Renewable Energy Diversification: Considerations for Farm Business Resilience

Dr Wyn Morris, Aberystwyth University

Dr Robert Bowen, Swansea University

Abstract

With a varied landscape, Wales is resource rich in terms of wind and water and a suitable location to develop many different forms of sustainable energy. Whilst farm businesses face increasing challenges in terms of economic stability and traditional production methods, this paper considers the role of renewable energy production as a form of diversification. The study adopts mixed methods as a means of undertaking an in-depth investigation into the role of renewable energy generation in supporting agribusinesses in Wales. Initially a questionnaire obtained 118 responses from farmers in Wales. Subsequently, 15 follow-up semi-structured interviews with farmers were conducted to further investigate the issues from the initial questionnaire. The theoretical contribution of this paper is a segmentation of farmer businesses which allows for distinctions to be made of different attitudes to off-farm income and the adoption of renewable energy sources. Five farm types were identified, varying in relation to farm characteristics, attitudes to diversification, access to renewable energy and resource allocation. These farm types highlight the need for specific policies towards facilitating the increase in renewable energy along with sustaining farming incomes. Furthermore the research provides valuable information to the farming industry on opportunities in renewable energy production, particularly for farmers and farm businesses who are considering diversification strategies.

Key words: Green economy, farm diversification, agribusiness, entrepreneurship, renewable energy

1. Introduction

Farming businesses are facing increasing challenges in particular the role of agriculture in the wider rural economy (Barnes et al., 2018; Loizou et al., 2019), along with concerns regarding agriculture's impact on the environment in terms of resources and emissions. Whilst some structural change is occurring in the rural economy, small-scale agricultural businesses remain at the core. The situation is even starker in large areas of Wales where agriculture is dominated by upland sheep faming (Morris et al., 2017). These farm businesses are seen as having deep historical structural issues, being fragmented with limited value-added activity (Roberts, 2014; Armstrong, 2016). As such upland sheep farms are regarded as being most at risk from agricultural policy reforms which focus on the reduction of direct payments and the greening of policies. The onset of Brexit proposes further challenges to the industry in terms of trading agreements and standards. However, with a varied landscape, Wales as a space is resource rich in terms of wind and water and a suitable location to develop many different forms of sustainable energy generation, particularly windfarms, solar parks, hydro-electric energy or biomass.

The main aim of this study is to discover the possibilities for farmers in Wales to utilise their resources and diversify into sustainable energy and build on the conceptual model of agri-environmental diversification behaviour established by Sutherland et al. (2016), as shown in Figure 1. Whereas diversification in farming has received increasing attention in recent years (cf. Brandth & Haugen, 2011; McFadden & Gorman, 2016; Morris et al., 2017), the focus on renewable energy as a form of farm diversification has seen little research. This has largely been part of a wider discussion of agri-environmental diversification (Sutherland et al., 2016; Ge et al., 2017), particularly in the context of Scotland. Thus, this study aims to develop a holistic understanding of the issues relating to farm diversification into renewable energy, focussing specifically on three research questions.

1. What drivers exist for farm businesses to diversify into renewable energy?
2. What barriers do farm businesses face in adopting renewable energy for diversification?
3. What types of farm businesses can benefit from diversifying into renewable energy?

The research utilises a mixed methods approach to explore the opportunities for farmers to diversify into sustainable energy in response to current farming challenges and uncertainties. The research setting for the paper is Wales, a predominantly rural country, where agrifood businesses represent a significant part of the economy, with 84% of the land area is used for agriculture (Welsh Government, 2013). The rural geography of Wales is considered abundant in natural resources, which is suitable for creating sustainable energy despite tis many challenges exist. As such, the study seeks to identify and understand the drivers and barriers that impact on the adoption of renewable energy generation as a form of farm diversification, and the types of farms that could benefit from these activities. The research contributes to previous research and proposes a sophisticated segmentation of farm business based on attitudes to diversification. The work informs both industry and policy of the opportunities from renewable energy diversification.

The next section explores the role of agriculture in the rural economy and the themes of agricultural policy, farm diversification and renewable energy generation in the context of Welsh agriculture. Qualitative and quantitative analysis methods are explained in section 3 and presented in section 4. The analysis identifies opportunities and barriers across all stages of renewable energy adoption, which can assist farmers and policy makers.

2. Agriculture's Role in the Rural Economy

With growing concerns regarding the increasing divide between urban and rural economies, as identified within The Prosperity for All: Economic Action Plan (Welsh Government, 2017a), sustainable agricultural businesses are essential to maintain upland communities. This is in contrast to the productivist view of agriculture and concerns regarding the industry's environmental impact from traditional farming practices, Midmore (2011) comments that agriculture's contribution to the rural economy goes beyond its economic functioning, where it provides public services such as stewardship of the landscape, along with creating and managing biodiversity. More specifically, Midmore (2011) adds that upland farmers in particular are becoming increasingly important, for example, in managing peat lands for carbon sequestration. On farm renewable energy generation could be an additional contribution where agriculture can assist in tackling climate change and support the rural economy.

However, with UK farmers facing continuing economic pressures (House of Commons, 2011), in addition, recent reforms, or 'greening', of agricultural policies require farmers to meet environmental targets, which may also have a negative impact on farm productivity (Boere and van Kooten, 2015; Gittins et al., 2020). In Wales Pillar 2 support, that is non-direct subsidies as part of agricultural support to deliver climate objectives, has been delivered through a range of interventions including the agri-environment schemes, with financial support targeting tourism, renewable energy and improving ICT, further reforms prioritising mitigation of climate change, water management and biodiversity, skills development, knowledge transfer and innovation. Therefore, Pillar 2 provides potential funding for farm diversification into renewable energy generation.

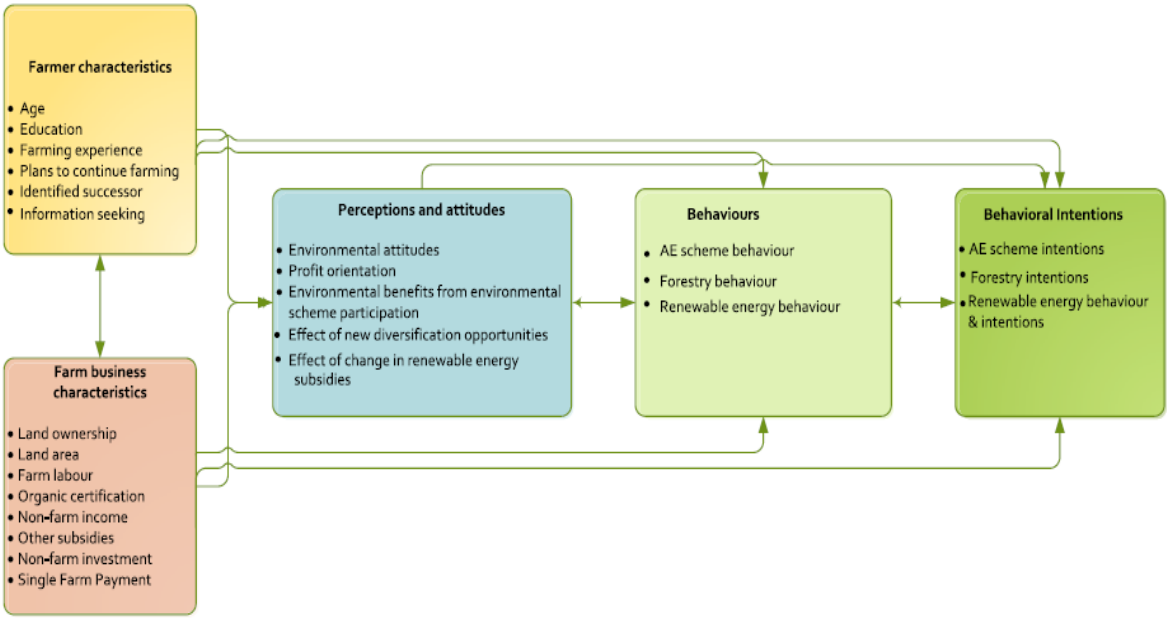
Effective delivery of policies is dependent on the participation of farmers and farm managers (Pollock, 2012), with farmers facing tensions between adhering to policies and following strategies in response to their business aims and objectives. These strategies will impact on the farm's profitability, its contribution to the rural economy and the ecosystem services it produces. The success of these strategies and the future of family farms are reliant on investment in infrastructure surrounding connectivity as highlighted by Bowen and Morris (2019), but also infrastructure in terms of national grid capacity. This investment will have spill over effects to the wider rural economy.

