FARMERS' RESILIENCE TO CLIMATE CHANGE IN THE WELSH MARCHES

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ABSTRACT

Climate change will exacerbate challenges facing food security in the UK. Increasing frequency and intensity of extreme weather events will further impact upon farm systems. At the heart of the impending challenges to UK agricultural production, farmers' resilience will be tested to new limits. Research into farmers' resilience to climate change in the UK is distinctly underdeveloped when compared to research in developing and other developed nations. This research gap is addressed through exploration of farmers' resilience in the Welsh Marches, establishing the role of risk perceptions, local knowledge and adaptive capacity in farmers' decision-making to limit climate shocks. Further contributions to agricultural geography are made through experimentation of a 'cultural-behavioural approach', seeking to revisit the behavioural approach in view of the cultural-turn.

The Welsh Marches, situated on the English-Welsh border, has been selected as a focal point due to its agricultural diversity, and known experiences of extreme weather events. A phased mixed methodological approach is adopted. Phase one explores recorded and reported experiences of past extreme weather events in local meteorological records and local newspaper articles. Phase two consists of 115 survey-questionnaires, 15 in-depth semi-structured interviews, and a scenario based focus group with selected farmers from the Welsh Marches. This allows farmers' resilience to climate change in the past, present and future to be explored.

Original contributions to knowledge are made through demonstrating the value of focusing upon the culture of a specific farm community, applying a 'bottom-up' approach. The priority given to the weather in farmers' decision-making is identified to be determined by individual relationships that farmers' develop with the weather. Yet, a consensus of farmers' observations has established recognition of considerable changes in the weather over the last 30 years, acknowledging more extremes and seasonal variations. In contrast, perceptions of future climate change are largely varied. Farmers are found to be disengaged with the communication of climate change science, as the global impacts portrayed are distant in time and place from probable impacts that may be experienced locally.

Current communication of climate change information has been identified to alienate farmers from the local reality of probable future impacts. Adaptation options and

responses to extreme weather and climate change are identified from measures found to be already implemented and considered for the future.

A greater need to explore local knowledge and risk perception in relation to farmers' understanding of future climate challenges is clear. There is a need to conduct comparable research in different farm communities across the UK. Progression into establishing the role of farmers' resilience in responding effectively to future climate challenges has only just begun.

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"If you want to see the sunshine, you have to weather the storm"
Frank Lane (n.d.)

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ABBREVIATIONS

CAP	Common Agricultural Policy
CCM	Constant Comparison Method (of analysis)
CO2	Carbon Dioxide
COIN	Climate Outreach Information Network
Defra	Department for Environment, Food and Rural Affairs
DFID	Department for International Development
EU	European Union
EWEs	Extreme Weather Events
GM	Genetically Modified
GHGs	Greenhouse Gases
IK	Indigenous Knowledge
IKT	Indigenous Knowledge Transfer
IPCC	Intergovernmental Panel on Climate Change
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
SL	Sustainable Livelihoods
SRES	Special Report on Emissions Scenarios
TPB	Theory of Planned Behaviour
UKCIP	United Kingdom Climate Impacts Programme
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER ONE

THE CLIMATE CRISIS

"One problem facing humanity is now so urgent that unless it is resolved in the next two decades, it will destroy our global civilization, the climate crisis"

Dr Tim Flannery (2009)[1]

The recent emergence of concerns over global food security amplified by anticipated challenges of climate change, have led to new debates over the nature of future agricultural change (Ilbery and Maye 2010, Maye and Kirwan 2013, Evans 2013). It is 95% certain that climate change through anthropogenic forces has significantly altered the Earth's climate over the past century (IPCC 2013), exacerbating key challenges facing the UK agriculture sector (Defra 2012b). Observations indicate that temperatures at the earth's surface have risen globally, with the average combined land and ocean surface temperature increasing by 0.85°C between 1880 and 2012 (IPCC 2013, 20). Against the backdrop of average climate change trends, the impacts upon social-ecological systems, including farming, are considerably amplified with the emergence of greater extremes (Tate *et al.* 2010).

This thesis will endeavour to contribute to the rapidly advancing body of climate change research in the social sciences, through exploration of potential impacts and responses to the impending climate challenge upon farmers in the Welsh Marches. This will allow farmers' resilience to be investigated within the context of the UK, using an agricultural geography perspective to readdress its underrepresentation in the rapidly advancing body of research exploring the impacts of future climate change. Such a perspective places the views and knowledge of farmers who live and work in the land at the centre of analysis. This chapter will introduce the purpose of this research and the subsequent concepts discussed throughout this thesis. The aims and objectives of this thesis will be outlined in view of the research problem (1.1). This will be followed by definitions and outlines of the integral concepts to this thesis through defining climate change (1.2), and farmers' resilience (1.3). The background of the Welsh Marches and its selection as a research area will then be

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[1] In: Flannery, T. (2009) *Now or Never: Why we must Act Now to End Climate Change and Create a Sustainable Future.* New York, Atlantic Monthly Press, p14.

discussed, in view of the suitability of this area as a case study location (1.4). Lastly, a summary of the thesis will be provided, outlining the content of each chapter to signpost the reader to the debates and findings discussed within this thesis to explore farmers' resilience to climate change in the Welsh Marches (1.5).

1.1 Aims and Objectives

The principal aim of this study is to examine farmers' resilience in the Welsh Marches to future climate change through exploration of the impacts incurred in past Extreme Weather Events (EWEs) and present farm pressures, in keeping with its distinct local farming culture. It will investigate risk perception based upon past events and responses to impacts caused by past EWEs, the role that changeable weather plays in farmers' daily decision-making, as well as farmers' perceptions of future climate change. It is intended that the outcomes of this research will make original contributions to knowledge through achieving the following objectives:

1. To investigate farmers' risk perceptions of EWEs, alongside farmers' vulnerability and resilience, as exposed in the scale and nature of previous impacts triggered by farm system shocks experienced in past EWEs, and the subsequent process of response and recovery.
2. To outline the context in which farm-decisions involving the weather are made in view of the complex demands on the farm system, and the associated priority and role of the weather in farmers' day-to-day decisions.
3. To explore farmers' interpretations of climate change, through outlining farmers' understanding and risk perceptions of weather variability, EWEs, long-term climatic conditions and future climate change.
4. To assess the adaptability of farmers to future climate change based upon farmers' adaptive capacity, as demonstrated in adaptive measures previously implemented in response to EWEs and potential future adaptations that have been planned or considered.
5. To determine the importance of local knowledge (non-scientific or lay knowledge) in the understanding of climate change impacts and long-term adaptations through exploration of responses to previous EWEs.

6. To open up new research possibilities focusing upon the potential future impacts of climate change upon UK farm communities from a locally specific, bottom-up approach.

To achieve these objectives, a conceptual framework will be devised. This will seek to readdress the philosophical underpinning of the behavioural approach in view of the cultural-turn. Therefore, the experimentation of a new 'cultural-behavioural' philosophical approach is anticipated to further advance the sub-field of agricultural geography. Each objective will be achieved by synthesising large bodies of literature on climate change and resilience from agricultural geography, as well as the application of relevant research from development geographies and risk management, bringing it into a UK agricultural geography context.

A substantial volume of original primary and secondary empirical research is required to complete this investigation and so will be discussed in light of evidence collected for this thesis. Traditionally, climate change impacts have been explored in a global context. A 'top-down' approach to research is often adopted, led by physical scientific investigations (IPCC 2013, 2007, Defra 2012, 2009), referring to global communities in the context of vulnerability and adaptation (IPCC 2014). However, criticisms of such an approach as identified in this thesis include the recognition of failures to identify specific, localised impacts and feasible responses in-keeping with the local culture of the affected community. Consequently, this research will strive to readdress such a balance by prioritising the local culture of farmers in the Welsh Marches through adopting a 'bottom-up' approach originating from research in development studies.

1.2 The Climate Challenge

A 'perfect storm' of an impending crisis of global food insecurity is on the horizon (Ambler-Edwards 2009, Foresight 2011a, and Marsden 2010a). Threats to future food security of the UK are identified to include: population growth, nutrition transition, energy, land, water availability and labour availability, all of which are likely to be significantly amplified by impending impacts of anthropogenic climate change (Ambler-Edwards 2009, Defra 2012b). Climate change is a fundamental pressure on the global food system, as it is predicted to magnify pre-existing global pressures faced by food producers (Ambler-Edwards *et al.* 2009, Foresight 2011a).

One manifestation of climate change comes through the increasing frequency and intensity of Extreme Weather Events (EWEs). EWEs have increased in occurrence in the UK since the 1950s (Defra 2012a, IPCC 2007, 2013) presenting a considerable challenge to farm systems. At the heart of this, an individual farmer's resilience will be tested to new extremes as they will need to have the capacity to withstand such system shocks on a more frequent and intense basis. This is evident in the likely increase in occurrence of heatwaves (IPCC 2013), alongside the frequency and intensity of heavy precipitation (IPCC 2013). Flooding is already a key concern, as major flood events have been experienced in parts of the UK, including the Welsh Marches in 2007, 2008 and 2014, have significantly affected farm communities (Defra 2009 and 2012a). From such events, it is apparent that EWEs have already exerted a notable impact upon UK agricultural production (Ambler-Edwards *et al.* 2009, Defra 2012a, Tate *et al.* 2010, IPCC 2014).

Extending beyond observed change, future climate change is thought to have the potential to disrupt farm systems outside of the range of disturbance already felt. UK Climate Change Projections, predicted under medium Greenhouse Gas (GHG) emission scenarios, indicate that central England temperatures will increase by 2°C – 6.4°C (2.1.2, Defra 2012a). It is highly probable that such change will be accompanied by a further increase in the frequency and intensity of EWEs throughout the 21st century (Defra 2012a, IPCC 2013). Therefore, it is necessary for farm systems to develop a large capacity to withstand future pressures and possible shocks brought about through increasingly erratic weather and climatic conditions. Lessons learnt from past and present responses to EWEs and climate pressures, can further understanding of future farm stresses likely to be faced in the immediate and distant future.

Contemporary debates in agricultural geography have slowly emerged in light of the 'cultural turn' in human geography (Morris and Evans 2004). Such subjects of enquiry have started to allow agricultural geographers to adopt a holistic approach to investigate the cultural barriers and influences of farmers' perceptions, attitudes and decision-making alongside socio-economic considerations. Such explorations have been demonstrated in four prominent debates in agricultural geography in consideration of key challenges to UK farm systems. Firstly, agricultural geographers are concerned with the emergence of 'neo-productivism' (2.2, Evans *et al.* 2002, Evans 2013, Morris and Winter 1999). Secondly, research has centred on the survival of the UK family farm (Lobley *et al.* 2012, Potter and Lobley 1992, Price and Evans 2009). Thirdly, agricultural geographers have explored farmers' ability to conserve the environment whilst maintaining high levels of production (Burton *et al.* 2008, Morris and Potter 1995, Wilson and Hart 2001). Fourthly, the adoption of technology has been of current interest to agricultural geographers, explored in view of the cultural-turn (Burgess and Morris 2009).

Pressures on the farm system as explored in the debates above are likely to be further exacerbated when the full impacts of future climate change bites (2.2, Ambler-Edwards *et al.* 2009, Foresight 2011a). Hence, a need to build upon such knowledge from agricultural geographers in view of the climate crisis is paramount to establish the impacts of climate exacerbation of the aforementioned pre-existing pressures. The contemporary debates above demonstrate that it is no longer deemed suitable to provide technological solutions to problems on the ground in a 'one-size fits all' approach to farm adoption of technological 'solutions'. Indeed, such a resolution of reliance upon technology has seemingly eroded traditional resilience, failing to empower farming communities to explore their adjustment options, increasing communities' exposure to risk (Beck 2000).

A body of literature has initiated the exploration of climate change pressures upon agriculture (2.4, Holloway and Ilbery 1996a, 1996b and 1997, Smit *et al.* 2000, Smithers and Smit 1997). However, such work needs to be revisited in respect of the 'cultural turn' in agricultural geography (3.2). By adopting a cultural approach in view of contemporary debates in agricultural geography, farm decisions in response to climate change can be understood in view of the complex environment in which they are made. Comparative research has been conducted in the developing world, allowing for farmers' understanding and adaptations to climate change to be explored in the context of the community and circumstances in which they are derived (2.3, Adger 2000, Adger *et al.* 2005, Chambers 1989, Mertz *et al.* 2009, Tall *et al.* 2014). Accordingly, a need to apply lessons learnt from the rapidly advancing research from the developing world, to the context of the increasing pressures in the UK, bridging the gap between the sub-disciplines, is prevalent (2.3 and 2.4).

1.3 Defining Resilience

In order to interpret such challenges, the concept of resilience needs to be introduced in view of its application in exploring climate change impacts. Farmers are a crucial group at the interface of the changing relationship between the environment and human society (Lobley *et al.* 2012). Farmers are vulnerable to increasing challenges, but are considered to be well positioned to possess a highly informed and rich understanding of the climate based on a wealth of experiences, and the considerable role of the weather in day-to-day operations. By utilising a risk paradigm building upon Beck's (2000) work on 'a risk society', the vulnerabilities and resilience of a group can be established to indicate the scale of possible impacts. The core elements of a risk centred approach will be defined in turn in relation to investigating farmers' resilience to climate change.

Resilient communities are less vulnerable to hazards (Cutter *et al.* 2008). Such an observation is particularly pertinent to farming communities in the UK. The full weight of the exogenous shock of climate change is yet to be felt. However, there are existing indications of the need for more resilient farming communities to meet the unprecedented challenge of climate change. Agricultural systems are recognised as continually evolving, thus farming communities possess a strong tradition in building resilience through strengthening adaptive capacity primarily driven by the adoption of technology (Bowler 1985, Evans *et al.* 2002). Yet, increased technological dependence has done little to reduce farm system vulnerability to risk (Beck 2000, Evans 2013).

In addition to the concept of resilience, the essential components of vulnerability, coping capacity, social capital and adaptive capacity, must be understood in context of UK agriculture to establish farmers' resilience. Recently, resilience thinking has emerged as a conceptual approach to exploring changes in response to system shocks and processes in social-ecological systems (Folke *et al.* 2010). The concepts of resilience, vulnerability, coping capacity, social capital and adaptive capacity will be introduced in this section in relation to the farm-system. The core principle of resilience thinking will then be explored in depth in view of its conceptual framework and evolution as a concept in 3.4.

General resilience is associated with coping with uncertainty in all ways, increasing the threshold of the shocks that the system can endure (Folke *et al.* 2010). In its simplest form, resilience is defined in the context of socio-ecological systems as:

> *"The capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks and identity"* (Walker *et al.* 2006, 2).

Comparably, Comfort *et al.* (2001) envisage resilience as a flexible response to a threat that can demonstrate an ability to 'bounce back' after a system shock. Cutter *et al.* (2008) express this in defining resilience as the ability of a social system to respond to, and recover from disasters. It includes those inherent conditions that allow the system to absorb impacts and cope with events, as well as post-event adaptive processes that facilitate the ability of the system to re-organise, change and learn in response to a threat (Cutter *et al.* 2008). Indeed, it is recognised in this thesis that, in respect of climate change and EWEs, a need to 'bounce forward' extending beyond the ability to 'bounce back' is required. Therefore, the term 'bounce-forward' has been coined in recognition of a need to re-adjust and adapt the affected system in response to exposed vulnerabilities, and will be used throughout this thesis accordingly (3.4, Figure 3.2).

Agricultural resilience comprises of three components: the amount of change a farming system can undergo whilst maintaining its functions and structures, the degree of self-organisation, and the capacity for adaptation and learning (Milestad and Darnhofer 2003). Darnhofer (2009) makes the distinction that resilience in farm systems does not involve the preservation of current activities, distinguishing farm systems from other social-ecological systems (supported by Sinclair *et al.* 2014). Instead, farming resilience is considered as:

> *"Farming resilience aims at the farm as a system, at preserving its functions, not at preserving individual production activities on the farm*" (Darnhofer 2009, 4).

Such an approach emphasises the dynamic concept of resilience in which constant change and evolution of a system's structures and functions takes place (discussed further in 3.4). This is particularly notable in family farms where the pressure to withstand shocks, and so to become resilient, is substantial. Agricultural systems in the UK are recognised as continually evolving with a strong tradition in strengthening a farm system's resilience (Bowler, 1985; Evans *et al.* 2002), through developing adaptive capacity to enable the system to 'bounce forward'. Farm resilience is considered as the ability of a farm system to undergo considerable shocks whilst maintaining its structures and functions to 'bounce forward' and adapt to exposed vulnerabilities to improve resilience to better withstand future shocks. Therefore, it is envisaged throughout this thesis that a 'resilient farmer' would embrace flexible responses to farm system shocks to reorganise the farm system, whilst possessing the ability to bounce forward, limiting future vulnerability (Building upon: Comfort *et al.* 2001, Cutter *et al.* 2008, Milestad and Darnhofer 2003, IPCC 2014).

The vulnerability of an agricultural system is dependent upon its exposure sensitivity to a hazard (Smit and Pilifosova 2003, Reidsma *et al.* 2010). As vulnerability and resilience are both dynamic processes, vulnerability is considered as the counter-part of resilience, mitigated by a system's ability to cope with shocks (Cutter *et al.* 2008). As such, a farmer considered to hold a high-level of resilience would be expected to display high-levels of coping capacity risk perception and adaptive capacity to a known risk.

Coping capacity lies in the trajectory between vulnerability and resilience (Lazarus 2011). Yohe and Tol (2002) perceive coping capacity as a range of circumstances within which the virtue of underlying resilience of the system is tested in its ability to cope and maintain existing structures and functions when a significant shock occurs. It is considered to vary dependent upon the community and location, influenced by demographic, social and economic characteristics (Lazarus 2011). As such, the ability of a farmer to cope with a shock is also dependent upon their social capital which is relied upon during an event to buffer adverse vulnerabilities exposed to risk.

Social capital defines trust, networks and value that people can draw upon in order to improve their livelihoods, resulting in positive outcomes (Putnam 1995). A social network is the pattern of friendship, advice, communication or support existing amongst members of a social system (Valente 1996). Such concepts allow for the norms of behaviour and trust to be analysed that are critical to understanding farmers' responses to risk and information provided to them (Fisher 2013a). Therefore, they are central to the functions of farmers, particularly the support that is required when the impacts of shock exceed an individual's capacity to cope (Curry and Fisher 2013, Fisher 2013a). The importance of social processes and circumstances to cope and adapt to increasing challenges are widely recognised in agricultural systems, playing a key role in enhancing resilience (Beck 2010, Moser 2010, Smithers and Smit 1997).

Hand-in-hand with resilience is the ability of farmers to adapt to changing risks and future challenges. The meaning of adaptation can be applied to social-ecological change in response to environmental change in a multiple of ways. In relation to environmental change adaptation is viewed as:

> *"A process of deliberate change in anticipation of or in reaction to external stimuli and stress"* (Nelson *et al.* 2007, 395).

Adaptation is a powerful option to reduce the negative impacts of climate change (Tol *et al.* 1998); however it is only possible with a high level of adaptive capacity. Thus, the adaptive capacity of an affected system enables appropriate responses to be made to uncertainty and change whilst taking advantage of opportunities for building resilience (Folke *et al.* 2002, Smit and Pilifosova 2003). Adaptive capacity is considered to reduce vulnerability through a system's ability to change, enabling appropriate adaptations to be implemented (Smit and Wandel 2006). It is context-specific and varies amongst individuals (Smit and Wandel 2006). Therefore, the role of adaptive capacity will become increasingly central to farmers as they are forced to adapt and respond to climate change in order to survive and thrive (Easterling 1996).

Risk perception also influences a farmer's resilience. Risk perception is often referred to as the process in which an individual evaluates their level of risk in view of the information they have received, observed and recalled (Solvic 2010). Risk perceptions are formed upon a judgement of new information and pre-conceived risk evaluations based upon prior knowledge (Johnson 1993). Attitudes and feelings of risk are intrinsic to risk perceptions

(Solvic *et al.* 2004), alongside place-identity (Cutter *et al.* 2008). A consideration and understanding of local knowledge and farmers' intrinsic knowledge of the land (Wynne 1992), provide an essential basis upon which risk perceptions are formed. The formation of a farmer's risk perception of climate change is envisaged to consist of not only information and knowledge, but also: memories, values, beliefs, attitudes to risk and farm priorities (Solvic *et al.* 2004, Solvic 2010). Thus, risk perception can only be evaluated through a cultural lens allowing for a holistic evaluation of a farmer's framing of information, built upon past experiences.

Each of the concepts defined above are inter-connected in determining the level of resilience that a farmer possesses to withstand potential climatic shocks that may be incurred. As such, the concepts of: vulnerability, coping capacity, social capital, adaptive capacity and risk perception will flow throughout this thesis to establish farmers' resilience to climate change in the Welsh Marches. Climate change as defined at the beginning of this chapter will be considered in terms of the 'near' and 'distant' future in relation to a farmer's working lifetime. This is contrary to climate change reports which often span across the 21st century up until 2100. To ensure relevance to present farm systems, this thesis will consider the 'near future' to be within 10 years up until 2023, and the distant future will be defined as 30 years in the future up until 2043[2]. Thus, the impacts considered throughout this period should theoretically be within the foreseeable future of a farm business.

1.4 The Welsh Marches

The adoption of a place-based approach to establish farmers' resilience is crucial to understanding local farming culture and experiences, in which risk perceptions and subsequent decision-making are anchored (Cutter *et al.* 2008). This permits the use of a culturally specific perspective to a local community. The Welsh Marches, situated on the English-Welsh border, has been selected as a location in which to situate this research. The Welsh Marches refers to the borderlands of England along the political boundary with Wales, comprising the administrative counties of: Cheshire, Shropshire, Herefordshire, Worcestershire and Gloucestershire (Rowley 1986, Evans, N 2009). Consisting of plain, upland and mountains, the Welsh Border landscapes is one of the most richly varied in Britain characterised by the dominance of rivers Severn, Wye and Teme (Rowley 1986).

[2] 2043 has been chosen as the upper limit of this thesis consideration of the 'distant future' as it is 30 years ahead of the time of data collection in 2013, therefore often still within a farm business plan for the future. IPCC (2013) and Defra (2009) also utilise a 30 year period to monitor periods of notable change in the climate system, allowing for comparisons with this study.

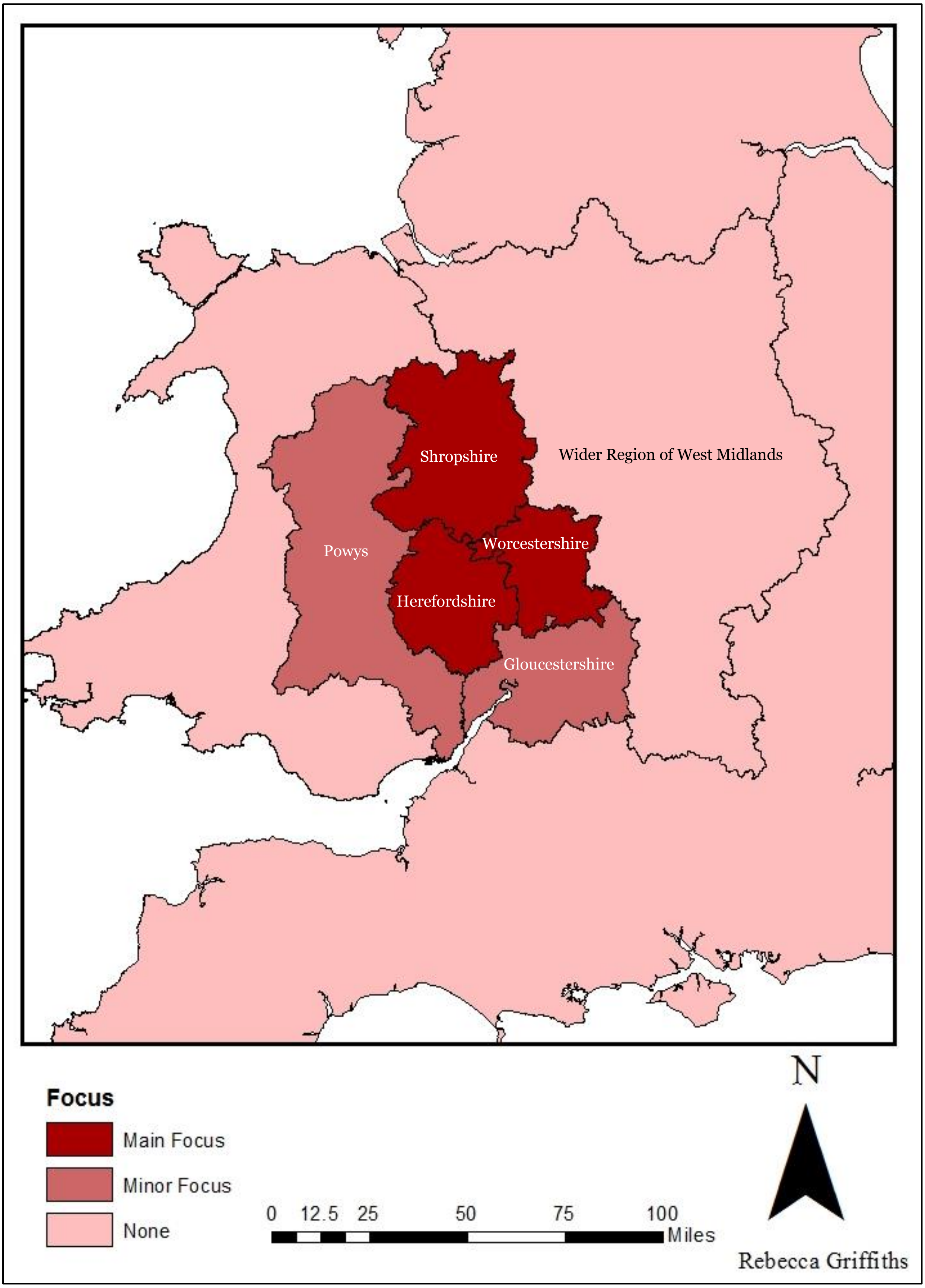
Traditionally, the Marchlands extend from the estuary of the River Dee, Cheshire in the north, to the Severn estuary, Gloucestershire in the South (Rowley 1986). This thesis will focus upon the central Marches consisting of Shropshire and Herefordshire, with the addition of Worcestershire due to its shared traits in landscapes and farming cultures, which collectively have a unique cultural history. This sub-section of the Welsh Marches has been selected primarily due to the history of EWEs and agricultural diversity throughout the three counties.

Figure 1.1 indicates the situation of the Welsh Marches, displaying Shropshire to the North, Herefordshire to the West and Worcestershire to the East. Figure 1.1 also indicates the marginal inclusion of some border farms on the Powys-Shropshire border, and on the Herefordshire-Gloucestershire border in data collection. This was deemed appropriate due to the synergies between the physical environment and climatic conditions expanding just beyond arbitrary administrative boundaries (4.5).

The central region of the Welsh Marches has been selected as the focal point for this research for two fundamental reasons: the frequency of EWEs that have been recorded, and the range of agricultural enterprises within the locality. Firstly, a considerable range of different EWEs have been experienced over the last 30 years (as evident in local meteorological records 4.1). EWEs frequently occur across the region, displaying different adverse conditions and associated impacts have triggered considerable shocks in local farm systems[3]. Such events experienced in the Welsh Marches within the last decade[4] include: heatwaves (2006), flash floods (2007 and 2008), prolonged rainfall (2012), heavy spring snowfall (2013) and prolonged flooding (2014). This has generated a rich evidence base from which the responses of the farming community to such system shock can be assessed, thus indicating farmers' resilience levels whilst exposing considerable vulnerabilities. Climate change is predicted to exacerbate the frequency and intensity of such EWEs, heightening the risk faced by farmers. From such experiences it is apparent that farmers across the region face increasing exposure to comparable events to those already experienced in the recent past. Therefore, farmers' responses to absorb such shocks in the Welsh Marches are increasingly important to ensure an overall high level of resilience to withstand a predicted growth in the frequency and intensity of future EWEs.

[3] Based upon observations and local meteorological records for each county in the Welsh Marches, interrogated in section 4.1
[4] The last decade as considered from the time of writing to be from 2004 to 2014.

Figure 1.1: the Welsh Marches Research Area



Secondly, this research seeks to build upon the expertise of the University of Worcester which has a long history of studying and documenting agricultural change in the Marches (Evans, N 2009). The region has a strong tradition of livestock production, particularly sheep in the east, beef in the west and dairying in the north (Evans, N 2009). There are also varied cropping systems including: wheat, potatoes, hops and horticulture (Evans, N 2009). Considerable diversity in agricultural production has evolved over time with contrasting landscapes of dairying, cropping and livestock (Evans, N 2009). All three counties have a strong tradition in livestock production and grassland systems (Evans, N 2009).

Considerable diversity in agricultural production has been under constant and intense pressure for agricultural change encouraged by the EU Common Agricultural Policy (CAP), encouraging farmers towards specialisation to grow more cereals at the expense of grassland (Evans, N 2009). Notably, a decline in apple production and hop farming (Ilbery 1982), allowed for intensive dairying, livestock and further specialisation in cereals to take place (Evans, N 2009). Such agricultural sectors have experienced dramatic swings in profitability over the last two decades (Evans, N 2009), increasing the necessity for farm businesses to adjust in order to survive. To the west, Herefordshire and Shropshire contain 'lagging regions' in view of the recognised difficulties of farming in these upland localities (Evans, N 2009, Saxena and Ilbery 2010). Increasing issues in this region include declining farm and allied trade incomes, coupled with decreasing rural employment opportunities (Saxena and Ilbery 2010).

Farm businesses within the region are dominated by family-based labour, which have a long history of diversification (Evans and Ilbery, 1992). The UK trend towards the industrialisation of agriculture is evident (Evans 2013), but the area is also noted for its adherence to traditional farming systems which contribute to areas of high nature-value (Evans, N 2009). As the farming region is known to embody a large proportion of family farms, it is of particular relevance to this research due to the perceived increase in farm vulnerability of family farms without large capitals underpinning such systems, increasing farm stresses (Price and Evans 2009). This is apparent in the more limited number of resources including financial, land and machinery that is often at the disposal of such farms. Therefore, a higher resilience to climate change is even more imperative to such farmers to preserve and enhance the farm system whilst remaining culturally intact.

The Welsh March farm community is characterised by the aforementioned attributes underpinned by a shared culture and history as the borderlands (Rowley 1986). Throughout this thesis the 'farm community' of the Welsh Marches is considered as an occupational community comprising localised farm networks within individual agricultural spaces across the Welsh Marches region. By envisaging the Welsh Marches' farm community as an extended region in which individual farmers possess common features, the type and severity of impacts of EWEs upon the farming community of the Welsh Marches can be investigated.

1.5 Thesis Overview

The aforementioned research aims and objectives will be accomplished throughout this thesis as each chapter will illustrate the delivery of these aims. The exploration of present concerns over climate change and UK food security will be anchored primarily upon farmers' resilience, vulnerability, coping capacity, adaptive capacity, social capital and risk perceptions (1.1).

This investigation will commence in chapter two through anchoring the research upon the body of previous academic and public sector research into this topic. A large body of literature will be reviewed in order to provide an agricultural geographical context of where this research lies. Primarily, the global challenge of climate change will be explored in consideration of international research exploring farmers' resilience to climate change. The research gap this work seeks to fill will then be defined in respect of limited research previously undertaken in the UK. Chapter three will then consider suitable theoretical underpinnings in relation to the research aims. Conceptual shifts in agricultural geography will be considered, with a particular focus on the behavioural approach combined with the more recent 'cultural turn' evident across the evolution of research in agricultural geography (Morris and Evans 2004). This chapter will respond to calls by Burton (2004b) that revisiting the behavioural approach is long overdue in respect of the cultural-turn. As such, a conceptual framework will be tailored specifically for this research resulting in the experimentation of what is referred to throughout this thesis as the 'cultural-behavioural approach.' Chapter four will then construct a suitable research design. The project's methodological approach will be outlined in terms of a series of research phases. The importance of qualitative and quantitative, as well as both primary and secondary data to ensure the holistic investigation exploring cultural-behavioural processes will be further justified.

Synthesising the core findings of data analysis, chapters five to seven will discuss in-depth the research findings of this investigation. A chronological framework will be adopted to allow the thematic discussion of such findings. Chapter five will explore past impacts and previous experiences of EWEs in the Welsh Marches. This will provide understanding of the background experiences that farmers draw upon to construct informed risk perceptions in view of present and future challenges. Chapter six will continue this theme, assessing farmers' present day decision-making context and daily challenges presented by the weather. The role the weather plays in farmers' lives will be explored in view of observations and use of weather forecasts. The chapter will then synthesise farmers' observations of changes in weather patterns over the last 30 years in association with concerns for future weather conditions. To complete the chronological discussion of results, Chapter seven will outline farmers' interpretations of climate change in the near and distant future. A disparity between farmers' understanding of the weather and climate will be explored in view of its influence upon farmers' risk perceptions. Adaptive measures found to have been adopted within the farm community will be outlined in relation to farmers' resilience to future climate change in the Welsh Marches.

Finally, Chapter eight will conclude this thesis by providing a synthesis of the key findings disclosed by this research with original contributions to be made in view of the findings illustrated in chapters' five to seven. The limitations of this research, alongside recommendations for further research will signpost directions for future investigations. The extent of farmers' resilience to climate change will be illustrated in respect of the expected climatic shocks to UK farm systems throughout the 21^{st} century.

CHAPTER TWO

THE GLOBAL CHALLENGE AND CONSEQUENCES FOR FARMERS IN THE UK

"Climate is what you expect; the weather is what you get"
Mark Twain (1887)[5]

In order to inform the context of this research investigating farmers' resilience to climate change in the Welsh Marches, a wide body of literature drawing upon a range of disciplines, needs to be examined. Firstly, this literature review begins by examining the key scientific theories, debates and projected change relevant to the potential impacts on UK agricultural systems. Secondly, the subject of food security will be examined in view of increasing pressures placed upon the food system, and the urgency to strengthen production. Thirdly, an increasing breadth of research investigating farming and climate change in developing countries is examined with the view to extract lessons learnt into a UK context. Fourthly, the notions of adaptation, resilience and vulnerability will be explored with the use of agricultural research from other developed countries. Finally, this literature review will focus upon a small body of literature exploring farmers' knowledge, perceptions and understanding of climate change in the UK. The synopsis of literature investigated in this review will then be summarised identifying key gaps in previous research, which are possible to take forward using the perspective of agricultural geography within a UK context, therefore informing the conceptual underpinning and methodological approach for this thesis.

2.1 Climate Change: The Physical Basis

Climate change through anthropogenic forces has significantly altered the Earth's climate over the past century (IPCC 2013)[6], exacerbating key challenges for global food production (1.2, Defra 2012b, IPCC 2014). Following on from the climate challenge outlined in chapter

[5] Twain, 1887. Published in Heinlein, R. (1973) *Time Enough for Love*. New York, Ace Books, p352
[6] To 95% certainty according to IPCC (2013, 15)

one, this section will further evaluate scientific understanding of climate change and the likely impacts felt in the UK. Such evidence will then be interpreted in view of the potential impacts on agriculture due to an identified deficiency of climate change literature from an agricultural geography perspective. This section will firstly clarify changes observed to date through the use of climatic records. Secondly, the notions associated with weather and climate will be defined in view of subsequent references throughout this thesis. Thirdly, projected change will then be discussed and analysed in view of the predicted impacts on UK agriculture.

2.1.1 Climate, Climate Change, Weather and EWEs

Unlike the weather which is something that can be experienced, climate is an artificial scientific construct (Qin *et al.* 2014). Therefore understanding of what is meant by climate can vary. 'Climate' is usually defined as:

> *"The average state of the localised[7] atmospheric system often given in a statistical description in terms of the mean and variability of relevant quantities over a period of time"* (Qin *et al.* 2014,5).

The most accepted period for averaging these variables is over 30 years (*Qin et al.* 2014, IPCC 2014). Therefore, the artificial construct of the 'climate' complicates the ability for lay understandings (COIN 2014).

In respect of this definition of climate, climate change is therefore defined as:

> *"A change in the state of the climate that can be identified by changes in the mean…for an extended period typically decades or longer. Climate change may be due to natural internal processes or external forcing's and persistent anthropogenic changes in the composition of the atmosphere"* (IPCC 2014, 1450).

The weather is defined in scientific terms as localised short-term variable atmospheric conditions which are forecast over short time-scales of less than 1-2 weeks (Diaz and Murnane 2008). The weather is something that is experienced on a daily basis allowing for perceptions to be formed based upon real experiences.

Providing a universal definition of a EWE is difficult as the properties and impacts are highly localised and continually changing (Stephenson 2011). Nevertheless, EWEs are usually considered as a rare event outside of the normal weather conditions, at a particular place and time of year (Qin *et al.* 2014, IPCC 2013). EWEs are unique to the place in which they occur,

[7] Localised to a specific location or region

dependent upon the normal conditions experienced in the local climate (Qin *et al.* 2014). Sometimes a distinction is made between EWEs and extreme climatic events, which is where a pattern of extreme weather is identified that persists for a prolonged period of time such as a drought (IPCC 2013). However, due to the range of different events and conditions that are experienced in the UK, such as heatwaves, droughts, rainfall, flooding, snowfall and storms, EWEs are referred to throughout this thesis as an umbrella term incorporating all of the above extreme conditions. Indeed, extremes are considered to be those conditions lying outside of 10th and 90th percentiles (Qin *et al.* 2014), and so forms a focus of this investigation due to the experiences brought about by such conditions and the influence upon risk perception. As a result of recent climate change[8], impacts have been observed on natural and human systems on all continents and across the oceans (IPCC 2014). Furthermore, impacts from recent EWEs show significant vulnerability and exposure of many human systems to climate variability (IPCC 2014).

2.1.2 Climate Projections

Human interference with the climate system is occurring (IPCC 2014). It is extremely likely that human influences have been the dominant cause of observed warming throughout the 20th century (IPCC 2013). The most widely used projections of global climate change are presented by IPCC (2000) Special Reports on Emissions Scenarios (SRES). The scenarios project the impacts of different economic, technological, population, globalisation and policy change in the 21st century. Variations are then explored in each scenario family, projecting estimated GHG emissions related to specific hypothesized temperature rises (IPCC 2000, IPCC 2013).

Global surface temperature change for the end of the 21st century is 'likely' (66-100% probability[9]), to exceed 1.5°C relative to pre-industrial temperatures of 1850-1900 (IPCC, 2013, 20). UK climate change projections under a medium GHG emissions scenario indicate that for the West Midlands region it is likely that there will be a mean increase in temperatures by 2-4°C (Defra 2012a, 12). This will be accompanied by a reduction in summer precipitation by 20-30%, and an increase in winter precipitation by 10-20% (to 90% certainty, Defra 2012a, 12). Notably, within all estimates warming will exhibit inter-annual to decadal variability, and will not be uniform (IPCC 2013). Consequently, such inter-variability may result in mean annual temperatures that are much larger than the averages

[8] Considered to be over the last 30 years in view of IPCC (2013)'s observations of recent warming across the globe.
[9] IPCC (2013, 36 Box TS.1) for Table of treatment of uncertainty for explanation of calibrated likelihood and probability levels.

predicted, in either direction (Defra 2012a, 13). As a result, this creates an increased challenge for community adaptation (IPCC 2014).

When interpreting future projections, it is essential to recognise that calculations of projected climate change are dependent on specific conditions of 'unknown likelihoods' (Defra 2012a, vi, IPCC 2013, 36). Significant unknowns remain in the uncertainty of future GHG emissions, as well as the significance of cooling effects of atmospheric pollutants. The limits of scientific knowledge remain in the importance of atmospheric and bio-physical processes, natural climate variability, and uncertainties in climate models and emission rates (Defra 2012a). Therefore, a wide range of conditions are encompassed in varying scenarios in IPCC (2013) and Defra (2009) projections, where no judgements of probability are made between each scenario considered under medium confidence (Defra 2009, IPCC 2013, Meehl *et al.* 2007, Murphy *et al.* 2009). IPCC (2014) evaluates how patterns of risks and potential benefits, shifting due to climate change will vary across regions and populations dependent upon a range of social-ecological factors (IPCC 2014). The findings of this have formed an essential basis of international and national policy targeted to mitigate GHG emissions which remains the focus of political debate (Adger *et al.* 2003, UNFCCC 2011).

Climate-related hazards, exposure and vulnerability interact to create risk (IPCC 2014). Accordingly, changes in both the climate and human systems including adaptation and mitigation are drivers of the scale of risk exposure, hazards and vulnerability (IPCC 2014). Climate projections incorporating both physical and societal changes in the international community, have formed the basis of the assessment of potential impacts, vulnerability and subsequent adaptations required to limit potential climate shocks incurred internationally (IPCC 2014).

Climate change will vary across regions and populations through geographical regions, depending upon multiple social-ecological factors (IPCC 2014). Therefore, national climate change impact assessments for the UK are necessary to inform further probable vulnerabilities to predicted risks (as provided in Defra 2012a and 2012b). However, within the UK large variations of risk vulnerability and resilience are apparent, therefore further estimates beyond such national and regional projections as provided in (Defra 2012a), are necessary to understand the specific risks faced by different communities and vulnerable groups. In response to the scientific understanding of physical climate change, international (IPCC 2014) and national (Defra 2009), adaptation plans and literature have been constructed to create broad top-down actions. The UK Climate Change Impacts Programme (UKCIP) is focused on building capacity to climate change by embedding it within a wide range of organisations, through supporting decision makers in their assessments of climate change adaptations (Defra 2009, Hedger *et al.* 2006).

2.1.3 Predicted impacts on UK Agriculture

The effects of climate change on crop production are already evident in several regions of the world (Porter *et al.* 2014). Negative impacts of climate change on food production have been more common than positive impacts (Porter *et al.* 2014). Grain quality, protein content and mineral concentration is adversely affected by elevated levels of carbon dioxide (Ainsworth and McGarth 2010). Globally, the most severe agricultural impacts are projected for lower latitudes (Meehl *et al.* 2007), yet Gosling *et al.* (2011) demonstrated that the severity of climatic effects on agricultural production in regions across the globe is significantly greater than that originally portrayed. Observations of existing effects of climate change on the UK agricultural system are already apparent (Defra 2012b); events such as the 2003 heatwaves across Europe, which are likely to increase in frequency, have already resulted in significant crop losses (Beniston and Diaz 2004, Defra 2012b).

Defra (2012b) provides the most holistic overview of climate change impacts on the UK agricultural sector to date. Within the report, Defra (2009) projections were interpreted from an agricultural standpoint recognising both opportunities and risks. Warmer temperatures may benefit crop growth by 2050, if water is not a limiting factor (Defra 2012b). Yield increases of wheat are projected from 40%-140%, sugar beet yields may increase by 20%-70% and grass yields are projected to increase by 20%-50%, stipulated under a 'medium confidence' climate model scenario (Defra 2012b). Furthermore, warmer temperatures are thought to allow production of new crops such as maize which is traditionally grown in warmer climates (Defra 2012b; Holloway and Ilbery 1996b).

The primary challenge to limit climate change impacts on agriculture is the decreasing availability of the water required to meet increased demand for crop irrigation (Defra 2012b). At the same time, increasing frequency of hazards, such as flooding is a future concern likely to cause short-term damage to crops (Defra 2012b). The risk of potential increases in drought, pests and disease by the 2080s should not be overlooked as a key agricultural concern in the UK (Defra 2012b). Yet, physical agricultural impacts are closely entwined with farmers' actions, understanding and priorities, which are overlooked by Defra (2012b), therefore this, will be discussed further in 2.2 and 2.5.

2.2. Food Security

Food security is a term that is extensively used by academics and policy makers to describe a desired state in which the considerable challenges of supply and demand faced by the global food system are overcome to meet the nutritional demand of the global population. Food security is defined by the UN Food and Agriculture Organisation (FAO) as:

> *"A situation that exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active healthy life"* (FAO 2003, 28, supported by Porter 2014, 490).

Without significant innovation and adaptation in capacities to produce, humanity faces a bleak and divided future in rising to the challenges of emerging demographic trends and patterns of economic development (Fish *et al.* 2013)**.** All aspects of food security are potentially affected by climate change, including food access, utilisation and price stability (Porter *et al.* 2014). There are increasing stresses on both the global and national food system that requires a response in agricultural production to continue to meet the needs of the population (Ambler-Edwards *et al.* 2009, Defra 2012b, Foresight 2011a).

Projected climate change presents a considerable challenge to the food system to ensure future food security (Foresight 2011a and 2011c, Porter *et al.* 2014). Regions close to the equator are likely to be most adversely affected by rising temperatures and lower precipitation, compromising their ability to main present levels of food production (IPCC 2014, Foresight 2011a, Porter *et al* . 2014). As a result, agriculture in more temperate regions such as the UK can be expected to compensate for this shortfall in production (Defra 2008, Fish *et al.* 2013). Thus, it is essential that the food security debate is analysed in relation to climate change to decipher likely impacts upon farmers in the UK.

2.2.1 Renaissance of a Food Security Focus

Global food systems are approaching a crossroads, resulting in a confluence of pressures in the 21st century (Ambler-Edwards 2009, Godfray *et al.* 2010 and Foresight 2011a). Hence, deep concerns are emerging over ensuring future global and national food security (Defra 2008, Horlings and Marsden 2011). There is substantial optimism that the necessary increases in food production required to enable food security can be achieved if the food system becomes more resilient, sustainable and equitable (Evans, A 2009). However, opinions vary over the best ways to address these challenges (Horlings and Marsden 2001, Marsden 2010a).

Farmers are generally very alert to the emerging contours of the wider food security debate (Fish *et al.* 2013). In the sample of farmers included in Fish *et al.* (2013)'s study, most farmers aligned themselves with the goal of increasing the productive capacity of UK land resources whilst asserting this concern in relation to sustainable land use, as it has become culturally ingrained following post-war production. However, differences between policy-makers' and farmers' values towards food security remain, as agricultural uses for land continue to be contested (Fish *et al.* 2013).

2.2.2 Reports on Food Security

Volatility in food prices between 2007 and 2009 (Dibden *et al.* 2013, Foresight 2011a) triggered UK food security concerns, resulting in Ambler-Edwards *et al.* (2009) and Foresight (2011a) to identify key pressures and stresses on future food security. A number of reports assessing the UK and global food security include: Defra (2008), Defra (2010b), (2010c) and Foresight (2011b). However, the nature of government reports presents issues surrounding researcher bias, as they are written to satisfy political agendas (Booker and North 2007). Marsden's (2010) critique of Defra (2010b) addresses the complexity of such strategies that focus on a global and long-term plan; stating that this encourages the delivery mechanism to be put off for another day in another place.

Table 2.1 Six Strategies of Food 2030

Six Strategies of Food 2030
1. Enabling and encouraging people to eat a healthy, sustainable diet 2. Ensuring a resilient, profitable and competitive food system 3. Increasing food production sustainably 4. Reducing the food system's greenhouse gas emissions 5. Reducing, reusing and reprocessing waste 6. Increasing the impact of skills, knowledge, research and technology

(Source: Defra 2010b, 7)

The cumulative result of such reports informed Defra's (2010b) plan to 'innovate' the food system by 2030. Defra's (2010b) ambitious target aims to protect food security and create a low carbon food system efficient in sustainable use of resources. The six-point strategy (Table 2.1) emphasises the continual cycle of ensuring a resilient, profitable, and competitive food system, with increased sustainable food production (Defra 2010b). Notably, the third and fourth targets to increase sustainability and reduce GHG emissions (Defra 2010b) are directly relevant to creating a resilient food system to climate change. Marsden (2010) denotes that the strategy does not sufficiently indicate or analytically distinguish what can be done in the UK, and what contributes to its global causes. Interestingly, Defra (2008) is the only official policy to have defined UK agriculture's role in terms of food production to meet rising demand elsewhere in view of the global climate challenge (Fish *et al.* 2013).

2.2.3 An Interdependency of Factors to Food Security

Six challenges to the global food process are detailed in Foresight (2011a) as: population increase, change in the size and nature of capita demand, future governance of the food system, climate change, competition for key resources, and changes in values and ethical stances of consumers. Foresight (2011a) theorise the food system as a partially self-organised collection of interacting parts, instead of a complex intertwined global system portrayed in the scenarios constructed in Ambler-Edwards *et al.* (2009), Defra (2010a) and Defra (2010b). Comparably, Ambler-Edwards *et al.* (2009) detail seven fundamental factors that are renewing pressures on the global food system as: population growth, the nutrition transition, energy, land, water, labour and climate change.

Ambler-Edwards *et al.* (2009), Defra (2008) and Foresight (2011a) all list energy and environmental pressures separately to climate change, ignoring the interdependency of the factors portrayed by Defra (2012a). Both Foresight (2011a) and Ambler-Edwards *et al.* (2009) list the 'stress' of climate change after more immediate and visible factors including population increase and rising food demand in developing nations. Furthermore, Ambler-Edwards *et al.* (2009) describe climate change as an important 'additional' stress, rather than a primary factor. Alternatively, Foresight (2011a) denotes climate change as one of the key drivers creating a challenge within the global food system.

The specific effects of climate change on agriculture are highly uncertain (Evans, A 2009). Few global scale assessments of food security have been carried out, hindered by their ability to capture uncertainty in climate projections and capability to include individual events such as extreme weather and disease outbreaks which are known to have significant longer-term impacts on agricultural production (Gornall *et al.* 2010). Although adaptation is important, regardless if a farm system adapts, negative impacts on average yields are likely to be experienced from the 2030s, with median global crop yields predicted to decline up to 2% per decade , until 2100[10] (Porter *et al.* 2014). Changes in temperature and precipitation will

[10] 66-100% probability (IPCC 2013, 36)

contribute to increased food prices by 2050 (Porter *et al.* 2014). Gornall *et al.* (2010) identify a lack of clarity of how impacts from droughts are quantified from an agricultural perspective. Effects will be felt differently and over different timescales, in different regions and by different agricultural sectors (Defra 2010a).

For UK farm systems specific challenges of climate change may result in a decline of: crop yields, groundwater, and water availability. Alongside this, increased heat stresses of livestock and farmworkers, losses to pest and disease and storm and flood damage are probable (Defra 2010a and 2012b). Defra (2010a) calls upon farmers to prioritise building resilience through: increased water efficiency, suitable fertiliser, flood management plans and the increase of productivity and efficiency of the farm business sustainably. Farmers are often flexible in dealing with weather and year on year variability; a high degree of adaptation to the local climate is required in the form of established infrastructure (Gornall *et al.* 2010). This is alongside 'cultural' dimensions such as local farming practice, and individual experience that can facilitate such change (supported by Defra 2010b, Maynard 2009).

2.2.4 Future Projections

It is widely agreed that decisions made now to adapt and mitigate possible impacts of climate change, will disproportionately affect the future (Ambler-Edwards 2009, Defra 2012a, Foresight 2011a, IPCC 2007). To aid future decisions and policy planning, Ambler-Edwards *et al.* (2009) adopted a similar approach to IPCC (2000) and Defra (2009) through the use of future scenarios, aimed to act as forecasts under different assumptions. Ambler-Edwards *et al.* (2009) conceptualised climate change in a similar manner to Foresight (2011a) by separating water shortages, oil and energy supply pressures. The four scenarios shown in Appendix A by Ambler-Edwards *et al.* (2009, 19) are based upon the seven challenges identified (2.2.3). The agricultural focus of the scenarios is based upon the dairy and wheat sectors generating story-lines on potential future impacts and influences upon food security (Ambler-Edwards *et al* .2009).

Unlike climate scenarios in Defra (2009) and IPCC (2000), the projections in Appendix A are not based on mathematical simulations. Instead, the projections provide abstract forecasts of what might happen under the pressures detailed in each scenario, to establish potential impact on the future food security in the UK (Ambler-Edwards *et al.* 2009). Comparably, the scenarios constructed in Foresight (2011c) utilised an intermediate approach in which abstract scenarios were constructed upon varying demographic, economic, political, social and environmental circumstances, yet placed in parallel to the most current climate global circulation model[11]. This enabled Foresight (2011c) to explore each scenario under a global temperature increase of 2.4°c by 2060 and its output on crop production. However, the scenarios in Foresight (2011c) are more generic in their conceptualisation of social, economic and political circumstance in a global context. As a result, Foresight (2011c) may portray a more accurate picture of long-term climate change globally, whilst Ambler-Edwards *et al.* (2009) focuses on short-term variance and EWEs which may affect specific crop growth and agricultural outputs in the immediate future. Nevertheless, all projections are hindered by fundamental concerns over the ability to project the effect of carbon dioxide concentrations on plant physiological processes (Gornall *et al.* 2010, Rosenzweig and Hillel 2007). Thus, Gornall *et al.* (2010) considers that it is not possible to provide a robust assessment of the impacts of anthropogenic climate change on productivity as there are too many variables.

Prevalent in all of the scenarios, is the reliance and assumption of significant advancement of agro-technologies (Ambler-Edwards *et al.* 2009, Defra 2012b, Defra 2009, Foresight 2011c, IPCC 2000). This bears a resemblance to the technological treadmill experienced in agricultural productivism, where technology is relied upon to continually develop in order to resolve new and emerging issues (Healey and Ilbery 1985, Ward 1993). Indeed, there are new debates around the potential use of Genetically Modified Organisms (GM) to address food security concerns (Dibden *et al.* 2013). There are discordant views on the use of GM in developed countries (Dibden *et al.* 2013). Australia and the USA have demonstrated the successful use of GM, yet the acceptance of GM crops and foods at government level is seemingly not enough in the UK to allow for consumer acceptance (Dibden *et al.* 2013). Conway (1997) recognises that technologies by themselves are not enough, as often they are injected into communities without support, therefore the implication of such technologies should be considered with caution when aiming to change social perceptions (Evans, A 2009). This notion is also demonstrated in Wynne (1992) where the lack of consideration and understanding of local knowledge led to unnecessary scientific and policy implications. In contrast, Foresight (2011a) state that much can be achieved by current technologies and knowledge if accessed in the correct way.

2.3. Lessons Learnt from Researching Farmers' Resilience in Developing Countries

This section will consider some of the key messages from a large body of research exploring farmers' resilience in developing countries. For farmers in developing nations, the challenges

[11] HADSM3 as used in IPCC 2000 and Defra 2009.

of climate change are already felt (Adger *et al.* 2003). Food is a continuous priority for subsistence farmers and rural communities who are already vulnerable to changing environmental conditions (Chambers 1983). Due to a continued reliance on agriculture for most livelihoods, the effects of climate change on productive croplands are likely to significantly threaten the welfare of the population (Mendelsohn and Dinar 1999). Selected articles deemed relevant to this research will be analysed in view of lessons learnt from this research, that may be applicable to agricultural geographers investigating similar issues but within the context of developed nations such as the UK. In particular this review will be anchored upon the work of two key authors: Robert Chambers and Neil Adger. Initial research by Chambers pioneered the 'farmer first' movement initiating a 'bottom-up' approach to utilise local knowledge when improving practice (Chambers 1983, 1994a, 1994b, 1996 and 2005, Chambers *et al.* 1989, Chambers and Conway 1992). Subsequently, Adger applied the facilitation of local knowledge and practices to enhancing farmers' adaptation to environmental change (Adger 2000, Adger *et al.* 2002, 2003 and 2005). Indeed, Agricultural geographers can learn from the emergence of climate change adaptation research with farmers and agricultural practices from researchers in developing countries.

Key work from development studies that are relevant to this research will be discussed in this section in five sub-sections. This review will commence with the chronological development of facilitation practices utilised by practitioners working with farmer adaptations to environmental change in the developing world. These concepts will then be discussed in view of specific adaptations to climate change evident in developing world literature over the past decade to draw out lessons that can be applied to researching farmers' resilience in the UK.

2.3.1. Indigenous Knowledge

Indigenous knowledge (IK) is a form of local knowledge unique to a given culture or society, providing the basis for local-level decision-making (Chambers 1983 and 1989, McCall 2004 , Warren 1991). Indeed, the adaptation of IK to particular environmental cultural niches strengthens livelihood resilience (Chambers 1989). In the late 1980s, IK was increasingly recognised as an important resource that needs to be utilised to encourage and facilitate farmer adaptation in cost-effective, participatory and sustainable ways (Warren 1991). IK is regarded as the basis for informed local-level decision-making in agriculture, yet the challenge of accessibility to scientific knowledge for decision-makers remain numerous (Chambers 1983 and 1989, Warren 1991).

Chambers *et al.* (1989) asserted that farmers should be seen as experimenters because they need less of a standard package of practices and more a basket of choices. Traditionally, development has utilised practitioners and scientists as 'experts', yet in practice it is evident that the experts in adapting local farming systems are the farmers themselves (Chambers 1989). Reij and Waters-Bayer (2001) concur with Chambers (1989) that, with growing population pressures and increasing awareness of environmental degradation, farmers are seeking more productive ways to use the rapidly depleting resources around them. Röling and Brouwers (1999) further argued that in order to ensure agriculture can be sustainable, the creation of continuous knowledge is essential. On-farm testing has to be adapted to suit the practicalities of the situation, differing from scientific experiments in controlled measures (Reij and Waters-Bayer 2001).

Indigenous Knowledge Transfer (IKT) embraces this concept, allowing the collective discussion of a community's knowledge of tools and techniques for the transformation and utilisation of resources specific to a location (McCall 2004). It is agreed that indigenous knowledge transfer (IKT) is key to utilising farmer groups in agricultural research eliciting farmers' ideas and problems (Chambers 1989, McCall 2004). Farmer groups utilise IKT to disseminate farmers' ideas and problems in discovering and enhancing knowledge and innovations in trials and technology (Chambers 1989). The benefits allow for increased communication, efficiency and linkages amongst farming communities, alongside farmer empowerment through farmer-to-farmer knowledge transfer (Chambers 1989, Osbahr *et al.* 2010). Indeed, most farmer innovators decide to trial on their land something that they have seen produced successfully elsewhere, leading to clusters of innovators closely integrated with each other as farmers compare gains (Chambers 1989, Reij and Waters-Bayer 2001). Regardless of increasing farm innovators seeking new means of adaptation to environmental change and climate pressures (Reij and Waters-Bayer 2001), the majority of long-standing IKT is that which has been passed down from generation to generation (Warren 1991).

Participatory Rural Appraisal (PRA) then developed from this involving:

> *"Growing family of approaches and methods that enable local people to share, enhance and analyse their knowledge"* (Chambers 1994b, 953).

Research by Chambers (1994a and 1994b), explores the effectiveness of utilising PRA to facilitate on-going IKT whilst achieving specific development goals, and has been further investigated since by authors such as Kothari and Cooke (2001). Such an approach could encourage further knowledge sharing amongst farmers in the UK.

2.3.2. Livelihood Resilience

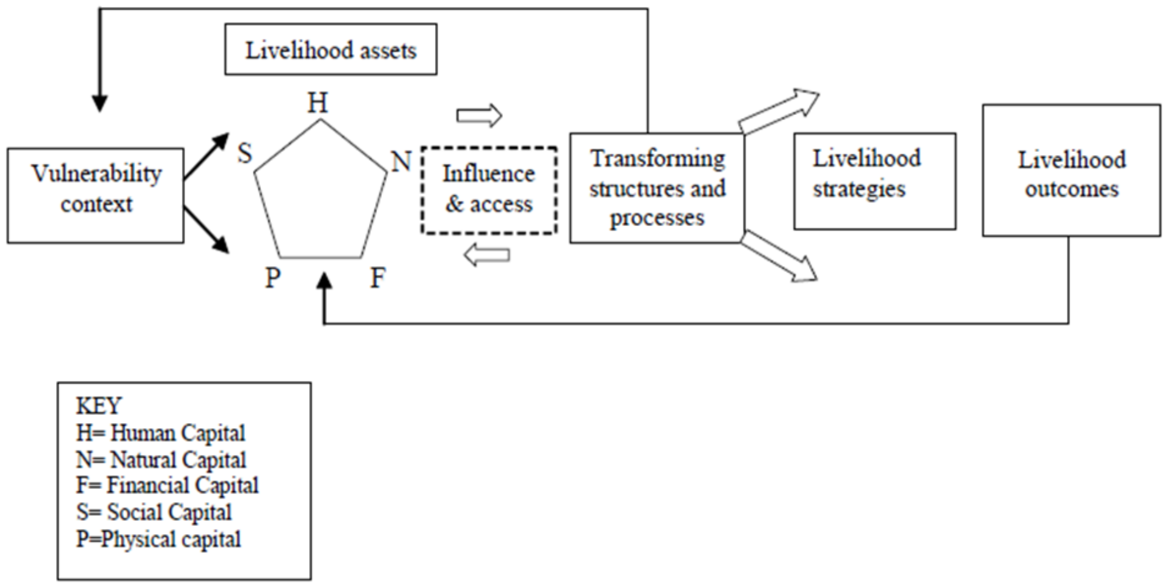
Resilience was defined in 1.3, conceptualising a 'resilient farmer' as an individual who would embrace flexible responses to farm system shocks to reorganise the farm system whilst possessing the ability to bounce forward (building upon: Comfort *et al.* 2001, Cutter *et al.* 2008, Milestad and Darnhofer 2003, IPCC 2014). Such a definition is derived from disaster management and climate change research in a developing context where the principles of resilience are most often applied. Therefore, a greater exploration of resilience which is most often applied using a livelihoods approach in developing studies is required to draw out the most relevant principles to be applied to farmers in the UK.

The sustainable livelihoods framework encompasses the complexity and diversity of how a rural population gain a living beyond a purely agricultural focus (Chambers 1996, Ellis 2000, Solesbury 2003). A livelihood is considered to consist of; "people, their capabilities and their means of living including food assets and income" (Chambers and Conway 1992, i). Livelihood resilience is an adaptive strategy relevant to climate change due to the focus of the concept to secure complex and fragile rural livelihoods (Osbahr *et al.* 2010, Mertz *et al.* 2009). Rural livelihoods often comprise several activities per household, diversifying the risk through a split of specialisations beyond a sole reliance on farming, providing both food and cash to satisfy household needs (Chambers and Conway 1992, Ellis 2000). Thus, rural livelihood systems demonstrate adaptive strategies in response to increasing agricultural challenges such as climate change (Adger *et al.* 2003, Mortimore and Adams 2001, Osbahr *et al.* 2010, Thomas *et al.* 2007).

The importance of livelihood resilience is demonstrated in the sustainable livelihoods framework, with the ability to maintain or enhance household capabilities and assets, both now and in the future using livelihood assets and capitals (Chambers and Conway 1992, DFID 1999a, Osbahr *et al.* 2010, Solesbury 2003). As shown in Figure 2.1, the SL framework consists of the use of a farmer's assets and capitals to build resilience (Solesbury 2003). Chambers and Conway (1992) identified that components of SL consists of assets including: tangible assets, including stores and resources; intangible assets, such as claims and access; and livelihood capabilities such as skills and knowledge. It is the flow between these components that create a livelihood with effective resource use (Chambers and Conway 1992; Solesbury 2003) and so is more resilient. Within SL, there are two forms of sustainability: environmental sustainability, encompassing effective use of natural resources; and social sustainability describing the resilience of a system and its ability to continuously improve (Chambers and Conway 1992). Solesbury (2003) further established five capitals of SL: human, natural, financial, social and physical which influence and determines the ability of a farmer to use their tangible and intangible livelihood assets. It is apparent from Figure 2.1, that within a vulnerability context; the five capitals are processes creating SL strategies resulting in positive livelihood outcomes (Solesbury 2003).

