to the spring market, spanning over a few months with higher prices or extending nearly a year to accommodate finishing all lambs or selling stores/breeding stock. The lambing date and the farmer's ability to manage lamb growth and animal retention determine the production approach.

Each livestock market tends to focus on a specific area and product. Although auction market coverage has diminished, it remains relatively good (See below). Market density is higher in areas with a denser farm network and higher output. The limited number of abattoirs complicates the possibility of direct sales. Seasonality plays a vital role in the Welsh meat production sector for each farmed area. Notably, there does not seem to be a clear premium for out-of-season slaughter in previous interviews. Therefore, the nature of markets varies significantly between locations like Dolgellau (for stores beef), Bala (for light sheep), Rhayader (for light and heavy sheep), or Raglan (for diverse products)(Fieldwork and AHDB, 2020).

Similar to the dairy markets, there have been numerous price fluctuations in this sector over the last three years, with the variations often tied to the type of output possible within specific agro-ecological conditions (HCC, 2022).

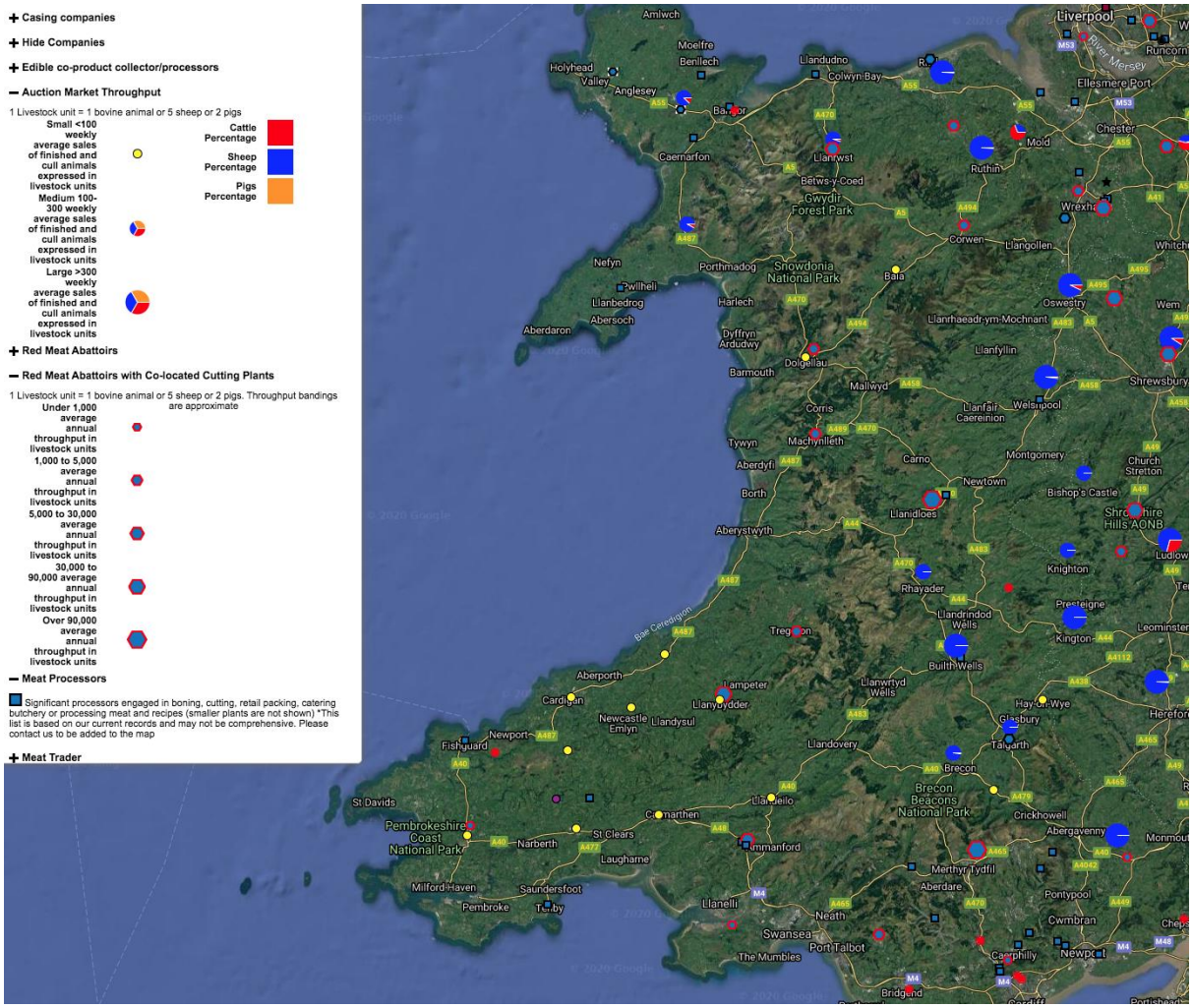


Figure A 3: eFoodChainMap for Wales with auction markets and abattoirs location (AHDB, 2020a)

Annex 2 Welsh Government plans for the Sustainable Farming Scheme and consultation document

Item 2-1: Welsh Government, Agriculture Wales Act (2023) goals and pledges that should be achieved by future policies Welsh Government, 2023)

Welsh Government, Agriculture Wales Act (2023) sets out the structure and powers necessary to ensure:
- Wales fulfils its international environmental pledges. - Farmers receive support to produce high-quality food and other goods sustainably. - Actions and outcomes that mitigate and adapt to climate change are encouraged. - Our rivers, soils, and wider ecosystems are resilient, diverse, and healthy, and biodiversity is able to flourish. - The significant role of agriculture in conserving and sustaining our culture and language is reinforced. - Promotion of opportunities to access our countryside and its benefits, balanced with the needs of the farming community.
The support for the agricultural industry will contribute to multiple Welsh Government commitments including:
- Keeping farmers on the land producing food in a sustainable manner. - Agricultural activities within Net Zero Wales. - The well-being goals in section 4 of the Well-being of Future Generations (Wales) Act 2015. - Commitments under the Environment (Wales) Act 2016. - Cymraeg 2050. - Commitments under the Animal Health and Welfare Framework. - Commitments to international agreements such as the 30 by 30 Biodiversity Target and targets 7 and 10 of the Kuming-Montreal Global Biodiversity Framework

Item 2-2: Outline of the Sustainable Farming Scheme; streams, sub streams and number/type of actions (Welsh Government, 2022a)

Outline of the Sustainable Farming Scheme; Streams, Sub-streams and number/type of actions **Stream of action (number of sub-streams)** a. Sub-stream (number of actions/action types U: Universal O: optional FC: Advice C: Collaborative)
Resilient and productive farms (3) a. Manage an optimising farm performance through measuring and monitoring (U, FC) (Assessment) Social/Economic b. Diversify, differentiate, specialise for added-value (3O, C, FC) Social/Economic/Environment c. Minimise the risk of catching and spreading disease (U, 2O, C, FC) Economic/Environment
Reduce, reuse, and recycle inputs, nutrients and waste (6) d. Make best use of artificial fertiliser through nutrient management and soil testing (U, O, C, FC) (Assessment) Social/Economic/Environment e. Prioritising the use of manure and fertility building (O,FC) (Assessment) Social/Economic/Environment f. Best use of supplements, antibiotics, and medicines (FC) – linked to 3.b AHIC Minimise use of pesticides and herbicides through integrated pest management (U, FC) (Assessment) Social/Economic/Environment. g. Make best use of grassland through alternative approaches to grazing, introducing multispecies leys and mixed grazing (3O, FC) Environment/Economic h. Lowering the environmental impact of ammonia emissions (O, C, FC) Environment/(Economic)
Reduce on farm emissions and maximise carbon sequestration (5) i. Adopting energy efficiency practices and producing renewable energy on-farm (O, FC) Socio/Environment/Economic j. Efficient animals: Animal Health Improvement Cycle (AHIC) (U) Environment/Economic k. Efficient animals: Genetic improvement (Advisory support) (FC) Socio/Environment/Economic l. Restore semi-natural peatland (U, O, C, FC) Socio/Environment m. Create new and manage existing agro-forestry and woodland (U, 3O, C) Socio/Environment/Economic
Protect and enhance the farm ecosystem (13 – 7 Water) n. Protect soils from erosion and degradation (U, O, FC) Environment/Economic o. Rich on-farm diversity: Mixed farming (FC) Socio/Environment/Economic p. Rich on-farm diversity: Preserving native breeds (O, C, FC) Socio/Environment/Economic q. Manage habitat and species: Habitat maintenance and creation (U,O, C, FC) Socio/Environment r. Manage habitat and species: Benefiting habitat on improved land (U, O, C, FC) Environment s. Manage habitat and species: Designated sites (U, C, FC) Environment t. Water is protected from pollution: Lowering the risk of diffuse pollution (O, C, FC) Environment u. Water is protected from pollution: Protected watercourse banks (U, C, FC) Environment/Economic v. Water is protected from pollution: Lowering the risk of diffuse pollution (O, C, FC) Environment w. Conserve and retain water: Ponds and scrapes (U, O) Environment/Socio/Economic x. Conserve and retain water: Water harvesting and storage (O, FC) Environment/Socio/Economic y. Natural Flood Management (O, C) Environment/Socio/Economic
Benefit people, animals, and places (5) z. Maintain and enhance the historic environment, heritage, and beauty (U, 2O, C, FC) Socio/Economic

aa. Enabling people to engage with and access the natural environment (O, C)
Socio/Economic
bb. Livestock have a good quality of life (O)
Socio/Economic
cc. Invest in people providing fair work and creating a valued workforce (FC)
Socio/Economic
dd. Be proficient to practice safely and efficiently (U, O)
a. Socio/Economic

Item 2-3: Response to the Welsh Government 2022 Consultation based on the Workshop conducted by the author, A. morse and L. Beaman

Feedback Form - Sustainable Farming Scheme: Outline Proposals for 2025

To use this form; please type your answers in the boxes provided, or add a tick, or type 'yes' next to the appropriate choices where a list has been included. Once you have completed your form please email it to **sfs-codesign@gov.wales**

About you

Name	Lydia Beaman, Theo Lenormand and Aimee Morse
Are you responding as an individual or on behalf of an organisation or group?	On behalf of a group.

Individual Response

Email Address	
Postcode	
Age	18 to 28 29 to 40 41 to 54 55 to 64 65+

Occupation	Farmer	
	Other (please specify)	

Farming Sector (Select all that apply)	Sheep	
	Suckler beef	
	Beef	
	Dairy	
	Arable	
	Horticulture	
	Poultry	
	Pigs	
	Not applicable	
	Other (please specify)	

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Do you currently have rights which you exercise to graze stock on a common?

Please indicate the land ownership of your farm: • Wholly owned • Mostly owned • Wholly tenanted • Mostly tenanted

Organisational or Group Response

Organisation or Group Name	This response is written on behalf of a group of individuals who came together for a Sustainable Farming Scheme workshop, held on Wednesday 26th October 2022, organised through the Economic and Social Research Council's Festival of Social Science. Representatives from organisations across the farming sector in Wales, and from environmental NGOs and academia, attended the online event which comprised a panel session and a workshop, to discuss the current proposals. LB, TL and AM organised the event and they have collated the feedback from these discussions for presentation in this feedback form.
Is your organisation based/operated in Wales?	Based, and operating, in Wales. LB is a PhD student at Cardiff University. TL and AM are PhD students at the University of Gloucestershire. The event attendees included individual farmers and representatives from farming organisations, environmental NGOs and academic institutions based in Wales. Some academic attendees carry out research in Wales, but are based at English universities.
Contact Email Address	[redacted]

Please indicate which of these best represent your organisation (select all that apply)	Farming	
	Forestry	
	Environment	
	Veterinary	

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	Tourism/Hospitality	
	Food and timber supply chains	
	Public Sector	
	Private Sector	
	Third Sector	
	Trade Union/Representative	
	Research/Academia	X
	Other (please state)	

Please provide your views on Chapter 2: Introduction

You may wish to consider in particular:

- **Sustainable Land Management Objectives**
- **Sustainable Land Management Outcomes**
- **Scheme Design**

The inclusion of all three pillars of sustainable development in the Sustainable Farming Scheme was well-received by attendees. It was agreed that the Scheme's proposals recognise the close relationship between farming, the natural environment, and Welsh language and culture. This should be maintained as the Scheme is developed.

There was concern about the balance of food production and the Sustainable Farming Scheme's environmental goals. Further communication may be helpful to emphasise how the Scheme will specifically support sustainable food production. It should be clear how the activities required to meet the Scheme's environmental outcomes may be integrated into farmers' activities as food producers.

The goals may be attractive in nature, but it is paramount that they make sense for a business to undertake them. Farmer decisions will likely be influenced by the economic and logistical feasibility of the Sustainable Farming Scheme and how the funds will be distributed across the Scheme's layers and actions. It will be necessary to consider the time commitment required of farmers to deliver the environmental outcomes and the budget will need to be ambitious to achieve the Scheme's goals. Future Scheme documents should focus on the benefits different options may deliver to farm businesses. Training and additional communication may also be required to highlight the production benefits of certain Scheme objectives, such as the multiple potential benefits of agroforestry and diversification.

It is clear that there are several competing demands of land and these must be carefully reconciled if the ambitious goals of the Sustainable Farming Scheme are to be reached. Careful attention should be paid to ensuring the Scheme's implementation is pragmatic, and sufficient education and training opportunities should be provided to ensure farmers and land managers can meet the requirements asked of them. In addition, attendees' comments reflected those made in the Sustainable Farming and Our Land feedback that the option to tailor actions to fit the specific strengths of an area would be vital.

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Please provide your views on Chapter 3: The Sustainable Farming Scheme Structure

You may wish to consider in particular:

- **National Minimum Standards**
- **Scheme Structure**

Accessibility of universal layers will be paramount in order to gain the critical mass to achieve the sustainability goals across Wales. A transition to achieving the universal requirements of the Sustainable Farming Scheme that maximises the initial entry to the scheme may be desirable for future participation in the Scheme. Consideration for getting the right level for the regulatory baseline will be important here, as well as consideration for whether more localised designs may be beneficial.

Within the collaborative element, there is a need for localised, accessible, skilled peer to peer advice, that coordinates landscape, and catchment scale work. In some cases, the guidance of skilled facilitators may be required to optimise coordination and collaboration efforts. In addition, financial incentives may be required to encourage farmers to work together. It would be useful to explore the experiences of Sustainable Management Funded groups, Commoners' Associations, collaborative marketing groups and other existing cooperatives across Wales to inform the design of this layer.

Please provide your views on Chapter 4: The Sustainable Farming Scheme Framework

You may wish to consider in particular:

- **Scheme Characteristics**
- **Farming Connect**
- **Proposed Actions**

Farming Connect

There is a significant focus on Farming Connect in the scheme; however, consideration should be given to the other ways in which farmers access training. Other training providers may need additional resources to improve their capacity. The scale of change required may lead to a huge demand for advice, across a range of farming issues, thus it is essential all providers are adequately resourced to provide this. Alternative ways to provide training via horizontal knowledge exchange could also be explored.

Proposed actions

4.3.1. Resilient and productive farms.
Farmers are subject to market uncertainty and Welsh Government must be explicit about the economic arguments to support environmental actions, so that farmers have access to the information required to make long-term decisions, and so they can readily foresee the economic feasibility. The scheme must cover costs, time and help to provide an income, as there may be an impact on previous farm productivity. In particular, it may be important to consider extra and targeted support for new and young entrants.

4.3.3. Reduce on farm emissions and maximise carbon sequestration
There was a clear consensus that greater clarity is required on the tree planting targets. This includes providing further details of the different ways planting could be implemented

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across different farm types and scales (and whether non-farming small woodland owners will be included). There was a suggestion that payment for woodland could be given on a sliding scale. Clarification is required on whether commercial plantation, which will subsequently be felled, is considered a carbon sequestering woodland.

Woodland plans should ensure that existing habitats that are important for carbon sequestration, such as peatland and species rich grassland, are not planted on (these sites may be established through the Habitat Baseline Review). In addition, these planting plans should fit in with existing farm management and the emphasis on land-sharing reiterated. These plans should also consider where saplings are sourced to maintain tree health and ensure foreign tree diseases do not enter Wales. In terms of biodiversity benefits, considerations must be made for the difference between the species supported by homogenous, commercial tree plantations and those supported by multi-species woodland.

4.3.4. Protect and enhance the farm ecosystem
There was consensus that further clarity was required on the habitat targets and what will be expected of farmers in order to receive payment. This includes communicating that a land-sharing approach is possible, for example, through agroforestry.

A mix of livestock at appropriate stocking levels plays an essential role in maintaining ecosystem functioning and lowers the risk of habitat degradation.

Additional comments
Pilot schemes will help to make the benefits of the proposed actions visible to all farmers, providing demonstrations of how the scheme works, and encouraging uptake through real-world examples. Farmers will need to have enough detail in order to make long term decisions and to build their farm business resilience.

Please provide your views on Chapter 5: The Sustainable Farming Scheme Process

You may wish to consider in particular:

- **Farmer Registration and Eligibility Criteria**
- **Sustainability Review**
- **Action Selection**
- **The Contract**
- **Scheme Rules**
- **Payment**
- **Monitoring and Checking**
- **Inspection Regime**
- **Penalties**
- **Reporting and Evaluating of the Sustainable Farming Scheme**

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5.1. Farmer Registration and Eligibility Criteria *and* 5.4. The Contract

Attendees were concerned that as the scheme currently stands many tenant farmers will be unable to enter the scheme because of barriers in their tenancy agreements. It is vital the Scheme works for tenants, as 30% of farmland in Wales is currently farmed by someone who is not the owner.

Farm Business Tenancies are, on average, just three years in length with 87% being less than five years long. Although Scheme contracts may only be up to five years in length, there is concern that the long-term options in the Scheme will therefore be difficult for short-term tenants to deliver. Wales may learn from other schemes in the UK regarding options which allow landlords and tenants to work together. This will be essential in ensuring farmers who are keen to deliver options, are able to do so.

5.3. Action selection

The continued use of RPW Online was welcomed, as farmers are familiar with this platform. However, there is a requirement for all information on the Scheme to be made available on RPW to ensure farmers can make informed decisions regarding the actions they choose. To ensure the system is suitable, tests of RPW online should be included in the Scheme Pilots.

5.6. Payment

Estimated payment rates should be indicated as soon as possible to enable farm business planning. The commitment to modelling based on outcomes, the cost of completing an action, and incentives (Proposal Document, p. 62) is important. The Scheme will need to demonstrate how it will reward positive environmental actions rather than just covering costs, and provide confidence that there is sufficient budget for this. It is important to note that outcome focussed models, by nature, tend to require more resources.

The impact of inflation should also be considered as current payment rates no longer cover the costs of some materials, which have become more expensive over the lifetime of current scheme agreements.

5.7. Monitoring and Checking

Care needs to be taken to optimise the time required for farm assessments and design plans as where these are considered too time-consuming this could affect uptake. If used, self-monitoring forms should be easy to access, with appropriate training offered to those who are required to complete them.

Please provide your views on Chapter 6: The Sustainable Farming Scheme: Transition Plan

You may wish to consider in particular:

- **Prepare and Pilot Phase (2022-2024)**
- **Transition Period (2025-2029)**

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6.1. Prepare and Pilot Phase

It is vital to engage with farmers in numerous ways. In-person, on-farm engagement was considered critical as not all farmers may be able to access the link provided in the Proposal document to express their interest in the Co-design process. There were concerns over how representative the Co-design process will be if engagement is not widely sought through online and offline formats.

The Co-design process should also be cognisant of farmers' previous experiences of agri-environment schemes, as this may affect their perceptions of the new Scheme and their willingness to get involved in the process.

The introduction of Scheme Pilots was welcomed. Farmers of all types should be included in these pilots to ensure the breadth of land management skills across Wales is captured. The results should be made readily available to all farmers, regardless of their participation in a pilot. There were concerns that current communications, such as the online publication of the Sustainable Farming Scheme FAQ page, were not reaching all farmers. Paper copies of future communications should be readily available in Welsh and English for those unable to access resources online.

6.2. Transition Period

Demonstrating that the transition from Glastir to the Sustainable Farming Scheme will be smooth may encourage farmers to enter the Scheme. This will include ensuring farmers have enough information to make the long-term decisions required of them when entering the Scheme.

If you have any other views or evidence you wish to share, please use this box to do so.

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Annex 3: Question list, informed consent form, participant information sheet and Gantt chart of the study

Item 3-1: Question list guiding the interview to understand a farming system

Questions about History & Technical-Economic aspects of the farm

Interview 1: history focus with existing farms and farms that have disappeared

Retrace the history of the farm, from decade to decade (or relevant time-series), discuss with the interviewee the technical, economic and structural characteristics of each time-period (on average). Discuss the timings of the changes made, the factors which contributed to it and how they were taken forward, discuss those changes with the farm operators of the time.

During this discussion, the link between the production and the environmental characteristics of the farm, and its significance or place within a regional or national scale is also discussed each step of the way. The interviewer asks about farms that are around to understand interview after interview the range of systems available. Another element considered is the issues faced, how they were solved and how often do they take place (e.g. climate change related weather impact, bovine tuberculosis).

To help support this phase of the process the research the interview is supported by secondary data and summaries covering the changes in agricultural policies, market price evolutions and topographical maps.

Interview 2: technical & Economic focus on existing farms

This phase of the interview will focus specifically on the current operations of the farm, the latest changes taken forward and potential future farm changes. The link between the production and the environmental characteristics of the farm, and its significance or place within a regional or national scale is also discussed each step of the way.

Elements considered to diagnose the production system:

Every question asked is regarding a normal average year – each part of this interview should be discussed with the operator in charge of this part of the farming system. The interview on history would not be as focused on prices, except to explore comparative differences between inputs/outputs/capital prices compared to today. Several interviews might therefore be necessary.

Although we aimed at drafting an extensive question list, the interviews varied significantly between interviewee, due to their specific farm, roles or knowledge, as a result the below list was adapted constantly to reflect the stakeholders' role or the farms' specificities.

1) General holding

- Landholding pattern, location of the fields, agronomy potential (link with geo-climatic features), significant cultural features
- Structure of the landholding, tenure types, costs and arrangements, stakeholders involved.
- Decision making process, structure of the business, lead operators through time for each part of the farm
- Discuss why some routes of evolution were not pursued in comparison to other farms

2) Livestock system:

- Organisation: How many cattle, what breed, how long are they kept
- Buying : how many bought every year and at what age, when, to whom, for what price
- Selling : how many every year, when, at what age and what carcass weight, what price (per kg), to whom or where

- Feed: what is bought and what is homemade, precise composition of mix, how many tones used, changes in feed during the year and depending on the age of the cattle (forage calendar), price paid
- Grazing: when, where, management of grazed land
- Veterinary: what kind of medicine, vaccine, antibiotics, quantity used and price, veterinary costs. Impact of disease and health challenges.
- Management of the muck or slurry
- Cost of the different operations and who does them?

3) Grassland

- What kind of grassland (permanent pasture, leys) and type of grass (rye…)
- Management: calendar of mowing, grazing, fertilisation, rotational grazing types
- Grassland renewal and management within the overall cropping system
- Link with geo-climatic conditions
- Cost of the different operations and who does them?

4) Cropping system/arable

- How many acres, link with geo-climatic conditions, precise localisation (map), type of contract (owned or rented)
- Crops rotation on different type of land and rationale behind it
- Crop management sequence for each crop and machinery used (work calendar)
- Yields of all crops and characteristics (link with geo-climatic conditions)
- Prices, origin, quantity of inputs in general; fertilizers, seeds, herbicides….
- Where the harvest is sold, What quantity, Price and Characteristics
- How much is kept for auto consumption
- Cost of the different operations and who does them?

5) Building, Machinery and other equipment's

- Machinery: list of all machines, characteristics inc. size/power, year it was bought, price, new or second hand, how long it is going to be kept, this is usually explored after identifying them in the cropping suste,
- Buildings: year it was built, price, characteristics
- Small Equipment – Fencing…

6) Labour and decision making

- Type (family, part time, permanent…) and number through the year, identify lead operators for the different part of the farming system. Decision-makers for different parts of the farming systems and link with farm structure.
- Allocation of work and wages if there are any
- Peak working times identification and processes in place to manage them
- Consider pluri-activity and its consequences on the farm

7) Agricultural policy

- Subsidy and grants per year, type, amount, reasoning structure of the participation to AES schemes (grouped or alone), costs involved
- Changes to level of subsidy and grants before SFP (how much grants before 2003)

8) Other Expenses

- Water, electricity, petrol -> quantity and price
- Storage and transport costs

- Costs of buildings and materiel maintenance
- Accounting, insurance and CAP declaration costs if there are any
- Council taxes

9) With Farming stakeholders

- We discussed the role played by the interviewee in the farming sector of the area, its evolution, how impacted it had been by past policies and the specific concerns/opportunities arising from their specific experience.

Item 3-2: Participant information sheet

Participant Information Sheet

PhD Farms Evolution in Wales – Upper Dee Vale Study Area – Farm Evolution Interviews

You have been invited by a Doctoral Researcher at the Countryside and Community Research Institute, Théo Lenormand to take part in a research study. Before you give your final consent, it is important you understand why the research is being done and what it will involve. Please take time to read the following information carefully and then decide whether you want to take part. You will be able to give your consent on the accompanying 'informed consent form'.

Contact details of the Researcher:

Theo Lenormand
Countryside and Community Research Institute
University of Gloucestershire, Francis Close Hall
Swindon Road, Cheltenham GL50 4AZ
[redacted]

Who is the researcher and what is the purpose of the research?

I am a French farming science graduate currently doing a PhD centered on farming in Wales. My research is focusing on farm evolution in the light of the ongoing changes to the policy and economic landscape. I am based at the University of Gloucestershire's Countryside and Community Research Institute (CCRI) and I am working on the whole of Wales.

To study this subject I am using a French research method called "Agrarian Diagnosis" fieldwork based approach to farming. Conducting this sort of work in several focus areas across Wales will give a baseline for understanding farming evolution and drivers enshrined in their landscape, for example considering how farms will fare after Brexit and in the light of the current Covid19 emergency. This will foster new policy reflexions as Wales is gaining more independence in its agricultural policy design.

- It means closely studying selected focus areas through months of fieldwork, to understand how agriculture has evolved through time within its environment (landscape, policy, economy…). Because farming is a complex subject the goal is to appreciate fully its complex and localized nature.
- It also entails understanding the landscape and the way that it is and has been used, also its geology, soil, climate... Trying to characterize all the different landscape types found within a small and coherent agricultural area.

These two steps are conducted by interviewing farmers and retired farmers- as many as possible - to get a good understanding of who has farmed and who is farming the land, in the selected focus area.

Why am I being asked to participate?

You are being asked to participate because you are a landholder or stakeholder from the area that has been involved in the farming systems evolution or in today's farming community. The goal of this study is to propose a diagnosis and farm evolutions or structures may differ between different land managers/farmers or landscapes and we want to give you a say.

Do I have to take part?

No. It is entirely up to you whether you decide to participate. This information sheet will be yours to keep in any case. Your participation in the interview is voluntary and you are free to withdraw at any time, without giving any reason. **Before the scheduled interview you will be asked whether you are willing to participate and to complete an informed consent form.** If you decide to **retract up to 2 weeks after the interview** you can contact directly Théo Lenormand and its supervisor and they have the obligation to ensure the information on you is removed.

What is the procedure if I do decide to take part?

Taking part in an interview (either on the phone or in face to face) will involve answering a number of semi-structured interviews on the farming system structure and its evolution through time. The interviews aim at feeling like a discussion. At no time will you be obliged to discuss anything you are uncomfortable discussing nor to disclose anything that you don't wish to. As such, any information you give us is completely under your control. The interview will last approximately 1h30 minutes, but will vary from person-to-person.

What will be done with my interview data? What will happen to the results of this study?

The only record of the interview is a confidential notetaking handled by the PhD student. It will be retranscribded and anonymised under a week time. The landscape analysis typification allows for a link to the land to be kept while preserving interviewee anonymity. **The notetaking and the resulting data will be locked securely in an office/password protected laptop hard drive.**

The interview information's will be analysed qualitatively, a process which involves identifying evolutions through time and their driver that emerge across all the interview data. This will enable the student to identify the range of different evolutions depending on the landscape position and past farm history. Your name will not be attached to your interview data.

The interview data will be used with other farms data to model archetypes and typified evolutions in the typified landscape the farm sits in. These modelled archetypes will be used to describe the farm evolution in the study area and will be featured in the final thesis as well as intermediary works.
In addition, findings from the research will be used to inform scientific papers which will be published in relevant academic journals.

Before the interview takes place you will be asked whether you have received enough information about this study.

What might go wrong?

No undue affects are anticipated. As researchers we are bound by anonymity and confidentiality rules – see below.
If following the conversation you wish to complain about any aspects of the way in which you have approached or treated during the course of the study then you can contact its main supervisor Janet Dwyer [redacted]

Will my taking part in this study be kept confidential?

All information collected will be kept strictly confidential. Any information that identifies you e.g. name, will be removed so that you cannot be recognised from it. It is important to note that the only person that will also have access to the anonymised interview data will be:

- Théo Lenormand – PhD student and interviewer
- Any member of the academia supervisory team for a matter of reviewing

Any data used in research outputs e.g. academic papers or project reports will only feature anonymised data or derived modelled information.

If you are particularly concerned about the removal of identifiable characteristics from the interview, please let us know. We can arrange for you to have a copy of your transcript to approve and remove any details you think are identifiable.

You can read the privacy statement of the University of Gloucestershire, CCRI lab at: http://www.ccri.ac.uk/data-protection/

Alternatively if you have any concerns regarding the way in which the University is processing your personal data, please contact the Data Protection Officer at:

Data Protection Officer
University of Gloucestershire
Registrar's Directorate
Fullwood House The Park
Cheltenham, GL50 2RH

Email: dpo@glos.ac.uk

Who is funding the research? *–Subject to change-*

This research project is a collaboration funded by the Countryside and Community Fund (CCF), the Environmental Evidence Programme (EEP) and the University of Gloucestershire.

Who has reviewed this study for ethical clearance? *-Subject to approval-*

This study has been reviewed and granted clearance by the University of Gloucestershire's Research Ethics Committee. Emily Ryall is the chair of the Research Ethic Committee for any details you can contact her at: [redacted]

What if I want to contact the researcher to ask about this study or my participation in it?

We are happy to discuss any concerns or answer any questions. In the first instance, please contact the PhD student, Théo Lenormand [redacted] or its main supervisor Janet Dwyer [redacted]

COVID Addendum: (*Depending on Government and University Guidance – Depending on the Covid19 Outbreak/Progress in fighting the virus → TO BE UPDATED REGULARLY)*
Due to the Covid19 outbreak face to face meetings will have to be done following social distancing rules. To mitigate the transmission risks; the researcher and the participant would stay 2m apart and avoid any physical contact (direct or indirect), would wear face masks and would wash hands and clean wash any items touched, the meeting would happen outside.

Item 3-3: Informed consent form

UNIVERSITY OF GLOUCESTERSHIRE ccri

Informed Consent Form
Farm Evolutions In Wales - Interviews

Title of project: **Wales farming evolution and post-Brexit implications: How can future policy sustain farming multifunctionality in rural communities in an uncertain context?**

Project lead: Théo Lenormand PhD Student [redacted]

Please initial each box

1.	I confirm that I have read and understand the participant information sheet dated [DD/MM/YYYY] 2020 for the above study and have had the opportunity to ask questions which have been answered fully.	☐
2.	I have received enough information about this study.	☐
3.	I understand that my participation in the interview is voluntary and I am free to withdraw at any time (until such date as this will no longer be possible, which I have been told), without giving any reason.	☐
4.	I understand my responses will be anonymised in any final write up relating to the study (e.g. reports or academic papers).	☐
5.	I agree to take part in the above study.	☐

Participant **name** _____

Participant **signature**_____

Date of interview_____

Remote Informed Consent Form
Farm Evolution In Wales - Interviews

You can print int, take a picture of it/scan it and send it back. You can fill it with your computer and send it back. This form has to be filled and returned prior to the interview.

Title of project: **Wales farming evolution and post-Brexit implications: How can future policy sustain farming multifunctionality in rural communities in an uncertain context?**

Project lead: Théo Lenormand PhD Student [redacted]

By filling the form you agree with the following statements but if you can please initial each box.

1. I confirm that I have read and understand the participant information sheet dated [DD/MM/YYYY] 2020 for the above study and have had the opportunity to ask questions which have been answered fully. ☐
2. I have received enough information about this study. ☐
3. I understand that my participation in the interview is voluntary and I am free to withdraw at any time (until such date as this will no longer be possible, which I have been told), without giving any reason. ☐
4. I understand my responses will be anonymised in any final write up relating to the study (e.g. reports or academic papers). ☐
5. I agree to take part in the above study. ☐

I hereby agree to the 5 statements mentioned:

Participant **name** _____

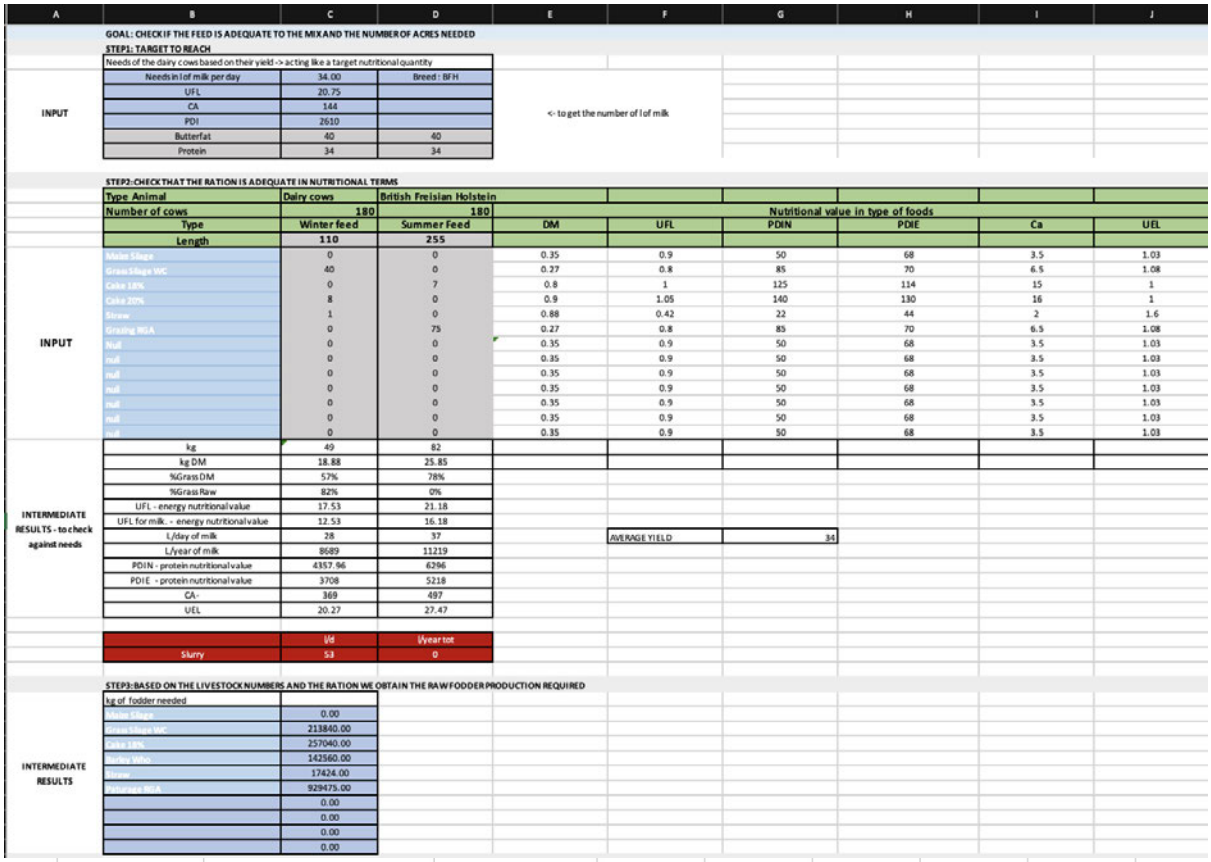
Participant **signature**_____

Date of interview_____

Comments or things you would like to mention:

_____

Item 3-4: example of the excel tools used to check the technical coherence of farming systems



GOAL: CHECK IF THE FEED IS ADEQUATE TO THE MIX AND THE NUMBER OF ACRES NEEDED

STEP1: TARGET TO REACH

Needs of the dairy cows based on their yield -> acting like a target nutritional quantity

Needs in l of milk per day	34.00	Breed : BFH
UFL	20.75	
CA	144	
PDI	2610	
Butterfat	40	40
Protein	34	34

INPUT

<- to get the number of l of milk

STEP2: CHECK THAT THE RATION IS ADEQUATE IN NUTRITIONAL TERMS

Type Animal	Dairy cows	British Freisian Holstein						
Number of cows	180	180			Nutritional value in type of foods			
Type	Winter feed	Summer Feed	DM	UFL	PDIN	PDIE	Ca	UEL
Length	110	255						
Maize Silage	0	0	0.35	0.9	50	68	3.5	1.03
Grass Silage WC	40	0	0.27	0.8	85	70	6.5	1.08
Cake 18%	0	7	0.8	1	125	114	15	1
Cake 20%	8	0	0.9	1.05	140	130	16	1
Straw	1	0	0.88	0.42	22	44	2	1.6
Grazing RGA	0	75	0.27	0.8	85	70	6.5	1.08
Null	0	0	0.35	0.9	50	68	3.5	1.03
null	0	0	0.35	0.9	50	68	3.5	1.03
null	0	0	0.35	0.9	50	68	3.5	1.03
null	0	0	0.35	0.9	50	68	3.5	1.03
null	0	0	0.35	0.9	50	68	3.5	1.03
null	0	0	0.35	0.9	50	68	3.5	1.03
null	0	0	0.35	0.9	50	68	3.5	1.03

INPUT

INTERMEDIATE RESULTS - to check against needs

kg	49	82
kg DM	18.88	25.85
%Grass DM	57%	78%
%Grass Raw	82%	0%
UFL - energy nutritional value	17.53	21.18
UFL for milk - energy nutritional value	12.53	16.18
L/day of milk	28	37
L/year of milk	8689	11219
PDIN - protein nutritional value	4357.96	6296
PDIE - protein nutritional value	3708	5218
CA-	369	497
UEL	20.27	27.47

AVERAGE YIELD: 34

	l/d	l/year tot
Slurry	53	0

STEP3: BASED ON THE LIVESTOCK NUMBERS AND THE RATION WE OBTAIN THE RAW FODDER PRODUCTION REQUIRED

INTERMEDIATE RESULTS

kg of fodder needed	
Maize Silage	0.00
Grass Silage WC	213840.00
Cake 18%	257040.00
Barley Who	142560.00
Straw	17424.00
Paturage RGA	929475.00
	0.00
	0.00
	0.00
	0.00