Farm Diversification

For some time, farm diversification has been a prominent strategy in rural spaces as farmers seek to supplement farm incomes and explore business opportunities. There have been varying attempts to define diversification, for the purpose of this paper we will use the definition of Vik and McElwee (2011, p. 394) which defines farm diversification as "a

movement away from core activities of the farm business by providing goods or services with a basis in a wide understanding of farm resources (human, physical, private, or collective)". Farm household incomes have often included subsidies, food production, tourism or other forms of off-farm income, however, it is recognised that the natural resources of rural spaces in Wales provide opportunities for growth in sustainable energy generation. In considering the above, the main aim of this study is to discover the possibilities for farmers in Wales to utilise their resources and diversify into sustainable energy. The work considers the skills set and managerial mind-set highlighted by McElwee and Bosworth (2010) as essential for successful diversification strategies and seeking entrepreneurial opportunities. The aim of the research is to build on the conceptual model of agri-environmental diversification behaviour established by Sutherland et al. (2016), as shown in Figure 1.

Figure 1: Model of agri-environmental diversification behaviour



Sutherland et al. (2016)

The model highlights the importance of farmer characteristics and farm business characteristics in adopting farm diversification strategies. Farm diversification is one strategy that may provide spill-over effects for the wider community and highlights the entrepreneurial side of farmers (Vik and McElwee, 2011). A pull factor towards diversification or pluriactivity may be related to household/family structure and the need to provide gainful employment for other family members. Another factor could be the desire to contribute to wider social and environmental objectives such as providing employment opportunities for others in the specific rural area or contributing to the care of natural amenity and landscape (Leck et al., 2014; Suess-Reyes and Fuetsch, 2016). Renewable energy generation could be a solution to these diversification drivers and this form of entrepreneurship may be critical for the resilience of the family farm business by allocating resources away from mainstream food production (Vik and McElwee, 2011).

Renewables

The European Union has set targets that 32% of energy consumed will come from renewable sources by 2030 (European Commission, 2020). However, the primary focus of this plan, along with previous reports, is on the energy sector, with the role of the agricultural sector in energy production generally ignored. In contrast, such reports consider agriculture to be a problem in achieving environmental targets due to the emissions produced from traditional production methods. It is apparent that the role of agriculture in renewable energy production requires greater attention. Whilst there is a large back catalogue of literature on farm diversification, entrepreneurship and off-farm income, the literature on renewable energy generation on farms is limited with the exception of (Cato et al,. 2008; Sutherland et al., 2015; Sutherland et al., 2016). However, whilst Cato et al. (2008) explores the renewable energy sector in Wales, the focus is on the entrepreneurial elements. Where all cases in the study demonstrated a drive to provide energy to their local community independent of the national grid, the majority of cases were concerned with sustainability. Two of the cases found financial achievements as being the most important factor. Sutherland et al., (2016) analysing agri-environmental diversification on Scottish farms found that young, better educated farmers that receive subsidies and have off-farm income are more likely to engage in future environmental activities which include renewable energy production. This is consistent with the work of Morris et al., (2017) analysing upland farm strategies in Wales. Sutherland et al., (2015) acknowledges agriculture's key role in renewable energy transition as agriculture is responsible for managing key resources such as land and biomass.

The Welsh Government (2017b) report on energy generation in Wales highlights that between 2005 and 2017 energy consumption in Wales fell by 17%. In addition, the Government has set a target by 2030 that renewables are to generate electricity equivalent to 70% of Wales's consumption. The report outlines that Wales already generates 48% of this target. However, only 22% of total energy generated in Wales is from renewables, as Wales is a net exporter of electricity. Of this renewable energy generation, wind power makes up 51% of renewable energy generation in Wales.

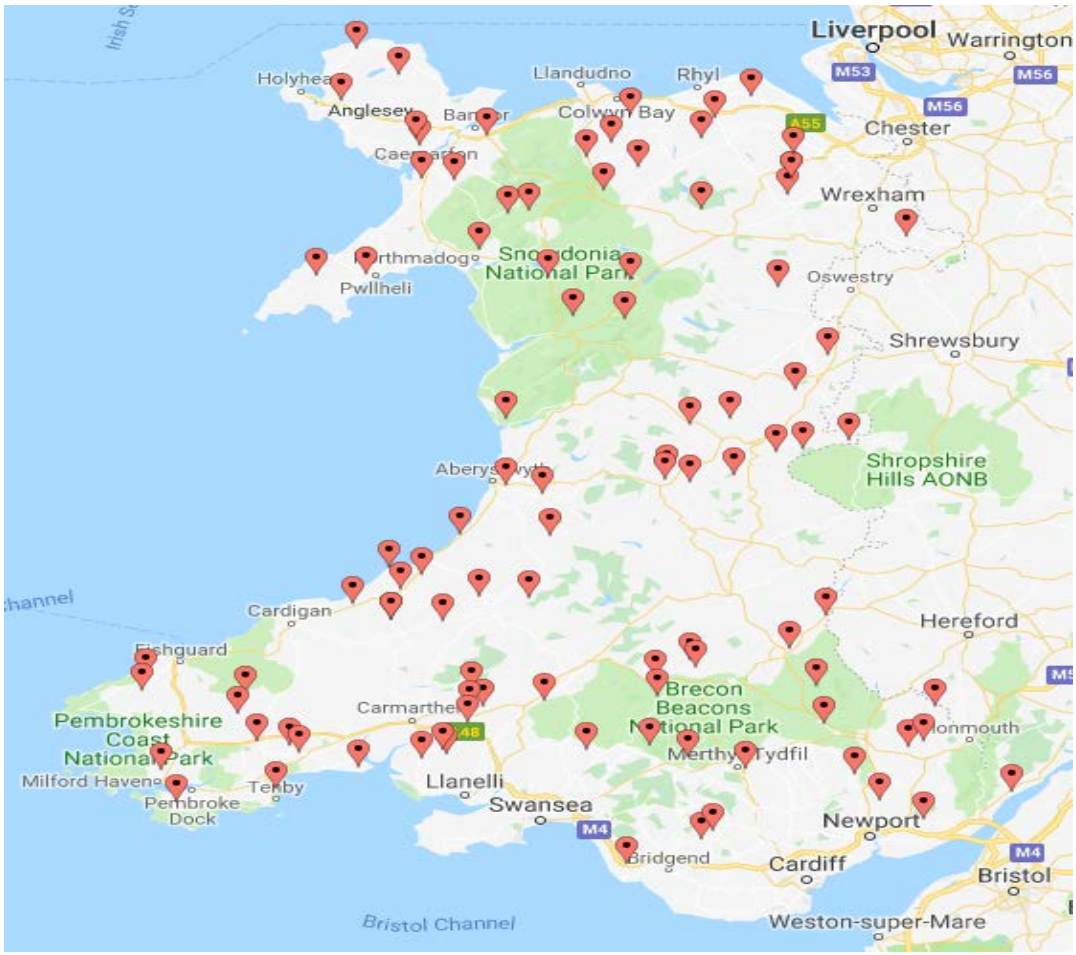
The Welsh Government (2017b) report highlights considerable regional variations between local authorities in terms of renewable energy generation and the types of renewable energy generation. For example the Neath Port Talbot local authority produces the largest amount of renewable energy which is dominated by onshore wind projects. Whereas Monmouth's renewable energy generation is dominated by biomass electricity, Gwynedd's energy generation is dominated by hydro projects, with Pembrokeshire focused on solar. Some of these statistics are skewed by large commercial projects, however, the regional variation is also influenced by local resources and planning regulations. Such factors must be considered if farmers are to adopt this form of diversification.