Gradual stresses which build up over time such as: soil degradation, abnormal intra-seasonal temperatures, precipitation patterns and EWEs are encompassed in the SL framework, shown to be address by use of capitals and assets (Chambers and Conway 1992, Mertz *et al.* 2009, Osbahr *et al.* 2010,Thomas *et al.* 2007). Hence, SL is highly relevant to climate change adaptation as it can account for diversification of risk to weather events through assessing the household split of specialisations beyond a sole reliance on farm incomes (Ellis 2000). Therefore, considerations of SL and the focus upon livelihood capitals can be explored in further application to farmers' resilience in the UK.

Figure 2.1: DFID's Sustainable Livelihoods Framework



(Source: Solesbury 2003, 11)

<u>2.3.3 Farmers' Perceptions of Climate Change in Developing Countries</u>

Climate change presents a key challenge to development through its potential to exacerbate any previous on-going societal and economic challenges (Adger *et al.* 2003). Maddison (2006) states that adaptation to climate change is a 2-step process: firstly, the recognition that the climate is changing; and secondly, the response to the perceived change through adaptive measures. Risk perception was defined in 1.3 as the process in which an individual evaluates their level of risk in view of the information they have received, observed and recalled (Solvic 2010). Risk perception is therefore applicable to assessing farmers' perceptions of the impending risk posed by climate change.

Increasingly, researchers have investigated farmers' perceptions of past and present climate change in developing countries (Deressa *et al.* 2011, Maddison 2006, Mertz *et al.* 2009, Osbahr *et al.* 2010). Farmers' knowledge and understanding of the climate are recognised as influencing factors on farmer awareness of climate change (Dressa *et al.* 2011). Unsurprisingly, farmers that are already living and surviving in harsh environmental conditions possess a higher awareness of change (Dressa *et al.* 2011), and so are more aware of EWEs. Mertz *et al.* (2009) showed that there is a high-level awareness amongst most of the farming population once a clear focus on climate change is placed in discussion. This is a result of the combination of many stresses on the farming system that raise concerns, encompassing more than climate change itself (2.2.3, Mertz, *et al.* 2009).

Osbahr *et al.* (2010) compared farmers' perceptions of climate variability in South West Uganda with local meteorological records. The study showed that farmers accurately noticed seasonality and temperature change coinciding with records of a steady increase of temperature and increased seasonality, therefore demonstrating a linear relationship between 'reality' and 'perception'. However, in contradiction to this, farmers recognised noticeably different rainfall patterns, yet there was a lack of weather records showing evidence of this (Osbahr *et al.* 2010). It was also found that if a large weather event had been experienced, then an increased perception is utilised to recognise subsequent events (Osbahr *et al.* 2010). Crucially, it is demonstrated that climate variation in a specific year was described by farmers as a deviation from their ideal weather conditions to enable a successful livelihood, not necessarily as a result of the predominant characteristics present (Dressa *et al.* 2011, Osbahr *et al.* 2010). From these studies it is clear that such concepts and notions of farmers' perceptions of climate change are highly applicable to exploring farmers' perceptions to climate change in the UK. The focus upon facilitating local knowledge and the use of a locally specific approach through use of PRA is particularly relevant to this research. As such, the findings and approaches adopted in this body of work will directly inform this research designed specifically with the culture of the farming community in the Welsh Marches in mind (4.1).

2.3.4 Adaptation in Developing Countries

Community-based adaptation is increasingly utilised in developing countries to place people at the centre of their own development (Kolle and Annecke 2011), as evident in the principles of adaptive capacity (3.4, Holling and Gunderson 2002, 34). Increasing agricultural adaptation to climate change in developing countries is being reported in academic literature, notably, a movement towards farmer adaptation through climate-smart agriculture is apparent (Osbahr *et al.* 2010, Kituyl 2011). This was demonstrated in the Khomele cooperative in South Africa which was set up to give farmers' access to weather forecasts, subsidised irrigation training, advice on suitable stock breeds and grains, and has succeeded with strong local support and leadership (Osbahr *et al.* 2010). Koelle and Annecke (2011) denote the rise in community based adaptation across many African nations that extends beyond a response to climate events, through initiating a holistic process encouraging farmers to be at the centre of their adaptations through enhancing their individual skills such as problem solving and coping capacities. This allows for future events to be anticipated and cropping patterns to be adjusted accordingly, to ensure that future shocks are buffered (Koelle and Annecke 2011). However, Mertz *et al.* (2009) recognised that farmers generally had a fatalistic approach when discussing climate concerns using the notion that it is a phenomenon not in their control as an argument against adaptation. Nevertheless, examples demonstrating adaptations which utilise local knowledge and a market base of agriculture are proven to be the most successful as farmers had made farm-level adjustments to their practices according to subtle environmental changes observed, (Thomas *et al.* 2007).

Adaptations are identified in development literature to exist in many forms as specific adaptations to a location utilising village-level knowledge are both effective and appropriate (Mertz *et al.* 2009). In South Africa, dry spells resulted in farmers reducing cropping efforts and focus on livestock (Mertz *et al.* 2009). Koelle and Annecke (2011) incorporated a variety of IKT, PRA and livelihoods approaches as key approaches to community-level adaptations. This is suggested through facilitating a learning process focusing on giving available place specific information to vulnerable groups, such as weather predictions and climatic trends, alongside the skills required to interpret and utilise the information (Koelle and Annecke 2011). Such a participatory process encourages community preparedness through shared experiences in an interactive workshop environment (Koelle and Annecke 2011).

An alternative participatory approach has started to emerge in the concept of climate services that provide climate information in a way that assists decision-making by individuals (Tall *et al.* 2014, 10). In order to successfully encourage adaptation, climate services must respond to user needs, to reduce uncertainty for farmers on climate risks (Tall *et al.* 2014). Indeed, it is apparent that a movement to deliver climate services by combining climate information including forecasts and advisories to create a useable service for farmers is in motion (Tall *et al.* 2014). Such an approach is thought to encourage adaptation, and better inform farmers of the most suitable risk mitigative actions to adopt, increasing preparedness (Tall *et al.* 2014, explored further in 3.3). The principles of such a concept which is still in its early stages of development are applicable to farmers in the UK, by emphasising the role of locally specific information and may help to remedy key issues identified with climate change communication (3.3).

2.3.5 Relevance of Developing Studies Literature to Researching Farmers' Resilience in the UK

This synthesis of applicable literature from development studies has demonstrated an evolution of people-focused adaptations as discussed in this section. Clearly one reoccurring theme of placed-based adaptation is fundamental to increasing farmers' resilience to climate change (Cutter *et al.* 2008). Alongside this, the facilitation of local knowledge and transfer of such knowledge and experience amongst farmer groups has proven imperative to successful climate change adaptations. A 'bottom-up' approach that puts the local culture, infrastructure and environment into consideration, whilst supporting farmers to choose from a range of adaptation options, has proven successful in its application to encourage farmers to adapt to climate change. Most recently, applications of this concept can be seen in the emergence of frameworks on climate services designed to clarify probable climate change impacts and reduce farmers' uncertainties (Tall *et al.* 2014). Consequently, lessons learnt over the past four decades in developing countries, could be applied to farmers in the developed world where research and facilitation of farmers' adaptation to environmental change has just started to emerge.

2.4 Farmers' Resilience to Climate Change in Developed Countries

Farmers in developed countries will also need to adapt in fundamental ways to avoid impending crises (Fish *et al.* 2013). A holistic livelihoods approach incorporates a range of different factors including sustainability, coping capacity and social capital of the household beyond the farm gates (Adger *et al.* 2003). Indeed, such approaches to evaluating resilience are applicable to assessing farmers' resilience in a developed world context and are starting to emerge in agricultural geography in relation to climate change. Specific studies of farmers' adaptation to climate change have predominantly focused upon agricultural regions of North America and Australia, as such, this body of literature will be analysed in detail throughout 2.4, in view of a deficiency of directly comparable research in the UK and Europe (reviewed in 2.5).

2.4.1 Complexities of Agricultural Change

There is a new urgency to facilitate agricultural adaptation to climate change in developed nations (Howden *et al.* 2007). Agricultural change is a complex and slow process, absent of a simple linear relationship between changes in environmental conditions and farm-level change (Reid *et al.* 2007). The stress of climate change on a farm-system to adjust accordingly is notable, with characteristics such as temporal, spatial and severity of the risk, determining the farm-system change are required (Bryant *et al.* 2000). Individuals, characteristics and prior experiences of the farmer can influence the acknowledgment of risk exposure by the farmer (Bryant *et al.* 2000). Indeed, adaptation to climate change does not occur in isolation from the influences of other forces. Instead, it occurs amid a complex set of economic, social and institutional circumstances that contribute to a complex decision-making environment (Beck 2010, Smithers and Smit 1997, 3.1). In order to understand farmer responses, there is a need to acknowledge the complex decision-making environment in which farm decisions are made (Bryant *et al.* 2000). In respect of this, Easterling (1996) places climate change as just one of a series of factors to which farmers must adapt and respond to in order to survive and thrive.

Bryant *et al.* (2000) recognise a progression of research focused upon a 'simple impact approach' focusing upon the effects of climate change on crop yields (Parry *et al.* 2004, Rosenzweig and Hillel 2007), towards a holistic interpretation of complex farm decision-making process (3.1, Agrawal 2008, Berry *et al.* 2006, Head *et al.* 2011, Reidsma *et al.* 2009 and 2010). It is no longer deemed acceptable to rely upon impact modelling without cross-sectional socio-economic analysis of more integrated vulnerability assessments incorporating crop yields, farm income and social capital (Berry *et al.* 2006, Easterling 1996, Nelson *et al.* 2010, Reidsma *et al.* 2010). Indeed, such integrated approaches are increasingly adopting a cultural perspective comparable to that which will be devised for this research encouraging a more encompassing approach (3.2 and 3.5).

2.4.2 Risk Perceptions of Climate Change

Resilience was considered in 1.3 to consist of a multitude of inter-related factors including risk perceptions, coping capacity, adaptive capacity and social capital. In order to understand farmers' resilience to climate change and potential adaptation options available, it is first necessary to understand how a farmer perceives climate change (Cross 1994). It is evident that a high level of risk perception is most likely to encourage implementation of adaptive measures to mitigate foreseen risk (Solvic 2000). Although, risk perception is crucial in enabling a response, it is apparent that perceiving a risk does not necessarily mean that an adaptation will be made accordingly (Bryant *et al.* 2000, Brklacich *et al.* 1997, Smit *et al.* 1996).

Climate is a unique system with social foundations (Hulme *et al.* 2008). Social perceptions of climate change are transformed through both external social, as well as internal filters (Hulme *et al.* 2009). Values, ethics, risk, knowledge and cultural constructs can limit the process of adaptation by presenting social barriers (Adger *et al.* 2009, Lorenzoni *et al.* 2007). Furthermore, individuals' underlying knowledge of the causes, impacts and solutions are essential to interpretation of climate change issues (Lorenzoni *et al* .2007). Cutter *et al.* (2008) denotes that locally specific 'placed-based' risk perceptions are the most effective in building resilience. This emphasises the importance of farmers' understanding of potential climate change impacts within the context of local cultural, social, economic, political and physical influences. A key barrier to this is a general feeling of irrelevance due to a distance in place and time, which is particularly associated with climate change forming a key barrier to farmers' risk perception of climate change impacts (Holloway 1999, Leiserowitz 2005, 2006, Reid *et al.* 2007).

Once decision-makers have acquired experience in using particular forecasts, they develop the ability to calibrate the strengths and weakness of potential adaptations (Dessai *et al.* 2009). This process is closely integrated with climatic memories (Hulme *et al.* 2009). Memory is not only the collection of notions about past events, but affects perspectives of more recent experiences, self-appraisals, beliefs and goals in future decision-making and interpretations of new information (Hulme *et al.* 2009). With past EWEs, memories of exceptional events can distort memories of other events that have been experienced (Hulme *et al.* 2009). Indeed, over time a psychological construct of 'norms' are developed creating expectations of climatic present and future that are distorted from true climatic trends (Hulme *et al.* 2009). Crucially, it is this that often triggers a response by decision-makers.

2.4.3 Social Capital and Coping Capacity

Closely inter-linked to risk perceptions in determining resilience is social capital and coping capacity. Socio-cultural perceptions of climate change are transformed through both external social, as well as internal filters (Hulme *et al.* 2009). Therefore, social capital has a direct influence upon risk perceptions. The importance of social processes to cope and adapt to increasing challenges in agricultural systems are widely recognised for their potential to enhance resilience (Beck 2010, Moser 2010, Smithers and Smit 1997). A farmer's ability to access new sources of knowledge, and the ability to share local knowledge within a social network is one of the most important direct benefits of their social capital to resilience

(Inkpen and Tsang 2005). It is apparent that the influence of a knowledge network to make decisions that may decrease resilience are also possible (Adger *et al.* 2005, Lorenzoni *et al.* 2007). Therefore values, ethics, risk, knowledge and cultural constructs can limit the process of adaptation by presenting social barriers (Adger *et al.* 2005, Lorenzoni *et al.* 2007).

Yohe and Tol (2002) perceive coping capacity as a range of circumstances within which the virtue of underlying resilience of the system is tested in its ability to cope and maintain existing structures and functions when a significant shock occurs (1.3). The ability of a community's coping capacity is dependent upon the social capital that exists to buffer adverse vulnerabilities exposed to risk. Nelson *et al.* (2010) utilised a vulnerability analysis; incorporating hazard impact modelling with holistic measures of adaptive capacity and coping capacity, on Australian farmers along with rural livelihood analysis. Thus, movements to utilise lessons learnt from practices in a development context are already evident. This fulfils the need for a more holistic approach to assess socio-economic and cultural processes resulting in increased resilience (Agrawal 2008, Berry *et al.* 2006, Nelson *et al.* 2010, Reidsma *et al.* 2009, 2010).

2.4.4 The Practical Application of Farm Adaptation in Developed Countries

Agricultural adaptation to climate risks is a relatively new field of enquiry in agricultural geography (Wall and Smit 2005). However, continual farm adjustments have been made throughout the history of agriculture due to changes in environmental conditions, technology, market factors and public policies (Wall and Smit 2005). Smit *et al.* (2000) incorporates both notions by defining adaptation as a series of adjustments in ecological-social-economic systems in response to actual or expected climatic stimuli of their effects or impacts. Farm adjustment strategies tend to resemble short-term immediately reactive measures to a system's change, the accumulation of which results in an adapted system. Evidence suggests that farmers adopt low-cost adjustment strategies to cope with climate change (Easterling *et al.* 1996).

Agricultural adjustments have traditionally been considered in view of mixed enterprises, yet this is just one farm adjustment strategy that has been identified as a potential farm-level response to climate change (Bradshaw *et al.* 2004). Agricultural adjustments to climate change are likely to take a different form than farm adjustments that have been traditionally observed. This is as adaptation measures are considered to consist of altering activities related to GHG emissions (Smit *et al.* 2000). Adaptation is likely to evolve from a multitude of adjustments which results in a systems change.

Adaptation strategies take many forms characterised by Bradshaw *et al.* (2004) by intent, timing, duration and spatial extent. Yet, there is no consensus of which form farm adjustment strategies might take. Common adjustments traditionally include changes to: farm occupancy, size, tenure, business organisation, employment of family members and hired labour (Evans, N 2009). Olesen *et al.* (2011) foresee adjustments to climate change as consisting of changes in cultivation timings including sowing and harvest, tillage practices to conserve soil water and prevent soil erosion, increased monitoring of pests and disease, alongside adjustments in fertilisation practices. Seasonal weather forecasts are also predicted to increase significantly in popularity alongside crop insurance to help mitigate the adverse effect of climate hazards (Olesen *et al.* 2011*).* In comparison to common farm adjustments, long-term planned farm adaptation strategies are described as major structural changes used to overcome adversity caused by climate change. Such adaptations consist of changes in: land allocation, farm systems, breeding of crop varieties, increasing farm enterprises, and land management techniques (Olesen *et al.* 2011, Wall and Smit 2005).

Research assessing farmers' adaptation to climate change in developed countries has slowly started to emerge since 1997. Assessments of adaptation in North America are dominant (Bryant *et al.* 2000, Reid *et al.* 2007, Smithers and Smit 1997, Smit and Skinner 2002), alongside evolving research in Australia (Kingwell 2006, Nelson *et al.* 2010) and Europe (Reidsma *et al.* 2009 and 2010). Indeed, Kingwell (2006), supported by Ilbery (1985), states that the gradual time-scale of climate change should provide farmers with sufficient time to develop adaptation strategies. However such an argument is rejected in this thesis as it fails to recognise both the scale of the climate challenge that farmer must adapt to, and the significant barrier to adaptation which the long-time frame presents, preventing pro-active responses in the present (see 7.1). Regardless of the time-scale, specific farm management and economic conditions are essential components influencing the ability to adapt, as additional costs are likely to be incurred (Berry *et al.* 2006, Kingwell 2006, Reidsma *et al.* 2009 and 2010). Nevertheless, Kingwell (2006) portrays costs as investments in long-lasting agricultural assets, such as irrigation and infrastructure.

According to the assessment by Smit and Skinner (2002), four types of adaptations are identifiable: technological developments, government programmes and insurance, farm production and practices, and farm financial management. In Canada, Bryant *et al.* (2000) found many individual farmers perceive that they are well equipped due to their extensive technological tool-kit, giving confidence in their ability to make climate change adaptations. Indeed, Kingwell (2006) found that Australian farmers considered the most plausible adaptation options as those that are extensions of existing activities.

Within Europe, Reidsma *et al.* (2010) found that impacts on crop yields cannot be directly correlated to impacts on farm income because farmers adapt by changing crop rotation and inputs, along with making a heterogeneous range of farm adaptations that are place specific (supporting Cutter *et al.'s* 2008, place based model). Reidsma *et al.* (2009) found that, within Europe, Mediterranean agriculture is the most susceptible to climate change, however effective adaptation is highly suited to the farm characteristics in the region (Reidsma *et al.* 2009). Indeed, agricultural systems are recognized as continually evolving systems, thus farming communities possess a strong tradition in building resilience through strengthening adaptive capacity primarily driven by the adoption of technology (Bowler 1985, Evans *et al.* 2002). Yet, increased technological dependence has done little to reduce overall farm vulnerability to risk (Beck 1992, Evans 2013).

Smit and Skinner (2002) highlight the fact that agricultural adaptation involves stakeholders with different, yet inter-related opinions, therefore creating potential for a complex and slow process. However, Kingwell (2006) recognises the drive for farmers to be self-reliant in adapting farm businesses in relation to socio-economic changes. Thus, there is a need to tease out the key forces affecting agriculture and how they are perceived by farmers, in order to establish how they are translated into agricultural decisions (Reid *et al.* 2000). It should be recognised that not all adaptations are autonomous from each farm adjustment made for different reasons, as farmers continuously change and adjust their practices to cope with current conditions building upon previous adjustments (Bryant *et al.* 2000, Reidsma *et al.* 2010). This results in similar adaptations found in similar climatic conditions (Reidsma *et al.* 2009). In contrast, Agarwal (2008) argues that adaptation to climate change is inevitably local, regardless of broad climatic similarities. Despite this movement towards adaptation research, Reid *et al.* (2007) state that climate change is still yet to become a high priority item, with little evidence in the Canadian agricultural sector of serious steps taken to facilitate adaptation.

2.5 UK Farmers and Climate Change

So far, this literature review has sought to identify previous research surrounding farmers' resilience to climate change in view of the impending climate pressures on global food security. Despite much research evident from developing countries (2.3), as well as specific research into farmers' resilience, adaptation and risk perceptions in developed countries (2.4), to date only a small body of research directly investigating the implications of climate change on farmers in the UK has emerged since the 1990s. This final section will therefore seek to analyse the small body of literature examining perceptions of climate change of the general public and relate this to farmer decision-making in relation to climate change in the UK.

2.5.1 Farmer Knowledge

Exploring farmers' knowledge has been a significant focus of agricultural geographers (Hu *et al.* 2006, Ingram 2008, 2008b, Ingram and Morris 2007, Wynne 1992). Learning through mutual interactions and shared understandings are key (Ingram 2008a). Knowledge barriers are often portrayed as inhibiting the ability for farm practices to change, undermining farmer motivation to utilise new information (Hu *et al.* 2006). Yet, little is known about the nature and extent of farmers' knowledge (Ingram 2008b). There are three forms of knowledge recognised by Ingram and Morris (2007), this incorporates the; 'know what', 'know how' and 'know why'.

The 'know what' is often in the form of scientific knowledge. Scientific knowledge is considered as if it was objective or context-free, yet the true value of such knowledge is in its application and interpretation by the end user (3.4.2, Wynne 1992). Despite polarisation of the concepts, it is considered that scientific and 'tacit' knowledge are fundamentally complementary (Ingram 2008b). Indeed, the true value of 'non-scientific' knowledge that has been derived from means other than scientific investigation is recognised by Tsouvalis *et al.* (2000) as something that is often overlooked (supported by Wynne 1992). Wynne (1992) sets lay criteria for the judgement of science which analyse the plausibility, credibility and trustworthiness of new information (supported by Blackstock *et al.* 2010). Furthermore, if information is recognisable to decision-makers then it can effectively inform decisions (Wynne 1992). A key barrier to utilising scientific knowledge is the skills and practice required to use such information effectively (Ingram 2008b). Hu *et al.* (2006) found that if seasonal and long-term forecasts were provided, then farmers typically failed to adopt such information in decision-making due to a lack of familiarity in utilising such forecasts. Conversely, Blackstock *et al.* (2010) found that well-researched data-based logical messages should be effective in persuading farmers to adopt certain preventative measures, as long as farmers are convinced that there is a problem and that their actions are required to solve it.

The 'know how' incorporates skills, capability and practical knowledge (Ingram and Morris 2007). It is also referred to as 'tacit' knowledge and is fundamentally linked to direct experience and practical, personal skills that develops with attention to a specific location (Ingram 2008b). Therefore, farmers have extensive tacit knowledge of their land which informs decision-making (Ingram 2008b). Whereas, the 'Know-why' incorporates the knowledge of principles, rules and ideas of science and technology (Ingram and Morris

2007). In section 3.3 farmer knowledge systems will be explored conceptually, in view of introducing local knowledge as a middle order concept into the conceptual framework.

2.5.2 Farmers' Resilience to Climate Change in the UK

This section will place particular focus upon five papers identified to be significant to research investigating farmers' resilience to climate change. Tate *et al.* (2010) is the most recent paper to place high relevance in exploring farmers' adaptations in response to EWEs in the UK. This will be compared to Holloway and Ilbery (1996a, 1996b, 1997) and Holloway (1999), which aimed to readdress the gap between scientific predictions of climate change effects, and agricultural adjustments made based on the farmer decision-making process.

Conceptual Approaches

It is apparent that Tate *et al.* (2010) conducted research from a farm business perspective and so focused primarily upon economic justifications to implement farm adaptations to EWEs. Comparatively, Holloway and Ilbery produced the first substantial research in the UK that explored farm diversification and adaptations from a holistic behavioural perspective focused upon farmers' decision-making (3.1). Farmers' adaptations in Tate *et al.* (2010) are considered to be based solely upon financial capital. DFID (1999) outline a sustainable livelihoods approach, which considers financial capital to be just one of five livelihood capitals, operating in farm systems and therefore influencing subsequent decisions (3.6.2). Therefore, concentrating on financial capital alone is simplifying a complex decision-making process (identified in Holloway and Ilbery 1996a, 1996b, 1997).

Although Tate *et al.* (2010)conducted both quantitative and qualitative data collection, the qualitative data was designed to assess the feasibility of implementation of adaptive measures in view of financial investment and probability of the hazard occurring. A list of potential adaptations is then tested for financial viability using partial budgeting and discounted cash flow techniques. Therefore, the focus upon the study is weighted towards quantitative analysis, assuming that farm decisions are based upon financial influences (Tate *et al.* 2010).

Alternatively, Holloway and Ilbery (1996a) set the preconditions for the subsequent papers through emphasising the process of decision-making by individual farmers based upon their established food production systems. This allowed the authors to make an informed decision as to whether a new system or adaptation can be feasibly adopted on the basis of farmer decisions and processes, made in view of the complexities of pressures within the farm system. Holloway and Ilbery (1996b) examine in depth the farm decision-making process. It is recognised that the decision-making process includes: the individual decision-making, the processing operation in view of the agricultural political-economic structure, and the links between the two. This therefore does not acknowledge cultural influences upon decision-making.

Research Findings

Although derived from different perspectives, it is recognised that there is an apparent trend that most farmers think logistical changes will enable farm adaptation to changing climate and environmental conditions, resulting in an adapted agricultural system (Holloway and Ilbery 1997, Tate *et al.* 2010). Such changes identified are thought to be most effective if they are extensions of activities that they are already doing (Kingwell 2006). A clear distinction between Tate *et al.* (2010) and Holloway and Ilbery (1996a, 1996b, 1997) is that the former is anchored upon EWEs and the influence of this upon encouraging farmers' adaptations to climate change, whereas the latter is focused upon the long-term issue of a changing climate and associated problems on a larger-scale, rather than specific events.

Tate *et al.* (2010) adopted a national approach to data collection seeking to gain a representative sample of farms in England and Wales. Such consensus allowed for 28 practical adaptations from a possible list of 124. These options were then costed and considered according to 'drivers of change' which included potential impacts of: the EWE aimed to mitigate, the potential impact of the EWE, the frequency of extreme, capital required to invest and the effect on profit. Of the farms surveyed by Tate *et al.* (2010), 16% of farmers in England and Wales were found to have already made an adaptation to extreme weather. Amongst those farmers, larger farms showed a slightly greater tendency to adapt than smaller ones (Tate *et al.* 2010).

It was found by Tate *et al.* (2010) that 71% of farmers across England and Wales did not indicate that they were implementing any form of adaptive measures in response to EWEs that they had experienced. Tate *et al.* (2010) recognises that whilst there appeared to be concern amongst farmers it was a matter for the future rather than the present. This is demonstrated in that 46% of farmers included in the study by Tate *et al.* (2010) farmers in intended to react constructively to climate change, but the scale and form of a 'constructive reaction' is ambiguous. This is particularly problematic due to the complexity of distinguishing between one specific farm adjustment and a multitude of farm adjustments that accumulate to create an adapted farm system (as discussed in 2.4.4).

In order to relate Tate *et al.* (2010) to the requirements of this research, Table 2.2 demonstrates the most favoured adaptation options by farmers in the West Midlands in comparison to the average for farmers in England and Wales (calculated from the data provided in Table 3 of Tate *et al.* 2010, 77). Table 2.2, demonstrates feasible adaptation options intended as a response to climate change based upon an economic analysis. It is apparent that the most favoured adaptive measure is to increase off-farm incomes, with 40.8% of farmers in England and Wales favouring this option.

Farmers in the West Midlands are 10% more likely to consider the introduction of new types of crops or livestock than the average for England and Wales. Although this is not balanced by a willingness to replace existing crops with new varieties, suggesting a cautious approach to change. Far fewer farmers in the West Midlands indicated that they would continually review and then respond to extreme weather pressures than the average, yet some stated that they may consider retiring or selling up (Tate *et al.* 2010).

Table 2.2: Adaptation options considered by farmers in the West Midlands in comparison to those across England and Wales

Adaptation	**West Midlands Farmers**	**Average for England and Wales**
Increase off-farm income sources	40%	40.8%
Introduce new types of crops/livestock	34%	24.7%
Change timing of sowing/spraying/fertilised application	31%	34.9%
House livestock earlier/ later in the year	25%	23.7%
Will retire/ sell up	23%	15.8%
Invest in livestock housing	15%	14.5%
Replace existing crops/livestock with new varieties	10%	21.8%
Energy (bio-crops/sustainable energy)	8%	11.4%
Continuous review/ will respond when required	7%	16.1%
Invest in irrigation	5%	6.1%
Will stop mainstream farming	3%	3.1%
Cut down on stock	0%	5.4%

(Source: Tate et al. 2010, 77[12])

Tate *et al.* (2010), adopt an evidence based approach by focusing upon conscious adaptations previously implemented, rather than explore influences upon decision-making. It is apparent that farm decisions are not individual or kept within the farm family, but instead is made based on the range of advice, help and services available to develop a wider food network (Holloway and Ilbery 1996b, 1997, Tate *et al.* 2010). Likewise, the need for suitable economic and political circumstances is required as precursors for the implementation of farm

[12] Questionnaire results in Tate *et al.* (2010) are based upon figures from 2006.

diversification and adaptations in response to a warmer climate (Holloway and Ilbery 1996a, 1996b, 1997). To assess whether this is a key factor identified in the farm decision-making process, a comparison to other research is required. Subsequently, a need was recognised by Tate *et al.* (2010) to take an alternative approach to exploring farmers' adaptations extending beyond the assumption of logical decisions using sound financial reasoning.

Holloway and Ilbery (1996b) consider the decision-making process in relation to the knowledge that a grower has of the environmental and climate conditions of the land. Such knowledge is significant in the vining pea industry due to the limited period allowed between harvesting of the crop and freezing of the peas in the processing plant. In Holloway and Ilbery (1996b) the importance of grower knowledge of average climatic conditions surrounding the environment is emphasised, the timing is crucial as it is predicted that with warmer temperatures there will be a smaller window between harvest and freezing the peas. Causing great concern is that the model utilised by Holloway and Ilbery (1996b) demonstrated that the period will decrease by 25%.

Farmers identify key issues associated with climate change lying in a shorter harvest period that include: summer drought, more rainfall at flowering therefore reducing the crop quality, carbon concentration in air and soil, increased movement of pests and weeds, as well as peas reaching the plant at a higher temperature thus requiring more energy to freeze. Furthermore, Holloway and Ilbery (1996a) seek to utilise different climate scenarios, to explore farmers' perceptions of the interaction between agricultural production and the physical environment, allowing for the implications of changing interactions on the farm economy and wider food system to be assessed.

Tate *et al.* (2010) anchored their research upon EWEs and triggers for adaptations on this rather than considering the overarching impacts derived from long-term climate change of which EWEs are likely to be a considerable part (2.1, Defra 2012a, IPCC 2013, 2014). Yet in its conclusion, Tate *et al.* (2010) recognise that adaptive measures are not found to be triggered by EWEs alone. Holloway and Ilbery avoided this issue by applying a long-term perspective to explore possible impacts of climate change, using a climate scenario based approach. Advantageous outcomes of utilising simplified temperature based scenarios is the concise data collected demonstrating farmers' identification of positive and negative effects of a mean temperature increase (Holloway and Ilbery 1996a, 166). Alas, the oversimplification of scenarios and potential impacts influencing farm diversifications and adaptations, can fail to consider many important factors likely to create diverse impacts extending beyond the simplified negative and positive impacts considered in scenarios (Defra 2012b).

Contrary to Defra (2012b), all but one of the expected climate extremes were found by Tate *et al.* (2010) to have a negative effect on farming (supported by Holloway and Ilbery 1996b). Moreover, climate extremes were found to place a greater burden on the livestock sector than arable and horticultural sectors due to financial and welfare effects. Whereas, adaptations identified in response to climate extremes affecting the arable sector were considered to be achieved through changes in working practices. Holloway and Ilbery (1996b and 1997) also identified a range of possible responses that farmers have on any potential adaptations or adjustments that could feasibly be made in the farm system. In one scenario that hypothesises a temperature increase of 5°C, the mentions of positive impacts outweighs the number of negative impacts that have been listed by farmers. This is evident with a wide recognition of a new basket of crops available to establish, including French beans, maize, soya beans, and an increase in cereals and navy beans. Unlike Holloway and Ilbery (1996b and 1997) which focus on the impacts on arable farming, Holloway and Ilbery (1996a) conclude that a mixed dairy and arable farming area such as Hampshire is far more resilient and adaptable to climate change.

Moreover, Holloway (1999) observes that it is commonplace for farmers to misinterpret climate information (2.4.2, 3.3). Indeed this is supported by Tate's *et al.* (2010) recognition that:

> *"Agriculture is neither well prepared nor well informed about climate change"* (Tate *et al.* 2010, 83).

This is particularly relevant to the observation that most farmers in England and Wales do not feel well informed about climate change (Tate *et al.* 2010). Those farmers that did consider them to be better informed are more likely to have responded already, or intend to do so in the next 5 years (Tate *et al.* 2010). Overall, just 6% of respondents in Tate *et al.* (2010) felt they were well informed on climate change. EWEs that did cause the most concern were drier summers, wetter winters, intense rainfall and extremely high temperatures. Most farmers have experienced extremes and in some instances have chosen to adapt, therefore it is identified as a key motivator. Many accept that loss as a result of climate variability is an inherent part of farming (3.2, Tate *et al.* 2010). Despite this, most farmers state that they are unlikely to adapt in advance of experiencing climate changes themselves (Tate *et al.* 2010).

2.6 The Need for Further Research

This literature review has examined a body of research encompassing a range of subject areas relating to farmers' interpretation of climate change. An inter-disciplinary approach has been adopted to reflect the true complexity and nature of the subject matter. Climate change is a complex and rapidly evolving science (2.1). Significant improvements in projections of climate change scenarios are now available (including Defra 2009, Gosling *et al.* 2011, IPCC 2013). Therefore, public understanding of the rapidly evolving science may have also changed (3.3). There is a distinct lack of research directly relating to farmers' perceptions and adaptations to climate change in the UK. As discussed previously, the most directly relevant research to this thesis is that of Holloway and Ilbery (1996a, 1996b, 1997), Holloway (1999) and Tate *et al.* (2010). However, it is noticeable that a rapid advancement has taken place in this area of research with the volume of literature in climate change impacts and resilience rapidly increasing over the last decade (IPCC 2014), as demonstrated within the literature included in this review.

The potential to apply lessons from research in developing countries, by adopting a 'bottom up' approach in exploring climate change resilience in developed countries has been identified. Tate *et al.* (2010) recognised the inability to assess holistically famers' adaptations to EWEs by adopting a purely economic lens which has previously been adopted in macro studies (Defra 2012b). Such a gap in research that has been identified will be addressed in this thesis, in light of a cultural-behavioural approach which will be constructed to explore farmers' decisions in light of cultural influences. In 2.1 and 2.2 it was recognised that scientific knowledge of impending food security challenges exacerbated by climate change was lacking insights into specific impacts that are likely to be experienced at a local level. Therefore, a need to go beyond exploring such issues on a macro-level is evident.

This literature review has emphasised a deficiency in research relating to farmers' resilience to climate change in the UK. The rapidly evolving science discussed in sections 2.1 and 2.2 have left applications of such knowledge in agriculture behind. It is apparent that there is a major disconnect between climate science and land use decisions in the information available to farmers on an appropriate scale of temporal variability. When increasing temperature and erratic precipitation is combined with population increase and increasing food demands, it is necessary that this scientific information is understood and interpreted effectively by farmers in the UK to allow for increased production through farm-level adaptations. A recurring theme throughout this review has emphasised the importance of local and tacit knowledge specific to farmers to allow for sustainable and viable farm decision-making to be made, specific to a community. Thus, this review has identified the need to adopt a 'bottom-up' approach encompassing local knowledge and culture to farm communities in the UK.

CHAPTER THREE

DEVISING A CULTURAL-BEHAVIOURAL CONCEPTUAL FRAMEWORK

"It is commonly observed, that when two Englishmen meet, their first talk is of the weather; they are in haste to tell each other what each must already know, that it is hot or cold, bright or cloudy, windy or calm
" Samuel Johnson (1758)[13]

This chapter will establish a suitable conceptual framework to inform subsequent data collection and analysis in this research. An experimental approach will be constructed seeking to combine elements of two conceptual theories applied by agricultural geographers over the last 50 years. Chapters one and two have outlined the research gap which this thesis intends to fill. In response to the body of scholarly work reviewed in chapter two, this chapter will seek to identify suitable philosophical directions for this research to be anchored upon in order to achieved the research objectives stated in 1.1.

In the last forty years, three substantial philosophical standpoints have been adopted in agricultural geography. Such movements in conceptual applications to explore farm-system changes are distinguished as: the behavioural approach, political economy and applications of the 'cultural turn', with political economy dominating. The behavioural approach (3.1) operates at an individual level devised to interpret decision-making within the farm gates, leading scholars to calculate farmers' attitudes and values in order to interpret farm-system change. Political economy has focused upon external influences of farm system change, and so considered as unsuitable for this investigation (3.2.1). Alternatively, the 'cultural turn' has slowly influenced agricultural geographers to return to focus upon the complexities of farm systems at a local scale (3.2).

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[13] June 14 1758, reproduced In: Johnson, S. (n.d.) *Works of Samuel Johnson*. Oxford, Talboys and Wheeler, 367.

Accordingly, an experimental approach will be constructed in this chapter, and subsequently trialled during this thesis, designed to revisit the behavioural approach through adopting a cultural lens. This conceptual framework will respond to the emerging 'cultural turn' in agricultural geography and a renewed call to update the behavioural approach (3.2.3, Burton 2004b). This innovative conceptual framework will experiment with the most relevant aspects of each philosophical standpoint to this investigation, in an attempt to draw upon the behavioural approach in light of the 'cultural turn' building upon the work of scholars within the sub-discipline of agricultural geography.

This chapter will commence with a review of the progression of the behavioural approach, identifying the most relevant aspects to understanding farmers' decisions following EWEs or based upon new information received associated with climate change (3.1). The 'cultural turn' in agricultural geography will then be analysed in-depth in view of its application to interpreting the complexities of farm-system change at a local level (3.2). Extending beyond the two main theoretical standpoints that are incorporated in the conceptual framework devised in this chapter, a series of complementary middle-order concepts will be incorporated. The complexities of scientific communication and interpretation in view of understanding uncertainties involved in climate change will therefore are considered (3.3). Resilience thinking and its application in agricultural geography will then be discussed as a middle order concept (3.4). Following this, the conceptual framework will be created specifically for this investigation extracting the most relevant theoretical standpoints to allow for farmers' resilience to climate change to be investigated adopting a cultural-behavioural approach tailored to this study (3.5).

3.1. Suitable Philosophical Directions: the Behavioural Approach

Following its formal introduction into agricultural geography by Found (1971), during the 1970s and 1980s, behavioural perspectives in agricultural geography became a popular theoretical focus (Ilbery 1985, Morris and Evans 1999). The behavioural approach is established upon the recognition that human decisions are not always financially rational (Wolpert 1964), but instead are a consequence of a multitude of socio-economic factors. Building upon this observation, and the comparative progression made by Found (1971); Gasson (1973) and Ilbery (1978) further developed the behavioural approach to eliminate financially rational choices made by 'economic man', through the incorporation of cultural, social and psychological influences (Gasson 1973, Ilbery 1978, 1985, Wolpert 1964). Such an approach was first adopted in response to a recognition of a lack of research which had incorporated a multiplicity of factors affecting farmers' choice of enterprise, and the role of socio-personal circumstances in decision-making (Ilbery 1978). Indeed, the progression away from a positivistic stance, towards the behavioural approach initiated the use of alternative data beyond statistical analysis of ordinal and nominal data (Robinson 1998).

The behavioural approach attempted to satisfy the need to place emphasis upon explaining the human activity that takes place within the farm gates, through the individual farmer's eyes (Ilbery 1985, Robinson 1998). This theoretical stance explores the differences between actual and theoretical land-use patterns by the degree of learning achieved by the farmer, resulting in the individual farmer's perspective as opposed to external pressures (incorporated in subsequent conceptual frameworks 3.2.1 – 3.2.2, Ilbery 1985). Gasson (1973) pioneered the classification of farmers' goals, values and non-economic factors in decision-making through considering farmers' motivations, information available, material resources and constraints. As a result, the notion of behavioural geography is considered to be the 'geographical expression of behaviourism' (Ilbery 1985, 27), incorporating such an array of factors and variables of a farmer's individual behaviour (Gold 1980). The most popular applications of the behavioural approach are anchored within the model making and testing of various decisions based predominantly upon farmers' attitudes and values. Indeed, it is apparent that agricultural geographers were at the forefront of developing this approach in human geography (Ilbery 1985). This is evident through the subsequent adoption of individual decision-making models and the focus on individualism in decision-making (Johnston and Sidway 2004, Robinson 1998).

Throughout 3.1, the behavioural approach will be evaluated to establish the potential value of revisiting the conceptual framework in contemporary agricultural geography investigations. This is in response to renewed calls to revisit the value of assessing farmers' decision-making to understand agricultural change (Burton 2004b). The dominance of decision-making in the behavioural approach is critiqued in 3.1.1 in view of its progression and different applications with a focus upon agency, rather than modelling. Particular attention is then paid to the understanding of information and knowledge adoption behaviour due to its relevance to this investigation. This section will then conclude with assessing the new directions that were employed following the demise of the conceptual framework, based upon the principles of the behavioural approach in 3.1.3.

3.1.1 Decision-Making

A significant advantage of the behavioural approach is the consideration of: socio-demographic factors, farmers' psychological make-up, farm household characteristics, structure of the farm business, social settings, and the characteristics of change to be adapted to (Edwards-Jones 2006). Blackstock *et al.* (2010) recognise that farmer behaviour is affected by: cultural influences, institutional mechanisms, economic rewards, the provision of advice, and collective actions. However, cultural influences are yet to take centre stage (Morris and Evans 2004). It is apparent that personal, family and farm business objectives and attitudes are closely correlated and need to be considered together as the socio-economic factors influencing farmers' decision-making (Ilbery 1985, Wallace and Moss 2002). Wallace and Moss (2002) assess significant variations among farm families in terms of the ability to attain key goals: concerning farm profitability, family consumption, farm investment, growth and cash flow. Farmers' goals are likely to be influenced by the household's stage of life and employment of the farmer's spouse (Edwards-Jones 2006, Price and Evans 2009, Wallace and Moss 2002). Despite this, very little is known about the motivations underlying farmer decisions in respect of their full complexity such as that of the farm family (Hu *et al.* 2006, Price and Evans 2009). This section will focus upon the exploration of understanding the complexity of farmers' decision-making through the role of modelling of decisions and psychological factors incorporated into the behavioural approach.

As a consequence of agricultural geography originating as a sub-discipline within economic geography, modelling of decision-making became dominant in behavioural theory after the publications of Ilbery (1982, 1983 and 1985). Ilbery (1982 and 1985) utilised Gasson's (1973) behavioural approach through focusing upon farmer values, attitudes and belief systems as essential components to the decision-making process. This earlier approach to farmer decision-making rooted itself in scoring and constructing quantitative analysis upon farmers' questionnaires, signifying a logical transformation from the statistical focus of the previous economy-focused approaches. However, although the modelling of farmers' values, attitudes and beliefs is an important component of the behavioural approach and farmers' decision-making, it arguably oversimplifies the farm decision-making process by drawing attention to just three constructs of farmers' values, attitudes and beliefs.

The decision-making environment is considered as the immediate decision environment where information is made available and processed by the decision-maker and, the extended environment that consists of information assumed in political and economic models (Edwards-Jones 2006). The importance of all decisions being considered in view of the uncertain environment in which they are made is also prevalent, as the unpredictable nature of their outcomes play a key role (Edwards-Jones 2006). The approach considered by Edwards-Jones (2006), focused upon factors affecting farmers' decision-making characterised into five main categories. Shown in Table 3.1, they consists of: the socio-demographic and psychological characteristics of the farmer themselves, characteristics of the farm household, structure of the farm business itself, the structure of social milieu and the characteristics of the policy or product that the farmer is deciding upon. Within each category, a range of variables affecting the decision are then considered (Table 3.1).

Within the categorisation of decision-making factors, it is generally agreed that a clear distinction between human perception including human values, education and experience; and physical and institutional factors should be made (Edwards-Jones 2006, Prager and Posthumus 2010, Wallace and Moss 2002). Notably, this approach does go some way to recognise the key factors that influence farm decisions, including influences from both inside and outside the farm gates. However, any approach such as in Table 3.1, which is so heavily anchored upon modelling decision-making has been seemingly made redundant as modelling to replicate decisions had little predictive value due to infinite variation. This is due to the recognition of the unique circumstances prevalent in each local environment and the individualist manner in which decisions are made, based upon understanding and knowledge processes which cannot always be analysed and interpreted outside of the situations in which they occur. Therefore, to produce a generic module which attempts to replicate and standardise is inadequate, as it fails to acknowledge the dynamic process that is highly localised, individualistic and unique to each farm system. Although Edwards-Jones (2006) incorporates some aspects such as social capital and local culture, such factors are highly variable meaning that they simply cannot be understood in a uniform manner that is attempted by modelling. Consequently, such attempts to understand decision-making have failed through their confinements within quantitative data to adopt a holistic approach to understand the true complexities of farm decision-making within its entirety.

Agricultural geographers began to explore factors outside of the farm gates through applications of political economy (3.2.1), yet behavioural geographers continued to develop theoretical analysis of behaviours through the exploration of psychological factors in decision-making, extending analysis of attitudes and values (Burton 2004b, Morris and Potter 1995). Intentions to perform behaviours of different kinds are traditionally predicted with high accuracy from human attitudes towards certain types of behaviour (Ajzen 1991).

Table 3.1: The five non-financial variables that impose on adoption decisions by farmers

Set One: Characteristics of the Farmer (socio - demographics & psychological make-up)	**Set Two: Characteristics of Farm Household**	**Set Three: Structure of Farm Business**	**Set Four: Structure of Social Milieu**	**Set Five: Characteristics of Product or Policy to be Adopted**
Age	Stage in family cycle	Farm Type	Level of extension	Scheme factors
Education	Level of Pluriactivity	Farm Size	Information flows	Financial factors
Gender	Work patterns of spouse	Debt to asset ratio	Local Culture	
Attitude to risk Personality			Social Capital Attitude of trusted friends Policy Environment Structure and impacts of institutions	

(Source: Edwards-Jones 2006)

Dominating the attitude approach to predicting human decision-making is the Theory of Planned Behaviour (TPB). TPB incorporated an additional central component of 'perceived behavioural control' to predict behaviour by motivational factors and the intention to perform the behaviour. TPB has been applied to farmer behaviour particularly with the movement to investigate farmer behaviour and attitudes towards environmental management schemes (Beedell and Renhman 2000, Lynne *et al.* 1995, Morris and Potter 1995), as well as more recently to farmers' attitudes to disease management putting the emphasis back onto the farmer (Fisher 2013b). Yet, criticisms of TPB are numerous, particularly on the grounds that it presents an overly individualistic and rational perspective of behaviour (Lorenzoni *et al.* 2007).

3.1.2 Information, Knowledge and Adoption Behaviour

The behavioural process of receiving information to result in behavioural change is considerably complex. This is reflected in considerations of social structure, participation and communication (Jackson *et al.* 2006). In Holloway and Ilbery (1996b and 1997), the significant role of external agencies in the decision-making process is evident, particularly with regards to research assessing associated pests and diseases, as well as more specific industry ties such as those outlined in the vining pea industry (Holloway and Ilbery 1996b). It is apparent that farm decisions are not individual. Rather, they are made based on the range of advice, help and services available to develop a wider food network. Knowledge exchange between agronomists and farmers is a crucial component of such processes and is found to influence a farmer's behaviour, not only with the farmers' but also with the agronomists' motivations and values playing a key role (Ingram 2008a). The way in which information is gathered alongside the attitude of the farmer appears essential within most information models, thus allowing communication and information seeking by the individual themselves to play a significant role (Laepple and Donnellan 2008). The role of scientific communication and value of farmers' local knowledge will be further explored as middle order concepts, outside of work derived from the adoption of a behavioural approach 3.3-3.4.

3.1.3 Diffusion of Innovations

Diffusion of innovations is a crucial process in the transition from communication to action. Yet, the decision-making and behavioural process in diffusion must be considered separately to adoption as diffusion is regarded as the process by which new technologies spread among users; whilst adoption is an individual and internal decision (Fisher *et al.* 2000).

Within a farming context, it is considered that innovation adoption is complex. Fliegel's (1993) non-linear model incorporates social structure, social participation alongside communication to generate a farmer's adoption of innovation (Fliegel 1993, Jackson *et al.* 2006). This incorporates the philosophical underpinnings of the behavioural approach dominant from the 1970s to the 1980s. This is evident in the incorporation of the social structure of the farmer, including age, education, farm size, income and tenure, all of which have been discussed previously as fundamental components to the behavioural theory on farmers' decision-making. In additional to these decision-making factors, social participation constructs including membership to farm organisation and participation in community organisations are also incorporated by Fliegel (1993).

3.1.4 New Directions

The early approaches and developments of the behavioural approach in the 1970s and 1980s focused upon quantifying decision-making concepts. However, the complexities of modelling such an array of highly variable constructs arguably distracts from the decision-making process. Such failures became apparent in the call for a new theoretical approach in agricultural geography in the late 1980s (Bowler and Ilbery 1987, Marsden *et al.* 1986, 3.2.1).

An increasing movement to revisit and understand the farm decision-making process in agricultural geography has built some momentum (Blackstock *et al.* 2010, Burton 2004b, Edwards-Jones 2006). This is in response to the need to recognise the specificity of the farm business and family change with reference to particular times and place (Marsden *et al.* 1986). Burton (2004b) emphasises the need to revisit the behavioural approach and readdress the key failings of quantifying the decision-making process. The focus is readdressed on behavioural motives of the farmers looking more specifically at the social psychology of farmers' decisions. Burton (2004b) denotes three areas of the behavioural approach to readdress including the role of subjective norms over attitudes in decision-making, measures of perceived behavioural control, and the importance of farmer self-identity. More contemporary explorations of the behavioural approach such as Edwards-Jones (2006) have increased in credibility due to the wider consideration of socio-economic factors.

Indeed, the value of the behavioural approach in focusing on the food chain from the bottom-up is an effective approach to evaluating the resilience of farmers themselves. This enables the likely vulnerability and impacts of a EWE upon the farm system to be estimated, by focusing within the farm gates. Therefore, a contemporary version of the behavioural approach is applicable to this research allowing farm impacts and adaptations to climate change to be interpreted through the perspective of a farmer as the central component to the farm system. After identifying lessons learnt from the 'cultural turn' in 3.2, an attempt to re-visit the behavioural approach through a cultural lens, with theoretical contributions from middle-order concepts in 3.3-3.5 will be made in 3.5.

3.2 Suitable Philosophical Directions: the 'Cultural Turn'

Towards the end of the behavioural approach's dominance in human geography, it became apparent that quantifying and justifying decisions through use of numerical models was increasingly unproductive. Decision-making models that became particularly central to behavioural approaches failed to incorporate a multitude of variables and dynamic factors that constantly change on an individual basis, thus requiring an individual model for each decision. Therefore, a transition to move theoretical standpoints from an individualist standpoint, to emphasising the importance of decisions based on the effect of wider society, was required. The transition from the behavioural approach to political economy will be synthesised in 3.2.1 to demonstrate the origins of the 'cultural turn'. Section 3.2.2 will then focus upon the conceptualisation of agri-'culture'. In direct relation to this investigation 3.2.3 will then explore culture of the weather.

3.2.1 From Political Economy to the 'Cultural Turn'

Diminishing returns from the application of the behavioural approach were increasingly apparent as agricultural geographers continued to concentrate upon farm inputs, structures and incomes (Bowler and Ilbery 1987, Marsden *et al.* 1986). The increasingly dormant progression in conceptual engagement is also thought to have triggered a decline in the number of agricultural geographers operating within the sub-discipline (Bowler and Ilbery 1987). Following the decline of the behavioural approach, recognition of the need to extend the focus of agricultural research to look at the entirety of the food system, extending beyond farming became increasingly apparent (Bowler and Ilbery 1987, Marsden *et al.* 1986, Morris and Evans 1999). Agriculture entered a phase of policy uncertainty with a conflict of production, environmental and budgetary issues exerting stresses upon agriculture from the top-down (Morris and Evans 1999).

Thus, a logical progression of research interests led to analysing agricultural change in view of an increasingly globalised system, although this was confined to developed market economies (Marsden *et al.* 1986, Morris and Evans 1999). Political economy emerged as a conceptual vehicle that sought to overcome the constrictions of the behavioural approach (3.1.3), through incorporation of high-level influences on agricultural production as a whole, extending beyond the confinements of the farm gate (Bowler and Ilbery 1987, Morris and Evans 1999). Political economy evaluates the nature and form of state intervention in agriculture, broadening previous restrictions to enable scholars to adopt a macro-level assessment of agricultural change. Political economy provided the framework that documented the post-productivist transition evident across European policy (Bowler and Ilbery 1987).

Following the philosophical dominance of political economy, perspectives evolved away from the focus upon individual agents and their decision-making (3.1.1, Morris and Evans 1999). Particular attention was also paid to the treatment of technological change in the agro-food system and its influence upon production (Marsden *et al.* 1996). Nonetheless, political economy perspectives generated as much dispute as agreement (Marsden *et al.* 1996). Notably, a key failing of political economy as recognised by Marsden *et al.* (1996) is the failure of the approach to illuminate the diversity and adaptability of farming practices. Indeed, this focus was heavily criticised for depicting farm families as passive recipients of new technologies (Marsden *et al.* 1996). Little investigation of how policy is mediated at a farm level, combined with little acknowledgement of the value of diversity were also key critiques of research anchored in the political economy framework (Morris and Evans 1999). Marsden *et al.* (1996) identified four gaps in the approach: the processes underlying uneven agricultural development, the need to incorporate historical and local identities, analysis of the family farm within the wider system, and the integration of state action into all levels of enquiry. Consequently, an increasing need to recognise the specificity of farm business with reference to particular times and places was apparent (Marsden *et al.* 1986).

The geography of agricultural change had been dominated by a political economy discourse overshadowing alternative philosophical frameworks following the demise of the behavioural approach in the 1980s, until the eventual recognition of the 'cultural turn' by agricultural geographers in the late 1990s (Morris and Evans 1999). This was a result of dissatisfaction with the theoretical hegemony of political economy identified as a trigger for a turn towards culture (Morris and Evans 2004).

It is a consequence of the above critiques and the focus of political economy on macro-scale changes in the food system, that political economy has been rejected as a suitable conceptual framework for this thesis. This is primarily based upon three justifications drawn from the observations of Marsden *et al.* (1996): the failure of political economy to focus upon the local, the inability to explore farmers' understanding and adoption of technological innovations, and the failure to illuminate the adaptability of farming practices (supported by Morris and Evans 1999, 2004). Each of the above concerns renders political economy as an unsuitable conceptual framework to achieve the research objectives of this investigation (1.1). Nonetheless, its significant contribution to the evolution of agricultural geography to progress beyond the confines of the farm gates, and acknowledge the complexity of farm business incorporating more than a sole decision-maker, cannot be ignored in its influence upon the foundations of agricultural geography.

3.2.2 Conceptualisation of Agri-'culture'

To some extent the consideration of the influence of the 'cultural turn' in agricultural geography has been neglected. Certainly, it is apparent that farming centred engagements with notions of culture have been relatively limited compared to those non-agricultural aspects of rural space (Morris and Evans 2004).

In the early 1990s the 'cultural turn' started to make an impact upon rural studies (Barnett 1998), yet a noticeable lag in evidence of the 'cultural turn' influencing agricultural spaces was apparent (Morris and Evans 2004). The trend of economic geography becoming 'encultured', combined with increasing dissatisfaction born from the theoretical hegemony of political economy (Morris and Evans 2004). Therefore agricultural geography began progressively to open up towards a culturally sensitive approach (Morris and Evans 2004). Yet the transition has been noticeably slow in agricultural geography in comparison to other human geography sub-disciplines including rural studies of non-agricultural spaces, with insights from cultural perspectives noted at the turn of the millennium yet to impact fully upon agricultural geography (Morris and Evans 2004, Pretty 2002). Cultural geography extending beyond the sole focus upon agricultural geography is considered to be part of a wider set of debates which emerged in the late 1980s, established from the consideration of postmodernism, following the application of political economy approach to interpreting agricultural change (Morris and Evans 2004).

There is increasing evidence of the conceptualisations of agri-'culture' (Barnett 1998, Burton 2004b, Cloke 1997, Morris and Evans 2004, Pretty 2002). Agri- 'culture' defined in Burton *et al.* (2008) incorporates three capitals: social, economic and cultural capital. Incorporating each capital, McCarthy (2005) documents that the rise and dominance of the multi-functionality of agriculture signifies the 'cultural turn' away from a purely decision-making and productivist focus. Indeed, some scholars now view that the farm is no longer seen as a mechanistic sum of independent parts, instead viewed in its entirety as a system (Darnhofer *et al.*2010). It is considered reasonable to expect that there would be changes made in farmers' attitudes and farming cultures from changing practices, thus allowing a two-way process of culture and cultural analysis to take place (McCarthy 2005).

A notable shift to adopt additional contextual data looking at the complex farm system as part of wider societal, political and economic circumstances is evident (Burton 2004a, Goodman and DuPuis 2002, Griggs 1984). Hayes-Conroy (2007) further conceptualises that a 'good farmer' is a cultural product that is made from the start of the training, and generations of experience, thus describing farmers' knowledge as part of the cultural phenomenon central to agriculture. The cultural approach in agricultural geography is still underdeveloped, as there is much that remains to be done to improve our understanding of the complexities of the agricultural sector (Morris and Evans 2004). The limited impact of the 'cultural turn' in analyses of agricultural change is described by Morris and Evans (2004) as somewhat surprising given the extent to which rural geography has engaged with cultural geography. However, there are still concerns over the application of the 'cultural turn' as Goodman and DuPuis (2002) acknowledge a danger of the approach overshooting the true motives and reasons for actions in agricultural production.

Burton (2004b) recognises the potential for combining and strengthening the behavioural approach, through incorporating lessons learnt from the 'cultural turn'. Essentially, the many previous applications of the behavioural approach simply measure farmer attitudes, yet the 'cultural turn' has signified that the reliance solely upon attitudes to theorise decision-making is simply not enough (Burton 2004b). Instead, Burton (2004b) signifies that theoretical development of the behavioural approach is now required to incorporate a more cultural and sociological perspective on agricultural behaviour including political and economic influences. A combined approach is recommended to incorporate the psychological constructs from the behavioural approach such as the attitudes, values and goals of farmers. Indeed, an approach allowing for cultural, societal and political influences and constraints, alongside information of the farm family, community, local knowledge, economic situation and successional status, is required to get a complete picture of the agricultural system within which a farmer and community operate and make decisions within. This will be discussed in further detail throughout 3.5.

It could be argued that the 'cultural turn' has led scholars to disengage with the study of the material and 'gritty social reality', in favour of identities and representation (Morris and Evans 2004). Cloke (1997) describes how culturally inspired studies are being overlain on existing behavioural and political economy geographies of agriculture. Indeed, the study of farmers' decision-making is still acknowledged as a valuable focus for analysis, but this needs to be complemented by wider views of farming in society as learnt through scholars since the demise of the behavioural approach (Morris and Evans 2004). In particular, the recognition for greater attention to be paid to cultural constructions of different groups within the farming community needs to be explored further within the complexity in which it occurs including other groups beyond the 'traditional farmer'. This included the need to acknowledge the role of women who play significant roles in farm decisions and households, farm workers, tenant farmers and the influence of farm successors (Morris and Evans 1999, Potter and Lobley 1992). It is recognised that there is a need to provide different constructions of farming as an activity of farmers themselves and of places in which farming occurs, providing a more detailed exploration of agrarian hyper-realties (Morris and Evans 1999). Such an approach demands the use of a variety of different methods including the media and press (Morris and Evans 1999), which will be incorporated in this methodological approach (4.1, 4.3).

It is from such observations of the failure of the cultural approach to engage fully with farm system changes and decisions in response to risk exposure, that a need to revisit the behavioural approach through the application of a cultural lens is increasingly apparent (Burton 2004b). Yet, it has been debated whether research should commence with farming or farmer cultural constructions in a conscious effort to avert the previous 'traps' of behavioural modelling of attitudes and decision-making (critiqued in 3.1.1, 3.1.3, Morris and Evans 2004). The conceptual framework devised in 3.5 will therefore respond to this, aiming to incorporate the most relevant aspect of the behavioural approach to the philosophical underpinnings derived from the 'cultural turn'.

3.2.3 Culture of Weather

Climate is a unique system with social foundations (Hulme *et al.* 2009). Social perceptions of climate change are transformed through both external social, as well as internal filters (Hulme *et al.* 2009). Values, ethics, risk, knowledge and cultural constructs can limit the process of adaptation by presenting social barriers (Adger *et al.* 2005, Lorenzoni *et al.* 2007). Individuals' underlying knowledge of the causes, impacts and solutions are essential for interpretation of climate change issues (Lorenzoni *et al.* 2007).

At the forefront of this application of cultural theory into social science research has been the work of Paolisso (2002 and 2003) and Paolisso and Maloney (2000). Paolisso (2003) focused upon the influence of the cultural attachment to the notion of 'weather', variability and changing conditions with watermen [14]and made synergies with their attachment to the weather, with that of farmers. In this approach it is apparent that there is a significant attachment of cultural rituals, values, beliefs, spirituality, nature,

[14] Defined by Paolisso (2003) as freshwater fisherman.

morality, work, independence and responsibility with regards to the influence of the weather on society (Paolisso 2003). Paolisso (2003) extends this notion to devise a cultural model framing experience and interpretations by the individual and community members. This was found to enable the watermen to make inferences based on this experience and influence, in order to solve problems or interpret specific situations or weather events. It is apparent in Paolisso (2003) that watermen depend on their knowledge of the weather to make key fishing decisions from both conscious decision-making and sub-conscious perspectives. Indeed it is hypothesised that the same could be said for the farmers in the community (Paolisso 2003).

Different types of cultural-environmental knowledge of weather need to be analysed and assessed in greater detail. The culture surrounding the weather is most commonly depicted through daily conversations over the radio and television weather forecasts, whilst analysed along with their own commentary and analysis of the current conditions outside (Paolisso 2003). These discussions and cultural perspectives of the weather are likely to extend to the notion of climate change, which are not only experienced but also discussed and understood at a local level (Paolisso *et al.* 2012). It is apparent that community residents would draw upon a range of local information and experiences in order to interpret and make judgements upon the source of information and the veracity and utility of the information received on climate change (Paolisso *et al.* 2012). Furthermore, Paolisso *et al.* (2003) found that workshop participants primarily interpreted and conceptualised climate change within existing cultural frames of reference of the weather acquired through past and shared experiences. It is this cultural knowledge that has proved to surpass scientific monitoring, as all participants of the workshop not only agreed that climate change was taking place but discussed and demonstrated robust and varied understandings of climate change from their own experiences (Paolisso *et al.* 2012).

