

HOW CAN CHEESE BE MADE SUSTAINABLE? AN ACTOR- NETWORK ANALYSIS

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Abstract

The notions of eco-localism and sustainable intensification have emerged as approaches for sustainable food and sustainable agriculture in the sustainability literature. With regard to these two notions, a lot of the focus in the literature has been on the farm or the dairy but this study seeks to explore their applicability to the study of the production, distribution and consumption of cheese, moving beyond the farm gate. This study examines the discourses of sustainability within three different cheese actor-networks including the degree to which various discourses of sustainability are embedded in the actual practices and products produced. This interdisciplinary study also investigates the sustainability issues and potential solutions for achieving sustainability as well as providing a system development system that has a potential for making actor-network theory (ANT) more practical.

Cheese is thought to be notoriously unsustainable, as on average 10 litres of milk is needed to make just 1kg of hard cheese and there are concerns over the amounts of methane and other greenhouse gas emissions as well as environmental waste across the network. Cheese is important for sustaining rural livelihoods and important for employment, especially in the context of concerns over milk prices, falling farm incomes and reductions in dairy farming. Many dairy farmers are therefore looking to diversify and add value to their milk production, by turning to cheesemaking. The Specialist Cheesemakers Association (SCA) has recorded an increase in both enquiries from dairy farmers and new members joining (Specialist Cheese makers Association, 2015).

This study explores the adoption of two approaches that can combine as a set method to explore sustainability. These two approaches are Actor Network Theory (ANT) and the computer science system development methodology, i*. ANT is used in combination with i* to develop a methodological framework. This research applies this framework to eco-localist and sustainably intensified cheese networks from production to consumption, from farm-to-fork. A collection of semi-structured interviews, questionnaires and ethnographic observations were used to assemble information on sustainability challenges within milk production, cheesemaking, distribution and sales. This research produced a sustainability framework and determined that ‘sustainable

cheese' is not a fictitious agri-food but it is hard to achieve 'sustainability' as there is no finite end. The study also identified sustainability problems for eco-localist and sustainably intensive cheese actor-networks and explored potential ways to demonstrably improve the sustainability of cheese.

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Abbreviations

ANT – Actor-network Theory

CSA – Community Supported Agriculture

FSA – Food Standards Agency

SBSE – Search Based Software Engineering

SD – Strategic Dependency

SR – Strategic Rationale

SSM – Soft Systems Methodology

TDD – Test Driven Development

USP – Unique Selling Point

LCA – Life Cycle Assessment

ELU – EU Livestock Unit

1 Introduction

This thesis presents a slice of research undertaken on cheese actor-networks in the South of England. The study is concerned with the identification of sustainable cheese networks in England and the discovery of potential sustainability problems or challenges that arise along the different cheese actor-networks from farm to fork for specifically selected cheese actor-network case studies. This research draws on Actor-network Theory (ANT), makes use of a range of data collection techniques and methodologies and the integration of different styles from different academic areas which reflects the interdisciplinary nature of this research. The different academic areas that this research draws on is human geography and computer science. This introductory chapter has four aims, which are:

- to situate the research into wider debates surrounding food scarcity, sustainability and the milk crisis;
- to introduce the research question, aims and objectives of this study;
- to provide a discussion of interdisciplinary research; and
- to outline the structure of this thesis.

1.1. Introductory Story

Food matters to us all and it is argued that there is a need for affordable, accessible food through a resilient, reliable and sustainable food system (DEFRA, 2008). However the food system is also seen to face a series of major future challenges, including growing populations (World Bank, 2008; DEFRA, 2008), hunger and malnourishment (FAO, 2009), environmental impacts (Cabinet Office, 2008; Godfray *et al.*, 2010), food safety and traceability, and an increase in global commodity prices. Growing population is widely seen as a problem. Even though there has been an increase in food production over the last 50 years, there are still people who do not have access to enough food despite there being a significant decrease in the proportion who are hungry (World Bank, 2008; Godfray *et al.*, 2010). Whilst the rate of it is decelerating, world population is continuing to grow to a predicted 9 billion by 2050, where it is thought it will plateau (Evans, 2009; Godfray *et al.*, 2010). This deceleration of population growth is widely considered to be associated with increased wealth as there is thought to be a causal relationship running from improved living standards to lower fertility (National Research Council, 1986). Increased wealth, however, presents its own challenges for the food system, because it leads to higher consumption and demand for processed food, meat, dairy and fish due to higher purchasing power (Godfray *et al.*, 2010). High energy prices, poor harvests, use of biofuels and

export bans have all pushed up the price of food ,contributing to an increase in global food commodity prices (World Bank, 2008; DEFRA, 2008; Evans, 2009).

There are also specific challenges for the food producers themselves as there is a great pressure to reduce the effects of food production on the environment (Tilman *et al.*, 2001; Millenium Ecosystem Assessment, 2005), increased competition for land, energy and water and threats from climate change (IPCC, 2007; Schmidhuber and Tubiello, 2007; Godfray *et al.*, 2010). This research doesn't just look at producers but attempts to look beyond the farm gate by looking at environmental impacts as well, which poses major challenge to the food system as a whole as the food system is responsible for up to 29% of global greenhouse gas emissions (Vermeulen *et al.*, 2012).

Specific challenges for the food system in the UK include the dominance and power of globally sourcing supermarkets, decline in farm incomes and public health concerns over food safety (DEFRA, 2006). Supermarkets have a lot of control over their supply chains which means that fresh produce is coming from a diminishing number of smaller producers as the big supermarkets want large suppliers who can deliver the food in large quantities. This means that the smaller producers cannot compete and are squeezed out of the market (Booth and Coveney, 2015). Often the price supermarkets offer to the smaller producers is less than what they could get elsewhere in the market (Richards *et al.*, 2012). This relates to the decline in farm incomes as farmers seek the security of supermarket contracts, but for a lower price of product, instead of risking sales on the open market (Richards *et al.*, 2012; Booth and Coveney, 2015). Food safety scares such as large-scale food poisonings and disease outbreaks to livestock can have a huge impact on how certain types of food are perceived within the public health domain which is a threat to the UK food system. There is also a growing perception of the need for the food system to be more sustainable – economically, socially and environmentally (Cabinet Office, 2008). Bearing in mind the increased demand for dairy products, the research undertaken and analysed in this thesis has focused on cheese.

What we eat has direct and indirect impacts on our health, the environment, the climate and animal welfare (Hamerschlag, 2011), this includes our consumption of cheese. Cheese can be notoriously unsustainable, as on average ten litres of milk is needed to make just one kilogram of hard cheese (British Cheese Board, 2017). There are concerns over the amounts of methane, other greenhouse gas emissions and also environmental waste produced by actants along the food actor-network (Aguirre-Villegas *et al.*, 2011). Cheese is important for sustaining rural

livelihoods and employment, especially in the context of falling farm incomes and reductions in dairy farms. On average nine dairy farms a week were closing in 2015 and milk prices have fallen by 25% (Ruddick, 2015b). Therefore because of this crisis many dairy farmers are looking to diversify and add value to their milk often turning to cheesemaking. The Specialist Cheesemakers Association has recorded an increase in both enquiries from dairy farmers and new members joining the Association (Jones, 2015).

A closer look at the milk crisis in Britain reveals that at the end of 2015, the farm gate milk price that farmers were receiving for their milk had dropped to 23.71 pence per litre (DEFRA, 2016) and by June 2016 the farm gate milk price was as low as 19.89 pence per litre (DEFRA, 2017). However, it is estimated that it costs a dairy farmer between 30p and 32p to produce a litre of milk and the average retail price for a litre of milk is 58p (Ruddick, 2015a). The National Farmers' Union (NFU) argues that a supermarket price war has devalued milk in the eyes of the public (BBC, 2015). Other factors affecting the price of milk include the global supply of milk exceeding the global demand, a Russian ban on imports and less demand from China where imports fell by 20 percent between 2014 and 2015 (Smyth, 2016).

If you choose to eat cheese and other dairy products, as many of us do, choices can be made to eat less and to do so in a greener way, such as buying locally or products that have been made in a sustainable way or from a sustainable supplier. This is important to consider, as cheese does not need to be cut from our diets but if everyone who does eat cheese makes greener choices the consequences of choosing to do so can be lessened. As this research focuses on cheese actor-networks it considers how it is not just the consumer who has the responsibility to make sustainable food choices but also the farmer who is supplying the milk and the cheesemakers producing the cheese.

1.2. Research Question, Aims and Objectives

The main research question posed in this study is:

Can sustainably intensive or eco-localist approaches produce sustainable cheese?

The research question is formalised by the following three aims and their related objectives.

Aim 1: Identifying eco-localist and sustainably intensified cheese networks

Related objectives:

- 1.1. Identify cheesemakers in England with an interest in sustainability
- 1.2. Establish and create a criteria for sustainably intensified and eco-localist cheese
- 1.3. Identify sustainably intensive and eco-localist cheesemakers
- 1.4. Select case study cheese actor-networks

Aim 2: Understanding the dynamics of actor-networks

Related objectives:

- 2.1. Map the actor-networks
- 2.2. Explore the difference discourses of sustainability within the actor-networks and explore connections to notions of eco-localism and sustainable intensification.
- 2.3. Look at the interactions between the actants that link to sustainability

Aim 3: Problems and solutions in realising sustainability for cheese actor-networks

Related objectives:

- 3.1. Identify problems in the sustainable cheese networks
- 3.2. Establish and evaluate suitable solutions
- 3.3. Develop and critically assess a suitable system development methodology

A common theme through the aims and objectives is the issue of interdisciplinarity as is described in the following section which outlines the interdisciplinary character of this research and the possibilities and barriers that this created for myself, the researcher and the research being conducted.

1.3. Interdisciplinary Discussion

This research project is interdisciplinary, being set up as a project that would connect computer science and social science perspectives as developed within human geography. Brewer (1999: 328) defines interdisciplinarity as “the appropriate combination of knowledge from many different specialities - especially as a means to shed new light on an actual problem.” However Evans and Randalls (2008) insist that interdisciplinarity is notoriously difficult to define and difficult to put into practice. In the literature there are a range of terms that are associated with work across disciplines, most notably multidisciplinary and transdisciplinary. Stokols *et al.* (2008: 79) define multidisciplinary as “a sequential process whereby researchers in different disciplines work independently, each from his or her own discipline-specific perspective, with a goal of eventually combining efforts to address a common research problem.” Stokols *et al.* (2008: 79) also provide a useful definition of transdisciplinary, suggesting it is “an integrative process in which researchers work jointly to develop and use a shared conceptual framework that synthesizes and extends discipline-specific theories, concepts, methods, or all three to create new models and language to address a common research problem.” To distinguish between the three terms further, Klein (2010: 16) provides defining characteristics of the three terms. Interdisciplinary is “integrating”, “interacting”, “linking”, “focusing”, and “blending”, multidisciplinary is “juxtaposing”, “sequencing” and “coordinating”, and transdisciplinary is “transcending”, “transgressing” and “transforming”. This research is definitely interdisciplinary as I am drawing on two different discipline perspectives to address a common research problem. This is discussed in further detail below.

The project was set up to be interdisciplinary from the very early stages as the funding body, the EPSRC, provided a studentship for an interdisciplinary project that addresses issues relating to ‘Engineering systems requirements for sustainable food’. ‘Engineering systems requirements’ is a concept within computer science research (Easterbrook, 2007; Pohl, 2010; Hull *et al.*, 2010) and ‘sustainable food’ is often addressed through geographical research. I was attracted to the interdisciplinary aspect of this research as I am no stranger to interdisciplinary research, my Masters degree being in Environmental Informatics, a subject which combines geographical information science with sustainable natural resource management. This gave me the opportunity to gain skills from both areas and apply them in my Masters’ thesis which used 3D landscape visualisation to see possible adaptation strategies to climate change in Leicester City Centre.

The interdisciplinary aspect of this current research project is reflected by my supervisors, with one being from the field of Geography and the other Computer Science. Interdisciplinary research happens in both of these subject areas. Geography encompasses a wide range of interests which ideally places it for interdisciplinary research as well Geography's ability as a discipline to envelop space, place, time and scale. Computer Science also has many interdisciplinary opportunities as computer based techniques are becoming more prevalent across a range of disciplines. Computing is becoming more and more relevant, therefore people in other disciplines are looking to computer science to address new problems. In my time at the University of Leicester, the Computer Science Department has become an Informatics Department, with the new name said to reflect an increasing focus on interdisciplinary and applied research within computer science. The interdisciplinary subject of bioinformatics, for example, has emerged as the use of computers in molecular and microbiology worlds has now become essential for laboratory research (Gardy and Brinkman, 2003).

Geographical studies using spatial analytical methods, geographic information systems (GIS) and remotely sensed data has increased significantly and signals both a heightened use of computers and an applied focus involving interdisciplinary research approaches (e.g. Gunasekera, 2004). These foci are some of the ways of combining geographical and computer science research, however this research takes a different approach. This research applies a system development methodology that is usually used to structure, plan, and control the process of developing an information system for a computer for example, but this research applies a system development methodology to a real world system. More information about this approach can be found in Chapter 3.

It is important to note at this stage that this research considers both human geography and computer science perspectives and attempts to merge the two disciplines and findings in the discussion. However, this research was not and did not set out to weigh the content of these two disciplines equally, in part because I have a geographical background. Due to this, my research has leaned more towards geographical content rather than computer science, in part because I have sought to play to my strengths. The intention of the research has been to explore how computer science may make contributions to human geography and also consider how human geography may assist in the conduct of computer science studies of sustainability.

It is widely argued that there is a need for interdisciplinary research because problems that need addressing often lie beyond the margins of a single or existing discipline, being parts of

something much bigger (Baerwald, 2010). However interdisciplinary research can be complex, with a sense of challenges often being identified, linked to:

- The presence of literatures that appear very different. It certainly proved a challenge to engage with two completely different disciplinary literatures, being both time consuming and difficult when switching from reading one set of literature to another.
- Each discipline has very different methods and different approaches to the research. For example, a system development methodology in computer science would normally be evaluated with a test whereas in human geography the methodology wouldn't necessarily need to be evaluated. Brewer (1999) discusses the obstacles faced whilst undertaking interdisciplinary research and identifies different methods and operational objectives as one of the common obstacles.
- The languages used within disciplines can vary immensely, and as Brewer (1999) notes, this forms one of the commonest obstacles to the conduct of interdisciplinary research. In the case of my research, computer science has a very scientific language whereas human geography language is much more akin to that of the social sciences. There was therefore a lack of a common vocabulary, even when writing about issues that had clear parallels. In this thesis, for instance, I will explore the parallels between actor-network theory, which has been widely used within human geography (Winter, 2003a; Marsden, 2000; Murdoch *et al.*, 2000; Müller, 2015a), and the i* system development methodology. Whilst having many parallels, different terms are given great emphasis: for example, ANT makes extensive use of the term actant whereas i* tends to employ the term actor. As will be outlined in Chapter 2 and 3, the use of different terms can obscure both similarities and important differences.
- Each discipline has a separate writing style that had to be considered when writing the different sections. Computer science writing is scientific and of a terse nature whereas human geography is a social science style and more often than not is written in the first person. Whereas, a scientific style would not be written in the first person in usual circumstances and is invariably more abstract. Both styles were adopted for this thesis depending on the section that was being written. In sections where the two disciplines came together, the style which was used was chosen on which read best for the topic being addressed.
- A sense of not belonging to either discipline: Brewer (1999) identified that this is a further barrier to interdisciplinary research as it creates highly personal challenges

related to the gaining of respect from others working in different disciplines or fields. In my case, I certainly felt during my first year as a PhD student that I did not fit in with either department. I was registered in the Computer Science Department but felt like an imposter. I felt like an imposter because even though I had studied elements of Computer Science in the past I felt like my knowledge of Computer Science wasn't in depth enough to adopt the expected methods and also to understand the language that was used around me on a daily basis. This lack of knowledge and understanding made me feel inferior to my peers. I also had a desk in the Geography Department, where I felt 'more at home', but also felt like I was in the way. The feeling of being an imposter is linked to the obstacle Brewer (1999) identified, the personal challenge of gaining respect from others working in different disciplines or fields.

To overcome such barriers to interdisciplinary research, Bracken and Oughton (2006: 373) have suggested that there should be "longer start-up phases of projects to promote cohesion and to learn to value contributions from other disciplines, to develop projects which satisfy complex societal problems, as well as the need for effective and experienced management of interdisciplinary teams, the need for flexibility of researchers involved in conducting the research, and the need to understand the ways of thought and language of others." From the points that Bracken and Oughton (2006) mention in the above quote, I identify with the suggestion of longer start-up phases of projects to promote cohesion. As during the first year of my PhD I was attending lectures in both computer science and the social sciences so that I was able to value contributions from both disciplines and they were able to shape my research. I realised that, as Bracken and Oughton (2006) suggested, I would need to be a flexible researcher, and although it took time, I became able to understand the ways of thought and language of computer science to a certain extent. However, my experience does not really connect to Bracken and Oughton (2006) arguments concerning effective and experienced management of interdisciplinary teams. Whilst interdisciplinary research is often undertaken by teams of researchers drawn from a range of different disciplines who can bring different strengths to the project, an interdisciplinary PhD doesn't involve teams of people and is principally a solitary endeavour. The solitude of a PhD can escalate some of the problems associated with interdisciplinary work that have already been mentioned above because there is not a team of people within whom you can bounce ideas off and ask questions of. On the other hand, there is a supervisory team when undertaking a PhD and supervisors are great for asking questions of and bouncing ideas off. In some respects a PhD can be viewed as an ideal opportunity to undertake interdisciplinary research as it involves an extended period of time

undertaking research, which allows for extended engagement with two separate disciplines and continued working to integrate the two within research.