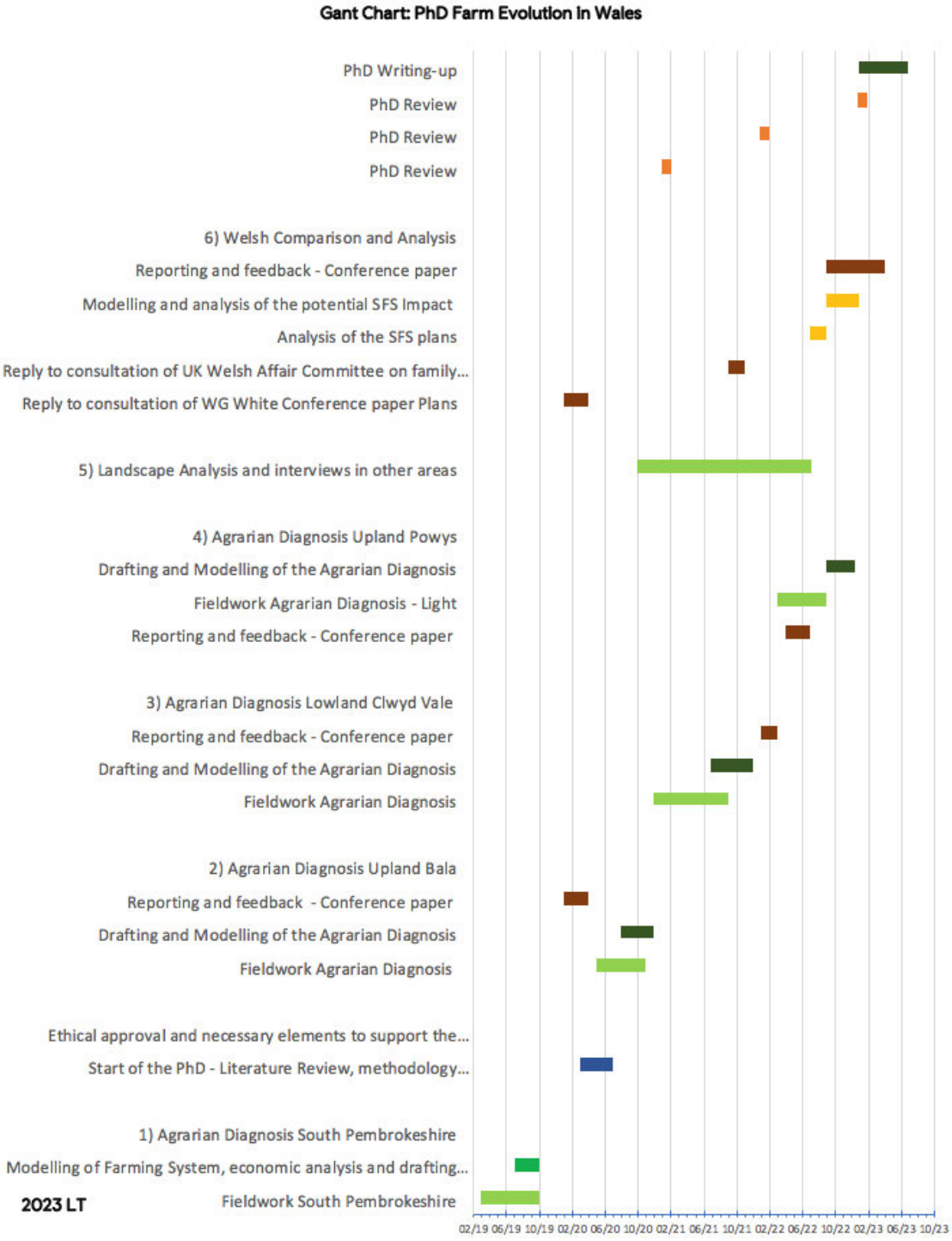
STEP 4: SUMMARY AT THE FARM SCALE

Crop type	Tonnes needed - from intermediate inputs	Acres Required - calculations
Barley		0
Barley & Peas Who		0
Barley Who	24.74	61.85
Grass Silage IRG	0	0
Grass silage RC		0
Grass Silage WC	44.98875	112.471875
Turnips		0
Hay		0
Haylage	8.5875	21.46875
Kale		0
Maize Silage	0	0
Paturage Clover		0
Paturage PP	27.89325	27.89325
Paturage RGA		0
Paturage RGI		0
Rapeseed		0
Straw		0

Milking cows		200	
Slurry tot l/year	l/yr		478080
	gal/year		105164.9802
	l/yr		gal/yr
Cleaning Dairy Parlour		1460000	321161.4606
Rainwater		6300000	1385833.7
Storage and spreading	l/yr		8238080
	gal/yr		2185075

To adapt	Type	Yield T	Number of harvests
INPUTS	Grass Silage IRG 4	6	4
	Grass Silage IRG 3	5	3
	Grass silage RC 3	3	3
	Grass Silage WC 3	3	3
	Grass Silage WC 4	6	4
	Barley Winter	3	1
	Wheat Winter	3.5	1
	Barley & Peas Who	6	1
	Barley Who	6	1
	Hay	2.5	1
	Haylage	5	1
	Kale early	4	1
	Kale late	6.5	1
	Maize Silage	6	1
	Paturage Clover		
	Paturage PP	4	
	Paturage RGA Dairy	5.5	
	Paturage RGI Dairy	6	

Item 3-5: Gantt chart of the course of study



Annex 4: Landscape analysis

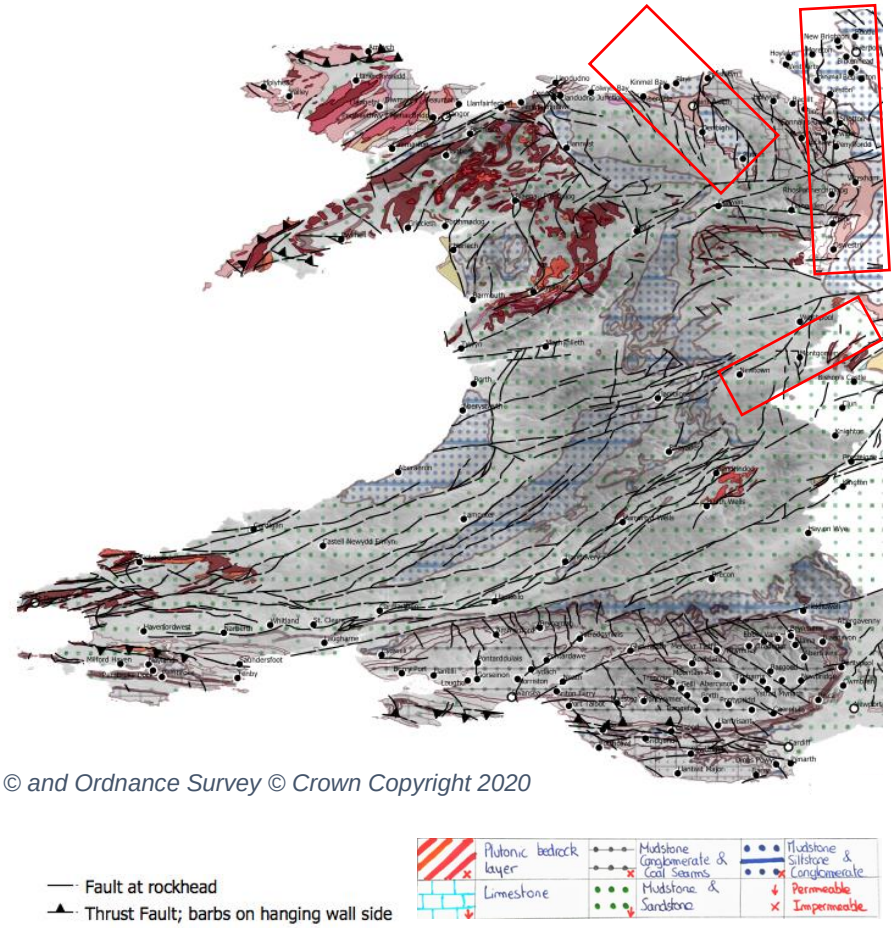
Item 4-1: Regional units from the geology and geomorphology

Two main categories of bedrock can be identified in Wales as shown below, leading to a regional differentiation in terms of relief (Batteau-Queney, 1978; BGS, 2022; Bowen et al., 1986; Talbot and Cosgrove, 2011).

Sedimentary Bedrock: Predominantly mudstones and sandstones, forming Wales' largest bedrock. Varied hardness due to compression differences, with few impermeable layers (green and blue dots/line). This creates high-altitude plateaus and hills, with V-shaped valleys and convex sides. Glacial deposits exist on elevated areas and drumlin-shaped hills.

Igneous Rocks: Plutons, primarily in red and orange, located in North-West Wales. Hard, impermeable, and acidic, these rocks appear as hills/mountains with craggy tops due to erosion. Glacial impact resulted in U-shaped valleys and concavo-convex sides, with glacial deposits on igneous outcrops, mudstones, and valleys (See below).

On the hard bedrocks of Wales', the altitude variations are due to the differential erosion process and higher glaciation erosion on lower landscapes. The glaciation led to hills with little glacial deposits on the tops and concavo-convex valley sides with glacial deposits. In South Wales and West of Wrexham, mudstones interbedded with coal seams and conglomerate (MDSS) can be found in the Coalfields with (grey points and line). They are covered by hard and impermeable sandstones. The glaciation impact has been heavy, giving a plateau with deep U-shaped valleys with concave sides. An important tectonic feature (circled in red above) is the sedimentation basins, linked with rifts or normal faults; the Vale of Clwyd, Newton/Welshpool area and the Dee Valley to the North-East. These areas have large quantities of superficial deposits (glacial and alluvial). They are distinct from deep and entrenched alluvial valleys, around main watercourses, that can be found in other parts of Wales with broadly similar characteristics. Fine layers of Devonian Old Red Sandstones (light red and grey) and Limestones (blue squares) from the Carboniferous can be found on the outskirts of Wales: these are soft, permeable, and erodible usually leading to a soft hill relief.



BGS © and Ordnance Survey © Crown Copyright 2020

Figure A 4: Simplified geology of Wales against the relief (Bedrock and Faultlines) (by the author from BGS, 2022)

Soils would be mostly thin, acidic, cold, and loamy with local variations, notably on glacial deposits (colder and heavier) or alluvial deposits (more free-draining, heavier, warmer). On the two “soft” substrates in Wales, these give comparatively deep, less acidic, and free-draining soils.

As a result of these factors, it is possible to distinguish a gradient of soil potential for areas in Wales (in terms of its fodder production potential) that depends on geology and geomorphology (Goudie, 2020). It goes down as one climbs up from the coastal soft hills and large alluvial valleys to the higher hills and finally to the mountains and mountainous plateau. Different context would be distinguished, in different types of coastal hills, alluvial basins, upland plateaux with entrenched valleys, with a high or moderate altitude difference.

Item 4-2: Climate data gradient in Wales (MetOffice, 2021)

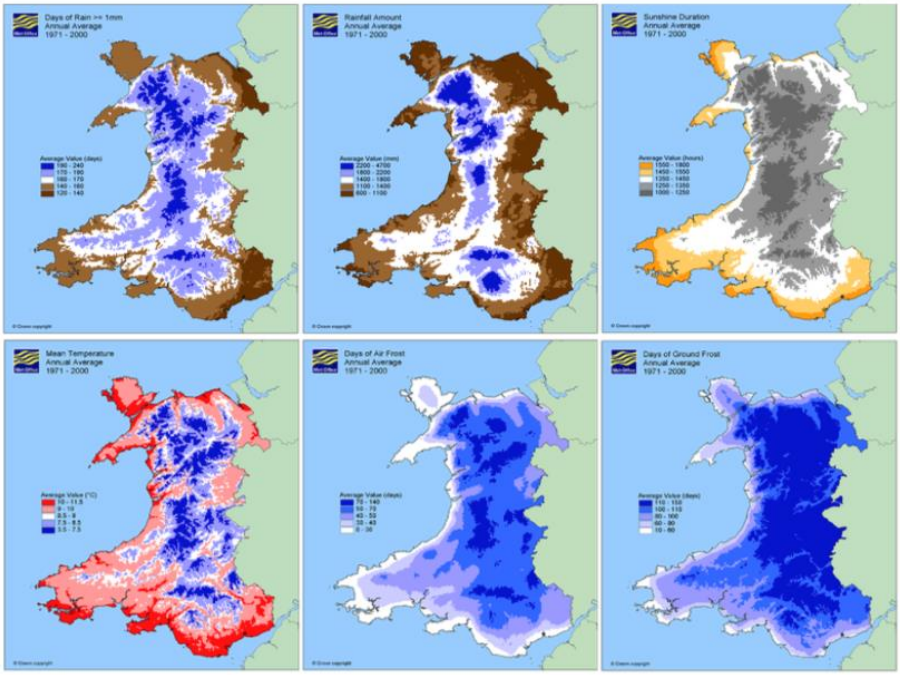


Figure A 5: Climate average in Wales (Metoffice, 2021)

A focus is placed upon the potential regional micro-climates as observed from the broad differences (MetOffice, 2022) that can be seen above. In Wales, the North and West/South sides face different prevailing winds: the North-West brings lower temperatures and more frosts, while the South-West brings higher precipitation. Despite this variance, the coastal areas generally enjoy milder climates (in both temperature and precipitation), when compared to higher elevations. The lowlands, characterized by smooth rolling hills, exhibit a mix of protected and exposed areas due to the terrain. These regions experience comparatively lower precipitation, reduced wind, and higher temperatures, especially in the South. The alluvial valleys, with their long and wide corridors, are relatively sheltered, receiving more sunshine and slightly less rain or frost compared to the surrounding hills. On the Eastern side of Wales, both the lowlands and uplands tend to be colder than their Western counterparts, with lower precipitation.

The uplands and hills endure harsher conditions, including exposure to cold, wind, and consistent rain throughout the year. The mountainous backbone of Wales experiences particularly severe weather, with a noticeable gradient of decreasing precipitation towards the East, coupled with even colder temperatures.

Item 4-3: uplands regional units description
In all the resources below, statistics collected from the Welsh Government will be utilised (Welsh Government, 2020a)

- North-West Wales Mountain – Snowdonia (Eryri)

Snowdonia, located in North-West Wales, stands out from other regions in Wales due to its powerful glacial influence. There are many deep U-shaped valleys and craggy mountaintops. Snowdonia's landscape is a blend of alluvial valleys and rocky moorland hills, with a scarcity of temporary pastures. Instead, it predominantly features permanent pastures, extensive rough grazing areas (over 50%), and craggy mountains with bogs and acid grasslands.

Snowdonia is highly recognized and protected, acknowledged as a specific landscape by the National Landscape Character Area classification. It hosts a National Park and is additionally safeguarded by numerous layers of protection, including Sites of Special Scientific Interest (SSSI) and nature reserves. Most of the area is registered as Least Favoured Area, either as Severely Disadvantaged Area (SDA) with very significant constraints for the food production process and some alluvial valleys in DA (Welsh Government and Statistics for Wales, 2023). Farming in this region primarily revolves around sheep, with over 80% of farms raising sheep and the remaining focusing on beef cattle. Dairy farming is almost non-existent. The area exhibits a low production potential, evident in the low number of lambs per ewe (<0.9). However, there is a significant population of suckler cows, especially in parts with less mountainous land.

Snowdonia's land use has remained relatively stable since 2002, with minimal decline in stocking rates. While the area has experienced a decrease in sheep farms, the decline has been comparatively lower than that of cattle farms this trend is very different from what was witnessed on the Cambrian mountain area. The region heavily relies on farming for its economy and boasts a high proportion of Welsh speakers (Chapter 1; DataMapWales, 2022). Notable products such as Snowdonia Cheddar contribute to its strong branding, and it attracts tourists with its unique features.

In terms of services, Snowdonia plays a vital role as a water reserve for lowland areas, including some regions in England (Senedd Research, 2023).This, combined with an influx of residents attracted by the area's natural beauty, has stirred cultural identity

discussions (e.g. Payne, 1985). The region lacks agri-food industry centres but features livestock markets (for trading animals between farmers) and farmers' cooperatives (AHDB, 2020a; Fieldwork).

- Cambrian mountains

The dissected plateau of the Central Wales Mountains, extends North wards, identifies the Cambrian Mountains. The watercourse organization here is centrifugal, originating from the mountainous plateau's centre, creating valleys along major faults and softer bedrocks. These valleys, deeply entrenched and relatively lush, serve as conduits for water flow. In contrast to Snowdonia, this region boasts a smoother relief with a more uniform bedrock. It covers the largest area as a region of -Wales, with open rough grazing occupying a larger area than Snowdonia. Conifer plantations are abundant, with marshy grassland on the mountains.

The hills here are less rocky and feature more semi-improved grassland than in Snowdonia. Rough grazing ranges from over 50% to over 25%, indicating central blocks of mountain rough grazing linked with the plateau relief. Grassland covers over 90% of the area, with semi-improved grassland prevalent, especially on the West side, exceeding 50 to 60% in many cases. Agriculture primarily revolves around beef and sheep holdings, with the highest concentration of breeding ewes in Wales, constituting the backbone of sheep farming in the region (75-85% of farms). The number of lambs per ewe is higher than in Snowdonia (>0.9), and there is a significant presence of suckler cows (StatWales, 2020). In the Eastern areas, particularly the lower hills, cereals (mainly barley) are grown, and young cattle are kept, possibly for finishing. Like Snowdonia, the region is mostly designated as SDA, with only alluvial valleys registered as DA.

Tourist recognition is lower compared to Snowdonia, although the area is renowned especially for its reservoirs (Senedd Research, 2023). While not protected by a National Park, most of the Elan Valley is protected under SSSI regulations, as are most of the Wye and Usk rivers (Welsh Government, 2020c). These are associated with well-publicised pollution issues (e.g. Guardian, 2022). The area's food culture recognition has started, notably through the PGI 2021 designation for Cambrian

Mountain Lambs and the presence of market towns (DEFRA, 2021a). Unlike Snowdonia, this region is more connected to the border region and has a lower proportion of Welsh speakers.

In terms of farming evolution, there has been a significant decrease in farm numbers, especially in suckler cows, with a loss of 10-20% of farms, particularly in the hills from 2002 to 2018 (StatWales, 2020). The farmed area has remained relatively stable, but stocking density has dropped, with more than 1 Breeding Ewe lost per hectare and 0.3 to 0.7 Livestock Farming Unit (LFU) lost per hectare between 2002 and 2018, indicating substantial farm losses in the area. Notably, there has been an increase and concentration of poultry farming, especially in Mid Wales. Field observations also reveal the development of spring calving dairy units in the North of this regional unit, which were previously beef and sheep farms. Key to the area's structure are the livestock markets (AHDB, 2020a), primarily oriented towards the English border (Fieldwork), where "upland" cattle/sheep stores are sold for rearing and finishing, both within and outside of Wales. The area features few abattoirs and significant processors at local scales (AHDB, 2020a).

- The dissected plateau and mountains of South Wales

In the South, the Brecon Beacons/Black Mountains area - characterized by expansive, lush alluvial valleys featuring both temporary and semi-permanent pastures, alongside limited crop cultivation such as maize, fodder crops, and barley – is observed. These valleys are surrounded by rough grazing hills consisting of marshy grassland and poor acid grassland. The Brecon Beacons, a prominent feature of this area, are recognized and safeguarded, designated as a national park, and with several SSSI. To the South of this region lies a cuesta[78] followed by smooth mountainous hills offering rough open grazing.

[78] A cuesta is a geological formation featuring a ridge with a gradual slope on one side and a steep slope on the other. It results from the differential erosion of rock layers, creating a distinctive landscape (Derruau, 2010).

Further South, the deeply dissected valleys of the South Wales Coalfield, oriented in a North-South direction can be found. These valleys exhibit U-shaped much-modified valleys, interspersed with hills featuring permanent grassland on their sides and in secondary valleys. Rough open grazing can be found on the top, characterized by boggy terrain and acid grassland.

Farming dynamics in both these areas mirror these of the Cambrian Mountains, with an overall reduction in stock numbers, particularly in beef and sheep, although these regions already had a less significant agricultural sector as early as 1945. Small scale horticulture plays a slightly more substantial role in the valleys. Conifer plantations, especially on hilltops, are significant features. These areas experience a slightly different trend from the Cambrian Mountains - while they saw a similar trend of stocking decline, they are the only regions gaining farms in the uplands. This reflects an influx of unconventional farm types, likely influenced by their proximity to the densely populated South Wales conurbation.

The valleys, historically central to coalfield exploitation and early industrialization, have evolved into a unique landscape. Farming here is linked to former industrial sites, resulting in a diverse mosaic of spaces, varying not only in altitude but also in land use. These regions have some processing units, including abattoirs and substantial local-scale processors, often connected to local food movements due to the high local population (AHDB, 2020a).

It is noteworthy that while the Brecon Beacons is under protection, designated as a national park with SSSI-protected rivers and safeguarded mountain land, the South Wales Coalfield area lacks such protective status, despite its historical significance and unique landscape attributes.

Item 4-4: Lowland regional units characteristics and trends (
In all the resources below, statistics collected from the Welsh Government will be utilised (Welsh Government, 2020a)

- West Wales Coastal lowlands and plateau

The West Wales Coastal lowlands and plateau is characterized by rolling hills and small alluvial valleys with a relatively uniform substrate in terms of its hardness. Notably, a coastal plain exists, particularly around estuaries, marked by patches of igneous rocks or harder bedrock, forming craggy hills. In the valleys, the soils are deeper and often clayish. The predominant land cover includes temporary grassland (up to 50% near the coast), semi-permanent grassland, and permanent grassland. Grassland occupies approximately 85% of the area, dropping to under 75% in the southern regions where there's more cropping diversity, including maize, potatoes, and cereals. Rough grazing covers less than 10% of the area, except in regions with igneous rocks. Unlike many other areas, it is generally not classified as SDA but there is some DA land, mostly at higher altitudes or on substrates with heavier soils.

Livestock farming is important in this area, particularly dairy and beef and sheep finishing. Over 15% of farms (and up to 30%) are dairy farms, making this region a significant dairy powerhouse in Wales. Farms tend to be more specialized, compared to upland areas. There is a gradual decrease in production potential further from the sea, and a reduction in dairy cow numbers around the fringe of the area. Sheep farming remains crucial, with 30 to 45% of farms keeping breeding ewes, often with high lambing rates (>1 lamb per ewe) and experiencing a smaller drop in sheep and cattle numbers in recent years compared to the Cambrian Mountains. However, the region has experienced a significant reduction in farm numbers, ranging from -8% to -25%, coupled with no decrease in farmed areas, indicating farm enlargement.

In terms of processing facilities, there are units for feedstuffs, as well as abattoirs and milk processing plants. Compared to the region's output there are not so many of them, and several have closed, such as the Whitland milk plant. Livestock markets are more numerous, although their throughput is lower compared to other regions. This region lacks extensive protected areas, except for riverbanks, estuaries, disseminated SSSI, and the small Pembrokeshire Coast National Park.

- North Wales Coast lowlands

The North Wales Coast lowlands unit encompasses areas such as Anglesey (Ynys Môn), the Llyn Peninsula (Pen Llyn), and the foothills of Snowdonia (Eryri). This region boasts coastal plains and smooth hills, along with larger craggy hills connected to hard plutonic outcrops. It is located between the sea and Snowdonia. With over 90% grassland (primarily semi-permanent pasture) and under 20% rough grazing, it resembles West Wales in production potential and trends, but it experiences colder temperatures and more pronounced seasonal precipitation patterns. While dairy is not as important, it has a higher proportion of beef and sheep farming. Livestock finishing is also important in this part of Wales. Sheep and suckler cows numbers have seen a higher reduction compared to West Wales. This region is a coastal lowland closely tied to surrounding uplands.

North Wales features a significant milk processing facility serving the entirety of North and West Wales, along with several livestock markets (AHDB, 2020a). The area's strong connection with the tourist sector (Velu, 2021), particularly in Snowdonia, is crucial, akin to West Wales. Local food processors play a key role, highlighting the area's significance as a feeder for Snowdonia (AHDB, 2020). Some parts of this region, specifically the coast of the Llyn Peninsula and Anglesey, enjoy protection as AONBs and localized SSSI (Item 4-10).

- East Wales sediment basins

In Eastern Wales, the landscape comprises large sediment basins with alluvial valleys, flanked by rising hills and some semi-mountainous regions. This area has good soils and stands out as an anomaly. Like the previous unit, this represents a composite landscape. The central valleys and hills exhibit high production potential, surrounded by regions more comparable to the Cambrian Mountains unit in terms of land use and trends.

These valleys are very similar to the best West Wales lowlands, with a high proportion of temporary pasture and some crop cultivation (spring cereals and maize). Livestock farming is the most important enterprise, with a focus on dairy production (over 15% of farms). Beef and sheep farms remain important, especially in beef finishing (with

low suckler cow numbers and less than 60% of farms raising sheep). Poultry farms can also be found. Farms here are specialised, displaying high productivity (over 1.1 lambs per ewe). Notably, these areas have experienced lower farm losses, ranging from -2% to -5% from 2002 to 2018, distinguishing them from West Wales. These regions have stronger connections with neighbouring areas across the Welsh border. The region has many livestock markets and abattoirs, historically serving farmers from other regions (AHDB, 2020a). The protected features include rivers and estuaries (including saltmarshes) designated as SSSIs, and significant AONBs such as the Clwyd and Dee Valley.

- South Wales Coastal lowlands

The South Wales Coastal lowlands has diverse substrates with gently rolling terrain and occasional coastal plains. Despite high human colonisation, it shares similarities with the West Wales unit. It faces challenges from the South Wales conurbation but demonstrates more local food and horticulture initiatives, reflected in rising farm numbers. Geo-climatically, it aligns with the South side of the West Wales unit and is not classified as SDA, boasting high productive potential (lambs per ewe > 1). Diverse production can be found, including cereals, with a shifting focus towards dairy in the East. The beef and sheep sector is gradually reducing in size, as seen in the South Wales Mountain area. There is a strong food-processing sector (AHDB, 2020a). Protected areas relate to the Severn estuary, Severn levels, and the Gower Peninsula AONB.

Item 4-5: Landscape of study area - Characterisation of the South-Pembrokeshire area, a lowland pastoral landscape

Geology and Geomorphology: South Pembrokeshire is a hilly lowland area under 200m of altitude with a bocage landscape (a landscape with fields delimited by tree lined hedges and lots of grasslands). Away from the coast, this area has a landscape which can seem very homogenous but in fact offers a variety of agronomic potential depending on the valley size and steepness of slopes which can be linked to different bedrocks (See below) and subsequent geomorphological processes. This diversity can be linked in the landscape to a range of typical Welsh lowland agricultural outputs including milk, beef, sheep and potatoes. In general, Pembrokeshire farming is focused on livestock farming and grassland but has probably the most notable cropping profile of our study areas. Understanding the diversity of landscape and landscape use in Pembrokeshire requires understanding the type of geo-climatic conditions available to farms.

The geomorphology and geology of Pembrokeshire can help understand and divide the region into 2 big valleys/hill types with contrasting agricultural potential as shown below. The relief differences that can be seen on the figure are due to a differential erosion process on bedrock of different hardness and folding. From the different bedrock originates key soil-type differences.

Climate: The climate is temperate humid all year round, with a climate gradient (colder and wetter moving further from the coast), but overall, it is warm in compared to other lowland areas in Wales.

In “small valleys”: on cold mudstone with coal seams, valleys are smaller and give rise to loamy, clayish, very heavy soils in the bottom while the slopes can be steep. They are not as free draining as other loamy soils in Pembrokeshire. The other substrates give bigger, smooth valleys and hills due to their increased permeability. The soils they

give rise to tend to be more free draining. Overall superficial deposits are scarce, alluvial (sand, gravel, clay, and loam) around the watercourse and in the talwegs[79].

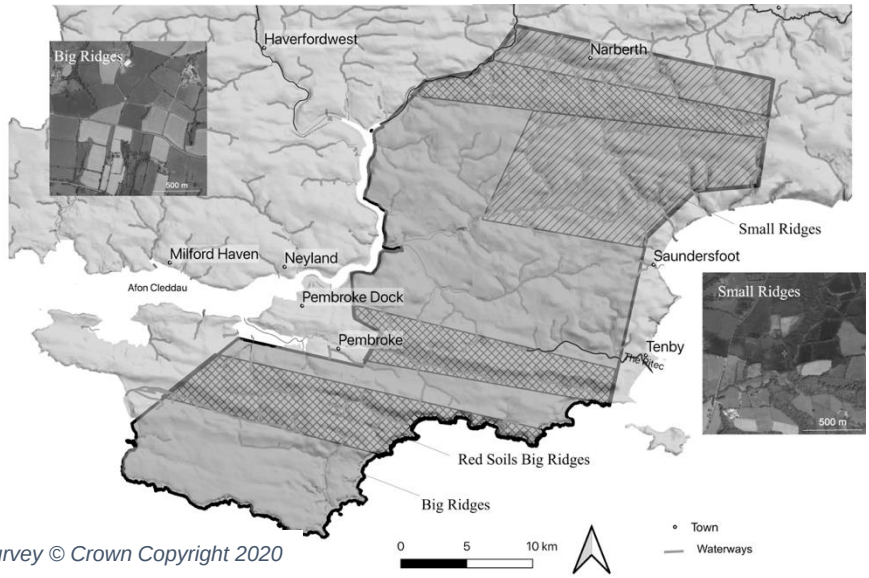


Figure A 5: study area of South Pembrokeshire and different landscape identified. Aerial photography samples for big and small ridges. By the author, from ordnance survey data.

Combined with the climatic conditions it gives not only a gradient in terms of grass and crop growth (Temperature; soil and air), but also significant differences in terms of potential access to the land. Combining benefits in terms of access and potential growth condition in soil types, the number of grass crops (silage), potential tilling and reseeding is much enhanced, the possibilities are extended in terms of land use and setting up the cropping system. With the lack of winter frost, the coast is suited to grow early potatoes with the ability to access the fields earlier with free-draining soils (The month of February for top of ridges and slopes). Put simply, in Pembrokeshire, the main limitation to grass growth is water (precipitation) and temperature, over wintertime but there are very few limitations to grass/plant growth over summertime apart on the driest large ridge slopes.

On big ridges (See below); the landscape is overwhelmingly green with most fields being temporary grassland linked to beef and dairy farming systems with islands of “crops”. Overall, the management of pastures is varied; there are some partially grazed, or mob grazed every 2 months 7 days by beef or sheep, or some temporary

[79] Line of lowest elevation in a valley or watercourse

grassland is intensively grazed 12-24-48h every 4-6 weeks or with frequent cuts (3,4 or 5) linked to different enterprises and times of the year to adapt to grass growth.

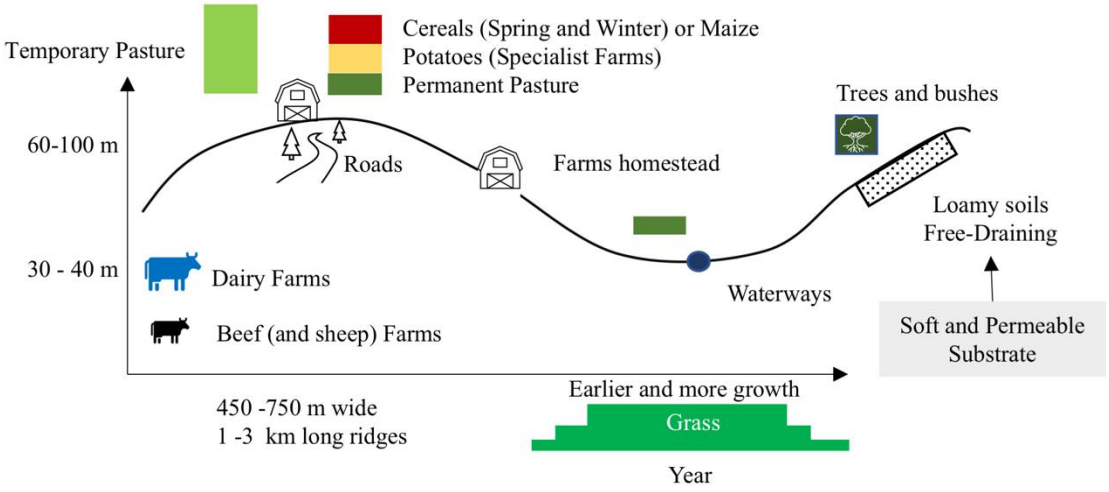


Figure A 6: Diagrammatic representation of the landscape on big dry ridges in Pembrokeshire (by the author)

Grazing can start early from March and end late November with a small drop in grass production over the summer, apart from the driest slopes. Pasture management (fertiliser, renewal) can be extremely different, as is the production of grasslands. It is possible to distinguish areas that are in rotation on the slope with some Maize and spring/winter cereal fields for fodder, short-term temporary grassland (ryegrass based) over 5–7-year rotations for harvesting or grazing by dairy youngstock/beef, that can integrate potatoes (both early and main crops or daffodils) that are the only commercial crop around. Nevertheless, there are some grasslands grazing blocks, renewed every 5-10 years based on ryegrass that might only partially be included in the rotation, these areas are predominantly grazed by the main herd and close to the homestead–particularly dairy cows of Holstein or British Friesian types and mostly Continental-breeds beef herds (Limousin, British Blue). Finally, parts of the landscape are under semi-permanent grassland (10-20 years or more), based on ryegrass but grazed more extensively by sheep, beef cattle and possible dairy dry-stock, potentially further from the homestead or in much less intensive farming systems (smallholdings, lower stocking density…). There are some permanent grasslands in the bottom of the valleys, albeit a small proportion and only grazed by animals with lower needs (e.g. heifers, sheep…) with a more restricted grazing season.

Among dairy farms different sub-types can be identified, mid to high yielding with high demand from the land and high intensity in terms of management and often a higher degree of crop rotation, grazing focused dairy farms mid-low yielding and beef farms (possibly with sheep) with relatively demanding breeds and finishing. More diversified and different farms or holdings can be found with less demanding systems (leisure, smallholdings…).

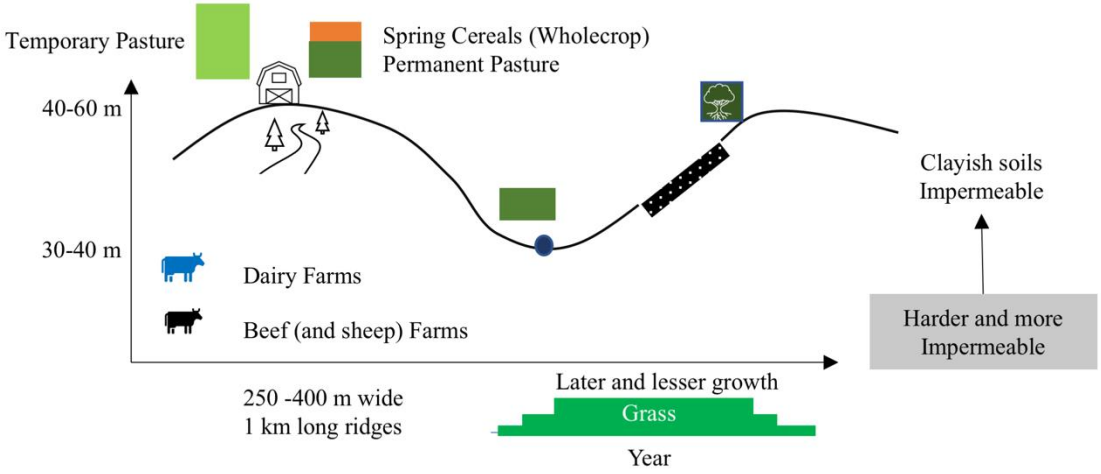


Figure A 7: Diagrammatic representation of the landscape on small and wet ridges in Pembrokeshire (by the author)

On small ridges (see above), fields are smaller, harder to work with and does not offer this range of potential ease of working (considering the calendar) and crops because of their limitations. Notably, some are too wet to be harvested with modern machinery (10%), others are not very free draining. The potential in terms of cropping systems is limited, with less access and fewer possible crops. There are no potatoes, scarcely any maize or cereals, crops would be on the driest most free-draining part of the landscape, the slopes with difficulties to reach crop maturity; fields for Maize would be required to be dry and probably drained, planted/harvested later with a lesser nutritional quality on harvest[80], cereals would be spring cereals. Obviously compared to large ridges, winter crops are more challenging to graze or harvest. Grassland represents a higher proportion of total land and particularly permanent grassland (20-25%) but the profile in terms of grass growth is later and lower. Yields and nutritional

[80] An additional 2-3 weeks of growth and not mature, with lesser level of dry matter.

quality are lower on these landscapes. A handful of potato field can be found on the terrace.

Among farm types, it is possible to distinguish dairy farms, mid to high yielding with high demand from the land and high intensity in terms of management and often a higher degree of crop rotation but with high reliance on grazing as well as more beef farms than on big ridges with lowlands and continental breeds but more that are finishing. Overall, farms tend to be smaller.

In summary, Pembrokeshire conditions are particularly favorable for grass growth, including in the small ridges area and for grazing if not always to cropping. Possibilities differ significantly for farming systems on the two areas with very different cropping and livestock systems. The pastoral, hedge delimited landscape, interspaced with small deciduous woodlands on talweg and valley steep slopes and the crops constitutes a mosaic.

Item 4-6: Landscape of study area - A lowland area organised around the Vale of Clwyd (Vale of Clwyd) with a relief and landscape defined by the glaciations

The Vale of Clwyd (Vale of Clwyd) is located in North East Wales and is a lowland area. It encompasses a vast syncline, forming an alluvial valley that is bordered to the East by the Clwydian Range and to the West by the Clocaenog forest, with hills interspersed between these natural formations. The valley displays a dissymmetrical shape and is oriented from the South to the North. On both sides of the valley, there is a gradual ascent from a dominant small field mosaic pastoral landscape towards bare mountain land or areas covered by forestry.

In terms of Geology and Geomorphology, the area's bedrock exhibits diversity typical of Welsh lowlands, with a lesser predominance of mudstone and a higher presence of softer limestone/sandstone. The latter have been more susceptible to erosion by water. During the glaciation period, a glacier in the vale carved out U-shaped, asymmetrical valleys from existing rivers. The bottom of the vale was subsequently covered with poor quality tills, followed by alluvial deposits in the central alluvial valley region. Finally, at the mouth of the valley, closer to the sea, thick layers of tidal deposits and blown sand have been deposited over time.

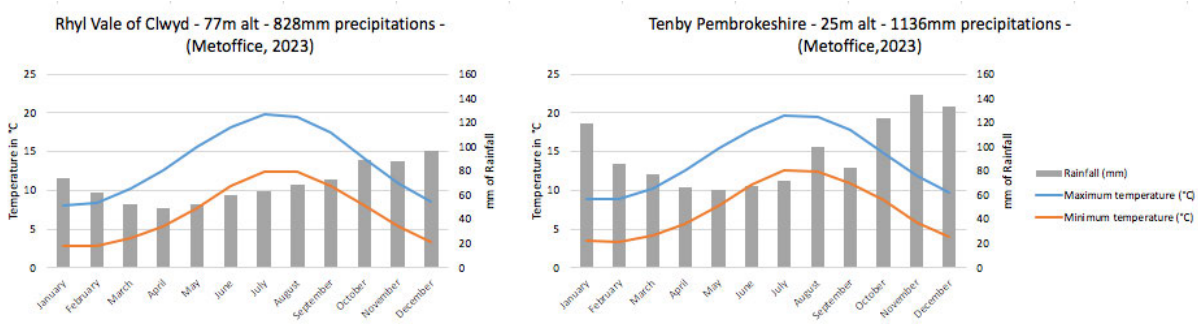


Figure A 8: Climate graph for Welsh lowlands average 1991-2020(Metoffice, 2023)

Climate: The climate is temperate though with an increased continental element. The area is impacted by Snowdonia in terms of rainfall with a dryer, profile, particularly over summer -even compared to Pembrokeshire -. Drought is quite a common problem in the area over summer, most of all in the centre. With the Clwyd Range and the drop down to the vale there is a decreasing rainfall gradient from the West to the East of the study area. Cold wind come from the East and North sides from which only part of the area is protected, some valleys and their sides.

Landscape: The first area would be the core, a wide protected alluvial valley surrounded by gentle slopes on soft substrates with a thick cover of alluvial deposits/till deposits of good quality: loamy, clayish. The further away from the river the lighter the soils. Even in the core of the vale there is a gradient from relatively heavy “wet meadows” to “light and dry” red soils the best of the area, and not far in terms of agro-ecological versatility to Pembrokeshire’s wide ridges. Due to the climate gradient, there is an opposition West-East, though most of the area suffers from summer drought, grass growth starts later than in Pembrokeshire by approximately 2 weeks and ends 2 weeks earlier. Yields attainable remain high for the area with a good grass growth profile. The dry spell over summer is more pronounced than in Pembrokeshire with easier crops to harvest (hay, corn) but lower grass growth. 2-3 weeks delay in growing can be expected between wet and dry parts. All these rest on permeable substrate, apart from winter on the floodplain, all these soils are rather free-draining and carrying on par with Pembrokeshire “workability” profile. There is a similar land use to Pembrokeshire’s large ridges, albeit without potato farms but with more beef farms and more cereal growing, smaller dairy units, and smaller operating blocks.

Smooth wide limestone hills can be found between the core and the mudstone hills to the East. The bedrock giving rise to good free-draining soils (no more than 80 m of altitude) though of fluctuating depth with only slightly better drought resistance than on mudstone hills with to warmer/deeper soils, with less clay. Some meadows can be found in the bottom of the valley. In general, this unit offers very similar conditions to the large hills of Pembrokeshire with a similar organisation, although farms tend to be smaller.