Although focused upon watermen with a brief focus upon farmers' experiences to date, numerous synergies can be made from this research to cultural perceptions of the weather by farmers, who, like the watermen studied by Paolisso *et al.* (2012), are in an abnormal position where their perceptions of the weather influence daily activities. Both groups are also associated with specific beliefs, values and experiences which play a significant role in their practices and production (Paolisso and Maloney 2000). This research provides further justification into the exploration of a cultural model of weather with farmers, and into the way in which the interpretation and cultural and local knowledge of variable weather conditions and changing climate are utilised to aid farmers' interpretation of climate change. Section3.5 will further conceptualise farmers' cultural regard for the weather and the role of this in farm decision-making.

3.3 Middle Order Concepts

There are additional middle order concepts that require analysis to allow the development of a holistic conceptual framework. Such a framework will aid the understanding of the process that farmers undertake when they receive new information about changing climatic conditions. These concepts consist of: scientific communication of climate change (3.3) and conceptual frameworks to interpreting risk and response (3.4). They have been selected due to the perceived significance of each concept in interpreting farmers' resilience to climate change, and so need to be incorporated into a relevant conceptual framework to this research. Each middle order concept is relevant to both behavioural and cultural considerations with regards to farmers' resilience to climate change. Each will be discussed in turn with a view to incorporate each within the author's own conceptual framework developed in 3.5.

During this section, the role and processes involved in scientific communication will be discussed, in relation to literature drawn from climate science (2.1), and information, knowledge and adoption behaviour (3.1.2). The communication of science is an extremely complex process, absent of linear processes. As such, the topic has long been a discussion of scientific, academic, policy and media interest, focused upon the communication to the public of a range of complex scientific findings and understandings. Such books written by: Booker and North (2007), Beck (2000), Crow and Boykoff (2014), Latour (1999) and Sismondo (2010), have all made significant contributions to further the understanding of the complexity of scientific communication. Due to the volume of research in this area, this section will not replicate the findings contained within these works or provide a detailed review of the work of such scholars on the topic. Instead, the most relevant elements from this body of research will be extracted to inform the conceptual framework (3.5), through understanding of the complexity of communicating climate change to farmers.

3.3.1 Scientific Communication

Science produces genuine knowledge, but that knowledge is too complicated to be widely understood (Sismondo 2010). The popularisation of science is considered by Sismondo (2010), as a 'necessary evil'. This is because considerable changes to the key message of the findings are often made unintentionally to allow for the media and public to digest the information and understand the implications of it from within their own social system. Technical knowledge is created, transferred and learned through skilled work involving multiple actors (Sismondo 2010). Communication is the connection between the social system and its environment (Coppola 1997). Scientific knowledge is often considered as if it was objective or context-free, yet the true value of such knowledge is its application (Wynne 1992). In order to gain a valuable insight into farmers' understanding and interpretation of climate change, it is crucial to have a conceptual understanding as to how such knowledge of the climate system is constructed and understood by the farmer. This will then support the wider conceptual framework using behavioural and cultural theories.

Scientists are not logical operators; instead, their investments in skills, prestige, knowledge and specific theories and practices influence their results (Sismondo 2010). The complexities of socially embedded use of scientific knowledge by lay individuals, decision-making and the knowledge and mechanisms available to translate understanding and concern into practice, must be addressed through relevant communication and supporting mechanisms (Moser 2010).

3.3.2 Communicating Information

Scientific literacy is in short supply outside of scientists (Wynne 1992). When interpreting communication from scientists, it is crucial to view the process of scientific discovery as a social process. Thus the creation of scientific 'facts' is not exempt from the influence of social and behavioural filters from outside the specific experiments in hand (Sismondo 2010). Therefore, if farmers do not hold the same values as the scientists, they are unlikely to interpret climate science as the 'truth' as interpreted by scientists themselves (Wynne 1992). It is often considered that science does not accumulate knowledge in a linear manner, as is often the case in the development of local knowledge, but instead scientific theory moves from one 'inadequate' paradigm to another (Sismondo 2010). Consequently, there is a need for mediators to translate genuine scientific knowledge into simplified accounts for general consumption, but simplification always represents distortion (Sismondo 2010). One-way information delivery and two-way interactive dialogue have very different potentials, impacts, benefits and limits (Moser 2010). Yet when dealing with populations such as farmers, 'hands on' experience is known to create a wealth of local knowledge, thus giving expertise to both the scientist and farmers, making two-way dialogue even more important (Wynne 1992).

There is considered to be a high level of conflict between lay and scientific understandings (Wynne 1992). Three distinct gaps in the public understanding of science are identified in Wynne (1992). Firstly, the recognition that public evaluation of scientific knowledge is via the evaluation of the institutions and scientists presenting that knowledge. Secondly, interested members of the public often have expertise bearing on the problem, conflicting with scientific expertise. Thirdly, scientific knowledge contains implicit normative assumptions about the social world that members of the public can recognise with which they can disagree. It is the second observation by Wynne (1992) which appears to be particularly pertinent to understanding farmers' interpretations of science, as the role of their local knowledge in the interpretation of new information cannot be underestimated (3.4, 2.5). Bulkeley (2000) demonstrates that public understanding of global environmental issues not only drew upon scientific understanding but also local knowledge, values and moral responsibilities. This directly relates to Wynne's (1992) recognition of the wealth of local knowledge developed from within the farm community that could inform the scientific community (2.4):

> *"Farmers' expertise was not recognised because it was not formally organised in documentary, standardised and control-orientated ways recognisable to scientific culture: and their later claims for compensation encountered the inflexible bureaucratic demand for formal documentation, dates, details proofs and signatures in a way which was entirely alien to their own culture"* (Wynne 1992, 296).

Such descriptions of the contention between scientific and lay knowledge, particularly through the role of farmers' local knowledge in a developed context is important to this conceptual framework. Therefore, this call for the prioritisation of local knowledge and the interpretation of scientific communication will play a crucial role in the division of this theoretical approach and application of the research design. This will be achieved through the adoption of a 'bottom-up' locally focused approach prioritising farmers' knowledge at the forefront of discussions (4.4).

3.3.3 Challenges of Communicating Climate Change Impacts

The greatest challenge of communicating climate change impacts is to find ways of encouraging broad reflection, discussion and re-evaluations of the values, structures and practices (Hall 2014). There is arguably something more complex about the nature of climate change and how humans themselves interact with the climate that makes it more challenging than other environmental issues (Moser 2010). This is firstly a result of climate change not being visible nor having direct health implications (Moser 2010). Furthermore, the recognition of the lack of immediacy and the temporal and geographical distance between cause and effect results in the topic having to compete for attention with more immediate needs (Moser 2010). Subsequently, many of the public adopt a 'wait and see attitude' concerning climate change (Sterman and Sweeney 2007).

The overall goal of climate science is to provide information and knowledge in a form that is accessible to decision-makers (Patt and Dessai 2005). However, there are numerous complexities and issues in portraying scientific uncertainties and notions to a 'lay' audience to inform the decision-making processes (Dessai *et al.* 2009, Kandlikar *et al.* 2005, Lorenzoni *et al.* 2007). Climate change communication is a unique and complex process, yet public misunderstandings of climate change may result in inaction and unnecessary fear and actions about its consequences, therefore it requires careful planning and implementation (Lowe *et al.* 2006). Furthermore, the distortion and influences of such information must be understood, in order to interpret appropriately the information that they receive. Moser (2010) recognises that much progress could be made if climate change communicators familiarised themselves with, and adopt lessons learnt from communication and behavioural research.

The notion of scientific uncertainty is one of the most difficult aspects of translating climate science because scientists are familiar with the complexity involved, yet the public seek deterministic solutions (Bradshaw and Borchers 2000). Furthermore, climate projections are based upon complex models and a range of assumptions, presenting issues for public interpretation (Dessai *et al.* 2009). Uncertainty can stem from the lack of data, lack of adequate theoretical understanding of environmental system interactions and unavoidable inadequacy in climate models (Moser 2010). There is no doubt that the complexity and uncertainty of climate change, and the insufficiencies associated with our understanding of it present a key barrier to communication and public understanding (Crowe and Boykoff 2014, Moser 2010, Lorenzoni *et al.* 2007).

The significance of climate change demands that communicators find clear and simple metaphors, frames of reference, imagery and mental models (Hall 2014, Moser 2010). The most effective way to communicate climate science is to provide examples that encourage the audience to reflect upon the examples and use them to draw their own conclusions (Newell and Pitman 2010). This process of 'framing' then allows the receiver to interpret information within their own experiences, knowledge and societies (Hall 2014, Newell and Pitman 2010).

The media are a dominant force in climate change communication, yet a lack of 'newsworthiness' associated with climate concepts inhibits the coverage of new climatic knowledge and bias towards others such as extreme events (Moser 2010). It should also be taken into account that communication by the media is bound by one-way information delivery (Moser 2010). Climate change, comparable to previous environmental issues has attracted a 'doom and gloom' discourse identified by Hall (2014), to be counter-productive in creating any aspiration to motivate change or response. Indeed, such 'doom and gloom' inspires fear, resistance, withdrawal, fatalism and a sense of powerlessness (Hall 2014). The greatest challenge identified by Hall (2014) was in encouraging broad reflection, discussion and re-evaluation of values, structures and practices whilst omitting the fear from climate change.

Challenges to communication are regarded as being background 'noise', distracting away from the most appropriate interpretation of a message (Coppola 1997, Norton 1998). A key source of much of the additional communication 'noise' is the media which occupies a grey area, where often the metrics of the scientific processes are lost in translation from academic findings to news headlines (Lowe *et al.* 2006). Indeed, it is reported by Newell and Pitman (2010) that the media routinely confuse the concepts of weather and climate, therefore this is a common misconception found amongst the public. It is apparent that there is a considerable deficiency in exchange between those 'doing' the research and those communicating the science (Moser 2010). Additionally, it is also evident that media efforts of scientific communication are often alarmist, resulting in a 'skew' of public perceptions where people have been misled by newspaper reports that fail to present objective information on the true balance of the climate change debate (Edwards 2008, Lowe *et al.* 2006). Boykoff and Boykoff (2004) denote that this is due to journalistic practice of balancing the scientific census, causing an overstatement of the actual degree of disagreement.

Another journalistic norm is to magnify the scale of environmental issues, yet Hall (2014) critiques such an approach as adding to 'doom and gloom' only making it worse. Certainly, fear of climate change is counter-productive (Hall 2014). By emphasising the magnitude of climate change, it undermines any personal willingness to make a change, due to an overwhelming sense of powerlessness (Hall 2014). A possible tool to overcome such barriers is identified by Hall (2014), by creating frames of references that convey an analysis of a problem in a condensed format.

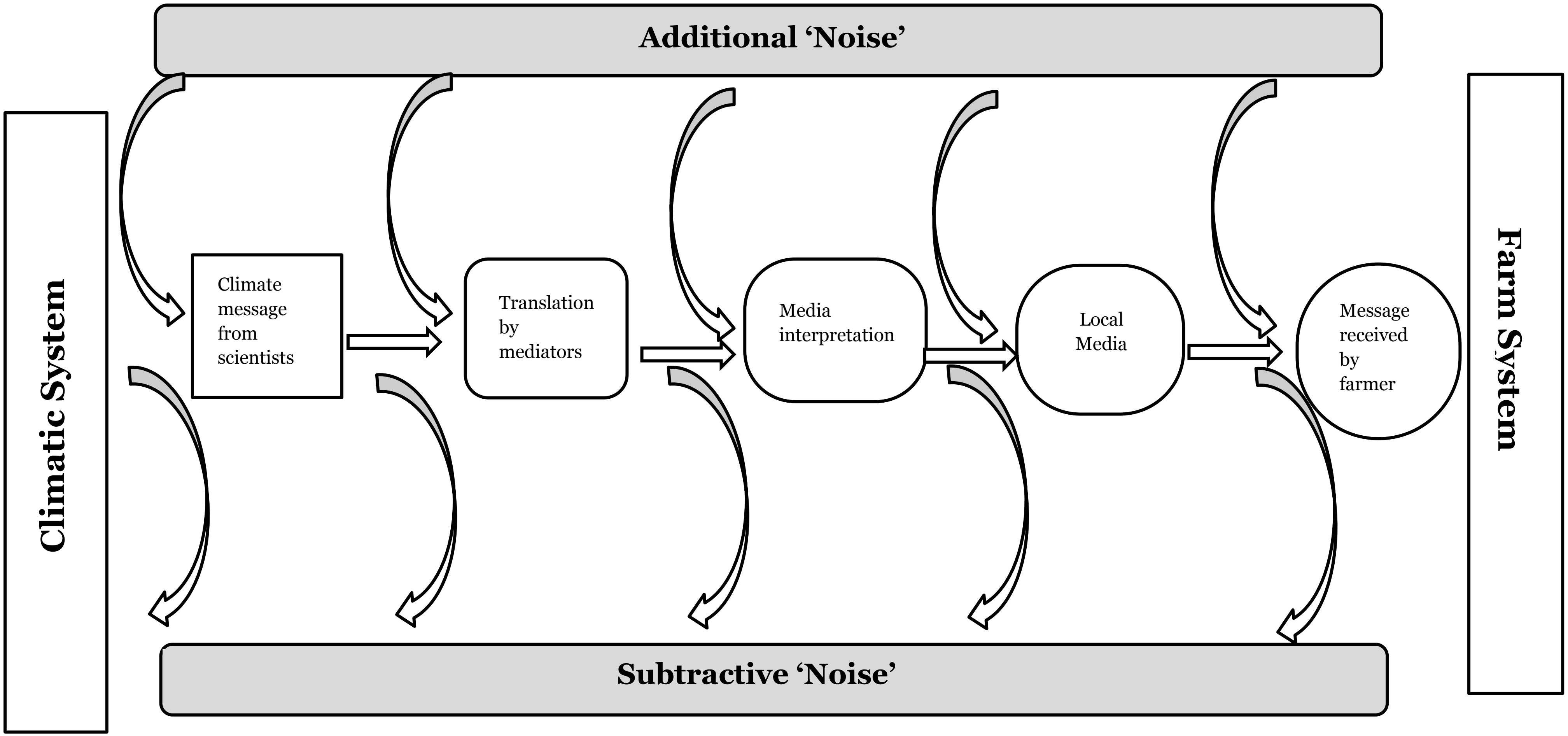
Figure 3.1 has been constructed by the author to demonstrate the 'Chinese whisper' effect of top-down scientific communication in relation to the dissemination of key information about climate science, to the farmers themselves. The transition of a square into a circle is constructed to represent the transition of the original message into a different form over time, eventually resulting in an altered message from the original communicated at the source. Background noise incorporates both 'additional noise' which includes social perspectives or constructs that add a value or paradigm into the original message, or 'subtractive noise' which represents the loss of information that may be deemed as unnecessary or unsuitable for public 'digestion'. Such noises constitute a realm of different processes, which include: a scientist's own agenda, social standards of scientific investigation, social influences of scientific interpretation, translation of mediators and communicators, priorities of the general and local media, local cultures, previous experience of the community and farmers' local and professional knowledge basis. It is the subtraction and addition of such noises that take place through numerous cultural and behavioural processes that result in escalated uncertainty and public doubt over the source and feasibility of such information. Therefore, this model of scientific communication will be conceptualised further when devising the conceptual framework for this thesis.

3.4 Middle Order Concept: Resilience Thinking

Resilience was defined in 1.3 as a flexible response to a threat that can demonstrate the ability to 'bounce back' or 'bounce forwards' after a system shock (Comfort et al. 2001, Cutter et al. 2008, Folke 2006, Walker et al. 2006). This is reflected in the consensus about the necessity of a system's continuous adaptation through continuous shocks exceeding critical thresholds (Folke, 2006, et al. 2002, Gunderson and Holling 2002, Walker et al. 2006, Walker and Cooper 2011).

Resilience thinking as a concept has emerged in the last decade, having overtaken the focus upon risk society, vulnerability and a purely adaptation focus (as previously explored by Comfort et al. 2001, Cutter et al. 2008, Beck 2000). The considerable movement in resilience thinking has increasingly been applied to social-ecological systems, building upon the foundations of: Gunderson and Holling (2002), Folke (2006, et al. 2010), Walker et al. (2006), including the early experimentation of resilience thinking in agriculture (Darnhofer 2009, et al. 2010,Sinclair et al. 2014).

Figure 3.1: Diagram of Chinese whisper effect of scientific communication



Indeed, Walker et al.'s (2006) discussion of propositions of resilience interaction with social-ecological systems presents a series of potential hypotheses which are not yet fully-developed conceptual frameworks. Although much interest has been expressed since, the conceptual power of resilience thinking in explaining adaptations in response to environmental change is yet to be realised (Davidson 2010).

Resilience thinking offers a compelling theoretical insight, however this hypothesis does not immediately explain farmers' actions using resilience thinking alone (Sinclair et al. 2014 supported by Darnhofer et al. 2010). Due to its underdevelopment in agricultural geography, it is not yet appropriate to apply resilience thinking on its own without the support or underpinning of a cultural-behavioural approach, built upon 50 years of research in agricultural geography, to inform the research design. Nevertheless, resilience thinking does offer highly valuable theoretical insights into risk responses through the dynamic conceptualisations of resilience, adaptations and transformative change (Sinclair et al. 2014). Therefore, in this conceptual framework, it is envisaged that resilience thinking will be complementary to the conceptual framework through allowing farmers' resilience and adaptive capacity to be viewed in their entirety, at a farm systems level from the 'bottom-up' (2.3 -2.4).

Resilience thinking will be considered as a conceptual approach in the early stages of development in social-ecological systems (3.4.1). The adaptive cycle and panarchy will then be introduced, in conjunction with the exploration of transformative and shock resilience (3.4.2). The adaptive capacity of farm systems will be discussed (3.4.3), before an evaluation of the effectiveness and progress of resilience thinking to interpret agricultural change (3.4.4).

3.4.1 Resilience Thinking in Social-Ecological Systems

The resilience perspective derives from ecologists in the 1960s and 1970s (Folke 2006), and is increasingly emerging as an approach offering a framework within which to understand the dynamics and processes of change that takes place in social-ecological systems (Brown 2014, Davidson 2010, Folke 2006, *et al.* 2010, Sinclair *et al.* 2014, Walker *et al.* 2006). Serious attempts to integrate the social dimension into a concept traditionally used in ecology are taking place (Folke 2006). Although this is not without difficulty (Brown 2014, Sinclair *et al.* 2014, Walker *et al.* 2006). Folke (2006) recognised advances to understanding social processes including social learning, memory, knowledge-system interaction social networks, adaptive capacity and transformability. Resilience thinking addresses the dynamics of social-ecological systems, providing a framework to explore adaptability and transformability of systems across multiple scales. Resilience thinking is founded on the premise that the natural state of a system is one of change rather than stability (Folke 2006).

Resilience on its own is considered as a complex notion incorporating risk perceptions, vulnerability, coping capacity, social capital and adaptive capacity to enable the exploration of the flexibility of a system to withstand shocks and change. It is this conceptualisation of resilience, incorporating several risk characteristics, that provides the meaning of resilience in this thesis. Resilience thinking is an emerging construct that incorporates some of the theoretical components that influence risk resilience.

Resilience thinking develops specifically upon the adaptive capacity of a system through exploration of: nonlinearity, adaptive cycle, panarchy, adaptability, transformability and general or specified resilience (Folke 2006, Gunderson and Holling 2002, Sinclair *et al.* 2014, Walker *et al.* 2004, 2006). The most notable difference of resilience thinking as a conceptual framework as opposed to resilience as a risk concept is that resilience thinking is anchored upon the complexity of social-ecological systems in view of future developments regarded as unpredictable, emphasising adaptive approaches to management as its central concept (Darnhofer 2009). This contrasts to traditional resilience in risk literature which is assessing the state of the system at the moment of impact (demonstrated in: Comfort *et al.* 2001, Cutter *et al.* 2008). The latter is the focus of this research due to its holistic inclusion of different components of risk resilience, although concepts included in resilience thinking can be applied to this conceptual framework and so will be considered in 3.4.2 – 3.4.4. This will be applied as a tool to help discuss the resilience of the Marches farm community.

3.4.2 The Adaptive Cycle and Panarchy, Transformative and Shock Resilience

Within resilience thinking, different models and triggers for adaptations have been explored. The most notable models seeking to describe the processes of adaptive transitions are the adaptive cycle (Gunderson and Holling 2002, Walker and Cooper 2011), and subsequent evolution of panarchy (Gunderson and Holling 2002, Folke 2006, Walker *et al.* 2006). As part of the consideration of these, the principles of transformative or shock resilience are also established. This is dependent upon whether the adaptive process is triggered by an immediate need for a response to an exogenous shock such as EWEs (Folke 2006, Miller *et al.* 2010, Walker *et al.* 2006), or a long-term condition such as climate change (Darnhofer 2009, Folke *et al.* 2010, Sinclair *et* *al.* 2014, Walker *et al.* 2006). These concepts will be discussed further in relation to their relevance to enable the interpretation of the adaptation process to reach an improved state of farm system resilience.

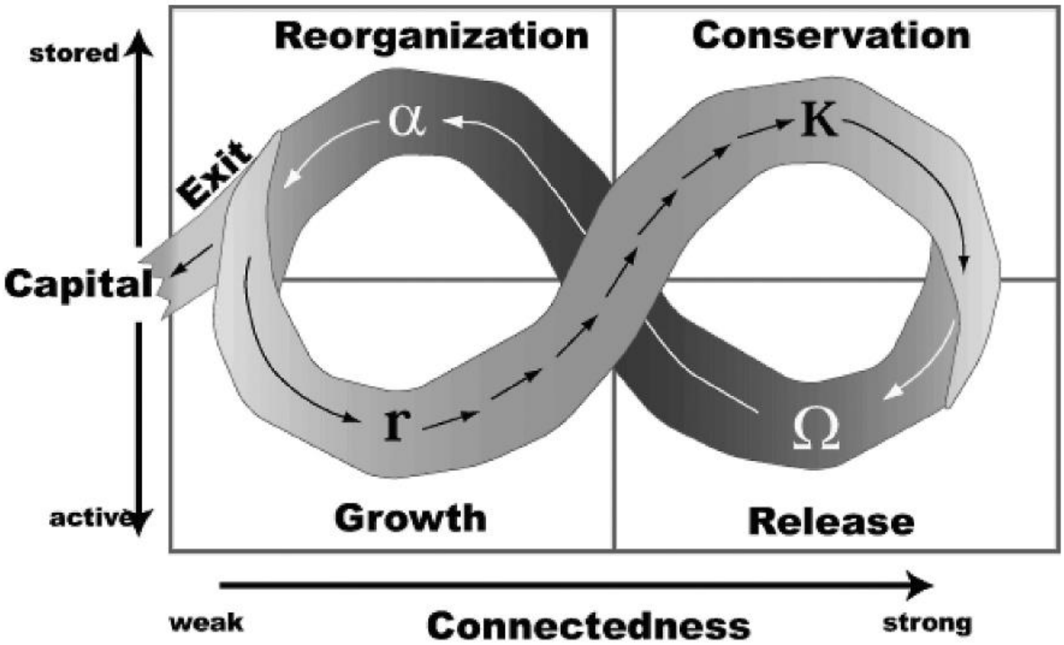
The Adaptive Cycle

The adaptive cycle will be explored further in view of farmers' responses to past EWEs (5.3) and future adaptations (7.2) in the Welsh Marches. The theory of complex adaptive systems focuses on understanding the implications of on-going change emphasising unpredictability (Darnhofer *et al.* 2010, Holling 2001). The adaptive cycle describes the dynamics of systems within and across scales (Walker *et al.* 2006). Presented in Figure 3.2, developed by Gunderson and Holling (2002), is a significant model in the field of risk and hazard management studies that conceptualises the continual process of adaptation. The four phase heuristic model is designed to demonstrate the process of change in complex systems (Allison and Hobbs 2004).

The four-phase adaptive cycle is a heuristic model representing: growth, conservation, release and reorganisation, as four ecosystem functions and the flows amongst them dependent upon the potential available change, degree of connectedness and resilience of the system (Allison and Hobbs 2004, Gunderson and Holling 2002). The relative level and speed of each of the phases is amplified by the system's potential, connectedness and resilience as the model combines space and time hierarchies.

The adaptive cycle designed by Gunderson and Holling (2002, 34) is highly applicable to changing systems in regards to climate change (replicated in Walker and Cooper 2011, 148, Figure 3.2). As shown in Figure 3.2, the first phase of the cycle is of growth (r) characterised by readily available resources and the accumulation of structure and high resilience, as this increases more resources are required to maintain them (Walker *et al.* 2006). Secondly, the conservation phase takes place (K), where the net growth slows and the system becomes increasingly interconnected, less flexible and more vulnerable to disturbances (Gunderson and Holling 2002). From r to K is known as the fore loop, resulting in development in societies (Walker *et al.* 2006). Disturbances lead to the next phase, a release of bound up resources (Ω) which leads to structure collapses (Gunderson and Holling 2002). The reorganisation phase follows (α) in which novelty can take hold leading to another growth phase in a new cycle (Gunderson and Holling 2002). When a system progresses from α to Ω, it is referred to as the back loop, where a new system state (bouncing forward) or a return to the original state of the system (bouncing back) could be achieved. After immediate reorganisation, long-term measures can be devised and put in place, resulting in an adapted system.

Figure 3.2: Replication of the Adaptive Cycle



(Source: Walker and Cooper 2011, 148[15])

Since the development of the adaptive cycle, the approach has been applied to encourage resilience adaptation to EWEs and natural hazards primarily in disaster management (Comfort *et al.* 2001, Cutter *et al.* 2008, Gunderson and Holling 2002). This traditional adaptive cycle is a suitable framework to enable the understanding of EWEs and a farm system's recovery and reorganisation following an event. It also goes some way to explain the effect of immediate responses to an event on the overall farm system and its stage of adaptivity and the origin of adaptive actions following a shock returning to the original or a slightly improved system state.

Panarchy Heuristic Model of Nested Adaptive Cycles

Compared to the adaptive cycle (Figure 3.2), panarchy shows the same process of building adaptive capacity in a model of nested adaptive and renewal cycles emphasising cross scale interplay (Folke *et al.* 2006). The idea of panarchy originates from Gunderson and Holling's (2002) recognition that the adaptive cycle should be considered in 3D. Panarchy asserts that the adaptive cycle could be considered as a dynamic process that may result in more complex changes than the original adaptive cycle represents. Walker *et al.* (2006) recognised that the adaptive cycle does not apply

[15] Based upon the original version in Gunderson and Holling (2002, 34).

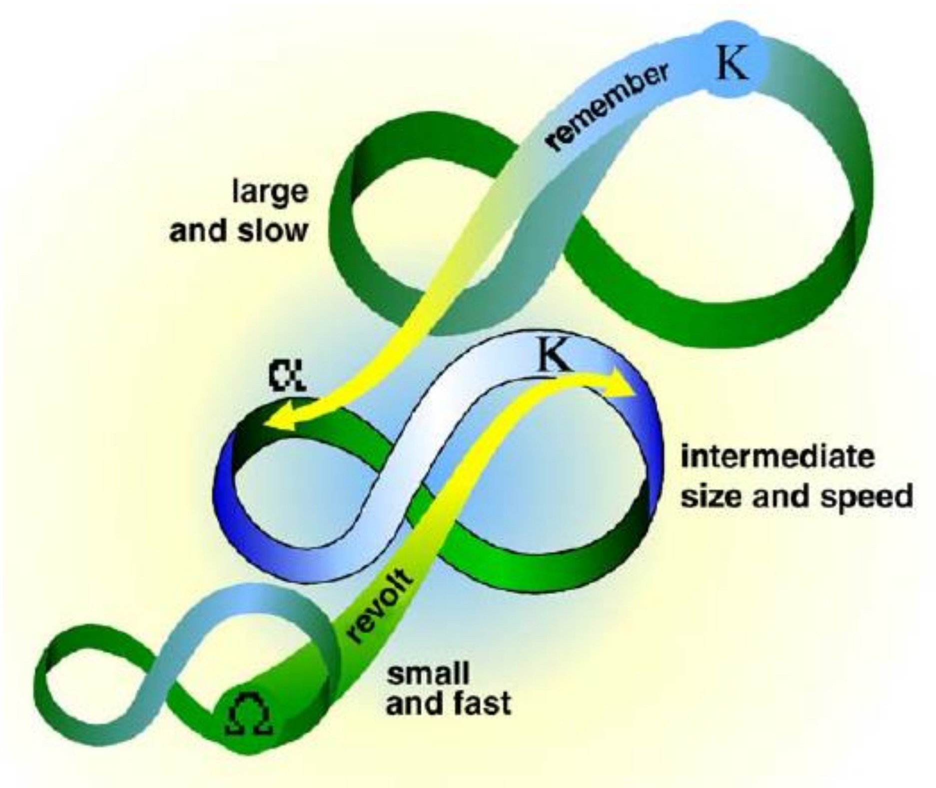
to all situations, as sometimes a sequence can pass from a growth phase to conservation in a different order than Figure 3.2 may suggest. It is apparent that the adaptive processes within a system are highly dependent upon the system itself with some phases bypassed, or returned to several times depending on a higher or lower level of resilience than may be expected.

Figure 3.3 demonstrates that the panarchical connection between scales provides opportunities for memory and learning from higher scales to influences lower scales (Folke 2006, Walker *et al.* 2006). Panarchy incorporates the acknowledgement that new adaptive cycles can emerge when memory is disrupted because adaptive cycles at higher levels of panarchy are in a back loop or in an early growth phase with many trajectories possible (Folke 2006, Walker *et al.* 2006). Furthermore, it allows the acknowledgement that social capital and social networks are particularly important aspects of adaptability, with the ability of the social capacity to respond to change particularly pertinent (Folke 2006), hence changing the dynamics of the adaptive cycle due to external influences. Indeed, this allows the system to be influenced by faster or slower change, dependent upon cultural influences and external pressures. This therefore helps understanding of gradual change to create an adapted farm system, through large and slow, and small and fast farm adjustments following a trigger event.

Sections 3.1 and 3.2 recognised the complexity of farm systems, farmers' decisions and actions. Farmers have always had to cope with a certain level of change and unpredictability and need to be flexible and adapt to new circumstances (Darnhofer *et al.* 2010). Therefore, the farm system is continually subject to change. Panarchy has been the favoured cycle for interpreting adaptive change in agricultural systems using a resilience thinking approach by Sinclair *et al.* (2014) and Darnhofer *et al.* (2010) as applied in a European context, when considering the long-term evolution and complexity of the process involved in agricultural change, characterised by non-linearity. To some extent, panarchy allows for nested adaptive cycles in farming systems to be explained by encompassing the prospect of the process reversing or accelerating based on memory, social networks and the changing nature of the risk the system is seeking to increase its resilience to. This is a continual cycle taking place daily, with an evolving farm system with increased adaptivity throughout the continuation of the process.

The model applied to the farm system symbolises the fluidity of farm-systems, and the ability for it to cope and change in response to the shock. Indeed, this will become increasingly paramount in response to the adverse effects of climate change. Panarchy is favoured by Sinclair *et al.* (2014) for its value as a framework for understanding resilience as it alters when undergoing changes in transformation. Yet, its application is not without difficulty to be applicable to the unique challenges faced by a farm system. Therefore panarchy requires considerable development to understand the true complexities and uncertainties of adaptation in a farm system (3.4.4, Darnhofer *et al.* 2010, Sinclair *et al.* 2014).

Figure 3.3: Panarchy, a Heuristic Model of Nested Adaptive Cycles



(Source: Folke et al 2006,258[16])

Shock Resilience and Transformative Change

In disaster management, the adaptive cycle builds upon shock resilience, the recognition of the importance of increasing resilience to address vulnerability to an unexpected shock (Folke 2006, Holling *et al.* 2001, Gunderson and Holling 2002 , Walker *et al.* 2004). This has been more recently applied specifically to social-ecological systems in Walker *et al.* (2004, 2006). Indeed, general resilience is about coping with uncertainty in all ways, increasing the threshold of the shocks that the system can withstand (Folke *et al.* 2010). Shock resilience is the capacity of a system to experience shocks whilst retaining essentially the same function, structure, feedbacks

[16] Adapted from the original version in Gunderson and Holling (2002, 34).

and identity (Walker *et al.* 2006, 2). Change can therefore be sudden, following a 'tipping point' following a crisis (Walker *et al.* 2006). Yet, it is a known danger that increasing adaptability to a specific shock may optimise the system to this type of shock, decreasing general resilience to unknown shocks (Walker *et al.* 2006). Therefore, the focus upon building resilience to a specific risk is not the most effective way to develop holistic resilience. This emphasised the need for farmers in the Welsh Marches to develop holistic resilience to climate change, as opposed to responses to specific threats identified following EWEs.

Learning to live with change and uncertainty requires a fundamental conceptual shift in most social-ecological systems (Darnhofer *et al.* 2010). As demonstrated in 3.1, 3.2 uncertainty and risk are consistent factors in farm systems to an array of external and internal pressures and shocks, therefore demanding a slightly different interpretation of the adaptive cycle in response. It is acknowledged that farmers need to cope with unexpected events including EWEs (Darnhofer *et al.* 2010), emphasising the value of shock resilience in agriculture. Therefore, shock resilience is considered most applicable to understanding the process of adaptive change following EWEs, to allow a farmer to maintain the functions and structures of a farm system following an unexpected shock. However, due to the complexity of farm systems and farmers' memories and experiences of dealing with uncertainty, shock resilience can only be understood in relation to cultural and behavioural influences upon farmers, in order to explain the processes involved in the adaptive process in a farm system.

In contrast to shock resilience, transformative change is increasingly used to explain the gradual evolution of long-term resilience in a social-ecological system that results in a transformation in the structures and functions of that system (Darnhofer 2009, Folke *et al.* 2010, Sinclair *et al.* 2014, Walker *et al.* 2006). Transformation is regarded by Sinclair *et al.* (2014) as the end point or the highest level of change spectrum. Indeed, contemporary resilience thinking is focused on resilience as a measure of persistence, adaptability and transformability, and the dynamic interplay between these three aspects in response to changing circumstances (Folke *et al* 2010, Sinclair *et al.* 2014). Yet conceptualising transformative change is complex as determining the magnitude of change before something is extensively changed is often impractical (Sinclair *et al.* 2014), and near impossible in relation to the complexity of farm systems that undergo constant change.

3.4.3 Applications of Resilience Thinking to Agricultural Change

As resilience thinking continues to emerge, the dominant research tradition remains focused upon adaptation to environmental change (Nelson *et al.* 2007). Adaptation is a fundamental process improving the resilience of a system. Thus, it has received attention in its application upon agricultural change (2.4). Building upon the traditional behavioural focus of decision-making in farm adjustments (2.4.4, 3.1.1), adaptation is placed closely to a specific risk and so is often considered in terms of deliberative action to mitigate the full extent of climate change impacts. Theoretically, the gradual time-scale of climate change should provide farmers with sufficient time to develop and implement adaptation strategies (Kingwell 2006, Ilbery 1985). Yet, in view of the complexities of climate change presenting multiple unknown challenges and hazards, a resilience approach that is systems orientated taking a more dynamic view to see adaptive capacity as a core feature is gaining momentum (Nelson *et al.* 2007).

The adaptive capacity of farming systems is based upon the premise that the key to coping with rapid and unforeseeable change is to strengthen the ability to adequately respond to change (Darnhofer *et al.* 2010). Adaptive capacity is defined in view of climate change as the ability of a system to adjust to climate change to moderate potential damages, taking advantage of opportunities to cope with the consequences (supported by IPCC 2001). The existence of uncertainty and surprise requires a continuous learning process that attunes to new information interpretation and subsequent changes to improve resilience (Darnhofer *et al.* 2010). Traditionally, a 'simple impact approach' quantifies agricultural risk as the adverse effects on crop yields and livestock (Holloway and Ilbery 1997, Parry *et al.* 2004, Rosenzweig and Hillel 2007). However, since the 'cultural turn', it is no longer deemed acceptable to rely upon impact modelling without cross-sectional socio-economic analysis of more integrated vulnerability assessments incorporating crop yields, farm income and social capital (Berry *et al.* 2006, Easterling 1996, Nelson *et al.* 2010, Reidsma *et al.* 2010).

Agricultural change is a complex and slow process, absent of a simple linear relationship between changes in environmental conditions and farm-level change (Reid *et al.* 2007). Therefore, any application of a generic social-ecological concept such as resilience thinking must be applied with caution. It is apparent from the work of Sinclair *et al.* (2014) and Darnhofer *et al.* (2010) that the application of resilience thinking upon farming in the developed world is starting to emerge. Yet, the application of a resilience lens with an applicable version of transformative panarchy is still rudimentary in its application. Nevertheless, that application of adaptive capacity

(Darnhofer *et al.* 2010) and the adaptive cycle in farm systems is a revelation in allowing farmers' resilience to be established. Sinclair *et al.* (2014) sought to apply the adaptive cycle to policy implications across the dairy industry in Australia. Comparatively, Darnhofer *et al.* (2010) presented a review of how the adaptiveness of farming systems can be analysed through adaptive capacity to establish sustainability. Both papers present work from a macro-scale, and although hints of a cultural perspective are apparent, Sinclair *et al.* (2014) firmly roots the investigation into a political economy perspective.

This thesis intends on extending beyond the confines of applying resilience in a macro approach by exploring a resilience lens as a middle-order concept of this conceptual framework. Due to the identified shortcomings of applying resilience thinking directly to agricultural geography and the embryonic stage in which this approach has just begun to be explored, it is not appropriate to apply resilience thinking to agriculture on its own. Upon reflection of resilience thinking as a concept in comparison to agricultural adaptations, it is envisaged that resilience thinking provides a complementary middle-order concept to the conceptual framework. This therefore allows for farmers' responses and adaptations to EWEs and climate change to be interpreted in terms of the impact upon farmers' resilience through applying ideas from the adaptive cycle, panarchy, shock resilience and transformative change, in combination with traditional interpretations of agricultural adaptations in view of cultural and behavioural influences.

3.5 Devising the Conceptual Framework

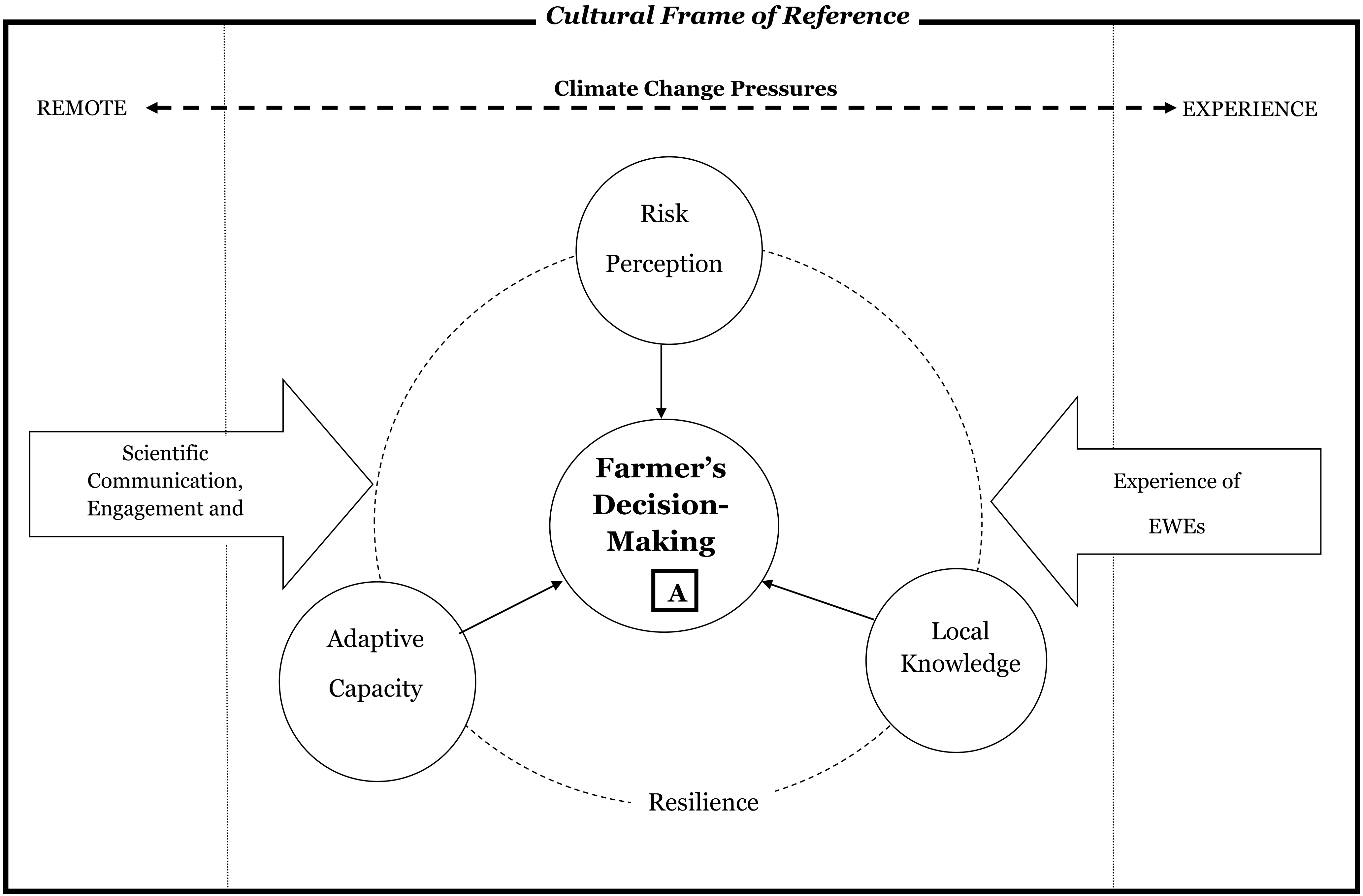
Chapters two and three have endeavoured to provide a synthesis of relevant literature and conceptual underpinnings. Building upon this literature with particular attention to the theoretical underpinnings presented in 3.1 and 3.2, a conceptual framework will be devised. Built upon the foundations of the literature previously evaluated, the conceptual approach will incorporate several ideas outside of agricultural geography itself, such as climate change communication (3.3), risk perception (2.4.2, supported by 1.3, 2.3.3), local knowledge (2.5.1, 2.3) , resilience thinking and adaptive capacity (3.4). The purpose of establishing this theoretical framework is to allow for the effective interpretation of farmers' resilience to climate change. Firstly, 3.5.1 will establish the notion of a cultural-behavioural approach. Secondly, 3.5.2 will provide a further explanation of the model explaining Figures 3.4 and 3.5. Thirdly, the intended application of the cultural-behavioural approach in this research will be outlined in 3.5.3.

3.5.1 Establishing a 'Cultural-Behavioural' Theory

It is apparent that culturally inspired studies are being overlaid upon existing behavioural and political-economic geographies of agriculture (Cloke 1997, Morris and Evans 2004). Subsequently, the conceptual framework is presented in Figures 3.4 and 3.5, established upon prominent cultural and behavioural constructs that have been explored throughout this chapter. It is the intention of the author to label this new conceptual framework as the 'cultural-behavioural' approach, drawing attention to the theoretical origins of this amalgamation. This approach has been devised in response to Burton's (2004b) recognition of the need to revisit the behavioural approach in light of the 'cultural turn'. Thus, all decisions and risk perceptions made in the framework are intended to be analysed in view of a farmer's cultural frame of reference and the cultural context in which the farm system itself is situated.

The cultural frame of reference is demonstrated in Figures 3.4 and 3.5 to provide a context in which farmers' decision-making and risk perceptions can be understood. In both Figures 3.4 and 3.5, a considerable focus has been placed upon how the individual behaviour of a farmer and particular characteristics of the farmer's personality, socio-economic circumstances, home and work life influence the 'economically irrational' decisions that are made. The interpretations of a farmer's decision-making (3.1.1) have been carefully considered in the creation of this cultural- behavioural approach. In particular, attention to the farmer's perspective of viewing decisions 'through the farmer's eyes' (Ilbery 1985), is a fundamental principle underlying this framework. It is recognised that these 'individual' decisions take place as part of a wider landscape of cultural processes including: political contexts, socio-economic backdrops, the media, local culture, and culture of the farm itself (shown in Figure 3.5). This philosophical approach endeavours to bring together farmers' decision-making, within the context of the established agri-'culture', by providing a cultural frame of reference around the decision-making environment. It is recognised that the individual process of decision-making is only individual to an extent, as it is still a process that is undergone by a farmer amidst a backdrop of a myriad of cultural processes, circumstances and influences.

Figure 3.4: Conceptualisation of the Development of Famers' Resilience to Climate Change



3.5.2 Explanation of the Conceptual Model

Figures 3.4 and 3.5 are considered to represent simultaneous processes. Figure 3.4, presents an overview of a conceptualised representation of the development of farmers' resilience specifically to climate change pressures. Figure 3.5 represents the specific dynamics of farmers' decision-making and so links into Figure 3.4. Figure 3.5 represents the complexity of farmers' decision-making in view of internal and external cultural influences. Each will be broken-down further to aid the reader's understanding.

Interpreting Figure 3.4

Figure 3.4 conceptualises the core processes involved in developing farmers' resilience (defined in 1.3). Within the cultural frame of reference it is envisaged that a series of processes and inter-connected relationships operate within the dynamic farm environment (3.2). Climate change pressures are external influences (beyond the farmer's control) upon the farm system (2.1) that trigger the cycle of development of farmers' resilience to climate change to commence. It is the increasing pressure of climate change that triggers the need for the development of farmers' resilience. Simultaneously, this pressure is conceptualised to also increase the need for scientific communication (3.3). Scientific communication is incorporated as an external process that flows into the process of developing risk perception in combination with local knowledge. The communication of scientific knowledge of climate change into the farm community is therefore conceptualised as a one-way process (Figure 3.1). This is where scientific knowledge is constructed upon scientific monitoring, and then translated into scientific communication that enters the resilience development cycle. Although simplified in this framework, it by no means eliminates the complexities of the process of scientific communication from either source of information to ensure that it reaches the farmer (Figure 3.1). Once scientific communication takes place, it is open to interpretation by the farmer, based upon their own judgements of trust and value. The extent to which scientific communication is interpreted and understood in relation to a farmer's local knowledge, determines the amount of information that informs the development of resilience and so, decision-making (3.1, Figure 3.5).

Conceptualised at the opposite end of this process, is the experience of past EWEs that informs the resilience process by allowing new pressures and events anchored against those experienced in the past (associated with local knowledge, 2.3). As climate change pressures increase, the wealth of a farmer's experiences due to an increase in frequency and intensity of events is envisaged to also increase. Similar to scientific communication, this experience of past EWEs is shown to flow into the development of resilience informing farmers' decision-making when faced with new, but comparable challenges to that of the past.

Central to the conceptualisation is the cyclical process of resilience development shown to evolve continually. The evolution of resilience is theorised to exist between risk perception (1.3, 2.3.3), local knowledge (2.3-2.4) and adaptive capacity (1.3, 3.4) representing a transformative change (3.4, 3.4.2). This is in view of Sinclair *et al.*'s (2014) recognition of the prevalence of transformative change in generating resilient farm systems. At the core is the complex process of a farmer's decision-making (detailed in Figure 3.4). Each concept in the cycle of resilience development is a fluid and dynamic process continually subject to change. Consequently, the level of a farmer's resilience as represented by the line connecting the three processes is dynamic, and so is continually evolving (in relation to resilience thinking theory 3.4). Each process and the evolution of resilience are conceptualised to have a direct influence upon the decision-making environment, and so flow directly into this process (Figure 3.4).

When interpreting farmers' responses to such complex issues such as climate change, it is important to consider scientific and 'local' knowledge equally, as both contribute significantly as receptors to change in the climatic system. Experiences of past EWEs create memories that are incorporated into local knowledge. This in turn influences a farmer's risk perception towards potential shock from possible future EWEs. Due to the relationship between EWEs and climate change (2.1.1), the lasting effect of the shock of an EWE is thought to influence a farmer's development of transformative resilience to climate change. Essential to this conceptual framework is the recognition of the importance of knowledge generated by alternative means rather than controlled scientific discovery. The use of local knowledge in farm adjustments can directly influence the information used to inform a farmer's decision in response to climate change. Adaptive measures are most often informed by a farmer's local knowledge and understanding of the land, climate and dynamics of the farm system.

In order for a farmer to form a risk perception of climate change, a complex process of framing of information is started where the information received is analysed in view of the context and the multitude of other information possessed by the farmer. Such influences include analysis of the farm business, a farmer's cultural and behavioural norm, and the flow of local knowledge and scientific communication (shown on Figure

3.4). These processes take place alongside an assessment of such information, resulting in the farmer's risk perception being formed. Risk perception is a highly fluid notion with the constant addition of information and experiences changing the ability of a farmer to assess the level of risk. Risk perception is a behavioural process; therefore it does not operate upon logical decisions or assumptions. The model does not necessarily imply that a particular farmer's response to climate information will lead to a perception resulting in action, or indeed that the motivation to take action is present. Likewise, an experience of an EWE does not always trigger a response. However, as shown in Figure 3.4, both are influencing factors in which decisions of possible responses are made. Furthermore, a positive perception of climate change that verifies the adverse impacts of changing conditions to be present and relevant to the farm system, does not necessarily result in the farmer believing that there is a need for action or even the belief that an action is feasible and would result in a positive change.

The evolution of adaptive capacity is conceptualised as heavily influenced by both risk perception and local knowledge. As discussed in 3.4, adaptive capacity is not a linear process. Instead, a series of phases as incorporated in the transformative panarchy model (Figure 3.3, 3.4.2, Gunderson and Holling 2002), are envisaged to take place involving the use of coping capacity and social capital (1.3). As demonstrated within the cycle of adaptive capacity in Figure 3.3, risk response processes take place amongst a cycle of assessment and development of the farmer's adaptive capacity. The establishment of the farmer's level of adaptive capacity is a complex process of analysis and continual fluctuation (demonstrated in 3.5). This incorporates a farmer's coping capacity and social capital to encourage adaptive change that decreases the farm system's vulnerability to the perceived risk. A farmer's adaptive capacity is conceptualised as the core process in which the estimation (perception) of the risk, vulnerability and resilience of a system is determined. Therefore, a farmer's adaptive capacity directly influences the ability to implement successful adaptations. Indeed, just as the system is continually evolving and undergoing change, so is the farmer's adaptive capacity. The greater the adaptive capacity when farm adjustments are implemented, the greater the likelihood is for their long-term success and ability to withstand short-term shocks through development of a higher level of resilience.

Farmers' decision-making is a complex process reliant upon a multitude of cultural-behavioural processes (3.1). As outlined in 3.1, a multitude of farm pressures are prevalent and so decisions must be interpreted within the decision-making environment in which they occur, rather than in sole response to the challenges of climate change. In order to ensure a holistic yet logical framework is constructed, Figure 3.5 presents a further deconstruction of a farmer's decision-making process to climate change, founded upon behavioural and cultural philosophical underpinnings theorised in this chapter.

Interpreting Figure 3.5

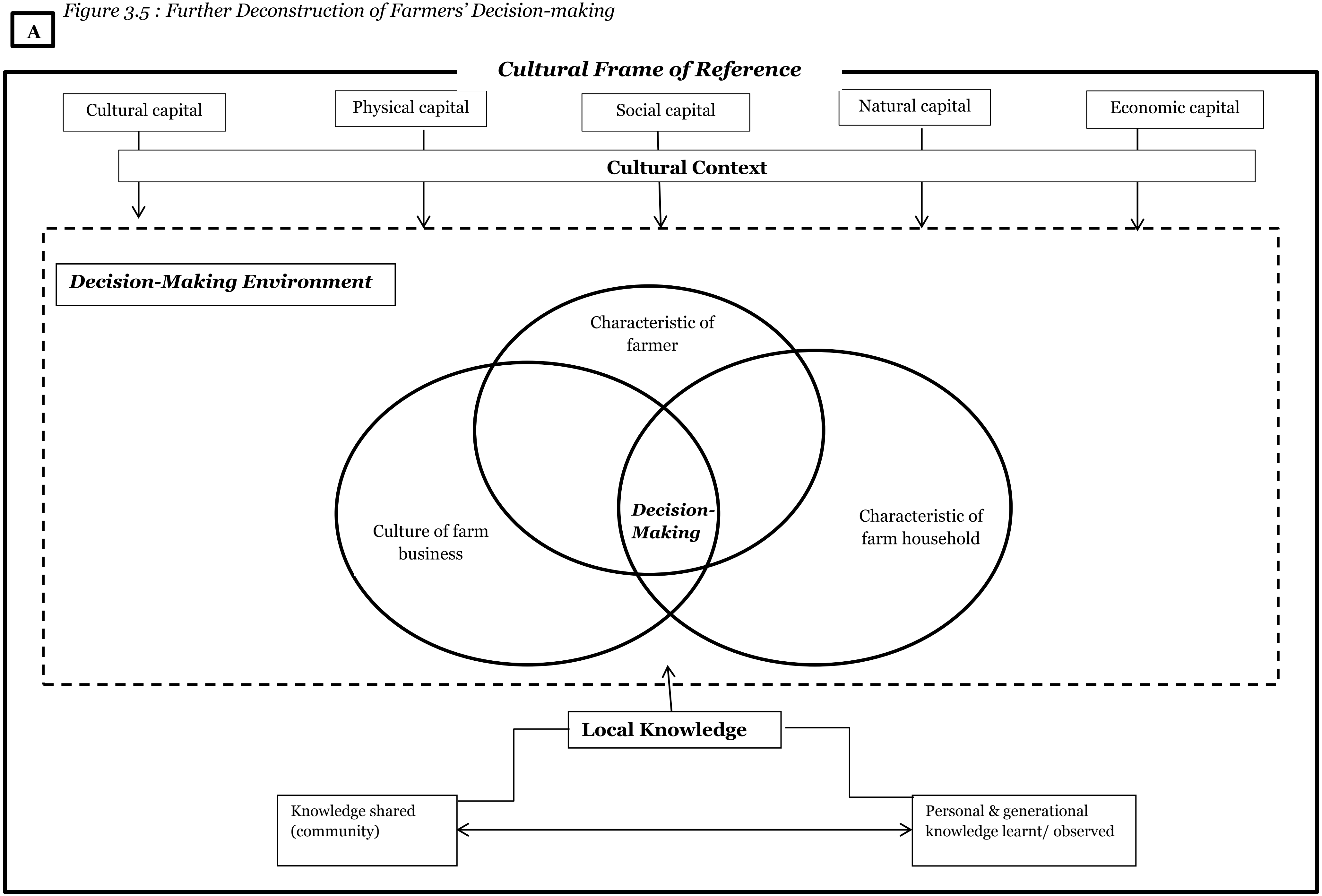
Figure 3.5 is a conceptualisation that has been devised to represent the convergence of cultural, with behavioural processes in the farm decision-making environment. The diagram details determinants of farmers' decision-making in relation to the development of farm adaptive capacity to climate change (Figure 3.4). Although the conceptualisation of decision-making is traditionally considered within the confines of a behavioural philosophical framework, this framework attempts to amalgamate key processes crucial to both cultural and behavioural theories. Local knowledge (2.5.1, 2.3), and livelihood assets (2.3) have been incorporated to represent the value of these processes in cultural decision-making. Comparable to Figure 3.4, the cultural frame of reference is represented on the outside which refers to the wide ranging processes and influences of key cultural factors (3.2).

The opening channels at the top of Figure 3.5 synthesise a network of social, cultural and economic capitals that are described by Burton *et al.* (2008) as essential in creating agri-'culture'. These are included alongside natural and physical capital incorporated into the framework to represent the five aspects of the sustainable livelihoods approach (2.3, DFID 1999). It is conceptualised that these capitals are influenced and transformed by the cultural context in which decisions are made, that then flows straight into a system of behavioural decision-making.

Within the decision-making environment the processes of a farm household, the farmers themselves and the culture of the farm business, are incorporated. The decision-making variables have been selected to most appropriately represent key factors discussed in 3.1. The culture of farm business signifies that the farm business itself creates a culture, environment and variables which influence a farmer's decision-making. The three decision-making variables interact together in influencing the decision-making process itself.

Outside of the behavioural and individual decision-making variables, the construct of local knowledge is depicted as flowing into the system. A distinction between knowledge that has been shared amongst a community and knowledge that has been

Figure 3.5 : Further Deconstruction of Farmers' Decision-making



gained through personal experience has been made to demonstrate the core components of local knowledge. As shown in Figure 3.4, the farm decision-making process as demonstrated in Figure 3.5 is conceptualised as influencing the development of farmer resilience through its influence upon adaptive capacity. Unlike the former, the latter diagram demonstrates the complexity of the farm system in which a multitude of pressures, risks and factors are assessed beyond a sole focus upon climate change.

This conceptual framework modelled in Figures 3.4 and 3.5, has attempted to summarise a construct of numerous systems and complex processes interacting together. It aims to map out a fluid and continuous process from information reception, to the formation of farmers' resilience through the complexity of cultural-behavioural processes. All components are significant in the process yet are not present all of the time in each individual case. Figure 3.5, endeavours to make an initial attempt to conceptualise the complexity of cultural-behavioural decisions, therefore it is in the very early stages of development. Likewise, Figure 3.4 is an amalgamation of key factors, processes and flows of information that may result in the determination of a farmer's resilience to climate change. Thus, although the author anticipates that several of these processes will be involved, in accordance with the philosophical basis of the cultural-behavioural approach, it is intended that both the processes represented in this conceptual framework are highly individual. Therefore, the exact process involved in developing resilience to climate change though cultural-behavioural influences are unique to each farmer.

3.5.3 Application of the 'Cultural-Behavioural' Approach in this Research

This 'cultural-behavioural' approach, is not just an amalgamation of theory, but is also reflected in the amalgamation of methods. The use of both quantitative and qualitative methods in agricultural geography has become common practice, yet often lacks a fully supported philosophical underpinning. The behavioural approach and assessment of the decision-making processes is founded upon the surveying and analysis of farm questionnaires. Indeed, this has proven to be effective in allowing a characterisation and overall understanding of key farm decision-making factors. However, a key downfall of the behavioural approach lies in complicated modelling and quantifying of decision making, primarily focused upon attaching numeric values to farmers' attitudes and values. The 'cultural turn', signified a need for more contextual and situational focused research, favouring in-depth qualitative approaches including non-structured and semi-structured interviews, focus groups and anthropological studies amongst a multitude of other methodological variations. According to these traditions a cultural-behavioural approach is most suited to a mixed methods approach which will be established in chapter four.

Consequently, this chapter has conceptualised the ‘cultural-behavioural’ approach as an amalgamation of the strengths of the behavioural approach in light of the ‘cultural turn’ in agricultural geography. Figures 3.4 and 3.5 have attempted to map out the key processes involved in this new philosophical theory in response to climate change. This lays the foundations for the research investigation in the following chapters.

Chapter four will detail the design of a suitable methodological approach in view of the cultural-behavioural approach. In accordance with the behavioural approach in agricultural geography, quantitative data collection was most favoured, whereas, the ‘cultural turn’ has encouraged agricultural geographers to favour qualitative methodologies. Subsequently, a prominent focus will be placed upon qualitative data collection, with an addition of quantitative data collection designed to inform the qualitative process. This represents the underpinnings of adopting a cultural framework with a behavioural element.

CHAPTER FOUR

INVESTIGATING FARMERS' RESILIENCE TO CLIMATE CHANGE THROUGH LOCALISED RESEARCH

"Conversation about the weather is the last refuge of the unimaginative"
Oscar Wilde (n.d)[17]

The need to investigate farmers' perceptions, knowledge and adaptive capacity to EWEs in the Welsh Marches has been outlined in view of predicted climate change. This chapter will focus upon the design of a tailored methodological approach and its application to this research in view of the cultural-behavioural approach. Due to this theoretical convergence, the pragmatist paradigm has been adopted as the main theoretical and ontological stance. This has allowed for the research question to be prioritised above theoretical restraints.

A multiphase approach consisting of both primary and secondary data has been employed using a sequential-explanatory approach (4.1). Phase one of data collection is detailed data analysis of local meteorological records from across the Welsh Marches in order to identify extreme weather conditions (4.2). This is cross-referenced with a thematic analysis of EWE impacts as reported in local newspaper archives (4.3), to establish understanding of challenges and impacts of EWEs upon the farm community. The purpose of the secondary data will be to inform phase two, some of the analysis of these data will be presented in this chapter as it formed an integral part of the design of the methodology. The data from the meteorological data, and to some extent the newspaper articles, are not intended to inform the findings of this research directly, but to inform the data collection in phase two.

Phase two consisted of 115 short questionnaires completed to establish a baseline of future farm stresses in the Welsh Marches (4.4). This was followed by 15 in-depth semi-structured interviews with selected farmers from the research area (4.5), and a

[17] N.d. between 1865-1900.

farmer focus group (4.6). This was conducted to explore potential future climate scenarios created to establish the challenges and opportunities recognised by the farm community in response to potential conditions triggered by climate change. This chapter endeavours to explain in detail the research design employed in this study. Sections 4.2-4.6 are dedicated to each data collection phase, and 4.7 will detail the qualitative analysis.

4.1 Methodological Approach

A sequential-explanatory approach utilising quantitative data to inform qualitative research has been employed. This section will demonstrate the relevance of this methodological approach to the conceptual framework (3.5). Firstly, the epistemology and ontology of the research will be outlined (4.1.1). Secondly, the relevance of adopting mixed methods will be outlined in view of its applications in agricultural geography (4.1.2). Thirdly, the research design will be explained explicitly (4.1.3). Fourthly, ethical and data protection considerations will be outlined in their application to this data collection process (4.1.4).

4.1.1 Theoretical Stance: Epistemology and Ontology

Every research tool is inextricably embedded in commitments to a particular version of the world (Hughes 2008). Ontological assumptions specify the relationship between the world and our human interpretations and practices (Braun and Clarke 2013). An ontological stance of pragmatism appears to be the most relevant to the conceptual framework based upon the convergence of both behavioural and cultural geographical schools of thought in agricultural geography (3.5).

According to Robson (2011), the reality of the world we experience and the emergent social world (cultural), together with the importance of the natural physical and psychological world (behavioural), is brought together within pragmatism. Pragmatism is praised for its 'what works' philosophy, advocating the use of diverse approaches valuing objective and subjective knowledge (Creswell and Plano Clark 2007, Robson 2011, Tashakkori and Teddlie 2009). As the pragmatist world view arises out of actions, situations and consequences, it can be directly applied to mixed methods research that draws liberally from both quantitative and qualitative assumptions in order to engage with the research question (Creswell 2009). Therefore, agricultural geographers (Fisher 2013b, Urquhart 2009) have increasingly applied such a stance. Pragmatism is associated with a subjective epistemological stance (Braun and Clarke 2013, Bryman 2012). Subjectivity is all-encompassing, taking account of a researcher's own values, assumptions and perspectives in the holistic analysis of research findings (Braun and Clarke 2013). Therefore, a subjective epistemology in combination with a pragmatic ontology has laid the theoretical foundations for the research design.