Despite the problems associated with interdisciplinary research there are also many benefits. This includes the foray into a richer depth of literature and a gaining of knowledge across the different disciplines which would not have been achieved if not interdisciplinary. This interdisciplinary research has also expanded my skills base and understanding of different disciplines. Interdisciplinarity is a key aspect of this research and is therefore discussed throughout the thesis. Some chapters have an interdisciplinary reflection at the end where the matters that have arisen in that chapter are discussed in more detail.

1.4. Overview of thesis

This chapter (being Chapter 1), has started to highlight the concerns which led to this research being conducted, has outlined the research question, the thesis aims and the objectives, and a discussion of interdisciplinarity character, as well as providing a chapter by chapter overview of the thesis content.

Chapter 2 is a literature review that investigates and explores some of the work relevant to this research. To start, a brief history of food geographies is outlined, followed by discussion of sustainability origins and engagements and then how sustainability and food have been linked. Then, two specific sustainable food transitions are explored, being sustainable intensification and eco-localism; and a theoretical framework of actor-network theory is proposed.

Chapter 3 is a methodological chapter. It is laid out according to the aims of this research, with the methods corresponding to each aim and objective being discussed. The methods outlined include interviews, questionnaires, ethnographic techniques and the development of a system development methodology. Near the end of this chapter is a summary table of aims, objectives and the methods used.

The next three chapters are analysis chapters that have again been arranged by aims. For example Chapter 4 corresponds to the findings and analysis associated with the thesis' first aim, Chapter 5 corresponds to aim 2, and Chapter 6 to aim 3.

Chapter 4 identifies sustainable cheesemakers in England. This chapter provides a map of the locations of cheesemakers who have a potential interest in sustainability in England and then shows the results from a questionnaire that was distributed to these cheesemakers to ascertain if their interest in sustainability meant they fulfilled the criteria for being a sustainable intensive cheesemaker or an eco-localist cheesemaker.

Chapter 5 investigates the dynamics of the cheese actor-networks (actor-network theory is explained in chapter 2) and actor-network diagrams have been composed to help visualise the cheese networks and these diagrams can be found in this chapter. Chapter 5 also examines the different discourses of sustainability within the networks.

Chapter 6 outlays the problems that affect the sustainability of the cheese networks. The problems are discussed for each case study and from different viewpoints and actors in the network. Possible solutions to these problems are also discussed. The latter half of chapter 6 discusses the use of a 'system development methodology' (the meaning of which is outlined in chapter 3) that can be used alongside actor-network theory as a way of making the theory more practical and its applicability for defining sustainability problems. A methodological framework is produced that works as a step by step process for assessing the sustainability of a network.

Chapter 7 is the conclusion chapter, and draws on what all the other chapters have discussed. It summarises the main findings and the lessons they provide for sustainability of cheese. This chapter returns to the research aims and objectives and considers how they have been addressed. This thesis ends with a consideration of the limitations of the study and a direction for further work.

1.5. Contribution

This thesis addresses the gaps in the literature which will be displayed throughout the next chapter, namely the concepts sustainable intensification and eco-localism are rarely applied to the food system from farm to fork. However, the most substantive contribution of this thesis is to develop a methodological framework that has potential to produce more formal definitions of sustainable cheese. This is by using the novel two-phased approach that combines actor-network theory widely used within Geography, to map human and non-human cheese actor networks for three different sustainable cheese producers, including associated sustainability discourses. The second phase is to apply a Requirements Engineering approach from Software

Engineering (i*) to refine and enhance the actor network maps. This is showcased in the later chapters.

1.6. Chapter Summary

This chapter has presented an outline of the work that is addressed in this thesis. It has situated the research in wider debates, and it has shaped the aims and objectives of the study and provided a chapter by chapter summary. The next chapter presents an in-depth literature review on the themes important for this research in order to set the scene and give a background to the work as well as to provide a justification for the study.

2 Literature Review

This research is a food sustainability study and, as mentioned in the Introduction in Chapter 1, it is interested in the whole network from farm to fork and specifically in the sustainability of cheese. As reported in the Introduction, the milk crisis has resulted in farmers diversifying and turning to cheesemaking to add value to their milk. This research looks at the intricacies of the cheese actor-networks and the sustainability problems and solutions that are found along the way. The first section of this literature review explores how geographers study food and how geographers' approaches to food have changed and developed over time. The second section of this literature review explores some notions of sustainability, food sustainability and then the sustainability of cheese specifically. The final part will attempt to provide an ontology for exploring problems and solutions for sustainable cheese.

2.1. Geographies of Food

Early geographical studies of food tended to approach it from the production angle - viewing food as one of the products of agriculture - and focus on the spaces in which it was being produced (i.e. the rural). As Woods (2009) notes, food production has been a core interest of rural geographers for a long time. In the late 1980s, for example, Bowler and Ilbery (1987: 327) were highlighting the significance of food within the literature of agricultural geography, although suggesting that existing studies of agricultural geography paid insufficient attention to how agricultural production was connected into "the larger food supply system". They argued that agricultural geography should indeed be re-defined to place it into the concept of a 'food supply system', where attention is paid not simply to how food is produced within agricultural spaces and businesses, but also to "the further processing, distribution and marketing of agricultural produce" (ibid.: 33). They also suggested that attention needed to be paid to how agriculture connects to wider society, in both rural and urban areas through, for instance, land use and environmental transformation and through labour markets. A third area of change they identified was to extend the theoretical base to consider perspectives, such as the political economy and rural sociology (e.g. Buttel and Newby, 1980; Lowe and Rüdiger, 1986; Marsden *et al.*, 1986). This latter suggestion did indeed come to fruition (Marsden *et al.*, 1990; Murdoch, 1994; e.g. Marsden *et al.*, 1996). Atkins (1988), whilst agreeing with Bowler and Ilbery (1987) that there was a need to redefine agricultural geography to establish a more coherent view of the sub-discipline and to emphasise the links between agriculture and the wider society and economy, suggested that they did not go far enough and that there should be a metamorphosis of agricultural geography into a geography of food. Atkins (1988) suggests this should be done

along the following lines. Firstly, that the exploration of food systems needed to encompass the Global South which he viewed was being largely omitted from discussion of the agricultural geography literature. Secondly, he argued that there was a need to recognise the role of food systems in processes of historical development. Thirdly, he promoted the idea that geographers needed to pay attention to the consumption of food and its role in diet and nutrition. Atkins (1988) not only redefined agricultural geography, but rather replaced it with a new geography, 'the geography of food': "Agricultural geography is dead: long live the geography of food!" he declared (ibid.: 272).

The concept of food systems and networks that emerged in this discussion of the redefinition of agricultural geography was not necessarily a new idea, with Atkins and Bowler (2001) arguing that food systems have been cited in the literature going back 150 years, including George Dodd's study (1856 as cited in Atkins and Bowler, 2001), which reconstructed the food supply of a particular city and considered the whole food system. The concept of food systems and networks that has emerged from the discussion of the redefinition of agricultural geography is relevant to this research, as this work is interested in the whole network, from farm to fork. This is because there are many actants along a food network who have agency and responsibilities for addressing sustainability issues. Sustainability cannot be achieved individually but instead requires every actant along the network to address it (Lowe *et al.*, 2006).

Winter (2003a) notes that the geography of agriculture was where food was discussed but was largely seen only as a raw commodity. A raw commodity is a product that can be bought or sold, with agricultural producers encouraged to produce raw food commodities at volume regardless of whether the market requires it or not. However this is not universally the case, as quite often it is seen as specific to capitalist/productivist agriculture (Wallis, 2010). Winter (2003a) does recognise that the geography of agriculture is not the only area of geography to mention food, there being another area of geography where food made a repeated appearance, namely in retail geography. Examples in the literature of food being mentioned in retail geography include Wrigley (1994), where the shift in competitive conditions in UK food retailing market is explored, and Wrigley (1998) which looked at the contrasting interpretations of the UK food store development process. Winter (2003a) stresses that the turn to food chain and consumption research was not just a fashion or a conceptual shift but was also reflective of "political and policy realities arising out of the shift from a homogenous agricultural commodity market to a more segmented market" (Winter, 2003a: 506). The shift towards food systems and consumption issues not only considers all the actants in the food chain who have agency but

according to Winter (2003a) also allows for reconnections and new connections to be made between elements within a food system that may have become separate or not thought of alongside each other. For example, when thinking of food systems, the following elements can be thought of as connecting or reconnecting: farming and food; food and politics; food and nature; and farmers and agency.

Winter (2003a) adds that the establishment of political economy approaches in both agricultural and retail geographies facilitated the emergence of an 'agro-food geography' (Winter, 2003a), where the focus was taken away from the farm and the shop as distinct entities and towards connections that connected these two sets of sites. According to Atkins and Bowler (2001: 22), for example, the political economy approach allows for the interpretation of national and global food systems and "provides a theoretically informed structuralist perspective on global tendencies with 'economy' understood as 'social economy'". They further suggest that when a political economy approach is used in agro-food studies, it allows for the analysis to go beyond the farm gate (Atkins and Bowler, 2001). Going beyond the farm gate allows for farming to be placed in the wider systems of food production, processing and supply (Lockie and Kitto, 2000).

Woods (2009) comments how rural geographers have gone in two directions with regards to food research whilst developing their horizons beyond agriculture to the larger agri-food system. From reviewing the literature it is apparent that 'beyond the farm gate' can be understood in two ways, namely horizontally and vertically. One way rural geographers have gone in a way of exploring the agri-food system is to trace agri-food commodity chains, which connects with perspectives in economic geography (e.g. Jackson *et al.*, 2006; Marsden, 2007). Horizontally, as Woods (2009) refers to this view of study, the phrase can be viewed as following the commodities as they move from the point of production in the farm along 'commodity chains' towards sites of retailing via distribution networks and onto consumption in the home and other locations, and indeed also beyond, in sites of the disposal of food waste (e.g. Buck *et al.*, 1997; Lockie and Kitto, 2000; Sims, 2010).

The other way that rural geographers have approached the wider agri-food system is to connect food production with consumption and to explore changing attitudes and practices of the consumers (e.g. Holloway *et al.*, 2007; Clarke *et al.*, 2008). This is in line with perspectives found in cultural geography (Woods, 2009). Thinking of beyond the gate vertically involves considering the social and economic embedding of the farm, linking the farm to national government policies, the operation of supermarkets (e.g. Dolan and Humphrey, 2000; Burch and Lawrence,

2005), how consumers behave (e.g. Wootton and Power, 1993; Verbeke *et al.*, 2007), and also linking the farm to global relations such as the flows of capital, trade and labour (e.g. Marsden and Arce, 1995). The advantages of thinking in terms of commodity chains according to Fine *et al.* (1996) include that it provides an interdisciplinary approach to food studies. Often food studies are only undertaken by researchers from a single discipline which according to Fine *et al.* (1996) can mean that the whole picture is not always seen. By contrast, they suggest, commodity chains are used by varying disciplines and give a fuller picture. Commodity chain research traces commodity flows to investigate the relationship between the raw material provider and the consumption (Atkins and Bowler, 2001). However, there are criticisms of commodity chain research. Leslie and Reimer (1999), for example, argued that analysis at the global scale allows for nodes in the chain to be forgotten and the approach completely ignores the role of human agency in the chain.

In the 1990s there was a cultural turn in geography and the broader social sciences which encouraged, along other developments, the employment of qualitative methods such as ethnographic techniques to collect data (Bell and Valentine, 1997) which allowed for food networks, systems and chains to be considered in more depth. Ethnographic techniques allowed for food systems to be considered in more depth because observations allowed for the study and following of the food. A method with increased access to research participants and elements of the system was created (Miller and Deutsch, 2009). An alternative system of food provision or alternative food networks (AFNs) literature has emerged from the geography of food (Goodman *et al.*, 2012; Le Velly and Dufeu, 2016; Watts *et al.*, 2005) focused on an area of this food chain research. This more in-depth vision into food systems also allowed for the important input from Actor-network Theory, or ANT as it commonly referred to, within the food networks literature. ANT has been adopted by many food systems writers (e.g. Whatmore and Thorne, 1997; Goodman, 1999). Goodman (1999) highlighted in his paper that Actor-network Theory (ANT) could be used as a way to move beyond political economy because he believes that in food networks, ANT can show more clearly how the natural and social actants are interwoven together.

The use of ANT within food systems research addresses the criticism made by Leslie and Reimer (1999) of commodity chains (mentioned in the previous paragraph) as ANT assigns agency to human and non-human actors and therefore the role of agency is not ignored. More on ANT can be found in the Cheese Actor-networks section later in this chapter. This study considers both the horizontal and vertical aspects of beyond the farm gate. The horizontal aspects are

considered as the whole actor-network is being considered from farm to fork, the milk and then the cheese are followed throughout the network, from the point of production at the farm to the consumers who are eating the cheese. This research considers the vertical aspect of going beyond the farm gate, as when mapping the networks and considering the problems they are linked to government policies, the operation and control of supermarkets and consumer behaviour. How this was done is discussed in the Methodology Chapter (Chapter 3). The adoption of both the horizontal and vertical aspects of food systems research with ANT will allow for the bigger picture to be seen with the consideration of the agency of both human and non-human actors.

Consumption according to Goodman and DuPuis (2002) has arrived in agro-food studies as a theoretical category since the 1980s. Consumption seems to be at the forefront of food geographies literature and there appears to be an increasing literature on consumerism (e.g. Coles and Crang, 2011; Jackson, 2010; Eckhardt *et al.*, 2010; Gilg *et al.*, 2005). This increase may be reflective of celebrity chefs on multiple cookery shows throughout television listings and cookery books featuring in the bestseller lists. There are also the links that have been made between food and health (Atkins and Bowler, 2002), with people becoming more aware about where their food comes from and wanting to know more (e.g. Harper and Makatouni, 2002). There are also links between food and environmental concerns (Magnusson *et al.*, 2003). Both Magnusson *et al.* (2003) and Grankvist and Biel (2001) found a strong correlation between the purchase frequency of eco-labelled foods and the perceived importance of environmental consequences as a criteria for purchase. In more recent years, campaigns by celebrity chefs, such as *Hugh's War on Waste*, have also gone a long way in making the general public more interested and more aware of the food they eat. This has led to more people being interested in, and wanting to be able to source sustainable food.

This Geographies of Food section has provided a journey through the literature of food studies in geography. Early geographical studies were centred on the production angle and the rural. The late 1980s led to the bold account from Bowler and Ilbery (1987) that food was not connected to the larger food system or wider society within the agricultural literature even though food itself had gained prominence. This led Atkins (1988) to suggest a new 'geography of food' that looked at the larger food system and food's impact on wider society. This introduction of the 'geography of food' promoted the emergence of food systems and networks research, which allowed for venturing beyond the farm gate. This research endeavour meant that networks could be considered from farm to fork, encompassing production, manufacturing,

distribution, retailing and consumption, along with links to governmental policy and consumer interest. This research is interested in the whole cheese network as many actors across the food system have agency and roles when sustainability is considered. Marsden (2006) stressed the need for the socio-ecological sphere of agriculture and food to be reinserted into broader sustainability debates. The next section therefore looks at the sustainability aspect of this research.

2.2. Sustainable Food

Food sustainability is thought to be part of a wider movement of sustainability and sustainable development. This next section gives ideas about sustainability, sustainable development and sustainable food.

2.2.1. Origins of Sustainability

The origins of sustainability have been considered in research since the 1980s when the concept was first introduced (e.g. Dixon and Fallon, 1989; Mitcham, 1995; Lumley and Armstrong, 2004). Mitcham (1995) describes sustainability as moving away from an imperfect past towards a perfect future, which is therefore a continuous overriding of the past. In the 1970s there was a debate around 'limits to growth', which was the name of a report published by *The Club of Rome*, suggesting that you cannot just compare the present to the past, the future also needs to be considered (Meadows *et al.*, 1972). Mitcham (1995) states in his paper that "by comparing the present only with the past and noticing how much better things are now than they were then, one fails to notice that in the near future things may well get worse - even worse than they were in the past." (Mitcham, 1995: 314). In the late 1980s there was a shift in discussion from 'limits to growth' to 'sustainable development'. Mitcham (1995) noted that it was a progression from what not to do, to what we should, or could do. The shift in discussion from 'limits to growth' to 'sustainable development' was instigated in the Brundtland Report (World Commission on Environment and Development, 1987). The term sustainable development became popular after the Brundtland Report and was identified as development that:

"meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987: 8)

This definition has been likened to the Kenyan proverb, “We do not inherit the earth from our parents, we borrow it from our children” (Pezzoli, 1997: 549). Put simply, sustainable development suggests that a more responsible development of the planet, people and profit needs to be considered (Kajikawa, 2008; Schoolman *et al.*, 2012; Hansmann *et al.*, 2012; Elkington, 1998). According to studies such as Lumley and Armstrong (2004) and Redclift (2005), there is a lot of ambiguity and contestation surrounding the term ‘sustainable development’, despite the term being regularly found in policy discourse and even in day to day language, ever since the publication of ‘Our Common Future’ (World Commission on Environment and Development, 1987).

Redclift (2005) and other studies (e.g. Place, 1995; Sachs, 1999) state that sustainable development is often construed as an oxymoron, the two terms being contradictory. Sustainability or sustainable, although widely contested as to what they mean (e.g. support, maintain, nourish), can have connotations to the environment and the idea of exploiting the natural resources without destroying the ecological balance (Lumley and Armstrong, 2004). Development, on the other hand is often viewed in terms of economic growth, which is often seen to rest on expanded exploitation of environmental resources. If the aim is continual economic growth, then this may be seen as being in contradiction, at least at some point, with the concern to set some bounds to exploitation of natural resources (Higgins, 2013).