In both cases, a mosaic of grassland with small deciduous woodlands and corn can be witnessed, particularly spring barley and winter wheat with a lesser proportion of Maize areas with slightly less production flexibility and potential. The livestock is of a lowland-type (Texel crosses, Charolais…) with more exceptions than in Pembrokeshire given the profile of surrounding areas.

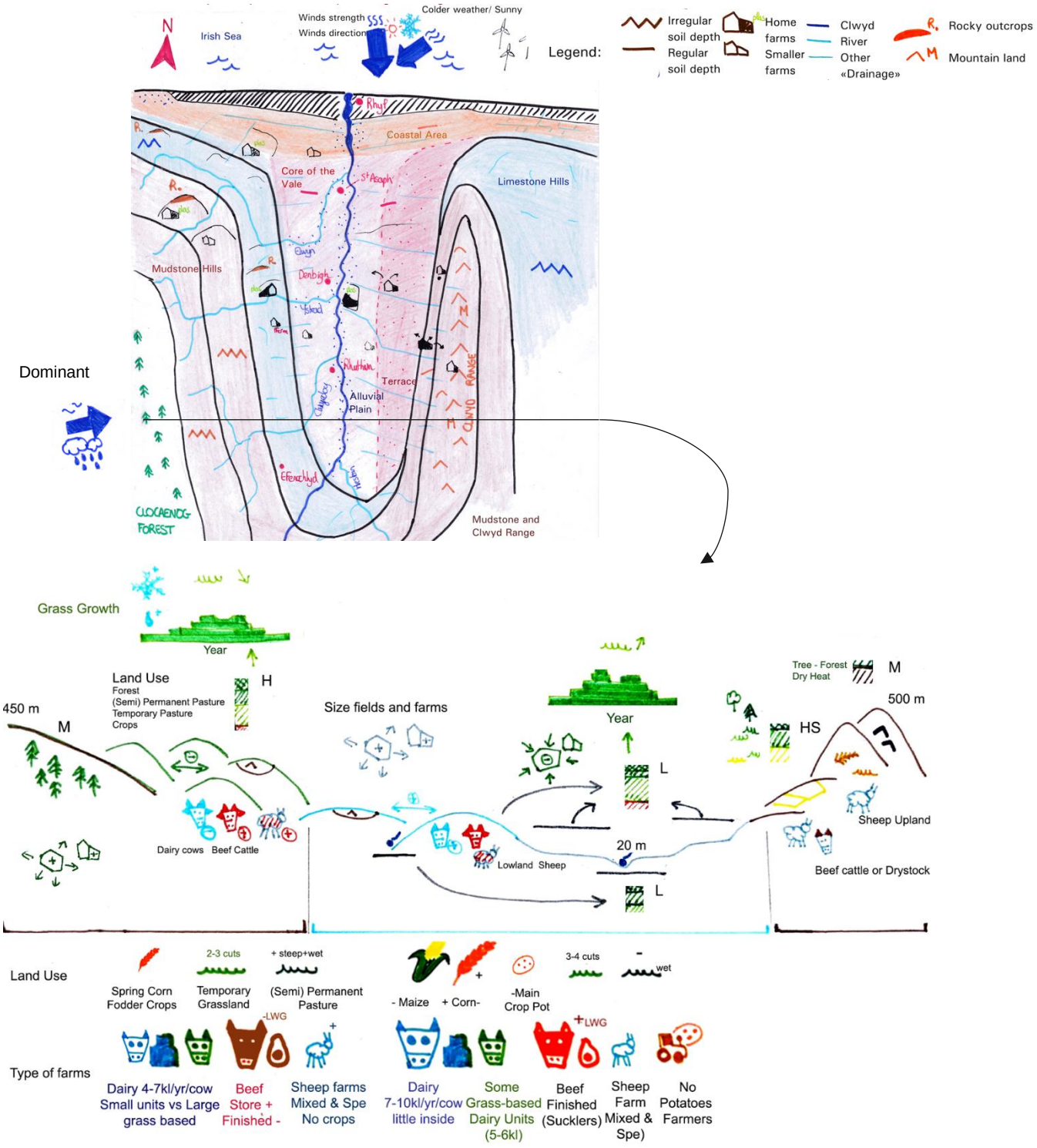


Figure A 9 & Figure A 10 : Vale of Clwyd area, landscapes, and general organisation from the geology to geomorphology and different geo-climatic potentials

By the coast there is a diversity of areas, close to the coast: salt marshes, dune grassland around the river and fields with marine deposits, drained wet meadows can be found. With no farms based there, the relatively free-draining conditions enable an all-year-round grazing albeit vegetation growth is limited (salt, wind) and of lower nutritional quality. Grazed mostly by sheep of lowland type except before/after lambing. There is an overwhelming tourism component there. Further from the coast, an alluvial/coastal plain similar in organisation or land use to the alluvial valley can be witnessed - albeit with soils tending to be heavier and in need of draining, and with fields also being larger.

The wintering of cattle is very similar to Pembrokeshire with an earlier start (2 weeks) and ending later (2 weeks) with the gradient small ridges/large ridges existing as well in the Vale of Clwyd. The slightly longer winter requires a more fodder.

The core is bordered on its sides by mudstone originated relief, hills and steep convex valleys rising up in altitude to the Clocaenog forest (West side) or the Clwydian Range (East side). The Clwydian Range is composed of ridges entailed by V shaped valleys with small watercourses. All these offers rather shallow (and fluctuating in depth), rocky, clayish, and loamy soils resting on impermeable substrate. During winter they are wet and not carrying while over summer they tend to be very prone to drought, with very limited vegetation growth as a result. The vegetation is growing on thin acidic soils, particularly on slopes with a rocky mosaic of bracken, dry acid heath with some acid grassland. As a result, this area is grazed by upland-type sheep with no cattle. The Clocaenog hillside has thinner soils and steeper slope than the small ridge area in Pembrokeshire with a smaller growing season (1-2 weeks, but not grazing) and less potential to mechanise. While soils tend to be thin on the slopes, colder and heavier soils can be found in the bottom of the valleys, more numerous on the Clocaenog side, with 15% steep permanent pastures and another 15% wet at the bottom of the talweg and valleys. Hill and mountain tops are usually even stonier with unimproved, dry heath, grazed by sheep. Some small conventional dairy farms can be found, some low yielding grass-based dairy farms along with beef and sheep farms producing storecattle or finished cattle (albeit not as fast as in the core and not to the same weight). To support this the land use has clear dairy grazing blocks, some hay fields

(whose numbers is limited given the steepness of slopes), some temporary pasture grazed by beef/sheep. This land use is more extensive than what was observed in Pembrokeshire.

To summarise, here is an area which benefits from a different climate compared to West Wales hilly lowlands and an organisation more connected to uplands. Despite conditions that would not seem as favorable for grass growth all year long compared to Pembrokeshire, particularly in the core of the area it has a profile less suited for grazing. The margins do not have access to such high energy fodder crops, the Vale of Clwyd even has some poor-quality rough grazing making it a very composite landscape. Mostly on the Clwyd range but also on top of some hills on mudstone and limestone. The area thus is shared between dairy farming and different level of land/animal production intensity in beef and sheep production, necessary to use the combination of landscapes.

Item 4-7: Landscape of study area - uplands, Bala a composite upland areas representative of Snowdonia

The Bala study area is to the south-west of the Vale of Clwyd one, it is a complementary lowland close to the uplands. In general, the succession of landscape agro-ecological units would be the following as altitude increases; The lush wide alluvial valley transitioning to green hills (brown topped) or slopes to climb up to the more mountainous parts (higher in altitude and wide ridge arrangement). This general organisation from the alluvial lowland (L) to the hills/slope (H) and then the mountain (M) can be found in every upland area (See below) a classification that broadly mirrors the LANDMAP classification for these landscape as a cartography study has shown. With a gradient in terms geo-climatic conditions. For example, on the Vale of Clwyd, the climb up on both side of the alluvial valley also fits this description, albeit the higher proportion of low-lying large ridges makes it a lowland area.

The geology is the tool to understand the landform for hills and Mountains, the heterogeneity of the rather soft and muddy substrate of the Denbigh Moor explains its hilly and contorted features compared to the plateau nature of the Berwyn side with a hard layer and a softer bedrock underneath. Snowdonia side has more plutonic bedrocks and offers a stark contrast, with outcrops pointing out to the sky in a landscape of taller hills.

In general, these bedrocks result in acidic, clayish, and loamy soils but with some localised variations with a gradient of colder and rockier soils. But the successive glaciations have smoothed landscape landforms and has resulted in massive deposits covering the study area, often poor-quality tills of different nature/origin (rock, clay, peat…). Snowdonia was the centre of this superficial surface glacier in North Wales. In turns giving rise to different types of soils with very different potentials and further differentiating it from other landscape units. The Dee Valley is the main watercourse for the catchment; dug out with glaciers melting and since then, its relatively large valley plastered with good quality alluvial deposits (500m- 2km).

On Snowdonia H and M, the poor-quality tills are everywhere (glacial superficial deposits), only rocky slopes (sometimes covered in scree) are not covered by them. On the rest of the landscape (Berwyn and Denbigh Moor), deposits did not reach the top of the H and M. They are thicker on the flat parts (peat). It is noted that the talwegs and valley bottoms have clayish deposits at the bottom. There is therefore a gradient in terms of nutrition and ability to mechanise/plough fields (to move away from the semi-natural vegetation in these different spaces and improve the fields). The two limiting factors would be the higher percentages of fields with steep slopes or wet/peaty fields/areas. The window for field operations gets smaller as one climbs up the geo-climatic gradient and on Snowdonia unit. Compared to lowlands nearly 2-3 months are lost.

In these areas, farming is the dominant activity, and the landscape is overwhelmingly pastoral with hedges delimiting large fields compared to lowlands or the valley on H; with most of the land under semi-permanent (30-60%, ryegrass dominated) or permanent pasture (20-40%, acid-grasses dominated), deciduous woodlands or large coniferous plantations, episodically some fodder crops and finally some rough grazing topping some hills. The M land is bordered by fences or stonewalls, often larger and less contorted than in lowlands. The semi-permanent/permanent grassland (10-20% acid grasses) or coniferous plantations encroach on the moorland line whether it is fenced into blocks or open (Heather, acid grassland, peat bogs…). The M unit is nearly devoid of farms or human dwellings.

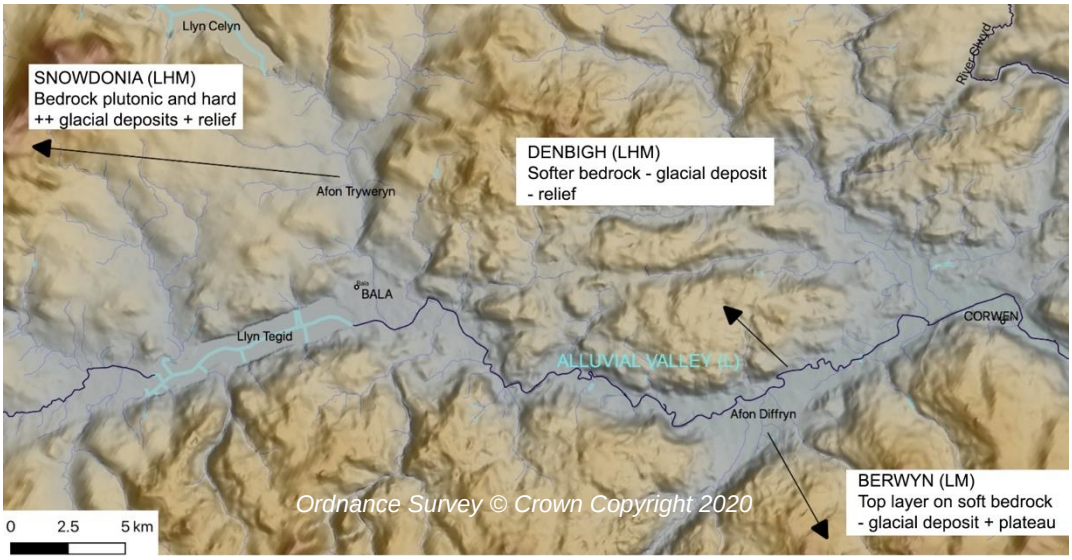


Figure A 11: Dee Valley Upper Catchment landscape organisation and characteristics (by the author from European Environment Agency, 2020; Ordnance Survey, 2020)

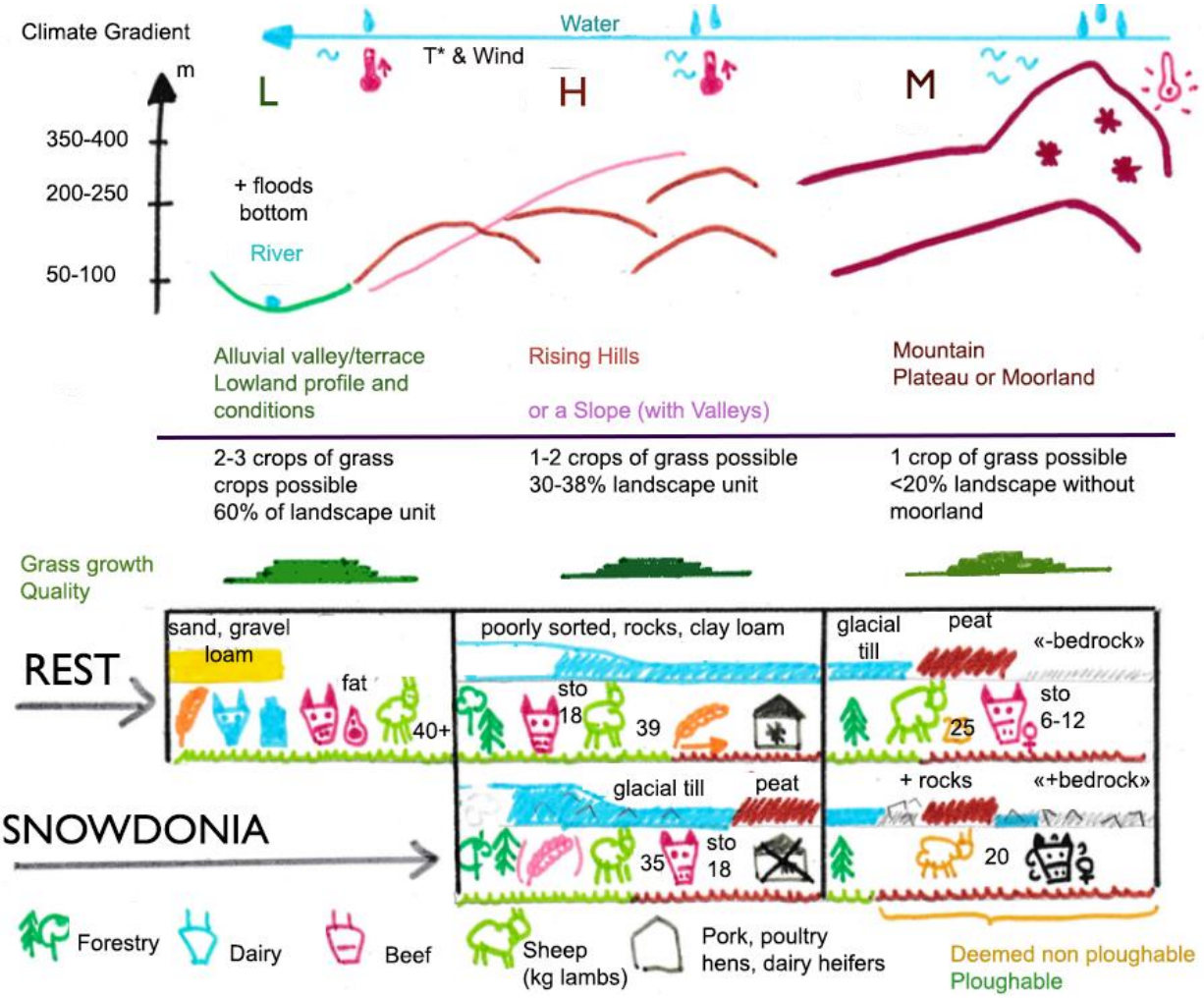


Figure A 12: Landscape units in Bala area, different bedrocks (by the author)

In terms of livestock grazing these areas 2 types can be identified; the mountain flock/herd (Welsh Mountain ewes and Welsh Blacks suckler cows) from the lowland flock/herd. The share of the mountain flock/herd is higher in the Snowdonia area and in farms with M/H units than in the valley.

The alluvial valley unit is the meeting point of the landscape units. It concentrates most of the infrastructure and inhabitants. The valley has deeper and more free-draining soils than the rest of the area. It can be temporarily waterlogged or flooded during winter, but it contains the most versatile soil of the study area with also the smallest fields (5ha). It can be grazed or ploughed early for the area, albeit much later than in a lowland (March to April) and grass growth will end later than on any other landscape unit. The grass is a mix of ryegrass with more white clover and the proportion of temporary pastures - more nutritious and with higher yields up to 10 T DM/ha/yr is higher. Some fodder crops might be found in this landscape to renew grassland in very small quantity. Livestock found on these landscapes could be dairy cows (mid to low yielding <6-7,000L), meat focused enterprises similar to the hills but with a bigger proportion of prolific sheep all with higher stocking densities (0.7 LFU/ha vs 0.5-0.4). Below it is demonstrated that even with broadly similar livestock the output would be different on each area.

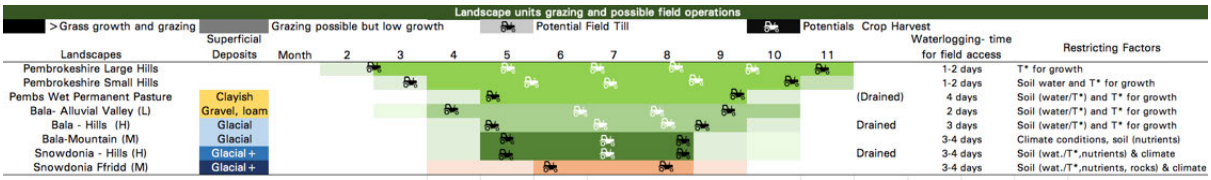


Figure A 13: Potential landscape units use and comparison: grazing and possible field operations combined to restricting factors

Above, the scale of the different geo-climatic operating constraints is demonstrated, more than in uplands. This signifies that operational groups of land use can be distinguished.

Hayfields/silage fields of which the proportion diminishes as the altitude increases - with more constrained timings for renewal and harvest, the higher the altitude, the later the crop. Those fields are also grazed outside of crops. Those field would be renewed from time to time (5-20 years).

Dairy farms would have grazing paddocks in the valley with a similar organisation and management to other examples highlighted before but with a shorter grazing season (From April to mid-October). Those field would be renewed from time to time (5-20 years).

On beef and sheep farm, winter is particularly long and grass growth is shorter, the higher the altitude. Farms need to clear up their hay fields (whose numbers are limited) and make in-field fodder stock in preparation for the end of the grass growth season on the upper parts of the farms. The lambing/calving dates aim at matching the lactation with grass growth. The livestock will therefore climb up the ecological gradient (available to the farm) over the summer and climb down over the autumn, the poorer/less nutritious ground being given to less demanding livestock (for example, suckler cows and calf compared to a mountain ewe with lambs). There is a complementarity between the in-landscape units to reach an optimum of livestock to carry.

While over winter and out of the grass growth season, most fields in the area would be set-stocked with livestock outwintered, the less demanding ones, around lambing (March to April) the fields used would be these around the farm with all the area used. There would be grass left for cattle to graze from April or May and that the sheep would vacate the fields to climb up with a rotational grazing pattern over 7 days with 2-3 months returns. The more challenging parts of the landscape (access or conditions - wet permanent pasture or moorland/mountain) would be set-stocked. The livestock would climb down, and the end of the rotation would be from September and cattle coming back inside from the end of October, beginning of November. It is at the end of winter that livestock kept outside might require supplementary feeding when requirement increase for pregnant livestock. For these farms, there is one crop of haylage during the year, with a very hypothetical and small second cut.

The moorland on M is used by farms that have some or grazing rights (common land), with a maximum use over the summer compared to winter and always with very low stocking densities (<0.1-0.3 LFU/ha). Farms with a high proportion of M land would be the only ones to graze it all year round and not select the livestock that would go there (other farm would handpick in their mountain flock, ewe lambs, dry ewes). Improving

the landscape by draining, reseeding can enable farm to raise their ceiling or have more flexibility.

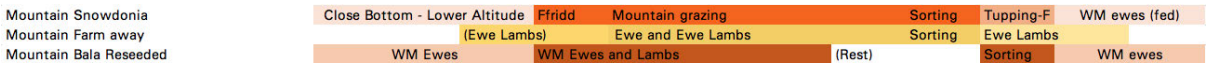


Figure A 14: Mountain use by different farms; improved or not (by the author)

Some farms are more restricted in this climb-up by their lack of some units in the landscape. Some other farms might be intensifying slightly the management, for example rotational grazing of livestock on their best temporary pasture for their best animals with only 2-3days on one field (e.g. lowland lambs).

There are more diversification units; particularly for electricity generation, integrated livestock units (poultry) and the tourism sector.

In summary, Bala area, is a mosaic to understand upland landscapes with a centrifugal organisation from the mountain and centripetal towards the alluvial valley, a land use focused on beef and sheep with a complementary use of the different altitudinal steps of the landscape by farms. The landscape remains a pastoral bocage apart when climbing up the hills up to the bare, sometimes rocky moorland. Snowdonia area is a more challenging area to farm with many improvements required for the same results. The enterprises and their organisation are very different to lowland areas, most farms are in the H and L steps but the M unit represents a very large part of the landscape accessible for a low production and many constraints, particularly on Snowdonia.

Item 4-8: Landscape of study area - The Cambrian Mountains Area– Rhayader a dissected plateau dominated by upland areas

The dissected plateau of the Central Wales Mountains is an area that is organised around Rhayader and the upper Wye river. The area features a diversity of landscape typical of the upland plateau of the Cambrian Mountain the area sits on a relatively homogenous type of bedrock. The landscape is mostly one of smooth upland hills and plateau with a relatively small alluvial valley.

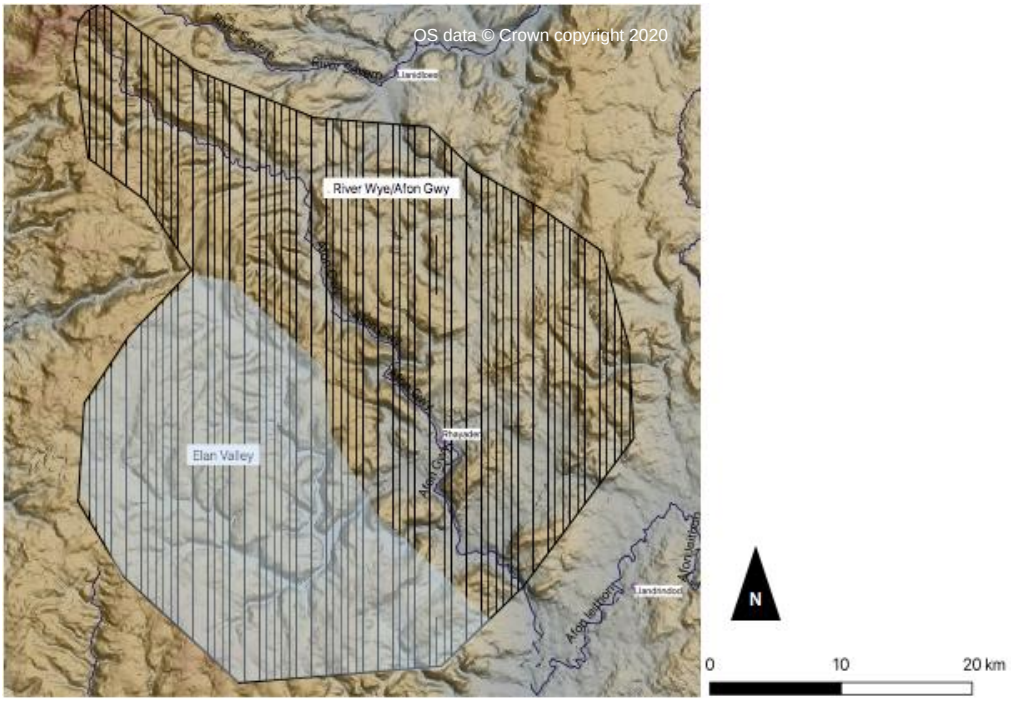


Figure A 15: Location and situation of the Rhayader study area in the Cambrian Mountains and the two important landscape units (by the author; Ordnance Survey, 2020; European Environment Agency, 2020)

Around Rhayader area (See above), folds and turbidites in the bedrock result in a gradient in terms of hardness/permeability giving a relatively smooth hilly and contorted landscape as water constantly finds obstacles within the substrate, valleys are V shaped and often dissymmetric as a result but without big altitude differences and limited steep slopes. The West side of the area has a more homogenous bedrock than in the East, but it tends to be harder and more impermeable. The limited number of folds and faults give a plateau differential relief with large V shaped, relatively straight valleys, feeding in few large alluvial valleys (Wye). In-between these valleys there are large tract of smooth gently hilly tops. Glaciations further eroded the existing profiles and added some deposits in the bottom of the valleys and on flat tops. It left a

mark in the form of the drumlin-like shape of many hills in the Rhayader area. A schematic landscape has been provided below. As in Bala, the three typical agro-ecological units can be observed; the alluvial valley (a smaller proportion), the hills and their slopes (more of it), the moorland/mountain tops.

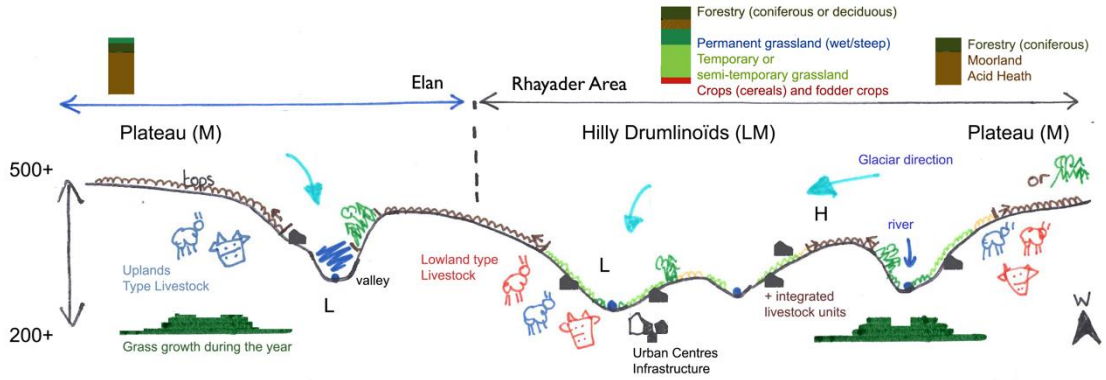


Figure A 16: Simplified landscape of the Cambrian Mountain area (by the author)

On the **Elan valley side**, only two agro-ecological units can be found. The main difference residing in the greater impact of the latest superficial glaciations impact compared to the rest of the area with more deposits and a higher proportion of deeper, U-shaped valleys. In the Elan, most of the alluvial valley and part of the hills have been drowned.

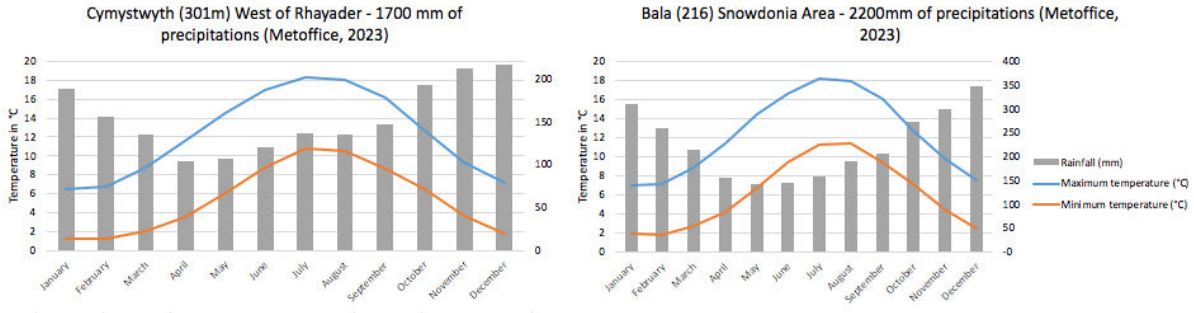


Figure A 17: Climate graph for Welsh uplands average 1991-2020 (Metoffice, 2022)

The climate conditions (see above) are different compared to the other upland areas studied, the precipitations are as important, but the pattern is different with less rainfall during summertime meaning that it does not impact winter fodder harvesting as much. The Eastern position of the area means that temperatures tend to be colder, particularly over spring but warmer over summertime. More of the grass growth takes place in the summer than in Bala and it is less adequate for grass-based dairy systems.

Soils tend to be mostly acidic, loamy with a clay component. These can be particularly heavy and deep in the valley bottoms and talwegs. On the flipside the depth of the soils can vary heavily on the slopes due to the bedrock underneath but on steep slopes they tend to be thin. In the more mountainous areas soils are shallow on the slopes, but heavy and peaty on talwegs and flat tops. Overall, these tend to be impermeable soils and do not retain water particularly well. The operating conditions between the climate gradient and the soils conditions are poorer than Bala at the start of the year but improve steadily being drier through summer with a safer harvest (See below). Nevertheless, the calendar in terms of cropping or livestock management has to adapt to the delayed access and limited fodder availability. The yields are lower on the hills with a lesser number of crops (2 crops maximum, 9T DM/ha/yr).

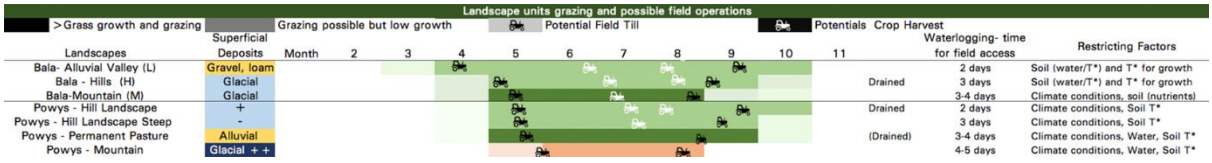


Figure A 18: Landscape units in the uplands, grass growth and possible field operations (by the author):

The Cambrian Mountains Area study area is characterised by a lesser heterogeneity compared to Bala, a slightly different climate optimum with different constraints around summertime and spring due to the Eastern position. It offers agro-ecological conditions that tend to be less extreme range (both ways) than Bala area but overall, as challenging conditions in terms of farming system potential, with a later start and a dryer period over summer.

The Cambrian Mountains Area is the area with the highest proportion of beef and sheep farms in terms of land use and tends to be slightly less diverse in terms of farming practices.

The Rhayader hills case where most of the sheep and cattle are of lowland/improved types and there are more integrated livestock units (poultry – broilers, pork), most farms do not have access to mountain land and manage their farm much like the Vale of Clwyd Clocaenog hills, albeit with more constraints from climate and wet pastures but less from steep slopes. Like in the Vale of Clwyd hills there are some crops being grown; cereals as well as fodder crops (under 5% of the area). The Rhayader hills,

feature the highest density of farms in the area, sheep are of lowland type with continental cattle, usually there is no specialised farm on cattle itself, the soils are less carrying making for a short grazing season for them, using residual grass growth is left to sheep. The diversification activities are less important for farms than in Bala area. More of the farms finish their lambs compared to Bala and they produce either finished or store cattle.

There are other types of farms that have access to the mountain land on Rhayader hills, their functioning and landscape use is similar to what was described in Bala. They are usually nearly entirely based on grass. They tend to have a mix of lowland and upland sheep (Welsh Mountain, albeit the specific type to the Cambrian Mountains Area) but retain some continental cattle types (Limousin, Charolais). The cattle might be of smaller size (Hereford Cambrian Mountains Area type) to graze the mountain as well (during the summer). There would only be one crop of haylage made.

The Elan valley is sparsely populated, the only inhabitants are the very dispersed farmstead, roughly one per ridge. The inbye fields only represent 5-10% of the landscape available compared to over 70% for Rhayader Hills farms, the rest is open moorland. Grass growth would start even later by late April, in-bye land is used during and around lambing to keep sheep while there is some haylage being made in early July, mostly on the in-bye land. Only part of the sheep would be always kept in the in-bye land at any time. Lambing and calving dates are adjusted with lambing delayed by 2-3 weeks compared to Bala.

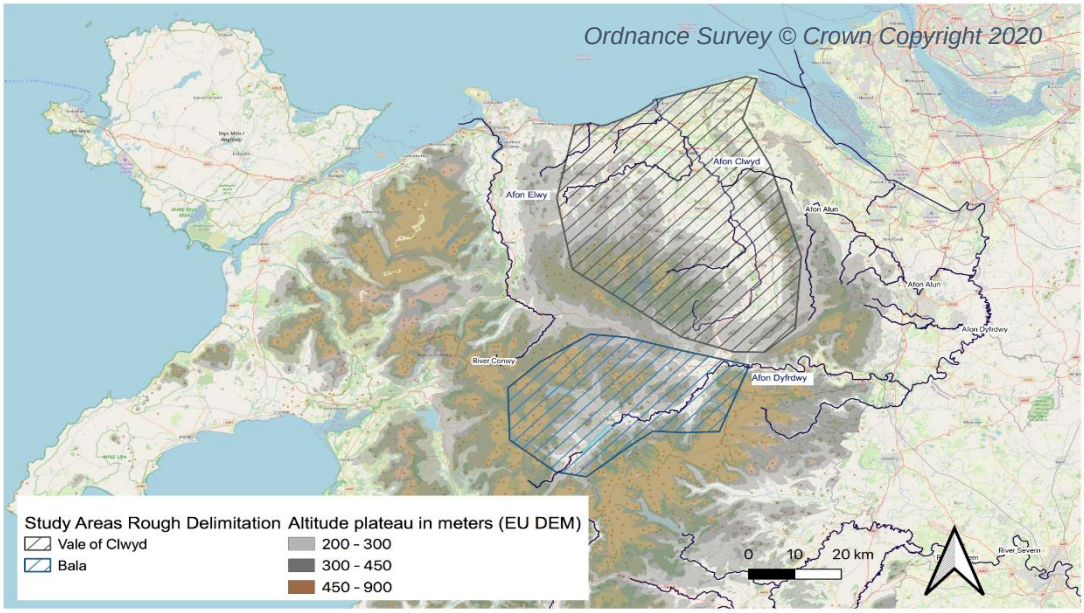
The mountain area is mostly covered in semi-natural vegetation, there is only management through grazing. The top bit with the bogs has a high proportion of Molinia, mosses as well as heather, there is a higher proportion of Agrostis type grassland compared to Snowdonia, which results in a higher production potential. As in Snowdonia there are large areas with peat and bogs, along the secondary waterway there are more wet patches with more rushes and mosses. These areas are grazed all year round by sheep and cattle of different farms, the land is managed as a common, there are more animals on the land over summer than over winter.

The type of sheep is Welsh Mountain (white and some blacks), badger-faced sheep, rough-breeds adapted to the open-mountain grazing. On the cattle side, suckler cows to produce stores are mainly of the Hereford breeds or dairy cows crossbreds (with a Hereford, Limousin or Charolais bull). What comes out of this landscape are mostly stores as well as couple finished lambs. Demanding breeds for this landscape but the stocking density is very low and the moorland more nutritious than the one in Bala.

The Cambrian Mountains Area has a higher proportion of land planted under forestry and managed by private or public actors (over 10ha), in the hills, smaller plantations and woodland are observed - 1-5ha - with few managed commercially.

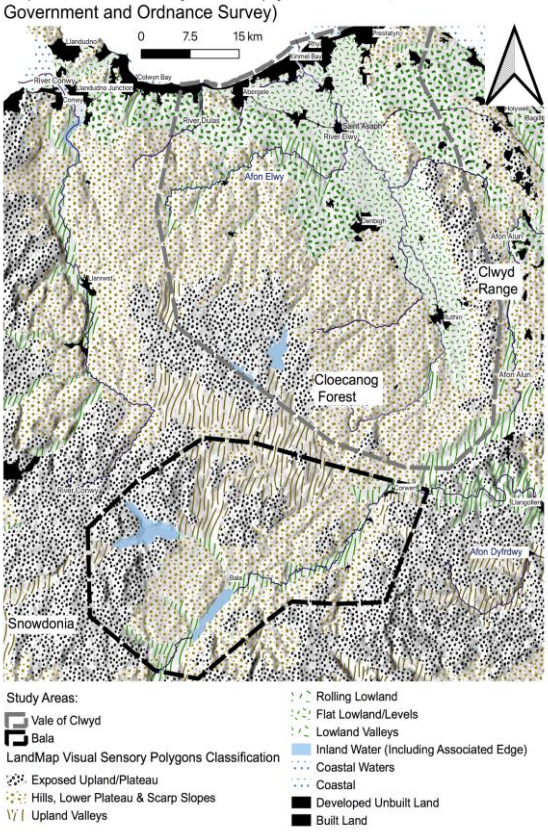
The three uplands agro-ecological units are different compared to Bala due to the climate and relief, the alluvial valley is much smaller, less lush and does not grow as much, it can be quite wooded as a result with many permanent pastures. The hills are much more asymmetrical but give more smooth slopes, there are of similar quality although with a different grass growth. Finally, the mountain is much smoother and maybe, more accessible and of slightly higher nutritional quality. All in all, most of the area could be compared to the Clocaenog hills or the Bala hills agro-ecological units but with a smoother relief.

Item 4-9: Situation map of the 2 study areas used to discuss the intermediate uplands concept in North Wales (by the author from DataMapWales, 2017; European Environment Agency, 2020; Ordnance Survey, 2020)

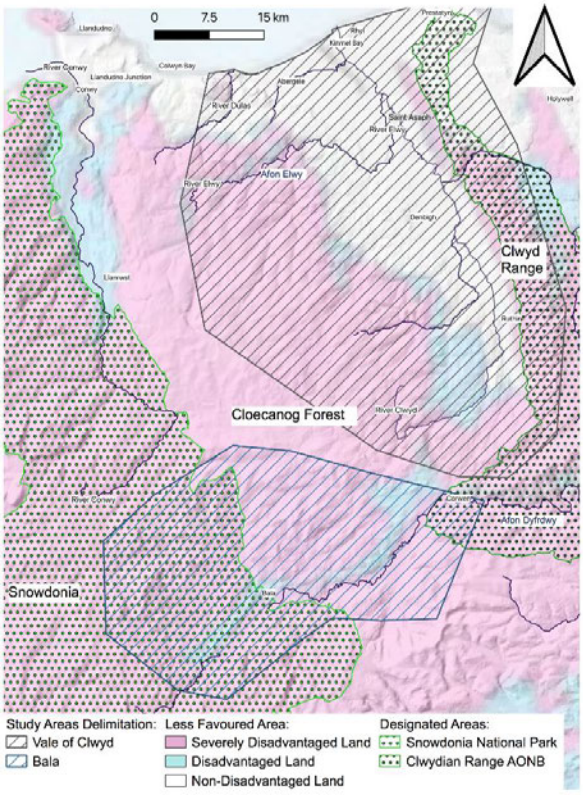


Item 4-10: Maps of the study area, of their landscape and LFA status (by the author from DataMapWales, 2017; European Environment Agency, 2020; Ordnance Survey, 2020)

Map of the two study areas, (By the authors, data from Welsh Government and Ordnance Survey)



Map of the two study areas, LFA status and designated areas (By the authors, data from Welsh Government and Ordnance Survey)



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- Context and policy changes after 1930

In the 1930s, the United Kingdom took substantive measures to support its agricultural sector against the backdrop of an economic downturn. Legislative enactments such as the *Import Duties Act* (1932) and the *Agricultural Marketing Act* (1930) were pivotal, imposing import tariffs on livestock products and instituting market regulations for various agricultural commodities, including milk, pork, potatoes, and cereals (Moore-Colyer, 1998). Particularly noteworthy was the pivotal role played by the Milk Marketing Board, meticulously analysed by Rooth (1985), in establishing a uniform national price for fresh milk. This strategic alignment with trade policies resulted in a discernible reduction in net imports of targeted agricultural productions.