As noted earlier, studies of renewable energy generation in agriculture are limited, however Morris' (2018) study on technology adoption in agriculture captured data on renewable energy adoption by upland farms in Wales. Solar electricity was by far the most popular form of renewable energy with 17.2% of respondents having electricity generating solar panels. The popularity of these panels is linked to Government incentives, feed in tariffs and the electricity usage on farms particularly dairy farms. A total of 525 (71.1%) of the 738 respondents to the survey had no renewables on the farm an area the Welsh Government must consider if it is set to meet its ambitious targets.

3. Methodological Approach

The research aims to examine farm diversification activities and farmer attitudes towards renewable energy generation in supporting agribusinesses in Wales, as such, the study uses a sequential mixed method design (Creswell & Plano Clark, 2011) of two equally-weighted independent phases to undertake an in-depth investigation into the matter. Initially an online questionnaire (November 2018-February 2019) obtained 118 responses from a database of 450 farmers (26.2% response rate) dispersed across Wales (see Figure 2) through a process of convenience sampling, with demographic questions within the questionnaire designed to confirm the suitability of respondents. Questions focussed on farmer characteristics, farm income activities, diversification and engagement with renewable energy, with distinctions made between farmers that have and have not adopted farm diversification activities. Questions were influenced by those employed by Sutherland et al. (2016), and were chosen to meet the aims of the research questions in understanding the opportunities for diversification into renewable energy, including the drivers and barriers to adoption. Questionnaire findings were analysed initially through descriptive statistics, and later through a cluster analysis.

Figure 2: Survey respondents' location



Subsequently, 15 follow-up semi-structured interviews were conducted with questionnaire respondents (April-June 2019) based on a purposive sampling method to identify farmers already adopting renewable energy and those who do not (Yin, 1989). Maximum variation sampling was used to ensure that the interview sample accounted for all characteristics of

farm size, farmer age, location and adoption of renewable energy (see Table 1). The purpose of the interviews was to provide a deeper understanding of farmers' awareness, attitudes and barriers to renewable energy adoption as a form of diversification. The interviews (n=15) ranged between 30-60 minutes in length. The number of interviews is consistent with other studies on agriculture (for example Warren, 2004; Downey, Threlkeld, and Warburton, 2017). More importantly, the interviews achieved data saturation in terms of themes, and concepts (Francis et al., 2010). Interview data was analysed using the six step process of thematic analysis by Braun and Clarke (2006). The mixing of methods occurred through triangulation of the quantitative and qualitative data, with a final phase of data analysis conducted using a two-step cluster analysis. The cluster analysis was informed by the segmentation work of Morris, et al. (2017) and conducted in SPSS using survey data to investigate company typographies that could explain approaches to off-farm income (Bacher et al., 2004; Mooi and Sarstedt, 2011). Results of the cluster analysis were analysed for validity using Chi-square analysis to ensure that distinct segments were developed. Table 3 outlines the 5 clusters obtained from the analysis. The next section provides detailed findings of the research, presented in chronological order.

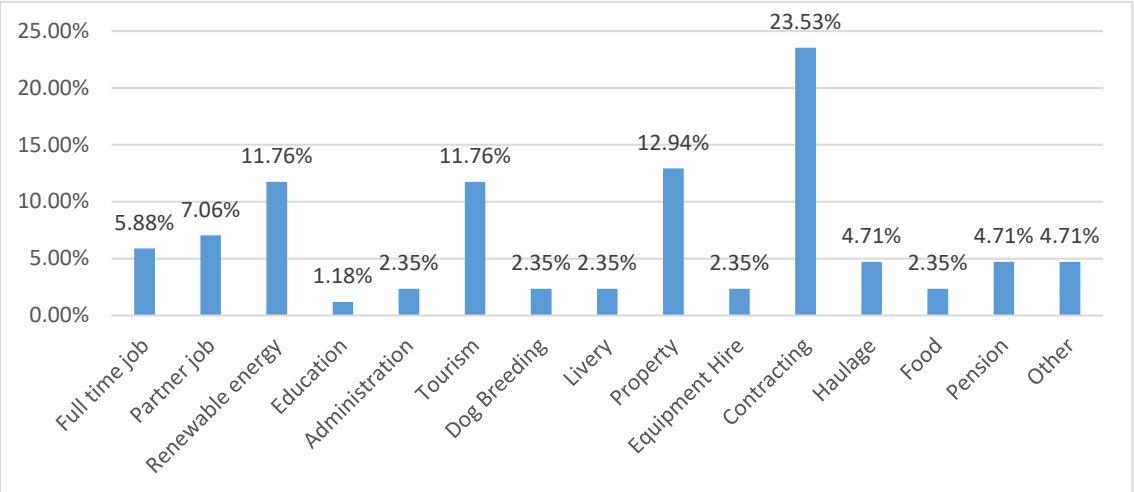
4. Findings

This section presents the findings of the data collection phases, with quantitative findings based on 118 survey responses from farmers, along with 15 follow-up interviews.

4.1. Quantitative Findings

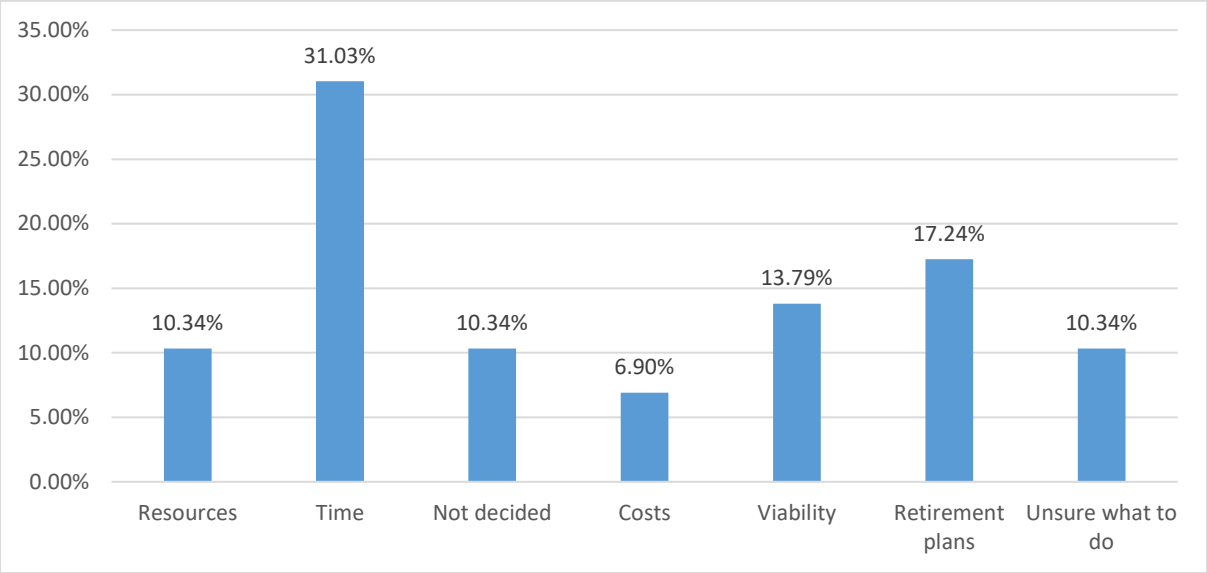
Of the 118 survey respondents 7.6% were aged between 18 and 35 years, 12.7% were aged 36 to 44, 28.8% aged 45 to 54 years, 32.2% aged 5 to 64 and a further 18.6% aged over 65 years. This reflects the aged nature of the industry. In terms of education 19.5% of respondents had school only, 6.8% has A-levels, 35.6% had further education and 38.1% had a higher education qualification. Descriptive statistics from the survey show that 62.7% of respondents were engaged in off-farm income. Figure 3 shows that a range of activities were evident, however contracting was the most frequent activity with 23.53% of respondents engaged in this. Several respondents were also involved in property letting and tourism activities, with 11.76% of respondents engaged in renewable energy generation.