Rittel and Webber (1973) and Peterson (2013) define sustainability as a ‘wicked problem’ because they claim it is a problem that cannot be solved but only managed. Sustainability is also viewed as a wicked problem because it is not a case of achieving sustainability, true or false, but rather better or worse, and stakeholders are continuously framing sustainability differently depending on what they have invested. It is due to the ubiquity of definitions of sustainability that different stakeholders have been able to frame it in different ways. Different discourses of sustainability have emerged, including, for example, social responsibility, environmental management or business sustainability. Everyone seems to agree that sustainability is important to achieve, however its nature and definition is often not explored in an explicit way (Giovannoni and Fabietti, 2013).

Although sustainability is widely seen as multi-faceted, it has quite often been viewed as crucially an environmental issue (Kidd, 1992; Giovannoni and Fabietti, 2013). According to the World Commission on Environment and Development (1987), for example, sustainability encompasses the protection of the environment and the provision of social and economic

welfare to both present and future generations. The environment is often the first thought and therefore some sustainability studies are thought of with the environment at the forefront. For example Boyd and Tucker (1998: 601) describe sustainable projects as “those that do not cause serious environmental and social impacts and do not deplete the resource base. Factors usually included in discussions of sustainable agriculture are land use, water use, energy consumption, feed utilization, environmental effects, and socioeconomic impacts.”. All the factors listed are environmental factors apart from ‘socioeconomic impacts’ that is listed as one factor together and not split up into separate factors. The two further aspects of sustainability mentioned in the World Commission on Environment and Development (1987) report, the social and economic, are indeed often viewed as fundamental dimensions of sustainability, often being conveyed as pillars of sustainability alongside the environment (e.g. Kahriman-Ozturk *et al.*, 2012; Dey, 2014; Duić *et al.*, 2015). The three pillars tend to be widely accepted but there are criticisms, mainly because stakeholders often favour the one pillar and there is not a balanced spread of focus across the three aspects (Hansmann *et al.* 2012). In the public planning discourse it is also widely accepted that there is a fourth pillar of sustainability; culture (Hawkes, 2001).

Kidd (1992) explains how there are six separate but related strains of thought that have emerged since the 1950s that now contribute to root concepts of sustainability. Those six roots of thought are the ecological/carrying capacity, resource/environment, the biosphere, the critique of technology, 'no growth-slow growth', and eco-development. Kidd (1992) stresses that these roots were used in discussions long before sustainability was defined, while Brown *et al.* (1987) looked at the areas where the term sustainability was first applied to. These areas were sustainable biological resource use, sustainable agriculture, carrying capacity, sustainable energy and sustainable development. Brown *et al.* (1987) question whether sustainability is merely a utopian ideal and how we would know if sustainability has been achieved. However, in more recent years there has been a significant amount of research into sustainability metrics (Sikdar, 2003; Shane and Graedel, 2000; Schwarz *et al.*, 2002; Martins *et al.*, 2007) and this goes some way to assess whether sustainability has been achieved. Sustainable development is also often thought of in shades of green for attitudes towards environmental management: deep green, shallow green and light green. Deep green is a very strong concept of sustainable development; eco-localist, eco-centric and a profound respect for nature. Shallow green is a strong to weak concept of sustainable development, and light green is a weak concept of sustainable development and is also techno-centric (Muir *et al.*, 2000).

In this section, the origins of sustainability have been explored. Sustainable development was a term that arose from the Brundtland Report in 1987, however, as discussed it is widely contested and ambiguous and the definition is often used to the advantage of the actor using it. Sustainability is frequently thought of as having three pillars. This research intends to adopt the economic, social and environmental dimensions of sustainability in accordance with the original definition of sustainable development mentioned in the Brundtland Report, which is widely accepted and, from which, more recent definitions of sustainability stem. The next section investigates the engagements of sustainability.

2.2.2. Engagements of Sustainability

The term sustainable development has been used and is used still by many different people including policy makers, politicians and environmentalists to suit their own agendas and ideologies (Mitcham, 1995; Pezzoli, 1997; Redclift, 2005). Mitcham (1995: 311) describes engagements with sustainability as “one of those ideals which, like love or patriotism, points towards something necessary and even noble, but can also readily become a cliché and be misused by ideologues.”.

There are different ways in which sustainability is theorised in the literature. There are some studies in the literature that think of sustainability as a discourse (Jamieson, 1998; Vallance *et al.*, 2012; Allen *et al.*, 2012). Weedon (1987: 108) describes a discourse as “ways of constituting knowledge, together with the social practices, forms of subjectivity and power relations which inhere in such knowledges and relations between them. Discourses are more than ways of thinking and producing meaning. They constitute the 'nature' of the body, unconscious and conscious mind and emotional life of the subjects they seek to govern.” There are some studies that see sustainability as something to be achieved by implementation. Goodman (2000) reports how Scandic Hotels were on the verge of financial collapse in the 1990s, but the implementation of sustainable development revived the business. The implementation of sustainability in agriculture features heavily in the literature (Lewandowski *et al.*, 1999; Fleury *et al.*, 2008). A post-structuralist critique of sustainable development is that it objectifies both people and nature and therefore, assumes that both are something that can be managed (Escobar, 1996; Castro, 2004). According to Castro (2004, pp. 220), “The main shortcoming of the mainstream approach to sustainable development is that it is driven by the rapid accumulation requirements of the capitalist economy, which means that it is about sustaining development rather than developing sustainability in the ecological sense.” Post-structuralists do not worry about

establishing particular definitions of sustainability but instead focus their attention on evaluating the consequences of it being thought about in different ways.

In another area of the sustainability literature, researchers are trying to make sustainability practical. Computer scientists have been moving into addressing and making sustainability more practical in recent years, through attempts to improve the understanding of how to tackle such issues of global importance as a transition towards more sustainable living in modern society with support of software-intensive systems (Mankoff *et al.*, 2008). Mankoff *et al.* (2008) believe that computer scientists have an important role in combating global climate change and creating a sustainable world. Ways that they identify computer scientists being able to fulfil this role include: reducing computational energy consumption by reducing processor cycles; tackling communication needs and architectural inefficiencies; hardware advances helping to save energy; smarter networking; more efficient data centres; and dealing with electronic waste. Software, however, has much more potential because software can change behaviours, for example, eBay has created a massive second hand market that has encouraged people to recycle their used belongings. Sustainability, and particularly food sustainability, is an emerging topic within Human-Computer Interaction (HCI) and ubiquitous computing (ubicomp) studies. Clear *et al.* (2013a), for example, state that there is a potential with digital technologies to substantially reduce the environmental impacts of food and there are many opportunities for HCI and ubicomp intervention to span across the whole food chain.

The term ubiquitous computing (ubicomp), was first introduced by Mark Weiser who was a Xerox PARC Chief Scientist (Friedewald and Raabe, 2011). Ubicomp, or pervasive computing as it is often also referred to, is the ability to enhance computer use by blending it into the physical world and social environments, such that it becomes essentially indiscernible to the user (Poslad, 2009; Weiser, 1993). Weiser first coined the term in 1998 when contemplating the use of desktop computers in everyday activities and the practicalities of it. He states that a recurring theme in anthropological studies of work life is that “people primarily work in a world of shared situations and unexamined technological skills” (Weiser, 1993, pp. 76). It was Weiser’s visions of computer use away from the desktop computer that spawned ubicomp (Friedewald and Raabe, 2011), as he felt that with a desktop computer the focus was too much on the computer instead of it being just a tool that we use (Weiser, 1993). Computers have become too much like ‘human assistants’ (Weiser, 1993). As well as pervasive computing, other terms that ubicomp is closely related to, if not identical in concept to, are ‘ambient intelligence’ and the ‘internet of

things', which are about helping people in the real-environment via technology that is integrated and discrete (Friedewald and Raabe, 2011).

To help understand ubicomp further, it may be important to define the term 'ubiquitous'. Poslad (2009) describes ubiquitous as appearing or existing anywhere. Therefore to think of this term in relation to computing, is simply to suggest that computers can appear or exist anywhere. Poslad (2009) again stresses the notion that ubicomp is to increase the availability of information and tasks everywhere to make things easier for the user, whilst appearing discrete to the user. Similarly, Gabriel *et al.* (2006), describes the goal of ubicomp as meeting the claim of "everything, always, everywhere" (Gabriel *et al.*, 2006, pp. 8). Friedewald and Raabe (2011) believe that ubicomp can have an influence across many different domains of life. These include individual homes, energy efficiency, road safety, personal assistants for offices, medical field and many more. Friedewald and Raabe (2011) also believe that because ubiquitous computing is generally through invisibly embedded objects, it therefore suggests that it is small intercommunication micro-processers and sensors.

A number of ubicomp technologies have attempted to address the food sustainability challenge. Several studies have focused on the consumer and the consumer's choices. Kalnikaite *et al.* (2011), for example, presented a functional lambent display that could be fitted to the front of a trolley when the consumer was doing their weekly shop. The display provided salient information about a product's food miles, the study showed that consumers were more likely to buy products that had fewer food miles due to a 'nudge effect' and that consumers felt guilty when their entire trolley's food miles was above average. Studies have not just focused on consumers in supermarkets but also the consumer at home, for example, considering computer augmentation of meal planning and cooking to reduce food waste (e.g. Aberg, 2009; Chamberlain and Griffiths, 2013). Chamberlain and Griffiths (2013a) describe a partially envisaged system that would allow people to locate locally grown food, create menus and recipes, and to understand the importance of local food culture, in a system called Tastebooks. Blevins and Morse (2009) describe several interactive techniques that could be employed to improve local food production and/or promote more sustainable land-use, including tracking food, garden sensors, online communities, grower management software, sister families, food exchange, organic and fair trade footprint calculators, food source monitoring, SimOrganicFarm, satellite images, time-lapsing images and GIS.

As already mentioned it is not just ubiquitous computing that can contribute to making things more sustainable. Software does not have to be embedded for it to address sustainability issues. For example, a business using solely electronic documents would not only be cutting down their cost on printed documents but would also be using a lot less paper and ink, and their carbon footprint would be smaller. This would be a more sustainable approach to their document practices. Requirements engineers are using system development methodologies to make systems more sustainable. The use of system development methodologies has been used to address food sustainability. Tavella *et al.* (2012), for instance, used the soft system development methodology devised by Peter Checkland (1993) to outline a suitable approach to designing and managing local food supply chains. However, they did not specifically refer to improving the sustainability of the food chain. Cabot *et al.* (2009) used the system development methodology, the i* framework, to improve the sustainability of a conference. More detailed information can be found on system development methodologies and the i* framework in Chapter 3.

This section has summarised some of the engagements that different actor/groups have with sustainability. The term sustainability and sustainable development are used for different purposes and is theorised differently in the literature. Computer scientists are exploring ways in which they can tackle sustainability problems. Many solutions are software related but the software does not have to be embedded. Another way computer scientists have started to address sustainability is to use system development methodologies to improve the sustainability of a real world system. This research is particularly interested in this approach and has applied the i* framework to a sustainable cheese network. Reasons on why the i* framework was used in this research can be found in Chapter 3.

2.2.3. Sustainability and Food

The growth in studies of food sustainability reflected increases in concerns over resource scarcity with regards to food, water and energy. The growth in food studies is also reflective of food security concerns. Godfray *et al.* (2010) believe an ever-increasing global population and climate change fears are contributing to these resource scarcity concerns for future generations. They predict that for the next forty years there will be an increased global demand for food because of increasing populations and consumption growth, with them, and other authors (e.g. Borlaug, 2002; Borlaug and Dowsnell, 2003; Ash *et al.*, 2010; Tomlinson, 2013; Godfray, 2014; Béné *et al.*, 2015), believing that the challenge is feeding 9 -10 billion people by 2050. They suggest that there are and will be many factors impacting global food supply including

competition for land, water and energy, as well as overexploitation of fisheries. Smith (2013) and Beddington (2011), however, suggest that food production is already unsustainable in many areas – rather than something that needs to be addressed in the future, unsustainable food is a problem that needs to be addressed now. They therefore feel something needs to be done; there is a need to be sustainable (Beddington, 2011; Smith, 2013).

The most concerning challenge that Godfray *et al.* (2010) believe affects food is food security. As already mentioned the expected world population by 2050 is 9-10 billion people and there is the distinct worry expressed in the literature that there will not be enough food to feed this many people (Borlaug, 2002; Borlaug and Dowsell, 2003; Ash *et al.*, 2010; Godfray *et al.*, 2010; Tomlinson, 2013; Godfray, 2014; Béné *et al.*, 2015). Godfray *et al.* (2010) and Beddington (2011) suggest ways of combating this need to feed 9-10 billion people, including closing the yield gap, reducing waste, changing diets to less meat and dairy intake, expanding aquaculture and increasing the production of potential crops. Other challenges affecting food found in the literature to date include: decreasing the climate impact of food production (Beddington, 2011; Smith, 2013); improving the resilience of food production to any future environmental change (Nelson *et al.*, 2009; Godfray *et al.*, 2010; Smith, 2013); being able to reduce the impact on ecosystem services of food (Beddington, 2011); being able to protect biodiversity and freshwater resources (Beddington, 2011; Smith, 2013); end hunger (Godfray *et al.*, 2010; Beddington, 2011); and moving towards more healthier diets (Beddington, 2011; Smith, 2013).

The growth in studies of food sustainability is not just purely linked to concerns over resource scarcity. Peterson (2013) describes how sustainability is now a product attribute that many consumers want or look for in their food, even though sustainability is not as popular as other attributes associated with food such as taste and freshness. Global food corporations, both large and small, have appointed sustainability officers, or someone in a similar role, to pursue enhanced sustainability, but it is still unclear as to how food sustainability is achieved (Peterson, 2013).

Pretty (1997) identified five schools of thought concerning potential approaches to agricultural development, as described below.

- 1) 'Business as usual optimists' are people who believe that there is no reason to worry about food scarcity as they believe there will always be enough supply to meet demand. They believe that the population trend of an increasing population will slow down while crop production will increase (Pretty, 1997).

- 2) 'Environmental pessimists' promote population control as the uttermost priority as they feel the environment has reached its ecological limits, or is soon likely too, and therefore will not be able to produce higher yields than it does already and some crops may even decline in production (Pretty, 1997).
- 3) 'Industrial world to the rescue' is a school of thought that the Third World is not advanced enough to ever feed themselves so needs saving by modern agriculture and industrialised countries (Pretty, 1997).
- 4) 'New modernists' believe that production on current land can be improved with improved technologies, including biological interventions such as pesticides and fertilisers, which they believe can increase yields without inducing any more pressures on the environment. It is a high input method and is also known as 'science based agriculture' (Pretty, 1997).
- 5) 'Sustainable intensification' is a final school of thought which claims that substantial growth is possible in current areas without impeding natural resources. It is argued that low-input agriculture can be highly productive.

Smith (2013) critiques Pretty's (1997) schools of thought, suggesting that sustainable intensification is not its own school of thought but instead, is a view that it is an enhanced form of the first school of thought, 'business as usual'. However, it can be argued that sustainable intensification does not constitute an extension of 'business as usual', because the first school of thought does not consider the exploitation of further resources and further land. Instead, it can be argued that sustainable intensification is closely linked to the fourth school of thought, the 'new modernists', because the emphasis is on increased yields. From Pretty's (1997) descriptions it is unclear as to how sustainable intensification differs from the fourth school of thought. They both focus on an increase in production without increasing any more pressure on the land and biological interventions such as more fertilisers and pesticides. This is discussed in more detail later. Pretty (1997) describes sustainable intensification as low input but this is not necessarily always the case for sustainable intensification. The idea of low input is often more regarded as an eco-localist approach. The characteristics of sustainable intensification are discussed in more detail in the next section.

Four out of five of Pretty's (1997) Schools of thought, have a focus on production (schools 1,3,4, and 5), this is similar to the conventional agri-food system identified by Morgan *et al.* (2006). The conventional system is seen as a system that is focused on a productivist approach, whereby large companies operate on a national and global scale, producing, processing and retailing. The

conventional system has long been thought of as one of the success stories, producing a cheap supply of accessible, affordable food, albeit primarily in the Western world, through focusing on quantity over quality (Morgan *et al.*, 2006). However, the environmental and health consequences of this productivist approach have been the focus of critical discussion in recent years and the so-called alternative approach has emerged, focused more on sustainable development instead of the mass production. The conventional system can be seen as being akin with four out of five of Pretty's (1997) school of thoughts, namely 'business as usual', 'industrial world to the rescue', 'new modernists' and 'sustainable intensification', although it has already been argued that these latter two may be viewed as synonymous.

Morgan *et al.* (2006) do not just mention the conventional food system, but make a distinction between two agri-food systems, even though they try to avoid making the binary oppositions of the 'conventional system' and the 'alternative system'. The alternative system is similar to Pretty's (1997) second school of thought. This research believes that Pretty's (1997) second school of thought can incorporate eco-localism. Eco-localism is often seen to propose the creation of self-reliant, local community economies (Curtis, 2003). Pretty's second school of thought, 'environmental pessimism', can be seen as closely linked to eco-localism although is not as pessimistic as Pretty (1997) makes the school of thought sound. Eco-localism is discussed in detail later on in this chapter. The alternative system is focused around a more ecological approach where smaller companies produce and sell products at a more localised scale (Morgan *et al.*, 2006), which can be seen as being akin with the new second school of thought, eco-localism, as proposed by this research. Schmitt *et al.* (2016) make a similar distinction but instead of using conventional and alternative they have used the contrast of global and local to compare cheese networks. Schmitt *et al.* (2016) argue that the global and local should not be seen as separate systems but rather as being on a continuum, a claim that resonates with the arguments of Morgan *et al.* (2006) who stress that there is not necessarily a clear cut distinction between the two approaches they identify, namely the conventional and the alternative. They give as an example how conventional supermarkets are both increasingly interested in local food and are the largest retailer of organic produce, despite local and organic food often being considered as elements of the alternative system (Morgan and Murdoch, 2000).