While these reforms engendered monopolistic structures for some agricultural outputs, they also gave farmers the right to establish their cooperatives. Subsidy schemes (House of commons, 1930), were instrumental in supporting land and farm enhancements, encompassing drainage initiatives, lime applications, livestock improvements, and refurbishments of farm buildings. There were two key objectives; elevating standards and mitigating the prevalence of bovine tuberculosis. Farmer support mechanisms included a modest flat-rate subsidy on cattle, conceptually structured as a potential levy (Moore-Colyer, 1998). In general, the Milk Marketing Board playing a prominent role in facilitating such improvements (Ashby and Evans, 1944).

This interventionist paradigm progressively extended support across diverse agricultural productions, particularly in the domains of milk and arable farming, ensuring equitability for producers irrespective of geographic location (Empson, 1998). In Wales, eligibility constraints were observed among pig producers, coupled with a relatively modest presence of arable producers. As the UK evolved into a more urbanised and industrialised entity, safeguarding a reliable food supply assumed paramount importance, necessitating additional state interventions (Coggins, 2018; Rooth, 1985). The establishment of the Forestry Commission in 1919, spurred by the timber short-supply following World War I, strategically targeted land acquisition and

afforestation initiatives, notably including the Clocaenog forest in North Wales[81], which predominantly comprised low-quality agricultural land (Forestry Commission, 1952). Given Wales' distinctive agro-ecological characteristics and expansive upland terrain, its substantive contribution to the Forestry Commission's initiatives encompassed the management of crown and council woodlands, along with the holistic development of the associated supply chain (Raum, 2020). Concerning other resources, for example water, reservoir-building was seen as a way to deal to provide towns with a stable supply, again focused on uplands with their low population, high precipitation and adequate valleys[82].

- The early beginning of the 20th century agricultural revolution

The 20th-century agricultural revolution, driven by technological advancements, witnessed two distinct phases. Initially, farmers focused on motorisation, acquiring tools like tractors for efficient ploughing and field operations with little change in their operating practices (Hodge, 2016). This enabled the expansion of acreage for fodder crops and corn, enhancing fodder production and quality for the livestock, this led to an increased output (Moore, 2010). This phase was not (yet) about farm specialisation.

In the first phase, innovations such as the bucket vacuum set in new buildings facilitated milking chores, allowing for the care of a larger number of higher-yielding cows. The adoption of tractors and the adaptation of 19th-century mechanized tools freed up space in stables by eliminating the need for workhorses. Simultaneously, the shift from haystacks to haybarns streamlined management and improved fodder quality. As much as 20 or 30 British Friesian replace the 10-15 Shorthorns in bigger

[81] Several hill farms disappeared or lost some land when being requisitioned and turned into forestry by the Forestry Commission with a 999-year lease or outright purchase from the landlord. This was dealt directly with estates in general with little involvement of farmers. The land selected would have been usually mountain sides or tops making a significant visual impact on the landscape.

[82] The Elan Valley dams a case-study of agricultural land used for other purposes in the Cambrian Mountain Area: the Birmingham Water Corporation, in the late 19th century, selected the Cambrian Mountains in Wales for a water supply to Birmingham due to advantageous features. The 1892 act initiated the Elan Valley water dam system construction. Birmingham's acquisition formed a new estate, impacting existing boundaries and causing challenges in 20th-century land registration. Water-focused management led to a comprehensive area restructuring, reducing stocking density and farms by a third. The purchased land, linked to the water table, cut through sheepwalks. Source: Elan Valley Trust Website; CPAT 2022; Joyce, 2013; Winchester and Straughton, 2009

buildings. A higher milk production can be achieved by buying some feedstuff (corn and soybean) and having better quality more fodder. The bucket vacuum set in new buildings makes it possible to milk more and higher yielding cows (up to 4KL). More milk than before would have to be transported to town/processing centers (using motorized tool/collection). Additionally, farmers adopted advanced rotational grazing techniques, bough-in inputs to correct the soil deficiencies, optimizing efficiency, reducing intervals, and increasing outputs. In this phase, side-enterprises were also improved using bough-in inputs (e.g. feedstuff for pigs). This description highlights the first steps towards heightened specialisation and much-changed environment.

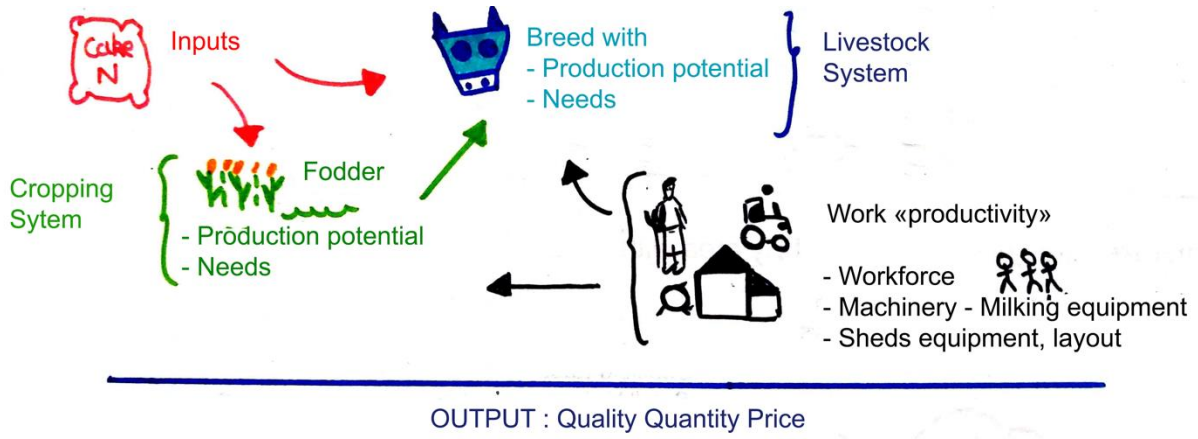


Figure A 19: Farming system equation and production gains using inputs a balancing act (by the author)

Illustrated by this example is the interconnected rationale behind higher work productivity and the alleviation of time-consuming operations. The augmentation of work efficiency primarily centered on optimizing the prevailing Norfolk rotation system, with a limited extent of artificialization of production. A significant indicator of this transition is reflected in the statistics, revealing a notable surge in green crops, specifically fodder crops for cattle, in Wales. The acreage devoted to green crops escalated from 7% in 1915 to 22% in 1939 (Ashby and Evans, 1944). Notably, this shift was more pronounced in lowlands compared to uplands territories.

The rapid adoption of tractors revolutionized farming, however, the advent of lorries and cars emerged as a similarly transformative force, providing farmers with enhanced mobility to access a broader range of inputs, outputs, and services, including veterinary care. The evolution of veterinary sciences played a pivotal role, significantly

reducing losses on farms by addressing issues like tuberculosis, worms, and maggots (Ashby and Evans, 1944). This advancement particularly benefited farming systems with animals spending extended periods away from the farm (e.g. mountain livestock).

The accessibility of new elements and tools, including veterinary services and supplementary feed like feedstuff, facilitated increased animal output without a proportional demand on land resources. Despite the potential benefits, the adoption of these innovations faced limitations in less favored uplands, constrained by cost considerations and agro-ecological conditions. All farms participated in general improvements, such as drainage, liming, and the livestock improvement scheme, as documented by Ashby and Evans (1944), highlighting the widespread commitment to advancements within the agricultural sector.

- Context and policy change after 1945:

After World War II, Western trade policies, mainly regulated by the General Agreement on Tariffs and Trade (GATT) and subsequent iterations, emphasized trade liberalization while safeguarding the heavily protected agricultural sector in many nations (Burfisher and Jones, 1998; Senedd Research, 2022b).

The UK, operating within a Keynesian economic framework that emphasized government intervention, nationalized its farming sector during the war to ensure food security (Bowers, 1975; Rackham, 1986). Post-war Agricultural Acts guaranteed prices and outlets for agricultural products, particularly crucial due to continued rationing for the industrial workforce (Bowen and Martin, 2016; Bowen and Morris, 2019). Key policies included deficiency payments, covering the disparity between government guaranteed and market prices, and schemes like the Hill Farm Compensatory Allowances, acknowledging varying production potentials across regions (Bowen and Martin, 2016).

Wales, characterized as a marginal area, highlighted the significance of such policies, with nearly 90% of the region classified as such. The *Agriculture Holding Act* (1948) provided tenancy security combined to death duties it was contributing to the rise in owner-occupied farms.

Forestry acts post-war increased the Forestry Commission's role, aiming for increased output and adopting industrial means of production (Raum, 2020). The *National Parks and Access to the Countryside Act* (1949) led to the establishment of national parks, areas of outstanding natural beauty, and sites of special scientific interest, emphasizing planning permissions and environmental conservation (Dwyer, 1991; Hodge, 2016). These policies underscored a balance between trade liberalization and protecting agricultural interests, with significant implications for agricultural development and land-use planning in the post-war period.

- And even further up until the late 1980s:

The above set of technical transformations were implemented through a second-phase policy support from the 1970s. From 1964, during the peak of the Cold War and amid Britain's declining balance of payments, a notable shift occurred in agricultural policy. The new Labour government viewed agriculture, which had surpassed productivity expectations post-war, as a potential export industry (Bowers and Cheshire, 1983). To support this vision, border controls and import taxes on animal products were imposed, allowing consumers to bear high farmgate price support costs without deficiency payments.

Direct subsidy payments persisted in livestock production:

- Sheep variable subsidies were introduced, assessing the sheep market on a union-wide basis, and providing subsidies to smaller upland farms or these producing smaller animals/stores, while guaranteeing wool prices.
- Calf subsidies for live or slaughtered calves and per-head subsidies on suckler cows were introduced, incentivizing farmers to increase livestock numbers.

In the early 1970s, following the 1972 oil crisis and amid soaring inflation with negative real borrowing rates, farm input prices rose significantly, pressuring farmers to expand to maintain income levels.

Upon entering the European Economic Community (EEC), the UK adapted its agricultural policy to integrate improved supply and demand control through Marketing Boards, managing surpluses from the Common Agricultural Policy (CAP) and

constructing specific butter and powdered milk plants. The UK retained the ability to adjust the pound value for converting CAP subsidies from the European budget. From 1975, stagnating real prices prompted the need for farms to enhance income through increased value generation via specialisation and adopting new tools. Investment and early retirement support schemes continued to assist this transition.

To increase farming productivity, farm development plans from 1970 (Mansholt, 1970) offered subsidies of up to 40% on buildings and equipment, encouraging specialisation and field adaptations. These plans also supported rough grazing reclamation and allowed for increased artificialization techniques. Additionally, an early retirement plan aimed to facilitate the exit of less efficient or smaller farms from the sector.

During the 20th-century agricultural revolution, the adoption of new practices and technologies significantly increased food production (inc. land and labour productivity). This era witnessed increased utilization of agricultural inputs/tools and artificialization of farming systems, primarily steered by investment in Research and Development (R&D) and extension services. However, this phase of advancements was costlier than its predecessor and led to a more industrialized supply chain that preferred standardized raw products in terms of quality (Hodge, 2016).

Notable innovations included (Fieldwork):

- Artificial Insemination (AI): Introduced for genetic improvements, particularly in dairy cows for higher milk yields. In beef systems, while AI was not as pertinent due to less daily animal handling, selection techniques and genetics improved for enhanced meat production and faster growth.
- Milking Practices: Purpose-built milking parlors streamlined milking processes, collecting milk into bulk tanks for efficient collection by tanker trucks. New building types emerged, featuring steel frames, concrete flooring, and cubicles for animals, enabling batch management and increased animal handling capacity.
- Machinery Advancements: Tractors became more powerful and versatile, enhancing productivity by 30-40% with newly developed machinery like square

bale machines, harvesters, and drum mowers. Specialized caterpillars were introduced for working in steep or challenging terrains.

- Fodder Production: Breeding of crops and grasses led to a range of varieties tailored for different purposes, including high-output grasses for cutting or grazing, suited for beef, sheep, or mountain reseeding. Artificial fertilisers supported increased fodder production, especially in lowlands, alongside rotational grazing techniques.
- Silage Revolution: Anaerobic fermentation techniques revolutionized grass harvest, enabling more reliable and mechanized processes for making silage. High-yielding grass varieties combined with fertilisers increased forage production and simplified rotations.
- Fodder Management: Silage storage in steel-framed buildings with controlled feeding methods or tractor-fed systems enhanced feeding practices for dairy or high-yield animals. Bought-in inputs complemented fodder needs, leading to specialisation in production types and comparative advantage focusing on grass-based production in Wales.

Item 5-2: Evolution up to 1945 of case-study areas

- South-Pembrokeshire a diversified lowland:

Key sources: Fieldwork, Davies and et al., 1993; Davies, 1939; Fenton, 1811; Hassall, 1794; Lenormand, 2019; Perkins, 2004

Pembrokeshire was always accessible (by sea, then rail, then road…) quite rapidly. Pembrokeshire (as was most of Welsh lowlands) was cleared and farmed early on. It was one of the first areas to be taken by the Normans in Wales; the feudal system was thoroughly implemented (by church, aristocracy, squires) and later evolved into estates. Landowners triggered the reorganisation and amalgamation of farms in the 19th century to adapt to changing market conditions (crisis in favour of livestock products and perishable products), adopting "ley farming" with the enclosures. Given the bio-climatic conditions, Pembrokeshire grass leys with clover were rightly seen as a terrific use of the land available. It was more work on smaller, wetter ridges with their heavier soils also impacted by their less favourable grass-growth profile. Surplus could be generated even on relatively small acreages and then marketed to pay the rent.

The early 20th century marked the move towards ownership for profitable Pembrokeshire farms, mid-size family farm and large-rented: gradually paying back the loan on their farm by selling surplus. This was done at a terrible time for farming; the 20s depression. But Pembrokeshire focus on grass-based systems enabled a high work productivity to keep selling "niche" rewarding perishable goods. In this scenario large ridges holder, red-soils farms, and farms close to the city and communication axis were favored. These were the farms that were able to adopt the early 20th century agricultural revolution ahead from the others.

The 1930s marked a general change of context. The MMB development offered a profitable and easy to focus on output with the rationalization of milk collection with one price offered for all and more support than ever. Every farm was sure to be able to sell their surplus, there was a gradual adoption linked to past good or bad fortunes (time to buy farm vs interest rates, already close to the railway, selling directly…). Ending the transformation of farms outputs meant the workforce was able to keep more cows, particularly on small farms. New inputs available, at cheaper price (feedstuff) meant it was possible to maintain other productions on the side. Farms that

had benefited before from the conditions might be able to develop their milk production further.

The Second World War marked an optimum of 'ecological intensification' of production with very diverse rotations (Norfolk rotations with potatoes on big ridges), combined with intense work, steady livestock output and higher arable production. It remained a relatively prosperous period. Farmers on small ridges would start to take the leap in endogenous production while big ridges farms were starting to get toward mechanisation and an increased use of inputs (fertiliser (for potatoes mostly) and bought-in feed).

- The Vale of Clwyd

Key Sources: Fieldwork; Forestry Commission, 1952; Howell, 1946; Peate, 1965; Pryce, 1974

The Vale of Clwyd was more integrated with existing food markets in close important industrial centres. Vale of Clwyd's farms had been less impacted by successive agricultural crises of the 19th and 20th century, indeed "improvements" to the land had been thoroughly done, all the more down in the core of the valley, and more than in Pembrokeshire. Representative of this the fact, most mid-size family farm and large farms were finishing cattle and sheep in the 1930's-1940's. Farms were mixed with a strong labour-consuming livestock element (allowing them to resist to crisis); egg, poultry, pigs, dairy produces… As well as some crops to feed livestock (corn, kale…) or the area (spuds…). The finishing and cropping benefits would be reaped by the large ridge areas farms. Along the middle of the core vale there would be a high concentration of large "home" farms, using the best land. It is important to keep in mind that the farming density was higher in the core of the vale and the large hills than in Pembrokeshire.

The arrival of the MMB in the 1930's or the Second World War were not as big a step change compared to Pembrokeshire; farms were featuring a much higher proportion of cropped areas on smaller acreages (-10a per family worker). Surplus heavy farms benefited more from it first, but it enabled mid-size family farm and SMH farms to generate a higher surplus securely. Another testimony of the comparatively positive market position was the rapidly dwindling estates from the 1920's with a much faster

and earlier farmer's owned movement that in isolated Bala. The exception to this general position would be the mudstone hills.

There was also an "early adoption" of the 20th century agricultural revolution. Farms other than very small cottages, and particularly home farms could have 3 to 4 cowsheds, some steel-frame/brick sheds and Dutch barn double the size of Pembrokeshire. This allowed in buoyant market conditions to increase the area in rotation to support more livestock. The harvest of hay (06 end), corn (08 end) or potatoes (09) is more "secure" (weather wise) but later than in the South-West but winter is longer and harder. The use of the mountain land next to the lowlands was traditional, on par with what was observed in Bala case-study though with slightly larger ewes. On the small ridges/steep valley the adoption was more gradual slower. This early adoption was using costlier buildings, in a context with lesser support while the price of land was higher than elsewhere, it would slow down the investment capacity for later phases.

- Bala, the Upper Dee Vale:

Key sources: Costello, 2021; Davies, 1935, 1810; Howell, 1946; Keeling, 2012; William, 1980

Given how isolated is the area and its self-sufficiency; the impact of the agricultural crisis was felt differently to lowlands. The relatively low surplus (apart from large farms) was on products that were challenged by overseas production from 1900. The isolation of Bala, the low surplus, of lower "quality" (as stores) meant that until the 1930's the available surplus for investments was really small, consumed by improving gradually the holdings (the First World War represented a temporary uptick). Farmers were not able to buy their farm. It is only from the Second World War that farms adopted the 20th century agricultural revolutions, except larger holdings that started during.

With limitations due to the need for a complementary use of the landscape; some farms had to use the moorland all year round, while others would only do it when conditions were favourable, as well as the complementary growth profile. An increased proportion of the H and L areas were ploughed for cereals, main crop potatoes due to the significant incentives and agriculture boards management. Reclaiming moorland

hill-sides. Milk collection began with the MMB for an area that was relatively deprived of it before. Surpluses had an outlet helping improve the holding and boost production with tools and subsidies.

It resulted in a greater ecological intensification using fodder crops but not necessarily grazing techniques to help intensify the food output on all parts of the landscape, partial motorisation helped to limit labour constraints.

Due to this challenging context with lower surplus and less valued than these of Pembrokeshire this explains the absence of farmer's buying their own farms before 1945. Proof of this challenging context the intense shuffling of farmers across farms, and the number of home farms let with preferential terms to attract tenants. Another indicator was the sheer amount of people leaving the area, to work elsewhere but also to farm in lowlands like in Denbighshire.

- Powys, the Cambrian Mountain Area:

Key sources: Fieldwork;Joyce et al., 2004; Redford, 1940; Winchester and Straughton, 2009

The Cambrian Mountains Area has been quite late into being linked to estates. This area had been attributed mostly to monasteries that took part in the agricultural development, organised the landholding and reclaimed the landscape, early they focused on breeding animals adapted to the agro-ecological conditions with specific types of Welsh mountain sheep. Mercantilist vision was behind this move but it provided farms with a steady surplus income. The dissolution of the monasteries meant that it was redistributed to several supporters of the crown, giving several small estates, few based in the area. As a result, they would later be sold quite early to the farmers in larger quantities than in Bala.

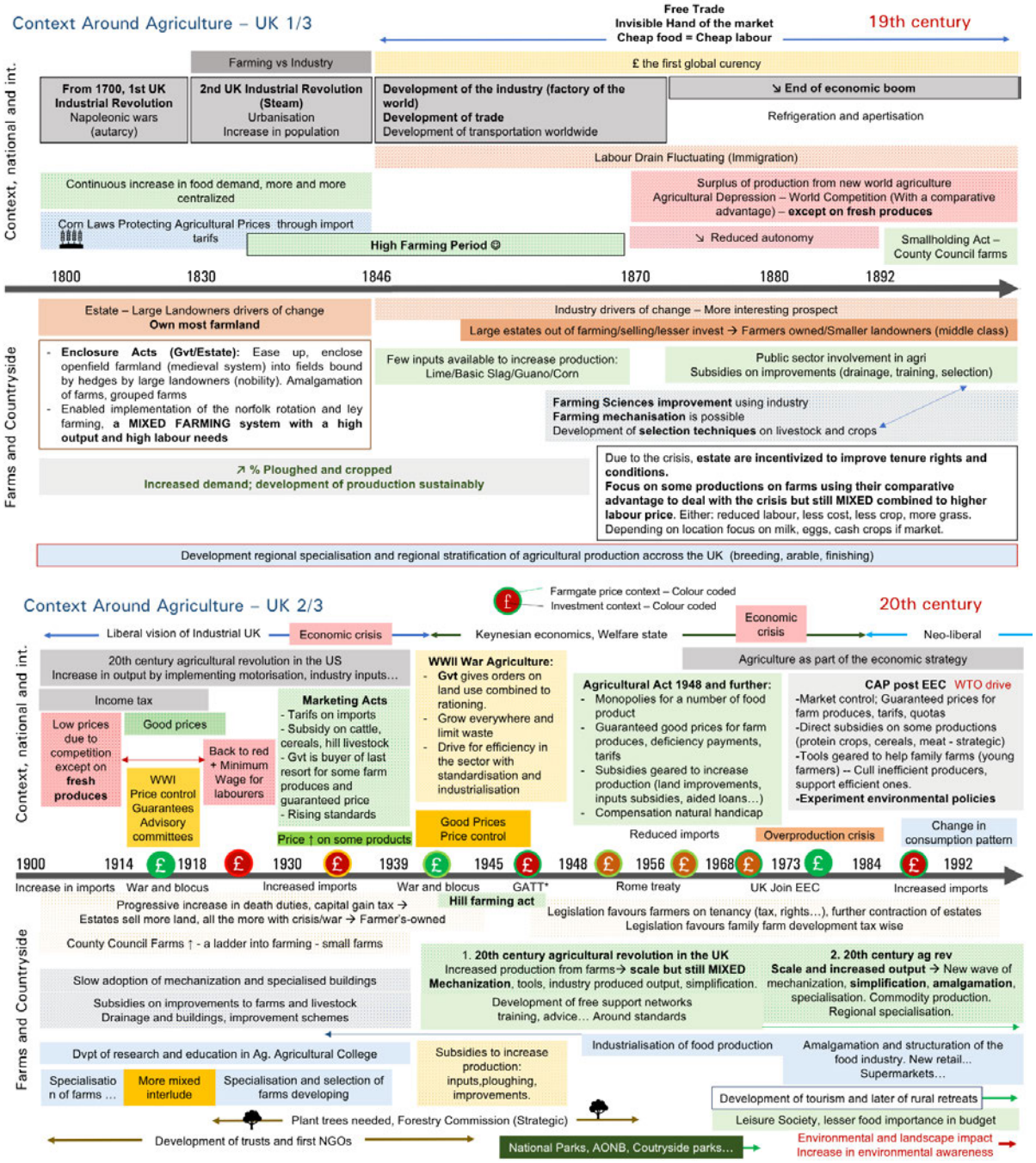
Likewise, the proximity of Herefordshire and populous area meant that there was a market for store animals waiting to be finished, the wool, and for labourers during peak working times. A denser network of farms could be supported compared to Bala, even if the farms could not produce all of what they needed. As a result, a beef and sheep system combining a maximum use of the resources available and manageable peak times in conjunction with potential contractor's work was implemented. Early on from 1900s it was possible for some farmers to buy back their land as this land was

perceived as less interesting for estates. Two defining moments for the area had also been afforestation by the forestry commission post First World War that took away some swathes of moorland with conifers but also the reorganisation of the Elan valley at the end of the 19th century in order for the water storage network to be implemented. Reducing the number of farms, farmers, and livestock drastically with a reorganisation, each farm having a small inbye land and access to the moorland, usually with grazing-rights (on commons or on private land).

There was a partial adoption of the 20th century agricultural revolution early on, the area did not benefit overly from the MMB development but more so from the war context as in Bala. Partial adoption would cover breeds, the use of some inputs, improvements to land (permanent pasture, wet or rocky) to incorporate it in the rotation and during the Second World War the reclamation of rough grazing or steep/hill-side permanent pasture. Increasing the livestock production as well as the arable (corn) one.

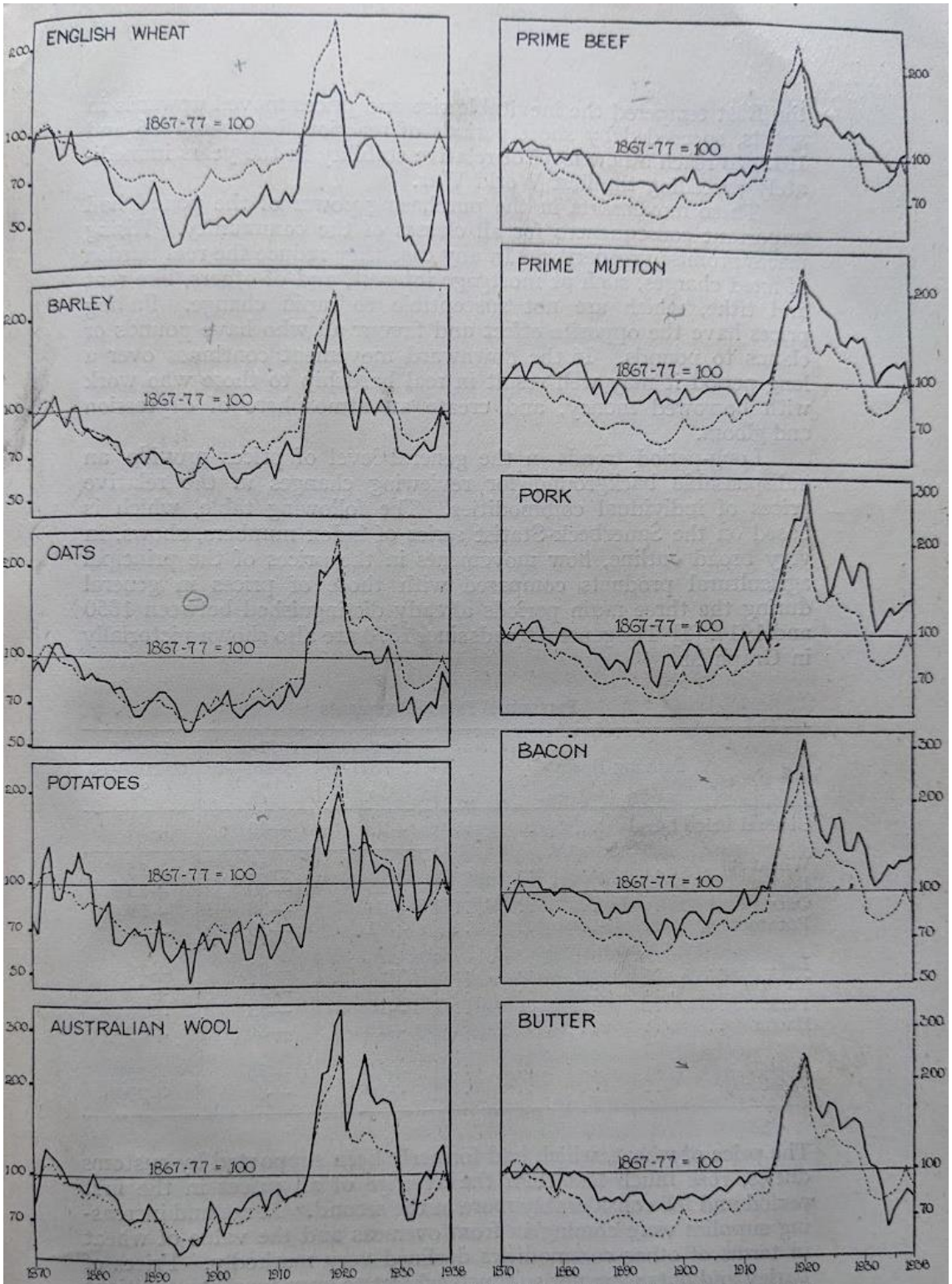
These two upland areas and the Vale of Clwyd hills had been impacted by the development of forestry and water reservoir extensively during this time period, removing part of the farmland.

Item 5-3: Context around UK agriculture 1870 to 1970 (by the author from literature)



Annex 6: Price, trade, and economic context graphs

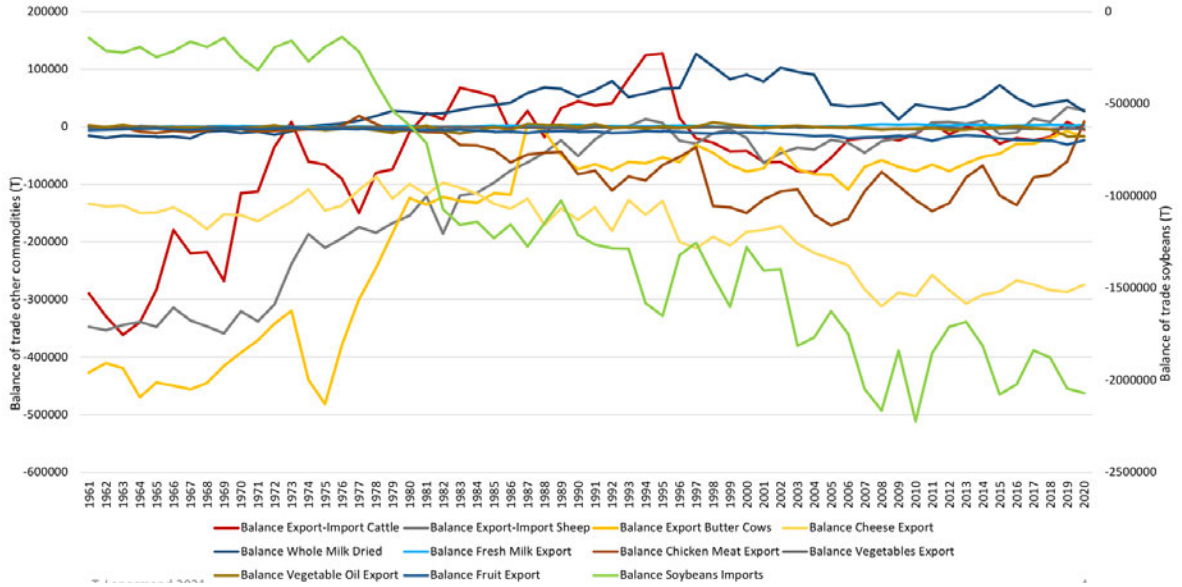
Item 6-1: Evolution of agricultural output prices from 1870 to 1938 (From Ashby and Evans, 1944, p45).



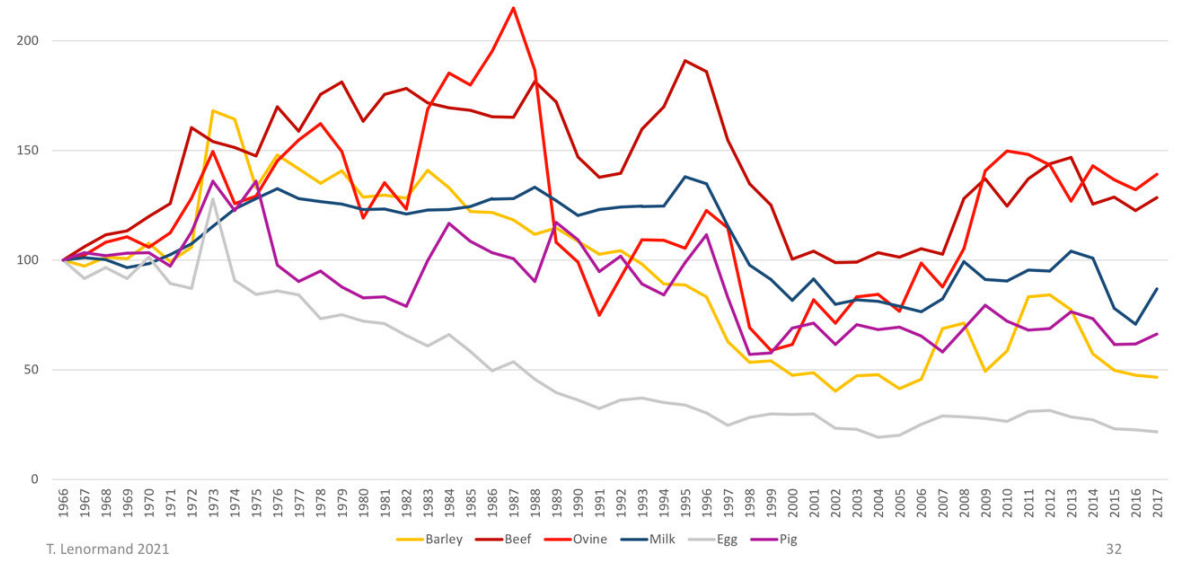
GRAPH M.—Price Movements: 1870-1938. The dotted lines indicate the general price index.

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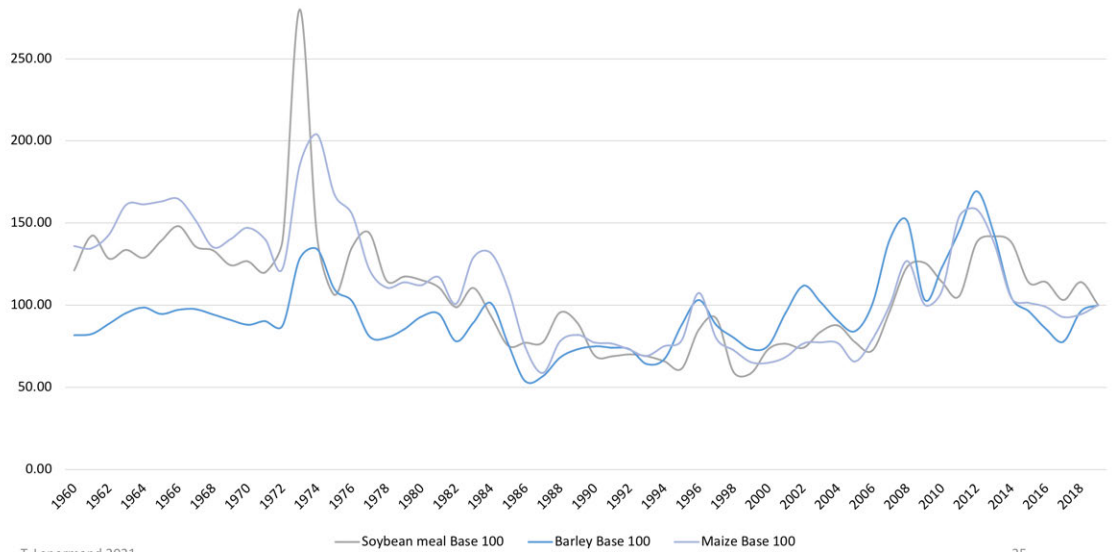
Item 6-2: Balance of UK trade in tonnes (exports-imports) for agricultural inputs and outputs from 1961 to 2020 (FAOSTAT, 2020)



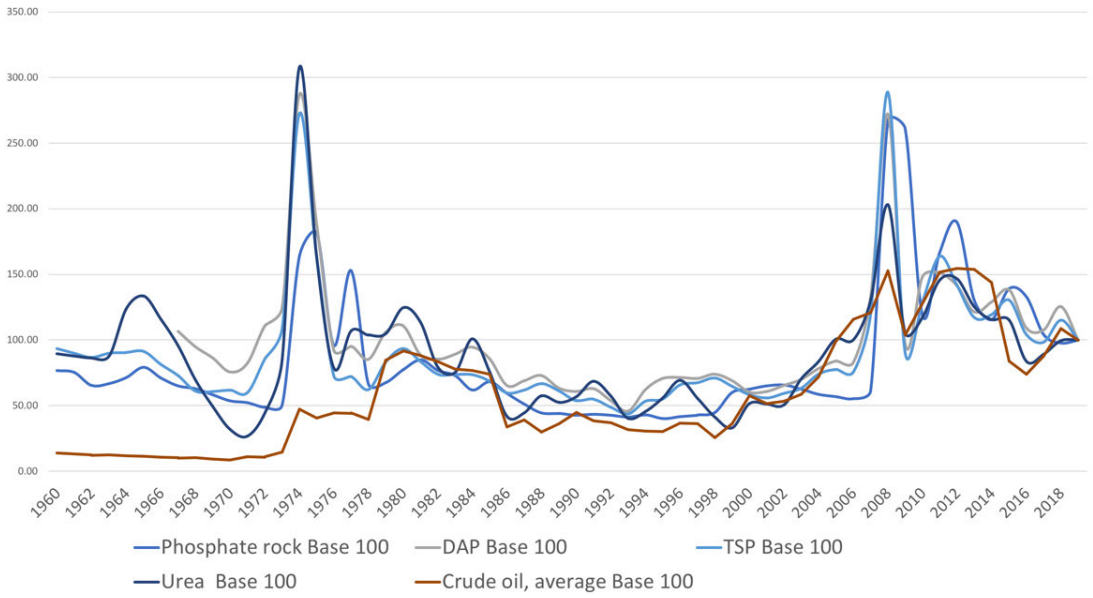
Item 6-3 : Evolution of UK agricultural output prices evolutions from 1966 to 2020 (100 indices for 1966) (FAOSTAT, 2021)



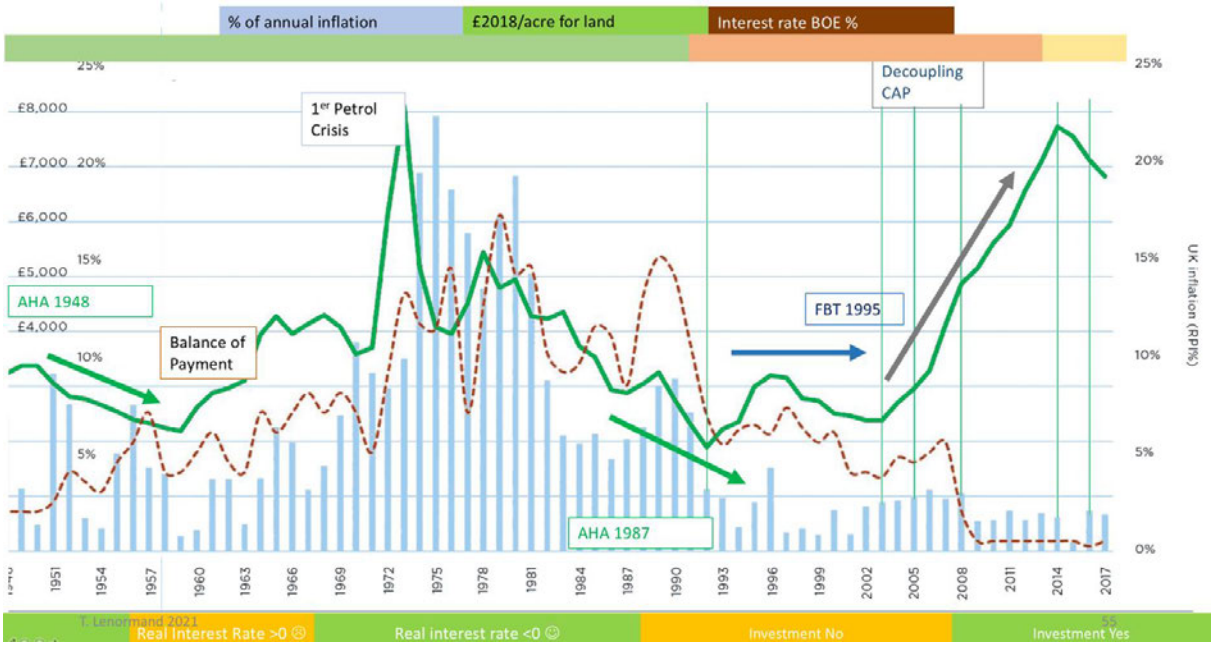
Item 6-4: Evolution of deflated agricultural input prices from 1960 to 2019 from World Bank data (indices 100 2019) (by the author from World Bank Data, 2022)
Inputs from agricultural origin:



Fertiliser and fuel:

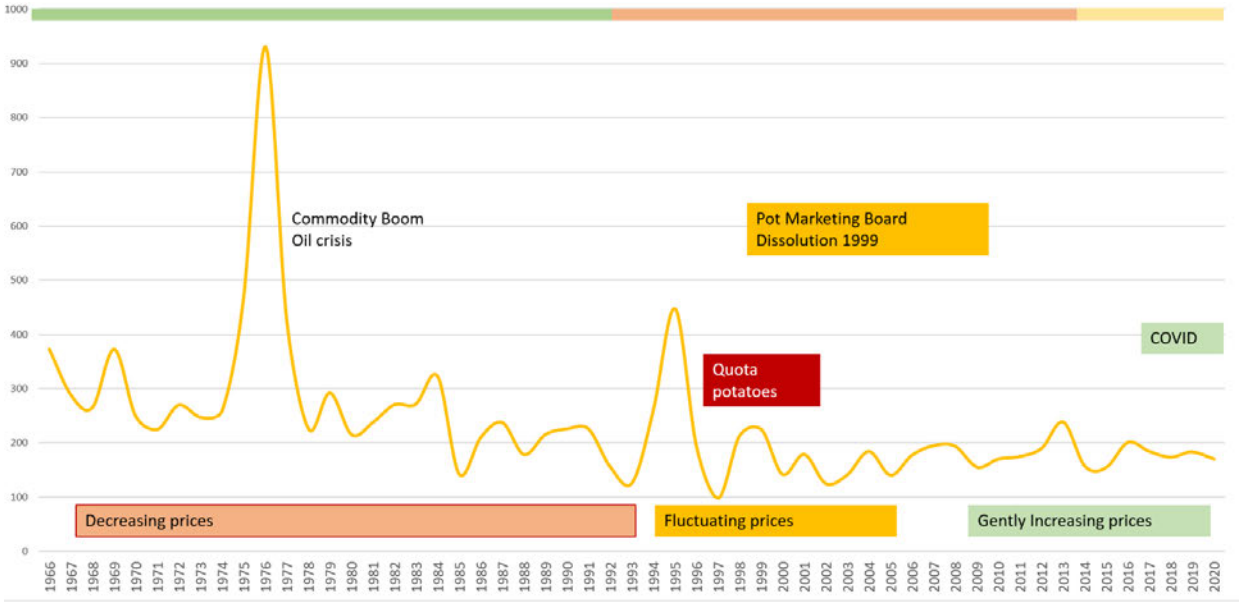


Item 6-5: Evolution of the UK economic context from 1945 to 2017, inc. Arable land price (adaptation from Savills Research, 2020)

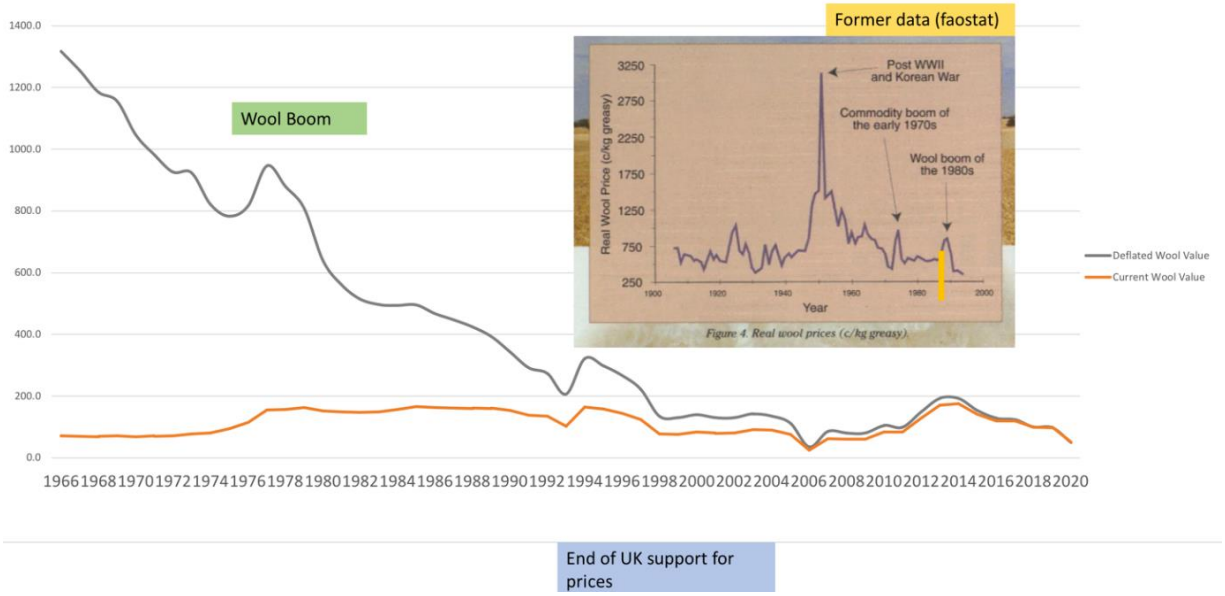


The real interest rate is used to (comparison between the interest rate of the Bank of England and the inflation rate) give an idea of the cost of borrowing (Savills Research, 2020). Since 1980 two contexts can be identified: from 1980 to 2008 real interest rates were high; then from 2008 to 2020 real interest rates remained low, offering a much more favourable investment context. Banks will lend to farmers with enough collateral (i.e. owning assets) or to support high added-value and relatively low risk business plans. Throughout the period, the government has offered a range of investment grants to farm businesses, but these typically cover less than half the total eligible costs of any investment wherever the result has a clear commercial benefit to the business. By contrast, for investments made where the main benefit is for the public (e.g. to enhance biodiversity or create new free amenities), government grants may cover up to 100% of eligible costs. Thus from 1980 to 2008 the context would have favoured investment in public goods and services over private ones whereas after 2008 this phenomenon would have reduced.