Figure 3: Off-farm income activities



Among the 37.3% of respondents not involved in off-farm income, the reasons for non-adoption are documented in Figure 4. The most frequent reason was a lack of time, followed by limited resources. Four respondents pointed to plans to retire rather than invest in the farm. Other reasons include lack of viability, costs, deciding against adoption and uncertainty over what to do.

Figure 4: Non-adoption reasons



4.2. Qualitative Findings

A total of 15 semi-structured follow-up interviews were conducted with farmers who had responded to the questionnaire. Table 1 outlines a profile of interviewees according to farm size, age range, location and whether they possess renewable energy sources. Eight of the fifteen respondents possessed renewable energy.

Table 1: List of interview respondents

Respondent	Farm size	Age	Location	Renewables
A	600 acres	35-44	Ceredigion	Yes
B	62 acres	65+	Carmarthenshire	No
C	650 acres	35-44	Gwynedd	Yes
D	690 acres	45-54	Powys	Yes
E	125 acres	45-54	Carmarthenshire	Yes
F	250 acres	35-44	Pembrokeshire	Yes
G	1800 acres	35-44	Ceredigion	Yes
H	1100 acres	45-54	Gwynedd	No
I	250 acres	65+	West Glamorgan	Yes
J	150 acres	65+	Mid Glamorgan	No
K	460 acres	45-54	Pembrokeshire	No
L	250 acres	45-54	Gwent	No
M	862 acres	35-44	Powys	Yes
N	450 acres	55-64	Powys	No
O	250 acres	45-54	Pembrokeshire	No

Interview data was analysed using the six step process of thematic analysis by Braun and Clarke (2006). Verbatim transcripts of the interviews were coded through a process of first and second cycle coding (Miles et al., 2014), reducing the data into themes. The first cycle coding process led to 245 codes from the interviews, which were reduced to 163 unique codes by removing duplicates, and further reduced to 85 unique codes through second cycle coding. This culminated in the formation of 5 themes (see Table 2), which relate to renewable energy in farm diversification. These include resources available to farms and the opportunities that exist in diversification, the drivers and barriers to adopting renewable energy, and the overall farm activity. Each theme is discussed hereafter.

Table 2: Themes derived from the thematic analysis process

Resources	Opportunities	Drivers	Barriers	Farm activity
- Natural resources bring opportunities in Wales - Resource availability limits risk - Research needed before adoption - Business knowledge essential - Suitable conditions for adopting renewables - Time needed to invest - Financial support needed - Opportunities through land resources	- Differentiation in off-farm and on-farm activities - High profit margins from renewables - Develop efficient farming - Invest in the farm for future generations - Reinvest income into more renewables - Farm location suitable to renewables - Diversification spread risk of farm activities	- Access to advice on investment - Awareness to diversification opportunities - Scale of the farm - Good feed-in tariff - Government policy needed to support farmers - Income generation - Incentives to invest - Relative ease in adopting renewables - Favourable ROI - Willingness to adopt - Viability of renewables - Subsidies	- Viability - Limited awareness of support - Cost of investment - Access to grid - Grid capacity - Financial risk - Isolated farm location - Limited connectivity - Limited financial support - Reduction of feed-in tariff - Limited resources - Planning restrictions - Regulations - Uncertainty in farming – Brexit - Deployment rates	- Balance different diversification projects - Continuous learning in farming - Innovation in farming - Keep up with changes in farming - Farm management important to renewables - Renewables need to be self-sufficient - Not all methods suitable to all farms - Off-farm income compensate for difficult periods - Timing of investment important

4.2.1. Resources

Respondents acknowledge the abundance of natural resources that exist in Wales provides opportunities for farmers to diversify into renewable energy, however, the type of renewable energy adoption varies according to the specific conditions of the farm. Hydroelectric is seen as a desirable energy source due to potential high returns, however, this is dependent on suitable water flow levels. Several respondents have installed solar panels or wind turbines on their farms, which are suited to farm locations. Wind turbines can be accommodated on farm land, with the rooves of farm buildings suited for the positioning of solar panels. Not

only do farm resources provide opportunities for renewable energy adoption, other forms of diversification are also recognised, including tourism, food production, horticulture, or alternative farming activities, such as poultry. According to respondent G, *"I think it's really important to maximise the farm's potential. Every farm has got different aspects which can be utilised"*. Respondents documented that the resource availability reduced their perceived risk in adopting in renewables, which represents a considerable investment for farmers. However, it is also recognised that support is essential in guiding farmers to invest in renewables, particularly financial resources, time and business advice.

4.2.2. Opportunities

As mentioned above, respondents acknowledged that natural resources provide farmers with opportunities for farm diversification, especially in renewable energy, but also tourism or alternative farming activities. These opportunities were dependent on the location of the farm, as to whether certain forms of renewable energy production were viable, such as the placement of wind turbines, or access to water flow for hydroelectric. Respondents commented that the alternative activities were a vital source of income for the farm to compensate for difficult periods in farming, and the difficulty in making a comfortable living from farm activities alone. Off-farm diversification activities were seen as an important way of spreading the risk of farm activities, as this provided different income streams for the farm.

> "To make it a viable business you need income other than sheep. You could keep 500 sheep and you still wouldn't make a living. But then you've got tourism. And the other thing is renewable energy. Because we're by the sea I would've thought there's more wind here. That should justify the construction of a windmill." (Respondent B)

Respondents C and G identified income generated from renewable energy as being half of the total farm income. Significantly, for these respondents, renewable energy activities on the farm generate high profit margins, which adds to the appeal in investing in such activities. Indeed, respondents pointed to opportunities to use income generated from initial renewable energy adoption to invest further in renewable energy sources later. Additionally, the investments made into renewable energy sources were recognised as an opportunity to secure the long-term future of the farm for the future generations. Not only were the benefits of renewable energy seen in income generation, but investing in renewable energy sources was also recognised as an important means for the farm to reduce costs, as renewable energy was used to power farm activities, thus making the farm more efficient. Cost savings were observed in the short-term from reduced energy costs, but savings would increase in the long-term as farmers were able to pay back loans for their investment:

> "It's probably worth £20-25,000 a year to me in electric and oil savings at the moment. So yeah, it's probably worth it. The projects will eventually be worth about £125,000 a year to me." (Respondent F)

4.2.3. Drivers

A third theme from the interviews related to the drivers to adopting renewable energy as a source of off-farm income. Despite the opportunities identified above, respondents pointed to drivers which influenced the decision to invest in renewables. This included the viability of

the farm to generate income from renewable energy, which could be influenced by the scale of the farm. Renewable energy sources are seen to be attractive as the return on investment (ROI) is perceived to be favourable. Respondents pointed to incentives influencing their decision to invest, including subsidies, financial support, advice, and good feed-in tariffs. Despite this, it is recognised that the conditions have become less favourable in recent years, particularly reductions to the feed-in tariff, which has made investment in renewables less attractive. As such, respondents called for Government policy to support farmers to invest in renewables.