4.1.2 Qualitative and Quantitative Data Collection

The objective of using both qualitative and quantitative methods is to draw upon the strengths, and minimise the weaknesses associated with a single research method (Flick 2009, Johnson and Onwuegbuzie 2004, Tashakkori and Teddlie 2009). Triangulation of mixed methods allows for a comparison of the findings underlining their complementariness, facilitating a robust analysis leading to application in climate change research including Lorenzoni *et al.* (2007).

In agricultural geography, both quantitative and qualitative data collection have been subject to periods of popularity. The behavioural approach in agricultural geography is theoretically rooted in the tradition of quantitative data collection (Ilbery 1982, 1985 and Fisher 2013b). Quantitative surveys were considered as the primary means to characterise farmers' values, attitudes and belief systems to particular behaviours and actions (3.1.2, Edwards-Jones 2006, Gillmor 1986, Wallace and Moss 2002). In response to the 'cultural turn', qualitative data was favoured allowing agri-'cultural' geographers to explore a farmer's cultural identity, knowledge, values and practices due to the prioritisation of societal influences (3.1.1, Burton 2004b, Goodman and DuPuis 2002, Johnston and Sidway 2004). Succeeding these methodological movements, mixed methods in agricultural geography has grown in popularity within the last decade (Fisher 2013a, Tate *et al.* 2010, Urquhart 2009).

There are several forms of mixed methodologies which can be implemented including: triangulation, embedded, explanatory or exploratory designs implemented either simultaneously or sequentially (Creswell and Plano Clark 2007). From the mixed methods agricultural geography studies listed above, sequential designs feature in each, with a variance between the uses of exploratory or explanatory approaches. An exploratory approach is weighted towards quantitative research following an initial phase of qualitative research, utilised by Fisher (2013b), Lorenzoni *et al.* (2007), and Tate *et al.* (2010). Alternatively, Holloway and Ilbery (1996a) and (1996b) have applied an explanatory approach involving qualitative research following an initial phase of quantitative research. The latter is most relevant to this research and so this research follows the previously established logic of this approach.

4.1.3 Research Design

Figure 4.1 is a diagrammatic representation of the methodological plan for this research incorporating both quantitative and qualitative elements. A sequential explanatory approach is the most preferable mixed methods strategy. This allows the cultural-behavioural framework to be explored through holistic and in-depth social, cultural and behavioural analysis of the research question (Creswell and Plano Clark 2007). Data collection was divided into two distinct phases. Phase one consisted of cross referenced analysis of secondary data including local newspapers and Met office data, to establish an index of past EWEs known to have impacts upon farmers in the Welsh Marches. Phase two involved primary data collection with farmers, including quantitative surveys, qualitative interviews and a climate scenario based focus group.

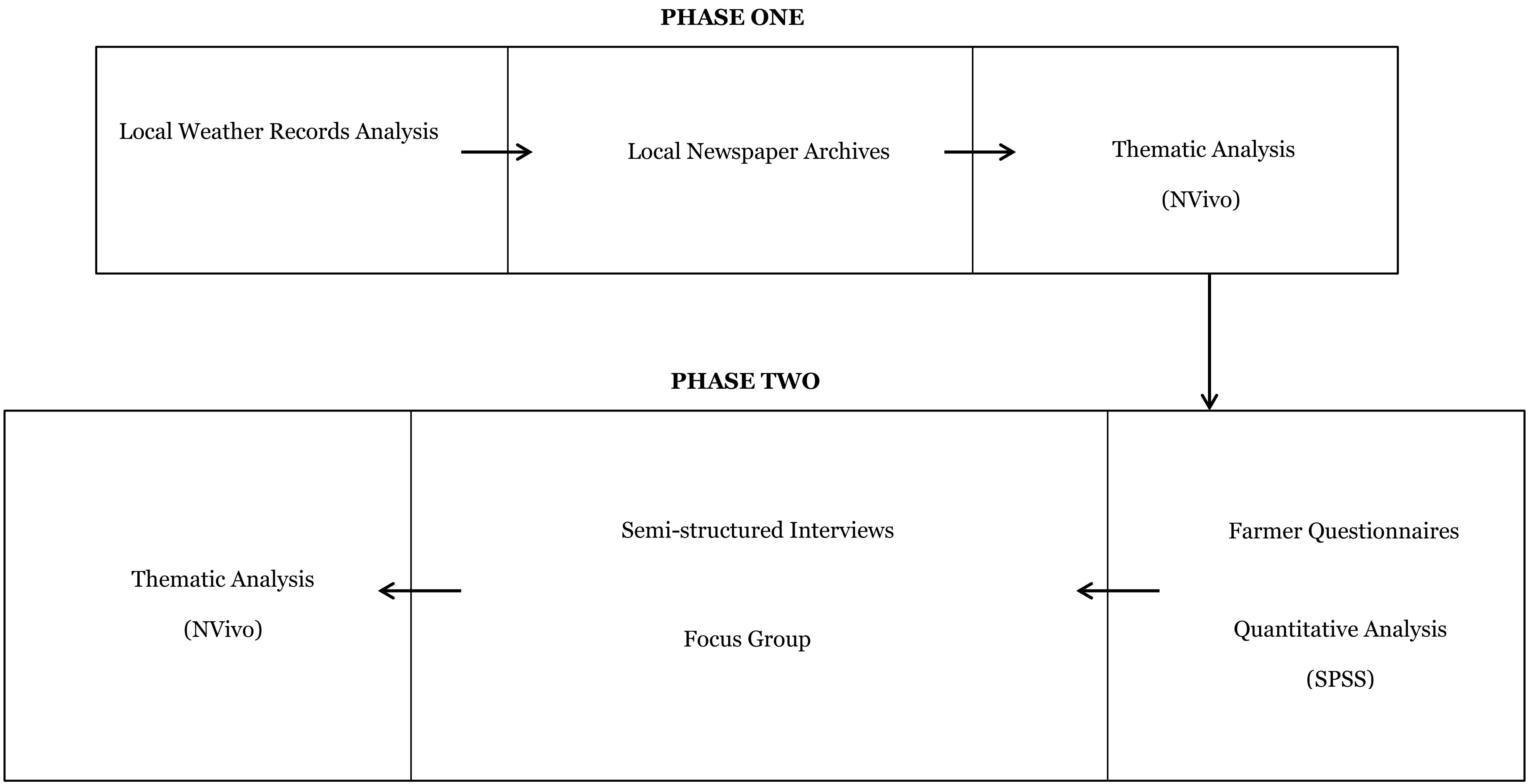
The design involved collecting and analysing quantitative then qualitative data in two consecutive phases (Ivankova *et al.* 2006), therefore allowing for the outcomes of the first quantitative phase to link into and inform the second qualitative phase. Figure 4.1 demonstrates the role of phase one to provide the background data needed in order to conduct phase two, and also demonstrates that the research is weighted heavily towards the qualitative data, with the quantitative data serving a supportive role. As part of the research design preliminary quantitative data collection was conducted to aid the recruitment of participants for the subsequent interview stage, in accordance with the 'participant selection model' (Creswell and Plano Clark 2007).

Research Implementation

The questionnaire and focus group stages were conducted at local agricultural events (4.4.3, 4.6.4). In order to maximise the research opportunity and generate a high response rate, additional research help was required. Three research students at the University of Worcester provided this assistance; therefore they had a good research understanding of both the particular methods being used and research ethics.

Each researcher was fully briefed on how to recruit potential participants, the research instruments employed (either questionnaire or climate scenarios) and any likely questions or enquiries to be generated. The lead researcher was present throughout the entire process to ensure that data collection was thorough and the quality of responses

Figure 4.1: Research design utilising a sequential explanatory approach



was secured by clarifying any queries as they were raised. Use of additional researchers may have had implications in the way questions were asked, and the nature of responses generated, and so these were closely monitored by the lead researcher.

4.1.4 Ethical and Data Protection Considerations

Due to the nature of research involving human participants, principles of the ESRC (2012) framework for research ethics have been applied in the research design. Throughout the collection of primary data, care has been taken to ensure that the research was designed, reviewed and undertaken to ensure integrity, quality and transparency (ESRC 2012).

Data collection in phase one required established procedures to be followed in data handling. The University purchased local meteorological data from the Met Office on an academic research licence (4.2). These data were only accessible by the researcher and kept on a password protected private folder. The archival research (4.3) required the researcher to apply for prior permission from the archive holders and adhere to the rules of that institute[18].

In phase two, ethical considerations were focused towards protecting participants; guaranteeing participant confidentiality during data collection and analysis. In accordance with data protection, the analysis of the quantitative study ensured that no responses could be attributed to a particular participant as individual identifiers were used for data entry (4.4). The completed questionnaires and qualitative transcripts (4.5-4.6) have been kept in dated and signed sealed envelopes in a locked cabinet when not in direct use. Participant contact details have also been kept confidentially on a password protected file. In the interview and focus group stage, ethical considerations were implemented with use of a participant consent form (Appendix G), which explicitly stated the research purpose, requirements of participating, and the intended use of data generated.

As the interviews were seen as a personal and lengthier commitment, prior to consenting to an interview participants were informed in full about the purpose of the research and intended use of outcomes via participant letters and leaflets. These were sent out to all potential participants prior to arranging a visit (Appendices C and D). Before commencing the interviews and focus groups, participants were given an option to opt out of the process, and were asked to give separate permission for a full

[18] reading and copying licences were purchased when required.

recording for research use on a MP3 recorder. During the qualitative data analysis, confidentiality of information was respected with the assigning of pseudonyms in the transcriptions. All interview consent forms, interview notes and focus group consent forms are kept in signed and sealed envelopes in a locked cabinet.

4.2 Phase One: Use of Local Meteorological Records

To assess farmers' perceptions of climate change and experiences of past EWEs, it is necessary to first establish the general climate conditions that are experienced in the southern Welsh Marches. This allowed 'extreme' events to be identified as occurrences where the weather conditions deviate away from the 'norm'. Observed climate trends from 1961-1990 are utilised by Defra (2012a, 2.1.1) to establish the recorded change in climatic conditions across the UK. However, few documents provide such observations of average conditions at a local level. To create an accurate baseline to enable the identification of past extreme events with which farmers' observations and memories can be compared, it was deemed necessary to conduct a basic analysis of data from local weather stations.

Convention in climate change science is to utilise a 30-year period to establish average changes in the climate. This timeframe is considered long enough to provide annual average and seasonal climate variables (Defra 2009). A 30-year timescale from 1st January 1982 - 31st December 2011 was selected for this analysis of local weather conditions. Local weather data were provided by the Met Office recorded at weather stations in: Shawbury (Shropshire), Ross-on-Wye (Herefordshire) and Pershore (Worcestershire), representing three Marches counties.

Due to the nature of using such secondary data, it was necessary that the raw data files went through a long process of refinement, required to ensure each dataset was consistent. Difficulty was incurred due to the long time-scale required and problems with consistency of data experienced by each of the weather stations. In Worcestershire, the station originally at Pershore College moved to its new facility in 1995. In this case, a 4-year overlap of data from 1995 until the Pershore College weather station was closed in 1999, allowed for calibration and amalgamation of both data sets. The station in Shawbury also underwent equipment change in 1999. However a lack of overlapping period has meant that a calibration of these data sets cannot be completed. The data obtained from Ross-on-Wye commences from 01/06/85, therefore there is a lack of data from Herefordshire before this period. Nevertheless, the amalgamation and comparison of these data sets has allowed for a database of local weather records to be established.

This section will provide an overview of the present-day climate in the Welsh Marches (4.2.1), as well as allowing for past EWEs to be identified (4.2.2 – 4.2.3) to provide an index that will inform the newspaper analysis. Data will be presented in 4.2.2 and 4.2.3 to serve the purpose of informing the second stage of phase one (4.3), as opposed to presenting data that will inform the results of this investigation on its own merit.

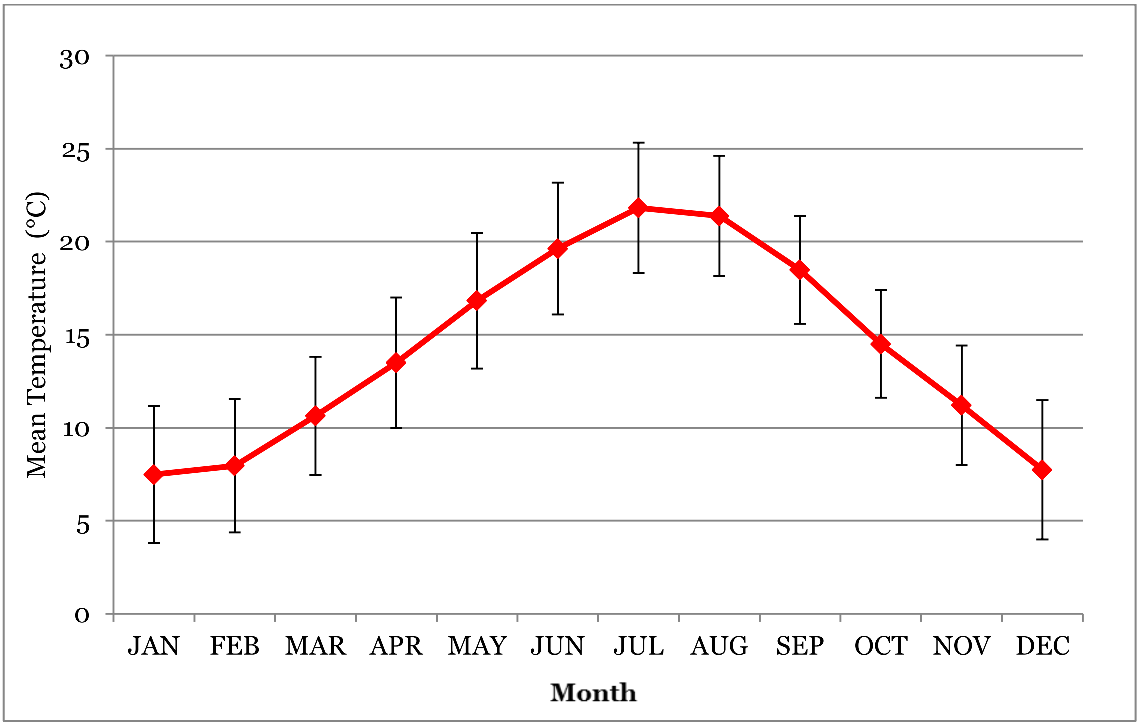
4.2.1 Establishing Climate Baseline

The datasets obtained from the Met Office included several variables of consistent and inconsistent data. To overcome this, the most relevant weather variables to this research were identified as: maximum temperature, minimum temperature, diurnal range (calculated from minimum temperature subtracted from maximum temperature), and the amount rainfall received in 24 hours. Inconsistencies in the recording of other conditions such as sunlight hours and air frost meant that they had to be excluded.

The amalgamated weather records were entered into Excel where graphs demonstrating average climatic trends and conditions over the 30-year period were constructed to establish a climatic baseline. After consideration of the graphs created for each weather station, it was deemed appropriate only to include in this chapter the graphs of the amalgamated dataset of all three weather stations, providing a general overview of climate trends and average weather conditions in the three counties. This was to build a more complete climate profile of the region as a whole, enabling a baseline to be established that is applicable as a comparison for all data collected in the subsequent phases. To allow for an understanding of the present-day normal conditions, the average conditions from the meteorological records will be outlined below to create a benchmark allowing further methodology to be applied.

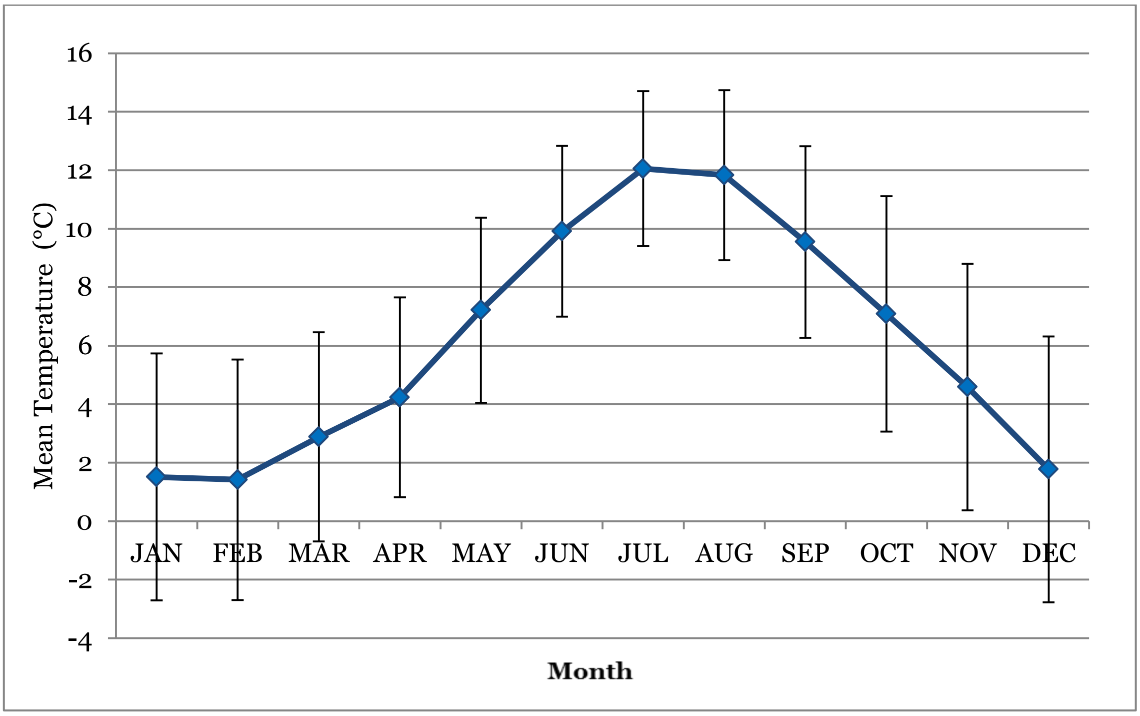
The mean daily recorded maximum temperature is 14.2°C, with the average mean temperature lying at 10.2°C. Figure 4.2, provides a mean maximum temperature graph, demonstrating the average maximum temperatures of each month, across all three sites between 1982 and 2011. The spread of the data is calculated using standard deviation that ranges from 2.9°C – 3.7°C from the mean, dependent upon the month, and is shown using error bars as an outline of the average monthly maximum temperatures.

Figure 4.2: Mean monthly maximum recorded temperature for the Welsh Marches 1982-2011



Source: Local meteorological records provided by the Met Office

Figure 4.3: Mean monthly minimum recorded temperature for the Welsh Marches 1982-2011

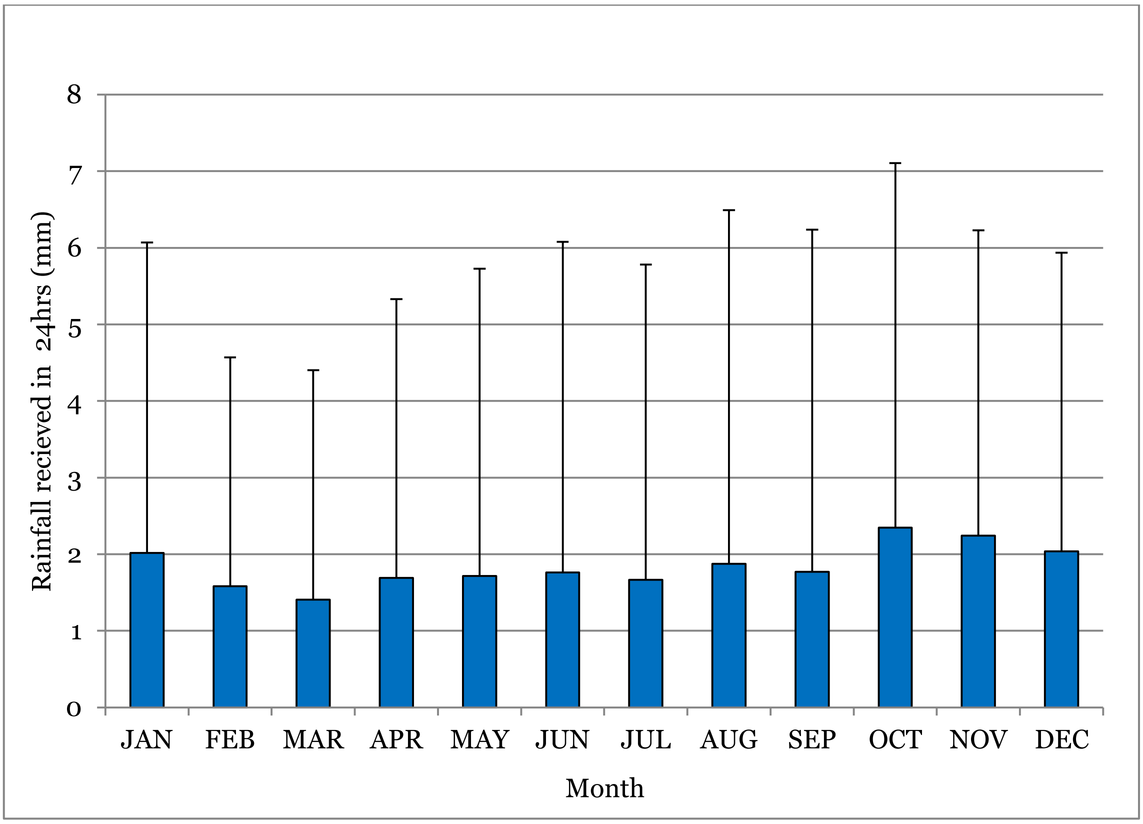


Source: Local meteorological records provided by the Met Office

Figure 4.3, demonstrates the average monthly trends across the three counties in minimum temperature from 1982 to 2011. The range of minimum temperatures recorded varies from -21.4°C recorded in Shawbury on 11/01/1982 to 20°C recorded in Ross-on-Wye on20/07/06, with a mean recorded annual minimum temperature of 6.1°C and standard deviation of 2.64 to 4.54°C[19].

Temperatures recorded in the three counties between 1982-2011 ranges from +35°C to -21.4°C. Diurnal temperature range has been calculated to establish the average difference between the recorded maximum and the recorded minimum temperatures. The mean daily diurnal temperature range is 7.2°C, although some seasonal shifts are apparent.

Figure 4.4: Mean Recorded Rainfall (per 24hrs) for the Welsh Marches 1982-2011



Source: Local meteorological records provided by the Met Office

Rainfall is recorded on a 24-hour basis from 0900-0900. This creates a standardised measure of the amount of precipitation received in a set period. This may lead to considerable distortion when trying to establish the amount of rainfall received during an extreme event such a flood, which is not always likely happen between these set times. If intense rainfall was to occur from 0400-1200hrs, the amount of rainfall

[19] As represented in the error bars calculated on Figure 4.3

received would then be split over two different dates giving a false impression that half the amount of rainfall was received than was actually the case. Figure 4.4 depicts the mean rainfall recorded in 24 hours per month, across the three counties from 1982-2011. The wettest period is from October to December. The wettest month is October with 2.34mm of rainfall received exceeding the 1.84mm annual average.

4.2.2 Identifying Extreme Weather Events

The purpose of identifying extreme values was to establish when past EWEs occurred and to provide an indication of the magnitude and frequency of the event as scientifically recorded (Tate *et al.* 2010). This was seen as a valuable process to allow some indication of the variance between EWEs as scientifically recorded, and farmers' memories of EWEs incorporated into local knowledge. By manipulating these data into a list of the most extreme events as scientifically recorded, the convergences between the 'remote' and the 'experience' could be calibrated. This is intended to provide some indication of the variance between the most 'extreme' events as identified in scientific data, and the most 'extreme' events as recalled by the farm community. This will aid the understanding of the extreme conditions that will expose the most vulnerability in farm systems from experience, in relation to the magnitude scientifically recorded.

Meteorological data was then entered into SPSS 21, allowing standard deviation to be calculated. As the data allowed extreme conditions to be identified on an individual site (county) basis, it was deemed appropriate to treat each site individually. This allowed individual county extreme events to be compared and analysed, providing a comparison of local events and scale. Standard deviation calculates the spread of 95% of the data to be identified. The individual recorded values under each condition were subtracted from the standard deviation value. The highest values signified a recorded value furthest away from the mean value for that condition. This allowed the construction of 'extreme' values that were identified generating an index of the 'most extreme' values.

To identify when an EWE occurred, readings from the index of 'most extreme' values, were amalgamated according to date and location of occurrence. A series of extreme readings for consecutive dates across all three counties and multiple extreme weather conditions recorded were ranked highest. Whereas, individual 'one off' readings of extreme conditions were ranked lower. From the ranking of each event, the ten most 'extreme' events as scientifically recorded that deviate the most from the mean, were created. Table 4.1 provides the list of extreme events established. The creation of Table

4.1 provided an index that informed the selection of the most relevant local newspaper articles identifying the local impacts of EWEs as they occurred (5.3.3).

Table 4.1 provides an indication of the local meteorological conditions that were recorded and a brief summary of the reported impacts on the ground from local newspaper articles. The purpose of the local meteorological data analysis was to establish the variance between the reported conditions and impacts reported in local newspaper articles (4.3). To serve this purpose, the initial impacts indicated from the newspaper articles are included in Table 4.1. The information from newspaper articles was identified using the meteorological data as an index which provided a list of dates to explore in the newspaper archives. However, a greater description of the detail of these articles and how they were collected and analysed will be provided in 4.3 and the key findings from this analysis in combination with first-hand accounts (4.5) will be presented in Chapter five.

From Table 4.1, it is apparent that there is some but not absolute correlation between the event rank and the number of newspaper articles that were found in the corresponding newspaper for that event date. Nevertheless, the most severe event in the meteorological records does correlate with the most number of articles. However, the event with the second most number of articles was ranked the third most extreme. In accordance with the scale of impacts reported in the articles (Table 4.1), the number of articles provides an indication of the scale of impact. As such, the EWEs with the most severe damage have the highest amounts of newspaper articles written about them, and the largest impacts reported in local newspapers. This has provided some indication that the impacts as remembered by farmers on the ground and incorporated into local knowledge do vary from the severity indicated in the meteorological records. Contrary to the anticipated, the number of newspaper articles covering an event does not appear to vary by weather condition. Instead, the coverage does seem to represent the scale of impacts as reported on the ground, regardless of whether a heatwave, cold snap or rainfall event occurred.

4.2.3 Identification of Flood Events

Rainfall events were not included in Table 4.2 because a direct comparison to other weather conditions is not possible within the scope of these data. There is a considerably large range of rainfall recorded, creating a much higher standard deviation than for the temperature records. The nature of rainfall records allows for

Table 4.1: EWEs Ranked According to Standard Deviation and Consecutive Days of Extreme Values (continued overleaf)

Event Rank [20]	Dates (extreme values recorded in event)	Counties Affected [21]	Weather Condition Recorded	Most Extreme Value Recorded	Number of Newspaper Articles Found in Archives	Main Impacts Reported
1	9/01/1982 – 16/01/1982	H, S, W	Minimum Temperature	-21.4°C (S), 28cm Snow	22	Growers struggle to harvest crops, causing crop shortage. All root crops and green vegetables had been wiped out by freezing weather. Milk wastage as access to dairy farms blocked by severe snow for 2 weeks. Thousands of sheep lost in snow drifts. Flooding after snow thaw.
2	18/07/2006-31/07/2006	H, S, W	Maximum Temperature	35.4°C (H)	14	Drought, incredibly hard ground causing difficulties in ploughing, silage and hay making. Record temperatures reported. Water shortages, reports of livestock heat stress. Severe fodder shortages.
2	19/12/2010 – 27/12/2010	H, S, W	Minimum Temperature	-19.5 (W)	10	Cold conditions present difficulties for growers. Sheep lost in snow.
4	12/07/2003 – 09/08/2003	H, S, W	Maximum Temperature	33.9°C (W)	17	Severe impacts of heatwave, tractor blaze reported and fire warnings issued for dry fields. Growers take advantage of hot weather to harvest/ haymaking.
5	02/08/1990 – 03/08/1990	H, S, W	Maximum Temperature	35°C (H)	13	Water shortages widespread, heat stress reported in pigs.
6	06/01/2010 – 14/01/2010	H, W	Minimum Temperature Snow	-12°C (H) 18 cm (H)	5	River freezes over. Snow impacts widespread, cold conditions difficult to overcome.
7	01/08/1995-03/08/1995	H, S, W	Maximum Temperature	33.2°C (H)	8	Heatwave widespread, drought panic across counties. New 'bug invasion' reported due to hot weather. Successful hay making in hot weather.

[20] N.B. events ranked the same were deemed to have an equal weighting in severity (the same variance away from the norm) and therefore hold an equal event ranking.
[21] Counties abbreviated to first letters: H= Herefordshire, S = Shropshire and W = Worcestershire.

Table 4.1: EWEs Ranked According to Standard Deviation and Consecutive Days of Extreme Values (continued)

8	20/12/1999-21/12/1999	H	Minimum Temperature	-12.7°C (H)	3	No reported impacts
9	13/01/1987	H, W	Minimum Temperature	-12.9 °C (H)	6	Snow storm reported. Crop losses mount as harsh winter sets in. Vegetable prices rise at markets as a result
9	10/02/1991	H	Minimum Temperature	-9.6°C (H)	5	Snow and ice causing issues.
9	21/07/1989	H	Maximum temperature	31.9°C (H)	3	Heatwave reported, some crops burnt.
9	12/07/1994	W	Maximum Temperature	33°C (H)	2	Drought reported – hosepipe ban.

Source: Local meteorological records provided by the Met Office and impacts identified from local newspapers

Table 4.2: Reported Flood Events From Archival Analysis

Dates of Extreme Rainfall Values Recorded	Counties Affected	Most Extreme Value	Number of Articles Found on Event	Main Impacts Reported Indicating Flooding Took Place
25/08/1986	S, W	44.2mm in 24hrs (P)	4	Intense rainfall (Shropshire Star 1986a) Flooding on farmland (Shropshire Star 1986b)
16/09/1989	W	38.8mm in 24hrs (P)	2	Poor harvest and fungus spreading across trees due to the damp, flood rescues (Worcester News 1998)
01/08/1992	H, W	69.4 mm in 24hrs (R)	1	Rescues of residents during flash flooding (Hereford Times 1992)
22/10/1998	S, W	52.8mm in 24hrs (P)	17	Severe flash flooding. Approximately 100 homes flooded, Villages (Bishampton) cut off, flood rescues, considerable financial losses of infrastructure, housing and businesses, National and European aid required for recovery in Worcestershire. 'Flood special' issue of Evening News produced (Worcester News 1998). Farmer died moving sheep to higher ground (Shropshire Star 1998), farmers forced to move livestock to safe ground or inside own homes (Shropshire Star 1998)
29/10/2000 – 5/11/2000	H, S	54.1mm in 24hrs (R)	13	Flooded roads (Hereford times 2000), 'record' floods (Shropshire Star 2000a), flood rescues (Shropshire star 2000b– bucket rescues)
13/05/2007, 24/06/2007 20/07/2007	H S, W	52.5mm in 24hrs (R)	16	165 flood rescues (Hereford Times 2007a), villages evacuated, homes, roads and infrastructure damage (Hereford Times 2007), significant farm impacts (Farming Times 2007).
05/09/2008	S	39.2mm in 24hrs (S)	5	Widespread flooding, failure to harvest crops (Shropshire Star 2008). Financial cost of clean-up, infrastructure damaged (Shropshire Star 2008).

Source: Local meteorological records provided by the Met Office and impacts identified from local newspapers large spread of data because the range varies from readings of below 0.1mm in the 24 hour period, as received on 40% of days recorded, compared to 69.7mm, as received in Ross-on-Wye on 8/1/1992. Around 11.8% of recordings are of rainfall above 0.5mm, less than 4% of recorded rainfall days across all three counties are measured above 10mm. Another reason for rainfall measurements to be less applicable in standard deviation analysis is that rainfall measurements are given from set times of 0900-0900hrs. Therefore, the timing of the rainfall will determine whether the intensity and volume of rain will coincide with the monitoring period or will be split over two monitoring periods, thus creating a false impression of a reduced volume of rainfallA flood event differs from other weather events, as it is reliant on a multitude of factors beyond the volume of rainfall. These include flood management measures, drainage basin, sediment, proximity to settlements, capacity of flood plain and rock type to name a few. Therefore, occasions have been identified in this analysis where extreme rainfall was recorded yet flooding was not apparent.

This data analysis has allowed for the identification of the highest volumes of rainfall within the monitoring times. These events were then researched in the newspaper archives (4.3.3) allowing Table 4.2 to be formed detailing intense rainfall events that were reported as having resulted in local flooding. The limitations of this analysis do not allow for all flood events across the case study region to be identified over the 30-year period; however Table 4.2 does list most of them.

4.3 Phase One: Newspaper Analysis

Section 4.2 described the process of creating a table of EWEs from 1982-2011 in the Welsh Marches, to be used as an index of past events to research in the local newspaper archives (Tables 4.1 and 4.2). This part of phase one is required to complete the baseline of previous events as impacted upon the Welsh Marches community (reported in local newspaper articles). Section 4.2 provided an overview of the first role of utilising secondary data, to provide an indication of impacts experienced on the ground compared to the associated conditions recorded in meteorological records. This section will provide a detailed account of the second role of analysing local newspaper articles: to establish experiences and impacts of past EWEs on the farm community in the Welsh Marches.

4.3.1 Value of Local Newspapers in Assessing Past Events

Local newspaper articles give a picture of the impacts of EWEs as experienced at the time of occurrence. This provides an indication of the level of risk of EWEs on the farm community that can be established based upon previous occurrence and reported impacts upon farmers (5.1.1). The role of farmers as part of the wider community can be established from analysing their reported involvement in assisting in past response operations following an event (5.3). This will then allow for an informed assessment of the future risk and probable impacts that could be incurred by the farm community, in view of the predicted increase of frequency and magnitude of EWEs due to climate change. This baseline of local impacts of EWEs on the farming community is necessary due to the lack of comparable research projects in the UK (2.5).

The purpose of local newspapers can be described as telling a society about itself (Franklin 2008). The analysis of such articles enables a valuable insight into local weather events, although they need to be understood within the context of the original purpose of publication. The 'newsworthiness' of a story is judged according to the way it can depict (either positively or negatively) climate change. A significant bias in the events and impacts reported in the press is created based on likely interest to the target audience (Boykoff 2007). Local newspapers are shown to be a crucial source in portraying local events and communicating local environmental information (Wakefield and Elliot 2003). As well as providing accounts of conditions 'on the ground' as they were experienced, local newspaper articles provide an insight into the flows of information that underpin the construction of new risk perceptions within a community (Wahlberg and Sjoberg 2000). Consequently, this analysis facilitated some insights into the means of communication by which the local community are receiving information and develop risk perception of weather events (4.5).

4.3.2 Newspaper Articles Analysis

Archives dating from 1982-2011 of the Shropshire Star, Hereford Times and Worcester News were investigated. As demonstrate in Table 4.3, all of the newspapers are considered comparable to each other, yet differences between styles, language, and regularity of publishing and average circulation figures are apparent. The differences present a range of 'journalistic norms' including: the format, style, diversity of stories, language and target audiences (Table 4.3 Smith and Joffe 2009).

Table 4.3 : Overview of Newspapers Interrogated

Newspaper	**Paper Style**	**Archives Available (from 1982-2011)**	**Frequency of Publishing**	**Average Circulation (ABC 2012)**
Evening News (1982-2005) Worcester News (2005-present)	Local with National edge, slight tabloid style.	Microfilm all issues Held at the Hive archives (Worcester)	Daily except Sundays	12,664
Hereford Times Farming Times Supplement within	Localised - supplements inside including farming times in every issue, along with the farming weather forecast.	Microfilm all issues available 1982-2011 Held at Hereford Library	Weekly – some issues with the published date in relation to the last event, goes to press two days before publish date.	30,612
Shropshire Star	Wider, national focus alongside local / regional perspectives. Tabloid style is evident throughout.	1982-1999 Microfilm 1999 - 2011 Loose paper storage Held at the Shropshire Archives	Daily	46,489

4.3.3 Analysis of Phase One Qualitative Data

The thematic analysis using NVivo10, was designed to establish key themes in the data that would directly inform the design of research tools implemented in phase two (for value of software see 4.7). The index of EWEs established in Tables 4.1 and 4.2 provided a list of dates in which extreme weather conditions were known to have occurred in the Welsh Marches. Each date that an extreme event had been recorded was searched for in the relevant archive. Therefore, if an event had been recorded in just one county only the relevant newspapers to that county were interrogated for that specific date. Every article related to the weather event was recorded in an Excel database (203 entries). Only those articles that reported specific impacts of the event on the local community or specific to farming, were then included in the thematic analysis in NVivo10. Overall, 164 articles were included in the thematic analysis. From these, 61 articles were from the Shropshire Star, 55 from the Worcester News and 48 from the Hereford Times. Obtaining a digital version of each article by microfilm scanner or digital photographs, allowed for each article to be uploaded directly into NVivo10. This meant that each article could be analysed in keeping with its original format and context, allowing for photographs, text, font, style and language to be assessed when looking at each article as a whole.

Table 4.4: Percentage of Newspaper Articles for Each Attribute

Attribute	Percentage of Articles
Newspaper	
Hereford Times	28.8%
Shropshire Times	37.4%
Worcester Times	33.7%
Date Published	
1982-1991	26.4%
1992-2001	25.2%
2002-2011	48.5%
Type of Weather	
Max Temp	31.3%
Min Temp	30.7%
Rainfall/Flooding	38.0%
Specific to Farming	
Yes	43.6%
No	55.8%

NVivo is designed to assist in the undertaking of analysis of qualitative data, with the software improving the effectiveness and efficiency of such analysis (Bazeley and Jackson 2013). NVivo software was chosen as a tool to conduct qualitative analysis as it provides an ideal platform to analyse a multitude of different qualitative data in a single file using the same coding frame (Bazeley and Jackson 2013). The purpose of such software is not to displace time-honoured ways of learning from data but to increase the efficiencies to manage the data and examine the meaning of what has been recorded (Bazeley and Jackson 2013). To ensure the quality of data, each source was coded individually avoiding auto-code functions available which might have compromised the quality of the coding. The use of this software allowed for the researcher to interrogate the newspaper articles at length observing themes and trends relevant to the research question (Bazeley and Jackson 2013). NVivo was particularly favourable due to the ability to incorporate considerable amounts of different sources including copies of newspaper articles as pictures files, and the ability to code different parts of the picture files accordingly. Therefore, a headline could be coded differently to the accompanying picture in the article in accordance to the theme identified. This aided the effectiveness of identifying patterns and themes amongst newspaper articles.

Passages of text and images were coded according to observed patterns and themes, where nodes[22] were created to signify different patterns in the articles. Attributes that were used are demonstrated in Table 4.4 with the number and percentage of articles coded under each. As shown in Figure 4.1, the themes and findings from the analysis of data from phase one directly informed the design of research instruments in phase two. The most effective part of this analysis was in the amalgamation of nodes into collections, identifying the key findings. This process of data analysis set the precedent for data analysis of phase two (4.7).

4.4. Phase Two: Farmer Questionnaires

Having interrogated secondary data, a context of past extreme weather events has been established, both from those events recorded scientifically and the reported impacts as experienced at the time of occurrence. In order to establish the specific impacts of past EWEs on the Marches community and establish an understanding of future concerns and possible responses, primary data needs to be collected. Sections 4.4-4.6 will

[22] See Bazeley and Jackson (2013) for description of nodes, classifications and attributes in NVivo10.

explain the primary data collection process and the purpose of each stage. As with phase one, each primary data collection stage informed the design of the next (Figure 4.1). To commence phase two, quantitative data was employed to gain an impression of farmers' experiences and concerns. This subsequently informed the in-depth qualitative data collection (4.5, 4.6).

Questionnaires are widely used across agricultural geography and climate change research (Reid *et al.* 2007, Smit *et al.* 1996). There were two primary objectives of the questionnaire process to establish farmers' experiences of EWEs, and farmers' concerns for the future on their farm. The questionnaire was designed to explore: farmers' memories of EWEs, knowledge of the weather and concerns for the future on their land. Moreover, the questionnaires were designed to serve the purpose of facilitating recruitment of farmers deemed suitable to share their experiences and opinions further in the interview process (in relation to the participant selection model discussed in 4.1.4, Creswell and Plano Clark 2007). Farmers with significant experiences and concerns of extreme weather were identifiable from the questionnaire and so were asked if they were willing to take part in the interview stage (4.5.3).

4.4.1 Devising the Questionnaire

In order to maximise the opportunity of potential responses from farmers within the Welsh Marches, it was decided that conducting the questionnaires at agricultural shows would provide a captive audience. The intention was to gain a maximum number of immediate responses from the specific target group. This was in response to the difficulties often experienced in conducting postal surveys with farmers, where low response rates are probable. The Royal Three Counties Agricultural Show provided a suitable arena in which questionnaires could be conducted face-to-face with farmers from a wide variety of backgrounds, experience, farm enterprises and locations. From conducting surveys at such a prestigious event situated within the study area, a proportion of farmers were from the Welsh Marches, whereas others were from further afield across the UK. This was a desirable mix allowing for experiences in the Welsh Marches to be analysed in comparison to those across the UK. The Shropshire agricultural show is a smaller yet comparable event to the Royal Three Counties show and provided an opportunity to pilot the questionnaire (4.4.2).

The objectives detailed in 4.4, formed the basis of the questions devised for this survey. To optimise the number of possible respondents and make the questionnaire appropriate for the busy setting of an agricultural show, it was limited to one side of A4.

The questionnaire was also designed to be conducted face-to-face by a researcher who could guide respondents through the questions to ensure richness of data and clarification of any ambiguity. Accordingly, it was decided that a minimal layout of three questions to explore basic demographics of the sample and three key questions exploring the main research aims were required. To establish influences of variations amongst farmers, the main demographics included in the questionnaire were selected as: farm location, farm type, and the length of time the farmer had spent on the farm (Questions 1 – 3 in Appendix B). Questions 1 and 3 were based upon standard demographic questions asked by agricultural geographers (Ilbery 1985). Question 2 was based upon the categories utilised in the Defra (2012c) agricultural census.

Three key questions to address the main research aims exploring famers' past experiences of weather events, knowledge of the weather and concerns for the future, were deemed to provide enough information for the interviews and focus groups to pursue (Appendix B). Question 4 was designed in view of Belliveau *et al's.*(2006) recognition of multiple risks in agriculture, with climate change being one of many (4.4.2). Therefore, question 4 (Appendix B) allowed the researcher to establish the concern of EWEs amongst a backdrop of numerous future risks identified by farmers (informed by Reid *et al.* 2007, Ambler-Edwards 2009). The fifth and sixth questions were designed to address the role of tacit knowledge, of past experiences and information seeking, in view of the literature and conceptual framework (see Appendix B, as discussed in 2.5.3).

<u>4.4.2 Conducting the Questionnaires</u>

Piloting at the Shropshire Agricultural Show

The nature of the questions meant that it was important to ensure that questions were worded and designed with consideration (Bradburn *et al.* 2004). These factors were considered during the piloting process. The pilot phase took place at the Shropshire County Agricultural Show. As this was a small county show it provided an appropriate setting to pilot the questionnaire. Appendix C was given to participants to introduce the project as research looking at future farm stresses in the Welsh Marches. It was explained that the research aims were to explore future farm stresses and that farmers from farm enterprises across the UK could participate. The purpose of the results to inform academic research was also made explicitly clear along with the assurance of the confidentiality of results. When recruiting, a purposeful effort was made not to make explicit reference to climate change or extreme weather, so that future farm stresses (question 4, Appendix B) could be assessed without any bias towards the subject matter (comparable to research conducted by Reid *et al.* 2007). The questionnaire was titled: 'future farm stresses in the Welsh Marches', rather than specifically making reference to the weather or climate change. This approach was seen to work well with a range of different responses given, led by the respondent rather than by the researcher.

The most challenging aspect encountered was recruiting farmers at the show when they were occupied with parading livestock in competitions. As such, the livestock ring area was the focus where two researchers roamed (see use of additional researchers 4.1.4), approaching farmers once they appeared to have finished most of their parades. This concentrated approach meant that over half of the responses were completed in the space of one hour. A total of 21 questionnaires were completed in the pilot study. From the experience of conducting the pilot questionnaire at a smaller event, a different approach to engage with farmers was required. Therefore it was decided that a more targeted approach where researchers were based at a stand rather than taking a direct 'roaming' approach was the most appropriate to maximise interest in conducting the questionnaire at the Royal Three Counties Show.

Implementation of Questionnaires at the Royal Three Counties Show

The next stage of conducting the questionnaires completion took place at the Royal Three Counties Show on the 14th-16th June 2013, to avoid additional bias towards respondents in one particular location. In association with the Three Counties Agricultural Society, it was made possible for a research stand to be situated in the farmers' area. In total, four researchers rotated across the three days, with the lead researcher present throughout the entire event. This ensured that the quality of responses was protected by clarifying any queries as they were raised. In addition to being based within the farmers' area, researchers also roamed the main livestock area, accessing farmers who were parading livestock. This allowed for a wider range of farmers to be encountered including dairy, poultry and pig farmers, with the majority of respondents focusing upon beef and sheep enterprises.

Across the event, 94 questionnaires were completed, creating a total of 115 completed questionnaires with UK farmers from both county shows. As there were no changes made to the questions the pilot results were suitable for inclusion. Where they fulfilled the criteria for the ensuing interview stage (by location and experience, detailed in 4.5.3), respondents were asked if they were willing to provide contact details to take part in the next stage of research, resulting in 27 contact details being obtained from suitable participants. Once respondents had completed the questionnaire, they were asked to sign and date the form to show that they understood the purpose of the questionnaire and that they were willing for their responses to be used confidentially (Appendix B).

4.4.3 Participant Demographics

The distribution of respondents' farms across the UK is shown in Figure 4.5, with 42% of respondents' farms in Worcestershire, Shropshire or Herefordshire. This facilitated comparisons of those in the case study location with those from across the region as well as those from across the UK.

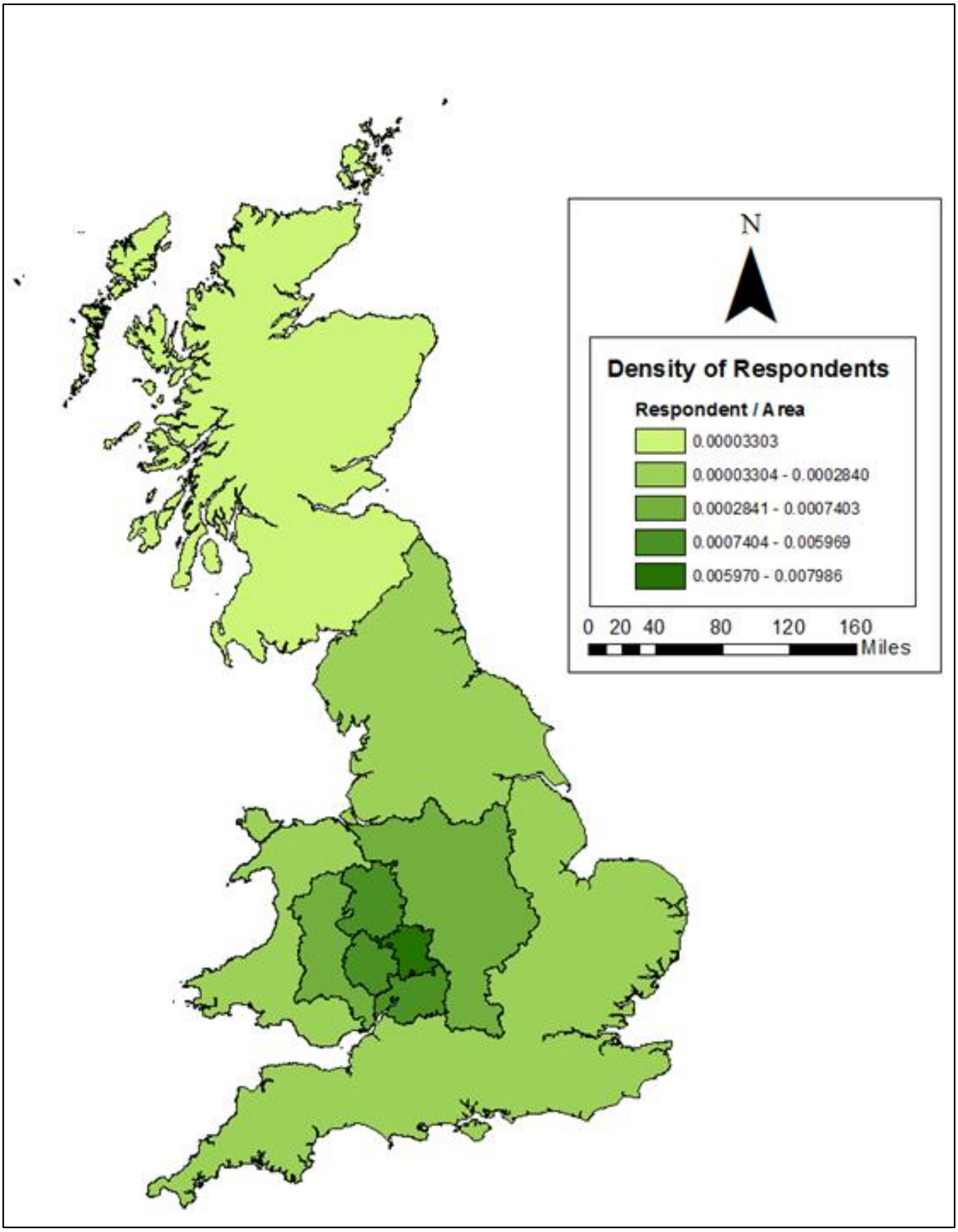
The number of respondents from different farm sectors was considerably influenced by conducting questionnaires at county shows. This introduced a bias towards grazing stock and mixed enterprise, with lower responses from horticulture, cropping and cereal focused enterprises. Figure 4.6 demonstrates this bias, showing 50% of respondents focusing upon lowlands livestock. The range of interviewees described in 4.5.3 selected from this sample was carefully constructed in light of this and included farmers with interests in arable crops, poultry and pigs, as well as the majority in mixed and lowland grazing enterprises.

As expected from national statistics demonstrating that the median age of land holders is 59 years (Defra 2013), 57% of farmers who responded had farmed on their land for over 30 years. Figure 4.7 demonstrates that 17% farmers surveyed had been on their land for less than 10 years. Time on the land does not directly indicate a farmer's age, as it is possible that a farmer has moved in the time they have been farming. Nevertheless, the results do show a high proportion of farmers who had been on their land for over 30 years, supporting the ageing population of UK farmers discussed in Potter and Lobley (1992).

4.4.4 Questionnaire Data Analysis

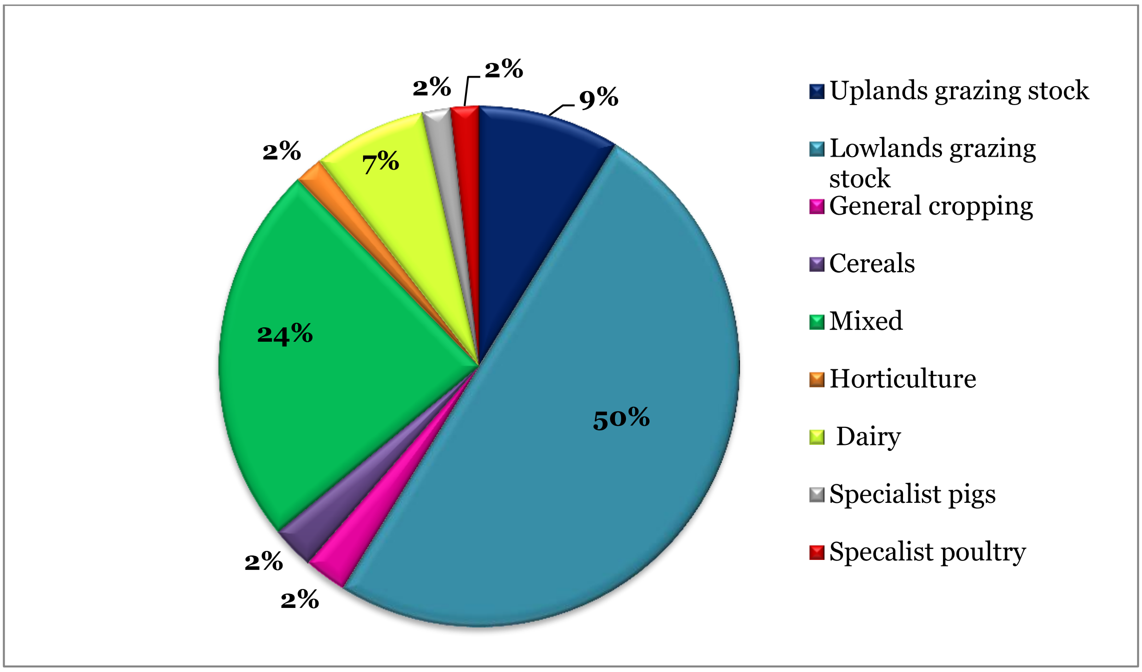
Once data had been collected at the county shows it was entered into an Excel spread sheet. Although 117 responses had been received, two were incomplete and therefore were not entered into the data analysis reducing the sample to 115. Data was transferred into SPSS, this enabled the use of cross-tabulation to assess relationships between two sets of variables at a time and easily include or exclude variables, depending upon a factor such as location. The focus of the quantitative analysis was to gain descriptive statistics for the responses to questions 4 to 6. Cross-tabulation was

Figure 4.5: Density of Questionnaire Respondents by Location



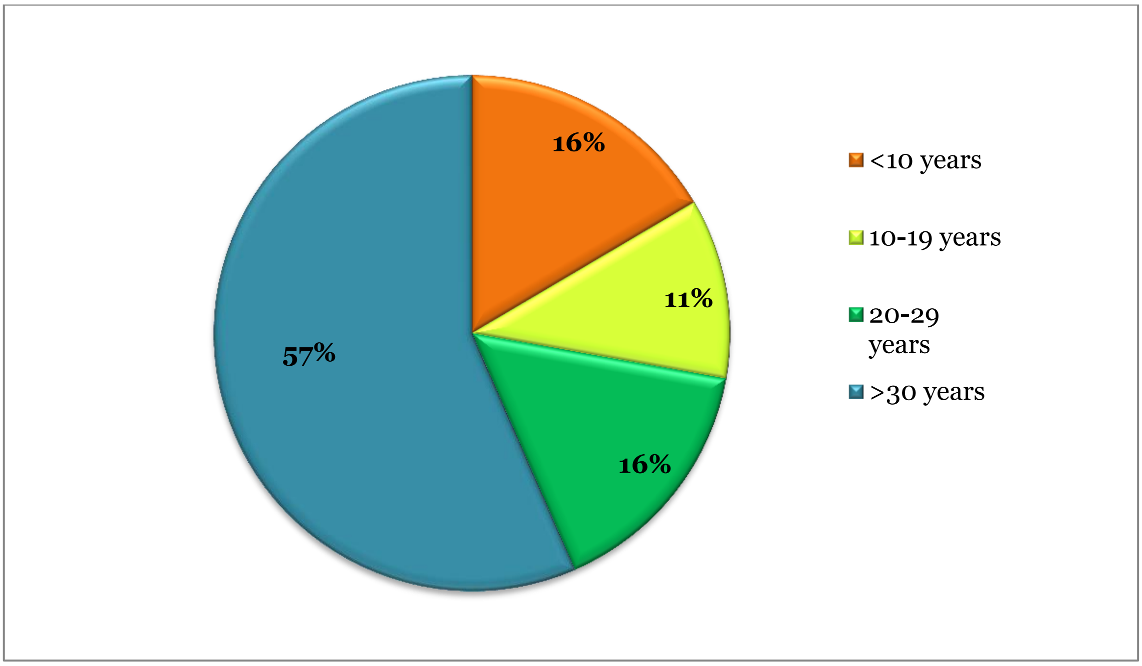
Source: Author's questionnaire

Figure 4.6: Questionnaire respondents by farm type



Source: Author's questionnaire

Figure 4.7: Respondent time on the farm



Source: Author's questionnaire

completed for these questions against each other and with the demographic questions in 1 to 3. These findings will be discussed in Chapter 6.

As with any questionnaire, there are potential influencing factors upon the results generated. Notably at a county show setting, farmers had a very limited amount of time to consider their responses. Also, it was inevitable that farmers from beyond the research area took part in the study. However, this allowed a baseline to be established of the experiences of farmers within the case study location in comparison to those across the West Midlands region as well as further across the UK.

The timing of the questionnaires is also thought to have influenced responses considerably, as the research was conducted in early summer 2013. This followed heavy snowfall in spring 2013 and a notably wet year of continual rainfall from April through to winter 2012, affecting both the 2012 harvest and establishment of 2013 crops across the UK (Defra 2013). This undoubtedly had a significant influence upon the farmers surveyed; with a high proportion of people listing either or both events as the most recent weather event causing a significant loss on their farm (see Chapter 6).

It is highly probable that responses to questions 4-6 were influenced by these recent experiences, and so responses taken during this period of time may well have varied in comparison to a questionnaire conducted prior to the events. Nevertheless, it provided a valuable snapshot as to how the recent weather events had influenced farmers' perceptions of the weather and concerns for the future. The interview process was designed in light of this and so looked to capture the impact of these most recent experiences further, as well as those that were in the more distant past (4.5.1).

4.5 Phase Two: Semi-Structured Interviews

The sequential explanatory approach (Figure 4.1) requires the collection of quantitative data to inform the collection and analysis of the qualitative data phase. The questionnaire described above (4.4) directly informed the design of the qualitative data collection. Not only did the questionnaire act as a recruitment tool to seek out farmers in the Welsh Marches who had been impacted by EWEs, but the interview schedule, structure and key components were based upon the findings from the questionnaire.

Semi-structured interviews were chosen as the primary method of qualitative data collection in phase two. By conducting in-depth interviews it becomes possible to focus upon the individual (Ritchie *et al.* 2003). Therefore, interviews were conducted to allow for further investigation of individual behavioural factors in line with the cultural-behavioural approach (devised in chapter 3). Certainly, factors included in behavioural theory such as individual motivations, attitudes, decisions, understanding, impacts and outcomes of complex processes and issues, are all considered to be explored within the interview process (Ritchie *et al.* 2003, Silverman 2011). Cultural influences and factors were also explored through evaluating the role of external influences in a farmer's decision-making (Figure 3.4).

4.5.1 Developing the Interview Schedule

The aim of the interview process was to expand upon farmers' past experiences of EWEs and establish farmers' understanding and perceptions of climate change. The investigation of the role of local knowledge networks in forming farmers' perceptions of climate change and decisions of adaptive measures are also fundamental to this phase of research.

Appendix E shows the final interview schedule designed to explore the main aim of the interview phase. As the interviews took a semi-structured approach, six key themes formed the main structure of the interviews, with the questions presented in Appendix E designed provisionally as a guide to explore the questions and lines of enquiry identified. Using a semi-structured interview, the researcher had the flexibility to adapt and change the questions in order to make them more relevant to the participant. This allowed the researcher to tap into their individual experiences as appropriate, ensuring a richness of data collected. Consequently, not every question was asked, or asked in the same way, in every interview[23]. Nevertheless, universal to each interview was the topic of climate change. This was only initiated by the researcher in the final stage of the interview where specific questions about climate change were raised.

The interview schedule (Appendix E) was constructed for this research in accordance with the cultural-behavioural approach devised in 3.5. The interview schedule was designed to explore individual experiences, decisions, judgements and perceptions, whilst taking into account the wider social network, community and cultural norms that these are formed upon. As the interview process progressed, the focus of the interviews and the structure evolved. This allowed for areas that were left unexplored in early interviews to be uncovered. In accordance with good practice in agricultural

[23] Different levels of questions were devised ranging from essential questions indicated in bold to prompts indicated in italics in Appendix E

geography, the interview began by gathering information about the participant's farm operation and then changes over time were discussed (Reid *et al.* 2007).

4.5.2 Pilot Study

Once a draft interview schedule had been constructed based upon the analysis from the questionnaires and data gathered in phase one, it was piloted with two participants. The pilot interviews were selected due to the noticeable differences between the participants' location, gender, experiences, farm enterprises, land tenure, and farm size. This ensured that the structuring of the interview and questions were suitable for respondents from different demographics and so would be applicable to all of the farmers that were consulted afterwards.

4.5.3 Implementing the Interviews

Participants were recruited from the pool of 40 farmers that were willing to participate in further research and were from the study area from the questionnaire (4.4). In order to be suitable for interview they had to be a farmer within the research area (1.4) for at least five years. This was the chosen timeframe as it would allow for some perception of the 'normal' weather conditions, and meant that experience of a past EWE was probable. The original time on the farm required was identified as ten years. However this prevented interviews with a younger generation of farmers which were extremely valuable when discussing the future, and so was lowered to five years accordingly. Farmers were selected based upon the information gained from the questionnaires (4.4). Recruitment of participants for the interviews was prioritised between three groups: those who had stated they had suffered a loss due to EWEs in the past, those who were particularly concerned about extreme weather in the future, and those who actively kept weather records to inform farm decisions. This was to ensure a richness of data and provide detailed accounts of farmers' experiences, concerns and understanding of the weather and possible responses to future change.

In total, 15 interviews took place, as this was found to be the number in which data saturation was achieved (see 4.5.4). One interview was conducted with two decision-makers in the same household. Both individuals had an active role during the interview, and with opinions expressed often differing from their partner's. Therefore, the statements from each decision-maker has been separated and considered on an individual basis during the thematic analysis, but is only considered once in the assessment of demographics. Hence in the thematic discussion of findings (chapters 5-7), it is considered that 16 interviewees participated in the interview process (Table 6.1).

Participant Demographics

Table 4.5 shows the key demographics of each farmer interviewed. From the total of 15 interviews that were held with different farms, four were in Shropshire, five in Worcestershire and four in Herefordshire. In two instances, the boundaries were extended beyond the arbitrary county boundaries to include a participant on the Gloucestershire/Herefordshire border, and another participant on the Shropshire/Powys border. These were justified in the physical landscape of their farm being more indicative of the research area than the administrative county in which it is located.

A variety of farm enterprises was included, comprising a mixture of lowland livestock, dairy, arable and mixed enterprises, with the most common consisting of pigs and vegetables. It should be noted that most farms were quite mixed and so had a multiple of different farm and non-farm enterprises such as in the tourist or leisure business ventures. However, farmers were asked to identify their dominant farm enterprise included in Table 4.5.

Land tenure was evenly spread between landowners (sole owners or in partnerships) and tenants. A scope of land sizes was included from 10 hectares (consisting of free-range poultry and sheep), to 500 hectares (beef, sheep and cereals), with most farm sizes ranging from 10-80 hectares (coinciding with Defra 2013 UK average holdings). Likewise, time and experience on the land varied between 6 to 61 years, with the majority of farmers having spent 20-35 years on their land.

From the age range displayed in Table 4.5, it is clear that farmers interviewed were at different farm life-cycle stages, from those that were just emerging as successors or establishing their own farm business, to those that were nearing retirement. As discussed in 3.1.1, age and gender can influence decision-making, therefore by incorporating a mix of ages and genders this allowed for different perspectives to be consulted (Edwards-Jones 2006, Price and Evans 2009, Wallace and Moss 2002). By including such a range of ages, a wealth of different opinions and perspectives centred around experiences in the past, challenges of the present, and plans and concerns for future, depending upon the farm household's stage of life, were accessed.