Although there are important differences between the arguments of Pretty (1997), Morgan *et al.* (2006) and Schmitt *et al.* (2016) they all point to similar differences in systems of food production, this research has created a diagram that clarifies how the different proposed ideas

fit together and shows the proposed schools of thought for this research. The diagram can be seen in Figure 2.1.

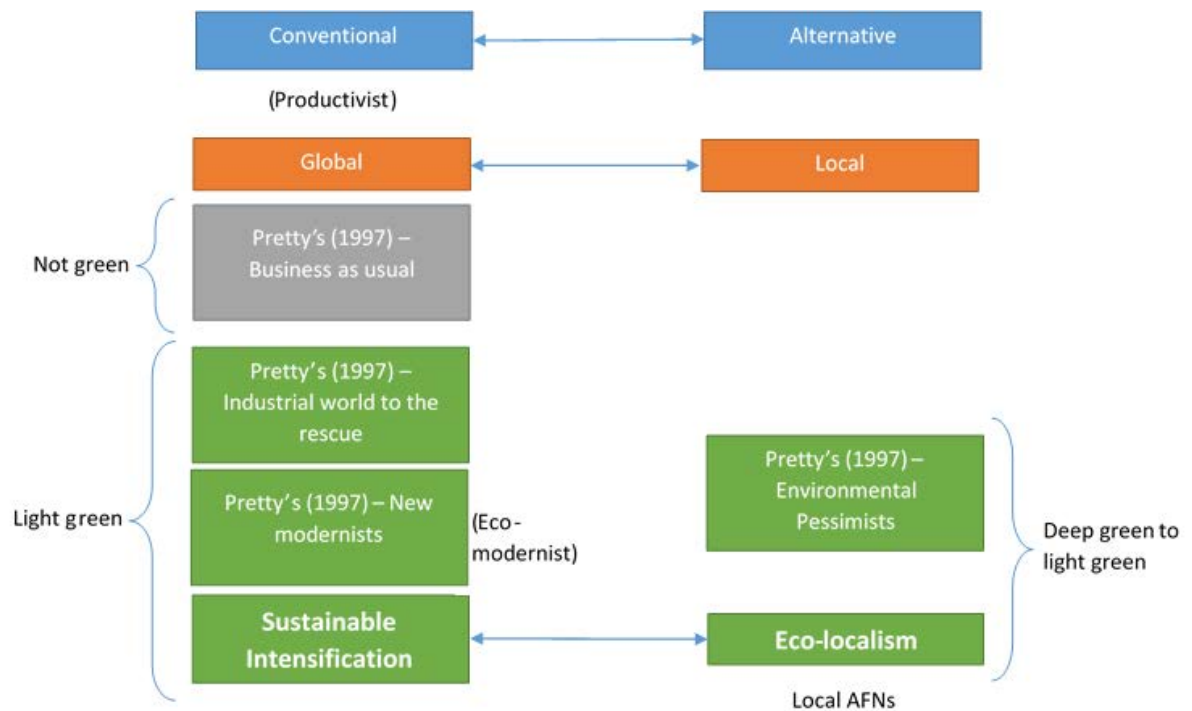


Figure 2.1 - Diagram showing how the arguments of Pretty (1997), Morgan et al. (2006) and Schmitt et al. (2016) fit together

The diagram shows how conventional to alternative taken from Morgan *et al.* (2006) can be seen as a continuum. Conventional, productivist, ‘business as usual’, ‘industrial world to the rescue’, ‘new modernists’, eco-modernist, and ‘sustainable intensification’ can be located in relation to each other. However ‘business as usual’ is not green whereas ‘industrial world to the rescue’, ‘new modernists’, eco-modernist, and sustainable intensification can be classified as light green (Muir *et al.*, 2000). Alternative, ‘environmental pessimists’, local AFNs, and eco-localism can also be located in relation together and ‘environmental pessimists’ and eco-localism can be classified as light to deep green (Muir *et al.*, 2000). This research maps onto distinctions Schmitt *et al.* (2016) made of global and local, placing global as conventional, though as already mentioned conventional does not have to be global. The two concepts in bold in Figure 2.1, the contrasting schools of thought of sustainable intensification and eco-localism are what this research wishes to investigate. In the following two sections, sustainable intensification and eco-localism are discussed.

2.3. Sustainable Intensification

Sustainable intensification is often seen as a response to the challenges that influence the food system. The main underpinning argument of sustainable intensification is centred on increased production. It is often portrayed as essential to meeting the food security challenge (Garnett *et al.*, 2013; Godfray and Garnett, 2014). However, there is a chance that there are companies who are operating under the sustainable intensification umbrella that do not see themselves as crucial to meeting the food security challenge but instead see it as a useful way of selling what they produce. This is because businesses can use a sustainable intensified product as a unique selling point (USP) (Collins and Chandrasekaran, 2012; Godfray and Garnett, 2014). However, the concept of sustainable intensification differs from other 'productivist' perspectives, in that whilst it shares an emphasis on increasing production, it recognises that expanded production can create significant environmental problems, including ones that threaten the long-term sustainability of food production. Firbank *et al.* (2013: 58), for example, define sustainable intensification as involving increased yields "without adverse environmental impact and without the cultivation of more land." Smith (2013: 19) defines sustainable intensification as "The process of delivering more safe, nutritious food per unit of input resource, whilst allowing the current generation to meet its needs without compromising the ability of future generations to meet their own needs". To arrive at this definition he applied the Brundtland Commissions definition of development to his own understandings of sustainable intensification.

An important aspect of sustainable intensification as highlighted by the definition of Firbank *et al.* (2013) is that increased production should not encroach on existing land or require further land becoming involved in agricultural production but must be met through higher yields. This is because many environmental costs are attributed to increasing the area of agricultural land, such as loss of biodiversity and problems of expanding production into environmentally sensitive areas. There are also issues of water and energy availability and climate change impacts if more extensive agriculture continues to expand (Garnett *et al.*, 2013; Firbank *et al.*, 2013; Godfray and Garnett, 2014). Garnett *et al.* (2013) acknowledge that a priority of sustainable intensification is the need to increase production but insist that this is not the sole priority. Other priorities include: urgent action on diminishing food waste; making food available and affordable to all; and reducing the demand for foods that are in high demand such as meat and dairy (Garnett, 2013). The main justification for sustainable intensification according to Tilman *et al.* (2002) is to stop destroying the environment by means of ecological agriculture.

Sustainable Intensification has become commonly mentioned within the sustainable food discourses, with Beddington (2011), for example defining sustainable intensification as “simultaneously raising yields, increasing the efficiency with which inputs are used and reducing the negative environmental effects of food production.” (Beddington, 2011: 3; see also Pretty, 1997; Firbank, 2009; Smith, 2013; Godfray and Garnett, 2014). More simply, Godfray and Garnett (2014, pp.6) argue that sustainable intensification aims to produce “more food with less environmental impact”. According to Garnett *et al.* (2013), its origins are positioned in discussions around increasing yields when threatened with challenges such as resource scarcity and environmental change. Increased yields are connected to debates of feeding a global population and a concern that this needs to be done without harming the environment (e.g. Tilman *et al.*, 2001; Godfray *et al.*, 2010; Tilman *et al.*, 2011). Increasing the yield does not have to be done through just increasing crop frequency, it could also be done by increasing the size of the existing crop.

Smith (2013) explains how sustainable intensification can be regarded as an ‘enhancement of current “business as usual”’ (Smith, 2013, pp. 21), because the agricultural systems generally continue as they are but the agricultural production becomes more proficient to cope with the increasing demand (Smith, 2013). However, Smith goes on to argue that the definition needs to be applied extensively as the needs of humans are not purely related to food production but also encompass a range of ecosystem services that apply to human health and well-being (Smith, 2013). Ecosystem services are defined as benefits provided by ecosystems that enhance human life and well-being (UK National Ecosystem Assessment, 2012). Ecosystem services were more widely recognised after the Millennium Ecosystem Assessment (MA) in 2005. There are several classifications and definitions but as suggested by the MA they fall under four main categories, which are widely accepted and used by others (e.g. Smith, 2013; UK National Ecosystem Assessment, 2012). The four categories are provisioning services, regulating services, cultural services and supporting services (Smith, 2013; UK National Ecosystem Assessment, 2012). Although the supporting services are vital for all other services, there is still a feedback for other services, for example pollination is extremely important for agricultural production (Smith, 2013). The UK National Ecosystem Assessment (2012) maintained that it is important to consider ecosystem services as being context dependent and therefore one ecosystem may be more important to one group of people than another ecosystem service and in some cases an environmental element may be considered an ecosystem service when by others is not valued at all. That is not to say that intensifying production does not create its own environmental

problems, but Tilman *et al.* (2001) suggest that the environmental problems created are less than when extensifying land for food production (Godfray and Garnett, 2014).

One of the key aspects to sustainable intensification is that it does not exclude any particular type of agricultural practice that achieves the goal of increased production with minimal environmental impact (Collins and Chandrasekaran, 2012; Godfray and Garnett, 2014). Smith (2013) describes sustainable intensification practices as being on a scale of technology; at one end there are the high-tech options and at the other end are the low-tech options. At the high-tech end are options such as genetic modification (GM) of crops and other living organisms, cloned livestock and nanotechnology. The high tech end of sustainable intensification practices is often the focus of attention. This could be because big tech solutions are often thought to be the answer to all world problems. Examples of how GM crops could be useful are crops that are modified to be salt tolerant crops, drought tolerant crops or crops with altered photosynthesis (Collins and Chandrasekaran, 2012). Another key practice at the high-tech end is 'precision agriculture', which involves the distribution of water, nutrients and pesticides only where they are needed. Whereas, at the low-tech end are suggestions such as closure of the yield gap by redistributing certain inputs to the land (Smith, 2013; Foley *et al.*, 2011; Mueller *et al.*, 2012). An example of this is nitrogen fertiliser that is overused in areas of China but is extremely limited in areas of Sub-Saharan Africa, therefore a redistribution of nitrogen fertiliser would close the yield gap between China and Sub-Saharan Africa (Mueller *et al.*, 2012).

Other practices that can be included as illustrations of sustainable intensification include the use of agroforestry, the adoption of pest management methods, and controlling waste from livestock by integrated management systems, all of which have potential for reducing net levels in some greenhouse gas emissions (Godfray *et al.*, 2010). Approaches such as pest management methods are adopted as the managing of farmland is seen as a key sustainable intensive practice to maximise outcomes across environmental, social and economic dimensions (Beddington, 2011). Agroforestry according to Leakey (2013) is a way of easing the tension between increased food production and environmental problems such as water runoff and flooding. The strategy known as no-till farming (zero or reduced tillage) also controls the inputs to land by increasing the amount of water in the soil. The management of aquaculture and fisheries is also important as it can moderate the negative bearings on biodiversity (Godfray *et al.*, 2010).

There are many criticisms of sustainable intensification in the literature, with one of the main being that the concept acts as a 'Trojan horse', in the sense that intensive farming practices are

being sneaked under the sustainability umbrella and therefore convincing the world that all intensive farming practices are acceptable. It is a concept that has been embraced by many organisations that represent the biotechnology, pesticide and fertiliser industries, as well as many agricultural trade bodies. Undoubtedly, some of these organisations will be using the term to their advantage and not necessarily welcoming the main goal of sustainable intensification (Collins and Chandrasekaran, 2012; Godfray and Garnett, 2014). Nevertheless, the potential commandeering of sustainable intensification could be monitored and does not mean the whole concept needs to be rejected (Godfray and Garnett, 2014). Another criticism is that 'intensification' can have negative connotations as it is associated with certain practices, such as factory farming (Godfray and Garnett, 2014). Factory farming involves the confinement of many animals in small spaces and impacts the welfare of the animals, which is understandably a source of criticism. However, Godfray and Garnett (2014) insist that, if welfare norms are defined and enforced and a standard of welfare can be maintained at each setting for each animal then intensive practices can still work for livestock. But they also rightly point out that it may not be possible to maintain a high welfare for animals in intensive systems. Therefore, it may be down to society to make decisions about their current high meat and dairy diets (Godfray and Garnett, 2014).

The concerns surrounding the use of the term 'intensification' have been acknowledged by researchers such as Godfray and Garnett (2014) but they argue that it is possible to continue to use the term 'sustainable intensification' in a "neutral sense of increasing yields while reducing environmental harm." (Godfray and Garnett, 2014, pp. 5). Another underlying issue of sustainable intensification is that it does not rule out any particular production method. This is a problem as it leaves itself open to criticism from detractors of technologies such as GM. According to Godfray and Garnett (2014), sustainable intensification has been attacked for its inclusion of GM as a potential technology but they also point out that the debate around GM technologies in sustainable intensification has been largely exaggerated by both supporters and opponents and GM is just one possible approach in a sea of many others options.

Another criticism of sustainable intensification is the main focus of food security and the need to produce more food to address this issue is detracting attention away from the need to supply safe nutritious food (Godfray and Garnett, 2014; Collins and Chandrasekaran, 2012). Therefore, there are worries that if food production is increased, it will lead to more mono-crops and GM crops and, in turn, a nutritionally inadequate diet (Godfray and Garnett, 2014). However, this is not necessarily the case as sustainable intensification encompasses the growing of crops that

have intensive nutritional profiles such as the orange-fleshed sweet potato which is rich in Vitamin A. Likewise, GM technology has been used to develop 'golden rice' which produces a Vitamin A pioneer (Godfray and Garnett, 2014). An additional criticism of sustainable intensification is there are implications of expanded food production, for example more food production will have a reliance on heightened water availability which might itself lead to water shortages, or may rely on inputs of fertilisers that can create pollution as well as increasing costs if petrochemical costs rise. The final criticism of sustainable intensification is that it may be perceived to substantiate Western models of agriculture which could harm smallholders in low-income countries (Godfray and Garnett, 2014).

As you can see from the above paragraphs, sustainable intensification is widely criticised throughout the literature surrounding it. However, when sustainable intensification is thought of in a neutral, descriptive way, it fits in with research such as Firbank *et al.* (2013), who have employed metrics of sustainable intensification. Firbank *et al.* (2013), go beyond defining sustainable intensification, identifying a set of metrics for sustainable intensification based on a set of measurable factors taken from categories of ecosystem services, namely agricultural production (supporting service), biodiversity (provisioning service), climate regulation (regulating service), regulation of air quality (regulating service) and regulation of water quality (regulating service). These particular ecosystem services were chosen because they are known to have changed significantly on UK farmland (Firbank *et al.*, 2013; UK National Ecosystem Assessment, 2011). Practicing sustainable intensification was said to have occurred if food production per unit had increased without any of the environmental variables selected deteriorating (Firbank *et al.*, 2013). They felt that this pragmatic approach could be used as a basis for a wider monitoring programme of sustainable agriculture.

For some, sustainable intensification is a truly flawed approach as Garnett and Godfray (2012) point out in their report. Therefore, there is a need to look for alternatives. If it is the use of the term 'sustainable intensification' that is the foremost concern than the same approach could be used just under a different term (Godfray and Garnett, 2014), such as 'sustainable yield increases' or 'ecological intensification'. Still 'ecological intensification' does not avoid the undertones of 'intensification' and 'sustainable yield increases' is not a catchy phrase for the media and policy documents. The thought behind the terms of a particular concept should not be dismissed, as words are deemed extremely important in policy making and the use of the wrong word could have substantial consequences (Godfray and Garnett, 2014).

A possible alternative to sustainable intensification is to focus not on increasing production, but on a shift to improving the complete food chain by focusing on changing diets, reducing waste and a fundamental change of global agricultural systems (Smith, 2013; Godfray and Garnett, 2014). Therefore the alternative should not be instead of sustainable intensification, but rather to apply sustainable intensification to the whole food network, from production to consumption. This would tie sustainable intensification approaches to complete food chain perspectives. Morrissey and Dunphy (2015) state that the sustainability of food chains are dynamic and differ immensely depending on the stage of the network, and because of this, an understanding of their sustainability could be difficult to obtain. However, sustainable intensification applied across the network could form a better understanding of the sustainability of food systems. In many studies to date, sustainable intensification as an approach for sustainable food has been applied at a farm level (e.g. Clay *et al.*, 1998; Tilman *et al.*, 2011; Vanlauwe *et al.*, 2014). This study intends to differ from this approach and apply it to the whole food network. The following section looks at an alternative approach to sustainable intensification that also attempts to consider the sustainability of the whole food chain but does not focus on a need for increased food production. This alternative approach leads to the paradigm known as eco-localism.