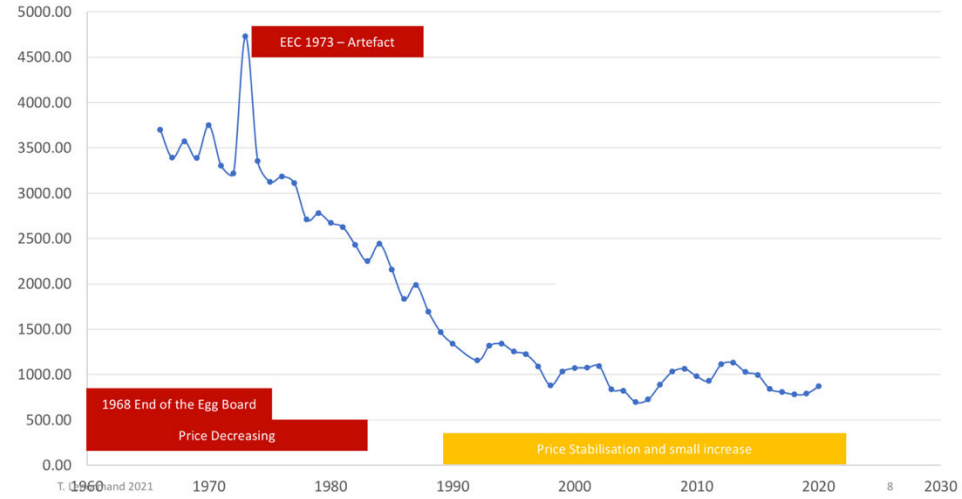
Item 6-6: Evolution of the UK deflated potatoes prices from1966 to 2018 (indices 100 2018) (FAOSTAT, 2021)



Item 6-7: Deflated and current UK greasy wool prices evolution 1900 to 2020 paid to producers (indices 100 2018) (FAOSTAT, 2021)



Item 6-8: Evolution of deflated egg prices in the UK in £2017/T (DEFRA, 2023c)



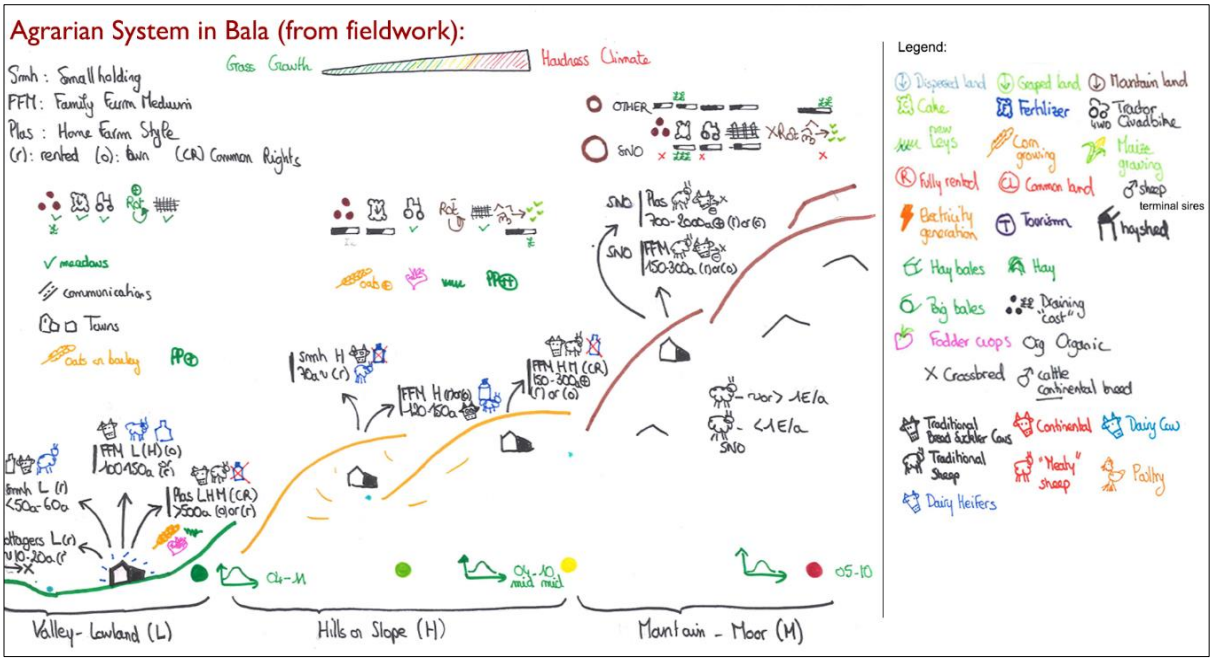
Item 6-9: Discussion of the impact on heifers rearing from further spring calving unit developments (Fieldwork).

More recently, the favourable context for dairying and the gradual increase in share farming, has trained and empowered a growing pool of potential managers ready to take up the challenge of operating their own unit. Recent volatility, as well as history, suggest that these systems will remain profitable. This means that more recently, lack of succession or end of tenancies on some mid-size family farm has meant the land was converted to dairying, by estates or by their farmer owners. Smaller grazing platforms require some additional land, less adequate infrastructure requires more investment per cow, and increased appetite from landholders given the scarcity of land on offer (Lenormand et al., 2021b). This accelerated the sub-contracting route described above. They have different sizes of herd depending on the size of the grazing platform available, but herds are usually smaller than these of the large farm-based spring calving dairy units.

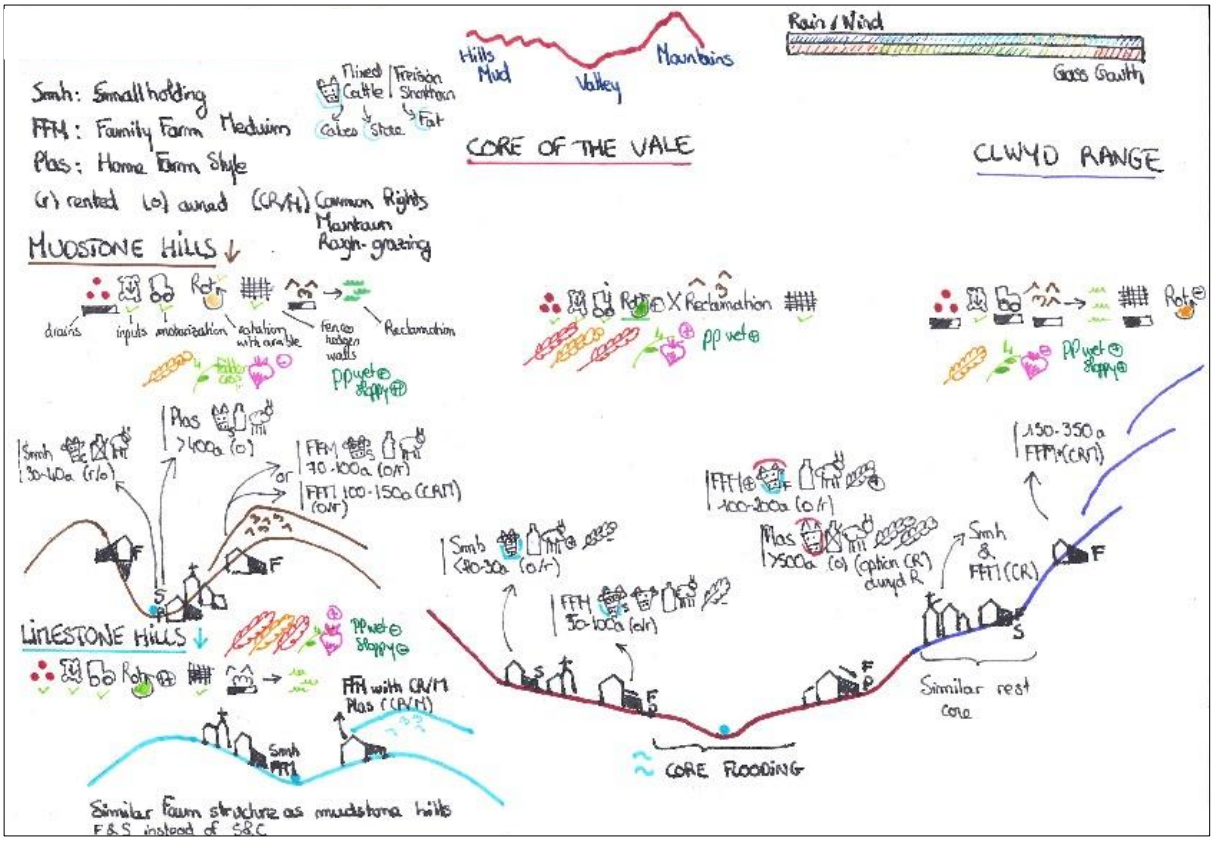
In general, the development of such units has gradually climbed ‘upslope’ in respect of the geomorphology, climate, and infrastructure. In the future, more diversity may arise, for example these relatively homogenous systems could go organic or adopt regenerative systems, with different contracts, lower yields, and stocking rates and potentially a more diverse land use than only grass, to manage fertility renewal.

Annex 7: Agrarian system in case-study areas

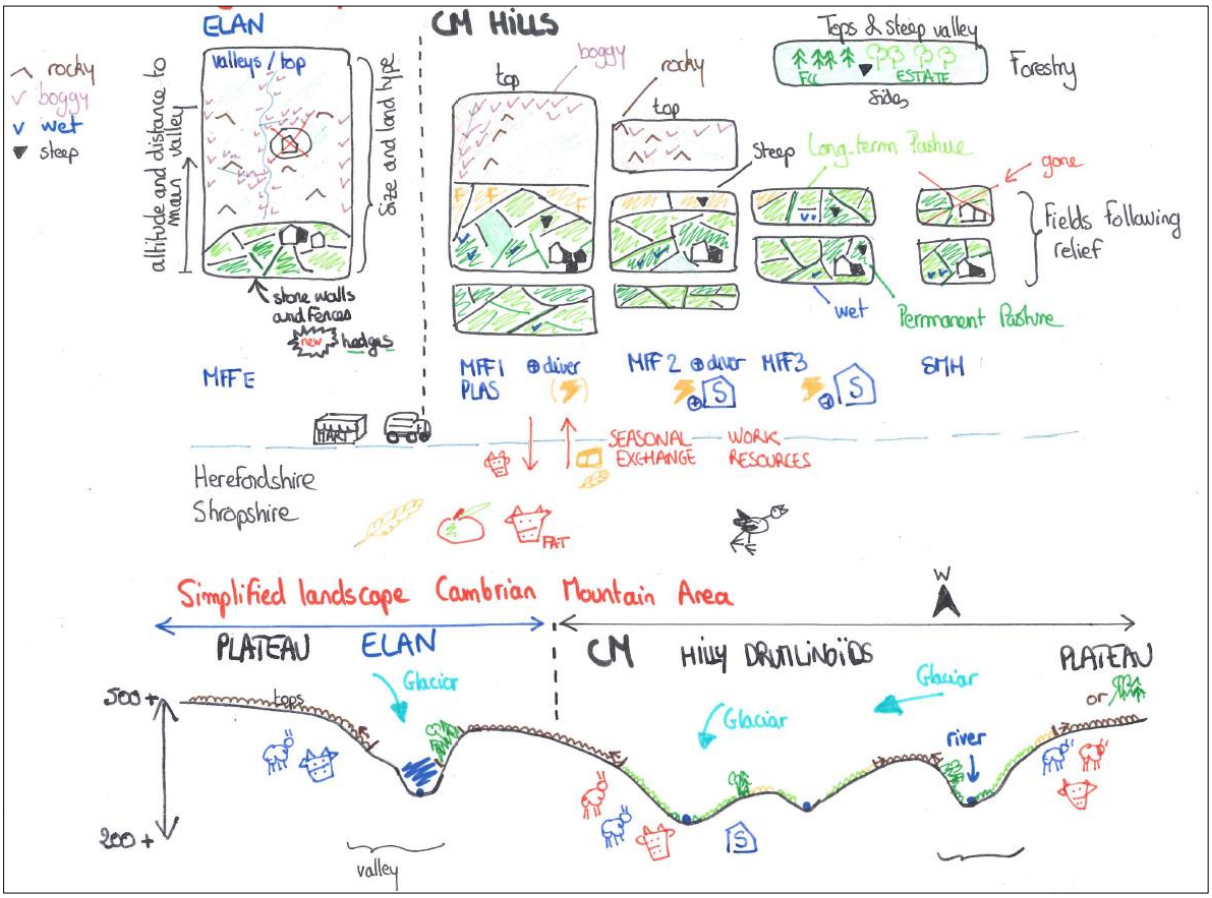
Item 7-1: Agrarian system of Bala area in 1945 (by the author)



Item 7-2: Agrarian system of the Vale of Clwyd in 1945 (by the author)



Item 7-3: Agrarian system of the Cambrian Mountain Area case-study area (by the author)



Item 7-4: Pre-1945 - Detailed description of the UK agrarian system (by the author)

The UK landholding has a complex history with centuries of evolution out of feudality (rights and obligations of each actors of a pyramidal society)(Thirsk, 1987). There was no revolution in the UK and the feudal system stayed in place, nobility that had fiefs gradually converted the set of obligations of peasants under their power into landlord-tenant relationship. A monetary rent was paid yearly for the occupancy of the land (Thirsk, 1987). This was linked to the industrial revolution, the increased need for commodities – the wool of the first industrial revolution - and by the 18th century agricultural revolution, linked to the Norfolk rotation[83]- both of these led to a reorganisation of farming system and field boundaries (Hodge, 2016; Perkins, 2004). This was driven by the landowners on their estates in study areas although there were few exceptions[84] to the dominant tenanted sector (Beckett, 1984; Thirsk, 1987). This enclosure movement went up gradually in altitude to stop when the improvements were too difficult or if the economic conditions degraded; this can explain the lack of enclosure of some moorland.

The first half of the 19th century context enabled landowners to gradually implement the 18th century agricultural revolution (Allen, 1999); heavily investing to increase production sustainably the production through improved agronomic logic and additional work (both in the year and overall). Tenancy duration, rent reviews, evictions, compensations for improvements were not regulated. The access to a tenancy was competitive and there was an obligation for the tenant to provide working capital (livestock, tools) as well as prove that had the funds to run the farm up to the first harvest[85].

[83] Norfolk is a four-course crop rotation where the crop structure is 50% cereals, it was characterized by an emphasis on fodder crops (including legumes) and by the absence of a fallow year compared to previous method (Skinulienė et al., 2022)
[84] Yeoman and copyholders, holding proof of their right to occupy the land and managed to avoid the conversion into the lords' property
[85] Labour representing at least 1/2 of the expenses of the farm

As a result of this agrarian history, the farms were organised for different types of tenants, three types of farms were distinguished (an illustrative example is provided below) (Howell, 1999, 1983, 1946):

- Large farms, either home farmed by the estates with salaried workforce or tenant farmers with large amount of capital (potentially over 40-60ha, 6% of farms), with the largest home blocks and on top of the large ridges/best parts of the landscape.
- Mid-size farms with a mix of family workers and salaried workforce with intermediate amount of capital (over 8ha, 38% of farms)
- Smallholders with only family workers, possibly even only working part-time on the farm and selling their workforce to other farms (often under 8ha, 48% of farms)

In the context of uplands, the landholding was even more important as it need to split much more different agro-ecological spaces (Howell, 1999; Fieldwork):

- Large home-farms (estate) would be larger than in lowlands (above 120ha) and most of all have access to the 3-landscape unit mentioned earlier, a strip from a large valley floor block (with the homestead, crops…) up to the un-enclosed land.
- Mid-size family farms would have access either to one or two landscape units (1-2), but smallholders would only have access to one (1 or 2).
- It was demonstrated earlier that with altitude the landscape agro-ecological potential was diminishing this explains an increase in terms of farm size for similar farm categories as is shown between farms 1, 2 and 3 (see below).

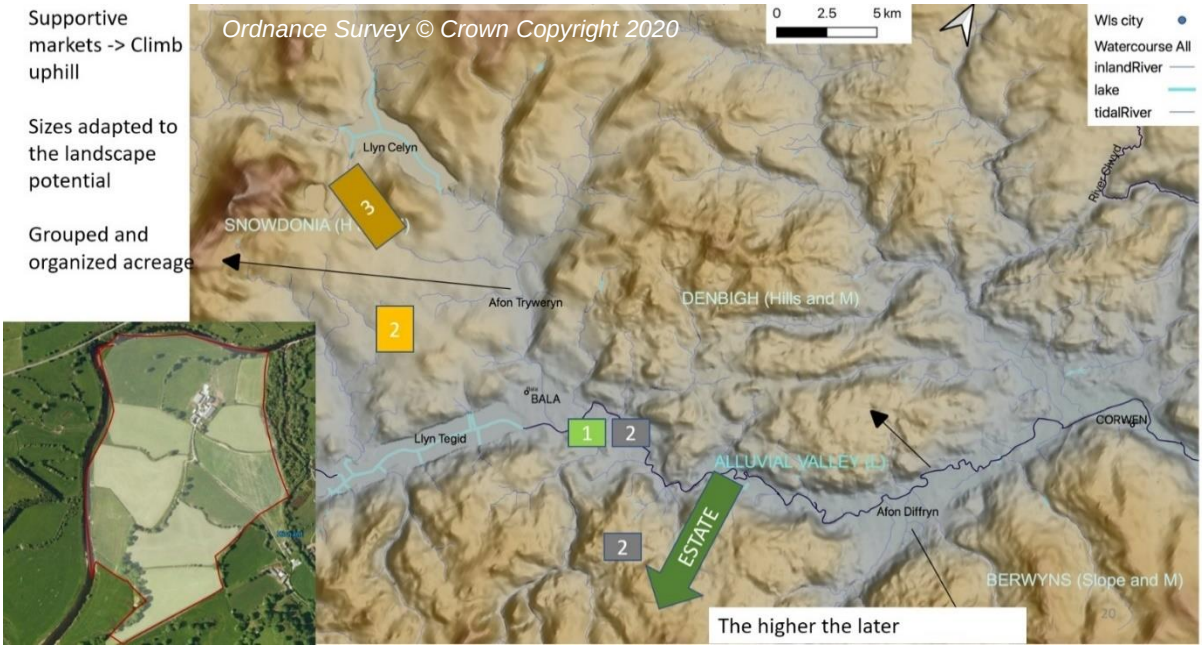


Figure A 20: Relief map of Bala's with the location and size of different farm types (by the author from Interviews, Google Earth,2020; European Environment Agency, 2020)

From the 1870s an agricultural depression linked to a free-trade policy on agriculture, with the 'repeal of the corn laws', that enabled food-exporting agricultural countries to access the UK markets, agricultural prices went down (Capie and Perren, 1980; Thirsk, 1987; Whetham, 1960). In all cases this was facilitated by the new transportation and food conservation technical breakthroughs. Now that farms were facing increased competition UK farmers had to deal with the fact that the labourers could access an ample job market in industry. This increased the cost of labour and cost of production at a time where mechanisation was not a common feature. There was a drop of "profitability", though farms were self-sufficient they still had to pay the labourers and the rent (Davies, 1994).

Several farms had to be re-let on the market or were struggling to meet the terms of their lease. At the time there was also a growing discontent represented for example by the farmer's alliance, reclaiming more balanced tenancies (Howell, 1983; UK

parliament, n.d.). Farms, in remote areas ended their lease, for example around St Davids (Pembrokeshire) or around the Llyn Celyn (Bala)[86].

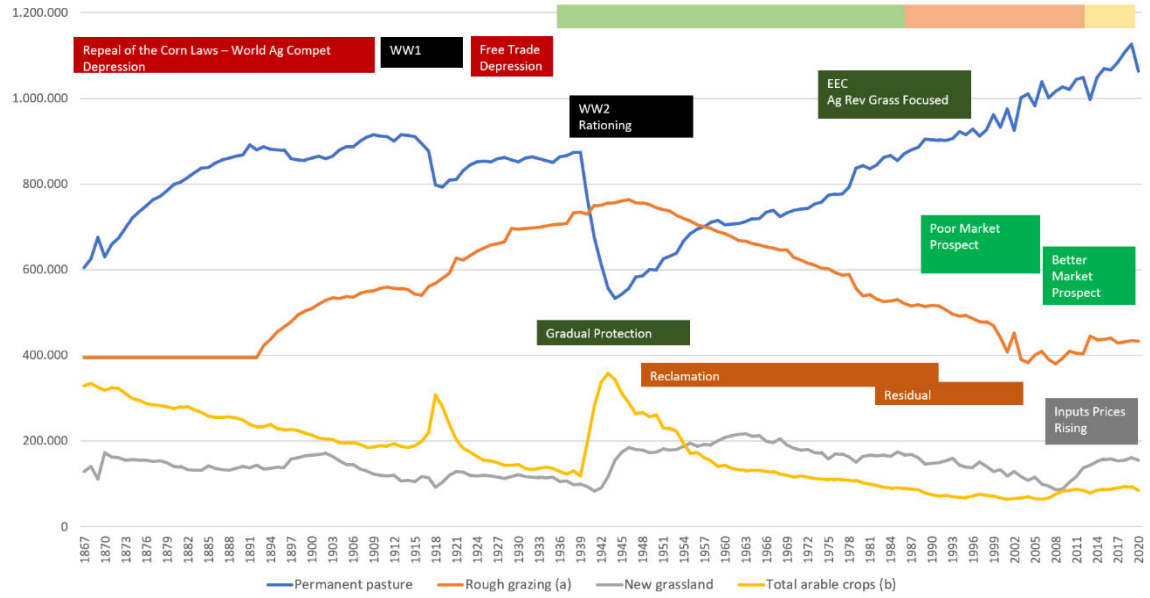


Figure A 21: Evolution of the land use in Wales (by the author from Welsh Government Historical Statistic, 2020)

Campbell, (1985), Hunt and Pam, (2002) and Perry, (1972) provide good examples of local evidence of these impacts. Landlords had to adapt to reflect the difficult context; offering longer and secured tenancies (100 years or three generations), scheduled rent reviews, rules on improvement compensations, free years of rent at the start, bidding by tender, reduced restrictive clauses. And through *Agricultural Holding Acts* (1883) and 1906 the law regulated tenancies regarding compensation for improvements as well as the freedom of the tenant (UK Parliament, n.d.). Some farms were also re-organised at that time to enlarge them and accommodate the lower output of farming systems, with less cropping and grassland taking an increasing part of the farms, and an increasing proportion of ruminants (See above)(Davies, 1994, 1810; Howell, 1999).

Some estates reduced the size of their landholding and went out of farming (Fieldwork; Beckett, 1984), leading to a change in the landholding structure of the agrarian system,

[86] For example, in Figure A 20 the black arrows are showing the colonisation that took place going-up the agro-ecological optimum through time with the establishment of new farms during supportive agricultural context. During crisis these farms were the first to struggle and abandoned. The remnants of former farms can still be seen in Bala.

a move accelerating with the development of succession taxes (Death duty increased from 5% in 1900 to 45% in 1920). In 1908 Welsh farms were 88% rented and only 12% farmers-owned (Ashby and Evans, 1944). , county council could buy land to then let it as smallholdings from 1894, offering new entrants a way into farming (Perkins, 2004). The 1908 act made it mandatory for county council to hold an estate. By 1945 they would represent 5% of the farms and 3% of the land in England and Wales (Prince, 2012).

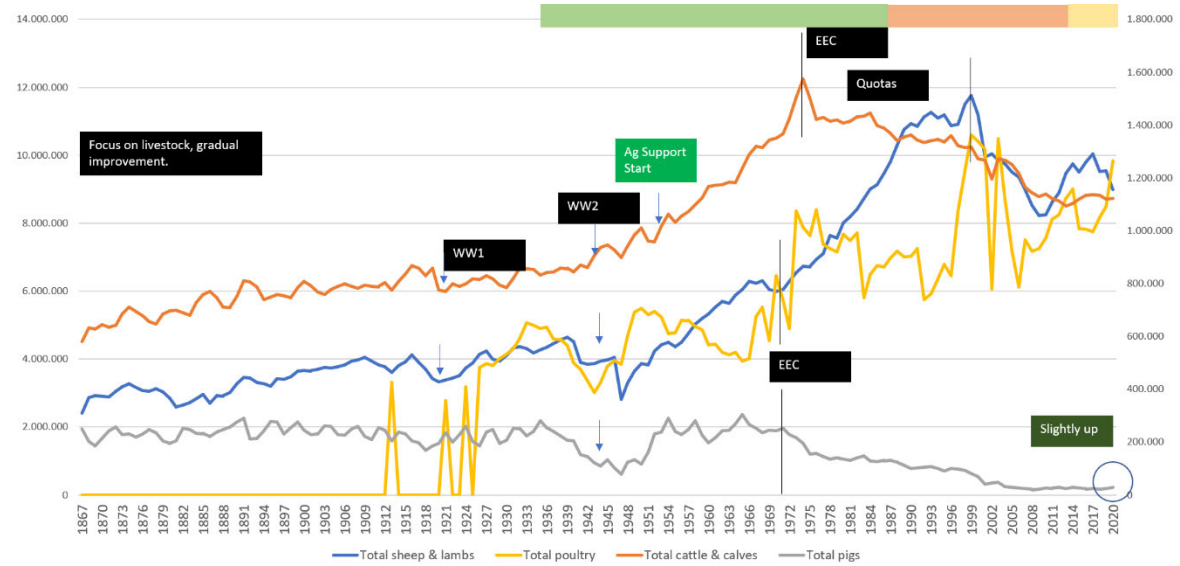


Figure A 22: Evolution of the livestock type numbers in Wales (by the author from (Welsh Government, 2021))

The context in farming changed at the same time, mechanization replaced labourers on farms, this meant that it was possible to increase fertility and livestock numbers (See above) with grass-based system using existing techniques (See above). The gradual development of farm building (See below) shows the fortune of different areas and their differential access to markets to sell products and buy emerging inputs (e.g. guano)(Williams, 2011). It can be said that the development was relatively endogenous in remote areas (Bala or Elan Valley) and quicker using more inputs for areas more integrated (Core of the Vale of Clwyd or Pembrokeshire).

British food supply was endangered during the First World War as Britain was only producing around half of its food (Campbell, 1985). Farms were incentivised by the government to increase food production most of all arable production; by the government offering grants for land drainage and setting market prices for key commodities. The best positioned market-wise small and mid-size farms could

become owner-occupiers from start of the 20th century onwards. But estates would usually start by selling the land far away from their base or with the low productive farms. The landholding began to be more differentiated as the result of these new actors.



Figure A 23: On the left a cowshed in North Wales is a slate-built longhouse (slits) from the 19th century adapted gradually (the windows were added after 1930). Housing the cattle and the fodder/grains directly linked to the 18th century agricultural revolution (by the author, 2021). To the right a more complex set of building of a larger farm in Pembrokeshire (by the author, 2020)

The crisis of the 1920s was a challenge for Welsh farms (Campbell, 1985) with a worldwide agricultural depression. Commodity that could be traded long-distance[87] saw their price drop (Annex 6) while only perishable product would be able to maintain profitable prices for farmers (Fieldwork; Moore-Colyer, 2011, 1998). For example, two key outputs were produced, fresh milk could not be transported for more than 1-2 days (without refrigeration) to remain edible and was recognised as being important for nutrition. In 1922, 30% of milk was sold as butter 50% as liquid, but by 1939 this changed to 10% in butter and 75% of milk sold fresh (Ashby and Evans, 1944). Niche products would also maintain a stable price, like early potatoes in Pembrokeshire (Davies, 1994) it could make the most labour available nearby while using a gap in the crop rotations on farm. This crop developed rapidly after 1930, similarly fresh vegetable conservation was limited. For producers that could not benefit from these niche products, pre-war trend resumed with a reduction of costs, cropping and more pastoral farming.

Item 7-5: 1945-1970, the transformation linked to the food production era, an exogenous evolution (from fieldwork)

[87] In the case of Wales Ashby and Evans (1944) gave lower prices compared to UK wide estimates highlighting the issue when farms were away from population centre.

Key sources used to complement the fieldwork on agricultural policy, technical and market changes (Baillet, 1972; Baker et al., 2023; Borchert, 1948; Bowen and Martin, 2016; Bowers, 1985; INSEE, 1955; Midmore and Moore-Colyer, 2005; Moore-Colyer, 2011; Robinson and Sutherland, 2002; Woods, 2007b)

The second step in the evolution of farms in implementing this specialisation, integral motorisation, and mechanisation as well as further integration with the supply chains lead to many more changes in the agrarian system and in the landscape.

- Pembrokeshire:

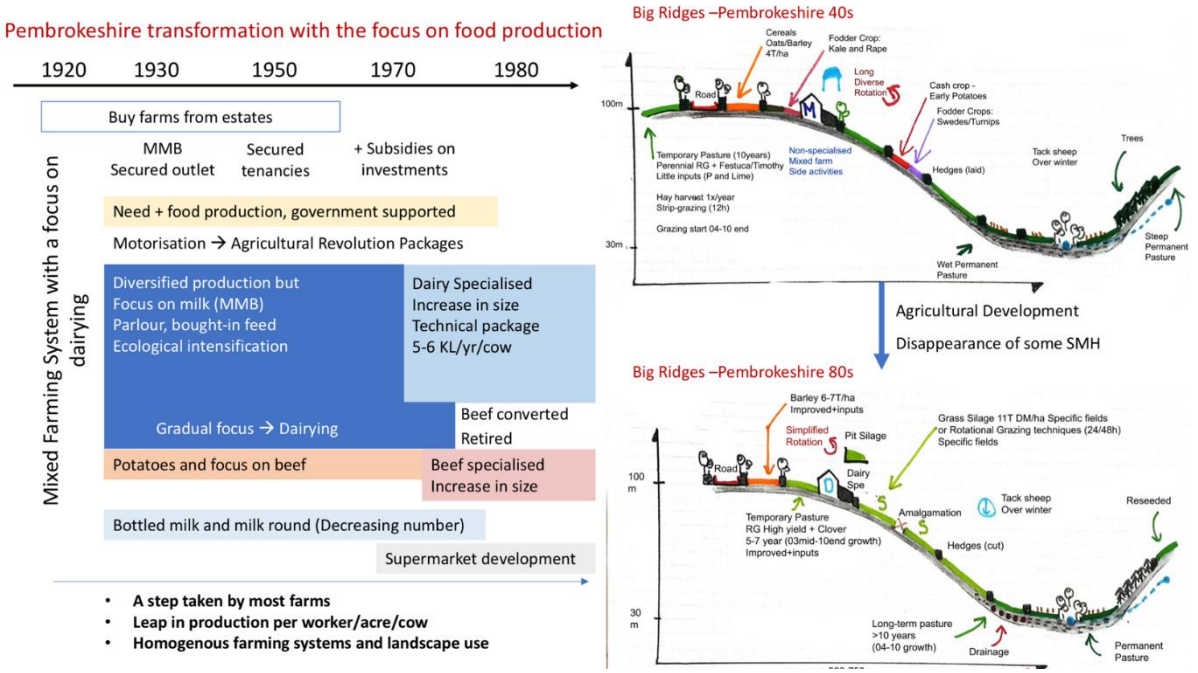


Figure A 24: Pembrokeshire farm evolution, an example of lowland evolution (by the author)

In the 1960's came a new revolution in dairy farming for this favorable grass growing area. The specialised element of the 20th century agricultural revolution could be easily implemented with a key focus on dairying on both small and large ridges. The package of new varieties, inputs and silage unlocked fodder production potential removing the limits around winter fodder harvesting and storage it worked as well on the two landscapes, albeit the areas that could be harvested as silage were lesser on small ridges. Other tools of specialisation/motorisation would only be implemented by mid-size family farm and home farms, particularly these that had already some measures of specialisation. The other farms would be catching up on the motorized elements.

Some of the motorized tools, -e.g. a combined harvester on grass-dominated farms- would have been of limited use for most farms and would be property of a contractor, usually one with a larger area to cover.

By early 1970 the continuous support for “improvement” and specialisation strengthened but on farms it was also necessary to deal with a challenging economic context. The adoption of this leap in terms of specialisation - viable only if livestock numbers were going up, minimum 40 dairy cows to 60 dairy cows- adopting all the tools of the packages on all size of farms. The movement described meant a specialisation away from mixed farming into grass-based dairying. All the resources on the farm turned towards milk production with work productivity gain driven by mechanization and full motorization. Farms gradually dropped their sideline production: sheep were the first to go. It gave a rather homogeneous landscape in terms of management and farming system arose from this period albeit mostly with small increases in terms of acreage size. Most of the farms would be autonomous equipment-wise except for combining.

Farms not able to adopt these moves were gradually phased out of the market because of a more challenging input/output price relation. For example, some smallholding under 10-15ha started to retire from 1970s to 1980’s – more so on small ridges- when milk began to be in oversupply on the EEC market with support to go out of farming. This enabled other farms to keep increasing with up to 120 dairy cows that could be carried with specialisation.

The farms not specialising in dairying would be these on large ridges with ample supplies of red soil, often large farms. They could use the “green revolution” tools to grow early potatoes and corn (wheat) easily in quantity and quality. This could be used for finishing beef cattle quicker with the use of more demanding continental breeds. Potato farming gradually fell into decline due to price pressure (volatile prices and an expensive crop in terms of inputs). These farms were less rapid to switch from dry hay to wet silage, with the need to invest on other elements first. ways.

- Vale of Clwyd

Mixed farming remained in place longer than in Pembrokeshire. In the 1960s-1970s the biggest step change was offered by the possible use of inputs and newly developed tools, without necessarily investing heavily (no silage). Farms could increase production and productivity gradually on similar acreages while successively mechanizing different parts of the farming system.

From 1970s the first smallholdings went out of production and fed other farms land needs to increase production in this high density of farms. On smallholdings, a hen shed, producing eggs using imported feedstuff and poultry could top-up farm incomes, helping them to support an expansion up to mid-size family farm. The reclamation of vast Rough grazing areas including on the mountain (Clwyd Range) that had not been ploughed before (spraying…).

Lambing dates moved forward combined to veterinary sciences offering output increase in sheep as well as in quality (conformation…). Rotational grazing had long been implemented but was stepped-up with fertiliser, particularly over summer leading to increased output. On cattle, the adoption of different sires and breeds was supported by increased fodder availability. On dairying it was possible to increase output without investing in the infrastructure.

It is only in the late 1970s, when the input/output price squeeze took place, that wool prices crashed (Annex 6), in a difficult economic context, that the area specialized more thoroughly into dairying on the one side, beef and sheep on the other side with the help of investment subsidies. It came with the adoption of specialized larger infrastructure. Both productions systems offered good level of income at the time and the mix of land held, particularly dry land and mountain land influenced the choice of pathway.