Table 4.5: Demographics of Interviewees

Attribute	***Number of Interviewees***
County	
Herefordshire	4
Shropshire	4
Worcestershire	5
Gloucestershire/Herefordshire border	1
Powys / Shropshire border	1
Gender	
Male	12
Female	3 (+1 in joint interview)
Age (approx. Years)	
20-35	3
36-50	3
50-65	3
65+	6
Time On Farm (approx. Years)	
5-10	4
10-19	1
20-29	3
>30	7
Land Tenure	
Owner	8
Tennant	7
Farm Size (Hectares)	
10- 40	4
40 - 80	4
80-200	3
200- 400	2
>400	2
Dominant Farm Enterprise	
Cereals	1
Dairy	3
Horticulture	1
Livestock	6
Mixed	4

Participant Consent

All participants contacted had already agreed to further participation in the interview stage prior to arranging an interview date and time. Letters were sent in July 2013 (Appendix D) after the county shows, giving further description of the project along with a project leaflet. The first participants were contacted by phone or email in October 2013 to arrange an interview date, whereupon they were then provided with further information about the interview. The consent form in Appendix F was given to the participant(s) to read and sign prior to the commencement of the interview. Separate permission was also gained at the beginning of the interview to record the interview on a MP3 recorder. This allowed for a transcription to be prepared for each interview for entry into NVivo10 (recommended by Silverman 2011, 278).

Respondent Bias

An interview does not tell us directly about people's experiences, but it does produce a particular representation of individuals' views or experiences (Silverman 2011). This is because interviews are considered to be different to 'natural' conversations (Keegan 2009). A tendency for participants to portray what they believe the researcher wants to hear, as opposed to what they believe, can be a key issue in the conduction of interviews (Binns 2002). To minimise this risk, participants were asked to talk more generally about their farm and their past experiences before the more contentious topic of climate change was discussed once a level of trust had developed (comparable to 4.4.2).

4.5.4 Data Saturation

To remain faithful to the principles of qualitative research, sample size should follow the concept of data saturation (Glaser *et al.* 1967). Data saturation is considered to be the point at which no new information or themes are observed in the data (Guest *et al.* 2006). The general principle of data saturation is to recognise the point of diminishing returns; identifiable when a study that continues to generate new data does not necessarily lead to new information (Mason 2010). In this analysis, data saturation is defined as the point where new nodes were no longer created when analysing new interviews in NVivo (4.7).

Whilst saturation dictates the number of interviews, other factors dictate how quickly this is achieved (Mason 2010). Such factors include the richness of data, clarity of the topic and the scope of the study as influencing the point of saturation (Morse 2000). The use of the participant selection model (Creswell and Plano Clark 2007), also allowed a certain level of richness of data to be assured. This was because all participants approached were known to have had past experiences of extreme weather and future concerns of climate change that they were willing to share.

Shadowed data, considered as the reporting on others' experiences, are shown to provide the investigator with a range of experiences beyond a participant's personal experience (Morse 2000). Shadowed data were found consistently throughout the interviews, with nearly all participants referring to the experiences of farming neighbours and friends in comparison to their own. This provides insights into the local farming culture, providing some indication of the role of the farm community in farmers' decision-making, allowing the cultural-behavioural approach to be tested (devised in 3.5).

Estimations of the number of interviews required to reach saturation is particularly poor in qualitative methods literature (Guest *et al.* 2006, Manson 2010, Morse 2000). Braun and Clarke (2013), provide some guidance depending upon the size of the project, so that for a medium sized project a recommended number of interviews are seen as between 10 and 20. Atran *et al.* (2005), assert that as few as 10 informants are needed to establish a reliable consensus. However, Bertaux (1981), identified that 15 is the smallest acceptable sample. Manson (2010) analysed interviews undertaken as part of social science PhD studies. He found that most data collection utilising interviews, included between 10 and 40 interviews. Manson (2010) identified that 80% of PhD projects adhered to Bertaux's (1981) concept of 15 as the minimum acceptable number of interviews as a guideline.

During this interview process and simultaneous qualitative analysis, it was envisaged that data saturation had been reached after 15 interviews due to the lack of new codes being constructed from the analysis of new data. As the number of interviews conducted to reach data saturation was in line with the indications provided by Bertaux (1981) and Manson (2010), a suitable point had been reached to close the interview process (using Appendix E).

4.6 Phase Two: Farmer Focus Group

The farmer focus group and semi-structured interviews took place simultaneously (Figure 4.1). Due to logistical reasons, the focus group was conducted halfway through the interview process, utilising all the data collection before it, to inform its design.

The focus group moved beyond the topics explored in the previous phase two stages (4.4, 4.5), to concentrate upon future challenges and potential local responses to a changing climate. A focus group can provide indications of: attitudes, priorities, frameworks of understanding, communication and interactions between others; providing insight into how strategies are achieved within the social context in which the phenomenon of climate change is experienced (Bedford and Burgess 2001, Hoggart *et* *al.* 2002, King and Horrocks 2010, Ritchie *et al.* 2003). Focus groups are a popular methodology in human geography when considering hypothesised climate change impacts (Tate *et al.* 2010). When utilising a focus group to look at hypothesised change in the future, lively discussion is likely to be generated, particularly when exploring climate change (Tate *et al.* 2010, Sinclair *et al.* 2014). In particular, the ability to explore the arguments that participants use with each other to discuss key issues was seen as advantageous, potentially captures tacit and experimental knowledge which is socially situated (as discussed in 2.5.3 and 3.4.3, King and Horrocks 2010). Therefore, focus groups were identified as a suitable methodology with which to explore farmers' future concerns in view of hypothesised climate change.

The objective of this stage was to discuss future climate, moving on from the focus of the interviews. The use of a scenario-based focus group was deemed appropriate as group responses allow for one idea to set off another in an exchange of thoughts and knowledge (Hoggart *et al.* 2002, 213, King and Horrocks 2010, Ritchie *et al.* 2003, 60). Specifically, this focus group aimed to explore the impacts, potential challenges and opportunities presented to farmers in the Welsh Marches.

4.6.1 Designing Climate Scenarios

A scenarios approach was adopted in order to explore the longer-term future, and the potential impacts and responses to future climate changes in the Welsh Marches. Scenarios are designed based upon a collection of possible future trends that are most appropriately discussed in a focus group environment that can include diverse points of view (Farrington *et al.* 2013). The topic of climate change readily lends itself to a scenario based approach to generate discussion and hypothesise possible outcomes. Several reports utilising scenarios to discuss potential impacts of climate change include: Ambler-Edwards *et al.* (2009); Defra (2009 and 2012b); Foresight 2011; IPCC (2014) and Tate *et al.* (2010). Scenarios have been further used to help respondents imagine and place themselves in a new context which appears to be more 'real' than they may normally be able to comprehend without prompting (Bryant *et al.* 2000, Tate *et al.* 2010, Sinclair *et al.* 2014). Bryant *et al.* (2000) considers that scenarios designed to establish farmers' perceptions of climate stimuli throw light on possible adaptions by farmers (supported by Tate *et al.* 2010, Sinclair *et al.* 2014). It also allows for farmers' responses to be explored further into the future, as anchoring farmers' responses ten years ahead was identified by Tate *et al.* (2010) to not go far enough into the future to explore climate change.

However, conclusions drawn from use of these scenarios is limited by its basis upon hypothetical behaviour and their focus upon annual average conditions rather than the small variations from averages which generated the most agricultural stress (Bryant *et al.* 2000). The latter observation was considered in the creation of scenarios for this research and was limited to some degree by the inclusion of EWEs to show variations from climate 'norms'. These factors, outlined by Bryant *et al. (*2000) will also influence the way in which scenarios are analysed. Even so, the use of scenarios is seen to provide the best insight into possible future impacts and responses of farmers to climate change at a local level.

The abstract approach, incorporating long-term physical changes within the UK farming system, was inspired from Ambler-Edwards (2009) to build a picture deliberately constructed to present a range of possibilities and generate some debate. Yet, several other elements were added from all of the climate change scenarios considered in 2.1.2. The expected conditions for the UK, as detailed in Defra (2009 and 2012b), formed the physical basis for each scenario, with the expected changes in temperature and rainfall calculated from the baseline data from the three counties Met Office data (4.2). This established a baseline summer temperature of 21°C across the three counties.

As rainfall is highly localised and varies considerably depending upon the specific farm location, estimated changes in rainfall were left as a percentage increase or decrease so that it could be made relevant to all, regardless of their farm location. Impacts such as seasonal changes, growing season windows of opportunity, as well as conditions for crops such as maize, sunflowers and oilseed rape, were adapted from the potential opportunities and challenges for UK farmers, as outlined in Defra (2012b) and (2013). The predicted farm impacts were adapted to the local farm context by taking into account farm enterprises together with present and past challenges that were established primarily from the newspaper articles (4.2). The chosen timescale for the scenarios was 30 years as it is the standard measure of time in which climate is able to be established (4.1, IPCC 2014, Defra 2009).

Prior to the focus group, the scenarios were tested with three people to ensure that they were easily explained and understood in lay terms, as well as to check discussion could be generated from each. From this process, the final scenarios (Figure 4.8), were created for discussion in the focus group.

Figure 4.8: Climate scenarios Constructed for Focus Group

Climate Impacts on the Welsh Marches in 2043...

1. Farming Fortunes

- Average Summer Temperature: 22°C
- Average Summer rainfall: 5% increase
- Average Winter rainfall: 1% increase
- Few extreme weather events

Overall climate has steadily increased in temperature by 1°C. Favourable weather in the UK has boosted crop yields. Spring arrives 2 weeks earlier, increasing the growing season. Seasonal changes are gradual and predictable. Wheat, oil seed rape and grass yields significantly increase all year round. There are opportunities to grow new crops such as maize and sunflowers.

2. Marginal Gains

- Average Summer Temperature: 23°C
- Average Summer Rainfall: 11% Increase
- Average Winter Rainfall: 5% Increase
- Regularly impacted by extreme weather events

Temperature has steadily increased by 2°C. Slightly favourable weather conditions over the past few years. Spring usually arrives 1 week earlier than present, extending the normal growing season. Weather patterns remain predictable with some extreme weather becoming regular events. Windows of opportunity of 'nice' weather on the land are increasing. Grass, wheat, and oil seed rape have all increased in yields by 20-40%.

3. Testing Times

- Average Summer Temperature: 24°C
- Average Summer Rainfall: 15% decrease
- Average Winter Rainfall: 10% increase
- Increasingly frequent and intense extreme weather events

Climate has changed noticeably, with temperature increasing by 3°C. Seasons have become increasingly variable and less defined. Growing seasons are often affected by drought, heatwaves, flooding and storms. Windows of opportunity of 'nice' weather are narrowing. Temperatures are no longer cool enough to reduce pests and weeds in the winter months. Water shortages are frequent.

4. Farming Crisis

- Average Summer Temperature: 25°C
- Average Summer rainfall: 35% decrease
- Average Winter rainfall: 21% increase
- Continuously frequent and intense extreme weather events

Climate change is stark; temperatures have increased by 4°C on average. Extreme weather events are becoming far more intense and frequent than ever before. The growing season is considerably disrupted and increasingly difficult to predict. Seasons are no longer possible to define. Water is scarce and shortages are very frequent. New crop and livestock diseases are widespread. Livestock are becoming increasingly distressed due to the heat.

4.6.2 Implementation of the Focus Group

The focus group was conducted as an activity at the Three Counties Farming Conference in November 2013. Ideally, a focus group requires between 6 and 10 participants to be able to both sustain and control discussion (Finch and Lewis 2003, Morgan 2007). This target was achieved through the recruitment of 8 local farmers to participate. It is considered that focus groups benefit the most from having diversity in group composition (Finch and Lewis 2003, 191), yet some commonality towards the discussion topic helps stimulate discussion and validate statements further (Ritchie *et al.* 2003). This was ensured by actively recruiting farmers of different generations and ages (ranging from 20 to 65 years), land tenures, farm sizes (ranging from 50-900 acres), enterprises (including dairy, lowland grazing stock, pigs and arable) and locations from across the case study location. Those who had shown interest in the activity were then provided with further explanation of the project and details of what the focus group entailed before they committed to participating.

Prior to participation each person was asked to read and sign a consent form which was then returned to the researcher (Appendix F). Separate permission was also gained at the beginning to record the focus group on two MP3 recorders placed at either end of the tables, allowing for a transcription to be analysed in NVivo10. Having two MP3 players allowed for all of the discussion to be picked up upon, this included informal conversation between participants about the topic that was not necessarily audible during the discussion.

The focus group lasted for approximately 45 minutes, throughout which conversations were stimulated using the scenarios alone. Each scenario was read out by the researcher in turn, and then participants were asked their initial thoughts on the potential local farm impacts of this, both challenges and opportunities. Participants were asked what they would consider doing in response to the impacts that they perceived. As ideas were shared and discussed, the key points were then written by the researcher on a flip chart in the middle of the room for everyone to see. Each participant also had a copy of Figure 4.8 in front of them so they could easily refer back to the details being discussed.

Challenges were primarily presented by the short time available to recruit and conduct the focus group. Generational differences were apparent throughout discussion, with more experienced farmers dominating discussion. However, the second MP3 recorder captured discussions between a small group of younger farmers who didn't necessarily have the confidence to share their opinions with the wider group but made several important comments about the scenarios as they were being discussed.

4.7 Thematic Analysis of Qualitative Data

Qualitative data analysis consists of preparing and organising data for analysis then reducing the data into themes through a process of coding (Creswell 2007), allowing the data to be represented in a discussion (chapters five to seven, Creswell 2007). From the sequential nature of this methodology and basis upon data saturation, the process of data analysis is not a distinct step and is often incorporated simultaneously into the research project (Creswell 2007). Computer software such as NVivo has increasingly aided dealing with voluminous data in qualitative research (Creswell 2007), changing the character of qualitative research (Flick 2009), improving the robustness of thematic analysis through systematic coding (Bazeley and Jackson 2013, Creswell 2007). Flick (2009) recognises strengths of computer aided analysis including: speed in handling, the increase of quality due to extra rigour in analysis, and the ease of data management assisting in the most relevant quotes to be easily incorporated in discussions. The use of such software is also emerging in agricultural geography with recent examples of similar NVivo analysis evident in Sinclair *et al.* (2014) and Fisher (2013a).

The use of NVivo10 software in thematic analysis was introduced in 4.3.3. Building upon this, the specific form of thematic analysis as conducted in phase two will be outlined in 4.7.1. Section 4.7.2, will then explain the process of combining the thematic outcomes from such analysis and its role in informing the results presented in chapters 5-7.

4.7.1 Thematic Analysis of Phase Two: Qualitative Data

The qualitative findings from phase two were combined in the thematic analysis (detailed in 4.5 and 4.6). This was deemed most appropriate as the primary qualitative data collection sought to explore similar research questions. Thus, when analysed together, the process of amalgamating data in the qualitative analysis would allow for overarching themes to be established from a multitude of methodologies. Commonalities between the methods are apparent due to the direct interaction between participants and the research topic (Hoggart *et al.* 2002).

Data imported into the analysis file consisted of 20 sources including: interview transcripts, focus group transcripts, and qualitative responses in the questionnaire. The coding began by adhering to an initial coding frame devised upon the core questions that the data was to be interrogated upon. Such categories included: adaptive measures, experiences and impacts of EWEs, decision making behaviour and attitudes, farmer knowledge, future concerns and opportunities, present challenges and observed changes in the weather. These were then expanded upon freely according to trends and themes uncovered in the data. In total, 538 nodes were created indicating different discussion points, opinions, specific types of impacts, events, specific adaptive measures implemented or specific terminology. These represent trends in the data that then allowed for 35 overarching themes to be identified from the data. This includes both analytical themes as well as objective categorisations between varying opinions and phases (such as stage of adaptation or response).

The thematic approach allowed for 'free nodes' to be created when new themes in passages of text or picture included in the articles continued to emerge, thus meaning that there were significantly more nodes created at the end of the coding process than at the beginning (recommended by Bazeley and Jackson 2013). In order to overcome such coding bias towards the articles analysed at the end of the coding process, the Constant Comparison Method (CCM) provided the main approach which involves cycles of coding to include 'new' data coded with 'old' data that is already coded on the NVivo project file (Boeije 2002, Leech and Onwuegbuzie 2011). Once an initial round of coding had taken place taking into account all of the sources, a second and third round of coding was then completed until no more 'new' themes were found. This ensured that all sources had been analysed in accordance to all the nodes established in the complete coding frame (Bazeley and Jackson 2013, Boeije 2002). Throughout the process, a series of 'parent' and 'child' nodes started to emerge in a hierarchical structure indicating related themes (as recommended by Bazeley and Jackson 2013).

4.7.2 Combing Analytical Themes of Phase One and Two

The themes established from phases one and two were combined to establish key analytical themes informed by both analysis files. After observations of the varying contexts of weather events and climate change issues from the past, present and future, these were then organised according to whether they were associated with past events, present challenges or future concerns. The richness of the primary data meant that findings were given priority in establishing analytical themes supported by evidence from secondary data. Core processes identified in accordance to the conceptual model were used to organise the relevant themes.

4.8 Summary of Methodology

The preceding chapters have identified the need to explore farmers' interpretations of climate change in the Welsh Marches through conducting a comprehensive literature review and construction of the cultural-behavioural approach. Chapter 4 has documented the methodology devised and specific processes undertaken in this study in order to address such issues. A sequential explanatory approach (Figure 4.1) has been utilised in relation to the cultural-behavioural approach (3.5), and discussed on a stage-by-stage basis throughout this chapter. Both secondary and primary data has been collected and analysed including quantitative and qualitative data. Quantitative data in both phase one and two, has been analysed using predominantly descriptive statics in Excel 2010, and SPSS 22 (4.2.2, 4.4.4), whereas, all qualitative data has been analysed thematically using NVivo10 software (4.7).

In accordance with the sequential explanatory approach, in both phases the quantitative data analysis has then directly informed the subsequent design, implementation and analysis of the subsequent qualitative phase. Phase one has provided essential base-line data from secondary sources which then directly informed the design and implementation of phase two. The subsequent results chapters are developed from an amalgamation of data from phases one and two. These are weighted towards the original findings from the primary data supported by secondary evidence.

This thesis has so far outlined the research problem, devised a conceptual framework and has now applied this framework through field investigations. Qualitative thematic analysis of primary data (4.7) provided evidence in allowing core findings to be identified. As outlined in the research design (Figure 4.1), these findings will be discussed in view of both supporting secondary (4.3.3), and quantitative evidence (4.7.2, 4.8). The discussion of results gathered from this methodological approach will be presented thematically in the succeeding chapters. As such, primary, secondary, quantitative and qualitative data will be discussed simultaneously in accordance to themes. This allows for overarching themes and findings to be discussed side-by-side, linking comparable findings in discussion rather than being bound to explore findings by the methodology in question. Chapters five to seven will explore past challenges (chapter five), present experiences (chapter six) and future concerns (chapter seven) surrounding farmers resilience to climate change. A discussion of all themes presented in chapters five to seven, will then be reviewed in chapter eight in relation to the conceptual framework.

CHAPTER FIVE

PAST IMPACTS OF EXTREME WEATHER EVENTS

"No one can prepare you for the psychological trauma of a flood"
Mary Dhonau (2014)[24]

Observed impacts of climate change on physical and ecological systems over the past century (2.1, 1.2, documented in IPCC 2013, Defra 2012a) are an indication of some of the challenges yet to be faced (Adger *et al.* 2005). Chapters five, six and seven will discuss different analytical themes in relation to each chronological stage in farmers' development of resilience (Figure 3.4). This chapter will begin the chronological discussion, by focusing upon farmers' experiences in the past.

The impact from general climate change trends are amplified in extreme weather (Tate *et al.* 2010). Observations of existing effects of climate change on the UK agricultural system are already apparent through a variety of EWEs that have been experienced in the recent past (2.1, 1.2, Beniston and Diaz 2004, Defra 2012b, IPCC 2014). Effects will be felt in different ways, over varying timescales, regions and by different agricultural sectors (Defra 2010, 2012b). To explore the possible effects of climate change on the Welsh Marches, the specific impacts of past EWEs that have already been experienced by the farm community will be investigated. This will enable the level of farmers' resilience to these events to be established as evident in risk perceptions, responses and recovery processes exposed in the past.

Climate change is conceptualised within existing cultural frames of reference of the weather acquired through past and shared experiences (Paolisso *et al.* 2003). Indeed, experiences of past events provide an insight into reality as it is experienced through the farmers' eyes (discussed in 3.1.2). Therefore, experiences will be considered in behavioural terms focusing upon individual attitudes and decisions to respond to an

[24] Dhonau, M. (2014) at: Responding and Adapting to Extreme Weather, London Policy Knowledge 5th August 2014.

event (Ilbery 1982 and 1985). Risk perceptions will be explored through evaluating an individual's assessment of their risk to EWEs in view of information they have received, observed and recalled (Lowe *et al.* 2006), along with the perceptions portrayed by local media (Carvalho and Burgess 2005, Lorezoni *et al.* 2007). In view of the conceptual framework, a cultural lens will be applied through a comparison of conditions recorded by scientific monitoring, with those which have been reported in the local media, and experiences recalled from first-hand accounts (Carvalho and Burgess 2005, Lorezoni *et al.* 2007). This then facilitates a discussion to explore the role of scientific communication and local knowledge (Ingram 2008b, Wynne 1992).

The principal aim of this chapter is to establish the influence of EWEs and challenges of the weather upon farmers in the Welsh Marches in the past. The 'past' is defined in this thesis as incorporating the last 30 years, from 1982 until data collection in 2013. This will be discussed in three stages. Firstly, 5.1 seeks to establish the impacts of past EWEs, and the level of risk that is posed to farmers in the Welsh Marches. Secondly, 5.2 will outline farmers' responses during an EWE in view of the recovery process and responses made by farmers both inside and outside the farm gates. Thirdly 5.3 will draw together the use of recorded, reported and recalled events in discussion of farmers' perceptions of past EWEs.

5.1 Impacts of EWEs

The scale and nature of impacts are exposed within past EWEs. A multitude of EWEs have been identified to have exerted a destructive physical presence in the Welsh Marches over the last 30 years (4.2). Undoubtedly, such events as those identified in Tables 4.1 and 4.2 had a widespread impact upon farmers at the time of occurrence. Yet, the nature and scale of impacts upon farmers is still yet to be explored, and so will be the focus of this section. This is intended to help establish: the level of risk that farmers are exposed to from EWEs in the Welsh Marches (5.1.1), the variations in farmers' resilience and vulnerability exposed by different types of weather events (5.1.2), and the impacts of EWEs that have been experienced on farms in the Welsh Marches in the past (5.1.3). A discussion of past impacts will then establish the value of identifying the nature and scale of farmers' risks as exposed in past EWEs and the subsequent impacts of this exposure (5.1.4). This will provide an indication of the impacts of possible future EWEs.

5.1.1 Risk of EWEs to Farmers in the Welsh Marches

To gain a holistic understanding of farmers' perceptions of EWEs, the scale of risk posed by EWEs needs to be established. This is accomplished through assessing the amount of significant losses that have been incurred by farmers in the Welsh Marches. The approximate number of farmers who have been affected by EWEs in the past, and their recollection of specific events, was determined. To establish this, findings generated from the questionnaire (4.4.), supported by qualitative evidence (4.5) are discussed. This will be in relation to: (i) the number of farmers found to have suffered a loss, (ii) the distribution of significant farm losses by location, (iii) farmers' interpretation of a significant loss, and (iv) the ability of farmers to recall the impacts of EWEs.

i. *Number of Farmers who had Suffered a Loss Due to Extreme Weather*

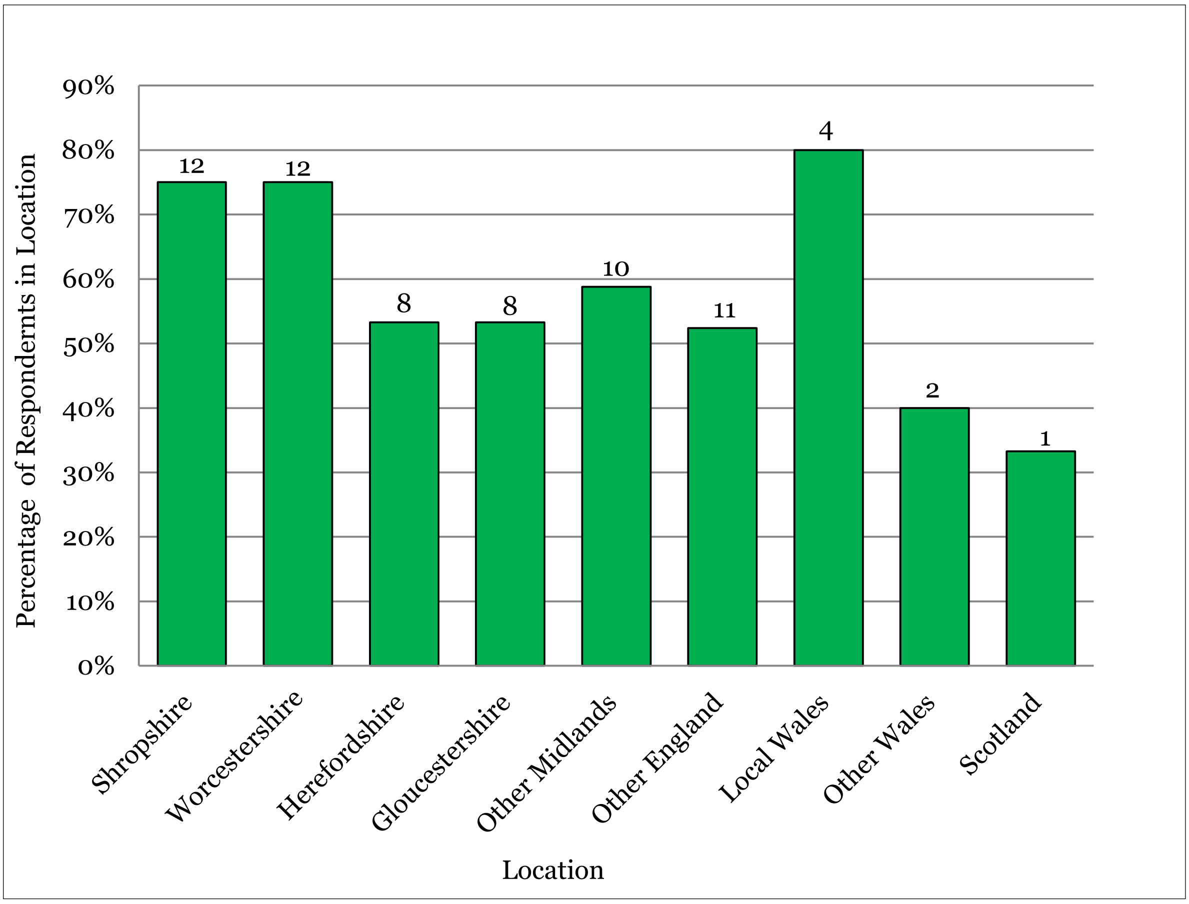
As shown in Appendix B, Question 6 was designed to identify the number of farmers who had suffered a significant loss due to extreme weather (4.4.1). Upon analysis, it was established that 60.2% of the total farmers that were questioned, stated that they had suffered a significant loss on their farm due to an EWE. This demonstrates that experiences of EWEs and impacts incurred upon the farm system as a result are not rare occurrences.

ii. *Significant Loss by Location*

Figure 5.1, demonstrates the proportion of significant losses that were reported by farmers in relation to their location. In total, 42% of questionnaire respondents were from the Welsh Marches (4.4.3). Of the respondents who indicated that they had experienced a significant loss on their farm due to extreme weather, 47% were from the Welsh Marches, indicating a higher than expected proportion. In Shropshire and Worcestershire, the highest percentage of farmers who had suffered a significant loss is apparent with 75% of respondents from each county claiming to have suffered a significant loss. In comparison, 53.3% of respondents from Herefordshire had suffered a significant loss. The average percentage of respondents from the rest of England who had suffered significant losses was 52.5%. Therefore, the percentage of farmers impacted by EWEs in all three of the Welsh Marches counties was notably higher.

It is apparent that a considerable number of farmers in the Welsh Marches had been impacted by extreme rainfall in 2012 and snowfall in spring 2013, which is likely to have influenced their responses given that data collection followed both of these events (4.4.4).

Figure 5.1: Percentage of Farmers who had suffered a Significant Farm Loss out of Total Respondents for each Location[25]



Source: Author's Questionnaire

iii. Interpretation of a 'Significant' Loss

Whilst 60.2% of respondents had reported a loss, a further 39.8% considered themselves to having not suffered a significant loss due to extreme weather. Yet, the question is subjective and so is open to interpretation, reliant upon the respondent's perspective. As such, what may have been considered a 'significant' loss to one farmer, may have been a minor and therefore unmemorable loss or impact for another. Upon further discussion, it does appear that some farmers had suffered a loss due to extreme weather but did not consider this to be 'significant' enough to have responded 'yes' to question 6. A significant loss was often relative not only to an individual's past

[25] N.B. Other Midlands incorporates all of Midlands' counties except for those shown separately, Other England Includes all English counties except those otherwise mentioned, Local Wales incorporates Powys and Monmouthshire, other Wales includes all Welsh counties except those included in Local Wales. Data labels are included to indicate how many respondents each bar represents

experience but also to the experiences of those within their social and knowledge networks.

For example, Victor considered himself 'lucky' in comparison to his neighbour:

> *"My Neighbour lost almost 300 ewes, I was lucky I only lost 30 lambs"* (Victor Shropshire, 2013 Snowfall)

Consequently, Victor did not consider the lambs he had lost to be significant in contrast to someone in his social network, and so responded 'no' when asked if he had suffered a significant loss (Appendix B).

Throughout the interview process, farmers were asked whether they had been negatively impacted by EWEs, and to talk about their experiences of them in the past (Appendix E). To this initial question, some farmers responded that they had not been impacted by extreme weather in the past, yet when recalling events and weather conditions could identify several instances when, in fact, it had resulted in negative impacts upon themselves and the farm business. This suggests that a person's vulnerability might be linked to their attitudes towards experiences (5.2.2), as well as their own relationship with the weather (6.3.1).

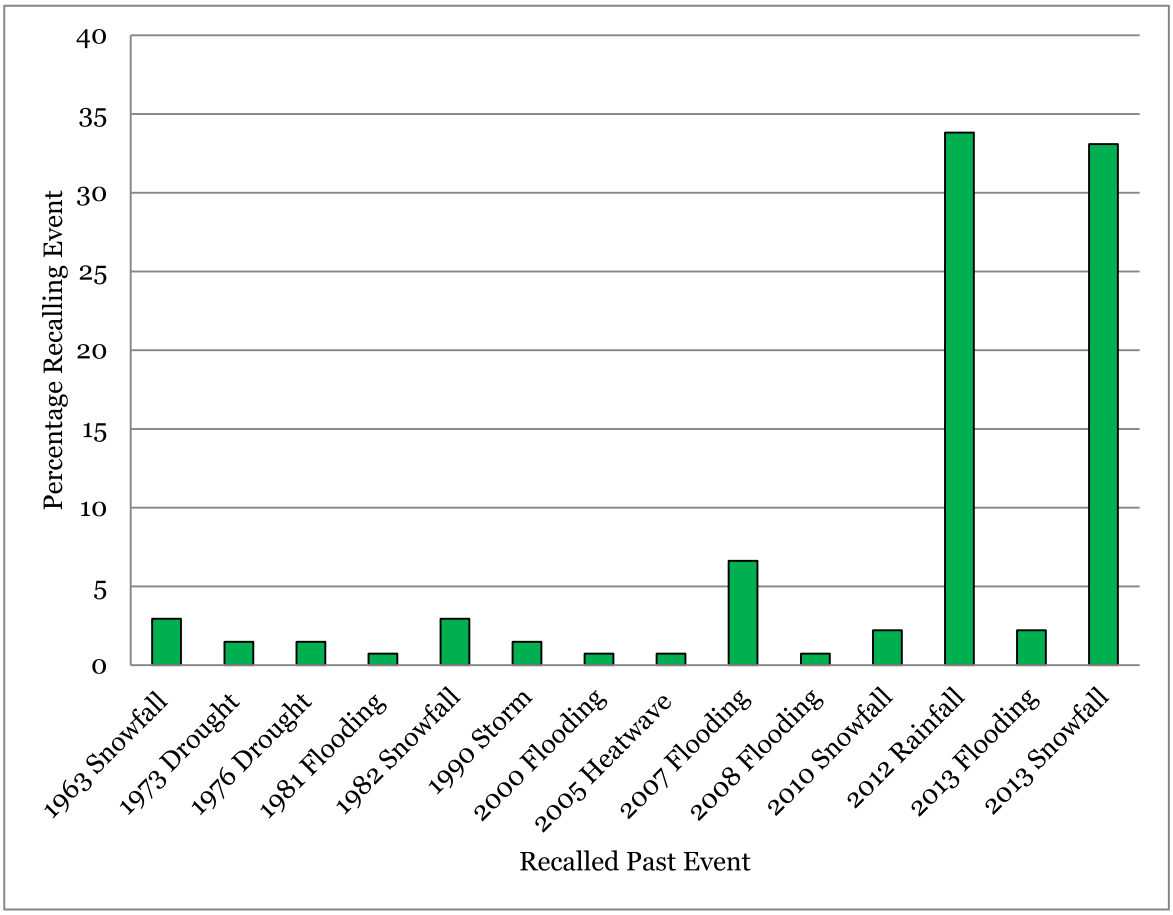
In contrast to respondents downplaying the impacts upon their farm in respect of others' experiences, is the role of the media who are also selective in which weather events are focused upon as 'major' or 'minor' events. This is influenced most dominantly by the apparent 'newsworthiness' associated with some weather events, creating a bias to the coverage of some EWEs over others (Boykoff 2007, Moser 2010), regardless of the scale of impacts experienced on the ground (Smith and Joffe 2009).

iv. Recall of EWEs

Farmers who had suffered a significant loss due to the weather were then asked to provide details of the weather event that had caused the most recent loss on their farm. Of the respondents who had stated they had suffered a significant loss, 56.9% indicated that the most recent event to cause this was the 2013 snowfall, whilst 27.6% said it was the 2012 rainfall. Figure 5.2 demonstrates the percentage of weather events that were recalled by farmers throughout the collection of primary data in phase two.

As expected, due to the reliance upon farmers' memory (Harley 2003, Hulme *et al.* 2009), a significant amount of coverage was given for the recall of most recent events, with events in the longer-term mentioned less frequently. Events as far back as 1963 were recalled, however with little accuracy and only by a minority of respondents. The highest accuracy of farmers' memory recall of past events is apparent in events stretching back over the past two years. This observation concurs with Malmberg's (2008) recognition that temperature is likely to be recalled up to two years later with a high level of detail, following this two-year period any accuracy in recalling the weather steeply declines. This is different from the consensus in agricultural geography where five years is usually considered as an appropriate time-frame to capture farm changes that took place in research (Evans, N 2009a).

Figure 5.2: Highest Percentage of EWEs Recalled by Farmers in Phase Two



Source: Author's Questionnaire, Interviews and Focus Group

It does appear that the proximity of data collection to weather events outside of participants' perceptions of 'normal climatic conditions' has distorted memories of previous conditions, allowing for the misrepresentation of interpretations of present conditions (as found by Hulme *et al.* 2009). Accordingly, the fixation upon recent events is due to this distortion, hence making the recent impacts of extreme weather seemingly the worst, until the next event takes places.

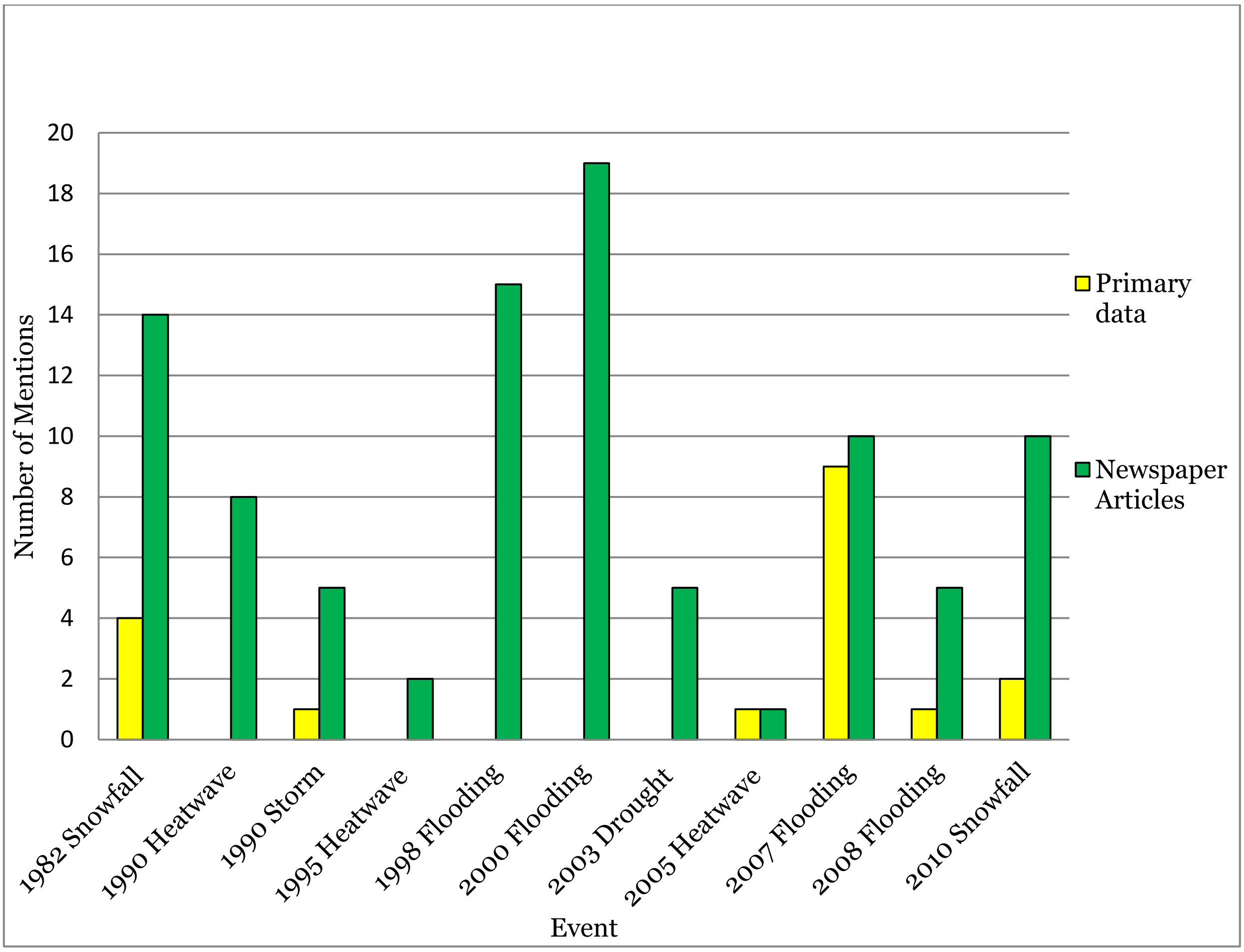
Figure 5.3 exhibits how the recall of impacts of past events fades, regardless of the physical scale of the event as it occurred. In correlation with Tables 4.1 and 4.2, it is apparent that the most extreme event in the meteorological records is the1982 snowfall has not been recalled by participants seemingly due to how long ago it occurred. Figure 5.3, further compares those events recalled in primary data with those reported by local newspapers, indicating the scale of local impacts as reported by the press. Once the most recent events had been removed from Figure 5.3 avoiding distortion towards recent events (Hulme *et al.* 2009), the highest memory recall is from the 2007 floods, 6 years into the past. This signifies a difference between memory of flood events and that of temperature recognised above to be recalled with accuracy up to two years after they occurred. This is likely to be due to the nature and scale of this event being a rapid onset event, the nature of impacts was also different to those that had been experienced since, thus confirming Hulme *et al's*. (2009), theory that weather will be recalled until a recent comparable event is experienced. However, a notable difference in the recall of events from 6 years after they occurred as shown by the 2007 floods, and the detail included up to 2 years following an event, as shown by the 2012 rainfall, is considerable.

This demonstrates that a six year period can allow for a representation of the event to be recalled, even if it is lacking the detail and depth of experiences that are detailed in the recall of more recent events. In Figure 5.3, the comparison between impacts reported to have been experienced by farmers at the time, and the volume of memory recall of the 2005 heatwave as identified in phase two shows a considerable discrepancy. Therefore, a vague level of recall of weather events including both temperature and flood events after eight years, up to the 2005 heatwave, has been identified. Nevertheless, the nature of weather events and the scale of impacts, also influence memory recall and so will be considered when interpreting farmers' recall of past impacts incurred by EWEs.

5.1.2 Variations in Resilience and Vulnerability Exposed by Type of Weather Event

Tables 4.1, 4.2 and Figures 5.2 and 5.3 have identified a range of EWEs known to have impacted upon farmers across the Welsh Marches. Although different types of weather events have exerted an apparent impact on farmers in the Welsh Marches, prolonged periods of intense rainfall appear to exert the most severe impacts upon the farm community. Such vulnerabilities were apparent during the interview process; as rainfall and flooding were repeatedly mentioned as being of most concern to all interviewees.

Figure 5.3: Comparison of Events Recalled in Phase Two Compared to EWEs Reported in Local Newspaper Articles



Source: Local newspaper articles in comparison to author's questionnaire, interviews and focus group

Primary data collection took place throughout 2013 (4.4 – 4.6), following a year of consistent intense rainfall. Rainfall totals from April to December were considered to be well above average with the wettest year being recorded in England since 1872 (Met Office 2012). For the Welsh Marches, approximately 15% to 35% more rainfall than the 1981-2010 average was recorded (Met Office 2012). In the Welsh Marches, 13.3% of total respondents stated that they had suffered a significant loss due to the 2012 rainfall.

The widespread impact of the 2012 rainfall upon farmers across the Welsh Marches is also prominent, with nearly every interviewee reporting some experiences of the event, demonstrating the scale of impacts on a diverse range of farmers across the region. Notably, most respondents were in agreement that everyone had been affected by the severe weather in 2012, signalling widespread impacts across the entire farm community.

> *"We haven't had a wetter year than the year we've just had"* (Albert, Shropshire 2012 Rainfall - interview)

> *"It were terrible last year with the rain"* (Dennis, Shropshire 2012 Rainfall - interview)

> *"It's made us very nervous…we've always had to battle the weather but there was never really a chance last year really"* (Bonnie, Worcestershire 2012 Rainfall - interview)

In particular, the unprecedented scale of continuous intense rainfall seems to have exasperated farmers by exposing their vulnerability to the impacts of the event:

> *"If we had another year like last year….well we would survive but I know a lot of farmers that wouldn't be able to survive"* (Henry, Worcestershire 2012 Rainfall - interview)

> *"Well last year, 2012…was just like nothing else. We had never seen anything like …it was so distressing, it really was"* (Bonnie, Worcestershire 2012 Rainfall - interview)

Bonnie focused upon the rarity of such events, forcing a farmer to cope with an event that they had had no experience of previously. This meant that a new decision-making process was undertaken unrelated to previous experience that could be drawn upon. Indeed, similar statements to Bonnie's were made 6-12 months after the event occurred, and so the interviewees were still in the recovery process. Subsequently, the impacts of the event were still being felt (as discussed in 4.4.6). Such accounts of the rainfall in 2012 appear to have exposed specific farm vulnerabilities and as such created a sense of fear towards the occurrence of comparable events that may exert negative impacts upon the farm system.

Following the challenges of 2012, many interviewees identified that their farm system was most vulnerable to the impacts caused by intense rainfall, and therefore they were concerned about the occurrence of more events such as that experienced in 2012. As discussed in 5.2.1, an absence of 'newsworthiness' of long-onset events has also led to the downplaying of the hazard in the local media (Boykoff 2007, Moser 2010). Prior to the experiences of 2012, most farmers had not been affected by a comparable event of prolonged and intense rainfall. As a result, several interviewees stated that they feared the possibility of the 'unusual' event occurring again, because the nature of such an event and possible impacts and responses were still relatively unknown.

> *"We've had some challenging times before but never for so long. I mean that was just rain, rain, rain"* (Henry, Worcestershire 2012 Rainfall - interview)

> *"We've had bad winters before in terms of cold and snow, we have had spells where it has been very dry…but we can cope with that…it's the rainfall that is the worst"* (Bonnie, Worcestershire - interview)

In comparison, a consensus that other types of weather events seemingly pose a lesser risk to farmers in the Welsh Marches is apparent. When asked to consider past experiences of other weather events, the impacts were often lessened in respect to that of rainfall events.

In agreement with Bonnie, several farmers made associations between what they feel they are equipped to deal with and what they have been able to cope with in the past. This suggests a higher level of resilience amongst the farm community towards temperature events, as opposed to rainfall. This higher resilience is confirmed in the volume of heatwaves and snowfall events found to have been experienced by the community in the past.

The low temperatures and harsh winter that was experienced in 1982 was ranked as the 'most extreme' temperature event. Comparable to the local meteorological data (Table 4.1), the volume of newspaper articles demonstrates the severity of the event as experienced on the ground (Figure 5.3). Due to the on-going recovery process from the 2012 rainfall event at the time of interviews, the severity of previous EWEs paled into insignificance. Nevertheless, some anecdotal evidence does demonstrate that these temperature events did have significant impacts on farms at the time:

> *"The winter of 1982 in this area was particularly severe, and we financially took a really large hit then"* (Charles, Shropshire 1982 Snowfall - interview)
>
> *"I remember in 1976 when there was a heatwave it was the last really big one because we had Hereford cattle and we sold them that year… everything as it was so expensive"* (Isaac, Herefordshire 1976 Heatwave - interview)

Figure 5.4, demonstrates evidence of the negative impacts of past heatwaves on farming (also evident in: Shropshire Star 1990, Worcester News 1995b,Worcester News 2006). From discussions, the impacts of heatwaves upon livestock appear to have the greatest effect.

Although all livestock are affected by high temperatures, the impacts of heat stress upon pigs and poultry appear to be the most severe. One farmer had lost several pigs in 2005 as there was not sufficient shade available to keep them cool with easy access to water. The incident in Figure 5.4[26] demonstrates a similar impact, but on a considerably larger scale.

Figure 5. 4: Headline of Hereford Times during 1990 Heatwaves


Chickens die as county bakes in heat

(Hereford Times 1990)

Instances of extreme heatwaves and snowfall have occurred in the past, it appears that farmers have already made adjustments to deal with such events and therefore feel more resilient to such events that have been previously experienced numerous times before.

Recent intense rainfall appears to have left the farm community feeling more vulnerable as adjustments to such impacts have not yet been made. It appears that due to the most recent and significant events being related to intense rainfall, this has eclipsed perspectives and considerations of the past experiences of other weather events in comparison. Thus, a farmer's perception to recognise subsequent events is heightened (Osbahr *et al.* 2010). Therefore, cultural adaptations towards rainfall events and decision-making in responses to 2012 to adapt farm systems are yet to be acted upon.

<u>5.1.3 Prevalent Impacts of EWEs on Farm Systems in Welsh Marches</u>

In 2.4.1, it was established that vulnerability of an agricultural system is dependent upon the exposure sensitivity of the system to a hazard, combined with the adaptive and coping capacity of a system (Reid *et al.* 2007 and Smit and Pilifosova 2003). Expected impacts of climate change on the UK agricultural system, as explored in Ambler-Edwards (2009) and Defra (2012b), were discussed in 2.2.5, yet the specific impacts of EWEs at a farm level are absent.

The impacts of past EWE need to be assessed in order to gain an indication of potential impacts on farm systems in the future if more frequent and intense weather events do occur as a predicted outcome of climate change (outlined in 2.1). Evidence from first-hand experiences describing the impacts brought about by a range of weather events

[26] Reaching maximum temperatures of 35°C in Ross-on-Wye, as recorded in Table 4.1 event 4TMax.

spanning across the last 30 years, will be discussed. The most significant impacts have been broadly categorised and will be discussed under the headings: impacts upon the land, fodder, livestock, crops and the farm business. Due to the large variety of impacts identified, only the most prevalent will be discussed in accordance to consensus amongst interviewees. This includes impacts upon: (i) the land, (ii) fodder, (iii)livestock, (iv) crops, and (v) the farm business, (vi) Influences upon all farm impacts will then be considered.

i. Impacts upon the land

Impacts upon farmland are particularly apparent in farmers' concerns regarding soil structure, soil nutrients, saturation and contamination of the land. Accessing the land became a particular issue in the 2012 rainfall due to the level of saturation.

> *"10th/12th I wrote down in the diary, 2 tractors here, 1 spraying, 1 to tow out…"* (Dennis Shropshire, 2012 Rainfall - interview)

Reports of such effects are often associated with heatwaves, rainfall and flooding. In particular, a key issue of flooding is the contamination of soil due to flood water. Simultaneously, the saturation of land also has a lasting impact upon the soil structure. In particular, saturated grazing land is a main concern with cattle, as many reported the churning up of soil during 2012.

> *"When it rains too much the grass goes all wet and mushy and then the cows make a mess and tread it all in so they don't get much next time…they make such a mess to soil structure and everything else"* (Henry, Worcestershire - interview)

The effects of this forced farmers to bring in the cattle to indoor housing when the soil was saturated to protect the land.

ii. Impacts upon fodder

When discussing weather events that occurred during the summer, silage and haymaking were nearly always noted as the most prominent impact. Qualitative analysis revealed that a total of 25 mentions by 11 different farmers were made, reporting the negative impacts upon silage making. Indeed, silage and hay making appear to have a crucial role in the ability for a farm system to quickly recover from extreme weather.

> *"It would have affected me financially because of the quality of the fodder"* (Dennis, Shropshire 2012 Rainfall - interview)

If this is disrupted, then negative long-term financial consequences are often incurred. This is because not only is extra fodder required whilst livestock are kept indoors for a prolonged period, but also the usual supply of forage for the following winter is of significantly degraded quality. Furthermore, if only poor quality silage is made, then additional inputs would be required to supplement nutrition, thus costing a considerable amount.

iii. Impacts upon Livestock

A range of different impacts upon livestock including cattle, sheep, pigs and poultry were apparent in every weather event, these include: (a) loss of livestock, (b) decrease in livestock produce, (c) problems with grazing, (d) disruptions to inputs and outputs, and (e) increase in pests and diseases.

a. Loss of Livestock

Loss of livestock was mentioned 28 times by 8 different participants. Some losses of livestock occurred during lambing; this appears to be predominately as a result of very low minimum temperatures such as those experienced in spring 2013.

> *"We lost about thirty lambs I think; even some of the older ones didn't survive"* (Enid, Gloucestershire 2013 Snowfall - interview)

Losses of lambs due to low temperatures were also incurred after lambing, whereby ewes hadn't been able to provide enough milk for the lambs, as well as through contraction of pneumonia. Another notable cause of loss of livestock has been flash flooding on grazing land, which doesn't allowing enough time for a farmer to respond appropriately.

> *"They told us it wouldn't rain one year and it did…we went out and then we had a real issue with the cattle getting stuck… and we've also lost fifty or so lambs this way …you just see them floating away"* (Nathan, Herefordshire Flooding 2008 - interview)

Such events as the 2007 and 2008 flash floods were reported by several other farmers, and in local newspapers as resulting in a loss of livestock in this way.

b. Decrease in Livestock Productivity

A decrease in livestock productivity is a common occurrence, particularly in conditions that are hotter or cooler than average temperatures, and as a result of a lack of sunshine and increased cloud cover for prolonged periods (as present in rainfall events).

> *"The chickens went off the lay, we had half as many eggs as we should of"* (Melissa, Worcestershire 2012 Rainfall - interview)

> *"Wet mushy grass is bad news from a milk production point of view…the cows weren't looking well at all"* (Henry, Worcestershire 2012 Rainfall -interview)

c. *Problems with Grazing*

A particular impact of the rainfall and flood events is the need for farmers to bring livestock indoors much earlier in the year than would normally be expected.

> *"Last summer we had to bring our cows in on winter feed in June because that the only way we could cope with the weather, we just about had enough feed but it's just a decision we had to make"* (Henry, Worcestershire 2012 Rainfall - interview)

This period of prolonged livestock housing, and reduced grazing period meant that winter stores of feed had to be relied upon, increasing costs of additional feed that would then have to be brought in.

> *"We went right down to the last bails of fodder for the sheep"* (Luke, Worcestershire 2012 Rainfall - interview)

d. *Problems with Farm Access to Livestock Inputs and Outputs*

Essential inputs, such as water and feed, are also key concerns. They were mentioned by all livestock farmers who had experienced EWEs. In particular, access to fresh water supplies was a key issue, with extreme minimum temperatures and snowfall events resulting in the freezing of water supplies as experienced by many in the 1982 snowfall. Access to fields for the disposal of slurry, was mentioned to have been an issue for four farmers during the 2012 rainfall.

e. *Pests & Diseases*

An array of different pests and disease were reported as apparent impacts of weather events. Notably, the 2012 rainfall resulted in different health issues that had not previously been experienced by farmers, including wool and foot rot. Pneumonia is also apparent during wet and cold weather resulting in losses of calves and lambs. An increase in pests is also notable. As such, it does appear that different pests occurring out of the usual seasons that they would be expected to occur within, is becoming an increasing issue. Many who reported such issues have already invested in vaccinations and pesticides to solve the problem (5.3.1, and chapter 7).

iv. Impacts Upon Crops

Over one half of participants mentioned some loss of crops due to extreme weather in the past.

> *"We had a series of wet autumns, and land was the heavier side of medium and that made it just tedious and expensive to lift crops from the ground"* (Albert, Shropshire 1970s Rainfall - interview)

Many reported a considerable degradation in the quality of crops produced, particularly the quality and weight of grain that then incurs significant price penalties. As a result of the 2012 rainfall, a significant loss of crops was reported due to the saturation of the land. Many mentioned the inability to lift potatoes and other crops from the ground, resulting in field crops rotting. The ability to sow crops became a key issue during heavy rainfall.

> *"We got a good crop but because it did nothing but rain from April until harvest the quality just suffered. In the shed it looked great but when you came to weight it, it was awful"* (Bonnie, Worcestershire 2012 Rainfall - interview)

> *"We bought all the seed, dressed all the seed…the contractor came but then he got bogged down and it took us three and a half hours to winch him out and get him back home…it was a disaster"* (Henry, Worcestershire 2012 Rainfall - interview)

Incidences of pests and diseases degrading the quality of crops are also apparent, resulting in increasing reliance upon pesticides (chapter seven).

v. Impacts Upon the Farm Business

Farm business impacts were apparent across all conversations of past extreme weather, including: road and track inaccessibility; farm buildings damage, ability to store reserve inputs ; and increased reliance on machinery and farm labour. Most prominently, financial losses and long-term financial implications were detailed by every interviewee. Specific losses that were quantified ranged from around £5,000 on a small farm enterprise (15 hectares), to £100,000 on the largest farm (527 hectares) because of the 2012 rainfall.

Indeed, the main cause of financial loss appears to result from a decreased earning capacity due to: a loss of livestock or crops, poor crop or grain quality, and increase of pests and diseases. As well as a considerable increase in inputs this including an increased use of forage, alternative seeds for spring crops, additional pesticide and fertiliser concentrates, and the cost incurred due to the increased reliance on extra machinery required to cope with the weather.

There were also mentions of an increased reliance on loans allowing farmers to cover direct losses incurred.

> *"We are still struggling from that now... I feel quite fortunate that we have a bank manager who is understanding"* (Phillip, Shropshire 2012 Rainfall - interview)

In particular, considerable financial debt incurred as a direct result of the 2012 rainfall was apparent amongst several interviewees.

vi. Additional Influences upon Farm Impacts

Varying types of weather events (5.2.2) have different impacts. The nature of impacts caused by EWEs is variable dependent upon farm enterprises. Favourable conditions for one farm may be unfavourable for another. A more adapted and resilient farm system can benefit from the market during an event:

> *"We were lucky in '75 we brought an irrigation set up, because everyone else was short of grass, the milk was down so we got a hell of price...that was a very good year!"* (Charles, Shropshire 1975 Drought - interview)

The timing of the event is crucial to the nature of the impacts incurred, particularly at crucial times in the farming calendar. Experiences with losses incurred included: the inability to sow crops at the preferred time (2012 rainfall), lambing outdoors in extreme temperature (1982, 2013 snowfall), and the inability to make silage (2000, 2007, and 2012 rainfall and flood events). The timing of EWEs in proximity to a previous EWE determines the scale of impacts incurred due to a lower resilience in the recovery phase.

5.1.4 Discussion of Past Impacts

EWEs are predicted to become both more frequent and intense as a direct result of climate change (2.1, IPCC 2013). As such, the number of affected farms, different types of EWEs and the most significant reported impacts of past weather events on the Welsh Marches, provide indications of what may occur as a result of climate change.

In section 2.2.5, predicted impacts of climate change were discussed in view of climate scenarios explored by Ambler-Edwards (*et al.* 2009). Crop and financial losses were emphasised as key concerns (Ambler-Edwards *et al.* 2009), yet this analysis has enabled a detailed insight into potential losses and impacts that demonstrate a spectrum of impacts extending beyond solely financial and crop losses. From assessment of the array of losses on the farm system, it is also apparent that they are interconnected. Subsequent losses form the impact upon one aspect of the farm system and exacerbate the impact upon the farm system as a whole. This is particularly apparent where losses and poor quality of fodder that is made due to poor conditions in the summer, requires the purchase of additional inputs. Simultaneously, livestock are kept indoors due to the inaccessibility of the land in the adverse weather, thereby significantly increasing costs incurred.

Experiences of EWEs form the basis upon which a farmer makes an informed vulnerability assessment of their farm system (Reid *et al.* 2007, Smit and Pilifosova 2003). Past experiences of previous events expose farm system vulnerabilities, becoming reliant upon a farmer's coping capacity to mitigate the scale of impacts (2.4.1, Reid *et al.* 2007, Smit and Pilifosova 2003, Tate *et al.* 2010). A range of vulnerabilities have been identified in this section, allowing for the specific vulnerabilities of farmers in the Welsh Marches to be identified. The range and increasing occurrence of impacts indicate the increasing flexibility that is required in a farmer's adaptive capacity in order to respond appropriately. Coping capacity determines a person's ability to respond appropriately to a shock, therefore is crucial to systems' resilience (1.3). Farmers' responses to EWEs at the time of occurrence will provide further indication of coping capacity and subsequent resilience, which will be discussed below (5.2).

5.2 Farmers' Responses During an Extreme Weather Event

Resilience of the farm system is reliant upon farmers' ability to be flexible, to respond to the threat to the system (Cutter *et al.* 2008, Comfort *et al.* 2001, 145). Moreover, farmers' attitudes towards past events and challenges demonstrate their resilience through the ability to 'bounce back' after a damaging event (Comfort *et al.* 2001, 145). Therefore, resilience displayed by farmers during past EWEs will be explored in light of the considerable challenges outlined above. This will be established through discussing: the response and recovery process to EWEs (5.2.1), risky responses within the farm system (5.2.2), risky responses outside of the farm gates (5.2.3), and the recovery period (5.3.4).

5.2.1 Response and Recovery to Past Extreme Weather Events

When considering the impact of past EWEs, it is apparent that farmers play a crucial role in responding to challenging conditions as the impacts upon a farm system unfold (discussed in 5.2.3). Indeed, a variety of reactions are apparent. This section will explore such responses as reported from farmers' memories of EWEs, supported by evidence from the newspapers analysed. Immediate responses to past weather events will be discussed in respect of: (i) the range of apparent response measures implemented and (ii) optimising windows of opportunity. Immediate response and recovery measures entwined with farmers' decision-making, perceptions and attitudes towards weather events will be explored further in 5.2.3 and 6.1.

i. *Apparent Range of Responses*

A variety of farmers' responses in reaction to weather events is apparent. Immediate responses are often made by a farmer in an urgent attempt to limit the scale of impacts on the farm system. Such reactions vary depending upon whether they were predetermined through logical reasoned decision-making or impulsive reactions based on intuitive feelings (Solvic and Peters 2006). Predetermined responses appear to be planned reactions to events based on previous experiences and measures encouraged by scientific monitoring such as Environment Agency flood warnings. Other responses are notably reliant upon local knowledge (supporting the connection of local knowledge in Figure 3.4). Alternatively, methods implemented based upon farmers' knowledge of their land, were also apparent triggers for when an immediate response is required.

> *"I tie a rag to a tree and if the water is around the rag, I know its 6ft from the bank, even if it's a couple of foot off it I move the sheep up"* (Owen, Shropshire - interview)

Both methods, whether informed by a farmer's own knowledge or by formal scientific warnings, have proved effective in limiting the negative impacts of extreme weather (see 6.1 for further discussion on farmer decision making). All of the cattle owners who participated reported bringing in cattle during the 2012 rainfall once the land was saturated to avoid further damage (as in 5.2.3).

Another notable response of being unable to sow winter crops in autumn due to the saturation of land meant that many undertook spring cropping, such as spring barley and wheat, as an alternative. Other responses, based on farmers' past experiences included: the use of alternative and additional equipment, increased pest and disease management, and the increase of forage that is stored.

ii. Optimising Windows of Opportunity

To limit the full extent of the impacts, most farmers stressed the necessity to optimise any windows of opportunity that may be presented where a pause in extreme conditions is sometimes experienced in the middle of an event. As such, farmers such as Bonnie described a rush to try and capitalise on periods of stable weather conditions.

> *"But whenever we now get a chance…we just work every hour to make the most of it"* (Bonnie, Worcestershire 2012 Rainfall - interview)

Following an event, taking immediate precautions such as stocking up on fodder or making extra silage, is also apparent. Over half of interviewees reported making considerably more fodder than required following the 2012 rainfall, with most wrapping hay to limit the amount lost if it was exposed to further rain.

5.2.2 Risky Responses within the Farm System

Unplanned, impulsive responses to EWEs may inadvertently place a farmer at risk. Such responses are most apparent in events such as flooding and heatwaves where the risk of rising water and fires are imminent. Indeed, it is a natural response to make impulsive reactions to mitigate the extent of potential farm impacts, in adverse conditions.

Accounts of flash flooding demonstrate a particular vulnerability of farmers, as it is apparent that the urgency of the event, in particular to move livestock to safe land, has left them exposed to the flood waters and put them in a dangerous situation. Three farmers spoke at length about potentially dangerous conditions they were battling against in desperation to rescue livestock:

> *"We had twelve rams marooned, so I decided to put the trailer on and tear into the water which was not a good idea… the water started to come into the cab of the tractor so I turned, and tipped the tractor… there was about 2ft of water coming out of the cab…we managed to get out, we thought well them sheep are lost"* (Owen, Shropshire 2008 floods - interview)

This indicates the priority and deep emotional attachment to the livestock that left Owen feeling compelled to act upon the situation before assessing his safety. Nine newspaper articles discussed farmers at considerable risk due to the sudden onset of adverse weather, two of which indicated farmers had died as they attempted to move livestock in extreme conditions[27] (Shropshire Star 1982 and 1998).