2.4. Eco-localism

This section discusses eco-localism as an alternative approach to sustainable intensification in addressing the sustainability of food systems. The section highlights the key arguments of eco-localism, some common practices and concepts with similar parallels. The central argument for eco-localism is, according to Curtis (2003), that the best way to achieve environmental sustainability is to rely as far as possible on producing and consuming things locally. Curtis (2003, pp. 83) believes that the road to environmental sustainability is through the creation of “local, self-reliant, community economies.” Eco-localism promotes the idea of self-reliant communities and has as its goal the establishment of healthy community economies. A healthy community economy is a community that preserves the ecosystem it depends on as well as the demotion of the economy to society. (Curtis, 2003). The main point of eco-localism is that “place matters”, mainly because a local place can provide diverse resources to the localised economy (Curtis, 2003). Orr (2004, pp. 161) describes the need for eco-localism thus; “we need stable, safe, interesting settings, both rural and urban, in which to flourish as fully human creatures”. The main values of eco-localism according to Curtis (2003, pp. 86) are “social and environmental responsibility, health of the community, stewardship of nature, affection for and commitment

to place, fidelity, propriety and sufficiency". As well as "independence, interdependence, security and self-reliance." (Curtis, 2003, pp. 86).

North (2010) provides a brief history of where thoughts around eco-localism have stemmed from as well as providing context for adopting eco-localism. Thoughts of localisation and decentralisation have a long tradition in 'progressive thought', dating back at least to the different utopias developed by William Morris and Edward Bellamy. Guild Socialists and Distributionists looked to build small scale communities in a response against the centralising Soviet model of socialism in the 1930s (North, 2007, pp. 62-63; North, 2010). In the 1940s and 1950s, the North American homesteading movement also promoted a return to local food production, while in the 1960s communes were promoted as an alternative to capitalism. In the 1990s, the concept of a 'locally owned economy' was proposed as a response to job losses and the recession (North, 2010), whilst more recently notions of 'localisation' has been picked up with the green movement and by Green Parties, which have become "advocates of the small-is-beautiful alternative production by participants in local currency networks, by opponents of supermarkets and other 'big-box' large retailers..." (North, 2010, pp. 587).

Authors such as Douthwaite (1996); Curtis (2003); and North (2010) describe eco-localism in relation to the following terms; economy, technology, scale and efficiency, consumption, and trade and self-reliance. These terms are now discussed for what they mean for eco-localism. In terms of economy, the eco-local economy is not centred on profit maximisation so is not solely defined by production, but instead, it is equally comprised of collectives and cooperatives. An eco-localist economy differs from the economy of conventional theory primarily by its geographic extent and sectoral dimension. The geographic extent is bound by the local and the sectoral dimension places value on the community and quality of life (Curtis, 2003).

With regards to technology in an eco-local community, there is usually a call for more low-input technology in contrast to conventional perspectives, which is in line with Pretty's (1997) 'environmental pessimists' school of thought and Murdoch *et al.*'s (2006) alternative system. Eco-localism is not only different from the conventional and 'business as usual' system but it is also different from sustainable intensification. Eco-localism is particularly different to the high tech, high-input end of sustainable intensification. However the low-input end of sustainable intensification has many parallels with eco-localism; both concepts are not discrete entities and could be thought of as on a continuum, which is reflective of what Morgan *et al.* (2006) said of not making binary oppositions between the conventional and alternative system. Eco-localism

sharing characteristics of low-input sustainable intensification supports this research's criticism of Pretty's low input sustainable intensification school of thought mentioned earlier in this chapter. The technology which is likely to be used is designed to minimise pollution and the need for non-renewable resources. Importantly, according to Curtis (2003, pp. 90) "such technologies are generally locally affordable, heterogeneous, and well adapted to local culture, economy, community and environment".

Scale and efficiency are common themes throughout the eco-localist literature. In relation to scale, Morris (1996) writes how "Small is the scale of efficient, dynamic, democratic and environmentally benign societies." Small-scale business and small-scale technologies fit into the boundaries of eco-local communities who are focused on the reproduction of local natural and social capital (Curtis, 2003). Curtis (2003: 90) does not explain 'how small is small' and only explains that it is "the appropriate size or scale of economies and firms (or production processes) relative to their local eco-system or bioregion." The general belief through an economies of scale lens (e.g. Koshal, 1972), is that efficiency is increased on a large-scale, centralised basis as resource cost and production cost both decline as output increases. Therefore, economies of scale characterise that production is most efficient on a large batch-basis of a standardised product. However, according to Curtis (2003), eco-localists reject this idea on two levels believing that large economies of scale are illusory and rejecting the need for a monolithic product.

Consumption, according to Curtis (2003), is reduced in an eco-local economy, which rejects the conventional theory that more is better and that greater welfare results in increased consumption. Green consumerism is also not thought of very highly in eco-localism as it promotes consumerism in general. There is also an environmental impact associated with consumption due to the use of transportation resources and embedded pollution, (Curtis, 2003). Consumption, it is argued, can be made to occur largely within the bounds of a so-called eco-local community. Curtis (2003) calls this the IMBY (in my back yard) effect. Eco-local communities or eco-communities are defined by Gilman and Gilman (1991: 7) as "human-scale full-featured settlement in which human activities are harmlessly integrated into the natural world in a way that is supportive of healthy human development, and can be successfully continued into the indefinite future." This allows an eco-community to be as self-reliant as possible. However, Curtis (2003) acknowledges that locally limited resources cannot support growing populations and, because of this, eco-localism is difficult to apply on an urban scale, as it is not possible to reduce a city's ecological or carbon footprint to its geographical boundary.

Curtis does suggest though, that some elements of eco-localism could be adopted to make a city more sustainable. The concept of waste is another important constituent of eco-local communities, in that waste is seen as something which would not really exist in these communities because something that was not consumed or absorbed would not be produced (Curtis 2003).

There are some tensions in the eco-localist literature. Curtis (2003) and North (2010) stress that the key element of eco-localism is that place matters and everything is reliant locally on everything else. However, Douthwaite (1996, pp. ix) contradicts this and highlights that localisation does not mean everything local, as emphasised in the following quote: "Some...imagine the aim of economic localisation is complete self-sufficiency at the village level. In fact localisation does not mean everything being produced locally, nor does it mean to end trade. It simply means creating a better balance between local, regional, national, and international markets. It also means that large corporations should have less control, and communities more over what is produced; and that trading should be fair and to the benefit of both parties.... Localisation is not about isolating communities from other cultures, but about creating a new, sustainable and equitable basis on which they can interact." (Douthwaite, 1996, pp. ix).

Common eco-localism practices are often presented as; local currency systems, food cooperatives, farmers' markets, permaculture, micro-enterprise, community supported agriculture farms and eco-villages (Curtis, 2003). Curtis' (2003) paper in my opinion has the fullest, richest explanation of eco-localism. He describes it beautifully as an amalgamation of place, community and nature, although with criticisms of eco-localism. Hahnel (2007) is better at addressing the criticisms of eco-localism. Firstly he suggests that the problems associated with dealing with large commercial businesses may be the same with small, locally owned businesses. Large corporations are not the only businesses that exploit their employees and overcharge their customers and this could be increased in locally owned businesses as they are not divorced from personal involvement. Other criticisms of eco-localism presented by Hahnel (2007) include the claim that not all communities will be able to produce everything its residents want to consume and if communities were completely self-sufficient, inequalities would arise if other communities had better natural, physical or human capital. Hahnel (2007) and Albo (2009) both address the issue of democracy and power relations, considering who is responsible for making decisions in such communities and whether they can remain democratic or whether capitalist power relations creep in.

Eco-localism has parallels with Halfacree (2007) discussion of radical rural spaces/localities, which involve "environmentally embedded, decentralised and relatively self-sufficient and self-reliant living patterns." (Halfacree, 2007, pp. 132). The best expression of this, according to Halfacree (2007), is low impact development, which is closely linked to Simon Fairlie. Fairlie (2010) describes low impact development as conforming to the following criteria: temporary, small-scale, unobtrusive, local materials, enhances biodiversity, consumes few non-renewables, generates little traffic, for sustainable purposes and with positive environmental benefits. All of these can be seen as being akin with the descriptions of eco-localism, apart from temporary. This literature ties into Fairlie's (2010) work on meat production. Fairlie (2010: 9) describes the intensive beef farming model as "one of the biggest ecological cock-ups in modern history." This statement is not in favour of everyone becoming vegan but instead an argument against the current farming model. Fairlie (2010) advocates a type of farming that is low energy, low waste, just, diverse and small-scale which ties into the notions of eco-localism by being small scale and low inputs. If this kind of thinking was applied to the whole food system from farm to fork it could have great implications for the suitability of a food system, allowing people to eat meat and dairy with fewer moral considerations. A turn to shorter and more local supply chains and therefore a possible turn towards more sustainable methods, has been investigated by many researchers (e.g. Marsden *et al.*, 2000; Cone and Myhre, 2000; Bowler, 2002; Morris and Buller, 2003; Winter, 2003).

Ilbery and Maye (2005) suggest that one way to radically change the conventional system of production is organic farming. Ilbery *et al.* (1999) describe organic farming as "a more sustainable and environmentally-friendly agricultural system, and as one possible solution to an 'international farm crisis' characterised by over-production, declining farm incomes and environmental degradation." According to the Soil Association (2017), organic food means "fewer pesticides, no artificial additives or preservatives, the highest standards of animal welfare and no GM ingredients." Low energy, low waste and just practices are often characteristics that are associated with organic farming. Another practice that has parallels with organic farming is biodynamic farming. Biodynamic farming uses no synthetic or chemical fertilisers and pesticides but instead emphasises the build up of soil through natural methods such as compost and animal manure. The biggest difference from organic farming is the eight preparations that biodynamic farmers add to their soil which are cow manure, silica, flowers of yarrow, chamomile, dandelion and valerian, oak bark, and stinging nettle (Reganold, 1995). The

preparations are based on a holistic approach to nature and not conventional farming. Research by Goldstein (2000) reports significant yield increases from a biodynamic approach.

This section has explored eco-localism as an alternative approach to sustainable intensification for a sustainable food system. There have been positive responses to localised food networks in the literature with some researchers claiming that local food is more sustainable, better for the environment and healthier for the consumer (e.g. Adams and Salois, 2010; Thilmany *et al.*, 2008). However there are some discrepancies as some studies believe that there is no empirical evidence that prove local food is more sustainable (Born and Purcell, 2006). Schmitt *et al.* (2017) point out that this could be because the notion of local is ambiguous, the local-global is not dichotomous and therefore the best way to think of the local is as being on a continuum. This research as mentioned in the above section, does place eco-localism on a continuum but with sustainable intensification. The sections up to now have discussed sustainable approaches to the general food systems. The next section narrows the focus from food systems more generally to cheese systems. The literature of cheese is explored along with the sustainability of cheese and cheese is then specifically discussed in relation to sustainable intensification and eco-localism.

2.5. Sustainability of Cheese

In the introductory chapter, it was highlighted that the main focus of this research would be on the sustainability of cheese from farm to fork, as cheese can be notoriously unsustainable. With regards to food sustainability and the dairy industry, there are many suggestions from the literature that we should eat less dairy (e.g. Godfray *et al.*, 2010; Beddington, 2011). This could be potentially damaging for the cheese industry and the dairy industry more widely. According to the Environmental Working Group (EWG), cheese is the third greatest producer of emissions at 13.5 kilograms of CO₂e per kilogram eaten, when ranked amongst other protein sources (Hamerschlag, 2011). Only lamb and beef are greater producers of emissions, this is partly due to lamb, beef and cheese all coming from ruminant animals. Ruminants constantly generate methane through enteric fermentation. Ruminant animals also require a more energy intensive feed and produce more manure than pork or chicken, for example (Hamerschlag, 2011).

There is an extensive food science literature surrounding cheese (e.g. Gobbetti *et al.*, 2015; Silveira *et al.*, 2015; Diana *et al.*, 2014) and there is also an historical literature on cheese (e.g. Cheke, 1959; Smith, 1995; Salque *et al.*, 2013; Harbutt, 2015). Salque *et al.* (2013) investigate the earliest evidence of cheesemaking in the sixth millennium BCE in northern Europe. Smith

(1995) gives us a history of cheesemaking in Scotland, Cheke (1959) gives an account of a British cheesemaking history and Harbutt (2015) looks at the history of cheese in general. According to Harbutt (2015), evidence of cheesemaking can be found dating back to 2800BCE, although she suggests that to begin with, this was very much an accidental process; milk was stored in the stomachs of animals, which served the purpose of being a sack, but when left, the milk would sour and the milk solids and the liquid would separate. Much later, it was realised that rennet, an enzyme found in the stomach of a milk producing animal, is the coagulant that caused the milk to set (Harbutt, 2015).

Cheese is now made all over the world (Campbell-Platt, 1994; Harbutt, 2015) and currently, as mentioned in the introduction, in the UK, the number of members of the Specialist Cheesemakers Association (SCA) who are dairy farmers has increased, perhaps as a way of diversifying income streams and adding value to their milk. Harbutt (2015), in her book *World Cheese*, explains how even though milk often tastes the same around the world, cheese varies immensely. The size, shape and milk of a cheese can be determined by many external forces, including historical events, religious orders, experimentation and the terrain, whilst the texture and taste of a cheese are influenced by the type and breed of animal, the soil, climate, grazing and the cheesemaker. The cheesemaking process varies from cheese to cheese and from cheesemaker to cheesemaker but the basic premise is the same. Milk is used to make cheese, which is sometimes but not always pasteurised by heating it to a temperature of usually 73°C. The milk is then heated in a vat to the required temperature or acidity level of the recipe. Once the milk has reached the desired temperature, a 'starter culture' is added which converts the lactose to lactic acid and contributes to the flavour and texture of the cheese (Harbutt, 2015). Then a rennet is added, which acts as a coagulant because it encourages the fat and protein to bond so that they are not lost in the next step and the milk then sets like a jelly. The curds and whey are then separated, the curds are the solid jelly like substance and the whey is the liquid component. The method by which you separate the curds from the whey results in different cheeses. For example, separating the curds gently creates a cheese that is high in moisture whereas if you cut the cheese, this allows for more whey to be released and creates a harder cheese. Once separated from the curd, the whey is drained off, whilst the curd is then removed from the vat and usually put into a cheese mould. The cheese mould holds the curds in place so that they set to a cheese. Once out the mould, the cheese is sprinkled with salt or put into a brine bath and is stored for the ageing process, being placed in a cheese store or a cheese cellar for a period of time which varies according to the type of cheese being produced (Harbutt, 2015).

A second area of literature on cheese relates to the lifecycle assessment. Sustainability performance in food, and sustainability performance more generally, is evaluated by using a set of indicators to assess and evaluate the practices being employed (Schmitt *et al.*, 2016). Lifecycle assessments (LCA) are a way of assessing sustainability and are often applied to calculate food production emissions and to assess the sustainability of food products. Berlin (2002) describes LCA as “a method of evaluating the environmental impact associated with a product, process or activity during its lifecycle by identifying quantitatively or qualitatively describing its requirements for energy, material, and the emissions and waste released to the environment”. LCA encompasses the whole lifecycle of the product, process, or activity, from ‘cradle to grave’, which relates back to the discussions of integrating production and consumption in food studies and concerns over sustainability.

Many LCAs have been applied to cheese, with studies such as (Hamerschlag, 2011; Aguirre-Villegas *et al.*, 2011; Berlin, 2002; Kim *et al.*, 2013) detailing how different stages of a cheese network cause sustainability concerns, including significant greenhouse gas emissions and environmental waste. Studies, for instance, have indicated that modern dairy practices produce between 0.75 and 1.5 kg CO₂e per kg of milk, although levels vary between studies (Aguirre-Villegas *et al.*, 2011; Thoma *et al.*, 2013; Cederberg *et al.*, 2009; Guignard *et al.*, 2009). The impact of cheese on the environment can be expected to be approximately ten times higher than that of milk, because, as already mentioned, 10 litres of milk is needed to make 1kg of cheese (a litre of milk weighs approximately 1kg). However as Guignard *et al.* (2009) point out, this is not always the case, in part because there are often co-products produced during the cheese-making process and therefore the different products share the impact of milk inputs as well as water and energy inputs as well. In their study, they estimated that cheese contributed 8.8kg of CO₂e per kilogram of cheese (Guignard *et al.*, 2009; Berlin, 2002).

LCA assessments have revealed that the largest greenhouse gas emission in the cheese lifecycle is during the production of milk at the farm (Aguirre-Villegas *et al.*, 2011; Hamerschlag, 2011), it being calculated that the dairy farm contributes to over 90% of greenhouse gas emission of a cheese lifecycle, approximately 8.3kg CO₂e per kg of milk Aguirre-Villegas *et al.* (2011) and Berlin (2002). Studies such as (e.g. Berlin, 2002; Aguirre-Villegas *et al.*, 2011; Hamerschlag, 2011) have all highlighted that the main point of origin of greenhouse gas emissions on dairy farms is rumen methane, as well as methane from manure and nitrous oxide from fertilisers. Feed production for the dairy animals also generates greenhouse gases and harms the environment, as grains in particular can require significant amounts of water, fertiliser, fuel, pesticides and land

(Hamerschlag, 2011). (Aguirre-Villegas *et al.*, 2011; Guignard *et al.*, 2009) both record that methane (CH₄) is the main greenhouse gas emitted at the farm level and that this is mainly due to enteric fermentation but also manure management. Nitrous oxide (N₂O) is the second largest contributor, mainly stemming from fertilisers and manure management, and then carbon dioxide (CO₂) from the production and use of fossil fuels, which is less important in the farm phases and mainly stems from tractor and truck emissions linked to the transport of herds and feed. Studies have identified that there are steps that can be taken to lower greenhouse gas emissions at the farm level and thereby make dairy farming more sustainable, including altering the feed composition (Aguirre-Villegas *et al.*, 2011), managing fertiliser (Weiske *et al.*, 2006; Aguirre-Villegas *et al.*, 2011), frequent removal of manure and scraping systems (Weiske *et al.*, 2006), capturing manure methane in a anaerobic digester (Weiske *et al.*, 2006; Aguirre-Villegas *et al.*, 2011) and optimising the lifetime efficiency of dairy animals (Weiske *et al.*, 2006).