> "The number one thing was the feed in tariff at the time. They were just so good. That and the savings then that it gives you. The renewable industry would not have even got off its feet without the feed in tariff…The feed in tariff all finished on 31st March, so there's absolutely no incentive for anyone else to invest in it." (Respondent F)

4.2.4. Barriers

As discussed above, the reduction in the feed-in tariffs was identified by respondents as a current issue, which acts as a barrier to further investment in renewables, and indeed as a barrier to adoption. For respondents without renewable energy, the lack of viability was cited as the main reason for non-adoption. Other adoption barriers point to the cost of investment, financial risk, limited support, and limited awareness of where to get support. Farm conditions, such as an isolated location and limited connectivity also impact on the viability of a farm to generate sufficient income from renewables. External environment barriers include planning restrictions, such as for respondent C, whose farm is located in a national park, regulations, and uncertainty in the industry, particularly related to Brexit, which discourages farmers from investing. Additional barriers to further investment in renewables included farmers gaining access to the national grid, particularly due to the grid being at full capacity, limiting farmers' ability to feed energy into the grid.

> "Where we are there's quite stiff opposition to wind turbines and solar panels, and our grid connection is not sufficient to allow it. I don't think there's spare capacity left in the local grid anyway." (Respondent K)

4.2.5. Farm Activity

Additional responses from the interviews related to farm activity more broadly. Diversification, especially in renewable energy sources, was acknowledged as an integral part of farm activity at present, representing an important means of spreading the risk across a range of activities, as off-farm income can compensate for difficult periods in farming. However, it is recognised that not all farms are suited to diversification in renewables, as this depends on the farm size, location and resources.

> "If a farm of this size can't make it, there's not a lot of hope for 200-acre farms. And I think that we're strong enough to pass that. Smaller farms, like half the size, they're going to struggle." (Respondent A)

Given the level of investment, farms may consider other forms of diversification, such as tourism, food production, horticulture, or alternative means of farming. The timing of investment is important due to changing conditions in farming, including different levels of

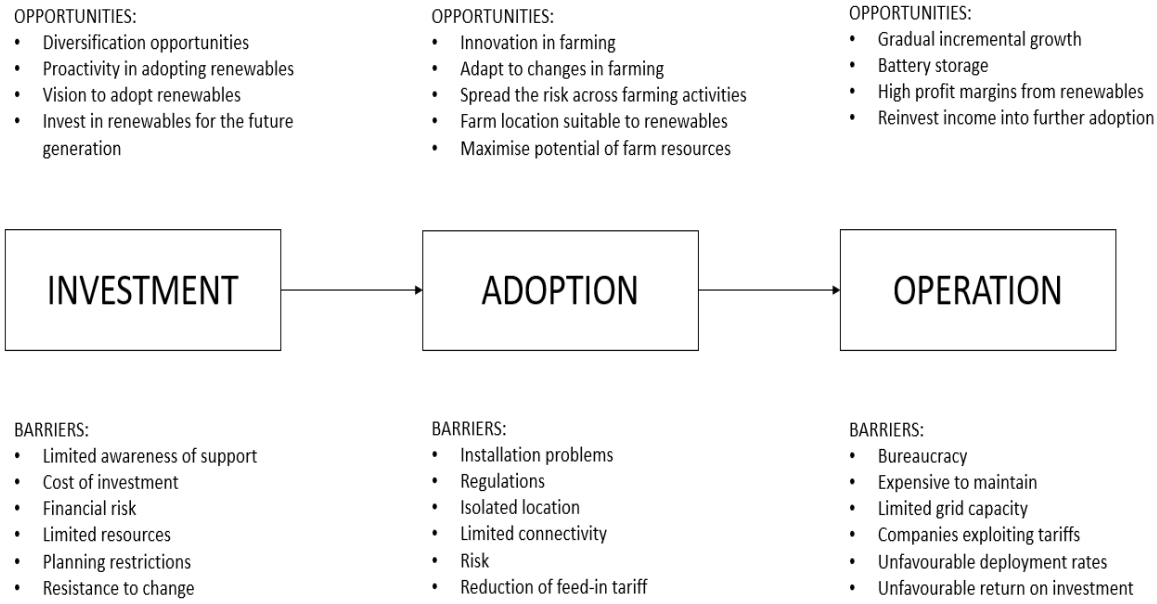
return from changing energy tariffs. Respondents pointed to investment in off-farm income as a means of long-term investment in the farm, which would serve for future generations, but also innovate the way the farm operated, as this involved investing in technology, such as respondent F, who invested in automation alongside renewable energy adoption. This represents the continuous development of the farm and seen as good farm management.

> "I wanted £100,000 a year of income off farm that we could do something else with, or if farming had a bad cycle, like it does, that it could basically prop the farm up. So that's my aim, anyway." (Respondent F)

4.2.6. Analysis of Interview Findings

The themes derived from the thematic analysis underline several opportunities and barriers that farmers face in relation to farm diversification, especially involving renewable energy sources. Figure 5 outlines the impact of these issues at different stages of the process of investing, adoption and operating renewable energy sources for farm diversification. Opportunities in the investment stage exist for diversification in different ways, dependent on the nature of the farm and its resources, however, this is also impacted by the vision and proactivity in seeking to adopt renewables for off-farm income. Barriers at this stage include limited support, limited resources, planning restrictions, high costs and risk, as well as farmers' resistance to change. Opportunities in the adoption phase point to farms making full use of its resources to innovate and adapt to changes in the industry. Diversification can also help spread the risk across a range of activities on the farm. Challenges exist through regulations, regulations, risk and issues relating to a farm's isolated location, such as limited connectivity. Once in operation, opportunities exist for farms to develop incremental growth. Respondents pointed to battery storage as a potentially profitable activity, as this would enable for energy developed through renewable sources to be stored and then fed into the national grid. Barriers exist at this stage, notably the cost of maintaining renewable activities, unfavourable return on investment and unfavourable deployment rates, depending on the type of renewable energy. Respondents also acknowledged restrictions in grid capacity limiting the opportunities for farmers to feed energy back into the grid. Additionally, respondents spoke of issues of companies exploiting opportunities in renewable energy, particularly when feed-in tariffs were high, which made it more difficult for individuals to invest in renewables.

Figure 5: Opportunities and barriers across all stages of renewable energy adoption



4.3. Cluster Analysis

A two-step cluster analysis was conducted in SPSS using survey data to investigate farmer typographies that could explain approaches to off-farm income. The two-step cluster analysis was chosen over alternative clustering methods since it does not require for the number of clusters needed to segment the sample to be specified in advance. This allows for the number and types of clusters to be explored through the clustering process. Ten variables observed in the questionnaire were used as inputs for the cluster analysis (Table 3), selected to represent characteristics of the farmer, the farm and its activity, which were consistent with findings expressed from the interviews. Alternative segment outcomes were explored, however, other solutions observed lower levels of cohesion, as the five cluster outcome obtained here displayed cluster sizes ranging from 18.6% (n=22) to 21.2% (n=25). The validity of the cluster analysis was supported using a chi-square analysis to indicate significant differences between the segments, as shown in Table 3. The work was informed by the segmentation research of Morris et al. (2017) which found the '*resource maximisers*', i.e. those engaged in off farm income activities and participating in environmental schemes as being the most likely to adopt renewable technology. Table 3 outlines the 5 clusters obtained from the analysis, with inputs listed in order of the predictor importance value, where farm size and off-farm income are listed as the most important outputs (1.0), and family the least important (0.05). For each input the most frequent category is listed, with the percentage of that category noted in brackets.