Milking equipment came first (mostly herringbones) and then gradually silage. The adoption of grass silage was quicker on the hills – who had less possibility to produce high energy crops and as good hay- compared to the core of the Vale of Clwyd but it was later than in Pembrokeshire. Most of the farms would be independent equipment-wise except for combining. Mid-size family farm with the adoption of the package

would increase herd-size from 30 dairy cows to 60 dairy cows (max 100-120 dairy cows) the acreage under corn went down and was gradually replaced by bought-in feed. It mostly disappeared on the small ridges hills. It allowed an additional cut of grass. The specialisation meant that most dairy farms dispensed with their beef and sheep herd if too small. This was not the case of larger farms, these would also keep growing corn, keep beef cattle and some sheep. Smallholdings were left aside of this move. Farmers owned farms were ahead of this move while some mid-size family farm farms were also buying their land at that time limiting investment capacity and the growth speed.

Farm specialising in beef and sheep would adopt silage in the 1980's, they would be characterized by either increased proportion of permanent pasture, mountain land in large quantity or large corn growing capacity to grow their own finishing feedstuff. But even before it would have been possible to switch to higher conformation continentals breeds (Limousin, Charolais…) as well as higher prolificity halfbreds breeding ewes (WelshXBorderleicester) (using gradually Texel sires) to meet market demands for more muscly livestock.

Some mid-size family farm and smallholdings went out of dairying as early as the mid-1970's if they had not invested in a bulk tank, going towards beef and sheep or renting-out the land to other specialised farms. These farms would mostly be smaller in size, located on the small hills (with high proportion of permanent pasture, mountain land…) they would focus on beef (mostly stores) as well as sheep (fat). They would only adopt part of the aforementioned package. Egg sheds were not as profitable as the price of eggs went down and were phased out.

The full implementation of the 20th century agricultural revolution in the Vale of Clwyd was gradual compared to Pembrokeshire, it shows the lesser influence of the weather felt by farmers of the area and the more positive market context earlier on. The specialisation in milk production was not as complete in the Vale of Clwyd due to the mix of landscape potentials available.

- Bala

The post Second World War drive for food production profoundly changed farms from semi-autonomous mixed farms (dairy being their main output) to specialised (relatively) homogenous beef and sheep holdings (couple dairy holdings had survived and increased mainly in the valley). This was the biggest change the landscape ever knew; Bala's area was included more intensively into the UK food production network.

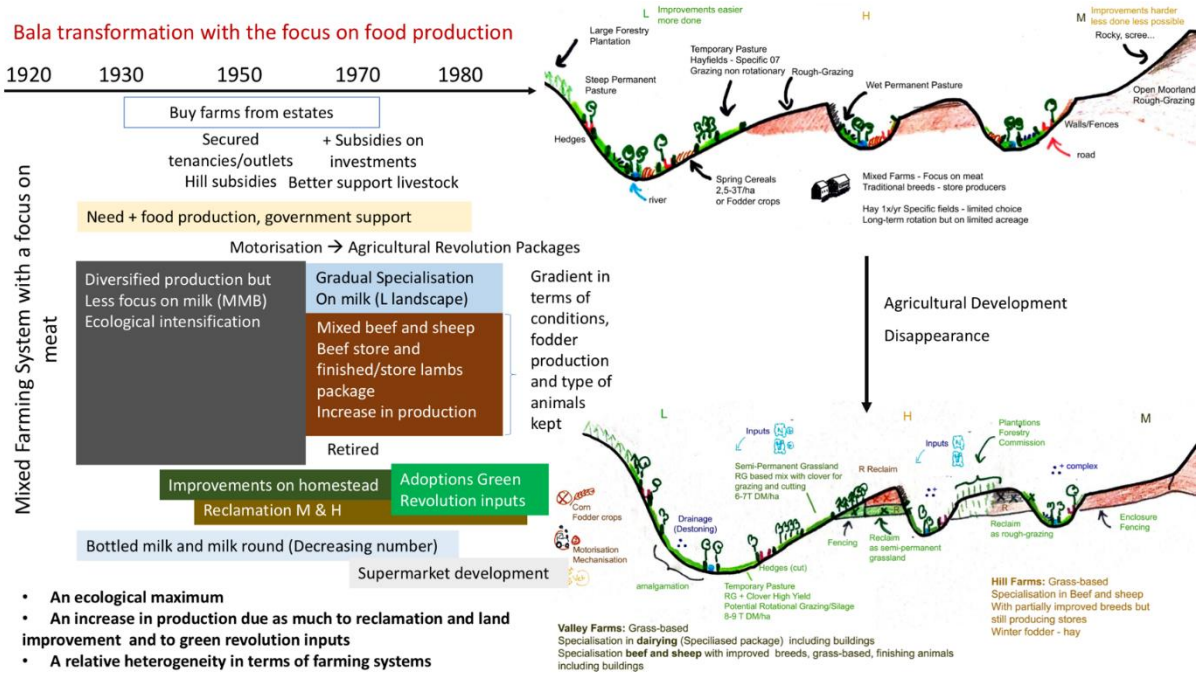


Figure A 25: Historical evolution in Bala area, an example of an upland area (by the author)

There has first been a drive for intensification of production linked to input-efficient systems and then moving to the input based green revolution as the policy changed and price/headage subsidy incentives changed.

Farmers started receiving a lucrative price for their products in two-steps, the first one with the MMB, milk cooperatives were created. As these were farmer's owned, farmers were pushed to keep milking at first. Later on, after 1960s there was a more positive context for developing beef and sheep production in uplands. At the same time, for many mid-size family farm and smallholdings farms it was time to buy their own farms limiting their capacity to invest even with a supportive market.

It is possible to distinguish mid-size family farm valley (L) farmers-owned farms, who could implement gradually and in full the dairy specialisation package at the same

speed as in the Vale of Clwyd due to their limited investment capacity, maintaining an element of mixed farming at first. They would nevertheless be larger than Vale of Clwyd farms in size. Other smallholdings kept dairying as long as possible with limited adaptations to their equipment, to the end of the bulk tank collection like in the Vale of Clwyd.

Farms with a strip of land uphill or some rough grazing on the mountain would also be advised to specialize on beef and sheep. Mid-size family farm would need 2-4 FTE (family) and the numbers of livestock on farms would vary depending on the type of holding (mix of agro-ecological conditions…). The complementary use of resources of the different agro-ecological altitudinal units was well suited to breeding beef and sheep operations, to produce stores, with the potential to keep 30 suckler cows and followers. Sheep number could gradually be taken up from 200 ewes to 400-500 ewes. Lambing date could be put forward toward march and farms could produce heavier and more numerous lambs. Breeding ewe flock renewal went towards selecting bigger animals and sires used would be partially of continental types. These farms gradually focused on producing fat lambs leaving the farm from the summer at 34-35 kg (liveweight). On the cattle side continentals breeds or bulls were adopted with bigger more demanding 18-24m stores (increased fodder demand but reduced shed space). But there were only limited hayfields and linked winter fodder production, something scarce in this case-study area. The adoptions of these changes required to increase fodder production. The more rough grazing, the less hayfields, the more sheep.

Large farms would have followed this path with a focus on grass-growth (possibility to keep a bit of corn) and moto-mechanising as much as much as possible limiting paid work but also their infrastructure investment. They would nevertheless not access silage as dairy farms.

In general, from the 1970s; the beef and sheep, breeder package of the green revolution was favoured. In those area it was used to produce storecattle and a mix of finished and store lambs. Continental breeds of cattle and meatier sheep breeds would be gradually favoured (when possible) over the low-maintenance, smaller Welsh Mountain Sheep and Welsh Black. The beef and sheep systems for upland were articulated around simplified farming systems relying on long lasting temporary

pastures. As well as a shift from brownish to vivid green as reclamation was taking place on rough grazing hill-sides first and then the fringe of the open moorland (inc. if it was a common) with very long-lasting grazing mixes. Another element was to secure access to these to make management easier. To put this in place, hills farms used the subsidies for drainage/destoning copiously, particularly around the homestead, increasing their proportion of hayfields and reducing poor-accessibility fields. In turns they could ensure to have an adequate fodder provision for more demanding and numerous livestock (quality, quantity, accessibility). Reclaiming mountain land and hill-side, improving the ground/grass around the homestead combined from 1970 to fertiliser. A phased introduction and a breeding reservoir for increasing output.

Mid-size family farms and smallholdings without rough grazing needing a regular income would maintain dairy productions (repaying the loan to buy the farm) but never implemented the full dairy package (limited hayfields and investment capacity) and ceased dairying when the bulk tank became necessary. Most farms mid-size family farms and smallholdings, particularly with rough grazing specialised less expensively into beef and sheep.

Smallholding farms without rough grazing could not keep enough beef and sheep cattle to access a sustainable income. They did not have the financial capacity to expand. When retiring they were bought back by other farms expanding from the later 1970s as a response to the input/output price squeeze.

Snowdonia is the real brown and black spot in a rosy picture. Its Hs and Ms required a lot more improvements to make them ploughable or manageable with motorised tools, the shallow/rocky soils or too deep a peat share is the bottom line. Any transformation goes slower and costs more. The hayfields area in these farms would be highly limited on top of climatic constraints. Nevertheless, these mid-size family farm farms would have a similar trajectory to these away from Snowdonia but there would be a lesser proportion of improved breeds.

The mountain land on Snowdonia could not be reclaimed, limiting their possibilities of evolution and output growth, nor could it be motorised (trials to “improve drainage”

proved counterproductive). Growth in size was within the limit of unchangeable work productivity, attached often to a specialisation in sheep only.

In summary, differences between farms would be in terms of how improved the farm could be and its mix of improved/traditional stock. There was a gradient across the agro-ecological scale in terms of adoption of these improved breeds in flocks and herds. Snowdonia Hill and Mountain farms remained with traditional breeds. On the other hand, other landscape units H and M farms could mix a traditional flock and an improved “commercial” flock, with continental cattle herd, the proportion of each depending on the proportion of rough grazing/high altitude grazing. Grazing management and timings for open-moorland use did not change in terms of use, with a seasonal use during spring/summer except for mountain farms.

Overall, the landscape management was greatly simplified and homogenised with grass-on-grass renewal on the ploughable parts and the use of bought-in seed. Fertiliser, feedstuff, and pasture renewal were the keys to this increase in output and land productivity.

- Cambrian Mountains Area

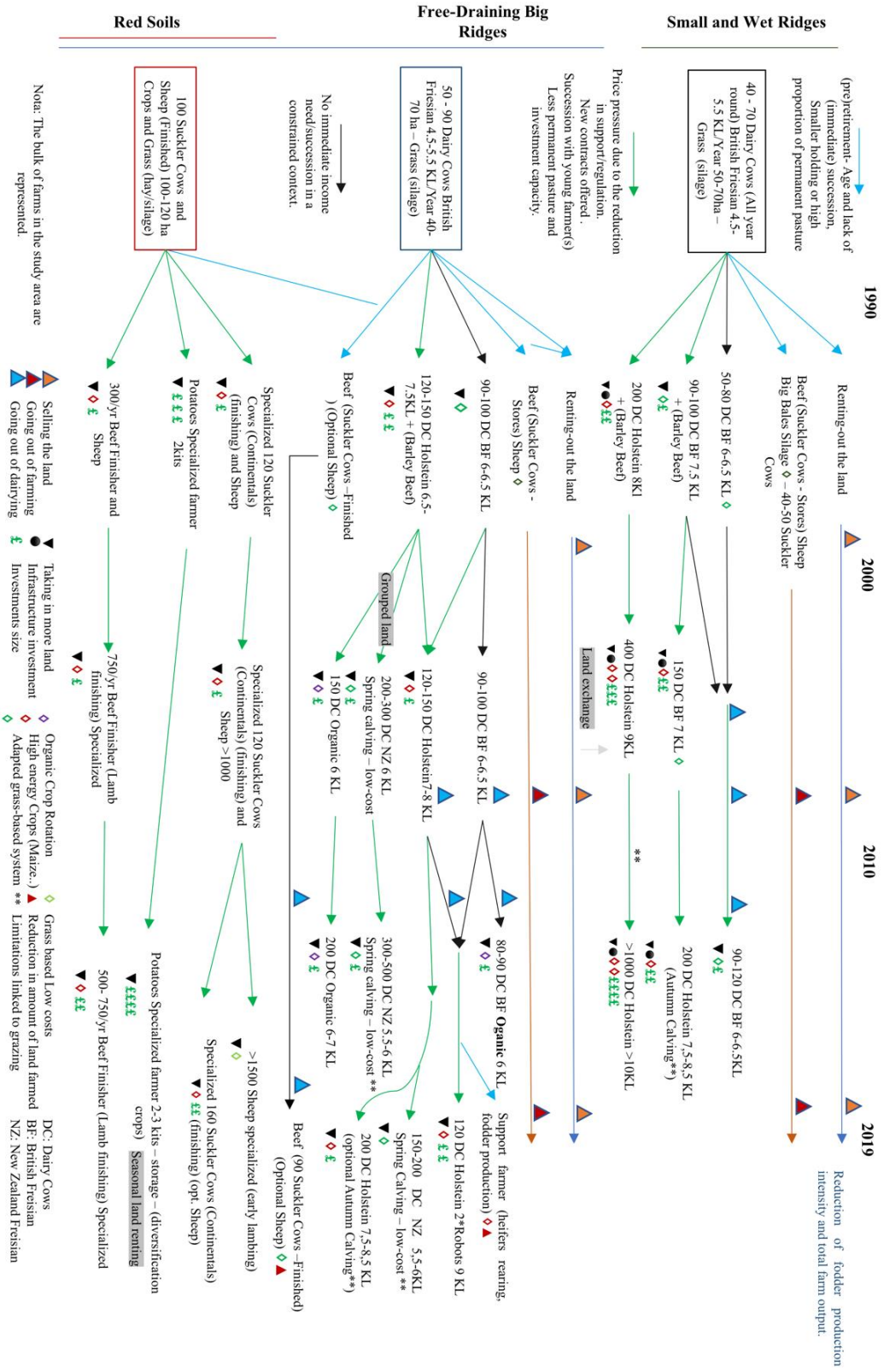
The post Second World War drive for food production changed farms from semi-autonomous mixed farms (wool and beef/sheep being their main output vs milk in Bala) to specialized relatively homogenous beef and sheep farms. But arguably it did not represent such a change in the landscape as in Bala area. It is noted that reclamation could take place to greater extents and has been gradual, adding semi-permanent pasture grazing areas for farms. The area was better integrated in the UK food network than Bala. Farms scaled-up and intensified their enterprises, first by using bought-in food/more specialised higher weight breeds and then moving to the input based green revolution. While the change was not as big on the cattle side, going towards dairy crosses (adopting more milk for calf) it was quicker on sheep compared to Bala area when possible – breed types, schedule to finish lamb instead of selling stores (i-e constrained by low quality rough grazing).

From 1965 as policy evolved and economic conditions were more difficult it was more interesting to farm beef and sheep in the uplands, securing further income, led to

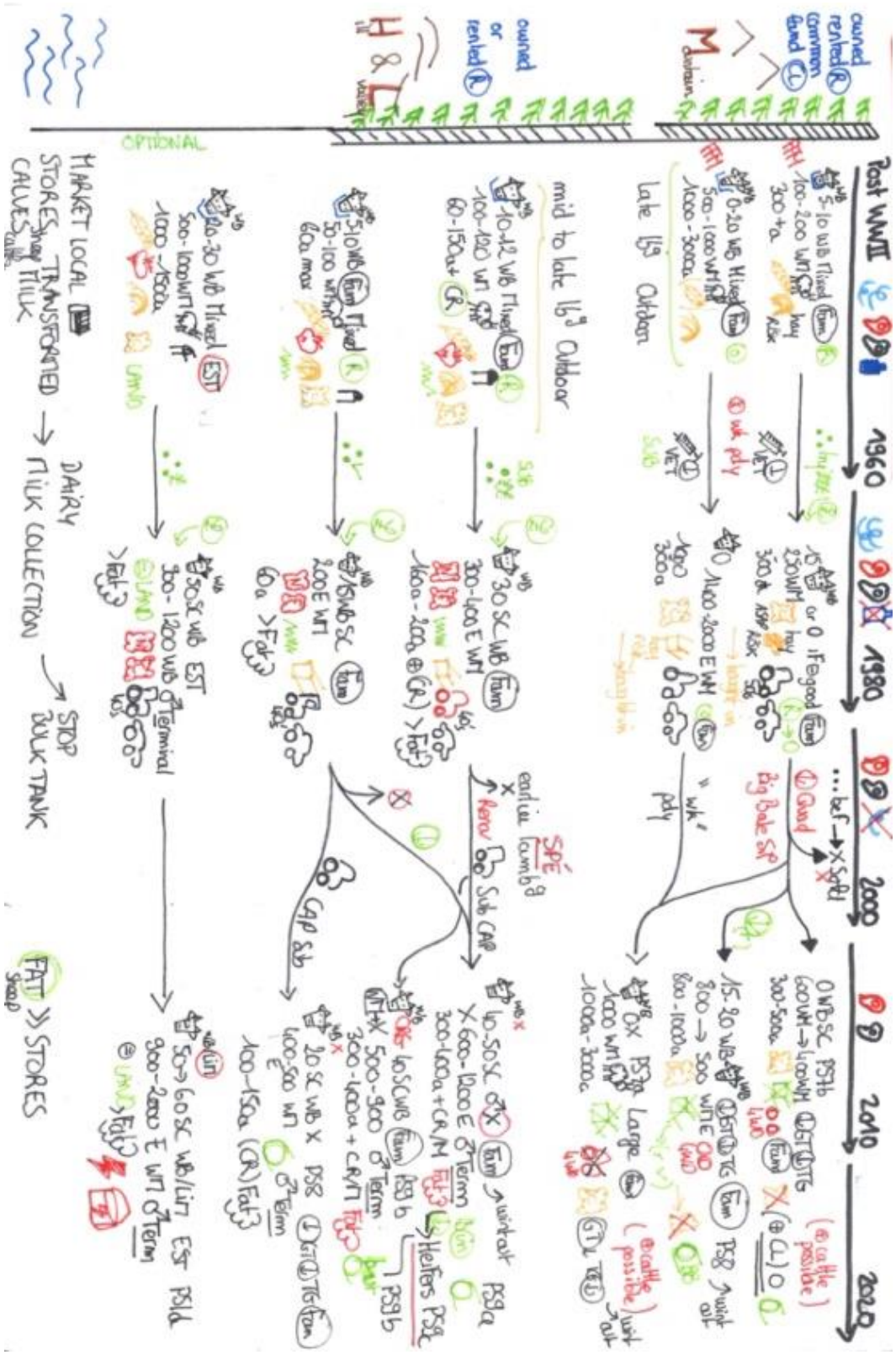
development and simplification of farming systems based on long lasting temporary pastures supported by inputs. The number of animals on farms would be linked to two parameters; the summertime maximum grazing necessary and the winter fodder harvest required. The limits in reclamation were linked to regulatory/legal elements more than the actual impossibility to reclaim; for example, the Elan valley was protected by the water board. But nevertheless, the number of livestock could increase considerably, particularly on sheep as it required less costly infrastructure.

Annex 8: supporting analysis on farm differentiation and economic analysis in lowlands

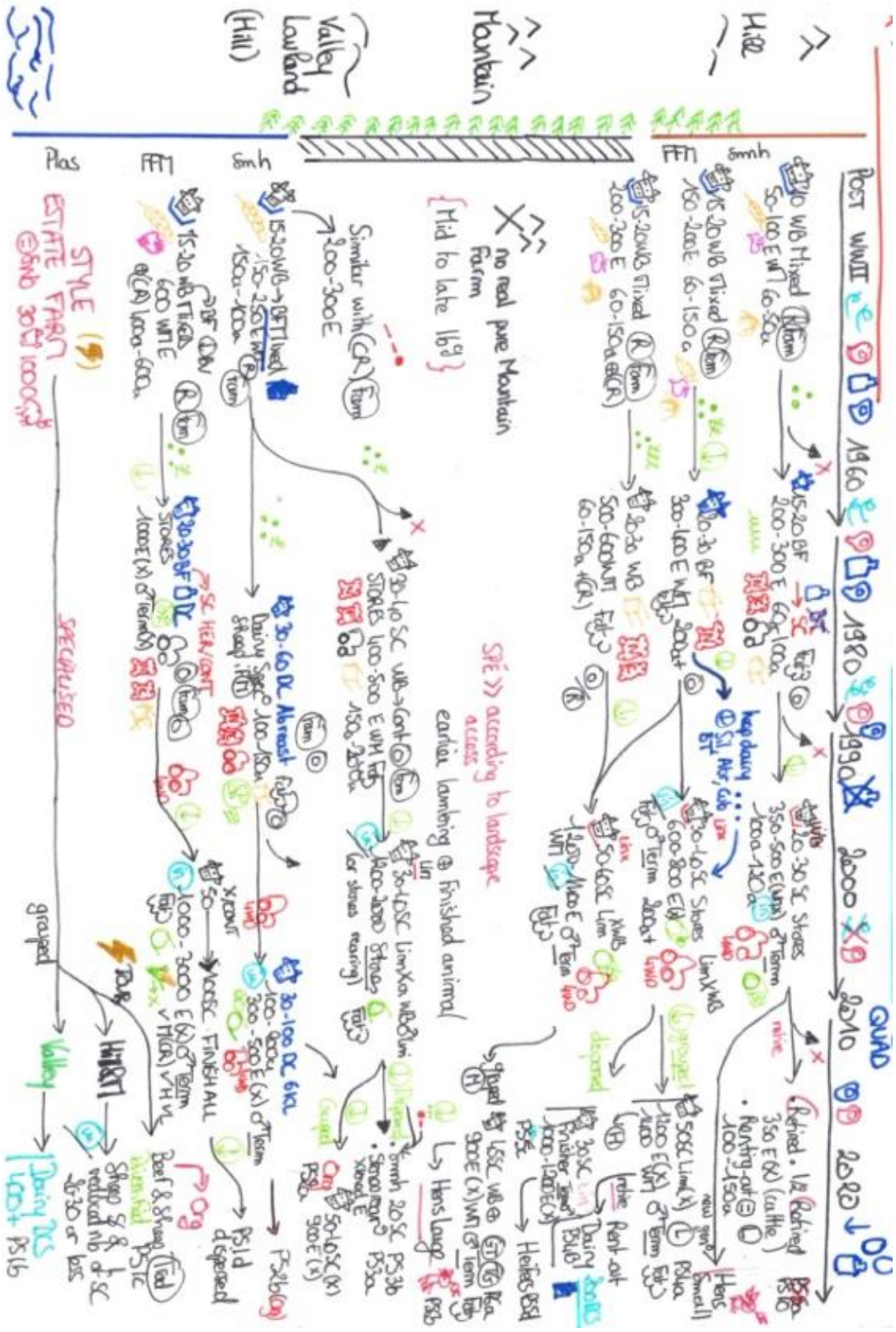
Item 8-1 : farm differentiation pathways from 1990 to 2019 on the three different Pembrokeshire landscape types (by the author)



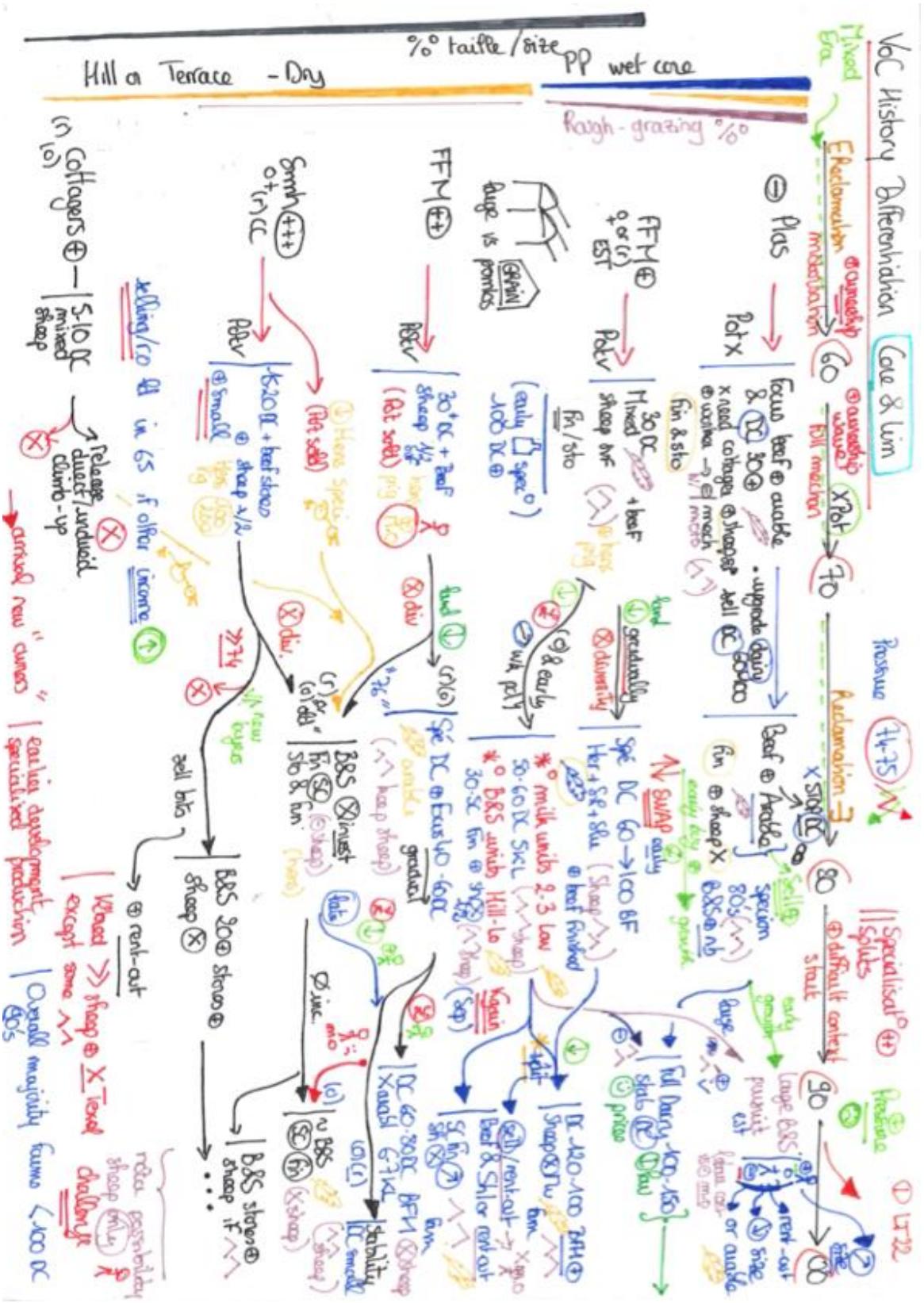
Item 8-2: farm differentiation pathways since 1945 for Bala case-study area – Snowdonia – Upper uplands and intermediate uplands area



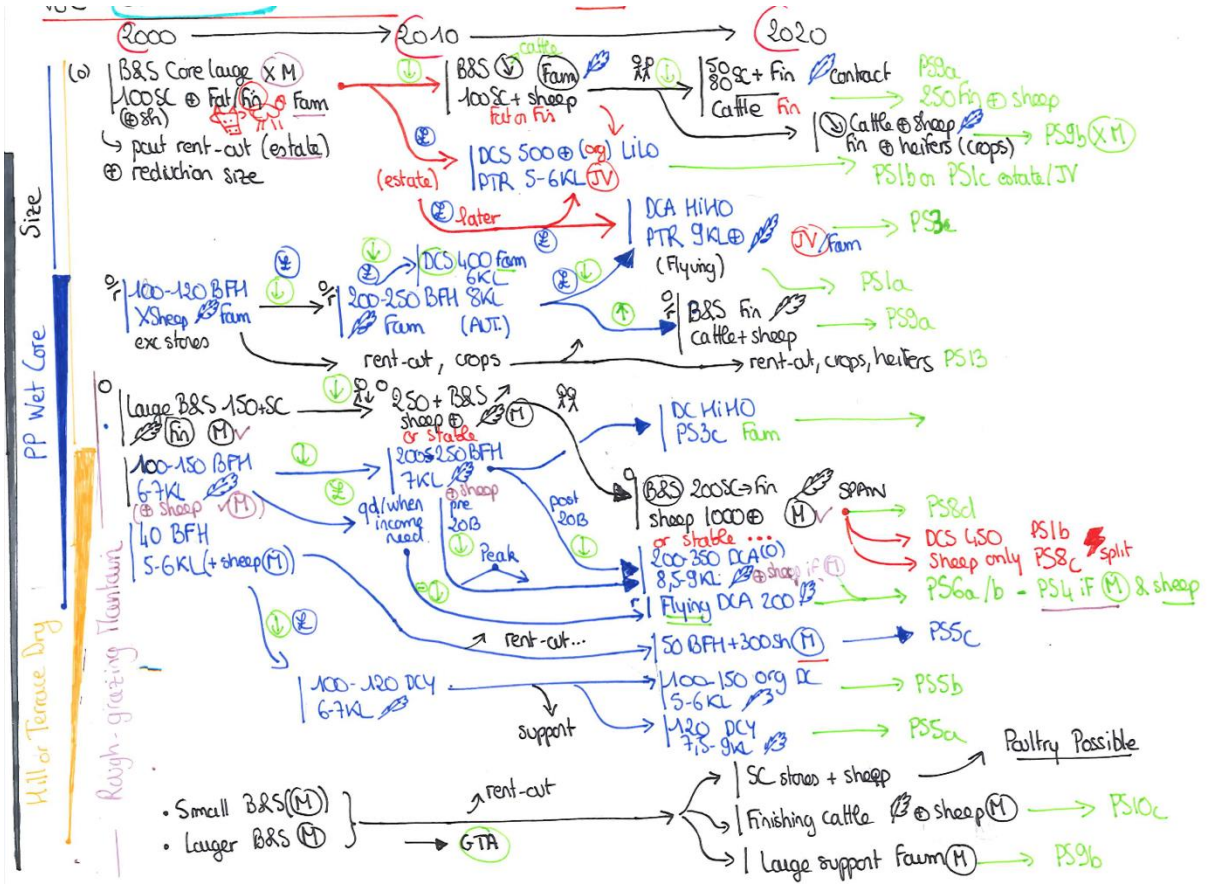
Item 8-3: farm differentiation pathways since 1945 for Bala case-study area – Berwyn and Denbigh area – Upper uplands and intermediate uplands area



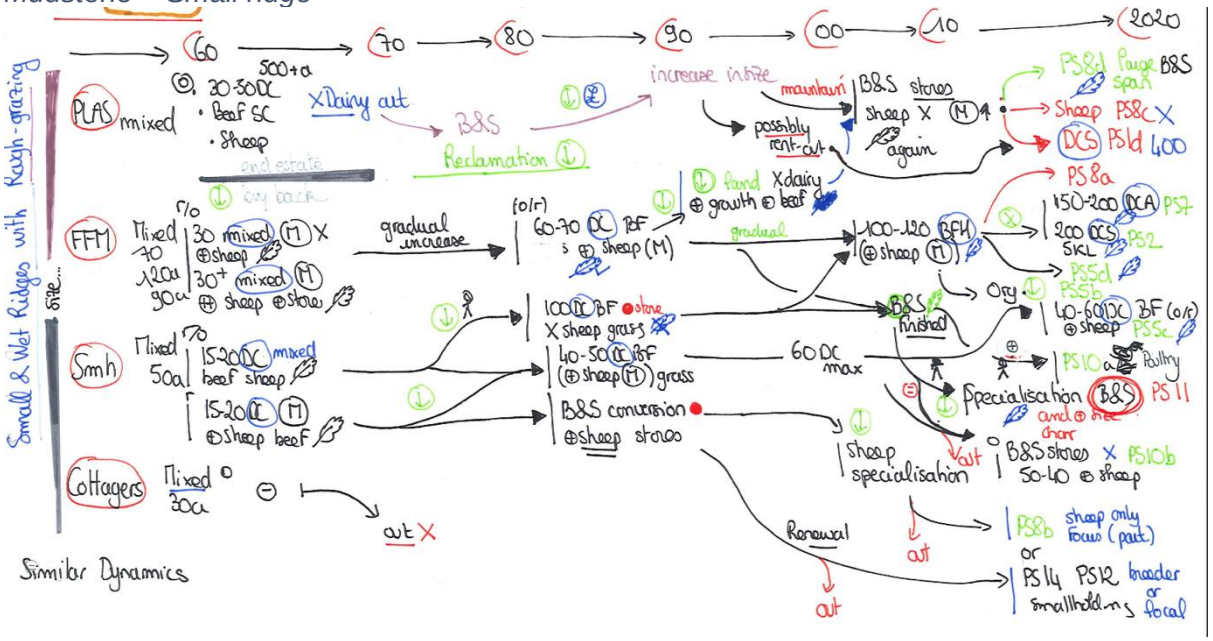
Item 8-4: farm differentiation pathways since 1945 for the Vale of Clwyd case-study area – Core and Limestone – Large ridge



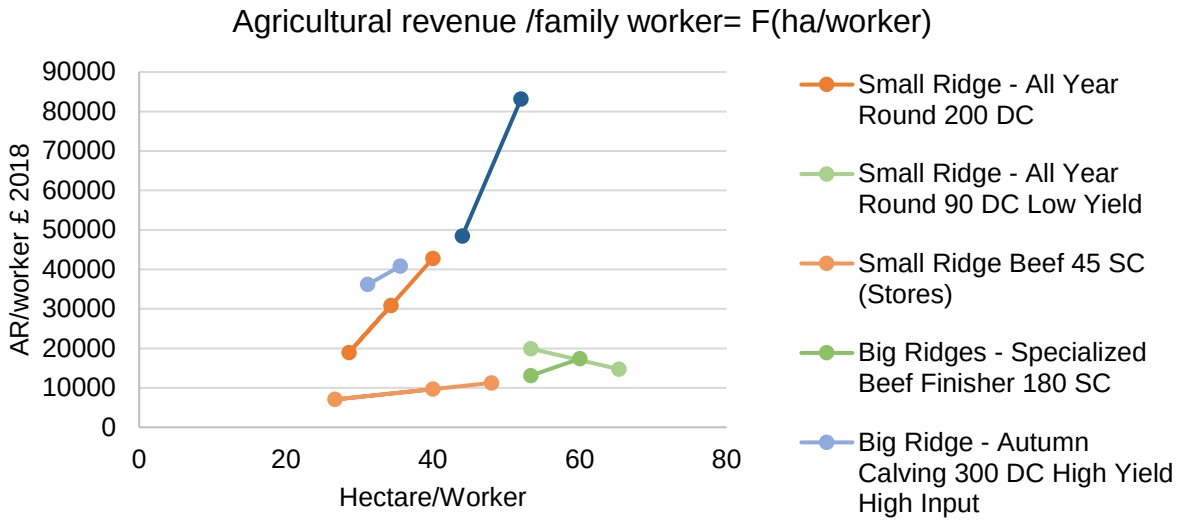
Item 8-5: farm differentiation pathways since 2000 for the Vale of Clwyd case-study area – Core and Limestone – Large ridge



Item 8-6: farm differentiation pathways since 1945 for the Vale of Clwyd case-study area – Mudstone – Small ridge



Item 8-7 : Evolution of the agricultural revenue/worker in function of the area/worker in the range of each archetype (by the author)



Item 8-8 : Agricultural Income per family worker evolution in different output price scenario (DC dairy cows; SC suckler cows)

Farm Archetypes	Reference: Income Reproduction Threshold	Agricultural income/Family worker and possible evolution if no/low subsidies	
		High output prices	Low output prices
Big ridge - All year round 90 DC org 6KL low yield	Yes, but dependance on subsidies (44%)	→	↓
		No need for immediate reorganisation. Higher dependence on subsidies.	
Big ridge - Autumn calving 300 DC high yield high input	Yes, small dependence on subsidies (8%)	→	↓
		No need for reorganisation. Similar levels of subsidy dependence.	
Big ridge - Spring calving 400 DC Low Yield Low Input	Yes, small dependence on subsidies (18%)	→	↓
		No need for reorganisation. No more income buffer during crisis. Lower subsidy dependence.	
Big/Small ridge - All year round 1000 DC high yield high input	Yes, small dependence on subsidies (5%)	↑	↓
		No need for reorganisation. No more income buffer during crisis that could prove problematic. Lower subsidy dependence.	
Small ridge - All year round 90 DC low yield	No but above subsistence level. Dependence on subsidies (56%)	↓	↓
		Need for reorientation. No more income buffer.	
Small ridge - All year round 200 DC	Yes, small dependence on subsidies (13%)	↑	↓
		No need for reorganisation. Similar levels of subsidy dependence.	
Small ridge beef 45 SC (stores)	No. Under subsistence level and dependence on subsidies (100%)	↓	↓
		Loss of income. Loss of a buffer. Need reorientation. Similar dependence on subsidies.	
Small ridge - Beef finisher 50/year	No. Under subsistence level and dependence on subsidies (100%)	→	↓
		Loss of income. If no subsidies loss of a buffer. Need reorientation. Similar dependence on subsidies.	
Big ridges - Specialized beef finisher 80 SC - organic	No. Over subsistence level but dependence on subsidies (100%)	→	↓
		Loss of income not as critical as non-organic. Loss of a buffer. Possible need for reorientation. Similar dependence on subsidies.	
Big ridges - Specialized beef finisher 180 SC	No. Over subsistence level but dependence on subsidies (100%)	↓	↓
		Loss of income. Loss of a buffer. Need reorientation. Similar dependence on subsidies.	

Income per family worker:		
Over the reproduction threshold	Higher compared to reference	↑
Between the reproduction threshold and the subsistence threshold	Similar Compared to reference	→
Under subsistence threshold	Lower Compared to reference	↓

Item 8-9: 1980-1990 - Changes in agricultural policies and market trends

The environmental epiphany in Britain as well as in some other EU member states in the early 1980s stimulated some experimental environmental conservation policies, the earliest Environmentally-Sensitive Area schemes started in 1987 (Buller, 1999;

Dobbs and Pretty, 2008; Dodsworth et al., 2020), which were then introduced across Europe with CAP support, from 1987 (Bazin, 2003). Several areas in Wales were included in the ESA schemes, whereby farmers were paid for agreeing a given management with the policymakers.

In response to budgetary crises and the growing international calls for policy reform to reduce 'trade distortion', from 1984 the Common Agricultural Policy (CAP) introduced successive production restraints for its main agricultural products (Barthelemy, 2001; NAO, 2000; Patton et al., 2008), reinforcing its market control mechanisms. This, plus ongoing negotiations within the World Trade Organisation encouraging moves away from trade protectionism led to a gradual switch from agricultural market support to (non-fluctuating) decoupled payments linked initially to the number of grazing animals or areas of crops that had been farmed, and eventually just to the land area of farms (Guyomard and Le Bris, 2003; Théo Lenormand, 2023). Due to the historic pattern of previous market-linked supports, the significance of direct payments for farm incomes were high for beef and sheep producers, particularly in the LFA but quite low for dairy farms, while for crop farms they were somewhere in-between.

By 1986, the CAP offer to UK farmers included a lucrative variable premium scheme on lamb and a finished cattle price guarantee, encouraging high levels of production. After this point, a decision was agreed involving gradual reductions in guaranteed prices and a move towards direct headage payments, in compensation. Payments were introduced on beef male calves and split into three different payment categories at different age, to benefit all members of the cattle-finishing chain and incentivize farmers to keep male calves on their farms. In the sheep sector, the variable premium was replaced by a fixed premium paid on each breeding ewe, which reduced the incentive to maximise the number of lambs per ewe (House of Commons, 2001; NAO, 2000; Scottish Executive, 2003). Also, in the 1980s there were price supports on most types of cereal crop, as well as particularly generous subsidies to encourage protein crops as a reaction to an international soya bean price rise post-1970s. Again, the reforms of the 1990s saw reductions in guaranteed prices accompanied by new direct payments on all of these crops, to compensate the price cuts (Théo Lenormand, 2023; Matthews, 2013).