Cheesemaking, including packaging, has been identified as the second biggest contributor to greenhouse gas emissions in the lifecycle of a cheese (Aguirre-Villegas *et al.*, 2011), although seen as producing considerably less than the dairy farm. According to the LCA conducted by Berlin (2002), for example, a processing plant making a hard cheese, emits 0.4 – 0.6 kg CO₂e per kg of cheese. This however does differ and is more variable than at the farm level.

The main factors that influence the environmental impact of cheesemakers is seen to be the moisture content of the cheese (Aguirre-Villegas *et al.*, 2011). A softer cheese, which has a higher moisture content, needs less energy to produce per kilogram than a harder cheese such as a cheddar (Aguirre-Villegas *et al.*, 2011), because it will be a fresher cheese that has not needed to be aged for nearly as long as a harder cheese. A harder cheese however, will have to be kept in storage for longer, which is using more energy in terms of refrigeration and possibly a humidifier in a cheese store. The length of the ageing process is not the only factor that affect the emissions per kilogram, with the type of aging also being identified as a factor (Aguirre-Villegas *et al.*, 2011). If a cheese needs to be aged through storage at a low temperature then more energy may be needed for refrigeration, although not all cheese needs refrigeration to be stored; some cheeses are stored in caves and therefore the temperature is naturally lower and refrigeration is not needed.

Studies have identified numerous ways that the dairy manufacturing process can be improved to lessen their environmental impacts. Berlin (2002), for example, suggests that one of the main things that can be done is to decrease the amount of milk that is needed in the cheesemaking

process. However, the biggest issue with this suggestion is that reducing the input of milk significantly changes the texture and taste of the cheese. Ways to reduce the amount of milk needed include increasing the water and salt content of the cheese and maintaining more whey protein in the cheese. Another way of doing this according to Berlin (2002), would be to increase the protein content of the milk used to make the cheese as it gives a better yield of cheese. Increased protein in the incoming milk can be achieved by the breed of animal that is being milked and increasing the protein content of the feed of the milked animal. However, Berlin (2002) suggests that the best way to reduce the amount of milk used in the cheesemaking process without affecting the final product is to identify and then minimise the losses of milk in the cheesemaking process such as reducing spillage. Other studies (Berlin, 2002; e.g. Audic *et al.*, 2003; Waldron, 2007) have focused on the production of co-products, which as already mentioned, can be seen to lower the environmental impacts of cheese production by spreading them across a range of products.

Aguirre-Villegas *et al.* (2011) state that the best way to dramatically reduce greenhouse gas emissions is to recover the energy from the whey permeate which is drained off during the cheesemaking process. Whey can be fed into an anaerobic digester and the energy can be recovered by converting it and other waste products to biogas. During the lifecycle of the cheese there are also environmental impacts from the transportation of the cheese to retail outlets or consumers. These mainly come from the combustion of fossil fuel such as petrol or diesel to power the lorries that transfer the cheese. Transportation is also used in the cheese lifecycle to transport the milk in tankers from the farm to the dairy, its significance varying according to where milk is sourced from. According to Hamerschlag (2011), transport emissions do not differ much for different food types, although because foods such as vegetables and fruit have much lower transport emissions compared to those of meat and cheese, vegetable and fruit transportation emissions contribute to a much higher fraction of their overall footprint. Transportation contributes to roughly 10-30 percent of the climate impact of vegetable production whereas transport is a relatively small percentage of greenhouse gas emissions in comparison to the farming and cheesemaking stages. Transportation contributes to 1-3 percent of the overall climate impact for cheese production (Hamerschlag, 2011). If food products are transported by air then this dramatically increases the amount of emissions produced. Cheese that is imported by air has a 46 percent larger footprint than cheese that has been produced domestically. However most imported cheese is done so by ship and this adds less than one percent to the overall carbon footprint of the cheese (Hamerschlag, 2011).

Tassou *et al.* (2011) discuss the different environmental problems associated with food retailing. Retailers use electricity and natural gas to power lighting and refrigeration, and the environmental impact that the supermarket causes is dependent on the size of the store and the different practices that they have in place. This all contributes to the overall environmental impact of the cheese (Aguirre-Villegas *et al.*, 2011).

The remaining greenhouse gas emissions produced during the cheese lifecycle link to the consumer. The discarding of packaging contributes to greenhouse gas emissions as the packaging goes to landfill. Landfill produces greenhouse gases CO₂ and CH₄, carbon dioxide and methane respectively. The gases are a by-product from the anaerobic decomposition of organic waste, although only CH₄ is considered in the estimation of greenhouse gas emissions. This is because even though CO₂ has a global warming potential, it is from a biogenic origin so is not considered (Lou and Nair, 2009).

There are ways of combating this by recycling the packaging (Aguirre-Villegas *et al.*, 2011) but that is dependent on the local authority policies on recycling as well decisions by the manufacturers of products related to the use of recyclable packaging. Food waste also contributes to the environmental impact of cheese, with mould being identified as a large contributor to cheese waste at the consumer level (Aguirre-Villegas *et al.*, 2011). Some consumers are put off by mould and throw large amounts of cheese rather than just cutting off and throwing away pieces of cheese that have areas of mould (this applies to cheese that is not already supposed to have mould). Some manufacturers are seeking to reduce or control mould (Aguirre-Villegas *et al.*, 2011), by vac-packing the cheese prior to maturation (Guinee *et al.*, 2004). Berlin (2002) also suggests that consumers could reduce greenhouse gas emissions linked to the use of car transportation from places of residence to retailers by taking responsibility for the environmental impact of their decisions related to buying food.

As can be seen from the above discussion, LCAs often consider many factors, including carbon footprint, energy use, water use and land use for each area of the food supply chain (Schmitt *et al.*, 2017) and according to Schmitt *et al.* (2017) and Tasca *et al.* (2017), LCAs should provide a full food system perspective beyond the farm gate. One of the main criticisms of LCAs provided by Schmitt *et al.* (2017) is that they primarily investigate the environmental side of sustainability assessments and do not tend to consider socio-economic factors, although studies are starting to integrate socio-economic considerations as Cueck *et al.* (2012) pointed out in their review of footprint analysis tools for monitoring impacts on sustainability.

Lifecycle assessments have been pertinent in discussing and investigating the environmental sustainability of cheese but do not tend to factor in socio-economic considerations. They are quantitative based, though Schmitt *et al.* (2016) have used a qualitative approach and also considered more than the environmental side. They applied an interdisciplinary multi-dimensional perspective, taking into account the three original Brundtland pillars, plus health and ethics, in order to structure the assessment of food chain performance for a range of food products. They came up with a set of indicators encompassing economic, social, environmental, health and ethical conditions. Across these dimensions, eight attributes of performance were established, namely affordability, creation and distribution of added value, information and communication, consumer behaviour, resource use, biodiversity, nutrition and animal welfare. The attributes they identified for economics were affordability and creation and distribution of added value. Affordability had the following indicators; ability to provide food at acceptable prices and price perception of customers. The indicators identified for creation and distribution of added value were producers' business profit, distribution of price between actors and contribution to the economy of the region. The attributes identified for the social dimension were information and communication and consumer behaviour. The indicators for information and communication were communication along the chain, availability of information and product labelling. The indicators for consumer behaviour were identified as cooking practices, taste preference, convenience and willingness to pay. The environmental attributes included resource use (with the following indicators of soil management practices, material consumption practices and waste reduction and disposal) and biodiversity (with the indicators of landscape management practices and diversity of production). The health attribute was nutrition which had the indicators salt content, fat content, fat types and calcium content. Finally, the attribute identified for the ethical dimension was animal welfare and the following indicators were established; animal density, lifetime of dairy cows and time spent on pasture (Schmitt *et al.*, 2016). These indicators are used to compare four different cheese food chains, two in the UK and two in Switzerland. The food chains were differentiated into local and global, it being argued that local cheese food chains performed better in relation to value creation and distribution, animal welfare and biodiversity, whereas the global chains studied did better under the attributes of affordability and efficiency and some environmental indicators.

The study by Schmitt *et al.* (2016) relates to my own research as it is a qualitative sustainability assessment of cheese supply chains. Sustainability is considered across the whole cheese supply chain beyond the farm gate, which is what this study aims to achieve. Instead of using the term

food supply chain however, this study uses an actor-network perspective where the chains studied are cheese actor-networks. The element of comparison between two different networks is also a similarity between the Schmitt *et al.* (2016) study and this research. This study does not, however compare local and global as Schmitt *et al.* (2016) have done, but instead compares eco-localism and sustainable intensification. Referring back to the diagram displayed in Figure 2.1, global and sustainable intensification are located in relation to each other and local and eco-localism are located in relation to each other.

There is very little literature on the sustainable intensification of cheese as sustainable intensification is usually applied at a farm level and has not been thought of with regard to the whole network. Vayssieres *et al.* (2011) aim for an integrated participatory modelling approach to support policy making in sustainable intensification, and their research considers a dairy farm which happens to produce cheese but where cheese is not the sole focus. Schmitt *et al.* (2016) look at global cheese networks and their sustainability but global networks are not, by default, sustainably intensive. This research seeks to provide criteria for sustainable intensive cheese that can be applied not just on a farm level, but to the whole network and other cheese research. From an eco-localist perspective, cheese that is local is quite often associated with being of a better quality, is often bought for a special occasion and consumers are likely to make an effort to buy it directly from the cheesemaker (Schmitt *et al.*, 2016). This research intends to apply eco-localism and sustainable intensification to cheese systems considering more than the environmental aspect of sustainability, and including the socio-economic aspects. This research has, from the beginning, been interested in networks and food systems, moving beyond the farm gate and viewing food with a wider food system perspective. LCAs have gone some way, as discussed in this section, towards researching cheese from farm to fork. They have parallels with commodity chains and food networks, and a theory that is well situated to view these networks through is actor-network theory, especially as it has already been applied to other food studies as mentioned in the *Geographies of Food* section. The next section is going to discuss actor-network theory and its applicability for this research.

2.6. Cheese Actor-networks

Actor-network Theory (ANT) has been adopted by food writers (e.g. Whatmore and Thorne, 1997; Goodman, 1999) as a way to move beyond the political economy and to look in more detail at food networks as mentioned in the *Food and Sustainability* section. ANT overcomes the criticisms made of commodity chains by Leslie and Reimer (1999) as it assigns agency to actors

within an actor-network. This section looks at ANT in more detail and why it is being applied to this research.

When pushed to place the origins of Actor-network Theory (ANT) to a particular time, Law (2009) suggested they could be traced back to Paris between 1978 and 1982. The term itself was coined first by Michel Callon and appeared around 1982. However Law (2009: 142) believes that “the approach is itself a network that extends out in time and place, so stories of its origins are necessarily in part arbitrary.” ANT is principally associated with the works of Michel Callon, Bruno Latour and John Law and can primarily be traced back to social studies of science (Burgess *et al.*, 2000; Michael, 2017). Law (2009: 141) provides the following definition of ANT: “the enactment of materially and discursively heterogeneous relations that produce and reshuffle all kinds of actors including objects, subjects, human beings, machines, animals, 'nature', ideas, organizations, inequalities, scale and sizes, and geographical arrangements”. As described by Phillips (2005), ANT “...seeks to explain how agency – or the power to do things – comes about, and suggests that agency is an effect produced by networks of heterogeneously associated entities (or actants as they are often called) which encompass both the human and inhuman”.

Advocates of ANT such as Callon, Latour and Law argue that chain or network activities can only be fully understood if natural, social and technological entities are all taken into account (Morgan *et al.*, 2006). Callon (1990) defines a network as “a coordinated set of heterogeneous actors which interact more or less successfully to develop, produce, distribute and diffuse methods for generating goods and services.” The definitions provided by Callon (1990), Law (2009) and Phillips (2005) are similar in that they all refer to the idea of heterogeneity. This abstract definition is quite often found in textbooks when discussing ANT (Law, 2009). To summarise this paragraph, ANT is a theoretical and methodical approach that views everything in the natural, social, and technical worlds in networks of relationships that are constantly shifting, and with everything existing within these relationships. Humans are not the only factor in creating social situations; objects, ideas, processes, and any other relevant factors are seen to be equally as important as humans (Latour, 2005).

Law (2009) in his chapter *Actor-network Theory and Material Semiotics*, provides four qualifications of ANT. The first qualification relates to the definition of ANT, as Law (2009) believes that it is possible to have a description of ANT in the abstract but that often misses the point as ANT is substantiated in empirical case studies. Law believes that ANT can only be fully understood when a sense of the case studies is gained. Actor-network analysts use detailed,

specific case studies such as Callon's (1986) study of scallops, fishermen and scientists. According to Flannery and Mincyte (2010) ANT is especially used as one of the ways to follow food chains – connecting where food is produced, packaged and shipped, to where it is consumed and potentially wasted.

The second qualification that Law (2009) makes is that ANT is not a theory, as it does not explain why anything happens but instead is descriptive. He argued that ANT tells “interesting stories” of how relations form or do not. The third qualification he presents is the claim that ANT does not actually exist as a standalone 'it' or entity, but instead overlaps with other intellectual concepts and/or methods and is better thought of as material semiotics. Law's (2009) fourth qualification is that “if all the world is relational, then so too are texts.” (Law, 2009: 142). Therefore, to beware of any text that discusses ANT with an overall view as it is more than likely not objective. Another key element to draw out from Law (2009: 145) is that ANT can be understood as “an empirical version of poststructuralism”. Law (2009) suggests that ANT could be thought as Michel Foucault's discourses or epistemes. ANT does not aim to explain why the network exists but is interested in the stability of the network, how it forms, how it can fall apart, and the infrastructure of the actor-networks. ANT has a refusal to accept traditional dualisms such as nature and culture or global and local (Burgess *et al.*, 2000), but instead looks for a flat, as opposed to a hierarchical, ontology in which humans are seen to produce or seek to control, other, non-human, entities (Phillips, 2005; Murdoch *et al.*, 2000).

Here are some key ANT terms that will be used throughout this research. An '*actant*', as already mentioned, is a human or non-human entity, which acts within and sustains the network (Michael, 2017). '*Associations*' are the links between actants, and are created when one actant forms a relationship with another actant and thus translates their interests to the same so that they exist in the network to work alongside each other, breaking some associations and aligning with other actants. A central concept to ANT is '*Translation*', which is to redefine an entity's interests or identity, a network in which all the actants agree that the network is worth building and defending. It is through translation that actants can be enrolled into the actor-network (Michael, 2017). In his study on the domestication of the scallops and the fishermen of St Brieuc Bay, Callon (1984) defined four moments of translation: '*problematization*', '*interessement*', '*enrolment*' and '*mobilisation*'.

'*Problematization*' is a term that refers to issues about an actant's identity and interests. It is the definition of the problem in a specific situation with an actant or group of actants and the

dependency that is then established (Callon, 1984). '*Interessement*' happens once the actants have been recruited by the problematization. The actants can lock in place in the network, submit to being integrated into the initial plan, or reject it, by defining its identity, goals, projects, motivations or interests (Callon, 1984). '*Enrolment*' involves creating a body of allies that are human and non-human by translating their interests so that they are aligned with the actor-network, and is how associations are formed. The enrolling of actants both social and material into the network forms associations, and is how networks become larger, more influential and durable. Power and connectivity are intertwined and networks, according to Cressman (2009), should be thought of as 'is this association stronger than another one?'. More simply the term 'enrolment' refers to the successful placing of entities into designated roles within a network. '*Mobilization*' is where all members of the network that are acting as a single agent are properly represented by spokespersons. An immutable mobile is a "general term that refers to all types of transformations through which an entity becomes materialised into a sign, an archive, a document, a piece of paper, a trace." (Latour, 1999). Immutable mobiles are always mobile; they allow new translations and articulations, the immutable mobiles grow as the network grows and more actants are enrolled.

A '*black box*' is another important concept in ANT, because it is seen to be a term applicable to many 'entities' identified within other approaches, with ANT working to 'open up' these entities by showing how they themselves are constituted from other actants and relations. For example, a human body is itself a network of constituent elements (e.g. limbs, organs, fluids, chemicals, bacteria) but the inner working of the body may not be of interest to everyone and therefore it can be thought of as a black box within some studies. Black boxes are resistant to problematization and can thereby act to form associations and build networks (Michael, 2017).

The terminology that is used in ANT is supposed to be a language that is neutral and abstracted. It means presuppositions can be avoided, in that to answer the who, what and how questions about networks requires empirically engaging with the actor-network (Michael, 2017). Michael (2017: 26) calls the terms 'vessels' "for tracing out the complexity and detail of network-building." To do this detailed fieldwork, observations and interviews need to be carried out such as to unfold the network. Latour (1988) describes how stories should be full of detail "We have to write stories that do not start with a framework but that end up with local and provisional variations of scale. ... Every time we deal with a new topic, with a new field, with a new object, the explanation should be wholly different. Instead of explaining everything with the same cause

and framework ... we shall provide a one-off explanation, using a tailor-made cause.” In essence ANT accounts aim to be stories full of detail (Michael, 2017).