It is apparent that the cultural value of livestock can outweigh the economic value (Burton *et al.* 2008). Immediate risk is judged by feelings and emotions (Solvic *et al.* 2003). Therefore, emotional attachment to livestock may rationalise such actions due to the significance and cultural value of the livestock.

5.2.3 Risky Responses Outside of the Farm Gates

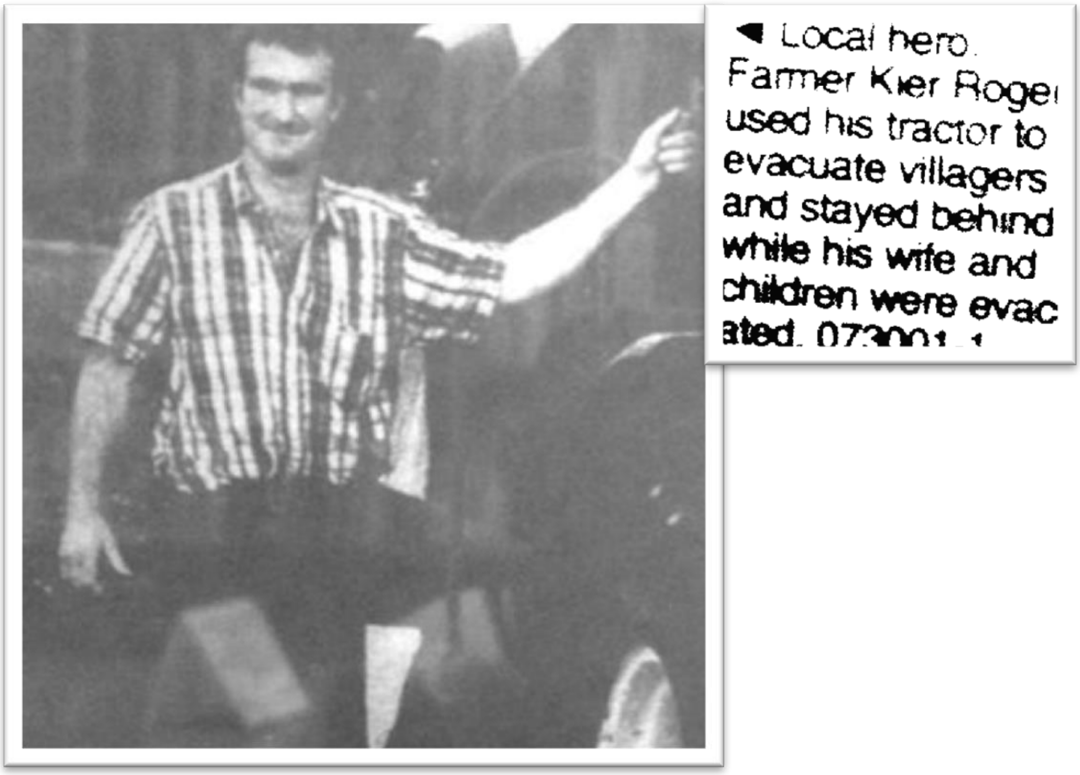
Evidence from newspaper archives suggests that farmers in EWEs have an active involvement in rescue operations, essentially providing an intermediate rural rescue service before emergency services become available. Indeed, flash floods appear to require the most external assistance by groups, such as farmers, who have tractors that are more likely to be able to pass through floodwater when the road may be impassable otherwise. The Shropshire Star (2000) details the dramatic rescue of a local resident and his son who had to climb into the bucket of a farmer's tractor to be rescued from the flood water. Figure 5.5, shows local farmer 'hero', praised for assisting with the village evacuation (Hereford Times 2007). Such risky responses beyond the farm gates are likely to result from a low perceived risk in respect of the potential benefits, therefore attachment to the community and willingness to help may limit the perceived risk through the farmers' eyes (Solvic *et al.* 2003). These responses demonstrate a large amount of coping and social capacity, indicating a high individual and community resilience (Adger 2000).

5.2.4 Recovery Period

In accordance with the adaptive cycle incorporated into the conceptual framework (3.4) most adaptations to climate change are triggered by past extreme weather events and related system shocks (Adger *et al.* 2005). Indeed, planned changes to the farm system to improve resilience were apparent in the recovery period following an EWE (7.2, Solvic and Peters 2006). The length of recovery is a consequence of the accumulation of impacts incurred and the initial responses implemented. Not only do financial impacts of an event have long lasting consequences, but the subsequent impacts of disrupted cropping systems, disrupted harvest and loss of livestock, mean that a recovery period following an event can last for months or years.

[27] Shropshire Star 1982 reports a loss of life due to extreme snowfall (1Snow), whilst Shropshire Star 1998 reports a farmer drowning in flash floods of 1998 (flood '98).

Figure 5.5: 'Hero' Farmer who Assisted Flood Evacuations in the Community



(Hereford Times 2007)

As detailed in 5.1.2, most interviewees were still recovering from the 2012 rainfall, at the time of data collection 9-12 months later. During this time, assessments of impacts are made and so possible adjustments to better withstand future occurrence of events were considered. Adjustments discussed by Luke included increasing the amount of vaccinations, improving hen shelters and immediately rebuilding access tracks that were inaccessible during intense rain to withstand such conditions in the future.

> *"We have really invested in improving access to our land so in theory I could get all over the ground without making it worse…we started it as soon as it was dry enough to do it!"* (Luke, Worcestershire response to 2012 Rainfall - interview)

Such immediate adjustments appear to form the starting blocks of adaptive measures that are implemented in the recovery process in direct response to adverse impacts experienced from past EWEs. Small farm adjustments in direct response to events lead to long-term adaptations, through the gradual evolution of adaptive capacity (3.4, 7.2.2).

However, only a few interviewees appear to have made immediate adjustments in response to the 2012 rainfall. This is likely to be due to the on-going recovery period, denying a farmer time, social and physical capital to reflect upon the impact and make appropriate adjustments. Some farmers appeared to be so consumed in returning the farm system to its original state (bouncing-back), that the opportunity to improve resilience through adaptive capacity like Luke demonstrated (bouncing-forward) was denied. This is evident where a lower coping capacity determined through the livelihood assets (Figure 3.5) exists. All decisions are made in an uncertain environment (Edwards-Jones 2006), so not all participants analysed the risk posed by a seemingly 'rare' event such as the 2012 rainfall to extend beyond a 'one-off' event. Therefore, the decision-making process informed by such a risk perception rendered a response as unnecessary (according to the processes in Figure 3.4). Moreover, farmer intention and behaviour is not linear (Bryant *et al.* 2000, Reid *et al.* 2007). Although an intention to make a direct response in view of the impact incurred, the actions may never be implemented.

5.3 Farmers' Risk Perceptions of past EWEs

From the discussion of impacts incurred from past EWEs a discrepancy between apparent significance given to events that have been recorded, reported and recalled are recognised. Perceptions of past events and impacts often vary from the meteorological record of the scale of event (Harley 2003). To conclude this discussion of past EWEs, the role of event anchoring (5.3.1) and recalled, reported and recorded events (5.3.2), will be synthesised. This will assist in establishing farmers' perceptions of past EWEs (5.3.3), and the value of this in present challenges (chapter 6) and future climate change (chapter 7).

5.3.1 Event Anchoring

Framing experiences and interpretations of experiences of adverse weather enable a person to make inferences based on past experience to interpret specific situations (Paolisso 2003), allowing the individual to anticipate and understand the likely scale of local impacts of the present event (Ritter and Wiltschko 2005). It is the process of event anchoring that informs decision-making based upon experience gained from past events (Figure 3.4). Anchoring is used as a natural starting point as an approximation of judgment (Solvic 2000). The 'anchoring condition' encompasses an individual psychological process, as well as forming a discursive norm regularly used to help explain present impacts of an event using past experiences (Ritter and Wiltschko 2005). Event anchoring helps to indicate the level of response that may be required in view of what was required to recover in the past. Examples of event anchoring of past EWEs are apparent in first-hand accounts and those reported in the press:

> *"We had problems about thirty years ago but nothing like this"* (Worcester News 1998)

Experiences of exceptional events can distort memories, resulting in false interpretations of present conditions (Hulme *et al.* 2009). Yet, communication of the event in this way allows for the scale of the present event to be anchored against a specific incident in the past that was embedded in the resident's memory. This anchoring process therefore provides an individual with an indication of the recovery period that such scale of impacts entailed.

5.3.2 Recalled, Reported and Recorded Events

Table 5.1 shows the apparent differences in the top five events identified in each data collection stage. This demonstrates that emphasis of EWEs documented in the past vary considerably depending upon the perspective and documentation of events (5.1.1). Temperature and rainfall events as identified in Tables 4.1 and 4.2, have been separated due to the complexities in identifying floods (4.2.3). Events that are mentioned in more than one data set are colour coded to show associations between the event mentioned in recorded, reported and recalled data.

A notable bias in the recall of events is shown in Table 5.1, with all of the most frequently recalled events being associated with rainfall or precipitation events. The 2007 floods and 2010 rainfall have been found in the top five of events recorded, reported and recalled. This is due to the bias towards precipitation events, the recent occurrence of both events allowing for accurate memory recall, and the timing of phase one of this research resulting in the exclusion of 2012 rainfall and 2013 snowfall events (prior to their occurrence).

When compared to Figure 5.2, a disparity in conditions that were recorded, reported and recalled are apparent. Data of reported and recalled events are all precipitation events, with no temperature events featuring in Table 5.1. This contrasts to heatwaves included in the first column of Table 5.1. It also appears that 'unusual weather' that varies from what would normally be expected in the summer months, has the greatest impacts upon farm production. Therefore, it is apparent that rainfall and prolonged cold spells and snowfall in the spring and summer are prioritised in farmers' memory recall of events.

Table 5.1: Top 5 Events According to those Recorded, Reported and Recalled

Event Rank	Temperature event recorded in local weather records	Rainfall event recorded in local weather records [28]	Reported in local newspapers	Recalled by participants [29]
1	1982 Snowfall	1992 Floods	2000 Floods	2013 Snowfall
2	2006 Heatwave	2000 Floods	1998 Floods	2012 Rainfall
3	2003 Heatwave	1998 Floods	1982 Snowfall	2007 Floods
4	1990 Heatwave	2007 Floods	2010 Snowfall	1982 Snowfall
5	2010 Snowfall	1986 floods	2007 Floods	2010 Snowfall

Source: Local Newspaper articles compared to author's questionnaire and interviews

A transition of knowledge has been identified between the events recorded in weather records, reported in the media and recalled by farmers and is demonstrated in Figure 5.6. The continuum demonstrates the relationship between the source of documentation of an event and the details of the event conditions and impacts. To enable a clear distinction between the types of data recorded (blue), reported (red) and recalled (green), data has been colour coded accordingly. In Figure 5.6 the volume of accumulated data derived from each process obtained in this research is demonstrated by the size of the circles. This volume of data peaks at recent event recall, then declines over time as the memory of impacts of past events diminish in light of the most recent challenges (see 5.2.1). The detail of impacts also peaks at recent event recall, before fading amidst an array of other challenges and past events, distorting memories of previous conditions (Hulme *et al.* 2009).

Figure 5.6 demonstrates the transition (represented by the interconnecting lines) from highly objective scientific measures of event characteristics, to individual detailed accounts of specific impacts as experienced by the farm community. This signifies a

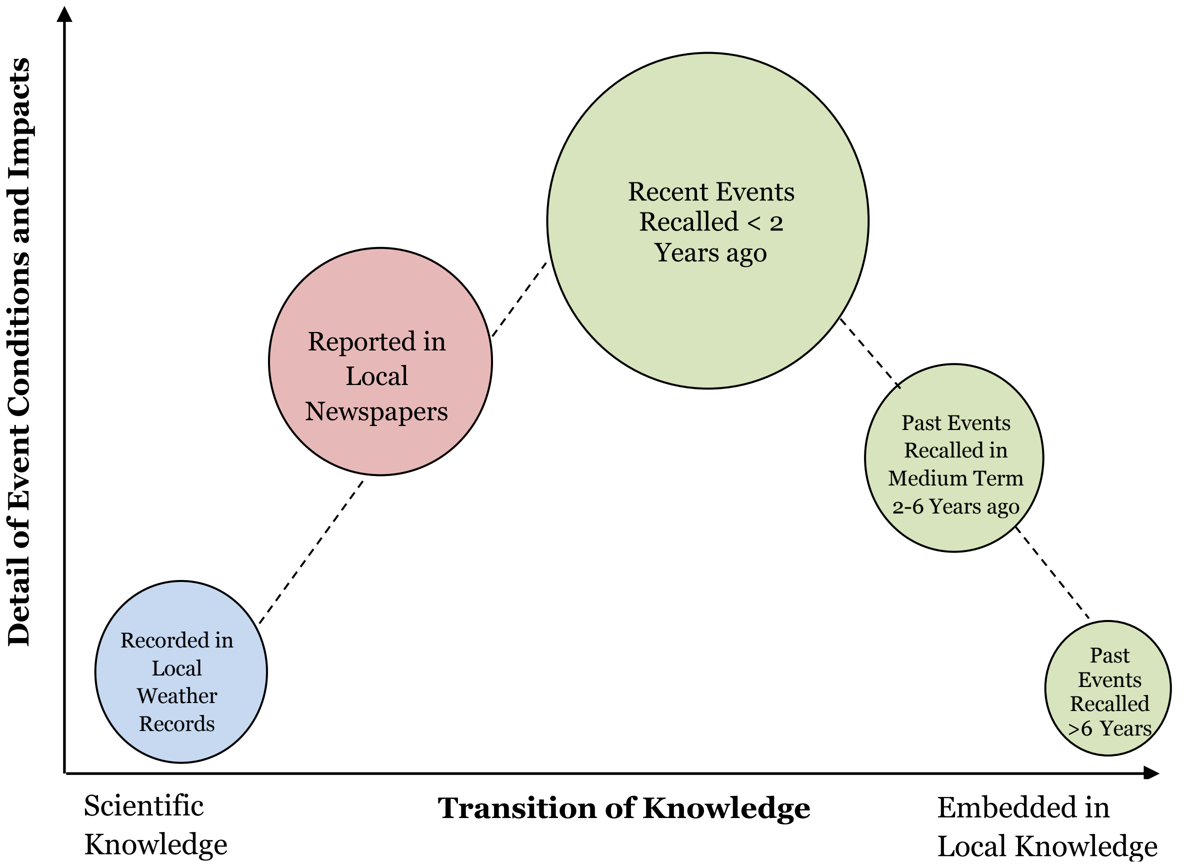
[28] As identified in Tables 4.2 and 4.3
[29] No comparable data is available for 2013 snowfall and 2012 rainfall due to the timing of events in relation to data analysis

transition of knowledge from the scientific record of events (and physical impacts experienced by a farmer), through to the interim interpretation process of media, and the slow process of embedding experience into local knowledge. As the transition moves through time, less generalisation and more specific individualised impacts are apparent. Recollection of events are most numerous and data rich up to two years after an event. Following this period, the knowledge gained from the event fades, with only a small amount of event memories becoming embedded in local knowledge. It is this knowledge that is then relied upon in event anchoring (5.3.3), when a new risk is perceived. Figure 5.6 does not demonstrate two separate objective and subjective processes, but a series of points in which objectivity from monitoring and subjectivity gained from first hand experiences merge through a series of cultural and behavioural processes.

Section 3.4.2 identified an 'artificial divide' between scientific and local knowledge, as complex and not a simple segregation between the two (Agrawal 1995 and 2002, Briggs 2005). In light of the results discussed in this section exploring the documentation of past events from scientific, media and behavioural perspectives, Figure 5.6 aims to revisit the discussion of scientific communication (3.3) and local knowledge in view of the data collected in this research. This is done by representing the transition of the physical record and of impacts incurred to embedding such experiences into local knowledge. Once such local knowledge is obtained (represented in event recall circles) it is then seemingly available for use in the development of a farmer's resilience (Figure 3.4). Figure 5.6 does not attempt to portray scientific knowledge as objective or context-free, but resides at one end of the spectrum as data is immediately recorded with little social influence (see scientific communication in 3.3), whilst the media occupies a grey area (Lowe *et al.* 2006), mediating between scientific conditions and local impacts felt.

Communication of physical impacts is influenced by the way it is communicated and by whom (Figure 3.1, Reid *et al.* 2007), relying upon journalists' own perceptions of the event portraying the key message (Carvalho and Burgess 2005). Place-identity is crucial to risk perception (Cutter *et al.* 2008), therefore local newspapers have the ability to tap into the local attachment of readers to influence risk perception of the probable local impacts of weather events (Wester-Herber 2004). As such, the influence of the local media undoubtedly feeds into the memory and perspective of the event as recalled from first hand experiences (Smith and Joffe 2009), whilst providing an indication of cultural impacts upon the community (Goodman and DuPuis 2002).

Figure 5.6: Transition of Knowledge of Recorded, Reported and Recalled Extreme Weather Events[30]



Source: Local Newspaper articles compared to author's questionnaire and interviews

Memory recalls of events, is not only the collection of information of past events, but affects perspectives of recent experiences (memory timescales discussed in 5.2.1, Hulme *et al.* 2009). All events as recorded, reported and recalled undergo behavioural and cultural processes, influencing the scale of accuracy of impacts portrayed. Certainly, the continuum strives to demonstrate the complexity of impacts as experienced and recalled by a farmer in perspective of the wider societal, political and economic circumstances, all of which operate simultaneously (Burton 2008, Goodman and DuPuis 2002, Griggs 1984).

[30] The size of shape around each data set represents approximate volume of data

5.3.3 Farmers' Perceptions of Past EWEs

The value of previous experiences and having recovered from past events is evident in the opportunities presented to strengthen the system through continual evolution of the adaptive cycle, creating resilience (3.4, Figure 3.3). This chapter has explored experiences of previous EWEs as recalled by the farm community. It is apparent that direct experience trumps vicarious experience and distant facts every time (Moser 2010). Yet, the value of comparing past experiences as recalled in first-hand accounts and reported in secondary data has helped to establish the role of scientific communication and local knowledge in resilience development.

This process of improving resilience is apparent in farmers' responses to past events, their resilient attitudes and perspectives following an event and ability to recall experiences that can inform and provide context when faced with comparable events in the future (5.3.1 -5.3.2). Risk perception is informed by these processes that are undertaken following an event (Solvic and Peters 2006). Yet, an enhanced perception of a risk based upon past experiences does not guarantee a response to limit the scale of impacts during or immediately after an event (demonstrated in Bryant *et al.* 2000, Brklacich *et al.* 1997). To prompt an appropriate response to limit the scale of possible harm, a stimulus needs to be viewed as a threat, which is directly informed by risk perception (Cutter *et al.* 2008, Reid *et al.* 2007).

Risk exposure leads to the application and development of a farmer's coping capacity, whereby a process of memory recall then results in the formation of a risk perception. Risk exposure incorporates possible farm impacts that could be incurred (5.1), combined with resilience (in constant flux Figure 3.4) of the farmer and farm system as established in 5.3 and 5.2.2.

Coping capacity has been considered in this chapter through the assessment of farmers' responses to past events and the recovery process. Farmer responses both inside and outside the farm system (outlined in 5.2.1-5.2.3), determine the recovery process (5.2.4). It is both responses and the recovery period immediately after an event which can then mitigate the true extent of potential impacts being incurred. Therefore, the accumulation of both determines the scale and nature of farm impacts that are felt following an EWE. As discussed in 5.2, farmers' responses to EWEs are crucial to limiting the risk exposure of a hazard which has been incurred upon a farm system. The scale of shock that can be absorbed by the farmer and farm system are exposed in discussion of past impacts and experiences of previous events (3.4). According to the adaptive cycle, the immediate shocks are then dealt with determining suitable responses (5.2, Solvic and Peters 2006). Section 5.1.1 explored the complexity of memory recall of extreme events that exists within the farm community. Diminishing returns of memory recall from medium to long term memory is evident from correlating memory recall with documented evidence of impacts.

Perception is formed prior to an event (Alexander 2002), following a complex process of framing of information based upon experiences (5.3.1). Farmers' experiences accumulate to inform risk perception, after undergoing a multitude of processes from risk exposure. Risk perception, adaptive capacity, scientific communication and local knowledge, have been conceptualised in Figure 3.4 as essential components of the development of a farmer's resilience.

This chapter has explored the influence of past experiences of EWEs into the development of resilience, and its influence upon the key concepts in accordance of the conceptual framework (Figure 3.4). Chapter six will follow on from this discussion by continuing the investigation into farmers' perceptions of the weather in the present. It will explore in depth the influences upon farmers' decision-making to consider further farmers' perceptions of the weather and climate. Past experiences of EWEs and associated challenges have been shown to inform risk perceptions. It is the application of these perceptions in the present (chapter six) and future (chapter seven) which determines a farmer's resilience and so will be the focus of the subsequent chapters.

CHAPTER SIX

PRESENT PERCEPTIONS OF THE WEATHER

"You can no longer say that the climate of the future is going to be like the climate of today, let alone yesterday"
Judi Greenwald (2011)[31]

Chapter 5 has laid the foundations for understanding farmers' perceptions of extreme weather and subsequent influences of past experiences upon current decision-making. This chapter will explore the next stage in this sequential process by focusing upon perceptions and observations of present weather[32] conditions. The purpose of this chapter is to provide the link between experiences, and future farm adaptations through exploration of farmers' perceptions of the weather, framed by the farm decision-making environment (Figure 3.5). Decision-making based upon the weather has been established as the direct result of a complex cultural-behavioural process undertaken in response to a perceived risk (3.5). The true complexity of decision-making reveals the importance of different forms of knowledge and values in agricultural production (3.1). Undoubtedly, the influence of past events, as discussed in chapter five, has a considerable influence upon those decisions that are made in the present, based on risk perceptions formed from past experiences. Yet perceptions of the weather and subsequent action in view of changes observed are also indicative of the adaptive capacity of a farm system, allowing overall farm resilience to be deciphered.

Farmers' perceptions of the weather and daily decision-making in response to variable weather conditions will be discussed in four parts. Firstly, farmers' perceptions of the weather will be established through the exploration of the role of the weather in a farmer's day-to day life (6.1). Secondly, the use of weather forecasts will be determined

[31] Greenwald, J. (29th May 2011) *Newsweek*. Pew Centre on Climate Change.
[32] The weather in scientific terms, describes localised short-term variable atmospheric conditions which are forecast over short time-scales of less than 1-2 weeks (Diaz and Murnane, 2008).

(6.2). Thirdly, farmers' observations of changes in the weather over time will be discussed (6.3), in view of their perceptions of the weather. Finally, perceptions of present weather conditions and farm decision-making will be considered (6.4).

6.1 Farmers' Perceptions of the Weather

Throughout chapter five, farmer perceptions of EWEs and the impact of this upon farmers' responses were explored (5.1, 5.2). Yet, it is also an individual's perception of the day-to-day weather conditions and expected variability that influences a farmer's ability to respond. Such perceptions are formed from observations, feelings and attitudes upon which everyday farm decisions are based. As such, cultural and behavioural constructs influence the way in which day-to-day risks presented by the weather are perceived. The extent to which the weather informs day-to-day farm decision-making is based upon the risk perception.

Climate is an artificial scientific construct, whereas the weather is a day-to-day phenomenon that is experienced and becomes embedded in local culture (Paolisso *et al.* 2012). A cultural regards for the weather extends beyond the description of atmospheric conditions, instead it becomes engrained in cultural values, beliefs, morality and work (3.2.3, Paolisso 2003).

Upon consideration of the research findings and evaluation of the cultural influences in farmers' perceptions of the weather, the way in which the weather is defined in this thesis needs to be re-evaluated. The consideration of the weather solely in terms of localised short-term variable atmospheric conditions (2.1, Diaz and Murnane 2008, IPCC 2013) appears to lack acknowledgement of the weather as a cultural construct. Therefore, for this discussion, *'the weather'* will be used to distinguish between personifications of the notion in which cultural and behavioural influences shape perceptions, and weather in regards to the physical conditions defined above in scientific terms.

Undoubtedly, a farmer's regard for '*the weather*' has a significant role in day-to-day decision-making. Through farmer interactions with *'the weather',* individual farmer-weather relationships are apparent. Moreover, habitual processes in which weather forecasts are sought, processed, and acted upon, are formed upon an individual basis influenced by the way in which *'the weather'* is perceived. As the former influences the way in which the latter is interpreted, these will be explored in turn in this section focusing upon farmer-weather relationships and in discussion of use of weather forecasts (6.2). This section will commence by introducing the notion of individual farmer-weather relationships (6.1.1). Each category of farmer-weather relationships: formal (6.1.2), informal (6.1.3), negative (6.1.4) and background (6.1.5) relationships are discussed in turn. The way in which each relationship can influence farmers' perceptions of the weather, and subsequent decision-making will be at the forefront of each discussion.

6.1.1 Individual Relationships with *'The Weather'*

Farmer-weather relationships describe the process in which the farmer, entering the physical construct into the cultural-behavioural context in which day-to-day decisions are informed, personifies *'the weather'*. A relationship is notable from the cultural-behavioural attachment a farmer has with *'the weather'*; apparent from an individual's regard to weather variability and changing climatic conditions (Paolisso 2003). Just as with human relationships, each farmer-weather relationship is unique. Such relationships are likely to be formed upon beliefs, attitudes, values and experiences, which have already been shown by authors such as Paolisso and Maloney (2000), Edwards-Jones (2006) to play a significant role in farmers' practices and production (3.2.3).

Although each relationship is unique, patterns and similarities between different relationships amongst the farmers interviewed are identified. Thematic analysis using NVivo, of the interview process has enabled the identification of four broad categories of varying farmer-weather relationships: formal, informal, negative and background relationships. Table 6.1, demonstrates how each farmer-weather relationship held by the interviewees is assigned to a relationship category based upon evidence of characteristics that they displayed.

Where a different element of more than one type of relationship was apparent, up to two categories are assigned (Table 6.1). This was often the case with informal relationships that are seen to also result in characteristics of formal or negative farmer-weather relationships being displayed. Sections 6.1.2-6.1.5 will introduce each relationship category and explore the influence of this upon farmers through using evidence from the qualitative data collected.

Table 6.1: Farmer-Weather Relationships Identified From Interviewees

Interviewee (Pseudonym)	**Relationship Identified** [33]	**Evidence**
Albert	Formal	Scientific approach, rainfall data collected and use of digital weather station to make logical decisions
Bonnie	Negative	Fatalistic to future conditions and events experience
Charles	Negative / Informal	Fatalistic use of local knowledge of weather conditions
Dennis	Informal/ Negative	Fatalistic use of informal weather diaries to asses conditions
Enid	Formal	Scientific in approach, rainfall data collected used to logical changes
Frank	Informal	Spiritual connection with weather, and many observations displayed in local knowledge
Geoff	Informal/ Negative	Informal connection and respect for *'the weather'* but negative influence upon decision-making
Henry	Informal	Informed regards for '*the weather*' used local knowledge and observations of conditions to adjust and experiment accordingly
Isaac	Background	No apparent connection with the weather
John	Informal	Informal connection with *'the weather'* built upon observations and intricate understanding of the way in which *'the weather'* impacts locally.
Kate	Informal	Informal connection and respect for *'the weather'*
Luke	Informal/Formal	Informal connection and respect for *'the weather',* but informed decisions with digital weather data
Melissa	Negative	Became 'obsessed' with the weather
Nathan	Background	No apparent connection with the weather
Owen	Negative	Little control over influence of weather on decisions / fatalistic attitudes
Phillip	Background	No apparent connection with the weather.

Source: Author's interviews

[33] Where distinct characteristics of more than one relationship category have been identified the relationships are listed in order of the most dominant first.

6.1.2 Formal Relationships with *'The Weather'*

Formal relationships are apparent in farmers who actively seek information from 'scientific' knowledge. Farmers who have a formal farmer-weather relationship display a purposeful interest in *'the weather'*. Such farmers base logical reasoning in response to the acquisition of new information of present atmospheric conditions.

A formal relationship is recognisable due to the collection and use of weather data, often gathered by the farmer directly or from within their social network. The questionnaire (Appendix B) revealed that 12.2% of farmers either collect or actively record weather data. From this, 8.7% of farmers made use of a weather app, whilst 3.4% kept a formal weather diary detailing secondary weather data (e.g. from weather forecasts). Three individuals were identified in the interview process to have kept weather diaries, two of which were intrinsically scientific, whilst the other appears to be informal (6.2.3).

Weather data is most commonly gathered on a farm using a rain gauge, allowing for monthly or weekly totals of weather to be collated. It appears that such information is utilised by the farmer to interpret local conditions compared to the rest of the UK and what would normally be expected;

> *"Now our average here is 25 [inches of annual rainfall] because it so happens that in North Shropshire we are in a rain shadow… whereas the average for the UK is around 30-32 inches which is fine if you're doing other stuff but for cropping 26 is more than enough"* (Albert, Shropshire - interview)

Albert's interpretation of the rainfall data he collected compares his record of conditions upon his farm in respect of the records kept by another farmer the other side of his village, which had then been amalgamated and compared to the national average recorded by the Met Office.

> *"I just thought it was interesting to know, it is important…it is vital for farming and if I knew what to expect it is another thing I can take account of"* (Albert, Shropshire - interview)

This systematic process seemingly held a lot of value to Albert in allowing him to gain an intrinsic understanding of how the recorded conditions upon his land varied compared to local and national averages, allowing him to create a baseline of data. From such an understanding, he would then make logical decisions in relation to cropping and haymaking, based primarily upon the interpretation of information gathered. Just as with decisions based on scientific evidence and probabilities, it is apparent that farmers' decisions in a formal relationship are directly informed by assessing patterns and trends in the weather data gathered.

Notably, Enid made the decision to implement a large-scale adaptation in response to observing from her own rainfall data, a trend of increasing and erratic bursts of rainfall in the spring:

> *"The main decision I think it informed is that we put up some big sheds. Before that we used to lamb outdoors and that is really hard work to do it outside… lambing indoors is a lot easier"* (Enid, Gloucestershire - interview)

Such displays of formal relationships by Enid and Albert demonstrate a convergence of 'lay' and 'expert' knowledge, demonstrating the role and complexity of local knowledge. Motivations for collecting weather data by farmers appear to be out of the desire for specific and accurate, highly localised data, which is not easily accessible from weather forecasts. Farmers who collect and analyse weather data in a formal manner become 'experts' of local weather conditions within their own right, drawing upon their experience of collecting and analysing information of local weather conditions, combined with their own expertise, experience and knowledge of farming their land. Indeed, the role of amateur meteorologists in the production of local weather knowledge is increasingly gaining academic attention (Endfield and Morris 2012).

Section 2.4.3 identified that, often, a key barrier to farmers utilising scientific knowledge are the skills and practice required to use such information effectively (Ingram 2008b). Yet within formal relationships, farmers gain the skills and experience required to effectively make decisions based upon the specific weather conditions. As such, the artificial divide between scientific and local knowledge in these relationships is notably blurred (local knowledge in 3.5, Wynne 1992). This is because local knowledge is utilised and applied once further informed by scientific information, collected or sought out by the farmer him/herself, thus providing further evidence to support a continuum of local and scientific knowledge (3.5). It is apparent that such knowledge seekers who enter into a formal scientific relationship with the weather may often possess resilient attitudes and are proactive in adding to their knowledge of local weather trends and conditions. In these situations, information is sought to inform the decision-making process.

6.1.3 Informal Relationships with *'The Weather'*

Informal relationships are more prevalent than formal relationships. Over half of the interviewees displayed an informal relationship with *'the weather'*. Informal relationships are less conspicuous than formal relationships, as the influence of an informal relationship subtly infiltrates all aspects of daily farm decision-making. Informal relationships with *'the weather'* appear to be founded upon a casual interest or curiosity in *'the weather'* constructed from multiple intuitions. Normally, informal relationships with '*the weather*' are sub-conscious, without the farmer actively recognising the relationship and the influence of *'the weather'* upon the application of local knowledge and farm decisions. Due to the inconspicuous nature of informal relationships with *'the weather'*, it is problematic to participants who display these characteristics; as such, an informal relationship is often present without the recognition by the farmer.

Evidence of an informal fascination with *'the weather'* is apparent in casual weather diaries that include a commentary or interest in the weather, thus displaying its role in all aspects of a farmer's everyday life. For example, Dennis kept a daily diary of everyday farm events, yet always started the diary with the weather. In this, he begins by describing both the weather conditions, he observed and as reported in the paper, then contrasted this with events on the farm thus keeping a record of specific weather conditions and their direct impact upon the farm system.

> *"Here you are [pointing at the diary] coldest spring since 1962 I wrote down there, I probably read that in the paper. That was on the 30th March this year [2013]. I wrote: 23rd March, 4 inches of snow in Shropshire, snow plough was needed then…I do like to record the weather and things like that"* (Dennis, Shropshire - interview)

It is apparent that Dennis defines a year by the weather that took place, but associated the conditions experienced to the impact that had on the ground as recorded in his diary.

Such processes are a display of an active relationship with '*the weather*' playing an important part upon numerous aspects of farming life. Alternative informal relationships with the weather are apparent in the monitoring of weather conditions through observations and use of local knowledge of the weather conditions. Yet such information is informal in its non-scientific and inherently cultural approach;

> *"I do like to think I can predict the weather, and I was usually right…I will still go up the hill look across to the border to the Welsh mountains, and I come back and say if it was about to rain!"* (Charles, Shropshire - interview)

Such displays of 'predicting' the weather demonstrate how informal knowledge is utilised in conjunction with local knowledge on a daily basis, allowing decisions to be made based upon such observations and sub-conscious reasoning. Moreover, such feelings of weather conditions in an informal farmer-weather relationship appear to be commonplace amongst the farm community;

> *"It is a second nature with farming…gut reaction I suppose you can call it. I think it's something that farmers do automatically know"* (John, Herefordshire - interview)

Regardless of the way in which a farmer displays an informal relationship, '*the weather*' plays a significant role in a farmer's everyday life influenced by numerous cultural-behavioural processes. Informal relationships, like formal relationships, are conceptualised as being a positive influence upon everyday decision-making through the encouragement of resilience.

6.1.4 Negative Relationships with *'The Weather'*

Negative relationships, like informal relationships, are spawned from a melting pot of cultural-behavioural influences including: attitudes, background, experiences, values, beliefs, connection with the land, as well as personality traits. Past experiences with the weather are likely to influence the farmer-weather relationship developed. However, there is no evidence to suggest a link between experiences of significant losses due to EWEs and a negative relationship. This appears to be linked more closely with farmers' attitudes to decision-making, and a reflection of the level of resilience which they believe that they possess. Indeed, it is expected that a negative relationship with *'the weather'* is associated with a lower resilience. As opposed to informal relationships, negative relationships differ in the apparent detrimental effect that the relationship has upon the farmer and the subsequent decisions made. Farmers who have a negative relationship with '*the weather*' can be identified by their seemingly passive responses to challenges encountered, with limited ability to recognise actions that can be taken in response to the impacts. Within a negative relationship, a hindered decision-making process is apparent. Farmers identified to have a negative farmer-weather relationship, exhibit fatalistic and vulnerable attitudes, as well as apathetic and indifferent responses to information regarding '*the weather'* (6.3).

Two distinct types of negative farmer-weather relationships are identifiable, (i) those who become 'obsessed' with the weather, and (ii) those who regard the weather as a 'dictatorship' exerting unrestricted control upon everyday farm life. Both will be outlined below.

i. 'The Weather' as an obsession

To some extent, an obsession with *'the weather'* and a desire to know when and to what degree variable conditions might change is a widespread fascination extending beyond the farm community. British culture is renowned for having an enthusiasm for the weather and such an interest in weather variability borders on a culturally accepted obsession (Harley 2003). It is culturally constructed that Britain's weather is particularly fascinating due to its variable and unpredictable nature throughout the year (Harley 2003). Hence, the quest for knowledge to seek out a better understanding of likely changes in the weather to impact upon the land may also become a culturally accepted obsession within its own right. Such 'obsessions' have been identified in formal relationships and associated with positive influences upon decision-making, yet other obsessions with the weather have been identified within this body of evidence to exert a negative influence upon farmers' decision-making.

A negative obsession with the weather is apparent where an interest and recognition of the importance of the weather develops into a habitual process, creating a disadvantageous relationship. Consequently, the balance between an interest in the weather and the influence upon a farmer's ability to make reasoned farm decisions then become imbalanced;

> *"I think it does become an obsession with farming…I am a bit obsessed with the weather…especially checking the forecasts"* (Melissa, Worcestershire - interview)

Such obsessions become a regular occurrence where the process of seeking information becomes a habitual process, exerting a significant influence upon a farmer's day-to-day life. Melissa identified that her need to research the weather at multiple times throughout one day hindered her ability to make informed decisions. The cause of such an obsession appears to be rooted in a fear of the elements that extend beyond an individual's control.

ii. 'The Weather' as a dictator

An alternative form of a negative farmer-weather relationship is apparent where 'the *weather*' is regarded to act like a dictator. In this scenario *'the weather'* is seen to behave in an autocratic role exerting an absolute power upon their farm system, therefore the farmer appears to have little control. Thus, *'the weather'* effectively rules the decision-making process and limits the perceived range of viable options.

> *"The weather in any form of farming dictates what you can do and when you can do it"* (Geoff, Worcestershire - interview)

Unlike other farmer-weather relationships, it is the way such variability is viewed with powerlessness that exposes farmers' vulnerability. Such regards for *'the weather'* further reveals associated vulnerable attitudes, restricting viable responses that are seen as plausible options by the farmer himself. Under the rule of such a 'dictator', it is apparent that a farmer would feel as though it was beyond their own control to make informed decisions that could mitigate the consequences of variable weather, and soften the extent of adverse farm impacts because of EWEs. This concurs with Mertz *et al.* (2009) who recognised that farmers generally had a fatalistic approach when discussing climate concerns, using the notion that it is a phenomenon not within their control as an argument against adaptation.

> *"I don't know I guess I haven't dared to think that far ahead really…everything that we do really the weather has a significant factor I mean our whole life is weather dependent, whatever we do"* (Bonnie, Worcestershire - interview)

Indeed, such a relationship creates a sense of powerlessness to respond to the challenges posed by '*the weather',* increasing the vulnerability of the farm system as a whole, as no viable adjustments or options are foreseen by the farmer themselves who are under the control of *'the weather'* itself. Although the characteristics of such a negative relationship may exist, a farmer may not always recognise that *'the weather'* exerts a negative authoritarian influence.

6.1.5 Background Relationships with '*The Weather*'

In contrast to negative and positive formal or informal relationships, background farmer-weather relationships are neutral in the influence exerted upon decision-making. This is due to a minimal influence that a farmer allows *'the weather'* to exert on decision-making in a background relationship. Other processes and constructs can dominate the decision-making agenda, extending far above the consideration for *'the weather'* (Figure 7.1, 2.2.3).

Comparable to human relationships, some people choose not to engage in an active relationship with that construct. Due to reliance upon the weather and the role of the physical weather conditions in allowing for successful farm production, it is seen to be impossible by the researcher, for a farmer to have no relationship with the weather. Whether the farmer chooses to actively engage or not, '*the weather*' still exerts an influence upon the farm system. In background relationships, the cultural influence of '*the weather*' is at a minimum and pushed into the background of a farmer's priorities, thus allowing for other processes and systems to dominate farm decisions instead.

> *"I don't bother worrying about the weather anymore – if it rains, it rains, that's it!"* (Trevor, Worcestershire - questionnaire)

Background relationships with '*the weather*' were identified in those interviewees who appeared disengaged and uninterested in discussing the influence of '*the weather*' upon their farm system. It appears as though a background relationship is sometimes developed in response to past events or impacts, or from continual extremes skewing a sense of normality.

Accordingly, it does appear that the conditions of 2012 exerting excessive and extreme snowfall encouraged the respondent to become disengaged and uninterested in the possible weather conditions.

> *"We used to check the weather every day, all the time in any way possible, but now we have given up"* (Spencer, Devon - questionnaire)

This demonstrates how a farmer has actively changed the nature of their relationship with '*the weather*', reversing from active information seeking to a passive disengagement with the weather. It is probable from their comment that the previous relationship was negative, and so a background relationship is more beneficial to facilitating the farmer to make appropriate decisions based on other information and priorities.

6.1.6 Further Exploration of Relationships with '*The Weather*'

Four categories of farmer-weather relationships have been outlined and explored using supporting evidence from data collected. It is clear from the evidence that the role of the weather extends beyond a physical presence in farm practices. It has been shown in view of this evidence that '*the weather*' is intrinsically linked to cultural influences, and is subsequently reflected in farmers' decision-making. A farmer's resilience is impacted by the influence of '*the weather*' upon farmers' decisions. In accordance to 3.5, formal and informal relationships enhance the development of resilience, whilst negative relationships may obstruct and background relationships are likely to have little influence upon the development of a farmer's resilience (in accordance to 3.5).

Undoubtedly, the cultural role in which farmers' relationships with '*the weather*' exert a significant influence upon a farmer's ability to make informed decisions in view of extreme weather and climate change, is a significant finding from this research. The application of a farmer's relationship with *'the weather'* is often applied through knowledge seeking or avoidance behaviours. Therefore, the way in which a farmer seeks and utilises a weather forecast is an indication of this relationship, which will be explored throughout 6.2.

6.2 Use of Weather Forecasts

Weather forecasts are valuable in providing farmers with informed forecasts of the likely short-term variability in local weather systems (Paolisso *et al.* 2003). The reliance upon accurate and timely information of local weather conditions amongst the farm community to inform daily-decision making, is high. The use of weather forecasts can be regarded as a behavioural expression of farmers' relationships with *'the weather'* (6.2) and farmers' understanding and ability to interpret scientific forecasting for the future (3.3).

Assessments of scientific knowledge synthesised into a weather forecast are applied on a daily basis within the context of local knowledge of variable weather conditions to aid interpretation of weather conditions (Osbahr *et al.* 2010, Wynne *et al.* 1992). This section will explore the way in which farmers in the Welsh Marches utilise weather forecasts in view of the influence of this upon daily farm decisions in six parts. Firstly, the influence of farmer-weather relationships upon the use of weather forecasts will be examined (6.2.1). Secondly, the frequency of farmers' use of weather forecasts to inform decisions will be established (6.2.2.). Thirdly, the roles of national and local media in communicating weather forecasts to the farm community will be established (6.2.3), in view of the complexities of scientific communication outlined in 3.3. Fourthly, the increasing reliance upon online forecasts and weather apps will be discussed in view of an emerging popularity (6.2.4). Fifthly, the use of alternative methods to predict the weather will be examined (6.2.5), in view of the direct application of farmers' local knowledge to make decisions (3.5). Finally, the role of trust that a farmer has in the communication of weather forecasts will be examined (6.2.6) in view of the complexities of scientific communication (3.3).

6.2.1 Influence of Farmer-Weather Relationships upon Use of Weather Forecasts

It is apparent that the nature of farmer-weather relationships explored in 6.2 is often applied to the way in which weather forecasts are sought, interpreted and relied upon. However, as indicated in 6.2.6, the link between a farmer's relationship with '*the weather*' and information seeking is not always linear, and although a direct link is apparent in formal and informal relationships, it is not always the case in negative and background relationships. This is likely to be due to the complexity of negative and occasionally background relationships being developed due to negative experiences. Therefore, such a relationship with the weather may be displayed when they discuss the weather, but may not be reflected in their habits in regards to routine information seeking. Despite some exceptions, most relationships including negative (in particular obsessive relationships) and background relationships do influence the extent to which a farmer seeks and utilises weather information.

6.2.2 Frequency of Use of Weather Forecasts

Weather forecasts play an important role in farm decision-making, which is growing in importance due to increasing demand for instant access to information through the internet, as well as widespread impacts of recent EWEs (in 2012 and 2013 in the Welsh Marches);

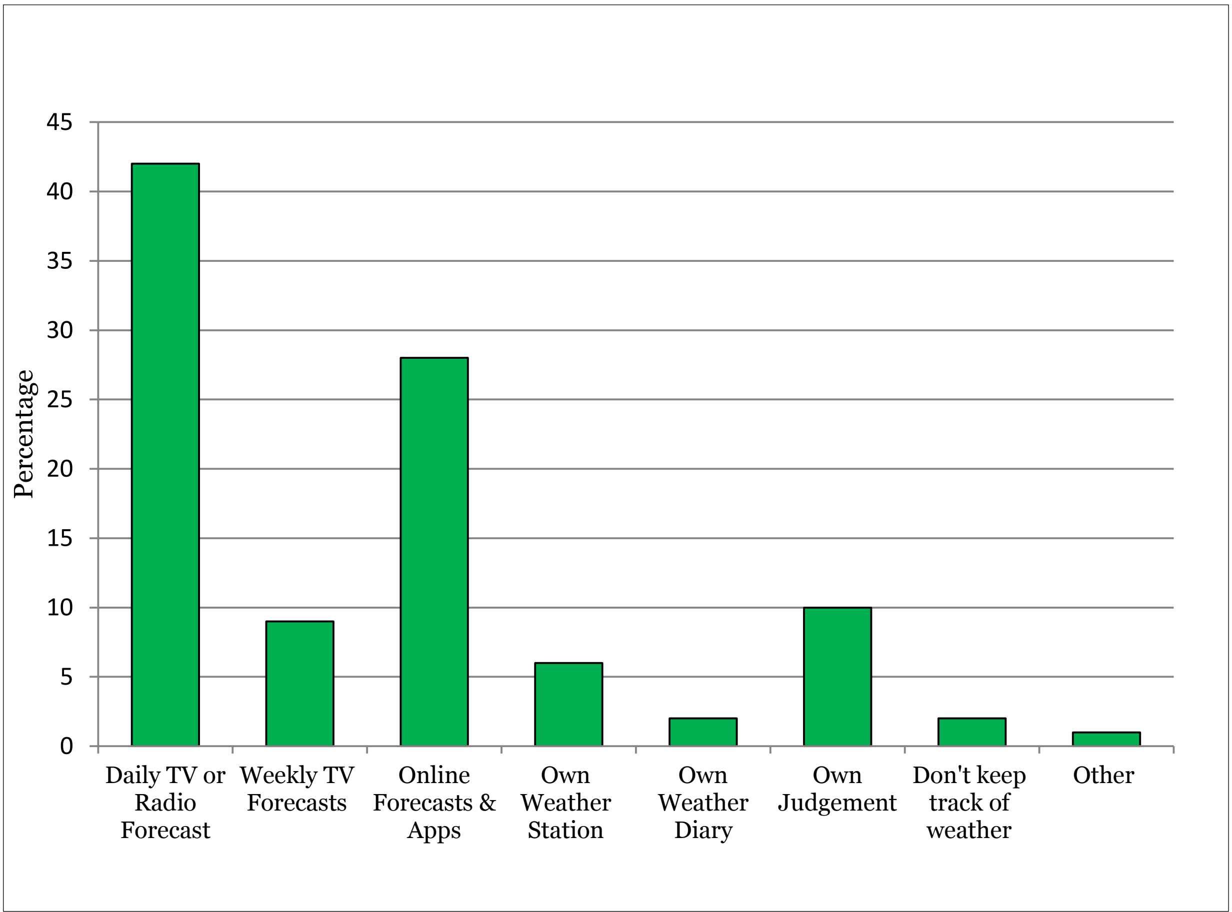
> *"But the thing is what I think the farming industry has now become very weather dependent…and what they are now is much forecast driven. Famer's are watching weather forecasts like a hawk…we want clear information about the weather"* (Geoff, Worcestershire - interview)

Information seeking behaviour connected to the weather is displayed both in the way in which, and in the frequency that, weather information is sought in forecasts. Figure 6.1 presents results establishing the frequency and nature of weather forecasts used. As a variety of different weather forecasts are utilised in combination, respondents were asked to select their most preferred method, with up to three different options allowed to be chosen. Thus, Figure 6.1 shows the total responses generated, giving a more accurate representation of the most popular and relied upon weather forecasts. The most popular sources of weather forecasts are daily TV or radio forecasts, with 42% of respondents saying that this is their preferred means of keeping track of the weather.

The second most popular method was online forecasts and weather apps, generating 28% of responses.

Notably, in several responses, an indication of using a combination of different weather forecasts was made. Yet, despite a variety of methods being utilised at once by several of the questionnaire respondents, most decision-makers have a preferred option for how and when they seek out such information. The habitual process of utilising weather forecasts is highly individual. It is likely that decision-makers actively seek experience in using particular forecasts so that they can develop the ability to calibrate the strengths and weaknesses of subsequent decisions (Dessai *et al.* 2009).

Figure 6.1: Preferred Means of Keeping Track of the Weather



Source: Author's Questionnaire

<u>6.2.3 Roles of National and Local Media</u>

The culture surrounding the weather is thought to be commonly depicted through daily conversations over the radio and television weather forecasts, whilst assessed alongside their own commentary and analysis of the current conditions outside (Paolisso 2003).

Figure 6.1 indicates that, despite increasing reliance upon online weather forecasts, TV and radio forecasts are still dominant.

However, differences between the preference towards local and national, weekly and daily forecasts are also apparent:

> *"The 5.30am weather on BBC1 is bang on every time…"* (Nathan, Herefordshire - interview)
>
> *"When it is raining we are constantly checking BBC weather online"* (Owen, Shropshire - interview)
>
> *"We always use the weather in the Shropshire Star…"* (Charles, Shropshire - interview)

Information seekers appear to have a preference towards a particular source and range of forecasts based upon trust in the information that is portrayed (6.2.6). More passive information seekers appear to choose forecasts depending upon whichever is most convenient to them at that particular time, rather than through conscious decisions based on trust:

> *"I tend to just see it on the television really…"* (Isaac, Herefordshire - interview)
>
> "*In the evening I watch the weather forecast if I can"* (Dennis, Shropshire - interview)

A mixture of local and national forecasts are apparent, with some having no preference and utilising both or whichever is most convenient (e.g. on the television). Others have a strong preference for the local forecast, as it is deemed more accurate for their specific location.

<u>6.2.4 Increasing Reliance on Online Forecasts and Weather Apps</u>

Away from traditional weather forecasts, online weather forecasts and the use of weather apps are emerging as a popular source of weather forecasts. Figure 6.1 demonstrates that 28% of respondents prefer online forecasts. Such sources of information allow for a different type of weather forecast to be accessed and interpreted (Harley 2003, Sivle 2013). Daily and hourly updates prove to be the most popular, indicating a general demand for instant detailed accurate information (BBC 2013).

> *"It wasn't very good in those days, but is good now. If I really want to know the weather I would go on XC weather website, it is so helpful planning day-to-day if an hourly breakdown is provided"* (Albert, Shropshire – interview)

The breakdown of conditions allows a farmer to make informed decisions based upon the forecast using their own knowledge and experience of weather conditions. Furthermore, the decreased reliance upon a presenter to interpret accurately such information, shortening the communication chain also seems to appeal to more farmers who do not always trust synthesised information given through a centralised platform such as national weather forecasts. Online forecasts allow farmers to interpret weather information directly without having to collect their own data, appealing to those in formal and informal relationships with *'the weather'*.

> *"Met Check [website] can show you all the temperature, wind speed and all the rest"* (Henry, Worcestershire - interview)
>
> "*I do find now the online weather forecasts are very, very reliable"* (Charles, Shropshire – interview)

As such, these decision-makers appear to regard online information as being more reliable since they are free to interpret the information for their specific location using the information provided.

In addition to the use of websites, increasing use of weather apps (BBC 2013) has enabled frequent monitoring and cross-referencing between different types of weather information and forecasts, in a timely manner:

> *"We've got all the weather apps, I think about four on the iPad because we check them all and see if there's a common theme each day"* (Bonnie, Worcestershire - interview)

However, with the ability to access weather forecasts instantly also comes a challenge to interpret such information, as often instant judgements are made without the interpretation of a scientific forecaster. In particular, weather apps can result in different interpretations of symbols as the metrological community may assign different meanings to symbols than user groups such as farmers would do (Sivle 2013). Thus, perceived difficulties in accurately communicating such information to specific communities such as farmers are notable (Sivle 2013). Nevertheless, Sivle (2013) states that the acknowledgement of uncertainty surrounding weather forecasts is apparent in its interpretation by user groups, yet appears to be overshadowed by concerns over the ability to trust the forecasts themselves (6.2.6). Climate change is difficult for most lay audiences to understand, therefore it demands more from communicators (3.3.3). Yet, the weather is a familiar construct in which information is regularly interpreted and considered within the context and parameters of a farmer's own knowledge and understanding (Wynne 1992). Interestingly, it does appear that age is not related to preferred method of use, with the emergence of online and weather apps being evenly spread amongst the sample of farmers interviewed, regardless of age and time on the farm.

Online forecasts, unlike traditional ones, do allow for an informed assessment of the predicted conditions to be made directly by the user. They are thus preferred by several of the interviewees who didn't trust the forecasters and communicators themselves. Indeed, such interpretation is likely to be more appealing to farmers as they are able to apply their own knowledge to interpret the forecast through own observations and trial and error (Sivle 2013). Yet, the popularisation of such science through different interpretations of forecasts does leave it open to misinterpretations, and for mistrust in the source to develop (6.2.6).

There are numerous different weather apps where the sources of information are not always known, and so they may scientifically be less reliable. Indeed, a professional webpage may disguise an amateur forecast that has not been constructed with the same accuracy that is ensured in weather forecasts prepared for the media. Indeed, this may be why farmers are checking the information from weather apps alongside several other sources (as shown by Bonnie). The uses of internet and weather apps are still increasing in popularity, and so the outlets are still evolving. Consequently, limited research has been conducted to explore the value of these; in particular further research could explore the role of weather apps in informing farmers' daily decisions. This will be particularly valuable to establish whether this new found access to instant, remote, detailed weather data, has changed the farm decision-making environment based upon the weather.

6.2.5 Use of Alternative Methods to Forecast the Weather

In contrast to formal weather forecasts, alternative means of keeping track of variable weather conditions are notable. Figure 6.1, shows that 10% of respondents prefer to use their own judgement of the weather (a characteristic of informal relationships 6.1.3). In such methods, the farmer is actively engaged with the process of assessing the weather, creating a two-way interactive relationship with weather forecasts. This presents its own benefits and limitations to decision-making (Moser 2010). Alternative approaches to keeping track of weather conditions appear to consist of: the use of barometers, digital weather stations, farmers' observations, old wives' tales and self-constructed indicators of conditions.

> *"We use everything, we have a barometer in the house…even the old wives' tales things like red sky at night…and the internet…we've got all the weather apps, and always watch the Sunday forecast for the week ahead*" (Kate, Herefordshire - interview)

Barometers allow local weather conditions to be assessed 24-48 hours in advance using atmospheric pressure (Barry and Chorley 2009). Due to the ease of use and localised monitoring of barometers, they appear to be a regular occurrence in farm households. Four interviewees mentioned having use of a barometer that they relied upon to inform their own judgement of probable weather systems and atmospheric conditions expected:

> *"Well I look at the barometer it gives you an indicator of how things are going"* (Henry Worcestershire - interview)
>
> *"I always use a barometer daily"* (Nathan, Herefordshire - interview)

As such, the use of barometers is an example of semi-scientific information which is obtained using traditional scientific methods, yet interpreted using farmers' own assessment and local knowledge of local weather conditions. This is also apparent in Kate's use of old wives' tales above. It does appear that informal 'non-scientific' means of making informed judgements of weather conditions are utilised by farmers to complement scientific forecasting of atmospheric conditions (see 3.4.1). This is through the application of their own observations and local knowledge developed in relation to the specific locality and nature of their land conditions (Ingram 2008b, Wynne 1992).

6.2.6 Role of Trust in the Use of Weather Forecasts

Essential to effective scientific communication is the 'trust' that a user group has in the source of information (3.3, Lorenzoni *et al.* 2007). This section assesses the application of weather forecasts to allow an insight into the way in which weather information is sought and interpreted to inform farm decisions based upon the weather. A barrier to utilising scientific knowledge is the skills and practice required to use such information effectively (Ingram 2008b). In order to interpret such information derived from scientific or informal constructs, a behavioural process is developed allowing farmers to make judgements based upon information provided as to what should be trusted and adopted into decision-making (Hu *et al.* 2006). Certainly, the influence of local knowledge and own cultural-behavioural processes on such judgments is considerable, leaving interpretation of information highly subjective (Sismondo 2010).

It has been identified in this research that a notable barrier to a farmer acting upon a weather forecast is the perceived reliability of such information. Preferences in weather forecasts are weighted towards sources in which a farmer trusts. It is commonplace that farmers have their own preferred source of weather forecast. Notably, perceived trust in local sources, particularly from 'local experts' appears to be greater than generic and national sources. It is portrayed by the newspapers and from interviewees themselves, that an 'expert's' opinion holds higher value than a journalist's, thus local meteorologists Paul Damari (Worcester News, Hereford Times, BBC Radio Hereford & Worcester), and John Warner (Shropshire Star) were used frequently throughout the papers to deliver weather forecasts and explain the extreme conditions.

> *"I usually listen to BBC Hereford & Worcester and specifically Paul Damari…I would always trust his forecasts. He stuck his neck out when they were predicting heavy snowfall one year. So I thought I would go with him and didn't move my cattle and he was right. Paul did his own forecasting, he lived round here all his life, he knew his weather"* (Frank, Worcestershire - interview)

Such trust in a particular source of information appears to take many years to develop as the ability to interpret effectively the information into effective decision-making (Hu *et al.* 2006). Conversely, trust in a source of weather forecasts can also be easily broken after a single instance:

> *"I wouldn't trust the local BBC Worcester and Hereford forecast. They told us it wouldn't rain one year and it did. We went away and we had a real issue with the cattle getting stuck"* (Nathan, Herefordshire - interview)

Extending beyond distrust in a single source is an apparent distrust in all weather forecasts due to a perceived lack of reliability. As mentioned previously, several farmers stated a preference to cross-referencing numerous weather forecasts in order to gain an informed impression of expected localised weather conditions. Such an explanation was also used in justification for installing own weather stations to ensure increased reliability and to check if both forecasts (online and own station) of conditions are correct. Indeed, increased trust does form through seeking information upon the process of developing forecasts.

In-line with increasing popularity of online forecasts and weather apps (6.2.4), a change is apparent in the use of weather information as more specific placed-based communication is readily provided tailored to a specific postcode. This may facilitate the ability to inform place-based adaptation (Cutter *et al.* 2008). A 'bottom-up' approach placing local culture, infrastructure and culture at the forefront of the agenda helps support farmers in making more informed adjustments based on local weather conditions (2.3.5). An increasing demand for a 'bottom up' approach to weather forecasts is adopted through the growth of online, apps, and own weather stations and observations taking place. This is in response to more traditional, centralised and highly scientific forecasts which have generated much distrust due to misinterpretation and the non-specified nature of such forecasts for the activities conducted by farmers (6.2.3). Thus a more specialised forecast is being actively sought to meet the community's specific needs. Indeed, those adopting 'bottom-up' approaches with information highly specified to the needs of the community have proved fundamental to increasing farmers' resilience to climate change (Cutter *et al.* 2008).

This section has presented evidence to portray the way in which weather forecasts are sought out and utilised in farmers' decision-making. Such evidence concurs with Paolisso *et al.* (2012)'s acknowledgment that a range of local information and experiences are drawn upon to interpret and make informed judgements from information received. Therefore, the way in which forecasts are sought, interpreted and utilised is a highly individual process informed heavily by the cultural and societal conditions in which they operate. It is considered that the way in which weather forecasts are used, is an indicator of an individual's ability to interpret scientific communication decision-making (In accordance with Figure 3.4). Therefore the extent to which such information informs decision-making can provide an indication of how judgements of climate change information may be interpreted and applied in farmers' decision-making, due to the familiarity of dealing with related, uncertain information (3.3, Osbahr *et al.* 2010, Paolisso *et al.* 2012). Furthermore, this synthesis of information has emphasised the importance of cultural-behavioural processes in utilising weather forecasts to inform decision-making.

6.3 Farmers' Observations of Changes in the Weather

So far, this chapter has explored different perceptions of the weather and the way in which this is applied to farmers' decision-making. Due to the significant role the weather plays in farmers' daily decision-making, farmers are well placed to make observations of any apparent changes in weather conditions over time. Research in developing nations has found that a high-level of awareness of changes in weather conditions were prevalent amongst most of the farming population (2.3.3, Deressa *et al.* 2011, Mertz *et al.* 2009). For instance, farmers' perceptions of climate variability in South West Uganda were accurate in portraying seasonality and temperature change in accordance to weather records; yet different rainfall patterns were perceived (Osbahr *et al.* 2010). However, as discussed, Canadian farmers were similarly found to be considerably more sensitive to variability in weather conditions and seasonal variations compared to that concerning the general public (2.4.3, Bryant *et al.* 2000, Smithers and Smit 1997).

Farmers' perceptions of climate change are expected to be based upon the perception of the norm and expected patterns in weather conditions (Hulme *et al.* 2009). Therefore, a part of the interview process was to establish any changes the farmer may have observed in the weather since they had been on their land in order to establish the association between such observations and their perceptions of climate change comparable to Bryant *et al.* 2000, Smit *et al.* 1996, Smithers and Smit 1997). When asked whether an interviewee believes that weather conditions have changed since they had been farming, 14 out of 16 farmers had mentioned observations that considerable change in weather conditions has taken place. Common themes of discussions are identifiable in the identification of changes in: extreme conditions (6.3.1), seasonal variations (6.3.2), fewer windows of opportunities (6.3.3) and those that observed no recognisable change in conditions (6.3.4). Each will be discussed in turn in respect of observations made and observed changes in conditions recorded in Defra (2012a) and IPCC (2013), along with references to the local meteorological records analysed. The significance of such observations in relation to perceptions of climate change will then be introduced in 6.3.5, before further exploration of futures in chapter seven.

6.3.1 More Extreme Conditions

One of the most prominent responses from interviewees across the Welsh Marches, as well as from questionnaire respondents across the UK, is the marked observation that there have been more instances of extreme weather, including weather variability as well as EWEs. Widespread impacts of EWEs in the Welsh Marches in 2012 and 2013, is likely to have heightened awareness of extreme weather in recent experiences (5.4).

It is considered that the uncertain variations from year to year felt in weather extremes are the greatest triggers to prompt adaptive behaviour (Bryant *et al.* 2000). As such, conditions including rainfall intensity and duration, incidence of early or late frosts, high temperatures and the intensity of drought are most likely to be recognised by a farmer due to the significant scale of impact such extremes exert on a farm system.