Findings show the main distinctions are observed between the inputs relating to off-farm income, farm size, education, age and renewables. Observations show three clusters with off-farm income, of which cluster 2 is the only one that possesses renewable energy sources. Clusters 3 and 4 have off-farm income but no access to renewable energy. This implies that members of this cluster recognise opportunities in diversification but have pursued alternative activities. This could indicate the potential for farms within these clusters to

pursue renewable energy activities in future. Reasons for non-adoption require further investigation however, could be a lack of access to suitable renewable energy sources, or limited infrastructure, which could be improved through national policies towards improving rural infrastructure. Two clusters operate without off-farm income, both of which have access to renewable energy sources. Cluster 1 is a mostly medium-sized upland cattle and sheep farm, whereas cluster 5 represents a mostly small lowland cattle and sheep farm. As both have access to renewables, diversification in renewable energy is a possibility, however reasons for non-adoption could be due to a lack of desire, particularly in the case of cluster 5, as this mostly represents farmers in the 65 and over age range who may be looking to retirement rather than investing in the farm. Although the least important input, family involvement is high in each cluster, which indicates that family help is necessary on all farm types.

Table 3: Cluster analysis

Inputs	**1**	**2**	**3**	**4**	**5**
Farm Size (1.00)* **	100.01-1000 hectares (66.7%)	50.01-100 hectares (36%)	100.01-1000 hectares (87.5%)	10.01-50 hectares (68.2%)	50.01-100 hectares (82.6%)
Off-farm Income (1.00)* **	No (91.7%)	Yes (100%)	Yes (62.5%)	Yes (100%)	No (56.5%)
Status (0.86)* **	Owner (79.2%)	Tenant (76%)	Owner (95.8%)	Owner (90.9%)	Owner (100%)
Education (0.66)* **	Further Education (79.2%)	Higher Education (56%)	Higher Education (66.7%)	Higher Education (54.5%)	School Only (52.2%)
Age (0.48)* **	55-64 (54.2%)	55-64 (40%)	55-64 (33.3%)	45-54 (54.5%)	65 and Over (52.2%)
Renewables (0.42)* **	Yes (79.2%)	Yes (76%)	No (70.8%)	No (72.7%)	Yes (78.3%)
Gender (0.28)* **	Male (75%)	Male (56%)	Male (91.7%)	Male (90.9%)	Male (100%)
Farm Type (0.19) **	Upland Cattle and Sheep (37.5%)	Upland Cattle and Sheep (40%)	Upland Cattle and Sheep (29.2%)	Hill Sheep (36.4%)	Lowland Cattle and Sheep (34.8%)
Experience (0.16) *	More than 20 years (100%)	More than 20 years (68%)	More than 20 years (70.8%)	More than 20 years (86.4%)	More than 20 years (91.3%)
Family (0.05)	Yes (87.5%)	Yes (76%)	Yes (83.3%)	Yes (63.6%)	Yes (65.2%)
Cluster Size	20.3%	21.2%	20.3%	18.6%	19.5%

****p<0.001, **p<0.01, *p<0.10 using chi-square tests*

Cluster 1 represents a large upland cattle and sheep farm with no diversification activities, but access to renewable energy. The farmer is experienced, aged 55-64, well-educated and owns the farm. The characteristics point to a farm more focussed on its core activity, aligning with the *Farm Focussed* typography expressed by Morris et al. (2017), where the business

focus is on utilising farm resources for income generation. Here, it is likely that renewable energy is generated as a means of reducing costs and operating more efficiently, rather than generating additional income for the farm. However, they possess resources to be able to generate income, which could support growth in the farm business. Strategies for this farm type could focus on developing diversified income streams through renewable energy, as the farm already possesses renewable energy sources. This would depend on the ability to expand on these existing resources, and whether suitable infrastructure is available, such as access to the national grid, or battery storage. Such farm types could be incentivised by government policy to expand upon these activities, notably through favourable feed-in tariffs. Cluster 2 is a medium-sized upland cattle and sheep farm with access to renewable energy and engaged in diversification. The farmer is a well-educated, experienced tenant in the 55-64 age category. This implies that the business is more aware of the need to engage in diversification activities, this may be due to limited financial resources as a tenant. The inclusion of renewable energy as part of diversification activities indicates an openness to innovation and technology adoption, which relates to the *Resource Maximiser* typography (Morris et al., 2017). This farm type could be an example to other local farms interested in exploring diversification opportunities through renewable energy. Indeed, such farms could play an integral role in community projects for producing renewable energy, such as Ynni Ogwen, a community social enterprise in the Ogwen Valley in North-West Wales, which produces electricity through hydroelectric power, with profits being transferred to a fund aimed to fund community projects (Partneriaeth Ogwen, 2020). Policies towards these farms should ensure that adequate infrastructure is in place to enable such farms to explore further growth in the renewable energy income streams, where possible.

Clusters 3 and 4 share similar characteristics. Both are involved in diversification activities but do not possess renewable energy sources. Farmers are well-educated and experienced farms owners. Both align with the *Lifestyle Farmer* typography (Morris et al., 2017) with their activities based on lifestyle choices, where innovation is low and diversification activities are aimed at reducing risk and supplementing income. Differences between both clusters are evident in the farm activity, size, and farmer age. Whereas cluster 3 represents a larger, upland farm with an older farmer, cluster 4 is a smaller, hill farm with a farmer aged 45-54. Although both clusters could look to adopt renewable energy production, cluster 3 may possess larger land resources for this, but lack a desire for innovation, whereas cluster 4 may be more constrained by its size, but possess a farmer more open to innovation. Thus distinctions could be classified between *open* and *closed lifestyle farmers*, referring to their attitude towards innovation. Both farms could be incentivised to seek to supplement their income through support to adopt renewable energy production, particularly financial support or favourable feed-in tariffs. It is possible that both farm types have decided against renewables adoption due to infrastructure constraints, such as limited grid capacity, therefore greater national investment in suitable infrastructure would improve the possibility of developing renewable energy production. Policies could seek to encourage higher levels of innovation within both farm types, especially cluster 4, where the farmer tends to younger than in cluster 3. This could be achieved through improving access to professional development and developing skills among farmers, as advocated by Morris et al. (2017).

Finally, Cluster 5 represents a medium lowland cattle and sheep farm with renewable energy access, but no diversification activities. The farmer is less educated, in the 65 and over age category and owns the farm. These characteristics point to a farm that has maintained consistent activity over many years, keeping a focus on the farm rather than seeking to engage in off-farm income activities, possibly as the farmer is heading towards retirement. This aligns with the *Passive Farmer* typography of Morris et al. (2017), with renewable energy likely being produced to cover energy costs on the farm, although there is potential that this could lead to income generation. Such farms display opportunities for growth, which could largely be constrained by a lack of desire from the farmer. Successors on the farm should thus be made aware of the growth potential and provided with suitable support in seeking to pursue these opportunities. This could be evident through financial incentives, and mentoring, especially where younger inexperienced farmers take over the management of the farm and may be more risk averse.

5. Discussion

Farming and the rural economy have experienced increasingly difficult periods in recent years (Marsden and Sonnino, 2008; Winter and Lobley, 2009; Marsden, 2016), with further uncertainty evident from Brexit (Morris et al., 2017) and the 2020 Coronavirus pandemic. As such, it is increasingly seen as essential for farms to diversify their activities to account for such downturns and enable resilient farm business models. These factors coincide with a period of increased focus on sustainability, following discussions and recognition of a climate emergency. Given the natural resources available in rural areas, such as Wales, there is an opportunity for farmers to explore diversified activities, such as tourism, food production, or renewable energy production. Considering theoretical underpinnings of the Resource-based View, the unique natural resources found in many rural areas offer rural businesses an opportunity to develop resilience and competitive advantage through the exploitation of such resources, which are valuable, rare, inimitable and non-substitutable to their specific place (Barney, 1991). Respondents to this study pointed to diversification activities as an important way to spread the risk of farming across a range of activities. Therefore, the exploitation of natural resources to produce renewable energy offers farmers an opportunity to develop new business activities on the farm.