Murdoch (2001) believes the main criticisms of ANT stem from language. Firstly, the terminology that is used in ANT is not necessarily as novel or innovative as its supporters assume. It is argued that the language does not do anything that conventional sociology does not, so ANT provides very little analytical insight. The second criticism that Murdoch (2001) provides is that the co-constructionist perspective adopted by ANT does not reflect the socio-natural world in reality. This is also a criticism of Bloor (1999a) and Bloor (1999b), who feels that the co-construction of nature and social entities in theory is feasible, but when applied to reality it reduces everything in the real world to a series of relations, networks and associations that cannot possibly do justice to what is actually happening. Another issue of ANT voiced by critics is that it is too descriptive and therefore not practical enough. Latour (2005) states how in ANT social forces do not exist in themselves and therefore ANT cannot be used to explain social phenomena, it can only describe social activity once empirical analysis has been carried out. For critics such as Amsterdamska (1990) the inability to provide explanations of social processes is a huge failing of ANT. However, this research is looking at cheese actor-networks empirically in detail so explanations of the social processes were not essential. The focus was more on how sustainable cheese-actor-networks form and the relationships between actants.

This research is using ANT to explore how cheese actor-networks are built or assembled and maintained to achieve sustainability. ANT has potential to be important, as the whole food system is a network of human and non-human actants who are linked by associations and aligned interests. ANT will allow for the relational ties within the cheese actor-networks to be fully explored. One of the elements that this research is drawing from ANT is the ability to look at food systems in more empirical detail such as in the work of Whatmore (1999). The concept of actants and associations in the formation of networks is also taken from ANT to use in this research. As mentioned already in this section, actant is used to denote human and non-human actors and the network takes shape because of the associations between actants; in a cheese actor-network there are a number of different actants. There are many human actants across a cheese-actor-network these include for example: farmers, cheesemakers, retailers, and consumers. Non-human actants could be natural, ‘more than human’ or technological actants, in the cheese actor-network. Natural actants in the cheese actor-network include grass, for example. Animals could be considered as natural actants but in this research the animals in the network are considered more than human as they are actants that are managed by humans (i.e.

they are fed and milked). Natural actants are being categorised for the purpose of this research as actants that could survive without human interference. There are also technological and 'more than human' actants. Technological actants in the cheese actor-network are humanly created but non-human elements, for example the cheese. It may be argued that the animals in the sustainable intensification are more 'more than human' than the eco-localist animals because of the level to which they are being managed, as the animals in a sustainably intensive network are often artificially inseminated, for example. Technological actants could be the vat, the cheese cutters, or the milking system.

This research is also drawing on the flat ontology presented by ANT and the division between micro (local) and macro (global) networks is not assumed. There are differences in size between these levels but viewing through ANT allows for the rejection of conventional distinctions and dichotomies between the sizes of the networks. This helps for viewing eco-localism and sustainable intensification as existing on a continuum, as they are not discrete entities. ANT's ability to map networks is also being used in this research to help fully understand the cheese-actor-networks so that actor-network diagrams can be produced.

2.6.1. Assemblage Theory – a potential alternative

This research has decided to draw on ANT because of the reasons above. However there are other theories that this research could have considered. Taking into consideration the nature of the PhD and the parallels that are drawn with ANT, Assemblage Theory would have been the other obvious theory to apply to this research. Assemblage theory is concept that is associated with French philosophers Gilles Deleuze and Félix Guattari. Deleuze defines an assemblage as "it is a multiplicity which is made up of many heterogeneous terms which establishes liaisons, relationships between them across ages, sexes and reigns – different natures. Thus the assemblage's only unity is that of co-functioning: it is a symbiosis, a 'sympathy'. It is never filiations which are important but alliances, alloys; these are not successions, lines of descent, but contagions, epidemics, the wind." (Deleuze and Parnet, 1987: 69). Muller (2015b:28) puts this more simply as "assemblage is a mode of ordering heterogeneous entities so that they work together for a certain time." There are no predetermined hierarchies and no single organising principle. Deleuze and Guattari do not necessarily see assemblages as a theory but instead as an analytical tool, whereas DeLanda's (2006) work has been an attempt to construct an assemblage theory (Muller, 2015b).

Even without delving into the many discourses of assemblages and Assemblage Theory, from the brief description in the above paragraph it can be seen that there are many similarities between Assemblage Theory and ANT so much so that Law (2009) believes there is little difference between agencement (French for 'assemblage') and actor-network. Muller and Schurr (2016:217) summarise the similarities between Assemblage Theory and ANT well:

- They both have a relational view of the world, action occurs from the linking of initially unrelated elements.
- Both emphasise emergence, where the whole is more important than its parts.
- Both have a topological view of space.
- Both emphasise the importance of the socio-material, there are associations of human and non-human elements.

Along with the similarities, there are also differences that exist between the Assemblage Theory and ANT. Muller (2015b) notes three major differences, the first difference is that ANT only considers what exists in the network and therefore there is nothing outside associations. ANT is criticised for being blind as to what shapes networks that are outside of an association. Whereas assemblage thinking hypothesises that beyond associations there are components that can shape the assemblage. The second major difference is that ANT provides a more set methodological approach that can be followed when undertaking empirical work. This makes ANT much more applicable than Assemblage Theory for empirical work. For example Latour (2005:9) talks about 'trail-sniffing', this research follows the cheese throughout the network, the cheese is sniffed, trailed and traced from farm to fork. The third major distinction made between ANT and Assemblage Theory by Muller (2015b) is that researchers working with ANT in mind have a much clearer view of ANT's relation to politics, parts of the network can partake and reshape the process of governing which can cause controversy.

This research considered the use of Assemblage Theory for this research. However there were several reasons why ANT was chosen instead. Firstly the networks that were studied for this research, the networks have an aspect of linearity to them, the cheese goes through the network; there is an element of linearity in ANT. However in Assemblage Theory there is no aspect of linearity. Another reason why ANT was preferable over assemblage theory is one of the differences identified by Muller (2015b) is that ANT has a more concrete approach to empirical work. There was a method that could be followed, the cheese was traced through the network from farm to fork. Thirdly and possibly the most important reason that ANT was chosen

as a theoretical framework for this research is because there are the similarities that were spotted early on in the research between ANT and the system development methodology used in a branch of computer science called i*. Lastly, a social science lecturer inspired me, theory was not prevalent in my educational background and in the early stages of my PhD I attended lectures as part of the Social Science Doctoral Training Programme. Here a lecturer spoke passionately about ANT and it led to me reading a lot on ANT and that was when I first spotted the similarities to the i* framework.

ANT is compared to the system development methodology, the i* framework. A possible methodology of using ANT and i* in tandem was then investigated and proposed in this thesis, ANT is used in information systems (IS) research and has a considerable potential to contribute to understanding of socio-technical systems (Walsham, 1997). ANT as identified in the above section has a number of weaknesses, i* has the potential to address some of the ambiguities surrounding ANT. The i* framework and ANT have many parallels and therefore are able to be used together, this is discussed in more detail in Chapter 3, where the notion that the i* framework could be used to make ANT more practical is explored and a methodological framework using both ANT and i* is proposed.

2.7. Chapter Summary

This literature review has outlined the literature that is pertinent to this research. As the above discussion highlighted, there has been a move towards food geographies and networks. Food was previously discussed in the geographies of agriculture literature but mainly as a raw commodity. In more recent years, there has been a shift to the geographies of food, where research tends to have focused on venturing beyond the farm gate to consider the food network as a whole. This research has taken a wider food system perspective that has allowed for all actants in the food chain to have agency (Winter, 2003). This research is concerned with sustainable approaches for cheese actor-networks and the above discussion has raised the debates surrounding sustainability. Also discussed in many sustainable studies, the environmental aspect of sustainability is more prevalent and there is a lack of focus on the socio-economic aspects of sustainability. This research intends to fill that gap in the literature by encompassing all three pillars of sustainability in relation to cheese actor-networks.

This research has decided to study approaches that have attempted to make the conventional and alternative systems discussed by Marsden (2006) more sustainable. Those chosen

approaches are sustainable intensification and eco-localism. In sustainable intensification debates there is a need for a greater body of empirical work looking at how sustainable intensification can be applied beyond the farm gate and there are significant gaps in the literature that this thesis will start to address. There is a lack of discussion on the sustainability of cheese networks. LCAs go some way in addressing the sustainability of cheese but purely from an environmental perspective. There is a lack of research of the benefits for eco-localism and sustainable intensification and of thinking of them as being on a continuum as they are not discrete concepts. There is also a lack of cheese systems being viewed from a sustainably intensified and eco-localist perspective. This research addresses that in Chapter 4, by creating criteria for sustainably intensive and eco-localist cheese. There is a lack of environmental, social and economic sustainability problems for cheese actor-networks, which chapter 6 addresses by collating a list of sustainability issues and potential solutions for the specific cheese-actor-networks studied.

In the above discussion the usefulness of ANT to look in detail at food networks was highlighted. This research is interested in cheese actor-networks and there is an absence of ANT being used to view cheese food systems. Both senses of the non-human are crucial to this study, although studies employing ANT have often focused on the technological side, except from within geography where they have been much more focused on the natural. This research will be using detailed specific case studies to achieve close observation of the processes involved in the construction of a network. ANT is adamantly empirical, and as such, yields useful insights and tools for sociological inquiry in general. Chapter 5 uses empirical studies to address the lack of ANT in cheese studies to illustrate in detail the actants and associations at three different cheese actor-networks.

In the introductory chapter, interdisciplinary research was discussed and its advantages considered for use in this research. Geography and Computer Science are well placed to investigate and critique sustainability problems and solutions for cheese actor-networks. In the above discussion the critiques of ANT were examined, with the critique that this research is particularly interested in being that ANT is habitually descriptive. Therefore, in Chapter 3 this research addresses that critique and proposes a framework of using both ANT and *i** for addressing sustainability problems. In the above discussion, potential computer science connections to ANT were raised and in Chapter 3 a link is investigated between the system development methodology, the *i** framework, and ANT in an attempt to make ANT more practical. There are distinct gaps in understanding cheese-actor-networks from a geographical

and computer science perspective. Chapter 3 discusses further developments that will contribute to new interdisciplinary research methods. It introduces a mixed methodology drawing on elements from ANT and Computer Science.

This literature review has highlighted the relevant research for this thesis. The chapter has addressed the gaps in the literature and why the aims and objectives were laid out as they were in Chapter 1. The next chapter is the Methodology Chapter, which sets out which methods will be used to achieve the aims and objectives.

3 Methodology

This research used a contextualised case study approach using ANT as a flat ontology, the research assessed the character of a range of different networks. Case studies were selected across the sustainable intensification – eco-localism continuum that was introduced in the previous chapter. The flat ontology may be better thought of as ‘anti-dualism’ sustainable intensification and eco-localism are thought of as on a continuum, there are no hierarchical presumptions about the two concepts.

This chapter details the methods that were used throughout this study and is arranged by the aims and objectives of the research. For each objective, it is discussed what techniques were used in order for that objective to be achieved.

A reminder of the aims and objectives can be seen below:

Aim 1: Identifying eco-local and sustainably intensified cheese actor-networks

Related objectives:

- 1.1 Identify cheesemakers in England with an interest in sustainability
- 1.2 Establish and create a criteria for sustainably intensified and eco-localist cheese
- 1.3 Identify sustainable intensive and eco-localist cheesemakers
- 1.4 Select of case study actor – networks

Aim 2: Understanding the dynamics of actor-networks

Related objectives:

- 2.1 Map the networks
- 2.2 Explore the different discourses of sustainability within the network and explore connections to notions of eco-localism and sustainable intensification
- 2.3 Look at the interactions between the actants that link to sustainability

Aim 3: Problems and solutions in realising sustainability for cheese actor-networks

Related objectives:

- 3.1 Identify problems in the sustainable cheese networks
- 3.2 Establish and evaluate suitable solutions
- 3.3 Develop and critically assess a suitable system development methodology

A range of methodological techniques was applied to conduct this research including ethnographic methods, questionnaires, interviews, a web-based investigation and the implementation of a system development methodology. These techniques and more are discussed in further detail in the next few sections relating to the aims and objectives that they are striving to achieve.

3.1 Identifying eco-localist and sustainably intensified cheese actor-networks

The following steps were accomplished for the identification of eco-localist and sustainably intensive cheese networks in England. First, an initial list of cheesemakers in England was compiled. Second, the cheesemakers were contacted and asked to provide information so that it could be determined if they were eco-localist or sustainably intensive. In order to do this, a criteria had to be formulated to establish on what grounds it would be decided whether the cheesemaker displayed characteristics that are predominately eco-localist or sustainably intensive.

3.1.1 Identify cheesemakers in England with an interest in sustainability

The best practical way to identify cheese actor-networks in England was to first to identify the cheese and the cheesemaker, and from there establish the network. As cheese was decided as the entry level to the network, a list of cheesemakers in England needed to be compiled. The Food Standards Agency provided a list of establishments that handle or process any dairy product, but unfortunately the list did not specify the dairy product establishments handled.

The Food Standards Agency (2014) list was of 821 approved milk and dairy product establishments throughout England. Establishments that handle liquid milk and dairy products in Great Britain have to be approved by local authorities and are therefore subject to any controls that are implemented by them. They also have to be approved by the Foods Standards Agency (Food Standards Agency, 2014). This study decided to focus on just the cheese establishments in England as a list of dairy establishments for the whole of the UK would have been time consuming to process, being over 1,200 establishments long. Each establishment from the list underwent a web-based investigation to find out initial information about the establishment to ascertain if they produced cheese. Relying on web-based information clearly may exclude some who do not maintain a website, 40 of the cheesemakers identified did not have a website for example. Once the list had been reduced to just the cheesemakers in England, further information was obtained from their websites. This information included what type of

cheese business they were, such as: a cheesemaker or a dairy cooperative that makes cheese; and how many farms supply their milk if they do not produce it themselves.

The investigation also recorded whether the establishment had any sustainability or environmental policies in place, along with any mention of the word sustainability or any paragraphs on the website relating to sustainability. This was to establish if the organisation already had an interest in sustainability. This was important because if the establishment was already conscious of environmental/sustainability issues or had an interest in sustainability, then they were more likely to qualify as being eco-localist or sustainably intensive as they are both approaches to sustainability as discussed in Chapter 2. Finding out if they had an interest in sustainability was also important because it may be indicative of them being more likely to participate in the study. The outcome of the research has the potential to make cheese actor-networks more sustainable. Therefore, a cheesemaker who has an interest in sustainability may want to improve upon their sustainability. Sustainability can always be improved upon and it is highly unlikely that a business would not be able to improve on what they are already doing, this links back to the discussion in Chapter 2, where Rittel and Webber (1973) describe sustainability as a problem that can only be achieved for better or worse and not ever achieved because it has no clear end-point.

Again relying on website information may exclude establishments that seek to be sustainable but do not choose to include this on their website. Having said this, sustainability is widely viewed as a being marketable and it might be expected that establishments who are seeking to be sustainable would wish to advertise this point within their websites. Once the list of cheesemakers who had an interest in sustainability had been assembled, it was important to ascertain which of the establishments were sustainably intensive and which settings were eco-localist, so criteria were developed for both.

3.1.2 Establish and create criteria for sustainably intensified and eco-localist cheese

The formulation of criteria for delimiting both sustainable intensification and eco-localism was important, as it had already been established that the cheesemakers were interested in sustainability so the research was interested in what approaches it had adopted. The criteria had to be based on certain specific characteristics rather than just a subjective judgement. The criteria were based upon an EU Synthesis Report on 'Options for sustainable food and

agriculture in the EU' by Underwood *et al.* (2013) and the sustainable intensification and eco-localist literature discussed in Chapter 2 (especially Garnett and Godfray, 2012; Garnett *et al.*, 2013; Godfray and Garnett, 2014; Curtis, 2003; North, 2010). The literature was used to decide which of the options in the EU report would qualify as sustainable intensification or eco-localism. The criteria had to be specifically engineered for cheese as there were no specific criteria for sustainably intensive and eco-localist cheese.

The final criteria for both sustainable intensification and eco-localist cheese networks can be found in Chapter 4.

3.1.3 Identification of sustainably intensive and eco-localist cheesemakers

Once the criteria had been formulated, the cheesemakers were approached for the first time and, in order to collect further information from them in order to see if they practised eco-localism, sustainable intensification, or neither according to the criteria. The criteria were translated into a short questionnaire that was sent to a contact email address, wherever possible a person rather than a generic business email contact. In a sense, therefore, the sampling strategy used in this study was a purposive one, as an invitation was sent to participate in the study to all cheesemakers that satisfied a common characteristic (McGuirk and O'Neill, 2016). In this case they had an interest in sustainability. The decision to use a questionnaire sent electronically was factored around ease of use and the convenience of respondents not having to leave their computer in order to return a questionnaire, making it an efficient method for them to complete the survey (McGuirk and O'Neill, 2016).

The main types of email questionnaire are embedded and attached. An embedded email questionnaire has the set of questions in the email itself and an attached email questionnaire is an email with the questionnaire attached as a separate document (Bryman, 2016). There is also a third option where a potential participant is emailed with a link to a web based survey (McGuirk and O'Neill, 2016). This study decided to include the questionnaire as an attachment. You could argue that an embedded questionnaire would have been the most efficient form as it requires the least computer knowledge (e.g. it does not require downloading an attachment, completing the form and then reattaching the document to return it (Bryman, 2016). This research could also have provided a link in an email to an online survey but decided not to so that all the questions could be viewed on the same page so that respondents would know that there were not too many questions. The main reason for using an attached document was that

this enabled the inclusion of a questionnaire with drop down menus and click boxes, which made it easy for participants to complete the questionnaire. It was also felt that it looked more professional and it was easier to read due to the formatting. A copy of the email that was sent to the cheesemakers can be seen in Figure 3.1.