Several interviewees discussed the apparent extremity of weather conditions observed in recent years:

> *"We've just noticed that everything is so extreme now we don't have normal weather now. It's exceptionally hot, cold, wet or dry"* (Bonnie, Worcestershire - interview)

> *"Well last year, 2011 was very dry and the year after was very wet, they were the two most extreme I have ever experienced, especially one year after another"* (Albert, Shropshire -interview)

These observations have been recognised regardless of apparent farmer-weather relationships, that Bonnie and Albert made from both a formal relationship with a scientific interpretation of changes experienced (shown by Albert), and a negative relationship in reference to significant recent losses incurred due to extreme weather (shown by Bonnie). Accordingly, it is apparent that regardless of a farmer's relationships with *'the weather'* (6.1) observations of increasing extreme weather conditions have been made.

The loss of 'normal' was apparent in discussion of extreme conditions in several responses in relation to an apparent trend of concentrated periods, varying from conditions that the respondents had become accustomed to;

> *"See when it rains, it rains heavier…in the spring you used to get warm, soft rain almost drizzly. The last four and a half years you get thundery more intense rain…it would help if we could just have a normal year…we haven't had a normal year in the last three years"* (Owen, Shropshire - interview)

> *"We get more extreme weather now…we will get dry spells for two years at a time, and then it will be wet for two years…that's what bothers me more than anything else, all these extremes we seem to be getting"* (Frank, Worcestershire - interview)

Such observations extend beyond the recognition of EWEs that had been experienced by farmers to distinguish a general pattern of extreme weather conditions over longer periods. Yet, specific events that occurred prior to data collection, including the 2012 rainfall and 2007 floods, also appear to have influenced farmers in recognising an increased dominance of weather extremes, as expected due to their memorable influence upon recent decisions (Smit *et al.* 1996).

> *"I think what I would say over my farming life is that things are getting more extreme I think…it has happened over the last twenty to thirty years…you get*

> *an extreme wet period or a dry period you know, or you get a wet period then a cold period"* (Henry, Worcestershire - interview)

Extending beyond a simple observation of extreme conditions, the prevalence of such extreme weather has already had a direct impact upon the farm family and subsequent decision-making. This is particularly noticeable following intense rainfall events, and several farms reporting an increase in flooding because of such changes in the weather.

Such observations by Henry coincide with recorded changes in extreme weather and the apparent increase in frequency of flood occurrence (Defra 2012a). Losses incurred by farmers from extreme weather have increased and observed increases in the scale of impacts of such events is apparent (Cutter *et al.*2008, IPCC 2014). This demonstrates that such observations and experiences of these farmers in the Welsh Marches concur with those that have been experienced, recorded and expected globally as a result of increasing effects of climate change (IPCC 2014).

6.3.2 Seasonal Change

Comparable to the seasonal variations reported to concern Canadian farmers, as discussed by Bryant *et al.* (2000), seasonal change is a substantial observation made by farmers in the Welsh Marches. Often discussed in reference to more extreme and variable weather conditions, changes in expected seasonal variations were observed by all but four interviewees (see also 2.4).

Without prompting through specific reference to seasonal changes, several farmers made reference to the apparent disappearance of the expected four seasons:

> *"Are there seasons anymore?"* (Geoff, Worcestershire - interview)
>
> *"Proper seasons just don't run now do they? It just seems to blend in…it's winter now and autumn's not really come in"* (Melissa, Worcestershire - interview)

Most explanations of such changes in seasonal variations appear to be founded upon recent justifications in having experienced less defined seasonal change. Weather conditions experienced prior to the time of the interviews, provides an explanation to observed seasonal changes, with such justifications anchoring upon the recent summer and autumn conditions.

Alternative to the recognition of seasons becoming less defined from each other, seasonal shifts forwards or backwards were also observed by others.

> *"I would say that the seasons have shifted a month i.e. in this particular area you're finding that March used to be a time we had spring corn in whereas they do winter corn now, and you could sow in March easily, the ground use to be light and it used to be warm. But not anymore it just seems to be now a bit more behind. The springs might be getting slightly later but the autumns are getting a little bit warmer. Temperatures do seem to be getting milder in autumn like today. It is only 15 degrees at night [in October]. That's more like September really"* (Charles, Shropshire - interview)

Comparable to memory recall (5.3) and event anchoring (5.3.1) processes, nostalgic references comparing noted changes in seasonal variations in recent weather are apparent in such explanations of seasonal change. This is often made in reference to the apparent changes in the farming calendar, and so changes having to be made in response to seasonal variations:

> *"When I was your age we could guarantee that we would always have the cows out by April, the seasons were much more predictable"* (Henry, Worcestershire - interview)

> *"We had a good spell late 80s early 90s where it was quite warm. Which if you were hay making it was quite good, as it was drier. Now springs and summers are wetter so you couldn't get the crop out and if you have the crop out you couldn't do much with it because the weather was so wet"* (Frank, Worcestershire - interview)

Such evidence that was abundant throughout interviews demonstrates the impact of varying seasons upon decision-making over time. Evidence of less defined seasonal variations is presented in Defra (2012a), and is thought likely to have a more profound impact over the next decade as result of climate change (Defra 2012a, Ambler-Edwards *et al.* 2009). Indeed, the variation and unpredictable nature of changing seasonal variations appears to increase complexity in farm decisions.

6.3.3 Fewer Windows of Opportunity

Reference to 'windows of opportunity' appears to be used by farmers to describe a period of optimum conditions required to conduct key farm activities. This was used in particular reference to farm activities that demand a period of stable conditions such as in silaging. Across several countries of research, it is demonstrated that climate variation in a specific year was described by farmers as a deviation from their ideal weather conditions to enable a successful livelihood, not necessarily as a result of the predominant characteristics present (Bryant *et al.* 2000, Deressa *et al.* 2011, Osbahr *et al.* 2010, Reid *et al.* 2007). As such, describing windows of opportunity are a means of making such comparisons of weather experience to the optimum conditions required.

Recognition of smaller windows of opportunity coincides with observations of increases in extreme conditions (6.3.1), and less defined seasonal change (6.3.2). As such, the identification of smaller windows of opportunity was mentioned as a consequence of extreme conditions outside of expected seasons resulting in a change in the timing of farm activities accordingly. In particular, these were made in comparison to 'more reliable' summers in the past:

> *"You could always get a good enough window together. Whereas, now you would be lucky to cobble together a few days"* (Charles, Shropshire - interview)
>
> *"The windows of opportunity are much less. So you want to make sure that a the kit is all on the tractor and that you're all ready to go. If you have fewer windows you want to make sure that you are maximising these chances, need to get the optimum out of these" (*Geoff, Worcestershire - interview)

As well as preparedness measures like Geoff's, small adjustments in response to perceived shortened windows of opportunity were discussed. In particular, more machinery that is efficient was considered:

> *"I mean our windows of opportunity seem to be shorter now, so if we could cover six metres at a time instead of three metres that is probably is the way to go"* (Bonnie, Worcestershire - interview)

Such changes would allow for more land to be covered at once, therefore optimising use of such windows of opportunity. The motivation of such periods to encourage adaptions will be explored further in chapter seven.

6.3.4 No Recognisable Change in Conditions

Observations are highly subjective, and so exceptions to the general conditions observed are apparent. Whilst acknowledging the small sample size a high majority of respondents noted the increase in extremes and seasonal variations. However, a minority of farmers mentioned that they have observed no significant recognisable change in weather conditions on their land since they have been farming.

> *"There's always going to be extremes aren't there"*
>
> (John, Herefordshire - interview)

Tables 4.1 and 4.2, shows that EWEs have been frequently experienced in the Welsh Marches since 1982; therefore it is probable that farmers have adjusted to dealing with continual extremes, and so develop resilient attitudes towards coping with extremes which may influence observations made:

> *"Well from a weather point of view in the UK there is nothing new, it's all happened before"* (Albert, Shropshire - interview)

Furthermore, from Albert's formal analysis of rainfall data, he has concluded that there is no distinguishable change observed in rainfall. Yet, he did recognise that 2011 and 2012 were both extreme years, thus possibly heightening others' perceptions of the weather becoming increasingly extreme. In accordance with Osbahr *et al.* (2010) farmers were found to portray seasonality and temperature change accurately in accordance to weather records, yet different rainfall patterns were perceived. Thus upon formal analysis of rainfall data collected, Albert is able to observe that less significant variations in rainfall are apparent than in temperature and seasonal change.

6.3.5 Significance of Observed Change

From analysis of the local meteorological data, less abrupt seasonal averages can be distinguished through less distinctive temperature variations in spring and autumn months identifiable in the 2002-2011 average than in 1982-1991. Seasonal variations recorded by local weather stations do appear to concur to that recognised by the majority of farmers. Therefore, Osbahr *et al.* (2010)'s finding that farmers accurately recognise temperature and seasonal variation in Uganda, can also be accepted for farmers in the UK.

Observations analysed in this section were discussed by a majority of farmers included in this study's sample, from a range of different perspectives of '*the weather*'. Therefore, it does appear that different types of relationship with the weather and perspectives have not directly influenced the observations made in changes over time. Yet, fewer observations were made by those in background relationships rather than those in formal, informal and negative relationships with '*the weather*'.

The weather is a familiar cultural construct (Harley 2003, Paolisso 2003) which is considered and discussed on a daily basis. Therefore, observations of changes in the weather were easily made by farmers as changes were apparent and recognisable. Climate change is a more unfamiliar, scientifically constructed notion, in which consideration of long-term conditions are more difficult to make. It is apparent that although a consensus of changes in weather conditions was displayed, wide-ranging differences in understanding and perspectives of climate change are apparent. Moreover, there is a considerable disparity between farmers' observations of the weather and perspectives of climate change (7.1). Yet, farmers' perceptions of weather conditions were strongly linked to their decisions by Smit *et al.* (1996), but such perceptions varied considerably dependent upon previous years' experience (supported by Bryant *et al.* 2000). This signifies the apparent importance of observations on decision-making and weather perceptions. Correlations between weather observations with future climate change perspectives will be examined in depth in chapter seven.

6.4 Perceptions of Present Weather Conditions and Farm Decision-making

This chapter has focused upon the role that daily weather conditions play in farm decision-making, and the influence of this upon the development of farmers' resilience (3.5). In relation to Figure 3.4, the farm decision-making environment is informed directly by risk perception. Risk perception has been explored in this chapter in relation to farmer relationships with *'the weather'* (6.1), information seeking of weather forecasts (6.2) and observations of changes in weather conditions (6.3). Individual relationships with '*the weather*' are envisaged to exert a variable influence upon farmers' perceptions of the weather, and subsequent information seeking behaviour and decision-making. Section 6.1.5, emphasised that: formal, informal and negative relationships involve the farmer actively engaging with '*the weather',* whilst background relationships represent a passive connection, and so are not so strongly associated with observations in the weather or the use of forecasts.

Formal, informal and negative relationships with '*the weather*' (6.1.2- 6.1.4), have been identified to exert some influence upon the use of weather forecasts (6.2). The use of weather forecasts and information seeking behaviour determines the scientific communication that enters and is used in the decision-making process (Figure 3.4). Section 6.2 has established the nature and use of information that is from 'remote' sources, in determining daily decision-making (in accordance to 3.3). By contrast, 6.3 established observations of weather conditions in the present-day.

Such observations of changes in the weather are verified through past experiences (5.3.1). This directly informs the parallel processes of 'experience' (Figure 3.4). It is such information from the remote and experience that are shown to converge in the development of farmers' resilience in view of this added information. Both observed changes and the use of weather forecasts are thought to be associated, although one doesn't seem to always exert a direct influence upon the other. Prominent findings of each (6.2.2-6.2.5 and 6.3.4), are displayed as the most likely outcomes due to the volume of supporting evidence. Indeed, 6.2.5 emphasises that the role of trust is prominent in the influence and use of weather forecasts on decision-making and so is a barrier in which information is filtered through, verified by farmer observations.

A farmer's perception of the weather is considered to help establish its priority amidst other farm pressures when undergoing adaptive change. Although risk perception is required to build specific resilience to a future threat, changing weather patterns have been reported by scholars including Tate *et al.* (2010) and Brklacich *et al.* (1997), who both demonstrated that observations of change did not directly result in a specific farm response (2.4.2). Thus, the complexities of future responses needs to be explored in further detail to interpret the value of such observations, in any potential application to building adaptive capacity and subsequently the development of farmers' resilience. Chapter seven will therefore respond to this need.

Chapter five established that past experience of EWEs exert an influence upon perceptions of extreme weather and provide an indication of probable impacts and responses. Therefore, chapter six has strived to develop this by establishing present perceptions of daily weather conditions and their influence upon the farm system and present decision-making environment. This foundation will establish the present environment in which future challenges, concerns and adaptations will be confronted, thus establishing a baseline for which future climate change perspectives will be developed upon, as investigated in chapter seven.

CHAPTER SEVEN

FARMERS' INTERPRETATIONS OF FUTURE CLIMATE CHANGE

"What need the bridge much broader than the flood?"

- William Shakespeare (1598-1599)[34]

It has been conceptualised throughout this discussion that farmers' experiences in the past and present influence future actions, understanding and interpretations of events. The cultural-behavioural approach devised in chapter three has been tested in its application to explore the development of farmers' resilience to climate change through experiences in the past and the present. Chapter five investigated how farmers' experiences of past EWEs create a baseline of experiences against which new challenges are compared. Chapter six investigated the role of farmers' perceptions of the weather in decision-making and the development of resilience.

The future is often ignored in agricultural geography where investigations are found to be anchored upon present and past changes, yet it is highly relevant in climate change research. Therefore, this chapter builds upon the chronological exploration of farmers' interpretation of climate change, to explore further future weather conditions and expected climate change for the Welsh Marches (2.1). This chapter looks at future climate conditions for a 30-year period from the time of data collection in 2013, up until 2043. Therefore, future climate change will be considered in view of predicted physical conditions, past impacts, present circumstances and the application of local knowledge. Within this 'future' period, a further division to the 'near' future (7.1-7.2) and the 'distant' future (7.3) shall be explored in relation to farmers' resilience towards future climate challenges.

A strong association between experiences of the weather in the past and present has been found. However, there is little link between present observations and experiences and future risk perception. Instead, an apparent gap between farmers' perceptions of

[34] Shakespeare, W. (1598-1599) *Much Ado About Nothing*. Act 1, Scene 1,13.

present and future climate is identified from this analysis. Perspectives of future climate change are continually changing, and so a complex web of risk perceptions, experiences, knowledge and communication exists. Alas, this chapter cannot present a logical pattern of risk perceptions leading to explicit adaptation to climate change. Instead, the interwoven concepts will be considered in view of the true complexity of developing farmers' resilience through decision-making and building adaptive capacity, to better withstand the pressures of future climate change in view of Figure 3.4.

Table 7.1 details key socio-demographic indicators alongside evidence of each interviewees resilience. This is to further aid the readers understanding of the examples included throughout this chapter from the qualitative interviewees. Therefore, Table 7.1 provides further context to the climate change perspectives and adaptations that are discussed.

To investigate explicitly farmers' resilience to future climate change, chapter seven will build upon the previous exploration of weather (chapter six) and EWEs (chapter five), to focus primarily upon future climate. The principal aim of this chapter is to establish farmers' resilience through investigation of farmers' perspectives of future climate change in comparison to predicted impacts, and potential adaptation option responses derived from the farm community. This allows the cultural-behavioural approach to be applied to explore farmers' perspectives and actions in response to probable climate change specific to the Welsh Marches. This exploration of future climate change will be broken down into three parts. Firstly, climate change perspectives will be established based upon farmers' opinions of climate change (7.1). Secondly, adaptive measures found to be implemented will be explored (7.2). Finally, the distant future will be considered with regard to potential future opportunities and challenges to the farm community in view of changes in the climate of the Welsh Marches by 2043 (7.3).

7.1 Climate Change Perspectives

Perceptions are built upon the enculturing of experiences through local knowledge and present concerns over the weather, in combination with scientific communication presented by the media (Hulme *et al.* 2009). Such processes are amalgamated through a farmer's interpretation of information derived from the application of their local knowledge of the land and conditions to portray perceivable impacts of future climate upon their land (according to Figure 3.4). Climate change is a particularly complex

Table 7.1: Evidence of resilience of interviewees

	Farmer Characteristics	Farm Classification	Experiences of Past EWEs	Evidence of Resilience
ALBERT	Sex: M Age: 65+ Shropshire	Cereals, family run farm, land owner, 40- 80ha	Crop losses due to drought	Highly scientific in approach to collecting rainfall data to directly inform farm decisions. Keeps a detailed record of farm rainfall data which he uses to establish trends and patterns over time. High social capital displayed in sharing data and information with other local farmers. High adaptive capacity evident in trialling and implementing different crop rotations as a result of patterns established from rainfall data.
BONNIE	Sex: F Age: 36-50 Worcestershire	Mixed, family farm in partnership with brother up until 2 years ago and so now sole owners of farm business, >400 ha	Significant recent losses due to recent 2012 rainfall.	High social capital due to heavy involvement in local community and NFU. Little sign of adaptations and slow recovery following 2012 rainfall indicates low coping capacity.
CHARLES	Sex: M Age: 65+ Shropshire	Dairy, partnership with family then became owner, 200-400 ha	Impacted by 2012 rainfall in terms of milk productivity and impact upon land/soil structure	Financial difficulties often mentioned in relation to impacts of EWEs, and a limiting factor to adaptation. Have explored adaptation options following advice of others in social network, but not fully implemented to great effect.
DENNIS	Sex: M Age: 51-65 Shropshire	Livestock, owner of family business specialises in rare breed cattle, 80-200ha	Impacted by 2012 rainfall due to heavy land saturation	Low social capital, coping capacity and adaptive capacity evident.
ENID	Sex: F Age: 65+ Gloucestershire	Livestock, tenant, family farm, 40-80ha	Impacted by 2013 snowfall, lost some lambs.	Already implemented some adaptations such as large livestock shelters following floods, high social capital due to heavy involvement in the local community and NFU.
FRANK	Sex: M Age: 51-65 Worcestershire	Livestock, tenant, 10-40 ha	Impacted by frequent floods, and intense rainfall.	Has significantly reduced stock, reduced social capital. High use of local knowledge and deep connection with the land.
GEOFF	Sex: M Age: 51-65 Worcestershire	Owner, horticulture, 10-40 ha	Impacted marginally by past droughts	High social capital, and coping capacity, good understanding of potential adaptation options.
HENRY	Sex: M Age: 36-50 Worcestershire	Dairy & arable, Owner , >400 ha	Impacted by 2012 rainfall	High adaptive capacity and coping capacity. Very innovative in trialling new crops and planning large indoor dairy system.

ISSAC	Sex: M Age: 65+ Herefordshire	Livestock, owner family partnership, 40-80ha	Impacted marginally by 2012 rainfall, impacted significantly by 1976 drought	Low social capital and adaptive capacity. Not engaged with the weather, and is uninterested in climate change due to distance in time and place. High vulnerability to future EWEs due to low adaptive and coping capacity.
JOHN	Sex: M Age: 65+ Herefordshire	Livestock, owner, 40-80ha	Limited past impacts – small losses due to 2012 rainfall	High interest in the weather built upon observations and high level of coping capacity apparent due to limited impacts of past EWEs experienced.
KATE	Sex: F Age: 20-35 Herefordshire	Mixed, tenant & successor to family farm, 80-200 ha	Impacted by 2007 and land prone to small and frequent floods	Very proactive in both adapting specifically to long term climate change and mitigating GHG emissions, large scale adaptations made and planned - includes trialling of new more resilient crops on a large scale, high social capital and coping capacity. Very aware of expected local climate change impacts.
LUKE	Sex: M Age: 20-35 Worcestershire	Livestock & free-range poultry, tenant, 10-40 ha	Impacted significantly by 2012 rainfall	High social capital and adaptive capacity – made several changes immediately following losses from 2012, so now a much more resilient adapted farm system to future EWEs.
MELISSA	Sex: F Age: 20-35 Worcestershire (partner of Luke)	*Same as above*	*Same as above*	*Same as above*
NATHAN	Sex: M Age: 20-35 Herefordshire	Mixed, successor to family farm, 80-200ha	Impacted by past floods – 2007, 2008	Little interest in the weather and climate, climate change. However some adaptations discussed in view of building a more sustainable farm system.
OWAIN	Sex: M Age: 36-50 Shropshire	Mixed, owner, 200-400ha	Impacted significantly by frequent flooding - 16 floods in 14 months from 2011- 2013	Very low coping capacity and ability to effectively respond to floods. Low social capital and very little evidence of suitable adaptations to mitigate effects of repeated floods.
PHILLIP	Sex: M Age: 65+ Powys	Dairy & livestock, owner, 10-40ha	Little impacts of EWEs	No interest in the weather or climate. High social capital and interested in innovative adjustments to improve production rather than adaptive responses to climate change.

Source: Author's interviews

notion as scientific understanding is still evolving, associated with a large volume of uncertainties (2.1, Dessai *et al.* 2009, Bradshaw and Borchers 2000, Carvalho and Burgess 2005). Risk perceptions are often disconnected to experiences of EWEs (COIN 2014), and observations of the weather. Unlike the weather, which has continuously played a crucial role in farmers' decision-making, climate change is comparatively new in terms of scientific understanding and communication (2.1 and 3.3). Therefore, decision-makers have little experience in using such forecasts (Dessai *et al.* 2009).

Unlike the consensus identified amongst the farm community of observed change in the weather, a disparity in farmers' climate perspectives is apparent, with evidence of widespread confusion. A high-level of awareness of climate change was found amongst farmers in the Welsh Marches, once a clear focus of climate change had been placed by the interviewer (comparable to Mertz *et al.* 2009). Yet, despite a consistent level of awareness amongst all participants, the extent to which farmers understood anthropogenic climate change causes, and potential impacts are considerably varied. Each individual had a unique perspective and level of understanding, indicating that the process of understanding climate change is highly dependent upon an individual's interpretation of information in respect of their unique past and present experiences.

Farmers' varying perspectives of climate change will be explored in this section based upon those found to be held by farmers in the Welsh Marches, in comparison to farmers' perceptions of the weather (chapter six). Perspectives of climate change that have been identified cannot be defined by whether climate change is perceived as a significant risk or not to the farm system in the future, due to the complexity of opinions that were expressed which displayed multiple opinions, attitudes and associations of climate change all entwined. Indeed, most farmers were found to express opinions that were often contradictory, displaying considerable confusion. For this reason, this section will outline different associations and attitudes that were identified in discussions of climate change. Four different associations of climate change were made: association with anthropogenic change (7.1.1), association with natural cycles (7.1.2), distance of climate change in time and place (7.1.3), and distrust in climate change communication (7.1.4). Each will be discussed in turn to represent different attitudes and associations of climate change. To conclude this section, a comparison will be made between farmers' perceptions of changes in extreme weather, and their perceptions of climate change (7.1.5).

7.1.1 Association with Anthropogenic Change

Despite a growing consensus in understanding of anthropogenic influences driving climate change in the 21st century (see 2.1, IPCC 2013), public perceptions of climate change appear to remain mixed (Lorenzoni, *et al.* 2007, Lorenzoni and Pidgeon 2006). This is particularly apparent in the widespread confusion of anthropogenic and natural causes (Lorenzoni, *et al.* 2007).

Within the findings of this study, two farmers demonstrated a high level of understanding and association of climate change with anthropogenic forces;

> *"I have noticed change and I am concerned for the future. We are very environmental conscious and try to mitigate our impacts as much as we can."* (Kate, Herefordshire - interview)
>
> *"It's definitely happening, definitely happening…. we have to accept that our lifestyles have contributed to it… I do think that probably emissions in general are one of the biggest contributors, and it's coming back to bite us. We all accept that climate change is happening, and we are now probably more aware of the consequences of that and subsequently would like to do something about it"* (Geoff, Worcestershire - interview).

From both quotes above, it is apparent that associations between anthropogenic climate change theory and a direct relevance to their farm has been made. In contrast, the majority of farmers who did mention anthropogenic climate change did so with confusion, highlighting the complexity of the subject. Others, who initially dismissed anthropogenic influences, labelling themselves as 'sceptical', then proceeded to outline how they believe humans have had a significant impact:

> "*Well something's going on isn't it? I have no idea if it's manmade or not."* (Owen, Shropshire - interview)
>
> "*I do think it has been escalated due to human influences"* (Charles, Shropshire - interview)
>
> "*We definitely are having a big effect but I'm not convinced all is as bad as they say. I know there are issues with planes and cars*". (Nathan, Herefordshire - interview)

Indeed, half of the interviewees like Owen, Charles and Nathan above, recognise that climate change is a problem, and do believe that man has had some influence, but question the extent of this.

The role of climate change altering the expected long-term climatic conditions are routinely confused with the label 'global warming'. This led some farmers to an assumption that milder and warmer conditions will occur (as found by Holloway 1999). This is apparent with farmers' descriptions of 'global warming' in the Welsh Marches, in contrast to scientific predictions previously outlined (2.1).

> *"And when I was talking to someone in March about the snow, we were all like, what …has happened to global warming" (*Dennis, Shropshire - interview).

> *"Although they say that with global warming we should be getting colder …what's that about?" (*Frank, Worcestershire - interview)

Similar to the views expressed by Dennis and Frank, such references of generalised myths of warmer and milder conditions are not uncommon in the public (Leiserowitz 2006), and amongst farmers (Holloway 1999), when discussing climate change. It is apparent that although there is often a basic level of understanding of anthropogenic climate change, this remains simplistic. Interestingly, there is no apparent link to the level of knowledge or interest in the weather, and extent of understanding of anthropogenic climate change. This is evident upon analysis of a farmer found to have a formal relationship with *'the weather'* and a highly scientific understanding of the weather, demonstrating a high level of confusion and scepticism surrounding anthropogenic climate change. Furthermore, those with the highest level of understanding of physical climate causes and predicted local impacts were not distinguished by age, sex or experience on the land. This indicates that such demographic factors may not play a significant role in farmers' perspectives of climate change within the context of the UK (opposed to findings from Deressa *et al.* 2011 in context of developing countries).

7.1.2 Association with Natural Cycles

Although a general acknowledgement of climate change is apparent (in contrast to findings of Leiserowitz 2005), a number of farmers made associations of climate change with naturally occurring climate cycles. The most frequent explanation of climate change as a natural phenomenon was associated with the earth system constantly evolving.

> *"I tend to be of the opinion that the world is constantly evolving. If you look back thousands of years there has been a massive change, I mean we had the ice age and all that sort of thing. And I'm not sure about global warming and I think maybe it's just a more natural course of events"* (Bonnie, Worcestershire - interview).

> *"They talk about since records began, but for goodness sake we have only had records for hardly any time. It wasn't that long ago that we had an ice age, or that they were having fairs on the Thames, and …they had vineyards in Roman times"* (Enid, Gloucestershire - interview).

Comparable to Bonnie and Enid's statements, others such as Frank held similar opinions, attributing the causes of climate change to a result of both natural processes alongside human influence. Yet a high level of confusion over the influences of both factors is present:

> *"But is it what man's doing that is causing it or is it just a natural cycle that the earth is going through? Is it just a natural cycle? Is it all of these things?"* (Frank, Worcestershire - interview).

Such statements confirm the findings of Leiserowitz (2006) in the US, indicating an international misconception. Likewise, Reid *et al.* (2007, 630) found that 21% of producers interviewed in Canada were entirely sceptical about the issue due to attributing changes to natural cycles. Indeed, amongst farm communities in the UK, Holloway (1999) demonstrated that the most apparent form of scepticism is often illustrated by justifications including natural processes that haven't previously been monitored (Holloway 1999, 2028). Interestingly, confirmation of this statement from this research, demonstrates that Hollway's (1999) statement, is still directly applicable to farm communities' perceptions of climate change in the UK, over 15 years later, despite significant scientific progress made within this period (Defra 2012a, IPCC 2000, 2001, 2007 and 2013).

7.1.3 Distance in Time and Place

A recognition of climate change as a concept being distant in time and space appears to be a significant barrier to public perceptions (Holloway 1999, Reid *et al.* 2007, Leiserowitz, 2006). A notably lower priority is seemingly given to climate change by farmers in the Welsh Marches due to its perceived distance in time and space. In the UK, Leiserowitz (2006), found that most perceptions of climate risk were associated with geographically distant dangers. Farmers in the Welsh Marches also appear to associate climate change impacts with faraway places, distant to the Welsh Marches.

> *"Some of these countries [in Asia], won't be able to export so many goods any more. If they believe in global warming how…are other countries going to have enough sugar to export it to us?"* (Owen, Shropshire - interview)

> *"Obviously they are saying that Australia is one of the hottest years that they have on record. But there are parts of the world which are getting higher temperatures…"* (Charles, Shropshire - interview)

When farmers did consider changes in relation to the local environment, this was sometimes used as a justification for showing a lack of interest in climate change all together:

> *"I think all the difference that it won't make much of a difference to us. Because the temperatures are only rising a small amount it's not going to make a difference in my lifetime. You can't expect to see everyone growing sunflowers in Herefordshire!"* (Isaac, Herefordshire - interview)

As demonstrated above, such distance in time as well as space, has proven to form a barrier to risk perception, with a lack of impacts within their own lifetime used as a justification that it is not of concern. This supports *Smit et al.* (1996) who reported that 42% of interviewees were entirely unconcerned with climate change due to the nature of it being a long-term trend, meaning that impacts may not be experienced until they had retired from the farm.

The distance in time also appears to be a significant barrier to farm managers focused upon survival in the present. Some farmers who noted that they had suffered a recent significant loss from the 2012 rainfall, appeared to be concentrating on recovery in the moment, so that they haven't considered future challenges:

> *"I don't know about the future I don't know if I dared think that far, that far ahead really"* (Bonnie, Worcestershire - interview)

Certainly, due to the complexities of the daily farm decision-making environment (3.1), it is probable that most farmers are concerned with present challenges rather than focusing upon the seemingly distant future. This is particularly apparent in farmers such as Bonnie, who were still in the recovery process from recent EWEs (5.2.4).

7.1.4 Distrust in Climate Change Communication

A distinct lack of trust in information given on climate change is prevalent. Holloway (1999) and Reid *et al.* (2007) demonstrate that farm communities tend to be highly critical of new scientific information, and how it is derived (as discussed in analysis of scientific communication 3.3.3). In the Welsh Marches, comments with regard to information portrayed and how it had been derived was notably linked to a distinct lack of trust in scientific consensus (utilised by IPCC 2013).

> *"Can I be honest with you? I am a climate change sceptic…I don't think they are right, they are never right [scientists]… I do think the pro-lobby seem to get a lot more airing on the TV than the anti-lobby do I don't know if that's right or wrong. But there is a lot of vested interest in this anti lobby"* (Charles, Shropshire - interview).

An association of such findings with political agendas were also justifications for distrust in the information received:

> *"I don't know…I think the jury's out on this climate change. I think politicians for their own ends have been stuffing a lot of nonsense into all these arguments …but you got too many people who got …agendas"* (John, Herefordshire - interview).

> *"Well each party has a spin doctor doesn't it, how much of it is spin?"* (Dennis, Shropshire - interview).

Scepticism over such scientific debates is exacerbated by perceived 'sensationalism' of the media portrayal of the climate change scientific debate.

> *"A it's a bit dramatic, B it's a bit conflicting, for everyone that says it's not happening there's another saying there's going to be no world in 20 years' time."* (Nathan, Herefordshire - interview)

Indeed, as displayed by Nathan's confusion towards the subject, discourse of the 'doom and gloom' of climate change is considered to foster resistance, apathy and despair instead of motivation to change (Hall 2014, 3.3.3).

In the sample of 115 farmers included in the questionnaire, it is evident that most farmers in England do not feel well informed about climate change, yet where they do feel well informed; a response to perceived risk is more likely. It was found that the main sources of information on climate change for farmers in the Welsh Marches are primarily non-scientific media. In particular, television programmes such as *Countryfile* and climate change documentaries were mentioned multiple times. This supports Holloway's (1999) recognition that farmers' perceptions of climate change are primarily informed by non-scientific television documentaries. Such secondary sources of information have already undergone a translation process by a series of scientific communicators and journalists (Holloway 1999), therefore leaving them exposed to subtracting away from the quality and accuracy of the message that is finally received by the farmer (see Figure 3.1).

7.1.5 Disparity between Weather and Climate Change Perspectives

This section has examined a range of different climate change perspectives held by farmers in the Welsh Marches. A high level of confusion is apparent from the different views that farmers hold. The weather appears to be interpreted in terms of local conditions and experiences in line with patterns and trends that have been directly observed.

As the weather is something that is experienced on a regular basis, farmers have become local experts applying their knowledge and observations when considering present and future weather concerns.

> *"I don't understand it...but you do notice the difference you don't get the winters like we did. But I don't worry about it"* (Frank, Worcestershire - interview)

Yet the use of the words 'climate change' triggers a barrier that is difficult to immediately relate to past experiences. Several farmers immediately declared their lack of knowledge on the subject, stating a lack of understanding. Farmers like Frank declared their confusion surrounding future climate change, yet have a good understanding of changes that have been observed and likely change in the foreseeable future.

Holloway (1999), recognised the disjointed understanding of climate change was apparent, and that it is:

> *"Likely that local understanding of scientific knowledge will be reconstituted as this future is approached"* (Holloway 1999, pp.2030).

Yet, it appears that a greater scientific understanding of climate change has still not significantly progressed in creating a greater level of public understanding. Notably, Weber and Stern (2011) recognise a trend for increasing polarisation of public perception of climate change. Indeed, in the Welsh Marches, a considerable level of ambiguity and confusion amongst individual climate change perceptions is apparent.

It is clear that the quality of information concerning climate change causes and impacts is highly variable (3.3). Therefore, there is an increasing need for climate change communication to be tailored to portray potential localised impacts, to engage farmers with the subject. Through providing localised information in view of EWEs already experienced, and changes in the weather observed, farmers can then interpret such information more effectively in respect of their local knowledge. Consequently, communication that is adapted to the specific culture for which it is intended is much more likely to have a greater influence in the development of farmers' resilience (Figure 3.4).

7.2 Adaptation Options

Long-term adaptation measures and specifically developing adaptive capacity are powerful options to reduce the negative impacts of climate change (Tol *et al.* 1998). Agricultural adaptations to climate risks appropriate for each agricultural region remain relatively unexplored (Tate *et al* 2010, Wall and Smit 2005). Yet, the need for farmers be able to adapt to future climate shocks and stresses on the farm system, is paramount (Tate *et al.* 2010, Smithers and Smit 1997). Due to the perceived value of local knowledge, experiences and culture in farm decision-making (Figure 3.5), there is a need to explore adaptation options within a local context. This has enabled an exploration of suitable adaptation options derived directly from farmers' knowledge, opinions and trials of suitable adaptive measures in the Welsh Marches in keeping with a cultural-behavioural approach.

Adaptive capacity is often developed within a farm system in response to farm adjustments made, to continuously adapt and change to numerous farm pressures and future stresses placed upon a farm system (Ambler-Edwards *et al.* 2009, Easterling 1996). Therefore, a resilient farm may have been developed in response to pressures other than a perceived risk of climate change alone (see 7.2.4). Adaptation to climate change does not occur in isolation from the influences of other forces. Instead, it occurs amid a complex set of economic, social and institutional circumstances (Beck 2010, Smithers and Smit 1997). Developing adaptive capacity to improve farm resilience is a continuous process (3.4); therefore adaptive measures are implemented as part of a dynamic interwoven system. Once this web has been strengthened by multiple adaptive measures, then a more resilient farm system is identifiable. Thus, such a complex process must be viewed within the non-linear web of a continually evolving farm system in which adaptive measures occur.

This section will identify localised adaptations already made and options that are considered by farmers in the Welsh Marches to build resilience to better withstand future farm pressures exacerbated by climate change. Multiple pressures have been found to influence adaptations, and often adaptation measures are implemented in response to several concerns. The adaptations that are discussed in this chapter are recognised to have been made in response to increasing pressures of extreme weather, or to build farm resilience in view of changes in long-term climate. This includes partial responses made to the weather and partially in response to other farm pressures. In turn, findings will be discussed in view of: motivations and barriers to adaptations (7.2.1), adaptations found to be implemented (7.2.2) and evolution of adaptive capacity (7.2.3). Potential adaptations in the future will be considered in 7.3.3, in view of responding to predicted challenges.

7.2.1 Motivations and Barriers to Adaptations

Adapting to climate change is considered as a 2-step process: firstly, the recognition that climate is changing; and secondly, the response to the perceived change through adaptive measures (2.4.2, Maddison 2006 and Tate *et al.* 2010). It is apparent that various motivations and barriers to developing an adapted farm system are present (7.2.1.), yet a high level of risk perception derived through persistent challenges (explored above), is most likely to encourage a specific adaptive measure to be implemented to mitigate foreseen risk (Solvic 2000). The larger a perception of potential risks posed to the farm system is, the larger potential to build adaptive capacity and implement adaptive measures is apparent in the Welsh Marches. Despite this, it is well documented that perceiving a risk, does not necessarily mean that an adaptation will be made to mitigate such vulnerability (2.4, Bryant *et al.* 2000, Brklacich *et al.* 1997, Smit *et al.* 1996). Tate *et al.* 2010, identified that a need for a farmer to adapt would be seen to arise after 2-5 years of consistent weather. Yet trigger events such as the 2012 rainfall have been found in this research to cause shocks, resulting in a direct response. Motivations and barriers to adaptations will be outlined in view of the findings highlighting the influence of: the priority of the weather in (i) decision-making, (ii) the role of financial capital, (iii) direct responses to specific shocks, and (iv) social capital.

i. *Priority of the Weather in Decision-Making*

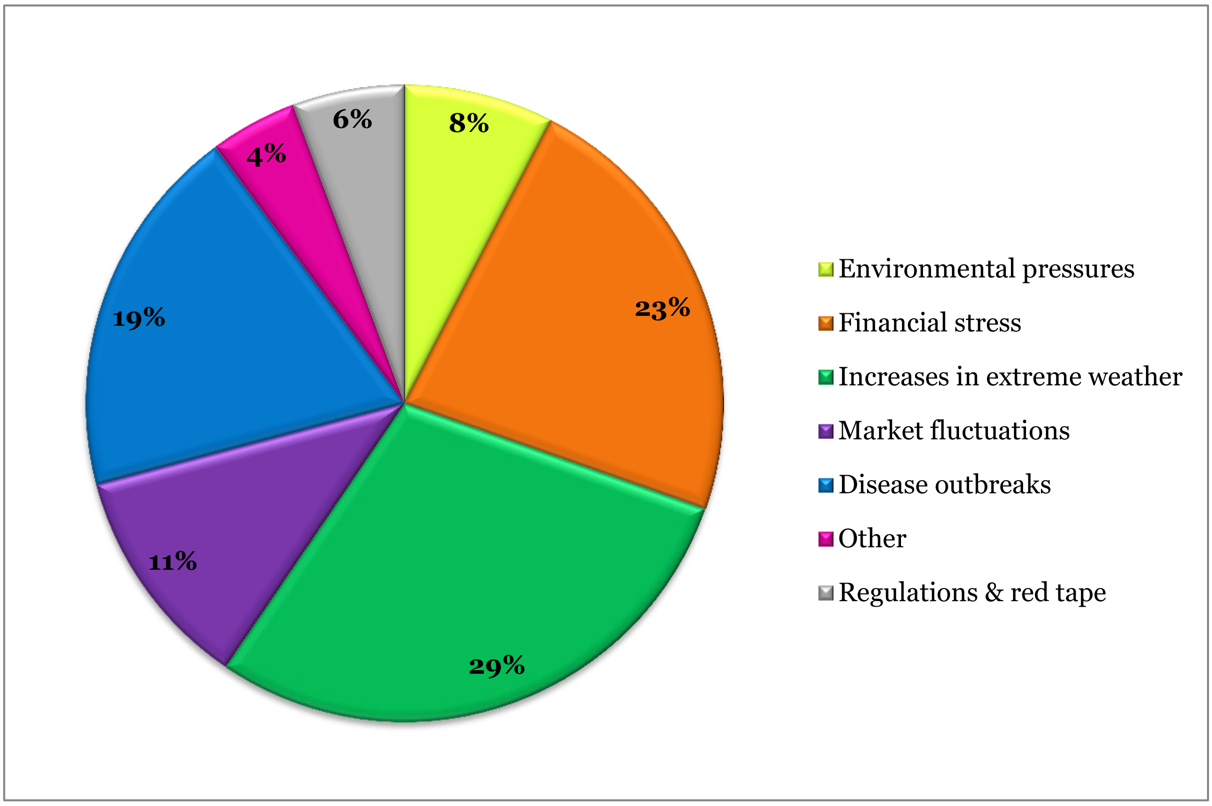
Due to increasing multiple demands upon the farm system (2.2.1) and subsequent complexity of the decision-making environment (3.1), establishing the priority of the weather amongst multiple farm pressures in the Welsh Marches is required to establish the backdrop of pressures in which individual decisions are made. Figure 7.1 demonstrates the priority assigned to extreme weather amongst the backdrop of multiple future risks for farmers and daily challenges in the agricultural system. In total, 29% of farmers were most concerned over the occurrence of future EWEs compared to the second highest future concern, financial issues, selected by 23% of farmers. Such concerns of present farm pressures over future decisions are indicative of the priorities given in decision-making when faced with a multitude of challenges.

Reid *et al.* (2007) argue that climate change is still yet to become a high priority item amongst farmers, and so recovery may be prioritised above improving systems' resilience to future climate change. Such a lack of priority appears to be inextricably linked to mixed climate perspectives found within the Welsh Marches farm community (7.1).

> *"I mean one or two degrees of global warming probably wouldn't affect us would it… you'd have to adapt but you probably wouldn't know if it's happening would you"* (Henry, Worcestershire - interview).

In particular, perceived distance in time and space of climate change creates a significant barrier to the implementation of conscious adaptive measures (supported by Tate *et al.* 2010).

Figure 7.1: Future Farm Concerns of Multiple Farm Pressures



Source: Author's questionnaire

ii. The Role of Financial Capital

Suitable adjustments had often been identified based upon the implementation of responses by others (7.2.1), but assessment of the financial investment required were not deemed suitable, such as Luke's assessment of sheep vaccinations against the Schmallenberg virus:

> *"I can't vaccinate that just costs a fortune" (*Luke, Worcestershire - interview).

Whereas, comparable responses made by Henry to spray aphid pesticides on his crops are still considered beneficial long term:

> *"It's expensive but is it expensive if it saves your crops?"* (Henry, Worcestershire - interview)

When such measures are possible, a sense of empowerment is noticeable within the farmer, able to implement a response to increase farm resilience, due to its viability. Alternatively, a sense of defeat and helplessness is apparent where the initial cost is too excessive to feasibly implement such action. This leaves the vulnerability of the farm system knowingly exposed.

iii. Responses to Recent Shocks Triggered by EWEs

It is evident that most adaptations are implemented due to necessity, in response to an exposed vulnerability during EWEs (See Figure 3.3., Holling 2001, Tate *et al* 2010). Extending beyond immediate responses that are intended to return the system to a state of 'normality' (identified in 5.2), long-term adaptive measures take place following the recovery from an event. Some viewed the 2012 rainfall event as an opportunity to not only revert the system to its original state in 'bouncing back', but to improve and adapt the system to mitigate the scale of potential impacts of a comparable event 'bouncing forward'.

> *"We've changed things drastically [since 2012 rainfall] …we started it in spring as soon as we could really, we wanted to do it earlier but we couldn't it was just too wet. I am really hoping the time and effort and expense of it now will pay off in that it is more efficient…so that sort of weather won't affect us too much in the future"* (Luke, Worcestershire - interview)

Such opportunities to 'bounce forward', based upon lessons learnt through the exposure of vulnerability in the farm system are noticeable in several farmers' discussions. Luke was not alone in having immediately implemented changes, or to be considering potential changes based upon the lessons learnt in the 2012 rainfall.

"We now wrap more, we all had taken the extra input cost of plastic wrapping, everyone's got so nervous about things and losing crop that they are just wrapping everything to just get it done" (Melissa, Worcestershire - interview)

This supports Tate *et al.*'s (2010) recognition that where farmers have adapted it is often in direct response to experience of extreme conditions, rather than as part of a long-term plan in view of climate change itself. Others such as Bonnie recognised exposed vulnerabilities in their farm system but chose not to act upon the shocks exposed.

"Well you always learn something from them" (Bonnie, Worcestershire - interview)

Such findings concur with Bryant *et al.* (2000), that there is a disparity between those recognising a risk and system vulnerability, and those who have acted upon them to make an explicit adaptation to the change observed (Bryant *et al.* 2000).

Alternatively, instead of making direct adjustments to foreseen risks, there was also evidence of farmers developing contingency plans to improve the coping capacity of the farm towards future weather and climate stresses:

*"But we still need good growing conditions and things to grow good stock. But you can build in a contingency" (*Henry, Worcestershire - interview)

"Well I think that was a once in a lifetime experience that…we have never experienced continuous rainfall like it…but if that's what's thrown at us you have to have contingency plans" (Frank, Worcestershire - interview)

Such contingency measures are increasingly identifiable in farm adaptations, with recognition to prioritise building reserves to help mitigate vulnerability to future events.

In contrast to recent events providing motivations to act, barriers to adapting to climate change can also be triggered by EWEs. Some farmers were found to be focusing solely upon returning the farm system to a state of normality, so that considering new changes became overwhelming. This is because farm resources, time and financial buffers are spent upon recovery and reorganisation of the system, blocking a potential opportunity to make improvements (following the adaptation cycle, Figure 3.3).

"I suppose we haven't really had a chance to deal with it and look back on it all" (Bonnie, Worcestershire - interview)

Certainly, this may due to a lack of willingness by the farmer themselves, or simply their coping capacity in recovering from an event being exceeded.

Many farmers await a trigger event, in which extreme weather exerts shocks beyond those that the farm system can withstand, triggering an adaptive response.

However, if an event or future risk is perceived as being beyond an individual's control, responses are irrelevant. This is most noticeable in responses to losses incurred due to past EWEs:

> *"No we haven't made any changes, we just hope it doesn't happen again, and we just got hope it settles down again. There's not a lot that we can do really is there?"* (Isaac, Herefordshire - interview)

From the lack of recognition of risks to the climate, a need to make a change is also absent from a farmer's perception, thus consideration of feasible adaptation options is not undertaken.

iv. Role of Social Capital

In contrast to individual experimentation, adoption of innovations based upon local knowledge and the adoption of others are also crucial to agricultural adaptions (Rogers 2003). Informal advice from members of a farmer's social network encourages others to make change based on the experience of others locally. A farmer's ability to access new sources of knowledge and the ability to share local knowledge within a social network is one of the most important direct benefits of their social capital (Inkpen and Tsang 2005). In the Welsh Marches, farmer groups such as breed societies and local branches of the National Farmers Union (NFU) provide a platform for knowledge sharing in which many interviewees appear to have engaged.

> *"I mean, for what they're doing for lambing how that had gone. We ask all sorts like what feed have you used? When are you having yours scanned? We're always comparing…seeing what works for some people and not for others"* (Melissa, Worcestershire - interview)

The facilitation of transfer of such knowledge and experience amongst farmer groups has proven imperative to successful climate change adaptations (Cutter *et al.* 2008).

An important finding of this research is the need for locally relevant and accessible recommendations for adaptive measures that can be implemented in the response to increasing extreme weather and climate pressures. Some farmers were willing to make a change, but found a considerable barrier in not knowing who would be able to provide both formal information on appropriate responses, as well as informal advice.

> *"I shall take advice from I don't know who yet. Because all the people I use to take advice from are all gone... I know I have to do something, but I don't know what yet"* (Frank, Worcestershire - interview)

It is clear from discussions with Frank that gaining advice from someone that he trusts is crucial to allowing him to decide on a suitable change. There is a need to encourage farmers to share such local knowledge in view of suitable adaptations that could be made to improve resilience to climate change in the Welsh Marches. Luke had already demonstrated that several adaptations found in direct response to climate pressures, were based upon or encouraged by discussions with his neighbour. Luke directly related his social network to encouraging him to make adaptations based upon others' experiences, capitalising on the local knowledge of others as well as his own:

> "*I didn't realise that my neighbourhad already vaccinated his sheep for the damp, and I said in hindsight if I had known that he had done it, maybe I would have bit the bullet and done it too...someone has to do it first I guess but you do need to have the capital to invest first"* (Luke, Worcestershire)

It was found in this research that farmers with a seemingly lower social capital who did not engage actively within a social network, were less likely to implement new adaptive measures (supported by: Valente 1996, Jackson *et al.* 2006, Diederen *et al.* 2003). Alternatively, the influence within a knowledge network to make decisions that may not increase resilience are also possible (Adger *et al.* 2005, Lorenzoni *et al.* 2007). Thus, values, ethics, risk, knowledge and cultural constructs can limit the process of adaptation by presenting social barriers (Adger *et al.* 2005, Lorenzoni *et al.* 2007). In light of this evidence, it is clear that such a need for locally specific farmer-to-farmer knowledge sharing is paramount.

7.2.2 Adaptations Implemented

Physical and natural capitals utilised to assess suitability of adaptive measures were often mentioned in discussion of suitable adjustments (Figure 3.5). This is demonstrable in farmers assessing the feasibility of a measure using local knowledge of the land, machinery required to implement it and often trials on the land utilised to ensure that it is appropriate to the specific environment. Tate *et al.* (2010) recognises that whilst there appeared to be concern amongst farmers, it was a matter for the future rather than the present. This is true to some extent, yet several adaptive measures were found to have already been implemented by farmers in the Welsh Marches, in responses to challenges associated with climate change. In relation to the findings discussed in 7.1 demonstrating mixed perspectives of climate change, some adaptations were implemented in view of extreme weather or climate concerns, but were not recognised explicitly by the farmer as a response to 'climate change'. Table 7.2 demonstrates a range of appropriate adaptive measures found to have been already implemented by farmers in the Welsh Marches.

Table 7.2: Types of Different Adaptive Measures Adopted by Farmers in the Welsh Marches

Adaptive Measure	Example	Type of Adaptation
Building up stocks	Silage and Hay	Small-scale
Climate mitigation	Carbon Impact mitigations	Alternative
Change in crops	To more resilient breeds – Lucerne, Spring Barley, Maize, Red Clover	Large-scale
Developing a range of enterprises	Variety of different enterprises to ensure against extreme weather	Alternative
Experimentation	In new crops or livestock e.g. Maize or Lucerne	Small-scale
Improved access to farm sites	Inserting paving or slabbing on fields	Medium-scale
Improving infrastructure	Improving piping systems to withstand extreme weather	Medium-scale
Livestock housing changes	Erecting large livestock sheds for lambing or calving	Large-scale
New machinery	Larger equipment to cover bigger areas	Large-scale
Pesticides	Against barley yellow dwarf virus	Medium-scale
Protecting winter feed	Wrapping hay	Small-scale
Vaccinations	Vaccinate lambs against midges	Medium-scale

Source: Author's semi-structured interviews

Most prevalent types of adaptive measures are detailed in Table 7.2, yet a further distinction is apparent in the scale and category of measures implemented. It is envisaged that adaptive measures in a farm system can be distinguished as being as: (i) small-scale, (ii) medium-scale, (iii) large-scale and (iv) alternative measures. A measure implemented may be considered as a 'small-scale adjustment', yet when several accumulate together it creates a significantly altered resilient farm. Examples of each category of adjustment measures will be explored in view of the types of adaptive measures outlined in Table 7.2.

i. Small-scale Adjustments

Small-scale farm adjustments are evident in response to a specific extreme weather event that has influenced the farm system. Often, such measures are relatively inexpensive and undertaken in the recovery period. Initially, they are implemented as small-scale adjustments, and then accumulate to become large-scale adaptations. Following on from adaptations identified following the 2012 rainfall (7.1), small-scale adjustments found to be commonplace include stocking up on forage, feed and other inputs.

> *"I increase stores year to year"* (John, Shropshire - interview)
>
> *"I think we are well covered we got a lot more fodder now"* (Dennis, Shropshire - interview)

Notably, wrapping hay in weatherproof plastic wrapping and making surplus amounts in good conditions to be used in extreme conditions, as demonstrated above, appears to be a common response mentioned by most interviewees.

Farmers are seeking more productive ways to optimise productivity in increasingly challenging conditions, therefore experimentation is becoming an essential process (Chambers *et al.* 1989, Reij and Waters-Bayer 2001). Trials and investigations within the local environment are key parts of non-scientific investigations, allowing local knowledge to be developed and shared (Briggs 2005, Ingram 2008b). Although the trial of new crops is a small-scale adjustment due to the small quantities of crops that are trialled, this is likely to lead to a large-scale adjustment where new crops that are more resilient to changing weather conditions are introduced on a larger scale. Indeed, Henry mentioned several new crop trials that they had started this year due to his son's willingness to experiment.

> *"The other thing we have done. We have grown 4 ½ acres of Lucerne this year. But [my son] was keen to grow some to see how it worked and long term it might be possible to have a big acreage because you're less dependent on the weather then"* (Henry, Worcestershire - interview)

In this case, Henry's son had encouraged him to experiment with more resilient crops to a warmer climate which is presently a small-scale change, but plans for more land to increase self-sufficiency of feed for an expanding dairy herd, as well as the erection of a large indoor dairy parlour are likely to result in a large-scale adjustment improving adaptation. Thus, farm succession has significantly influenced decision making (as shown by Potter and Lobley 1992), to encourage adaptations. Such experimentation is apparent in farm succession, where the emergence of a new farm manager from within the family has encouraged Henry to experiment and improve farm resilience to ensure greater farm prosperity in the future.

ii. Medium-scale Adjustments

Medium-scale adjustments are investments that are more substantial in financial commitment, but are not a large systems level change. The most recognisable medium-scale adjustments appear to be infrastructure adjustments or pest and disease management to mitigate a specific risk such as the introduction of new vaccinations.

Such measures, implemented because of the damaging effects of pests and disease are alterations as part of an on-going strategy to manage disease. Yet the changing nature of the risks associated with pests and disease, in view of changing climate conditions are notable. For example, Henry and Owen discuss changes in their pest and disease management due to an increasingly damp environment, and flooding on the land.

> *"One thing we do …is use a seed dressing called deter, because it deters slugs, and it will deter the slugs away from eating the seeds. It covers a disease called barley yellow dwarf virus, and that's transmitted by aphids"* (Henry, Worcestershire - interview)

> "*Another consequence [of flooding] is we have to fluke all the sheep all the cattle. We have to go for the dearest, there's no messing around*" (Owen, Shropshire - interview)

Similarly, infrastructure is another farm asset that is continually being changed and upgraded in view of changing weather conditions, on a small and sometimes larger scale.

> *"We have opted now that all access routes, everywhere we operate from has paving either concrete or slabbing to make sure that we can get from building to building now. It is designed to minimise the amount of mud etc."* (Luke, Worcestershire - interview)

> *"We are adapting to the wet again. Everything our pipes and the lot, we have made sure we can cope with it, it won't affect us and we won't have to worry about it all freezing over"* (Enid, Gloucestershire - interview)

Such precautionary measures are implemented in response to past issues anticipated to get worse with a changing climate.

iii. Large-scale Adjustments

Large-scale adjustments require substantial capitals (Figure 3.5); most prominently they often involve substantial economic capital that can result in a change in the farm system. Moreover, large-scale adjustments often take a lot of a farmer's time, knowledge and willingness to implement. Therefore, they are seen as long-term 'investments' extending beyond precautionary measures.

The most prevalent example from the Welsh Marches includes the change towards an indoor dairy system in which cows are no longer kept outside in an uncontrolled environment:

> *"Once the cows go out, you lose control…where the cows are in 365 days you are in complete control of what they are getting. I don't like it personally, but I'm afraid that's the way that things are going because of the mess they make to soil structure and everything else." (Henry, Worcestershire - interview)*

Likewise, other farmers including Enid mentioned similar adaptations such as increasing farm buildings allowing for lambing to take place indoors.

> *"We put up some big sheds…before that we used to lamb outdoors…it just got too hard with such changeable weather"* (Enid, Gloucestershire)

Other livestock farmers who hadn't already implemented large infrastructure allowing for livestock to be kept indoors for longer periods of time, had discussed it in view of plans for the future. Becoming 'weather proof' was an increasingly favourable option to limit extreme weather impacts. The introduction of new machinery is also considered to be a large-scale adjustment due to the likely nature of it changing the way in which a farm response can be made (see Table 7.2).

Extending beyond the small-scale experimentation of new crops (outlined above), where a significant proportion of crops have been replaced by more resilient varieties, a large- scale adaptation is achieved.

> *"We are already growing resilient crops to climate. Lucerne is grown currently for silage-has best weight on. Use red clover, maize as a mass feed/ main source of feed"* (Kate, Herefordshire – interview)

Such a response by Kate appears to be targeted specifically to become more resilient to future climate change, and is part of a long-term plan to improve farm resilience.

iv. Alternative Measures

Alternative measures to improve farm resilience to foreseen climate challenges were also highlighted. In one case an alternative source of income outside of the farm gates, is considered by some as a means to buffer the adverse financial impacts of EWEs on struggling family farm enterprise.

> "*My wife had to get a job [last year] because you don't know what's gonna happen. You can't factor in 16 floods in 14 months. You can't…especially in the summer. The weather's just not there that's why we had to take on extra work"* (Owen, Shropshire - interview)

Indeed, this is a substantial change to the farm operation in response to continual pressure from extreme weather. Comparable examples are found where hired farm labourers were no longer employed, thus changing the way in which the farm system operates. Such measures demonstrate adaptive strategies in response to increasing agricultural challenges such as those presented by climate change (Adger *et al.* 2003, Mortimore and Adams 2001, Osbahr *et al.* 2010, Thomas *et al.* 2007).

The rarest response found in the Welsh Marches, was to adopt mitigative measures towards anthropogenic climate change to reduce carbon emissions on the farm itself, although farmers in response to climate change perspectives (7.1.1) did discuss mitigative measures.

> *"We are on a rota of 2:1 Crops /livestock at the moment to balance out CO2 – carbon mitigation. We have the lowest CO2 rating in the county. So we are very aware of these issues and view mitigation as really important"* (Kate, Herefordshire - interview)

This is in contrast to Bradshaw *et al. (*2004) and Smit *et al.* (2000) who considered such measures to be the main type of response to climate change. In the one instance that this did take place, a high risk perception of anthropogenic climate change and associated local risks and plausible farm impacts were identifiable.

7.2.3 Evolution of Adaptive Capacity

With the exception of the latter, all of the categories above were found to have been implemented by an array of different farmers, regardless of their relationship with the weather (6.2) and their perception of climate change (7.1). However, a more positive farmer-weather relationship and a higher risk perception towards specific risks appear to encourage the implementation of adaptive measures. Farmers from all perspectives were identified to implement different adjustments, but those with higher risk perceptions were more likely to implement a range of appropriate responses in a timely manner due to the higher priority assigned. Moreover, it also appears that opposed to what may be expected, age and time on the farm do not appear to influence a farmer's motives to adapt. Indeed, farmers of all ages and experiences appeared to be at the forefront of adaptation.

Long-term adaptations are a complex and gradual process, absent of linear relationships between environmental conditions and farm-level change (Holling 2001, Reid *et al.* 2007). Yet, from the evidence above, it is apparent that some farmers in the Welsh Marches have already implemented adaptive measures, albeit mainly in response to extreme weather as opposed to long-term climate change. Certainly, a feeling towards Geoff's recognition that *"more adaptable is the key"* (Geoff, Worcestershire), is noticeable.

It is also evident that several farmers themselves mentioned becoming more 'resilient' or 'future-proof' to better withstand future challenges. This indicates that it is becoming an agenda for the farm community, as the pressures of extreme weather are already emerging as something that requires a response. The adaptive measures discussed above, appear to be early signs of farmers in the Welsh Marches starting to evolve their adaptive capacity towards future challenges. Events such as the 2012 rainfall events appear to be tipping points, which generate shocks triggering a response. Therefore, if more shocks are generated through the predicted increase in frequency and intensity of EWEs, then continuous reorganisation and bouncing 'forwards' through adaptations are likely to happen resulting in a more resilient farm system (in accordance to panarchy Figure 3.3).

Where adaptive measures were not found to have been implemented in view of extreme weather or climate pressures, future adaptation options were widely considered in anticipation of the need to build farm resilience to survive and thrive when faced with future climate pressures. Future responses will be considered in 7.3, in relation to expected challenges and opportunities of climate change as identified by farmers in the Welsh Marches.

7.3 Expected Challenges and Opportunities

Farmers' perceptions of climate change and adaptive measures found to have been implemented have been discussed so far in this chapter in relation to the foreseeable future[35]. It has been highly valuable to explore farmers' understanding of climate change and probable changes in the next decade (7.1-7.2), yet the full extent of climate change impacts will be experienced gradually across the 21st century. This section will extend further into the future, and explore possible impacts upon the farm system and farmers' responses, as the pressures of climate change intensify. The 'distant future' is

[35] Considered to be up to 10 years in the future, based upon farmers' descriptions of this 'immediate future' and plans already considered.

used to refer to 10 to 30 years into the future, extending up until 2043[36]. Indeed as discussed in 7.1.3, the distance of climate change in time and place is a considerable barrier to overcome in farmer discussions. As such, the findings present in this section are anchored upon discussions generated using the locally specific climate scenarios that were constructed in Figure 4.8.

Upon consideration of the distant future, much of the discussion is based upon hypothetical reasoning rather than derived from evidence as utilised in 7.1 and 7.2. Hence, this section will provide a succinct snapshot of possible challenges and opportunities as identified by the farm community, in relation to the distant future.

Section 2.1.3, synthesised findings from Defra (2012b) which outlined numerous challenges and opportunities for the UK agricultural system in view of predicted climate change. This climate risk assessment of agriculture emphasised that although challenges will be faced, with suitable large-scale adaptations opportunities are possible. In response to Defra (2012b), this section will explore future challenges and opportunities from the perspective of the farm community in the Welsh Marches. From investigating potential challenges from the 'bottom-up', the reality of future challenges and the way in which potential opportunities could be implemented was made. It is discernible that Defra (2012b) are considerably more optimistic in the potential opportunities outlined, than farmers in the Welsh Marches are.

This section will present findings based upon the focus group, exploring farmers' concerns and possible responses when presented with four hypothetical scenarios of varying changes in the climate felt by 2043. As shown in Figure 4.8, ranges of different weather conditions were incorporated into each scenario including variations in: temperature, summer rainfall, winter rainfall and EWEs. Of these conditions, the most influential factor in farmers' future concerns is seemingly the increasing frequency and intensity of possible EWEs. When asked which scenario would cause the least concern and why, Scenario one was selected due to its lack of EWEs. Interestingly, many farmers stated that if Scenario four, which included the greatest extreme temperature and rainfall changes, had no EWEs, then that would be the most preferable. This was due to recognition of gradual change allowing time for adaptations. From such justifications, it is clear that such extreme events cause the most concern due to

[36] 2043 has been chosen as the upper limit of the consideration of the 'distant future' as it is 30 years ahead of the time of data collection in 2013, therefore often still within the average farmer's lifetime. IPCC (2013) and Defra (2009) also utilise a 30-year period to monitor periods of notable change in the climate system, allowing for direct comparisons.

unpredictability, thus requiring a consistent level of adaptive capacity and overall system resilience to withstand such shocks.