Given the passive tendencies farm businesses show towards adopting change (Bowen and Morris, 2019), support is necessary in assisting farmers to capitalise on the opportunities from renewable energy. Respondents engaged in renewable energy spoke positively of Government incentives in facilitating the adoption of renewable energy sources on the farm, however, the reduction of the feed-in tariffs was cited as a barrier to adoption, as investment in renewable energy sources has become less attractive as a consequence. The scale of investment in several forms of renewable energy is significant for farmers, especially considering the uncertainty in the industry, therefore a reduction in the perceived risk is essential in encouraging farmers to invest. Some respondents acknowledged that this investment was not only a short-term benefit to the farm, but also a legacy for the future generations. Findings in Figure 5 outline opportunities and barriers along the process of renewable energy production, from investment to operation, highlighting the need for

Government policy to align better with farmers' needs on this matter, particularly in supporting investment through financial support and less restrictive planning regulations; encouraging adoption through improving connectivity and re-introducing favourable feed-in tariffs; and optimising operations through improved grid capacity and battery storage facilities.

In recent times there has been an increasing emphasis on developing sustainability particularly in light of discussions around the climate emergency. Renewable energy represents an important part of this, and the European Union has set a target of achieving 32% of consumed energy from renewable sources by 2030 (European Commission, 2020). Findings from the cluster analysis show that many types of rural businesses possess opportunities to diversify, and are presently involved in off-farm income activities. Clusters 2, 3 and 4 operate with off-farm income, but only cluster 2 also possesses renewable energy sources. However, findings imply that rural business also possess opportunities to adopt renewable energy sources, as clusters 1 and 5 possess renewable energy sources despite not currently engaged in off-farm income activities. Suitable support programmes could encourage rural businesses to seek off-farm income opportunities, particularly in adopting renewable energy sources, however, this is dependent on favourable conditions, as shown in Figure 5.

Findings imply that farmers display some entrepreneurial activity by engaging in off-farm income, however there is limited evidence of farmers exploiting the opportunities for off-farm income through renewable energy. This could be explained by farmers' passive tendencies to change (Bowen and Morris, 2019), as the perceived risk of investing in renewable energy sources may be too great; or by limited support for farmers in these activities, including a lack of incentives, or inadequate infrastructure. As such, rural policies should look to overcome these challenges, by encouraging more proactivity to change, providing financial support or incentives, such as favourable feed-in tariffs, and ensuring adequate infrastructure is in place. The sudden loss of activities experienced by many businesses during the 2020 Coronavirus pandemic underlines the precarity that many businesses face, thus diversification provides opportunities to spread the business risk across a variety of activities. Indeed, as an essential commodity, energy provides opportunities for diversification in an industry that is likely to be impacted by sudden economic changes in future, particularly renewable energy, due to an increasing emphasis on the climate.

The cluster analysis of this study underlines the differing opportunities and challenges that farms face in diversifying through renewable energy, according to their situation. The farm segments developed from this analysis align with the 4 farm types developed by Morris et al. (2017), while also shedding further light on distinctions that could be observed within one of these types, the *lifestyle farmer*, with this study identifying two clusters that equate to this type, where differences exist in *open* and *closed* attitudes to innovation. The clusters developed within this study point to the need for specific policies to be tailored towards the farm type. Farms in the *farm focussed* type could be incentivised to seek growth through diversification into renewable energy, particularly through favourable feed-in tariffs, and access to suitable infrastructure. *Resource maximiser* types could be encouraged to pursue

further growth, and to support community renewable energy generation projects. Policies towards lifestyle farmer types could encourage farmers to engage in more innovative practice, and promote skills development, particularly among younger farmers to ensure a longer-term vision for farm activities. *Passive farmers* should also be encouraged and supported to explore new opportunities through diversification, notably through financial incentives, as well as mentoring for younger generations of farmers who may take over from elderly farm managers. Government policies in different places could also account for location-specific factors that may impact on farm diversification, such as the natural resources observed in Wales, which present opportunities for engaging with renewable energy.

6. Conclusion

The research presented in this paper finds a desire among Welsh farmers to seek off-farm income opportunities to supplement farm income. The quantitative findings highlight that farmers are engaged in a range of diversification activities. However, despite recognition of diversification opportunities from renewable energy, this form of diversification only represents 11.76% of diversification activities within the sample. Whilst there is an existence of resources and opportunities to diversify into renewable energy, barriers to implementation exists. These are associated with an increased reliance on support, such as access to finance, favourable feed-in tariffs and less restrictive planning regulations. Previous studies (Bowen and Morris, 2019; Gittins et al. 2020) highlight that farmers have a reactive attitude towards technology adoption, hence government intervention in providing incentives to adoption is necessary.

Following empirical research among Welsh farmers, the contribution of the paper is to propose a sophisticated clustering of farm businesses in terms of strategies adopted. Findings show the main distinctions are observed between the inputs relating to off-farm income, farm size, education, age and renewables. Observations find three clusters with off-farm income, of which cluster 2 is the only one that possesses renewable energy sources. This categorisation identifies variation in a number of distinguishing characteristics of Welsh farmers. The findings lead to the segmentation of farmers which allow for distinctions to be made of different attitudes to diversification and the adoption of renewable energy sources, resulting in a better understanding of environmental entrepreneurship and targeted policies.

Overall findings highlight farmers' ability and willingness to diversify despite significant challenges facing the rural economy. It must be noted that despite access to natural resources such as wind and water, not all farms are suited to renewable energy generation due to location, environmental or infrastructure restrictions.

The research highlights that greater support for farm businesses and further investment in national infrastructure would enable farm diversification into renewable energy. Findings underline opportunities in Wales to exploit the natural resources available and enhance farm household with an increasing emphasis on the environment and sustainability, there is justification for investing in renewable energy sources to ensure a greener and future, whilst supporting more efficient and sustainable farming activity. As key actors within local rural

communities, farmers could play a significant role in renewable community projects by sharing resources, notably land. .

Implications of the research are evident for both practice and policy. The data in Figure 5 informs the farming industry of opportunities and barriers to diversification into renewable energy across all stages of the investment, adoption and operation process. In terms of policy, the research informs Welsh Government of the importance of renewable energy to the rural economy and how natural resources in rural spaces in Wales could be harnessed for environmental entrepreneurship. Additionally, research findings provide evidence for government in supporting farmers to diversify, and influence policies towards facilitating the increase in renewable energy generation. There is a requirement to amend planning, regulatory and infrastructure policies, which the qualitative data highlights as being restrictive. Consequently, the research can also inform government in supporting the development of sustainable energy companies by utilising natural resources in rural places. In terms of renewable energy generation rural areas in Wales have lost the opportunity to capture the value from large-scale projects and facilitating value. More often than not, more value is added outside Wales than inside. Therefore, the

The Covid-19 pandemic has had major economic and social implications, while the rural economy has not been exempt from these impacts and has accelerated technology adoption. However, Brexit will likely pose a greater threat to Welsh agriculture than the Covid-19 pandemic and as such diversification into the renewable energy sector may provide a more robust and resilient business model. The work has wider implications beyond Wales in informing rural locations and governments in terms of the role of renewable energy generation in supporting rural economies, underlining the need for substantial investment in infrastructure of rural regions to embrace environmental entrepreneurship opportunities.

References

Armstrong, E., 2016. Research briefing: The farming sector in Wales. National Assembly of Wales. URL: http://www.assembly.wales/research%20documents/16-053-farming-sector-in-wales/16-053-web-english2.pdf (Accessed 15/08/2017).