To reduce incentives to over-produce, quotas had been introduced on milk production (1984) and were then applied on farms' eligibility to claim direct payments per head of cattle and breeding ewes (1990-1992). Member states (MS) could choose their own implementations of quotas. The neo-liberal UK chose to make the right to produce milk and entitlements to direct payments tradeable at the level of each farm. Quotas could be bought and sold, or leased between farms on an annual basis .UK quota was extremely costly to buy for milk, until 2005 (Barthelemy, 2001; Patton et al., 2008; Townsend Chartered Surveyors, 2016). By then, UK milk production had reduced substantially and was below the total UK quota ceiling. The removal of quotas was agreed in 2003 to be implemented in full by 2015, but by 2008 they were gradually worthless due to the reduction in the local milk production. In 1992 the Milk Marketing Board monopoly on milk sales by producers was liberalised, ending a 'one price for all' policy and giving way to farmers agreeing direct processing contracts with processing companies with variable bonuses/cuts and increasingly stringent milk specifications, which has meant that small dairy farms tend to be these who receive the lowest prices (Finney, 2021; Pouch and Trouvé, 2018). The quotas on suckler cow and ewe premia aimed at limiting the soaring direct payments applications (effectively as tradeable entitlements to these subsidies), and they were split between lowland and LFA entitlements, to prevent the accumulation of entitlements on the best quality land. Supply controls also took place on cereal crops, with the compulsory set-aside measure used as a condition to get access to crop subsidies (House of Commons, 2001).

The MacSharry reform of the CAP in 1992 supported the idea of a multi-functional approach to farming. In the subsequent decade the policy developed its 'second pillar', with subsidies supporting environmental measures (management, restoration or investment) and rural development (Dobbs and Pretty, 2008; Jacquet, 1993), while the market measures of the 'first pillar' were transformed through successive price cuts

and the introduction of direct payments as compensation – and an overall to control further CAP expenditure. The policy moved gradually from a market support system

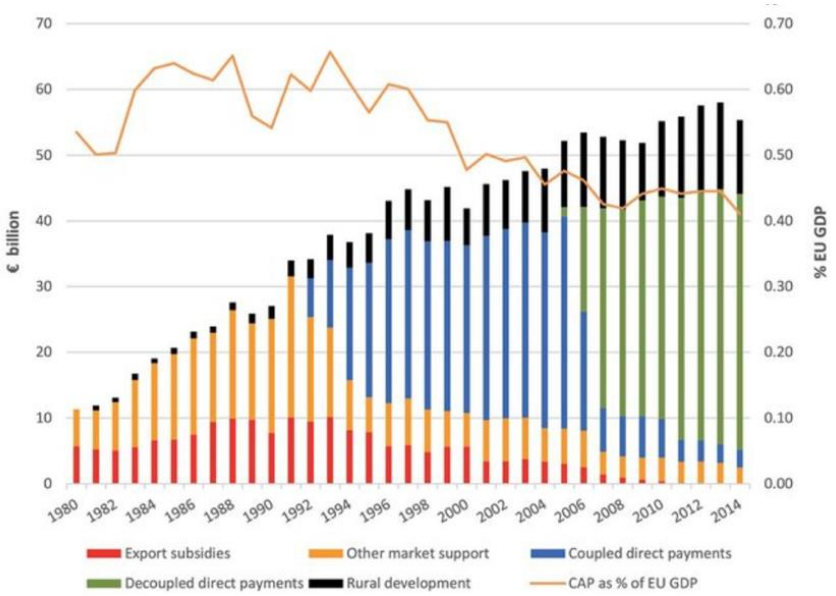


Figure A 26: EU budget expenditure on CAP from 1980 to 2014 (Billion €) and as a percentage of EU GDP in current prices (Swinbank and Daugbjerg, 2017), a switch from coupled subsidies to decoupled subsidies

With the UK rebate, the CAP budget was slightly lower but with the re-evaluation of the pound sterling from 1995, intervention prices after conversion into pounds sterling were mechanically lowered and they were not activated until they were abolished on all productions (D'alfonso, 2016). EU wide, there were a drops in intervention prices for milk, beef and cereals in order to fit in newly adopted WTO regulations while restriction with tariffs and quotas on imports were weakened. In general export and storage subsidies were abolished and high sterling prices hampered UK livestock prices (Théo Lenormand, 2023). Although most of Wales' products were destined for the EU and UK market - as the rest of the UK uses most of Wales' key commodities except sheep (Annex 6 Item 6-2), by 1998 agricultural farmgate prices gradually mirrored world markets. Inputs prices went up in the same timeframe (Annex 6 Item 6-4). Increased volatility has been witnessed since then, both for inputs and outputs (Annex 6 Item 6-4).

This less favourable environment for farmers was also the result of a deep-reaching market restructuration: UK markets on dairy were not self-sufficient due to the quota limits set in it, the UK was still exporting red meat products on which subsidy rights

were implemented instead of quotas. The overall domestic demand per capita on livestock products decreased except on specific commodities not produced in Wales (eggs, poultry) in the UK. The supply chain has focused on price, most retailers have managed to concentrate most of the UK food retail, for example capturing in 25 years most of the UK fresh milk market away from to the door delivery (Competition Commission, 2008a; Fearne et al., 2005; Hingley et al., 2006; Hollingsworth, 2004).

The number of processing units diminished, with a concentration and specialisation of the processors, tailoring their processing to the needs of their client mix (Deconinck, 2021; DEFRA et al., 2023; Glover, 2011; Hollingsworth, 2004) and operating with reduced margins, hence trying to grow (Empson, 1998; HCC, 2022); with a reduction of abattoir numbers or livestock markets faster than the output reduction (Welsh Government, 2019a).

A reduced number of “end retailer” with a focus on price led to further demand for standardisation of products throughout the supply-chain and sometimes some integration of the supply chain through contracting for required specifications. More widely this gave signals regarding the requirements in terms of quality (conformation, weight, fat or butterfat, protein), and sometimes quantity at given times through farmgate product pricing grids/contracts (Fearne et al., 2005). Around 70% of the UK’s annual milk intake was processed by 9 companies in 2021 (Competition Commission, 2008b). Farmers’ position was weakened because of a concentration of the retail and food-processing sector in meat and dairy with competing actors and a commodity focus.

The land market previously in favour of the tenant farmer was liberalised through a new set of flexible tenancies, from 1995 (Gibbard and Ravenscroft, 1993). This reversed the balance of power with landlords able to adopt a best-price approach to renting land, with the possibility to retain control of land (CAAV, 2005; DEFRA, 2006; Lenormand et al., 2021b).

Finally, agricultural regulations were tightened most notably in the form of an expanded implementation of the EU Nitrates Directive, from 2002 (Burt et al., 2010). Investment subsidies were more limited (but for example supported Nitrate Vulnerable

Zone required adaptations) and clear restrictions on rough grazing or environmentally sensitive areas were put in place with an increase in management prescriptions.

Under devolution in 1997, Wales gained new powers to determine its own agricultural policy as more options were offered to EU member states in respect of how CAP was implemented, and UK devolution legislation specified agriculture as a devolved policy area in all matters except international trade (Boinon et al., 2006). At first, Wales kept the implementation of first pillar subsidy partially linked to output, using historical reference levels (Boinon et al., 2003) to calculate a decoupled Single Farm Payment in 2005, with an effective removal of direct LFA support. These direct payments were conditional on basic compliance with standards - Cross compliance standards (Statutory Management Requirements and Good Agricultural and-Ecological Condition)-. It also aligned with the end of direct coupled subsidies based on headage or per hectare.

From 2013, a Wales-wide, flat-rate decoupled single payment scheme was gradually introduced, including strengthened conditionality with the greening payment (representing 30% of the total) and the basic payment, but also with a redistributive element favouring smaller holdings (under 54ha) (Bardají et al., 2016; Bouyssiere and Buczinski, 2015; Chambre d'Agriculture Normandie, 2015). Full decoupling was finally attained in 2019, with payments subject to cross-compliance conditions (Townsend Chartered Surveyors, 2020). This process was less radical than that followed in England, where full decoupling and the move to a flat-rate payment was complete by 2012. The first pillar was still seen as a safety net for income support, also contributing to the goal of having sustainable rural areas, indirectly. Specific support for young farmers (one support payment) was also introduced.

For the second pillar, after ESAs and Tir Cymen scheme (effectively wide-scale pilot),the WG followed on from 2005 two Agri-Environment schemes, Tir Gofal and then Glas-Tir focused mostly on the management or creation of environmental and historical features through 5-year contracts including annual payments (agreed management and abiding by prescriptions) and environmental grants (investment support) (Banks and Marsden, 2000; Wynne-Jones, 2013). The Welsh government also developed business support for farming with investment grants and public-funded advisory bodies Farming Connect and Menter y Busnes. When modulation was introduced in the CAP reform of 2003 enabling member states to reduce first pillar funds to move them to second pillar, Wales moved 15% of its first pillar towards second pillar from 2007, which was the maximum possible level of transfer (Townsend et al., 2017).

The trade negotiations with the WTO were not progressing by then but more agreements would be reached bi-laterally between the EU and other trade entities with a case-by-case approach to agricultural trade liberalisation. From 2008 onwards, output prices started to gently increase again in real terms on most livestock products, as developing countries' demand began to pick up supporting price increases steadily on all products (Annex 6 Item 6-3). Most inputs used in farming are imported with costs based on world markets. They have increased steadily (in real terms) over the last 4

decades (i.e. doubled for petrol-derived products 1990-2019) with high volatility from 2000 (most notably in the financial crisis of 2008) (Annex 6 Item 6-4). Feed costs prices have also increased since 2008) (Annex 6). .

Tourism can offer a high return on investment to farmers (W. Morris et al., 2017) for a commitment during a season when they are particularly busy – over summer when many major farming operations including silage and shearing take place. It means that there is usually a trade-off in terms of farming system put in place, one requiring a lower time-investment over summer. Planning permission, adequate electricity and sewage can only be combined in the valleys or on the hills or on most lowlands. Camping or caravans tend to be easily accessible and relatively sheltered in uplands. Overall conditioned to the planning permission; many farms could create a B&B to the farm.

From 2010 to 2019 some incentives were available to farms under the Feed in Tariffs or the Renewable Heat Incentive to install some renewable energy units (Energy Saving Trust, 2022). In the case of the second, one condition was that part of it had to be used for the farms and associated activities and buildings: including cottages, BnB, camping, cattle sheds… (Nix, 2013). The electricity generator could not be constructed anywhere in the landscape. For example, solar panels are only on rooftops around Bala, wind turbines, anaerobic digester, and CHP (combined heat and power) are not allowed in Snowdonia national park and could only be found in valleys. Wind turbines would be located on the top of the hills to benefit for the highest wind power but not on the mountain. The location of the national grid connection would also be important (Nix, 2013). Hydropower can only be constructed by farmers that control the entire length of a sufficient drop in altitude with a steady waterflow (to avoid conflicts about compensation and to have sufficient power generation) (Nix, 2013). This is the only other type of renewable electricity generation that could be tolerated in Snowdonia National Park with wood production.

Item 8-11: From 1980s -Agricultural technologies and tools made available
From fieldwork

- Low-costs technologies for all farms

In 1985 the big bales silage and quadbikes became available these offered a potential increase in labour productivity and the production potential of land. The flexibility of these relatively expensive tools and processes enabled one baler to cover 200-300 ha of silage. It became possible to harvest grass with an intermediate level of dry matter between silage and hay: fodder that would be adequate for beef or sheep while the crop could be bulkier and did not need to be dried as much, hence securing the harvest for farms even when conditions were too limiting for other forms of harvesting (e.g. too wet for hay; too steep for silage).

Big bales wrapped in plastic were easy to store outside and did not require any additional investment, releasing shed-space for livestock. Carrying bales with tractors was also easy. This evolution was also significant for lowland farms by enabling a possible third cut of grass or increasing labour productivity for farms that had not yet moved to making silage.

The quadbike facilitated the movement of cattle and accessing the mountains/fields of larger farms, making it easier to keep more animals with potentially the same workforce. It was now possible to have 1 or 2 family workers looking after 40 suckler cows and 700 ewes. These changes were accessible regardless of the socio-economic status of farms. Big bale silage could also be done by contractors, on farms that could not afford their own equipment.

Once these technologies arrived on farms, only the very worst areas –too wet, too overgrown, too rocky, too steep - would remain untouched by mechanised operations. Very steep areas remained a challenge for any operations with heavy machinery. The efficiency gains from such mechanisation were generally higher in the lower-lying parts of upland farms as well as in more difficult lowland settings, but a positive impact was felt even in Snowdonia Mountain conditions.

In the 1980s, to make the most of subsidies paid per head of stock sold, the emphasis was on increasing productivity (more lambs per ewe). Thus, more lambing sheds were

built or adapted to deal with more demanding ewes and lambs, with breeds that needed a controlled lambing environment to make the most of increased prolificacy. This would also allow farmers to potentially lamb earlier in the year if they could sustain the fodder needs.

Increased fodder production could increase the amount/type of ewes kept and provide them with supplementary feed during winter. This move increased the number of ewes kept to around 500 per family worker, but only farms on lower hills and/or valley land moved towards the use of terminal sires (from lowland breeds, ensuring lambs with large weight and conformation best suited to the meat market). Lambing rates were also increasing, and the first F1 hybrid crosses (mules or crossbreeds) were introduced.

- High-cost and highly specialised technologies

Further specialisation on farms, using equipment to increase labour productivity and farm output, was also a feature of the 1990s particularly on dairy farming. The specialist British Friesian Holstein breed was gradually introduced and allowed farmers to increase their milk yield per dairy cow to 7-8,000L in 1990. However, this breed is more demanding in terms of the energy density of its feed, and it requires a complete redesign of all stalls as the animals are larger than conventional sheds' cubicles). This led to new investment and changes in the use of the farm environment and its cultivated area.

Winter wheat varieties without vernalization became available for free draining land. Wholecrop harvesting techniques became available (for use after 10-12 weeks of growth); harvesting "green" cereals (winter or spring) to store in silos or wrapped: it is as easy to make as grass silage. With the development of low-temperature maize varieties it was possible to grow it on dairy farms in the Welsh lowlands. Maize is sown from late April to mid-May (as soon as the field is ploughable) and harvested from October on gentle slopes. Maize is at the very edge of its viable growing area, it is not always ripened by October, but to harvest it, soils have to be carrying enough. It is not grown on small ridges as a result. Harvesting it after the end of October is risky. Likewise, winter cereals could not be grown effectively on small ridge areas.

The new developments meant farmers could produce more fodder than before with at least 30% dry matter and a higher energy density than grass. This allowed a significant increase in milk yield with the same acreage of land. After about 2000, farms also invested in I.T (Chivers and Rose, 2020; Lowenberg-DeBoer et al., 2020; Martin et al., 2022), as new opportunities were opening up for farmers to access new forage and labour productivity gains, maximising the use of these inputs that were more costly.

Continuing with our dairy farming example, to milk cows, the newest options range from robot parlour to rotary parlour from 2005 onwards, although both are very expensive to set up and maintain. Without making such a significant shift, farms could opt for a renovation of existing parlours with automatic feedstuff bins, automatic milking cluster removal and automatic cluster cleaning. Animal management can then be automated with automatic sorting gates on large farms (over 500 milking animals). Farmers can now offer rations with a towed wagon mixer, or independent automated feedstuff bins. Genetic improvements made it also possible to work with sexed semen with a good success rate, thereby reducing the number of male dairy calves born and compensating for an increased culling rate that has become the norm with increasing incidence of bTB.

Crop management on dairy farms has benefited from satellite data to monitor grass growth, and tests for nutrient levels. Rotational grazing will be rationed every 12 hours on dairy farms with a paddock system combined with grazing infrastructure where necessary (i.e. with tracks and water supply to fields). GPS guidance of tractors and machinery allows more refined application of fertiliser and sprays. Adding nitrogen as liquid N (foliar) or by injection into soils has enabled better management of nitrogen run-off.

- Grassland management techniques

New varieties of high yielding ryegrass (Italian and early ones) with a very high palatability (high % sugar) permitted an increase in the number of good quality silage cuts (3 or even 4) for pit storage (15Tonnes DM/ha). Cuts made before August are for dairy cows (as a high sugar content), while the next cuts with a lower digestibility and lower sugar content are generally for young animals and non-milking cattle. The new

varieties would yield better on gentle slopes than sharply undulating land and would generally offer one additional cut compared to the older varieties that they replaced.

In slurry management, the "umbilical" spreading system became available. Pumping manure from the pit or tower to the fields was done via a pipe connected to the tractor spreadplate or with a dribble bar system. This system can limit the compaction of soils under temporary pastures during spreading and causes less nuisance for neighbours as it avoids using the road. Slurry tankers and muck spreaders can load 10 to 12T with low-pressure tires.

Mechanization evolved rapidly, every single machine was scaled up with significant gains in terms of labour productivity, but for a high cost. For example, forage harvesters were now auto propelled and hay harvesting equipment was 2.5 to 5 m wide, also tractors and motors grew more powerful to cater for the bigger tools. The wagon mixer was now available to distribute a complete ration matching the needs of demanding dairy cows or other livestock with a mix of fodder and chemical inputs. However, due to its high cost, it was not accessible to all farmers.

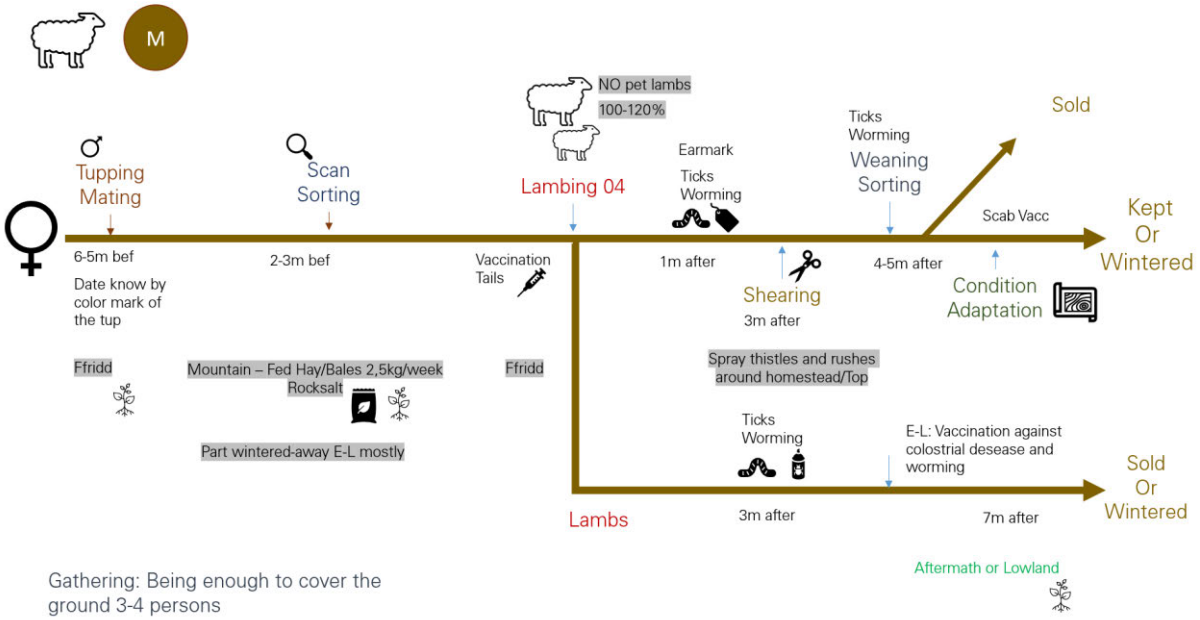
Not all these measures could be implemented together as a package, but using some of the tools limits their possible combinations in building a workable farming system. The interdependency of the different elements of modern farming systems is not limited to dairying; it holds true for every hi-tech production approach; including in poultry, potatoes, or horticulture (for standard retail channels), where producers must meet high specifications in terms of products and prescribed management methods.

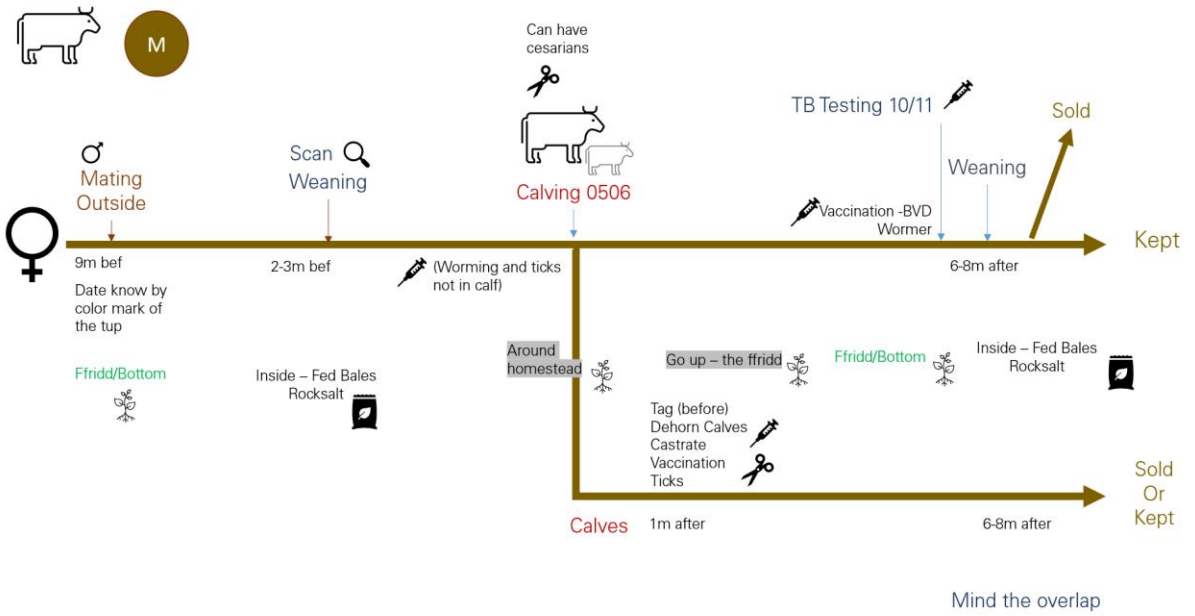
Annex 9: Supporting information on uplands farming system differentiation and economic analysis

Item 9-1: From grass to milk: spring calving dairy farms systems operating logic, structure, and development

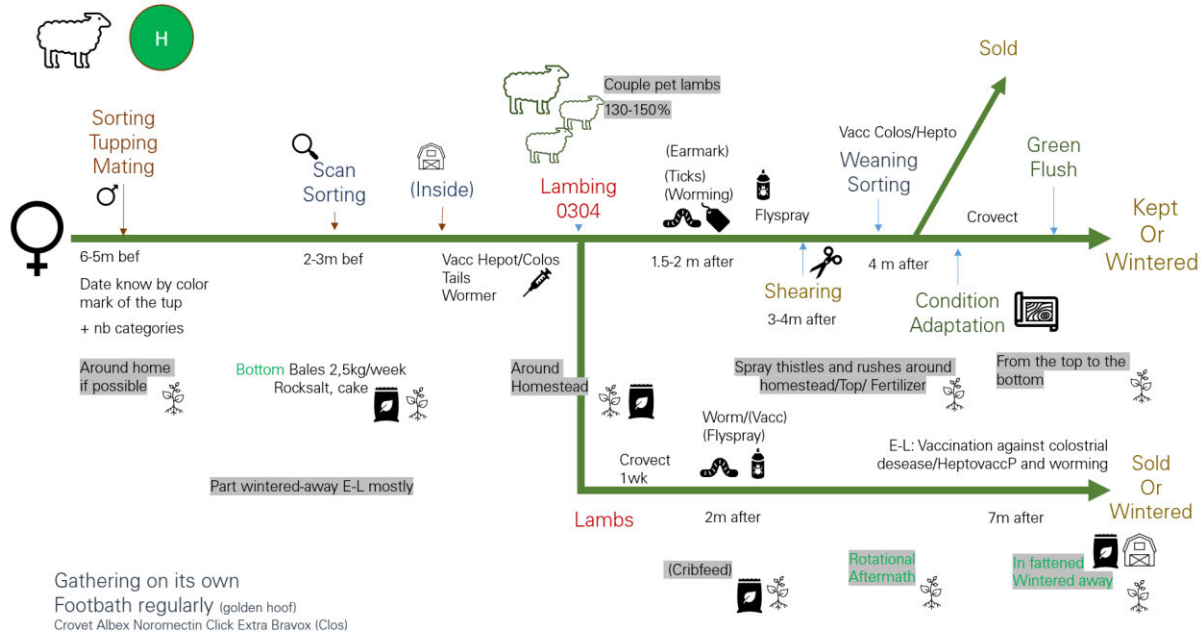


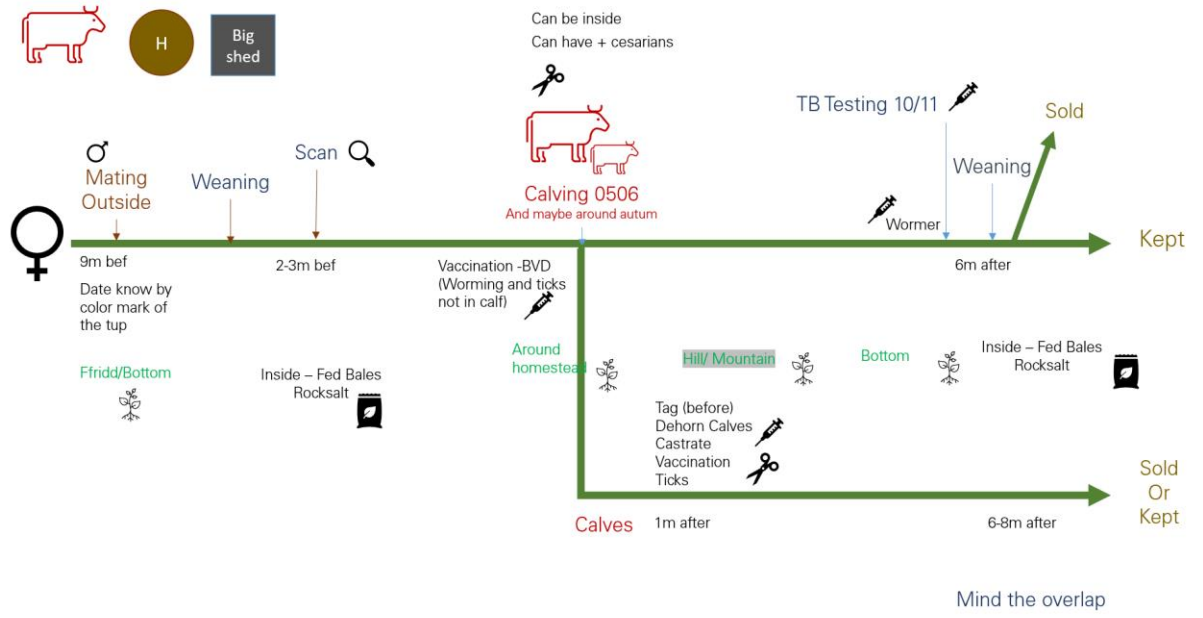
Item 9-2: Management of "uplands" type of flocks and herds





Item 9-3: Management of "lowland" type of flocks and herds



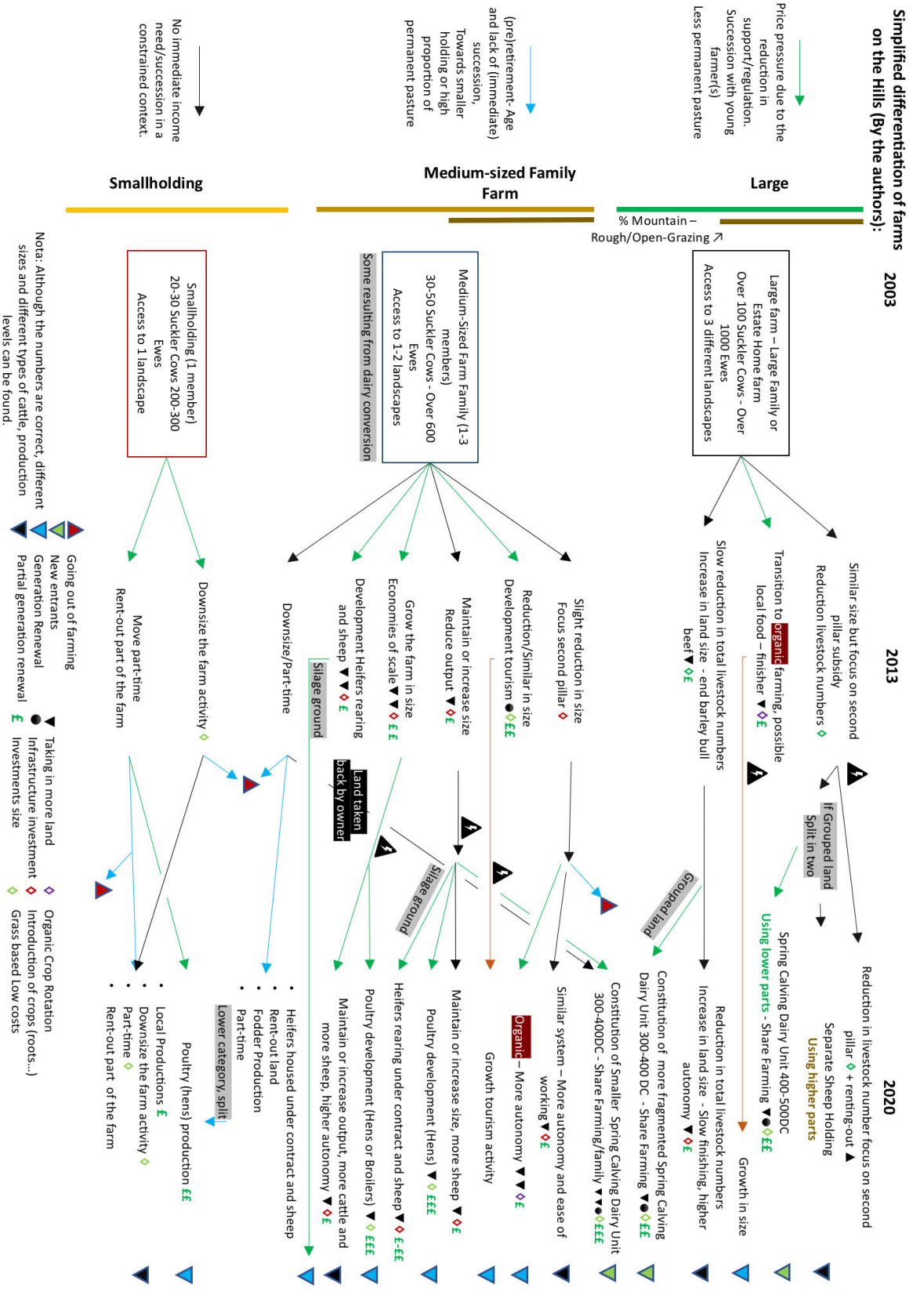


Item 9-4: Discussion on the farm evolution witnessed on smallholdings

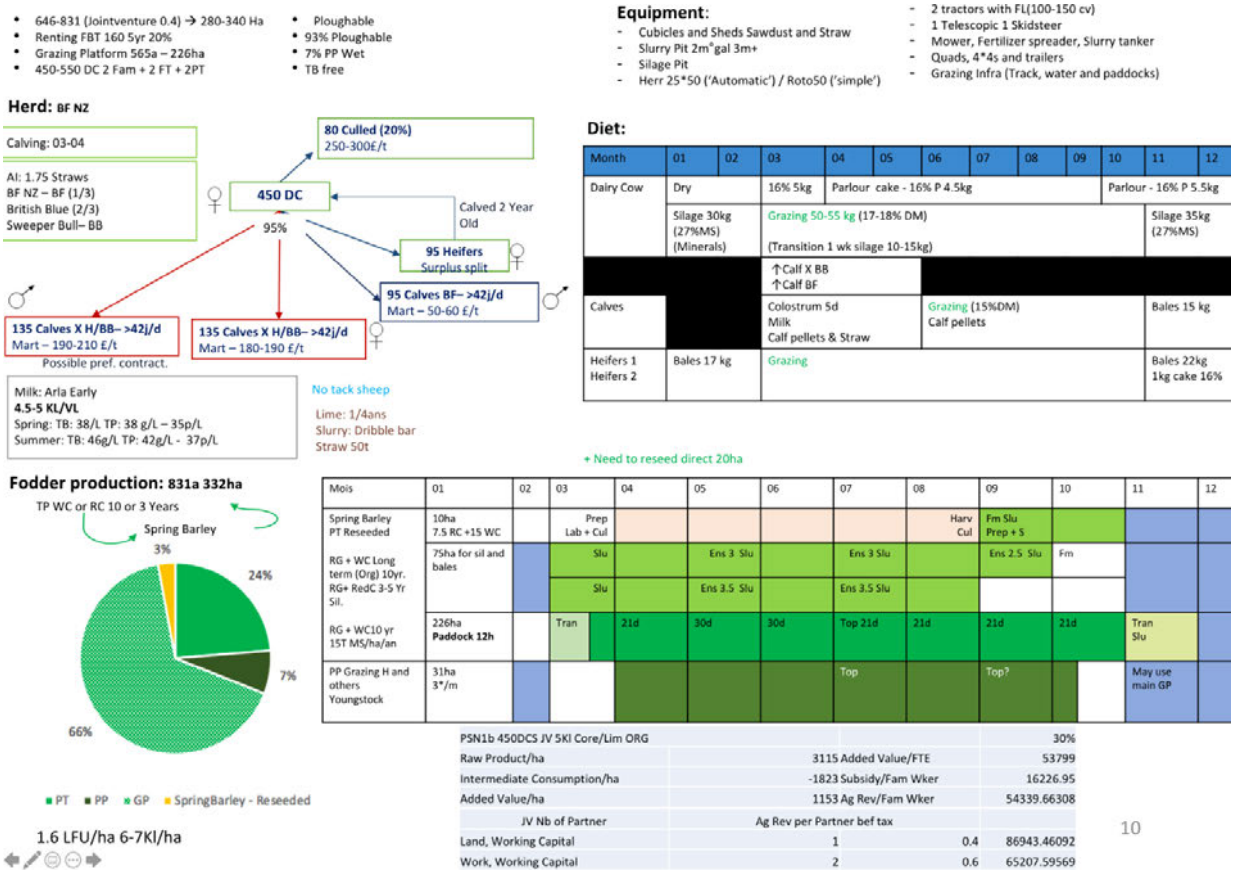
For a hen unit, it would be small in size (3-6K birds) and more gradual in its development, using second-hand tools/sheds and not having a contract. The farms locally selling meat or dairy products would also tend to adopt agro-ecological practices (Giller et al., 2021) with improved rotational grazing (Béranger et al., 2002) and grass-focused systems (Garambois and Devienne, 2010). They might use different forage types (e.g. Alfalfa, as a leguminous Smith, n.d.) or push mixed farming further, with crops (Ryschawy et al., 2012). The development of these systems would take place as links with consumers/local supply-chain actors strengthened. Initially fully grass-based farms would then experiment with mixes and different forages (rye…), agro-forestry and fodder crops: tailoring breeds to the system, in terms of the grazing profile.

These actors were at the forefront of small-scale horticulture based on their existing network and using their additional labour on a small acreage. With an established activity and landholding, they could take the limited risk of developing horticulture on a small acreage, taking advantage of the diversification grants available.

Item 9-5: Differentiation of farms in Bala after 2003 depending on opportunities available (by the author)



Item 9-6: Archetype of a spring calving dairy organic/regenerative system with a more diverse landholding and lower stocking density (by the author)



Item 9-7: Modelling of the potential combined impact of Welsh Government's future scheme and market changes (by the author)

- Assumptions of the modelling:

To examine prospects, this analysis is focused on five different archetypes: a beef finisher with some mountain land, a spring calving dairy farms herd with 500 dairy cows, a laying hen farm, a smallholding selling locally, and a sheep farm resulting from the split of a large farm in two (dairy and sheep). The future time horizon is 10 years, therefore reducing some of the localised volatility but also considering the likely duration of a potential new support scheme with no income support.

Dairy markets are likely to benefit from a modest economic upturn arising from the increased transaction costs now faced by imports (Dwyer, 2018; Thomas et al., 2021). The picture is much more complicated for beef and sheep markets: although *ex-ante* analysis seemed negative, the COVID crisis and current buoyant market context present a more nuanced picture, particularly in a context where the Wales breeding herd and flock is contracting (HCC, 2022). This signals a tightening of British supply that is unlikely to be impacted by trade deals in the short-term. But these market contexts will be accompanied by the volatility typical of liberalised markets, for both inputs and outputs, as witnessed in the COVID crisis. Some other hypotheses in the general economic context are listed in Annex 9 Item 9-9 and took a similar assumption as in Chapter 4, with both high and low prices scenarios.

The new subsidy scheme replacing the CAP will be conservative in terms of subsidy allocation between uplands and lowlands, and design. The scheme will also be conservative in terms of approach, offering an entry-level payment (L), an advanced one (H) and an organic/afforestation one (O) similar to today's structure (BPS, Glastir…). A payment redistribution takes place between these pillars with only 50% maximum of funding in the entry level payment (BPS). A 'low budget' option was considered which would result in a cut of 30% of agricultural subsidies, against a 'generous budget' option which retains the current overall amount of support. There are some transaction costs of approximately 20% (lower bracket of Falconer and Whitby, 1999). All the SFSs target active farmers producing agricultural outputs from

their land, as is done today. More details have been given on the hypotheses retained in Annex 9 Item 9-8.

- Results of the modelling:

These variations led to the creation of four different scenarios to test on the farm archetypes mentioned above. The scenarios are as follow:

- Scenario 1: low prices inputs and outputs, combined with low subsidy payments
- Scenario 2: high prices for inputs and outputs, combined with low subsidy payments
- Scenario 3: high prices for inputs and outputs, combined with high subsidy payments
- Scenario 4: low prices inputs and outputs, combined with high subsidy payments

The results of the simulation are shown below.

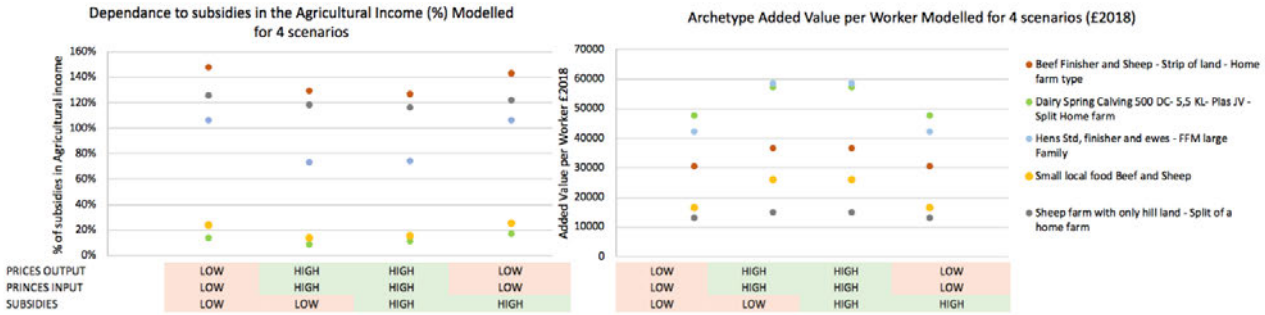


Figure A 27: Evolution of farm agricultural income and added-value generation for five different farm archetypes over four scenarios

The dependence on subsidies remains high for beef and sheep systems in all cases, particularly if they are based in the harsher parts of the landscape or have mountain land, but their income is high and stable. It is likely that in this case there will be relative stability for these able to access the subsidy scheme in the higher parts of the uplands.

Farms supplying local food systems and these with spring calving dairy farms depend relatively little on subsidies. The modelled hen farm has some mountain land and features and remains large, which maintains some level of dependence on subsidies, it also has a high number of family workers. These who would struggle the most to deal with a crisis would be small farms, despite a better economic return than for the sheep-only farm. All the models that result from new differentiation options fare well

whatever the future scenario, except perhaps the smallest farms for which it could be assumed that they would grow gradually in size.

It can be noted that maintaining subsidies based on acreage and a relatively conservative scheme would favour large farms, as did the past iterations of the Welsh CAP. It would also validate the splitting strategy that some have decided on, trying to separate areas for conservation compared to areas dedicated to economic production; this is obvious for large farms but is also a possible trend for mid-size farms at a smaller scale.