Each scenario presented progressively incremental climate challenges, as these were discussed the challenges seemingly became greater, and opportunities lessened. Moreover, identified responses became larger in scale; with greater challenges to the implementation at a farm system level identified, requiring external assistance from

policy. Although each scenario was discussed in turn, due to slight variations in physical conditions, challenges and opportunities identified will be drawn out because of themes identified rather than on a scenario by scenario basis. Future challenges will be outlined (7.3.1), alongside perceived future opportunities (7.3.2.) in relation to climate scenarios for the Welsh Marches in 2043. To conclude, 7.3.3 will then discuss potential adaptation options that were considered for the future.

7.3.1 Future Climate Challenges in 2043

Future challenges are inextricably linked to future perceptions and adaptations that have previously been outlined in this chapter. Although focused upon expected challenges to farming in 2043, many of the impacts, challenges and adaptions are discussed are based upon present challenges. Noticeably, impacts of wet weather were mentioned above other concerns in relation to recent EWEs. Defra (2012b) identifies that a primary challenge for the UK agricultural industry will be water availability, alongside increasing frequency of hazards including flooding and drought. Similarly, such concerns are apparent amongst farmers in the Welsh Marches, having dominated discussions.

Table 7.3 presents expected challenges in the Welsh Marches for 2043 The need for more land, and increasing land pressures are also considered as a decrease in stocking density was seen as the most feasible response to warming temperatures and increasingly variable conditions. There are considerable concerns over protecting soil structure from degradation and erosion due to increased drying out (from increasing temperatures) and saturation (from intense bursts of rainfall).Alternatively, others suggested an indoor system, due to seemingly less pressure on the land, increased resilience to extreme weather and unforeseen conditions. At the same time, drainage ditches and potential irrigation possibilities are also probable options suggested to address such concerns.

Table 7.3: Expected Challenges in 2043 (continued overleaf)

Type of challenge	**Challenges discussed**	**Examples**
Crop Impacts	○ Fruit rot ○ Impacts upon tree orchards ○ More pests ○ Decreased crop yields ○ Fungal disease ○ Harvest disruptions ○ Loss of fruit due to rain ○ Loss of cool period for seeds ○ Unpredictable crop yields ○ Impacts of seed germination due to soil saturation ○ Blossom period damaged by heavy rainfall	*"We will have less armoury to attack disease."* *"Saying that, last year our maize crop was down to 9 tonne an acre... and this year, last August, its' about 22 tonne an acre because we had much better weather, that's a massive difference."*
Energy & fuel	○ Anaerobic digesters taking away production land ○ Rising cost of fuel ○ Less land suitable for production	*"Where a lot of people in the county I think in Herefordshire are affected by these anaerobic digesters put in corn and potato farmers can't compete with the rents."*
Extreme weather	○ Summer flooding ○ Flash flooding ○ Summer drought impact on grain crop ○ Impact on intense rainfall on soil ○ Impact on market and commodity prices ○ Greater differences between good and bad years ○ Increased challenges for small farms ○ Reduced harvest	*"So like summer flooding we had last year, that was quite a novelty, normally we see flooding in the winter, and then the ditches, like, for example"* *"Rain concerns us the most, we flood quite easily. More flooding would be bad."*
Farm Business planning	○ Availability of bank loans needed for adaptations and to survive season variability ○ Profitability ○ Dealing with unpredictability ○ More time will be required to implement usual activities	*"The banks are going to be reluctant to lend what they would have on predictable seasons"* *"Everything's slower to do like shearing"*
Grasslands	○ Making silage and hay increasingly difficult ○ Grazing land disappear ○ More land needed to for grazing to decrease pressure ○ Less nutrients in grass ○ More mud	*"Well then even the hay crop will just disappear."* *"And if you've got livestock you'd need more land in reserve because there will be so many unknown factors."*

Table 7.3: Expected Challenges in 2043 (continued)

Type of challenge	Challenges discussed	Examples
Livestock Impacts	○ Cattle have to spend more time indoors ○ More reliance on inputs e.g. feed ○ Need to alter livestock system ○ Heat stress ○ Decreased milk production Slurry storage	*"Rainfall would make everything more expensive will have to have cattle in a lot of the time."*
Soil Impacts	○ Land drainage ○ Degrading soil structure ○ Soil erosion ○ Soil nutrients decrease ○ Leaching of nutrients	*"Drainage will be needed or considering what sort of crops can survive these conditions need to be considered to sort the soil structure"*
Wet / dry conditions	○ Greater difference between good years and bad years ○ Water shortages ○ Need for irrigation ○ Summer rainfall impacting harvest	*"Rainfall would be much more expensive, we would have to bring in the cattle for the majority of the year if so wet."*

Source: Author's focus group

7.3.2 Future Opportunities in 2043

Future opportunities are presented in Table 7.4. It is clear that there are far fewer opportunities that have been identified from the climate scenarios than the challenges identified. Furthermore, far fewer opportunities are identified by farmers, than those identified by Defra (2012b).

Many opportunities are aimed at exploiting the creation of an indoor system. Such large-scale adaptations such as polytunnels and indoor dairy systems are seen as opportunities by farmers in the Welsh Marches to control the elements, eliminating the heightening variability presented by a changing climate. In response to irrigation concerns and the widening disparity between winter and summer rainfall, the opportunity for rain water harvesting and becoming more self-sufficient and creating a more sustainable farm system was discussed as an appealing opportunity. The effect of increased sunshine and the potential increases in grass growth and crop yields were also welcomed, in alliance with Defra (2012b).

Table 7.4: Opportunities foreseen for 2043

Type of Opportunity	**Opportunity discussed**	**Examples**
Benefits of more summer rainfall	○ Rain water harvesting ○ Cost go down if less irrigation needed ○ More water available	*"Increased rain water harvesting in the winter to conserve more for the summer."* *"Less irrigation required for potatoes"*
Benefits of increased sunshine	○ More flexible conditions if drier ○ More favourable conditions for livestock	*"And in the dry it, it's more flexible"*
Increase in crop yields	○ More crops to trade ○ Increased apple crops ○ Better quality of crops	*"My apples would benefit from warmer temperatures"*
Increase control of elements due to adaptations	○ Chance to develop indoor systems. ○ Indoor livestock system ○ Polytunnels	*"It would be more controlled environmental production, which … not what you would regard as farming, really."*
Increase grass growth	○ Increase in silage ○ Increase in hay crop ○ Reduction in inputs and costs ○ Opportunity to sell bales of hay to elsewhere.	*"with more grass growing, the level of inputs if more grass growing will be less"*
New crops	○ Maize ○ Grape vines ○ Soya ○ Grains ○ Strawberries and berries (due to increase of polytunnels) ○ Use more polytunnels to consider more crop varieties	*"It may be, it could come to being better for maize as it's better for sun and that side of things"* *"We've got the chance to put a different crop in. "*

Source: Author's focus group

Such responses are based on past experiences, yet are large-scale adaptations which require a large investment of time, training and finances which may well stretch beyond a typical family farm in the Welsh Marches. Many farmers also recognised that there will be future opportunities, although they are not yet known.

"Well there will be pluses but they'll be different to what everybody's used to"
(Douglas, Herefordshire – focus group)

Furthermore, the introduction of new enterprises, such as vineyards, would also extend beyond most knowledge bases within the Welsh Marches at present. This will potentially create a barrier for farmers to adopt such an approach within their pre-existing local knowledge base (as found in Holloway and Ilbery 1997).

7.3.3 Future Adaptive Measures

It is intended that the above identification of future challenges and opportunities may provide some indication of potential responses by farmers in the distant future. Specific adaptations were suggested in response to future challenges. In contrast to those measures already implemented, Table 7.5 demonstrates adaptive measures specifically in relation to future adaptations.

Such measures are comparable to those identified in Table 7.2, demonstrating an extension or alteration in activities that are already undertaken (supporting Kingwell 2006's observation of adaptations). Notably, suggestions of adaptations such as experimenting with new crops and breeds of livestock, soil management, monitoring local weather conditions and farm equipment, are all familiar concepts resulting in small or medium scale adaptations. This provides further support for those adaptations that have already been implemented and the potential suitability of them for farmers adapting in the future. Extending beyond such familiar adaptations, larger-scale measures are suggested which involve much larger scale changes from the 'top-down', often involving policy support. This includes the suggested role of GM and flood defences, which are outside of farmers' control (supporting the findings of Smit and Skinner 2002).

With the use of scenarios when discussing potential impacts, it is noticeable that farmers appear to be more empowered to suggest and to consider potential changes on their land. Challenges and local responses from within the farm community in the Welsh Marches were identified, specific to the local culture, using farmers' expertise (fulfilling the gap identified by Gornall *et al* 2010, Maynard 2009, Wynne 1992). This provides a valuable indication of possible responses that can be considered for the future. Such insights allow for the notable gap in establishing behavioural responses (recognised by Lorenzoni *et al.* 2007) to be addressed.

Table 7.5: Potential Future Adaptations

Adaptive Measure	Example
Flood defences	Focus upon improving flood defences for farmland – soft and hard engineering.
New farm equipment	Purchase different more adaptable equipment to better withstand difficult conditions, be able to cover more land in less time and operate in all weather.
Monitoring of weather and land conditions	Installation of weather station, on land sites to be able to access and store specified data as required making informed decisions.
Improve drainage of the land	Create drainage ditches.
Improve soils	Focus on sustainable soil management.
Improve pest and disease controls	Increase expenditure on pesticides and vaccinations to deal with new pests and damp conditions.
Introduction of new crops	Growing corn on the cob using new equipment, more grape vines and vineyards, changes in break crops
Indoor livestock systems	Change of dairy systems to be all indoors
New breeds of livestock	Use more 'hardy' livestock used to more 'tropical' conditions.
Reduce stocking densities	Change stocking densities and increase grazing land for livestock to reduce land pressure and heat stress.
Polytunnels	Increase use of polytunnels to protect crops.
Role of GM crops & breeds	GM technology to provide more resilient crops and livestock breeds modified to withstand difficult weather conditions, following lead from USA.

Source: Author's focus group

7.4 Perceptions, Impacts and Responses to Future Climate Change

The relationship between risk perception and implementation of adaptive measures in respect of perceived future challenges within this locality have been established throughout this chapter. Indeed, as this chapter has endeavoured to highlight, such a process is inextricably complex (supporting Reid *et al.* 2007). The first part of this chapter has explored farmers' perceptions to climate change and responses through adaptive measures to impacts in the near future. The second part has extended further into the future through exploration of farmers' interpretation of probable impacts and possible responses to climate change in the long-term. It is increasingly apparent that adaptive measures are only considered as a feasible option if they are in keeping with the local cultural context, existing farm system, individual farmer's knowledge and expertise, alongside their own risk perception of future challenges. From establishing the cultural context in which adaptive decisions are made, feasible adaptive measures appropriate to local pressures have been identified. As with any exploration of future processes, it is highly speculative having used hypothetical scenarios to anchor feasible responses in consideration of the distant future. Yet, an indication of plausible adaptive options, the processes and relation to climate change perceptions has informed this research.

A direct relationship is absent between risk perception and immediate adaptation, however some perception of a future risk is required to allow adaptive options to enter the decision-making process (Reid *et al.* 2007). This is demonstrated with the identification of positive farmer-weather relationships and associated higher risk perception, encouraging adaptive measures to be considered. This exploration of future perceptions allows a baseline to be established regarding farmers' present understanding and resilience through adaptations to a host of future challenges. Through exploration of the near and distant future, it is apparent that adaptive options are implemented and are increasingly considered, even though perceptions of climate change remain mixed. Adaptations are often reactionary measures to EWEs and associated risk perceptions of this, as opposed to long-term climate change which may appear to be distant in time and place.

The role of climate change communication has been explored in relation to its influence upon climate change perspectives (7.1, Figure 3.1). Indeed, the ranges of varied and conflicting climate change perspectives found within this investigation are associated with a notable inconsistency in media communication of climate science. Such a deficiency, combined with a lack of locally relevant research and communication of impacts and potential adaptations appropriate to the specific farm culture , has undoubtedly created mixed perspectives and a high level of confusion amongst the farm community. It has been found that there is a distinct need to improve the clarity of climate change communication, tailored to specific farm communities in keeping with local climate challenge. Such an approach, providing tailored communication will allow farmers to make decisions informed by locally relevant information in combination with their own local knowledge. Indeed, as suggested in 7.2, a need to provide a platform for farmer-to-farmer knowledge sharing on viable adaptations is paramount. Nevertheless, it is recognised that informing suitable climate communication is a slow process, and will gradually evolve, alongside increased farmer experimentation, over time encouraging more locally relevant and specific adaptive measures to be implemented.

The complexities of farmers' decision-making have been considered through application of a cultural-behavioural approach. Upon analysis of farmers' risk perception, a gap between a consensus over observed weather conditions (6.3) and diverse climate change perspectives is apparent (7.1). Curiously, it is prominent that little relationship between farmers' perceptions of the weather and climate appear to exist. Such separation is also found in the media's communication of climate, and little overlap to the weather and EWEs. Thus, unlike the consensus of observed weather change amongst the farm community (6.3), risk perceptions of climate change are highly varied. Yet, those who perceived the highest level of risk due to climate change have the most adaptive measures put in place and have considered different options to withstand better future stresses. Adaptive options to climate change are evaluated in terms of suitability to the local environment, sustainability and economic cost, alongside cultural-behavioural influences.

Figure 7.1 demonstrates that climate change and increasing pressures of EWEs are just two of several farm pressures in which farm adjustments are made in view of the complexity of cultural-behavioural influences. However, it is clear that specific adaptations to mitigate against potential farm system shocks triggered by climate change impacts are increasing in importance. In view of the near and distant future, such responses to developing a farmer's adaptive capacity will increase in implementation, in response to increasing climate change pressures (in relation to Figure 3.2 and 3.4).

As identified in 7.2.2, adapting towards a resilient farm system is a gradual process, with multiple adaptive measures required to be implemented. Small and medium scale measures are already apparent, with the success or failures feeding into the decision-making process when considering future large-scale climate-specific adaptations. At present, the most successful measures appear to be those that increase the farm's overall sustainability and resilience to future challenges. A variety of different adaptation options are found to be implemented and considered in the near future. A spread of different levels of farm adaptations is found within the Welsh Marches. This leaves many farmers yet to begin a long journey to experiment and adopt locally appropriate adaptive measures in pursuit of creating a resilient farm system to withstand the pressures and shocks of future climate change.

A chronological exploration of farmers' perceptions of past, present and future perceptions of weather and climate in the Welsh Marches has now been completed. Chapter seven has built upon the findings from chapters five and six, through applying a cultural-behavioural approach to future challenges. Chapter eight will conclude this investigation by synthesising key findings discussed throughout this thesis, in respect of the limitations of this research and future recommendations for research.

CHAPTER EIGHT

FARMERS' RESILIENCE TO CLIMATE CHANGE IN THE WELSH MARCHES

"Can we talk about climate change now?"
Climate Outreach and Information Network (2014)[37]

Throughout this thesis, farmers' resilience towards anthropogenic climate change in the Welsh Marches has been examined. Farmers' experiences of past EWEs, present perceptions of the weather and future concerns have been evaluated, underpinned by a cultural-behavioural theoretical approach. The research has been conducted in light of impending impacts of climate change and subsequent concerns over the future food security of the UK. Farmers' risk perceptions, adaptive capacity and local knowledge are established in view of their influences upon farmers' decision-making and subsequent development of resilience.

This research has built upon previous work in agricultural geography examining the impacts and potential responses of farm communities to the climate challenge (chapter two). It has experimented with creating and applying a new conceptual framework building upon established philosophical approaches in agricultural geography (chapter three). A multi-phased approach has been applied to gain a holistic understanding from first-hand accounts, speculative future responses, physical challenges and reported impacts of EWEs and climate change in the past, present and future (chapter four). Original findings have been presented in discussion with farmers' resilience in the past (chapter five), present (chapter six) and future (chapter seven). This chapter will conclude this thesis, in view of the original contributions to knowledge that have been made (8.1). The suitability of a cultural-behavioural approach to explore farmers' resilience will then be critiqued, with regard to the value that experimentation of the approach has given this research (8.2). Methodological considerations will be evaluated in view of the exposed limitations and opportunities that it has presented

[37] Jamie Clarke, COIN (2014) at: Responding and Adapting to Extreme Weather, London Policy Knowledge 5th August 2014.

(8.3). To conclude, recommendations for future research will then be suggested (8.4) in consideration to the original contributions of knowledge that have been made in this thesis.

8.1 Original Contributions to Knowledge

Climate change is a fundamental pressure on the global food system, predicted to amplify pre-existing global pressures faced by food producers (Ambler-Edwards *et al.* 2009, Foresight 2011a). Within the context of future challenges facing farmers in the 21st century, there is a distinct pressure to apply lessons learnt from studying the past and present to further understanding future farm stresses. Agricultural geography has evolved as a subject area primarily built from reviewing present and past stresses exerted upon farmers. This thesis has pushed the boundaries of this tradition to explore farmers' decision-making into the future, readdressing criticisms of the behavioural approach focusing on replicating decisions that have already happened. To overcome this theoretical barrier of the behavioural approach having no predictive value, this research has demonstrated its originality by experimenting with a cultural-behavioural approach constructed in this thesis to enable a cultural perspective to be used to explore future decision-making.

This research has sought to contribute to the rapidly advancing body of climate change research in the social sciences (chapter two), through exploring the resilience of farmers to one of the most significant challenges that farm communities will inevitably face. A 'bottom-up' approach has been adopted through a geographical focus specific to the Welsh Marches, anchoring this research upon local culture and local climate. This has allowed the research to establish farm systems' resilience to future shocks, placing the farmer at the heart of the system, influenced by the social network and local culture of the community surrounding them (Figure 3.5).

From this exploration of farmers' resilience, three prominent findings can be distinguished, identifiable in explorations of the past, present and future. Firstly, farmers' perceptions of the weather are established in keeping with the local culture (8.1.1). Secondly, a discrepancy between farmers' observations of changes in the weather, in comparison to understandings of climate change is found (8.1.2). Thirdly, adaptation options and responses to extreme weather and climate change are identified (8.1.3). Each finding will be discussed in turn, in view of its original contribution to knowledge.

8.1.1 Farmers' Perceptions of *'The Weather'*

The significance of the role in which the weather plays in farmers' everyday lives is explored from application of a cultural lens. Farmers' perceptions of the weather are established in keeping with the specific local culture. It is identified by the author in chapter 6, that the consideration of the weather in terms of localised atmospheric conditions, lacks the acknowledgment of the influence in which the weather has as a cultural construct (6.1). This is as farmer-weather relationships are recognised to demonstrate how cultural perceptions of '*the weather*' influence subsequent decisions and information seeking (6.1). Such relationships allow for the priority of the weather in farmers' decision-making to be further understood (7.1). Farmer-weather relationships are identified as a cultural construct in the way in which farmers' perceive the weather. The cultural container in which farmers perceive *'the weather'* therefore influences decision-making and the priority that *'the weather'* is assigned in farm business planning, obstructing or encouraging subsequent adaptations. A typology of farmer-weather relationships has been formulated based upon different roles identified that *'the weather'* plays upon farmers' decision-making. Formal and informal farmer-weather relationships are established to facilitate decision-making and aid the assessment of suitable responses to EWEs and encourage the development of adaptive capacity. Conversely, negative and background relationships with *'the weather'* are found to obstruct or slow decision-making concerning the weather, and subsequent development of adaptive capacity.

This finding is supported by the identification of farmers' experiences of past EWEs (5.1), in view of the impacts that have been incurred. Such experiences have been found to develop local knowledge forming a basis upon which present decisions are anchored upon (5.3). The specific hazards and potential farm losses that climate change may incur have been established for the Welsh Marches based upon past losses (5.2.3). The questionnaire revealed that 60.2% of farmers consider themselves to have already suffered a significant loss due to EWEs in the past. With EWEs predicted to become both more frequent and intense (Defra 2009, IPCC 2013), farm systems in the UK are likely to be exposed to suffering even more losses such as those identified throughout chapter five. EWEs that took place during the course of this research, including the 2012 rainfall and 2013 snowfall event, further emphasise the regularity and scale of extreme weather conditions that farmers in this region have to contend with.

Farmers' perceptions of EWEs have been determined in view of event anchoring, and interpretation of information relating to plausible impacts of future climate change. It is noticeable that weather forecasts (6.3) are relied upon heavily by the farm community. It was found from analysis of the questionnaires that 42% of farmers rely upon daily forecasts on the TV or Radio, and a further 28% rely upon online forecasts as their primary source of weather information. Yet it is apparent that such sources are not always considered by the farm community to be sufficient in their accuracy, local relevance and ability to provide information immediately relevant to farm decision-making. It has also been demonstrated in this research that farmer-weather relationships may influence the way in which forecasts can be utilised, although it is not always a direct linear relationship between forecasts and farmer-weather relationships. The uniqueness of each farmer's perception of the weather, due to the individual nature of experiences, knowledge, engagement with local culture and social networks, cannot be underestimated in its importance in influencing farmers' perceptions of the weather.

8.1.2 Discrepancy between Farmers' Weather Observations and Understanding of Climate Change

Farmers' understanding of the weather, climate, and climate change as a phenomenon has been examined. A discrepancy between farmers' observations of changes in the weather, in comparison to understandings of climate change is noticeable. Observed changes in the weather have been identified (6.3), to establish a consensus of significant variations in the weather over time. In this research, a consensus in observations of the weather was identified, as nearly all of the interviewees have observed the weather becoming more extreme, less defined seasonal variations and smaller windows of opportunities. Conversely, in comparison to perspectives of future climate change, a significant mix of responses is identified demonstrating widespread confusion (7.1). In particular, an array of disjointed opinions was apparent when analysing farmers' concerns and observations of the present weather, to future climate. Thus, it is discernible that an inconsistency between farmers' understanding of the weather and climate exists.

It has been found in this research, that daily weather conditions and observed changes in the weather over the last ten years have already influenced farmers' daily decision-making as a result of experiences of EWEs. Such experiences, such as the 2012 rainfall and 2013 snowfall events, have resulted in direct responses, and increased concern over potential future shocks in the near and distant future. However, as identified in 6.4 and 7.1, observations of increasingly challenging weather conditions does not associate directly with farmers' perceptions of potential impacts associated with climate change.

It is apparent that farmers' understanding of future climate change is distinctly diverse, indicating the significant role of the individual and behavioural process in which climate information is interpreted and understood. Widespread confusion and disjointed understanding of climate change in the future is a considerable consequence of mixed media representations of the underpinning causes of anthropogenic climate change. This, in turn, has created mixed opinions over the underlying triggers of anthropogenic change and the role in which natural climatic cycles influence long-term climatic systems. Yet, the most distinct finding is the scale of confusion over the process as a whole, with an association of political influences and a general sense of scepticism identified across the community.

It has been demonstrated that disjointed opinions are most associated with the distance of time and place, associated by most farmers with climate change (confirmed in 7.1, supporting Holloway 1999, Leiserowitz 2006, Reid *et al.*2007). This research has identified that such distance and perceived irrelevance to local climate remains the most substantial barrier to farmers' interpretation of climate change in relation to observed and expected change on their land. Indeed, the analysis of local newspapers revealed no mentions of climate change after the reporting of EWEs, supporting the notion of climate change being geographically distant (7.1.3). Therefore, such a perception of climate change as a global challenge in the distant future seemingly prevents farmers in the Welsh Marches interpreting climate information in relation to their own farm systems. Hence, a general sense of local irrelevance of the impacts of climate change within a farmer's working lifetime, presents a significant obstacle to farmers implementing direct adaptive measures.

Communication of climate change causes and possible impacts is considerably complex. It is increasingly apparent that receiving generalised information designed for a lay audience from the media is undoubtedly insufficient for the farming community. This thesis has emphasised the failure of scientific communication to portray future information that is seemingly compatible to farmers' needs and local knowledge. Therefore, there is a need for climate communication for farmers as a user group to be redesigned. Such communication of future challenges needs to converge effectively scientific projections and farmers' local knowledge of the impacts of projected changes in the climate directly upon a farm system. This would empower each farmer to apply such communication to their own expertise in view of their wealth of knowledge and experiences of climate pressures on the land. Hence, the value of communication of specific impacts within a given period for the near and distant future, which has been designed within a local context, tailored for a specific locality and user group, should not be underestimated. Indeed, the insights uncovered in section 7.3, that farmers have provided, based upon climatic predictions tailored to the farm community of plausible impacts and feasible responses, have further emphasised the value in viewing farmers as experts of probable local climatic impacts (Wynne 1992).

8.1.3 Adaptation Options and Responses to Extreme Weather and Climate Change

Adaptation options and responses to extreme weather and climate change were identified. This was by way of responses made to mitigate the full extent of shocks incurred by past EWEs (5.2), in addition to adaptation options that have already begun to be implemented by farmers in the Welsh Marches (7.2). This research has confirmed that a considerable gap between knowledge, risk perception and adaptation exists (supporting Reid *et al.* 2007, Brklacich *et al.* 1997).

Different types of adaptive measures found to have already been implemented by farmers in the Welsh Marches are identified, with distinct differences between small, medium and large scale measures identified (Table 7.2). This is in contrast to alternative adaptations such as mitigation of a farm's carbon footprint, and alternative sources of income (7.2.2). Feasible adaptation options suitable to the Welsh Marches farm community have been established based primarily upon trials and experiments of members of this farm community, alongside their willingness and opinions of suitable actions (7.2, Table 7.4). Unlike general reports that have previously conducted comparable research at a national-level (Defra 2012b, Tate *et al* 2010), small-scale adjustments have been the primary focus within this community due to the ease of the implementation of such measures, in accordance to pre-existing machinery, knowledge and cultural feasibility. The implementation of a small adjustment will then encourage adaptive capacity, allowing for increased confidence in implementing medium or large-scale adjustments. Therefore, support of accumulative small adjustments now, will help farmers to gradually build adaptive capacity, increasing resilience to withstand future shocks.

Such measures involve time and financial commitment, and yet with such accumulation of adjustments and a significant increase in adaptive capacity, an adapted farm system is then established (7.2). Therefore, it is apparent that such an approach, in keeping with the cultural context of the specific locality, is foreseen as a slow and gradual process. Nevertheless, the pertinence of a tipping-point causing significant shocks to a farm system, triggering decisive behaviour to instigate the implication of adaptations, has also been established. This is particularly evident, where a direct response to losses from an extreme weather event has been identified. Adaptive measures found to be implemented following the 2012 rainfall event (5.3.1, 7.2) have provided opportunities for some farmers in the Welsh Marches to improve their adaptive capacity 'bouncing forwards', as opposed to returning to the same farm system state prior to the EWEs.

Undoubtedly, the application of several small-scale adjustments is also advantageous due to the limited financial commitment involved. Conversely, this research has demonstrated that it is futile to consider adaptation options based upon economic costs alone (7.2). This thesis has endeavoured to outline the complex cultural-behavioural web, in which all farm decisions are made influenced by cultural, social, physical, political, environmental and economic influences. To consider adaptations in view of just one of these components is too simplistic.

Adaptive measures that have been identified to have already been implemented (7.2) have been compared to measures that may be considered in the near and distant future in view of future challenges and opportunities (7.3, Table 7.3and 7.4). This is alongside detailed and specific hazards that have been identified by farmers in the Welsh Marches (5.2.3). Defra (2012b) identified considerable opportunities and challenges for farmers under a changing climatic system. It becomes increasingly apparent throughout this thesis that such literature, despite its focus upon the UK, lacks detail of the specific probable implications of physical changes in the climatic system on farm systems at a local level, and subsequent feasible responses. Therefore, feasible responses to future challenges identified in 7.3 provide an insight into possible responses by the farm community.

8.2 Value of the Cultural-Behavioural Conceptual Framework

This research has further contributed to agricultural geography by developing, and testing a new theoretical approach, in response to Burton's (2004) call for a need to update the behavioural approach in light of the 'cultural turn'. A cultural–behavioural conceptual framework has been constructed in section 3.5, built upon the traditions of the behavioural approach in agricultural geography in view of the 'cultural turn' (Figure 3.4). The cultural-behavioural approach, as demonstrated in Figure 3.4, places the complexity of farm decision-making (Figure 3.5) at the heart of the development of farmer resilience influenced by the concepts of scientific communication (3.3), risk perception (2.4.2), local knowledge (2.5.2, 2.3), and adaptive capacity (3.4.2). This approach has been utilised to facilitate the role of farmers' decision-making in the development of their resilience.

A lack of cultural research in agricultural geography has been a concern, recognised by Morris and Evans (2004, 3.2). From applying a cultural lens, farmers' perceptions of the weather and climate change have been established. Notably, the value of understanding farmers' perceptions from within the cultural container in which they are established has allowed individual relationships with the weather, and the role of this upon decision-making (outlined above) to be identified. The cultural-behavioural approach has enabled the true complexity of the development of farmers' resilience to be understood within the complexity from which it derives. This is because it has enabled the investigation of the process, including 'remote' and first-hand experiences, to be incorporated within the continuous cycle of resilience development, which is in continuous flux. Therefore, it has proven effective as a tool to conceptualise the development of farmers' resilience, therefore opening up research possibilities further exploring the cultural-behavioural approach.

By adopting a cultural-behavioural approach, it has been possible to revisit comparable studies conducted in the UK from an alternative perspective. Notably, research from Holloway and Ilbery (1996a, 1996b and 1997) and Holloway (1999), has been reviewed utilising information from rapidly advanced understanding of climate change causes and impacts that has been conducted over the last 20 years. Indeed, little change in farmers' understanding of climate change has transpired over this period, indicating that, despite scientific outpourings, a distinct failure in communicating such evidence has occurred.

The cultural-behavioural approach has enabled this research to be conducted from the 'bottom-up' in view of lessons identified from research in the developing world (2.3). From anchoring this research upon the Welsh Marches, the value and role of the local community and culture in farm decision-making has been incorporated. This has allowed this research to respond to national studies that have favoured a top-down approach anchored upon financial and political influences (such as Defra 2012b, Tate *et al.* 2010). Indeed, this new avenue of research has allowed for different insights and perspectives to be generated from a locally specific culture, contributing to the rapidly advancing investigations of agricultural impacts and responses to climate change. This therefore provides further details of probable specific impacts and responses to climate change, that are likely to be experienced at a farm systems level.

Likewise, in response to the literature reviewed from a developing world context, the role of local knowledge in farmers' interpretation of observed and future scenarios of change is highly relevant and applicable to the context of developed countries also. From the incorporation of local knowledge into the conceptual framework, considerable synergies have been made between farmers' observations and perceptions of the weather, as well as adaptations through the adoption of innovations across social networks. Thus, emphasising the potential value in looking towards the 'front-line' of farmers coping with climate change, where adaptations are adopted now in order for farmers to survive or thrive. This may give an indication of how farmers in the UK might be able to apply their own local knowledge, experiences and cultural relationships with the weather to make suitable adaptations to improve the resilience of their farm system to withstand future climatic shocks.

The concept of updating behavioural traditions in agricultural geography with the 'cultural turn' has liberated methodological constrictions, permitting the use of qualitative and quantitative data. Indeed, a phased approach allowing a baseline of past cultural experiences has enabled the identification of the role of past experiences, in the use of local knowledge and subsequent event anchoring when faced with new challenges. The significant role of the local community and social capital in encouraging resilience through suitable responses to cope with the adverse impacts of EWEs has also been identified through applications of this theoretical perspective (5.2). Furthermore, the role of social capital in encouraging suitable adaptive measures, and subsequent adaptive capacity has also been established (7.2.1).

Indeed, the development of the approach has only just begun; therefore much further research is required to ensure its effectiveness in understanding farmers' decision-making from a cultural lens. Unlike theories such as TPB, the cultural-behavioural approach is not designed to predict behavioural responses or calculate financially the cost of possible responses through economics. Instead, suggestions of feasible adaptive responses have been made in view of farmers' local knowledge, risk perception and adaptive capacity. Overall this conceptual framework has provided a useful tool forming the foundations of this research. In particular, its effectiveness is noticeable in providing a holistic framework that allows the analysis of the complex processes involved in establishing farmers' risk perception and adaptations to climate change. The further development of the cultural-behavioural can provide a platform from which to understand farmers' development of resilience. Indeed, this could lead further to understanding of other areas of interest to agricultural geographers, and wider explorations of climate change impacts upon society. In particular, this approach can be used outside of agricultural geography as a tool to further explore community resilience.

8.3 Methodological Considerations

The methodological approach adopted for this research has demonstrated the value of utilising a sequential explanatory approach to establish a baseline of information and provide a local context before conducting primary research with the farming community itself. The adoption of a 'participant selection model' (Creswell and Plano Clark 2007) has allowed for the identification of participants with the most relevant experiences to be identified and included in this research. Indeed, such an approach identifying participants based upon experiences, was supported by use of the cultural-behavioural approach. This means that this research was anchored upon the dominance of family farm enterprises in the Welsh Marches, predominantly focused upon mixed, arable and livestock enterprises, in keeping with the region's dominance of sheep, beef, dairying, wheat, and potatoes (4.5.3, Evans, 2009a). This methodology did not seek to gain a nationally representative sample. Indeed, such representative research from a 'top-down' economic perspective has previously been conducted in studies such as Tate *et al.* (2010) focusing upon financial gains and losses of farm adaptations to climate change.

The findings from this research have drawn upon the experiences and perceptions of farmers from the Welsh Marches. Needless to say, the findings of this research are specific to the culture of this locality. As a consequence, the findings, opinions, perceptions and complexities identified are not necessarily directly representative of other farm communities across the UK. This is particularly salient as this research has been designed to incorporate the specific cultural variations of this community in light of EWEs that have been experienced in this location. The Welsh Marches was chosen as the focus of this case study, primarily due to its history of experiences with a wide range of past EWEs (1.4). Numerous problems and impacts have occurred such as flood and heatwave events, and are highlighted because of their relevance to other localities in the UK. This locally specific approach has provided an indication of the potential challenges faced by other farm communities in the UK. Therefore, this research on its own is constricted in its ability to contribute to global debates of food security. Yet, when considered alongside other case study research from across the UK, it can contribute to wider food security debates.

Farmers in the Welsh Marches have been shown in this research to be most impacted and concerned around wet weather, due to the tendency of land to become heavily saturated after intense or prolonged rainfall, and for areas within this region to flood. Needless to say, the primary concern of farmers in other locations in the UK may differ. It is considered that the timing of this research has significantly influenced the risk perceptions that have been captured (4.4). This is particularly pertinent as data collection followed two consecutive EWEs in 2012 and 2013, which therefore provided a unique opportunity to allow for the experiences of farmers undergoing a period of recovery and adjustments, and the influence of this upon their risk perception, to be captured. Such accounts have provided rich insights into the role of EWEs in building local knowledge based upon experience. However, this has created a likely bias in farmers' perceptions being heightened to the effects of the most recent EWEs, which they were still recovering from (5.2.4). This was demonstrated by the increased concern about prolonged rainfall, following the impacts incurred from the 2012 rainfall.

Methodological limitations were a factor constricting the effectiveness of the data collected. Notably, the way in which primary data was collected has resulted in a suitable but small-scale sample. Primary data collection was implemented in accordance with the cultural-behavioural focus upon in-depth, rich, locally specific data, and so relied upon the principle of data saturation (4.5.4). If more resources were at the disposal of this project, it would be beneficial to expand the last research phase by increasing replication of the farmer focus group more often in different locations across the region. This is recognised due to the considerable value of future opportunities identified, as revealed from the data gained from the focus group using future scenarios. This activity has been proven to be a considerably effective tool in enabling farmers to visualise potential future impacts, extending beyond the confinements of anchoring perceptions of the future upon present pressures and past experiences alone. Due to the experimentation of this methodology, it was not until the analysis of the focus group data that the value of using scenarios in allowing future responses and adaptation options to be established was revealed.

Likewise, the value gained from the secondary data was minimal in comparison, thus contributing less to the discussion despite taking a significant proportion of the research time. In spite of this, the value of the secondary and quantitative data in enabling the qualitative data to be tailored in light of the specific experiences and needs of the Welsh March farm community cannot be underestimated, in keeping with the experimentation of the cultural-behavioural approach. The necessity of this is particularly pertinent due to a lack of previous studies in this region adopting a comparable 'bottom-up' approach. It was envisaged as a necessary starting point in order to establish the experiences of past EWEs. The use of qualitative analysis software has been successful in allowing interlinking themes to be drawn out from the data, and providing evidence to support key arguments. It has been particularly effective in facilitating the discussion of results by chronological theme, thus allowing results to be presented in alignment to the conceptual-framework.

Climate change is just one factor exacerbating global food insecurity. Hence, this investigation has solely anchored itself upon the possible impacts and adaptations made in farm systems in response to this specific threat. Yet, in reality, farm systems are subject to a complex flux of continuous pressures exerting an influence, demanding an understanding and adjustment in response. Unlike the assumptions made in this thesis, the future impacts of climate change, as estimated in 7.3, may in fact be mitigated by increasing farm resilience built upon other farm pressures and vulnerability. Other external farm pressures, such as market fluctuations and policy reform, may exert the biggest influence upon exposing farm systems' vulnerability. Regardless of other pressures, climate change is not a threat that will disappear in the near or distant future (2.1, 7.3), with some of the effects having been already felt (5.2, 6.3). Indeed, it has been a theme established throughout this thesis that climate change is not the only challenge testing farmers' resilience in the future, but is likely to significantly amplify other farm pressures (2.2, Figure 7.1).

8.4 Policy Implementations

This thesis has emphasised that there is an urgent need for policy-makers to facilitate and encourage farmers to make suitable sustainable adaptations in order to mitigate the full impact of climate change on the UK's future food security. Indeed, deficient attention and specific action by policy-makers to address food security of the UK by focusing upon farmers' resilience to climate change has resulted in greater concerns over the preparedness of the UK agricultural sector to the mounting challenges (2.2).

This research has identified the need to develop farmers' resilience to climate change by focusing upon local experiences, knowledge, impacts and challenges, which informs farmers' risk perceptions and subsequent adaptation options that may be implemented. The need for policy-makers to return to the grass-roots level of the UK agricultural system, and focus specifically upon the risk perceptions, coping capacity, adaptive capacity and social capital of farmers, is imperative.

A crucial barrier to enabling farmer's perception of climate change has been identified in 7.1, to be the present state of ineffective communication concerning expected climate change impacts. Therefore, policy-makers need to recognise the need for a co-ordinated local relevant communication strategy to engage farmers with climate science. Such communication should be derived from locally accurate and accessible scientific data that is accessible for farmers' interpretation in view of their local knowledge systems. Specifically, the farmers' that participated in this research, on a whole appear to lack a direct association with climate change to their locality and lifetime. Such a barrier of time and place of expected climate change impacts that are often seen to be of concern to geographically distant locations, in a far distant time, is a significant failing in present climate science communication hindering the implementation of suitable adaptive responses by a majority of farmers in the Welsh Marches.

Policy-makers can overcome such barriers to communication by prioritising the need for locally relevant and specified information tailored to the UK farm sector, available through a multitude of platforms including facilitating workshops that use participatory methods. This research demonstrated the value of using tailored climate scenarios to generate interpretation, thought and discussion of expected climate change impacts in a specific locality. Such an approach could be employed across the UK to effectively engage with the climate issue, breaking down the barrier of distance in time and place. Furthermore, face-to-face community facilitation workshops would also help to mitigate farmers' distrust in climate science, as such engagement will allow a two-way discussion and sharing of climate knowledge.

A wealth of farmer knowledge, expertise and experience in dealing with EWEs has been established in this research. Such local knowledge is an invaluable tool that could be capitalised upon by policy-makers. Indeed, an effective approach to encourage farmers' resilience would be to develop a platform which will formalise pre-existing informal farmer knowledge concerning observations of the weather, implications of expected climate change and suitable responses. Farmers' have been established in this research to engage in both formal and informal relationships with the weather, building a wealth of experience and knowledge, alongside detailed formalised weather data, and observations of physical change, and implications for the land. Such pre-existing knowledge could be amalgamated in a formalised platform such as a website in which farmers can add their own experiences and knowledge. At the same time such a platform will allow farmers to compare experience and findings, as well as learn from other farmers' who have observed, coped with and responded to comparable challenges. Such knowledge, interest in the weather, and data has been shown in this study to exist. Therefore, the next step is to attract policy attention, in order to capitalise upon such pre-existing resources and capacity to implement suitable adaptive measures to climate change.

Farm communities should be empowered to implement suitable adaptive actions that are locally relevant, feasible and in-keeping with pre-existing knowledge systems and structures. Such adaptations have already been established and implemented by some, and so need to also be accessible and understood as potential options for others with similar vulnerabilities to future EWEs and climate change in general. Such an opportunity for policy-makers therefore exists to build upon the philosophical groundwork already established by policy makers in a development context. Indeed, lessons should be learnt from such policy-makers who have established that by facilitating knowledge sharing and allowing farmers to build, develop, learn from and access a basket of choices is effective in encouraging farmers to implement adjustments to improve the resilience of their farm-system. Such an approach allows farmers' to also contribute to and benefit other farmers in the community by reporting back and sharing experiences of successful and ineffective adaptation options.

Indeed, farmers' adaptations to climate change have been identified to have previously been built up over time moving from small to large-scale adaptations in keeping with local farming culture. Farmers' in the Welsh Marches have been found to have already experimented with, trialled and implemented different adaptive measures in direct response to the increasing challenges that they have observed. Therefore a significant opportunity for policy-makers would be to seek to encourage farmer networks and knowledge sharing through facilitating adaptation networks and other means to allow farmers to build upon each other's success, allowing more efficient and resilient farm systems to be developed from the escalation of proven successes. Furthermore, a system such as locally specific adaptation networks will also contribute to further develop upon farmers' social capital and thus increasing their resilience and coping capacity in view of future EWEs.

From a localised approach, specific communication and adaptation measures that build upon and strengthen existing farm enterprises have been demonstrated here to effectively develop farmers' resilience to not only expected but also unknown climate challenges. Instantaneous policy action alongside further academic research is crucial in order to further strengthen, and encourage the development of farmer's resilience to climate change. As recognised in the UK climate change risk assessment report, the UK is in unique position in which some opportunities are presented to the food system in response to climate change impact. However, such opportunities as emphasised in Defra (2012b) will not be exploited without policy intervention and facilitation of building farmers' resilience from the bottom-up across farm communities in the UK.

8.5 The Need for Further Research

In response to the methodological limitations and research findings identified above, the need for further research has been established, building possible avenues of research identified from the discoveries that this thesis has made. To explore beyond the scope of this research, it is apparent that there is a need to conduct comparable research in different farm communities across the UK. This will allow for research findings from the Welsh Marches to be compared directly with other farm communities. It would provide a direct response to the limitations of this research anchored upon one farm community in the UK. Through the selection of locations known to be impacted primarily by different EWEs, such as drought and those known to suffer from more or less frequent and intense events, this greater comparison and analysis could be made of the findings anchored upon farmers in the Welsh Marches (see limitations above). This would allow an exploration of whether a higher frequency of EWEs influences a farm community's resilience to future shocks. Likewise, further research with farmers from other farm sectors, larger enterprises and with different experiences on the land, could be constructed through facilitating a representative sample. Indeed, increasing the number of in-depth interviews and conducting a series of scenario-based focus groups will allow for greater verification and exploration of different interpretations and adaptation options implemented by farmers across the region (as indicated in 8.2). Such comparisons with farm communities with more or less experience of EWEs would provide a contrast to establish the role of EWEs in risk perception and local knowledge to develop resilience and adaptive capacity.

It is apparent that the timing of this research was conducted prior to an impending 'tipping point' of increasing losses from EWEs due to climate change (IPCC 2014), this is before the majority of farmers are pushed by incurring mounting losses to implement adaptive measures to mitigate their exposed vulnerability. Indeed, this is indicated by the seemingly significant influence of the 2012 rainfall and 2013 snowfall upon farmers' perceptions towards making accumulative adaptations. Nevertheless the bias of these events upon the data collected cannot be underestimated (5.1-5.3). Thus, it would be constructive to follow up this research by following subsequent events, allowing for the identification of a 'tipping point' triggering most farmers to explore adaptation options, which may have occurred at this point following these events, or occur in the near future. Likewise, the need for future research to document farmers' understanding of climate change and the development of this in ten years' time as the growing body of scientific climatic research develops further is apparent. Indeed, IPCC (2013) and IPCC (2014) have been published during the course of this research. Therefore, the full impact of the confirmation of increasing certainty in anthropogenic climate change to 95% certainty (IPCC 2013), and increasing calls to implement agricultural adaptations to withstand better climate change, is yet to filter through the communication chain.

This research has further emphasised the value of farmers' local knowledge and their considerable expertise in respect of local land conditions, and their relationship with the weather. Consequently, a greater need to explore such knowledge in relation to future climate challenges is clear. An exploration of the role of local knowledge in farmers' decision-making in the UK is needed to reverse the top-down communication of scientific predictions that has been found to create a distinct distance in time and place. The relevance of research conducted in developing countries, allowing lessons to be applied to farmers' resilience to climate change has been established. Further research is required to explore the possible value of applying lessons from research with farmers in developing countries to the UK. Indeed, this opens up a new suite of research opportunities using other methodologies such as participatory research to exploring farmers' resilience in the UK. This requires a more consolidated, inter-disciplinary thinking between agricultural and development geographers. Additional research adopting a bottom-up approach to communication and identifying suitable adaptations based on local farmers is highly recommended in light of these findings.

The current communication of climate change information has been identified to often alienate farmers from the local reality of probable future impacts. To address this failing, this research has indicated that tailored information is required to denote the specific challenges that farmers are likely to face. There is a need for information to be informed directly from the experiences of local farmers, allowing for demonstrations of local adaptation options to improve local farmer resilience is required. Furthermore, further research extending beyond the recognition of different farmers' sources and uses of weather information is identified in this study. In particular, the division of a suitable platform for locally accurate weather information, directly relevant to farm decision-making would be invaluable in its assistance to daily farm decision-making under an increasingly erratic climate. Alongside this, engagement with plausible adjustment strategies that could be feasibly adopted in keeping with local culture, knowledge and resources would be invaluable for farmers.

Specifically, 8.1 identified three main contributions to knowledge that have been made in this thesis. Accordingly, each finding requires further investigation to establish its further value in the development of farmers' resilience to climate change. Firstly, further investigation of farmers' perceptions of the weather could be explored in view of the influence that farmer-weather relationships have on farmers' perceptions of climate change, and the possible barriers or facilitation to adaptive capacity (8.1.1, 6.1). Further experimentation of the typology of relationships would establish whether this is applicable to other farm communities, and prevalent in other local farm cultures. Secondly, further exploration into the disparity between farmers' observations of the weather and understanding of climate change needs to be conducted (8.1.2, 6.3, 7.1). This would verify whether this is due to a failing of climate change communication to make it locally relevant, or due to other factors that are beyond the scope of consideration in this thesis. Thirdly, further exploration of the knowledge action gap is required to conceptualise why key barriers to adaptive capacity are presented (8.1.3, 7.2, 7.3). The influence of farmer-weather relationships upon the specific development of adaptive capacity is a future avenue of research that could generate significant answers of the known gap between knowledge and adaptations (Reid *et al.* 2007, Smit *et al.* 2000), surrounding farmers' responses to climate change.

As demonstrated in 8.2, the development of the cultural-behavioural has provided a platform from which to understand farmers' development of resilience. Indeed, this could lead to further understanding of other areas of interest to agricultural geographers, and wider explorations of climate change impacts upon society.

Concluding Remarks

This thesis has explored farmers' resilience to climate change in the Welsh Marches. It has contributed to contemporary research through exploration of impending challenges of climate change and food security that we will undoubtedly face in the 21st century. This thesis has endeavoured to provide one piece of the puzzle in which social research need to complete in order to holistically investigate the true impacts of anthropogenic climate change that will be experienced, and the effect of this upon global food security. This research has explored farmers' resilience to climate change in the past, present and future. Such an approach has enabled farmers' perceptions and relationships with *'the weather'*, perceptions of climate change, feasible adaptation options, and the development of adaptive capacity to be established. It has been demonstrated that adopting a local approach focusing upon specific cultural and behavioural processes unique to that community, allows for specific challenges of climate change to be identified, discussed and mitigated against.

The importance of anchoring this research on a specific farm community to explore the culture, knowledge and experiences cannot be underestimated. Consequently, it has been demonstrated that using a 'local approach', can suitably address a global issue such as future food insecurity, with a view to inform a more sustainable future, with systems resilient to inventible shocks that will be experienced throughout the 21st century. Alongside providing some answers, a series of questions have been raised from this investigation. In order to accurately establish and encourage the development of farmers' resilience in response to numerous farm pressures in the near and distant future such as climate change, it is clear that research into this topic in the UK has only just begun.

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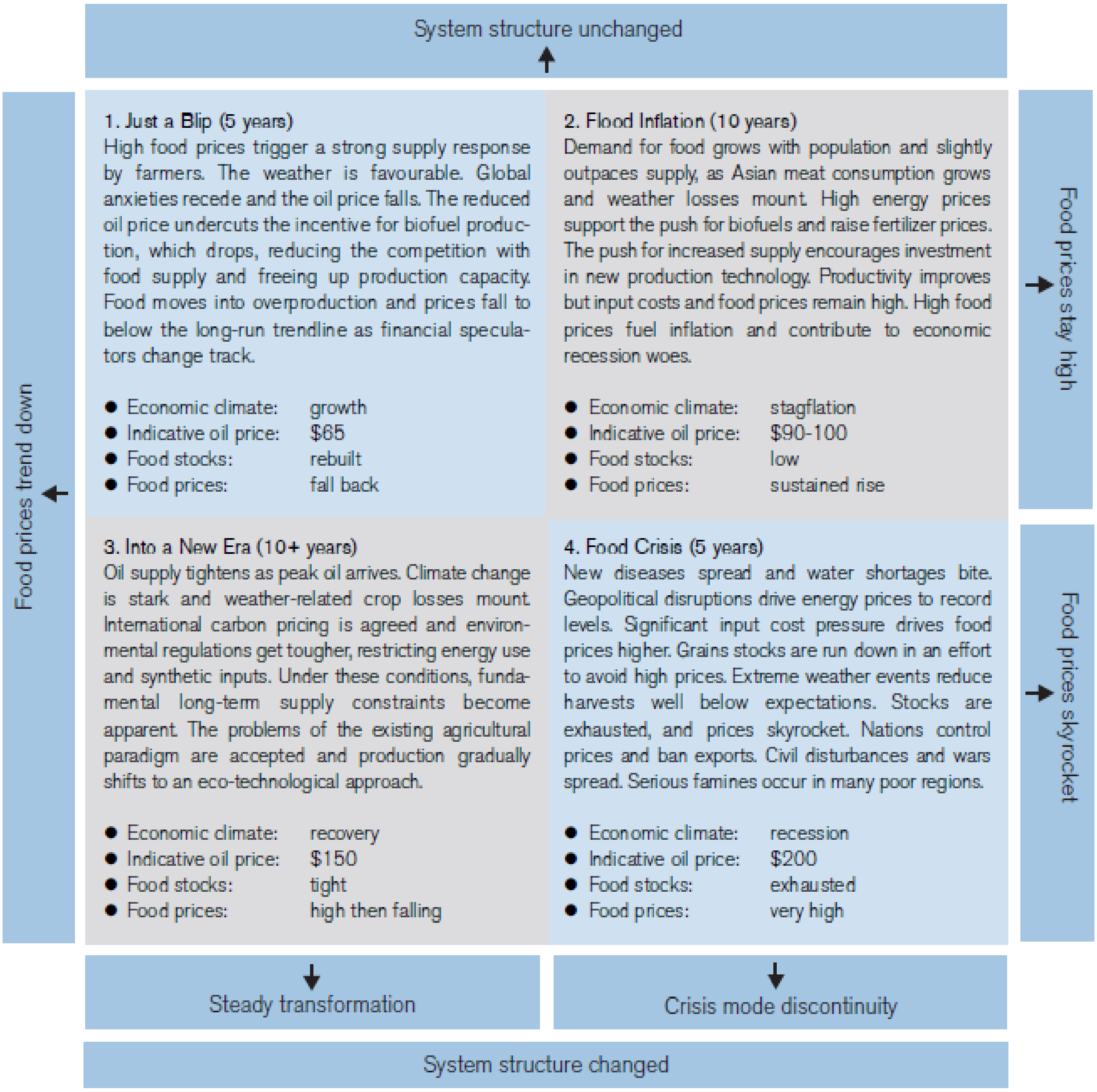
APPENDICES

Appendix A – Food Future Scenarios



(Ambler-Edwards et al. 2009, 19)

Appendix B –Farmer Questionnaire

Future Farm Stresses in the Welsh Marches

1. Which county is your farm situated in? (*Please tick one only*)

a. Shropshire ☐
b. Worcestershire ☐
c. Herefordshire ☐
d. Gloucestershire ☐
e. Other Midlands ☐
f. Other England or Wales ☐

2. Farm type (*Please tick one only*)

a. Uplands grazing livestock ☐
b. Lowlands grazing livestock ☐
c. General cropping ☐
d. Cereals ☐
e. Mixed ☐
f. Horticulture ☐
g. Dairy ☐
h. Specialist pigs ☐
i. Specialist poultry ☐
j. Other *please specify:*

3. How long have you been on your present farm? (*Please tick one only*)

a. <10 years ☐
b. 10-19 years ☐
c. 20-29 years ☐
d. >30 years ☐

4. What is your main concern over the future of farming on your land? (*Please tick one only*)

a. Environmental pressures ☐
b. Financial stress ☐
c. Increases in extreme weather ☐
d. Market fluctuations ☐
e. Disease outbreaks ☐
f. Other ☐

5. How do you keep track of the weather conditions? (*Tick as many as appropriate*)

a. Daily weather forecasts ☐
b. Weekly weather forecasts ☐
c. Online weather forecasts ☐
d. Own weather station ☐
e. Own weather diary ☐
f. Own judgement/ looking outside ☐
g. Other *please specify* ....

6. Have you ever suffered a significant loss on your farm due to extreme weather? (*Please tick one*

a. Yes ☐
b. No ☐

If yes please provide more details...

Name:

Address:

Email:

Phone:

I am happy to be contacted to participate in a: Interview ☐ Workshop ☐

I agree for this information to be used for academic research purposes

Signed: Date:

Appendix C - Project Information Leaflet

Future Farm Stresses in the Welsh Marches

University of Worcester

What is the research project?	The research aims to explore past, present & future challenges facing farmers in: Shropshire, Worcestershire and Herefordshire.
Why do you want participants?	The project aims to let local farmers discuss key challenges to their farm in the past, and voice concerns for the future.
Who can participate?	Any farmer in Worcestershire, Herefordshire or Shropshire, that has been farming on their land for longer than 5 years.
What does it involve?	Either a 45-60 minute conversation/ interview with Rebecca, or attend a small evening farmers' focus group or just comment on how potential scenarios may affect you.
What will happen with the results?	The results will be analysed confidentially. The outputs will be presented at agricultural and academic conferences, and published in newspapers and academic journals.

If you wish to participate or have any further questions please contact:

Rebecca Griffiths Rebecca.griffiths@worc.ac.uk 01905 855416

Institute for Science and the Environment, University of Worcester,

Worcester WR2 6AJ.

Appendix D – Letter to Participants

Rebecca Griffiths
University of Worcester
Henwick Grove
Worcester
WR2 6AJ
01905 855416

Rebecca.griffiths@worc.ac.uk
18th July 2013

Dear Sir/Madam,

Re: Understanding Your Concerns over Weather Stresses on Your Farm

I am writing to request your help with a research project looking at local impacts of increasing weather stresses across Shropshire, Herefordshire and Worcestershire (and surrounding areas).

You kindly participated in a research questionnaire at either the Royal Three Counties Agricultural Show or The Shropshire Agricultural Show in the last couple of months and consented to being contacted to participate further in this research project. As we discussed on the day, the second phase of research involves conducting informal interviews/discussions with local farmers. The interview will last no longer than 1 hour (usually 45 minutes), and is designed to provide a platform in which you can express your past and present experiences with highly variable and challenging weather conditions, as well as any concerns you may have regarding the likely weather conditions in the future.

The research is being conducted as part of a three year PhD research project at the University of Worcester; therefore the study is entirely independent. The aim is to try and provide an insight into the challenges that farmers in the local area are presently facing. For more information on the project see the attached leaflet or please do not hesitate to contact myself or project supervisor Professor Nick Evans.

I will aim to contact you in due course to arrange a time for an interview that is most convenient to you, however it is anticipated that most interviews are likely to take place from September to November at a location most convenient for yourself – usually on your farm. If you have a preferred date or time then please get in touch as interviews can also be held before this time if necessary.

Your participation in this research will be greatly appreciated as it is important to get a range of views and experiences.

Yours faithfully,

R. Griffiths

Rebecca Griffiths

Appendix E - Interview schedule [38]

Past, Present & Future Weather Stresses: Interview Schedule

Participant (incld. Number)

Location

Time & Date

Researcher Topics Checklist:

1. Farm background
2. Present conditions
3. Past weather events
4. Knowledge of the weather
5. Future weather conditions
6. Climate change

1. Farm Background

So let's start by talking a little bit about your farm,

1.1 How long have you been here, how many acres of land do you have and what enterprises is your main focus? *Diversification, farm sector*

1.2 Can I ask what your land tenure is? *farm tenant, larger farm network*

1.3 Besides yourself who else works on the farm? *Farm hands*

[38] *N.B. questions were adapted to the conversation with each participant, therefore were used and worded as appropriate. Questions in bold were seen as essential and therefore were asked in each interview. Questions underlined were seen as important and therefore the information was obtained throughout the interview but not necessarily through asking a direct question. Questions in italics and plain text were used as prompts where necessary to guide the conversation.*

1.4 Are you the main decision-maker? Do you have any assistance in making farm decisions? *Motivations to farm*

1.5 Thinking about the local community, do you cooperate with/help other local farmers & neighbours, would you be able to go to others nearby for help if you needed it?

2. Present Conditions

2.1 What has been your experiences of the weather over the last 18 months? *How impacted, what has been the most challenging thing about the weather to your farm activities/decision making, and what has been the most beneficial weather condition to you.*

2.2 Which type of event presents the highest risk to your farm at the present? Why?
E.g. heatwave, drought, flooding, heavy snowfall, frost, intense rainfall, wind, storms, lack of sunshine.

2.3 How do you manage this risk?

3. Past Weather

3.1 **What has been your most significant challenge due to the weather since you have been farming your land?** *Would you call this a 'significant loss'? When, what, actions taken*

3.2 How would you say you have been able to recover from this event? Have you had any assistance in the recovery process – from who / how? *How long*

3.3 **Have you made any changes to your farm system to better cope with extreme conditions again?** *Adjustments to events, adaptations*
3.6a Why did you decide to make these changes?
3.6b Do you now consider yourself to be more or less at risk?
3.6c Do you consider other options open to you to adjust in the future?

4. Future Weather Conditions

4.1 So thinking about the future, what are your plans for the future in terms of your business? *Retirement succession, diversification.*

4.2 Would you say you are more or less likely to better recover from extreme weather events in the future than ones you experienced in the past? Why?

5. *Knowledge of the Weather*

5.1 What is your main source of information with regards to the weather? *Is it reliable? Do you make judgments based on this information? Word of mouth, looking outside, weather records, knowledge of others.*

5.2 How often do you read the local paper? *Is it trustworthy? What sort of information do you look at/obtain from this, are you more or less likely to read a paper during an extreme weather event?*

5.3 So here I have 3 different news articles from weather events in the past 15 years, how do think the reporting has represented the events? (Hot,cold,wet)

5.3a How do you think the challenges to farming are presented?

5.3b Do you think the reporting is trustworthy?

5.3c Does it coincide with your memories of the time?

5.3. d How do you think it presents the challenges/seriousness of the event?

6. *Climate Change*

6.1 Do you think weather conditions have changed in any way since you've been farming?

6.2What do you think of climate change?

6.2a Opinion

6.2b Sources of information – media / social network

6.2c Clarity of information – level of understanding

6.2d Potential impacts foreseen (general)

6.2e Potential local impacts

6.2f Is it a concern for the future? (Do they think their system is vulnerable or resilient?)

6.2g What would be the impact on your system if it was warmer with increased rainfall?

6.3 <u>Climate change is predicted to make extreme weather events become both more frequent and intense how do you think this will affect you?</u>

6.4 <u>Do you feel as though it is necessary to respond to climatic changes in view of information about climate change?</u>
Potential changes to be made
Adjustments already made / planned - why

6.5 Do you think your experiences of extreme weather events, and difficult farming conditions in the past have well equipped you to tackle issues in the future?

Well that's all the questions that I wanted to ask, is there anything else you would like to add? *Thank you.*

Appendix F- Participant Consent Form

University of Worcester

Future Farm Stresses in the Welsh Marches

Participant Consent Form

Thank you for showing an interest in this project. Please read all the information on this form carefully and the accompanying leaflet. Participation in this study is completely voluntary. If you decide to take part, you will be asked to sign this form and return it to Rebecca before the interview can start. Your participation and time given to this interview is extremely appreciated.

What are the aims of this project?

To establish how different farmers across Shropshire, Herefordshire and Worcestershire are directly and indirectly affected by changes in the weather, extreme weather events and long-term changes in the climate. The project aims to allow local farmers to discuss key challenges to their farm in relation to weather events in the past, and voice concerns for the future.

Potential Risks and discomfort

There are very limited foreseen risks involved in participation in this study. The discussion will be led by your experiences so there is a possibility of some subjects causing you a little distress. However as the project researcher I must consider your social and psychological wellbeing, and will put this first if you show signs of distress. If you do become distressed at any point please let me know immediately and the subject will be changed or the interview terminated.

Can I withdraw from this study?

You can change your mind and decide not to take part at any time. If you decide to withdraw from the study, you do not have to give any reason for your decision, and you will not be disadvantaged in any way.

Benefits

Participation in this research is entirely voluntary and no financial reward for participation can be given. However by taking part, you will help us to increase knowledge of the area being studied, and aid the development of the outcomes of this research project.

What does participating involve?

It involves a 45-60 minute interview or focus group with Rebecca. We will discuss your past experiences of the weather on your land, present farm pressures and your concerns for the future.

How will it be used?

The data collected from the interviews will be predominantly qualitative in nature (your thoughts and feelings) and will be compared to other views. This data will then be analysed, interpreted and be written up as part of a PhD thesis. The findings of this project may be published, but the information will not be linked to any specific person. Your anonymity is carefully guarded and I promise full confidentiality. A copy of the results may be given to you upon request.

Should you require further information please do not hesitate to discuss this further with Rebecca at your interview or contacting Rebecca afterwards by: **01905 855416, or rebecca.griffiths@worc.ac.uk.**

Alternatively contact: Professor Nick Evans Project Supervisor on 01905 855187 or

n.evans@worc.ac.uk.

Statement by participant

I have volunteered to take part in this project and agree to this interview to be recorded, for academic purposes only.

I have read and understood this form it. I agree to take part in the project: Future Farm Stresses in the Welsh Marches.

Signed (Participant): **Date**