Bacher, J., Wenzig, K., & Vogler, M., 2004. SPSS Two Step Cluster - a first evaluation Berlin, DE: Lehrstuhl für Soziologie, 578-588.

Barnes, A., Thomson, S. and Ferreira, J., 2018. Disadvantage and Economic Viability: Evidence from Scottish Upland Farming (No. 2038-2018-2969).

Barney, J., 1991. Firm resources and sustained competitive advantage. *Journal of Management*, *17*(1), 99-120.

Bauwens, T., 2016. Explaining the diversity of motivations behind community renewable energy. *Energy Policy*, *93*, 278-290.

Boere, E., van Kooten, G.C., 2015. Reforming the Common Agricultural Policy: Decoupling agricultural payments from production and promoting the environment. Working Paper 2015-01. REPA Research Group, Department of Economics University of Victoria.

Bowen, R., & Morris, W., 2019. The digital divide: Implications for agribusiness and entrepreneurship. Lessons from Wales. *Journal of Rural Studies*, 72, pp.75-84.

Brandth, B., Haugen, M.S., 2011. Farm diversification into tourism - implications for social identity? *Journal of Rural Studies* 27, pp. 35-44.

Braun, V. and Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.

Cato, M.S., Arthur, L., Keenoy, T. and Smith, R., 2008. Entrepreneurial energy: associative entrepreneurship in the renewable energy sector in Wales. *International Journal of Entrepreneurial Behavior & Research*, 14(5), pp.313-329.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and Conducting Mixed Methods Research*. SAGE Publications.

Downey, H., Threlkeld, G. and Warburton, J., 2017. What is the role of place identity in older farming couples' retirement considerations? *Journal of Rural Studies* 50, 1-11.

European Commission, 2020. Renewable energy directive. URL: https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive/overview#national-action-plans-and-progress-reports. (Accessed 07/01/2020).

Francis, J. J., Johnston, M., Robertson, C., Glidewell, L., Entwistle, V., Eccles, M. P., & Grimshaw, J. M., 2010. What is an adequate sample size? Operationalising data saturation for theory-based interview studies. *Psychology & Health* 25, 1229–1245.

Ge, J., Sutherland, L.A., Polhill, J.G., Matthews, K., Miller, D. and Wardell-Johnson, D., 2017. Exploring factors affecting on-farm renewable energy adoption in Scotland using large-scale microdata. *Energy Policy*, *107*, 548-560.

Gittins, P., McElwee, G. and Tipi, N., 2020. Discrete event simulation in livestock management. *Journal of Rural Studies,* 78, 387-398.

House of Commons, 2011. Environment, Food and Rural Affairs Committee. Farming in the Uplands. Third Report of Session 2010–11, Vol 1. URL: https://publications.parliament.uk/pa/cm201011/cmselect/cmenvfru/556/556.pdf. (Accessed 30/11/2018).

Leck, C., Evans, N. and Upton, D., 2014. Agriculture - Who cares? An investigation of 'care farming' in the UK. *Journal of Rural Studies* 34, 313-325.

Loizou, E., Karelakis, C., Galanopoulos, K. and Mattas, K., 2019. The role of agriculture as a development tool for a regional economy. *Agricultural Systems*, 173, 482-490.

Marsden, T., 2016. Exploring the rural eco-economy: beyond neoliberalism. *Sociologia Ruralis*, *56*(4), 597-615.

Marsden, T. and Sonnino R., 2008. Rural development and the regional state: Denying multifunctional agriculture in the UK. *Journal of Rural Studies* 24, 422-431.

McElwee, G. and Bosworth, G., 2010. Exploring the strategic skills of farmers across a typology of farm diversification approaches. *Journal of Farm Management*, 13(12), 819-838.

McFadden, T., Gorman, M., 2016. Exploring the concept of farm household innovation capacity in relation to farm diversification in policy context. *Journal of Rural Studies* 46, 60-70.

Midmore, P., 2011. Food and the Economy in Wales. *Welsh Economic Review* 22, 29-31.

Miles, M. B., Huberman, A. M. and Saldaña, J., 2014. Qualitative Data Analysis. SAGE Publications, London.

Mooi, E., and Sarstedt, M. 2011. Cluster Analysis. Berlin, Springer.

Morris, W., 2018. Technology Adoption, Entrepreneurship and Efficiency in Agricultural Businesses: The Case of Upland Sheep Farmers in Wales. PhD Theses, Aberystwyth University.

Morris, W., Henley, A., Dowell, D., 2017. Farm diversification, entrepreneurship and technology adoption: Analysis of upland farmers in Wales. *Journal of Rural Studies* 53, 132-143.

Partneriaeth Ogwen, 2019. Ynni Ogwen. URL: https://www.ogwen.org/cy/cynaladwyedd/ynni-ogwen/ (Accessed 16/04/2020).

Pollock, C., 2012. Repairing a fractured pipeline: improving the effectiveness of agricultural R&D in the UK. *International Journal of Agricultural Management*, 2(1), 1-4.

Roberts, K., 2014. Review into the resilience of Welsh farming. Independent review, Welsh Government. URL: http://gov.wales/docs/drah/publications/140128-resilience-review-kevin-roberts-full-report-en.pdf. (Accessed 22/06/2016).

Suess-Reyes, J. and Fuetsch, E., 2016. The future of family farming: A literature review on innovative, sustainable and succession-oriented strategies. *Journal of Rural Studies* 47, 117-140.

Sutherland LA, Peter S, Zagata L., 2015. Conceptualising multi-regime interactions: The role of the agriculture sector in renewable energy transitions. *Research Policy*, 44(8), 1543-54.

Sutherland, L.A., Toma, L., Barnes, A.P., Matthews, K.B. and Hopkins, J., 2016. Agri-environmental diversification: Linking environmental, forestry and renewable energy engagement on Scottish farms. *Journal of Rural Studies*, 47, 10-20.

Vik, J and McElwee, G, 2011. Diversification and the Entrepreneurial Motivations of Farmers in Norway. *Journal of Small Business Management,* 49(3), 390-410.

Warren, M., 2004. Farmers online: drivers and impediments in adoption of Internet in UK agricultural businesses. *Journal of Small Business and Enterprise Development*, 11, 371-381.

Welsh Assembly Government, 2007. Rural Development Plan for Wales: 2007-2013. Cardiff: Welsh Assembly Government. URL: http://gov.wales/topics/environmentcountryside/farmingandcountryside/cap/ruraldevelopment/rural-development-plan-for-wales-2007/?lang=en. (Accessed 09/11/2016).

Welsh Government, 2013. Welsh Agricultural Statistics 2012 and 2013. Cardiff.

Welsh Government, 2014. Rural Development Programme: 2014-2020. Cardiff: Welsh Government. URL: http://gov.wales/topics/environmentcountryside/farmingandcountryside/cap/ruraldevelopment/wales-rural-development-programme-2014-2020/?lang=en. (Accessed 28/01/2018).

Welsh Government, 2017a. Prosperity for All: economic action plan. Cardiff: Welsh Government. URL: http://gov.wales/topics/businessandeconomy/welsh-economy/economic-action-plan/?lang=en. (Accessed 12/12/2017).

Welsh Government, 2017b. Energy Generation in Wales 2017. Cardiff: Welsh Government. URL: https://gweddill.gov.wales/docs/desh/publications/181212-energy-generation-in-wales-2017-en.pdf. (Accessed 01/07/2019).

Winter M and Lobley M (Eds.), 2009. What is Land For? The Food, Fuel and Climate Change Debate. Earthscan, London.

Yin, R.K., 1989. Case Study Research: Design and methods. Sage Publications, Newbury Park, CA, revised edition.