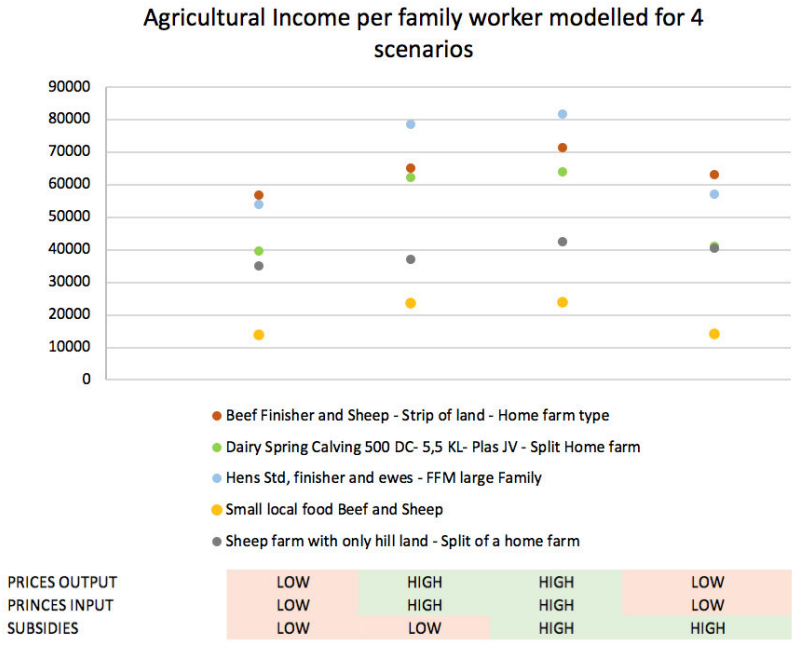
Item 9-8: Hypotheses retained to model future context in a conservative scenario (by the author from literature and fieldwork)

General economic assumption	It is taken as a hypothesis that the investment context will remain favourable in the short-term with low real interest rates (Bank of England, 2022). The current trends in milk and meat markets will continue, in terms of price and volume.
Assumption on market behaviour	On market prices, it is assumed that low input prices will occur when prices are low and that high prices would concur with high input prices (mirroring trends on commodity markets and sellers' pricing strategies - from fieldwork and secondary analysis)
High prices	Low prices
Milk: 110% - 30 pence/litre* Sheep: 105% - 90 £/lamb* Beef: 110% - 1100 £/Store* Input costs: 120% Average price given by farmers depending on their product characteristics, in interviews.	Milk: 95% - 26 pence/litre* Sheep: 95% - £80/lamb* Beef: 100% - £1000/Store* Input costs: 100% Market conditions selected as gathered from literature and interviews.
*Prices are purely indicative and do not reflect output pricing in the archetypes **All prices would be converted to $£_{2018}$ afterwards	

Item 9-9: Future simplified scenarios of funding for upland farming in Wales (Lenormand et al., 2021a)

	Generous funding	Low funding
Hypothesis	Funding Constant Transaction cost 20% for High and Organic scheme Investment Support - NVZ/ Welfare/ Business	Funding -30% Transaction cost 20% Investment Support - Poor and Competitive
(% of the land)	40% L 30% H 30%O and F	50% L 25% H 25% O and F
Low tier (L)	+ €119/ha	+ €90/ha
High tier (H)	+ €210/ha	+ €183/ha
Organic and Forestry Conversion/ Maintenance (O)	+ €164/ha	+ €239/ha
It is taken as an assumption that supporting advice will be retained as it is now with provision by Farming Connect and Menter a Busnes, and that investment and processing subsidies will remain at current levels in the 'generous funding' option (helping NVZ adaptation). The farmed area is kept to a similar level as now and set inflation at 2% per year. **All prices would be converted to £$_{2018}$ afterwards		

Item 9-10: Evolution of farm agricultural income for five different farm archetypes over 4 scenarios (by the author) (Lenormand et al., 2021a)



Annex 10: Supporting element for the analysis of the impact of the SFS

Item 10-1: Adaptations of selected farm archetypes in the SFS scheme (by the author)

Adaptations on farms to fit in the SFS scheme (MFF: mid-size family farm; JV: joint venture)	
Spring calving dairy farms 500 dairy cows- 5,500L-Estate- JV – 220ha – 6 FTE	Tree planting of 5% required. There is a need to add 15% more land (rented) to the landholding, Permanent pasture will have a different management. As it is a flying herd, the farm is heavily stocked and has a high LFU/ha. The cheapest and least number of adaptations to adapt to the new NVZ rules were chosen. Increased culling to increase efficiency, 10% reduction number of cows most efficient, reduced input use by 10% feedstuff and 10% fertiliser. Outwintering some animals on Kale and Rape, small acreage of Barley mixed with feedstuff. Optional scheme: permanent pasture, tree parts, hedges.
Dairy heifers rearing and sheep - MFF Fam – 160ha – 2FTE	Already compliant tree wise and ecological areas. Cost of production alignment for their contract but decided to go for a slower growth rate. Reduction in feedstuff consumption - 35%, silage receive - 15% fertiliser, development cereal growing 1-2 fields (as wholecrop), turnips field for Outwintering. Trees plantation couple steep slope. Outwintering in valley. Optional scheme: permanent pasture, tree parts, hedge, rough grazing land
Beef finisher and Sheep - Strip of land - Estate type family farm – 1000ha – 4FTE	Already compliant tree wise and ecological areas. Adaptations with a bit more acreage under crops, 35ha of spring barley, reduction of feedstuff use for sheep 60%, only protein, same for other animals. Reduce top weight of animal to save on cost 5%. Red clover. Optional scheme: permanent pasture, tree parts, hedge, rough grazing land
Organic beef and sheep - Strip of land - Large MFF family– 280ha – 2 FTE	Already compliant tree wise and ecological areas. Adaptations higher proportion of homegrown cereals/clover. Reduction in bought in feedstuff - 10%. Reduction in weights -5%. More red clover.
Hens Std, beef finisher and ewes - MFF large family– 300ha – 3FTE	Already compliant tree wise and ecological areas, development orchard and agro-forestry. Adaptations higher proportion of homegrown cereals/clover, a little sold as it cannot be used for hens. Reduction in bought in feedstuff - 15%. No fertiliser bought-in. Reduction in weights -5%. Red clover. Optional scheme: permanent pasture, tree parts, hedge, breeds
Smallholding local food beef and sheep– 7ha – 0,7FTE	Not compliant tree wise and ecological area but low stocking density, development orchard and agro-forestry. Adaptations higher proportion of homegrown cereals/clover 1 field in partnership with neighbours. Reduction in bought in feedstuff - 10%. Reduction in weights -5%. Optional scheme: permanent pasture, tree parts, hedge, breeds
Hens local and sheep - SMH family– 60ha – 2 FTE	Adds land to the farm to adapt but room as little sheep. Cost of production contract possible for the inputs/outputs, local market possible to increase price. Grow crops to reduce inputs cost. Optional scheme: permanent pasture, tree parts, hedges.
Dairy - 200 dairy cows grass– 130ha – 3,5 FTE	Add 5-7% more land to be compliant, permanent pasture different management with no fertiliser. Tree planting required on 5% of the acreage, residual tree in hedges. Reduction in feedstuff use 25%, maintain number of cows, yield down to 7.5KL, reduction fertiliser 20% past, 10% silage production of cereals to add to the mix for 25%, spring barley, add-on grazeable Kale and rape. Outwintering. Optional scheme: permanent pasture, tree parts, hedges.
100 beef and sheep from calves– 90ha – 2 FTE	Add 5-7% more land to be compliant, permanent pasture different management with no fertiliser. Tree planting required on 6% of the acreage, residual tree in hedges. Already high autonomy, grow more crops, grow kale and rape to complement in proteins. Optional scheme: permanent pasture, tree parts, hedges.
Potato farm with on-tack livestock estate farm– 260ha – 5 FTE	Reduction in fertiliser of 20%, increase in unsold potatoes by 5%, new chunky pot category taking 50% of waste, yield diminution by 10%, reduction in treatment by -20%, acreage for trees/pond/rent-in or buy with 12% more land, reduction in number of animals compared to current stocking rate -5%, a portion of potatoes sold locally at £1000/T approx. 10-30kg/d - on average 6T/yr (honesty box). Development of red clover in the rotation.
Small dairy farm 90 dairy cows – FFM-120ha – 2FTE	Reduction in feedstuff bought-in by 20%, further development of red clover and kale and rapeseed crops, more intensive grazing technique, increase proportion of barley, introduction of lucerne in the rotation. Add 5-10% of land. Develop local sales if possible but in this one cashflow problem and busy market.

Item 10-2: Analysis on the uptake of the SFS by tenanted farms (by the author)

- Assumptions

It is intended that challenges associated with mostly tenanted farms be considered in more detail and to assess what is likely to be their response to the SFS. The analysis considered the reference agricultural policy (2019 reference) combined to the reference, high, low and inflation prices scenario to analyse how vulnerable are tenanted farms.

Six[88] archetypes representing different conditions were used (see below) only two were fully tenanted (in red), two were a mix of tenanted and owned (in white) and two others could be mainly owned (in orange). Two types of tenancy mix can be found on the whole farm arrangements:

- A main secure/lifetime Agricultural Holding Act 1986 agreement complemented by Farm Business Tenancy and more unsecure tenancies
- A main long-term (5-15 Years) FBT complemented by several other FBTs/more unsecure tenancies.

- Economic performance

Looking at the economic results through the agricultural revenue per family worker on tenanted farms, it is interesting to note that tenanted farms are more impacted by the high price scenario (with increases in rents), than their non-tenanted counterparts. In these cases, all challenging scenarios see farm incomes falling under our sustainability thresholds. Beef and sheep farms, particularly upland ones, tend to be in a more challenging position than the high added-value types. These farming dairy or poultry are in a better position even at a small scale, with incomes above the UK median income. There is a particularly high-risk for non-differentiated tenanted beef and sheep farms, but overall, the impact on the farm's economics of being tenanted should not be overestimated. Buying land can be a problem in a high inflation scenario with high real interest rates.

[88] For others archetype it was unrealistic given their history that they could be fully tenanted

Table A 3: Agricultural income per family worker for tenanted archetypes in different scenarios (by the author; MFF mid-size family farm; DC dairy cow; SMH smallholding; JV joint venture)

Status	Archetype	Reference prices	Reference low	Reference high prices	Reference inflation
Now fully tenanted	Dairy heifers rearing and sheep – Mid-sized family farm – Bala	32727	27776	52307	26038
Now fully tenanted	Organic beef and sheep – Strip of land – Large family farm – Bala	26965	17023	37129	7754
Now fully tenanted	Dairy 200 DC all year round – Medium-sized family farm -Pembrokeshire	54873	47767	74310	45134
Now fully tenanted	Slow finisher 100 Head – Mid-sized family farm- Pembrokeshire	22462	14550	27336	11693
Already tenanted	local food beef and sheep – Smallholding – Voc	19631	10440	31059	22575
Already tenanted	Hens local and Sheep – Smallholding - Bala	41045	38719	44006	35367

- Challenges for tenanted farms

Where the challenges might lie for tenanted farms would be in operational flexibility and cashflow. It is more difficult to fit into the SFSs without landlords' agreement (for the change of land-use), to secure the necessary funding to adapt to regulatory changes or make necessary productivity investments (not having enough capital to borrow against). Finally, the cashflow around rent payment dates is very important for tenanted farms, this might further pressure them into differentiation, more than diversification (given again, the restrictions in terms of operations/changes to the holding for tenanted farms). It is noted that in respect of cashflow, beef and sheep systems tend to be more fragile.

Tenanted beef and sheep farms may be guardians of the Welsh SEPLs (Chapter 6). Their options are limited to add value in a sufficient manner to reward the different production factors, with the restrictions of rented land.

For beef and sheep farms rent increases might be unsustainable with their current mix of production (see above). The reliance on subsidy for farm incomes would also be a problem with significant alterations to land use, as the landlord could claim part of these, further limiting their income (e.g. in the case of afforestation support). The type of tenancy will then be key in terms of the bargaining power that farms might have in their relationship (Chapter 6). But whilst AHA tenants will have more bargaining power, these in FBTs could accommodate the SFS better with their more frequent reviews. The dispute process is expensive in general, so would be avoided by farms (FUW, 2022b).

Item *10-3: Analysis of the Woodland Creation Scheme in light of the future context*

- Assumptions

On tree planting, it has been analysed that the current small Woodland Creation Scheme (Welsh Government, 2022c). The assumption was taken that it was likely that funding levels will keep covering expenses (as happens now) and then provide a management payment based on income foregone, in the SFS in the future. If retained, applicants can plant 2ha per application window, so after five years the planted acreage could stand at 10ha. While it represents a small proportion for large farms, it would already represent more than 20% of their acreage for the average size of farm in Wales (48ha). It is estimated that this programme acknowledges the fact that large farms often already hold some tree-planted land[89] and that it is aimed at smaller farms.

To investigate the interest in tree planting on farms, the range of archetypes selected in part B was utilised. Three separate scenarios were considered for tree planting payments:

- The WG payment levels remain similar over the next 12 years, with around £410/ha (management and loss of income)
- The payments are lowered due to a shortage of funding or non-compensation of inflation (~£235/ha).
- The payments are increased by 50% to target farms with a low input system but good quality land (~£615/ha) this would enable the payment to be above the economic performance of the organic dairy farm of 90 dairy cows (Added-value of £600/ha).

Two price scenarios were considered - the reference one and that of the low prices - representing the more challenging conditions for archetypes as shown in the previous analyses.

[89] a hypothesis validated during fieldwork

- Economic performance

A comparison was then conducted of the economic performance of farms to the potential revenue from subscribing to the tree planting scheme, to understand if it would be attractive for our range of farms.

Table A 4: Economic results per hectare of the range of archetypes studied in two operating scenarios (Reference prices and Low Input Low Output prices), the results have been colour-coded (by the author; FFM mid-size family farm; DC dairy cow; SMH smallholding; JV joint venture)

£2018/ha	Added-value/ha		Agricultural income/ha	
Scenario	Reference	Low prices	Reference	Low prices
Spring calving dairy farms 500 DC – joint-venture	1712	1443	821	520
Dairy heifers rearing and sheep - FFM	452	388	509	447
Beef finisher and sheep - strip of land - large family farm	207	137	297	226
Organic beef and sheep - strip of land - large FFM	87	37	272	219
Hens' sheds, cattle finisher and ewes - large FFM	810	755	775	720
Local food beef and sheep - SMH - tenanted	2082	1160	1963	1044
Hens local and sheep - SMH - tenanted	1493	1403	1368	1291
Dairy 200 DC all year - FMM	2033	1843	1540	1362
Slow finisher 100 head - FFM	369	253	452	339
Potatoes producer	2215	994	1424	181
Small organic dairy farm 90 DC	694	601	765	678
Large high yielding dairy farm 400 DC - FFM	9443	8244	5587	4320
The color coding is assessing how the farms' economic performance compares to the potential level of payments for the tree planting schemes (£/ha)	<235	235-410	410-615	>615

Looking at the comparison in above, it can be noted that high added-value producers are unlikely to go for the tree planting scheme, except for marginal land that does not directly benefit the farming system. But from this point of view, a permanent pasture providing a "medicine field" – drought resilient fodder production - is directly benefiting the farming system. Therefore, farmers should be encouraged to consider their system logic before focusing on planting up marginal areas. Arguably, land which is less mechanisation friendly is more likely to be selected first: this was a concern voiced by farmers and environmental professionals (RPSB, 2024; Tomkinson, 2024).

These finding it interesting from an economic point of view would be low added-value systems (Green or Blue), mostly beef and sheep farms, particularly extensive producers, even if they must share the funding with a landlord (as shown by the green

option). For large farms, particularly in uplands they already tend to have forestry, they are used to dealing with it, which will not be as much the case for other farms. Their interest for the SFS would grow in challenging market conditions, for example, to improve resilience in times of crisis with different income streams (Fieldwork).

Considering the agricultural income per hectare there could be a wider interest in the SFS particularly for the lower levels of high added-value archetypes; heifer rearing, small hen farming or small-scale organic dairy farms.

Despite the general economic vision and analysis not always supporting tree planting, there could be an operating/opportunistic logic to go into the SFS. For example, if high economic performance is not directly dependent on the land, it can be interesting – e.g. for a farm with a hen unit. For tenants as shown above it could be potentially interesting depending on agreement with landlords, and the share of funding that these would retain, but it would be possible for most farms. Based on this analysis it is believed that small and medium low added-value farms would be more ready to accept forestry planting, particularly if it is needed to enter the SFS.

Finally, this could also be used to compensate for reduced activity on the rest of the farm, for example when retiring, with potential to add £820 of income per year with medium-term (12 year) security. It also questions whether these areas will be doubly subsidised within the SFS - which is unlikely in our opinion but will have to be clarified.

- Carbon markets

Some companies and institutions are buying land to offset carbon at market rate over 10-15 years with the cost of land ranging from £400 to £1000/ha/year (in 2018 values; from fieldwork) without considering currency depreciation. These levels of prices in that horizon will compete with agricultural production or the SFS. This reinforces our recommendation for a land-use policy/framework to understand what would be needed from land and from which actors in the future.

The WG has not clarified so far what will be done in terms of selling carbon credits and how it interacts with SFS (Welsh Government, 2023c).
In summary, it is suggested that it will be key for the SFS success to match the capacity

of the Woodland Creation Scheme with future ambition to support the sector towards the 10% goal. Tree planting could be of interest for some producers. Given the latest guidance provided in 2024 (Welsh Government, 2023d), the inclusion of trees in hedges or agroforestry, the inclusion of the canopy area in the area for the SFS payments, and the absence of 10% requirement in tree cover for the transition period (2025-2029) as well as amendments to the WCS[90], represent positive steps. Several potential exemptions have been added.

Based on this analysis, it is suggested that requiring a proportion of farm area with set land use (tree planting or management for biodiversity) could be achievable. Nevertheless, effort and time is necessary to adapt farms (e.g. planning the acreage that can be planted every year in WCS), the key to the SFS success is likely to be the balance between the efforts to enter the SFS, the abilities of farmers, and the reward. Communicating and facilitating these changes, ideally in person, would increase costs but hopefully help highlight some potential benefits and increase uptake (e.g. from agro-forestry). This sort of impact has been shown for example with the facilitation fund (Breyer et al., 2022; Morse, 2022).

[90] Renamed Woodland Creation Grant with increase in funding, inclusion of agro-forestry, no limit of acreage, similar payments levels (Welsh Government, 2024).

Item 10-4: Increased challenges for Welsh farming since 2010 up to today

- Reduced prospects for exports and increased domestic competition

From 2010 to 2020 the UK was on a slow trend of deteriorating food export balance (See below and Annex 10 Item 10-6). UK food supply increasingly depends on imports, including for domestic agricultural production. The only exception is Dairy products, where exports have grown slightly since the end of quotas (Chapter 4). But general trade policies are not devolved matters - Wales can support and promote itself as a key food exporter but it does not control the UK-wide policy which likely to have a bigger impact on the supplies available on the domestic market.

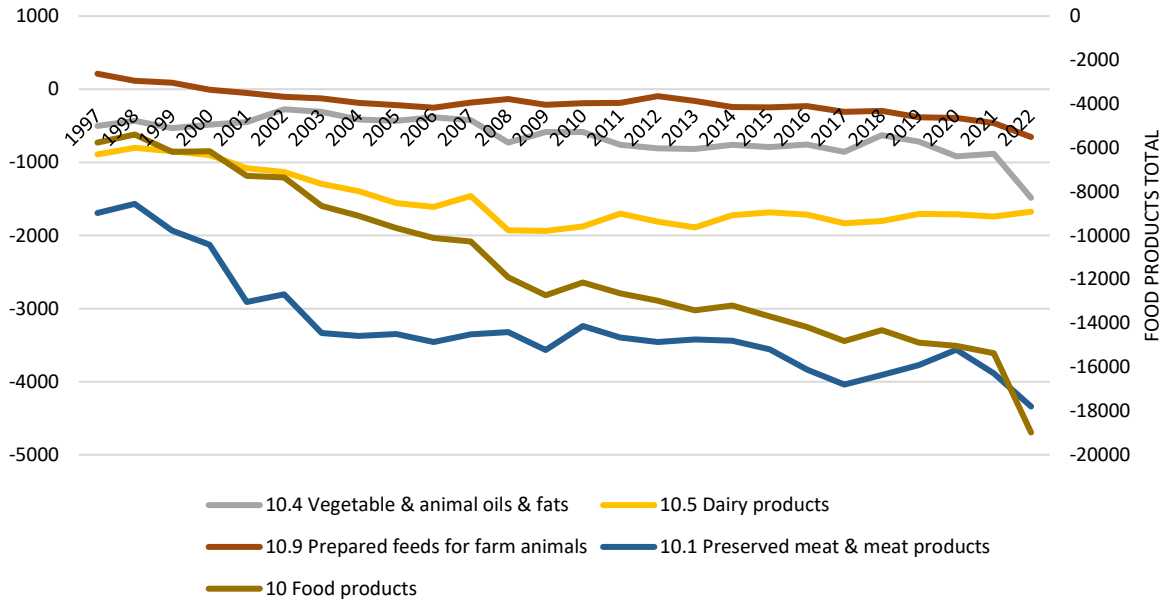


Figure A 28: Real-Term balance of export on key agricultural commodities over the last 20 years in term of value in £2018(ONS gov.uk, 2023)

For example, post-Brexit trade negotiations have recently had the knock-on effect of potentially opening-up the UK domestic market further to competition, for Welsh agricultural produce (Birley and University, 2024; Gobey, 2021), while EU exports have been more difficult (AHDB, 2023d; Gerval, 2023). This was a major fear about the post-Brexit context (Calvin et al., 2017), and agri-food imports, despite still being mainly from the EU, have diversified (AHDB, 2023d; Gerval, 2023). The UK is one of the leading agri-food importers (ranking 5th globally, according to USDA, 2023), and FAOSTAT data (Annex 6) tends to show that it is the case for sectors with strong

domestic production (e.g. meat) as well as these with lower self-sufficiency (e.g. Fruit and Vegetables).

- A more complex context domestically

The UK traditionally had a relatively low percentage of disposable income spend on food and non-alcoholic beverages; plateauing at 11% on average, which is a similar level to Austria or Germany but lower than France (DEFRA, 2023d; Eurostat, 2023). In this context, the price-evolution in agricultural products was below the general inflation level (See below). Products in which Welsh farming is specialised, like milk or red meat have witnessed a fall of 10 to 20% in real-terms prices over a decade (Bakker et al., 2022).

During this period, real-terms prices of food and drink expenditure remained level (Item 10-5), but prices of food items declined (DEFRA, 2023c; See below) even if their volume gradually increased. At the farm gate, the prices paid to farmers fell significantly in real terms and in line with retail prices, though sometimes more significantly (e.g. Beef).

Table A 5: Changes in price for key agricultural products (by the author from ONS, 2020; AHDB, 2023; Defra, 2023)

2010-2020	General Price change	Change in Average Consumer Price Index	AHDB average	Farmgate Price change	Farmgate price change, real terms
Milk, cheese and eggs	1%	-20%	Beef Price	4%	-12%
Vegetables incl. potatoes and tubers	6%	-15%	Sheep Price	23%	-6%
Meat	11%	-10%	Milk Price	17%	-11%
Bread and cereals	14%	-7%	Egg Price (DEFRA, 2023)	13%	-14%

Low-price pressures have led to economies of scale, specialisation, and concentration of farms in Wales, as has been demonstrated in the previous chapters.

Since Brexit and the COVID/Ukraine crises, fears of supply-chain failures have increased (Chapter 1). The major supermarkets were tasked by the UK government to solve any problems as they arose (e.g. Farrell, 2023). The use of food banks has increased, the availability of food not necessarily ensuring food security (Google

Trends, 2023; The Trussel Trust, 2023). The share of food in spending now stands at 15.5% instead of 11% for the 20% of population on the lowest incomes (DEFRA, 2023; similar to Italy). Wales was already amongst the nations with the highest use of food banks, given its relatively high proportion of deprived areas.

Inflation hit all the sectors of the economy but particularly these key commodities linked to Ukraine. It has led to an increase in the price of food and non-alcoholic beverages of more than 20% since 2020 (ONS, 2023a). Food insecurity is rising particularly in Wales, with an increase of 41% in the demand for food parcels in 2022/2023 (The Trussel Trust, 2023;Figure below). Wales has the highest reliance on food parcels, of the four UK nations. The share of incomes spent on food has risen by 2-3%, now standing at more than 18% for the lowest income households (DEFRA, 2023d). People are reportedly buying less food (ONS, 2023b). These factors combined with the pandemic have increased food spending by 10% in real terms, compared to 2010-2020 (DEFRA, 2023).

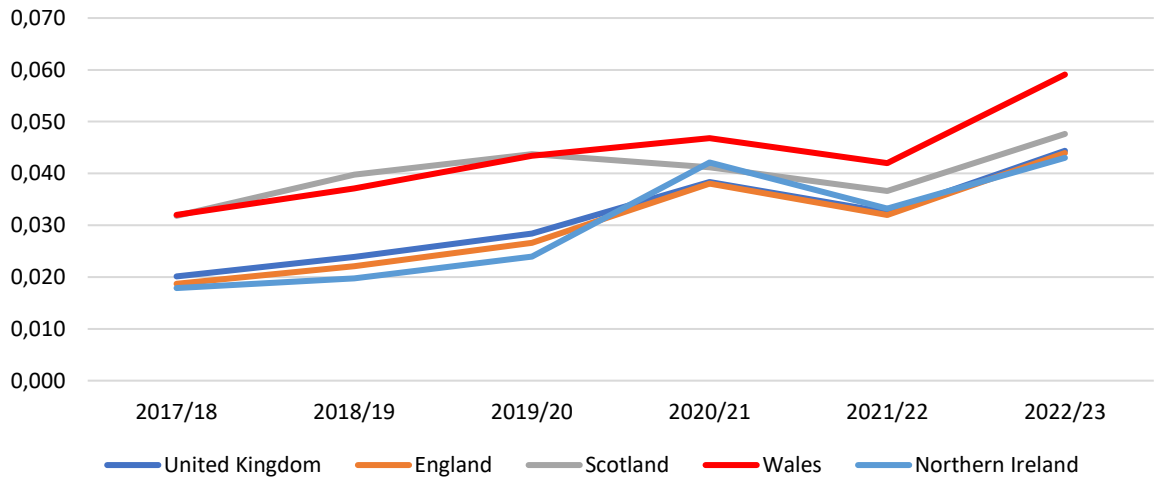


Figure A 29: Evolution of the number of emergency Parcels delivery per inhabitant (Trussel Trust, 2023)

Recent trends have shown a focus on lower price-range products (Kantar, 2023), this does not align with the WG vision for agriculture to attain “a sustainable premium” for its livestock products (HCC, 2020; Welsh Government, 2023f, 2020d). There have been many questions raised around the UK food production system and its adequacy, most of all in nutritional terms (Dimbleby and et al., 2021; Fagioli et al., 2017; Farstad et al., 2021), with too much consumption of less healthy products. Eating healthy is more expensive, but the food ecosystem (Saujot et al., 2023) does not support enough

healthy foods in its wider socio-cultural context. The National Food Strategy concluded that there was a need for the UK to change its diet (most notably to eat more fruit and vegetables), but also to adapt the wider agri-food environment, to support these changes. These considerations link to food security concerns: it is unlikely, given the analysis made of the SFS, that it will do much to alleviate these concerns.

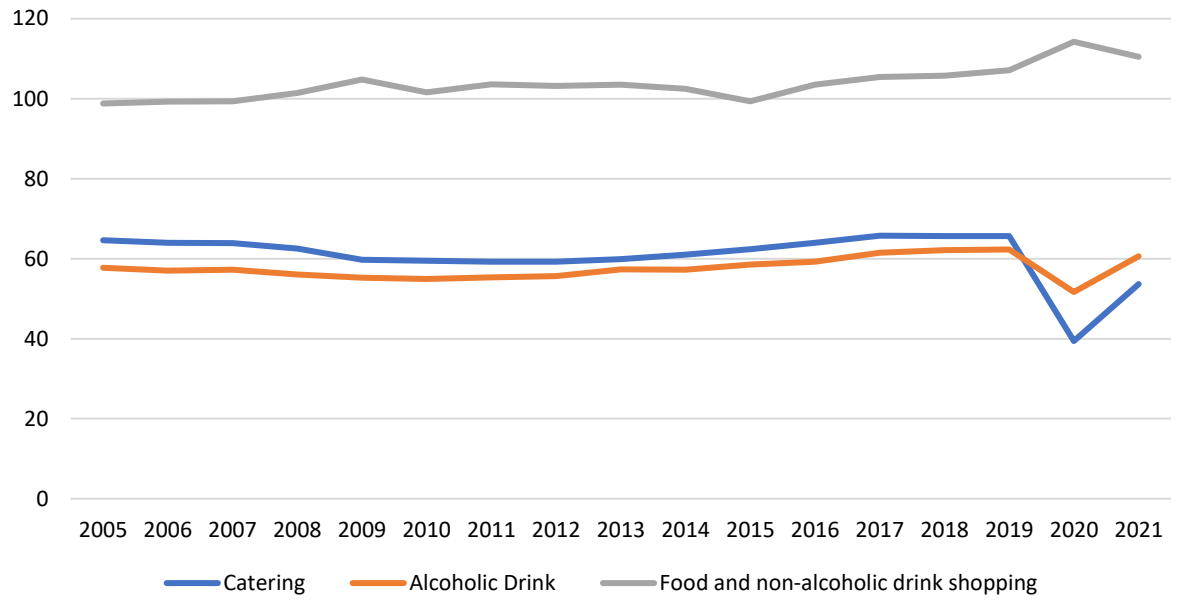
Farming has also been hit by these successive crises of Covid and the war in Ukraine (Lenormand, 2021; Lenormand and Dwyer, 2022; Meuwissen et al., 2021). Farm gate price increases since 2020 have not matched the increase in terms of input costs, as shown below. For example, egg producers saw a 14% increase in farm gate price compared to an estimated 25-30% cost increase (AHDB, 2022a).

Table A 6: Farmgate price trends 2020-2022 and 2010-2022 (by the author from AHDB, 2023; AHDB UK, 2022; DEFRA, 2023; ONS, 2023)

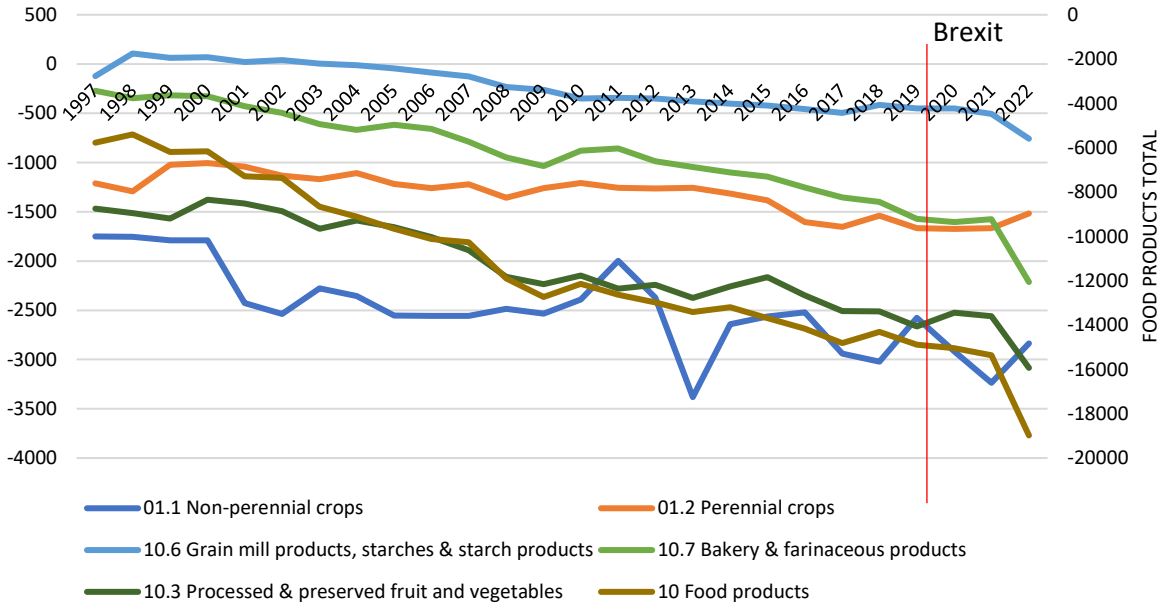
	Farmgate prices % change, 2020-2022	Cumulative CPI change, 2020-2022	Farmgate prices % change 2010-2022	Cumulative CPI change, 2010-2022
Beef Price AHDB Average	23%	12%	25%	36%
Sheep Price AHDB Average	21%		48%	
Milk Price AHDB Average	52%		78%	
Egg Price Defra Average	14%		24%	

Price trends were not as significant for beef and sheep producers compared to dairy or egg farmers. While the demand is stronger for these products, our fieldwork showed that more dairy and egg producers have ‘cost of production’ contracts which prevent them from benefiting from increased demand. This is likely to pressure producers further, sometimes with mental health consequences (RABI, 2021); it is also likely to lead to further concentration and specialisation, as shown in previous chapters. Farms that do not concentrate or specialise have survived by adding activities (diversifying) or adapting their product types (differentiating). Overall, this would lead to negative knock-on consequences (in respect of stocking density, nutrient loadings…) and a reduction in the number of the Welsh Family Farms.

Item 10-5: Evolution of real-term expenditure for the food and drink sector from 2005 to 2021 in £2018 (Defra, 2023)



Item 10-6 : Real-Term balance of export on key agricultural commodities from 1997 to 2022 in term of value in £2018 (ONS, 2023)



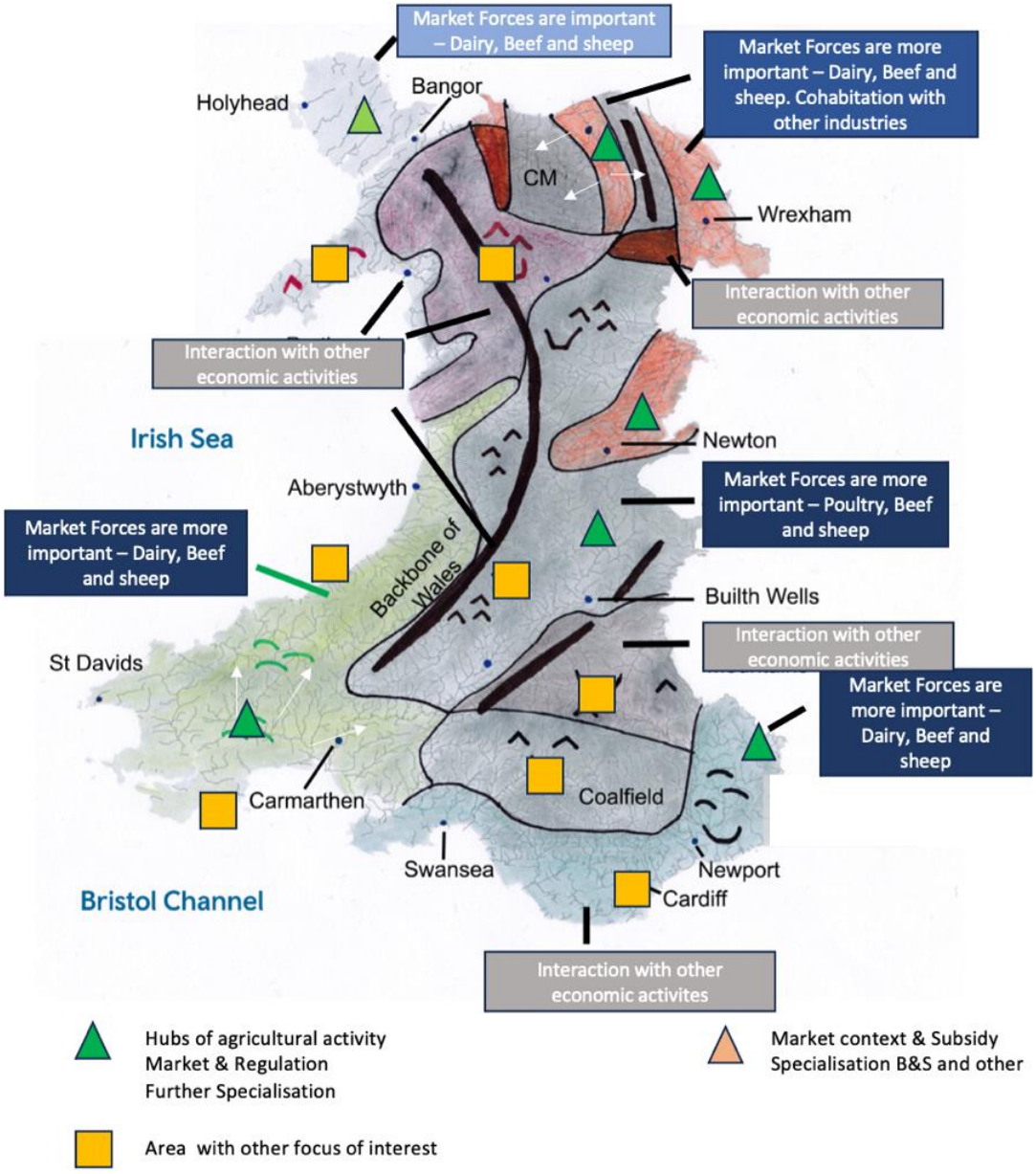
Item 10-7: Description of the 2023 Common Agricultural Policy (by the author from the literature)

The EU's 2023 CAP has been very iterative as demonstrated in Lenormand, (2023). The key changes in 2023's CAP while the first pillar still represented 78% of the funding, Good Agricultural and Environmental Conditions (GAEC) rules for direct payments were strengthened (Théo Lenormand, 2023). The first pillar's Greening Payments have been replaced by Eco-Schemes, redirecting at least 25% of the direct payments envelope towards farm-scale, simple, environmental, climate, and animal welfare-focused actions. In terms of income support and entitlements, MS are directed to align entitlement values to ensure that, by 2027, all entitlements are at least 85% of the national average amount in the EU (European Commission, 2022). Direct payments are supposed to further converge inside member states and the option of capping payment or degressive values are now available.

Moving to the second pillar, Agri-environment schemes have to represent at least 30% of the second pillar funds (European Commission, 2022). Moreover, MS are now mandated to allocate over 35% of their funds to the second pillar after co-funding, with a specific focus on rural development projects through LEADER programs, which must constitute above 5% of the second pillar funds.

Annex 11: Map of the likely impactful drivers of change in the future and commentary to support the discussion

Item 11-1: Map of Wales key regional units and key drivers of farm evolution (by the author)



Item 11-2: Issues of communications and Sustainable Farming Scheme (by the author)

The imprecise nature of many words used to discuss agricultural development is problematic (Cristache et al., 2018; de Bonneval, 1993; Pépin et al., 2021). For example, intensive agriculture is generally assumed as bad, but is a farm that is labour-intensive bad? - not necessarily (Devienne and Garambois, 2021; Garambois and Devienne, 2012; Griffon, 2013; Gržinić et al., 2023). Agro-ecological farms may be more intensive in terms of labour use, but less intensive in terms of other inputs (Devienne and Garambois, 2021; Morsel and Garambois, 202. Clarity is needed to express correctly what is meant; for example, instead of Intensive Poultry Unit, the term “Technologically Integrated Livestock Unit” would be clearer: it is highly intensive in inputs and technological production, with a significant degree of integration in the supply-chain. An organic farm can be intensive but will never be seen as such: for example, an organic unit of 200 dairy cows with yields of 7,000 L/Cow, is intensive in terms of labour, other inputs (e.g. feed) and ecologically (from Fieldwork).

Naming elements and concepts and using them correctly is therefore highly relevant to the field of agricultural policy. For example, the WG promoted ‘diversification of farms’ by which they meant at the same time differentiating (taking a significantly different course in terms of agricultural production) and diversifying (incorporating a mix of activities beyond farming). In effect, these two elements are not mutually exclusive but in our uplands case-study, compromises were touched upon that might be required on the farm, and how the environment is managed. Another example is the meaning of “Food Security” for the farming community: having a scheme that was not supporting farmers to produce food, but including food security among its goals, is perhaps a political risk for the WG since there is no way in which the SFS directly promotes this goal. Developing lexicons and being precise in the use of field-specific vocabulary is recommended as many words carry implicit value-judgments. For example, the Welsh Government (2022) used the terms; “rejuvenate grass” or “pest-resistant”. Agronomically (de Bonneval, 1993), this reflects a preference for one side of a polarised vision of farming; with production on one side and environment on the other. This kind of language acts in opposition to the route set in terms of WG sector goals.