Dear _____,

I am a PhD student researching sustainable cheese making. I have identified your company as being involved in this activity and would really appreciate learning more about your business. I have written a short questionnaire which is attached and I would really appreciate it if you could spare the time to fill it in (it should take around five or so minutes). Also attached is an information sheet that outlines more about who I am and what my research involves.

The questionnaire document has drop down menus and click boxes, if for any reason you cannot see these or you experience any problems in completing them please do get in contact as these forms may not work on some operating systems, in which case I will send you a different version of the questionnaire.

Look forward to hearing back from you soon. If you have any questions please don't hesitate to get back in touch

*Kind regards,
Hannah Brooking
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University Road,
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E: hb110@leicester.ac.uk*

Figure 3.1 - Copy of the email that was sent with the initial questionnaire and information sheet to the cheesemakers.

The questionnaire had sixteen questions over five sections: 'Characteristics of your business', 'Source of milk', 'Your farm', 'Cheesemaking' and 'Further Research'. The questionnaire was designed to take no more than five minutes to complete and included a range of mainly closed questions as it was just an initial investigation to see if their business qualified as either sustainably intensified or eco-localist. Closed questions are easily analysed but one of the drawbacks is the responses are limited to a range of categories designed by the researcher (McGuirk and O'Neill, 2016). Therefore an 'other' option was added to many of the questions, with a text box provided where respondents could expand on their response if required. Two of

the questions from the questionnaire showcasing the 'Other' option can be seen below in Figure 3.2.

5. Where do you source your milk from? (tick all that apply)

- a. Own farm ☐
- b. Other farms ☐
- c. Dairy ☐
- d. Other source ☐

If Other, please specify: [Click here to enter text.](#)

8. How many of the following dairy animals do you own for producing milk?

Cows: [Click here to enter the number of cows.](#)

Goats: [Click here to enter the number of goats.](#)

Sheep: [Click here to enter the number of sheep.](#)

Other: [Click here to enter the number of other animals you own for milking.](#)

If Other, please specify: [Click here to enter text.](#)

Figure 3.2 - Questions from the initial questionnaire showing examples of the 'Other' option and a space to be more specific.

Another issue with closed questions is that they rely on all of the words, categories and phrases that have been provided by the researcher having the same meaning for each respondent (McGuirk and O'Neill, 2016). This is a risky assumption in some cases: it has already been shown in Chapter 2 that terms such as sustainability have multiple interpretations. However, closed questions are extremely convenient for seeking quantitative attributes about a respondent, especially when determining if they fit a particular categorical entity, such as, in this case, sustainable intensification or eco-localism. Consequently, closed category questions were used quite frequently in this questionnaire as well as grid questions. Examples can be seen below in Figure 3.3 and Figure 3.4.

14. Where do you sell your cheese to? (tick all that apply)

- Own farm shop ☐
- Farmers markets ☐
- Local delis and independent stores (within 30 miles) ☐
- Non-local delis and independent stores (beyond 30 miles) ☐
- Local pubs, restaurants and other eateries (within 30 miles) ☐
- Non-local pubs, restaurants and other eateries (beyond 30 miles) ☐
- Local supermarket branch ☐
- National supermarket chain ☐
- Wholesalers ☐
- Other ☐

If Other, please specify: [Click here to enter text.](#)

Figure 3.3 - A closed question from the initial questionnaire

11. Do you undertake any of the following practices or intend to in the near future (tick all that apply):			
	Already doing	Planning to in the near future	Not doing
a. Adjusting dietary intakes or feeding techniques to maximise production	☐	☐	☐
b. Artificial insemination of dairy animals	☐	☐	☐
c. Stocking rare breeds	☐	☐	☐
d. Taking action to improve animal health and welfare	☐	☐	☐
e. Using of artificial fertilisers	☐	☐	☐
f. Reducing fertiliser use	☐	☐	☐
g. Increasing fertiliser use	☐	☐	☐
h. Using smart technology for fertiliser application	☐	☐	☐
i. Protecting or restoring natural or semi-natural grassland.	☐	☐	☐
j. Restoring or establishing landscape features (e.g. hedges, treelines, woodland patches, terraces, ponds, stone walls)	☐	☐	☐
k. Decreasing grazing density	☐	☐	☐
l. Using wind power or solar power	☐	☐	☐
m. Using anaerobic digestion	☐	☐	☐

Figure 3.4 - A closed grid question from the initial questionnaire

Of course, one of the main shortcomings of an email questionnaire is that qualitative research is often most effective when carried out face to face (McGuirk and O'Neill, 2016). However, this questionnaire was just an initial enquiry before more in-depth research involving interviews and ethnographic methods, as will be discussed in the rest of this chapter. As a result it was deemed that a questionnaire was an appropriate method to apply in this research context. A full version of this initial investigatory questionnaire can be found in Appendix 1.

A further potential short-coming of emailed questionnaires is that they have low response rates although a much higher response rate than a postal questionnaire (Alan, 1998). It was thought that the response rate to this questionnaire would be higher than identified in studies that have used emailed questionnaires to a general population because of the employment of purposive sampling strategy which implied that interest in the research topic would have been strong. However, the number of responses received back was not as high as expected. The reasons as to why are discussed in Chapter 4. The questionnaire data was entered into Microsoft Excel and analysed, before being presented using a series of tables and graphs.

3.1.4 Selection of case study cheese actor-networks

Once it had been decided whether the cheesemakers were either sustainably intensive or eco-localist, the case studies were selected for the research. The last question on the questionnaire asked respondents to indicate if they were interested in participating in further research. This meant that if they were suitable and qualified as either sustainably intensive or eco-localist, they could be chosen as a case study. This suitability was decided after, and involved assessing whether they satisfied the criteria of either sustainable intensification or eco-localism

categories. In total 8 out of the 34 cheesemakers replied to the questionnaire, out of these 8, 2 were qualified as eco-localist, 3 were qualified as sustainably intensive and 3 as a combination of both. This exploration can be found in more detail in Chapter 4. Four case studies were chosen in total, one for the pilot study, and then three for the main study. Of the three case studies chosen for the main study, one was sustainably intensive, one was eco-localist and the third showed both sustainably intensive and eco-localist characteristics and was therefore an intermediary case study. Throughout Chapter 4, a series of maps are shown to display the location of the cheesemaker establishments. These maps were created in the open source GIS software, QGIS.

3.2 Understanding the dynamics of actor-networks

The case study locations were decided and initial information about the cheesemakers and their networks collected from the initial questionnaire. The next stage was to explore and understand the dynamics of the actor-networks, which require the achievement of a number of research objectives as highlighted in Chapter 1: the networks mapped; the different discourses of sustainability within the network explored; and the links between the actants and sustainability investigated. A range of different methods were employed to achieve this, including ethnographic methods as well as questionnaires and interviews, this study involved multi-method research which were all employed at each case study (Handwerker, 2001; Phillips, 2014). As already mentioned, this research is interested in the whole networks from farm to fork and therefore needs to engage with actants across the network. Different modes of collecting data were developed for different parts of the network because some methods were more appropriate than others to particular actors within the network. The following sub-sections detail the range of data collected and analysed across these networks, linked to achieving my research objectives.

3.2.1 Map the actor-networks

To fully understand the network and its dynamics, the network was mapped by using ethnographic methods, interviews and questionnaires, which followed the cheese and more to establish the different actants, both human and non-human, throughout the network. Following the cheese through the network is connected to the notions of ‘following the thing’ outlined by people such as Ian Cook. ‘Following the thing’ research was initially energized by Harvey (1990) who called for geographers to “get behind the veil, the fetishism of the market” to re-connect consumers and producers, this re-connection was discussed in Chapter 2, in order to tell fuller

stories of the food system, from farm to fork. Cook (2004) used ethnographic research to journey through a supply chain from a Jamaican farm to UK supermarket shelves and then onto a North London flat, following a papaya.

Ethnographic methods was favoured over a full ethnography, the term ethnographic methods is also favoured by the following authors such as Gray (2002), Matthews *et al.* (2005) and O'reilly (2012). A full-blown ethnography, or participant observation as it is sometimes known, is where a researcher “immerses him- or herself in a group for an extended period of time, observing behaviour, listening to what is said in conversations both between others and with the fieldworker and asking questions.” (Bryman, 2016, pp. 423). Therefore a full-blown ethnography involving sustained participant observation was not carried out, as continued access to the actor-networks would have been extremely difficult as many of the participants were farmers or cheesemakers, both which have very busy schedules. Fetterman (2010), writes how not all researchers have the luxury of completing a full-blown ethnography due to time constraints, therefore elements of a full-blown ethnography can be teased out and used instead. The amount of access also varied at the different case studies, depending on how much time each one could commit. Elements of this were applied but only certain ones, hence the use of ethnographic methods and not a full ethnography. The elements that were applied included being immersed in an environment, observing behaviour, listening to conversations and asking questions. This study differed from a full-blown ethnography because the researcher was not immersed in the environment for an extended period of time. The time I spent at each case study varied and so did my role as a researcher, as this depended on the case studies’ constraints. As with an ethnography, for ethnographic methods to be applied it had to be decided if my role was overt or covert and what type of setting I was going to.

Covert roles are often adopted to overcome an access problem (Bryman, 2016), such as, if the researcher discloses that they are undertaking research then their research subjects may not open up to them or not let them become a participant in the setting because they are a researcher, or else may alter their behaviour as they know they are being observed by a researcher. I, however, adopted an overt approach as I was honest about what I was researching and what my research entailed involved in the community or relevant setting. Settings, which are often differentiated into open/public or closed settings. An open/public setting is likely to be a community, such as a community of British expatriates living in the Costa del Sol (O'Reilly, 2013) or a group of football fans (Pearson, 2012), whilst a closed setting is likely to be an organisation or a firm. In my research both types of settings were present across the cheese

actor-networks. The cheesemakers, for example, were a closed setting as were farms that provided the milk. However, when I was observing customers this was a public setting, as it was a community of cheese buyers that I was observing.

At the first case study, my role was much more of a participating observer. I was volunteering for the business when I was there and I lived on the farm; I was fully involved in the main activities, albeit only for 2 weeks. The activities I undertook whilst on the farm included bringing the sheep in from the fields with the sheepdogs, milking the sheep, making the cheese, going to market, selling the cheese and talking to the customers. However, at the other two settings, I was mainly a non-participating observer with interaction, this meant I was observing but not participating in the day to day activities and the interactions of the business but I did converse with people from the organisations through interviews and questionnaires (Bryman, 2016). Having different approaches to the observations could have caused different results from each different setting. The different approaches to observations caused the following differences at each organisation: at the first case study a stronger rapport was built up between myself and the participants, whereas because I was not actively participating in any of the activities at the other two case studies, the rapport was not as strong. Therefore, the information gathered could be biased, however this research feels that the information gathered was not affected by the strength of the rapport because rich information was still gathered from all three actor-networks.

Mapping the network was mainly done through observations or ethnographic methods but interviews and questionnaires were used to a certain extent to find out more information about the network itself and where the cheese travelled to after it had been made.

At each case study, semi-structured interviews were conducted with key participants along the network. In every case a farmer was interviewed along with a cheesemaker. At the sustainably intensive case study, with it being a larger setting, more participants were interviewed along the network as there were more key people involved in roles such as directors, finance managers, sales and marketing representatives as well as a cheesemaker and a farmer.

Semi-structured interviews were used as a means of obtaining information, as these allowed for the departure from the interview schedule where tangents could be opened up and 'rambling' was encouraged (Bryman, 2016). I did not want the interview to be solely lead by my questions as I had a greater interest in the interviewee's point of view. The more the interview was not

structured by my questioning, the richer and more detailed the responses to the interview were. However, as is the nature with semi-structured interviewing, there was still the option of having a guide of questions to follow so that even if the interview diverged, most of the topics were still covered. Semi-structured interviews were also the most appropriate interviewing technique because the research had multiple cases. Therefore, for cases to be comparable there needed to be some sort of structure that was sometimes adhered to.

A variety of question types were used when interviewing participants. A section of the interview would generally start with an introductory question such as 'Tell me about...' and then follow-up questions would be asked to get the interviewee to expand on their answer if necessary. In the interview guide under the introductory question, there was a checklist of topics, in brackets, that I hoped they would talk about. If they did not, I would ask follow-up questions relating to the items not covered in the checklist. Often, as well as a follow-up question, a probing question would be asked such as 'Could you tell me more about...?' and these questions were not scripted in the interview guide or schedule. Structuring questions were often used to move onto another topic 'I am now going to ask you some questions on...' (Bryman, 2016). One of the interview techniques used was to interview the key actants to find out more about their setting and their cheese actor-network was to show them a network diagram. This network diagram was my perception of their cheese actor-network from the information that I had gathered from the initial questionnaire and also their own websites. This way if I had made a mistake it was corrected and it prompted the interviewee to talk in more depth about each element of the setting and the actor-network. Using diagrams as a measure to aid the thinking process is now a well-accepted means. Mind maps and road maps, for example, are useful visualisation techniques (Bell and Morse, 2013). The network diagram that was shown to Case Study 2 can be seen in Figure 3.5, the other network diagrams are in Appendices 2 and 3.

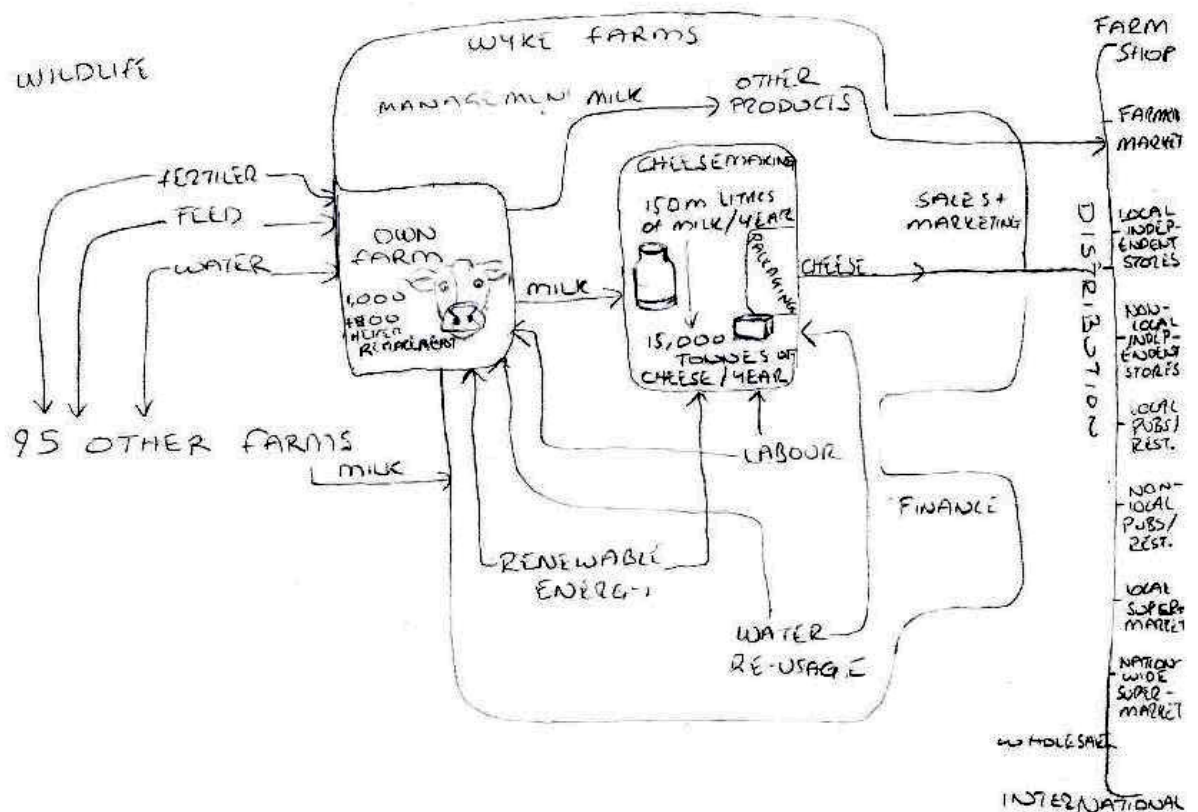


Figure 3.5 - Network diagram that was used as a prompt in the interviews for the second case study

The interviews were carried out in a variety of different settings, including on farm; in a cheesemaking dairy; and in a milking parlour, in order to explore the whole actor-network. Therefore, the semi-structured nature of the interviews allowed me to ask questions about what I could see in the setting, which was often completely off script.

Customers or consumers of the cheese were also identified as key actants in the network, because what they do when they get the cheese home could affect the sustainability of the cheese. However, semi-structured interviews were not suitable for obtaining information from the customers as they were either in a shop or at a farmers' market and this would have been too time consuming for the public to complete when out shopping. Therefore, a more convenient, less time consuming questionnaire was developed for them to complete in no more than 5 minutes. This questionnaire was a paper questionnaire that was handed out to shoppers. At the first case study customer questionnaires were left on the tables at the farmers' market where customers were drinking tea or coffee. This way, they could fill them in at their own leisure. This method worked out well as the customers could lean on the table to write and they were interested in the topic of my research, 7 consumers of Middle Campscott cheese filled in

a questionnaire which does not seem a lot but Middle Campscott in the time I was there did not have many customers. For the second case study, my contact at the company gave out the questionnaire in supermarkets to people buying the cheese. This method was less successful as customers were either not interested or too busy with their shopping. To overcome this, the questionnaire was converted to an online questionnaire, using SurveyGizmo, as a higher number of responses was required than in the other case studies to be more representative of the number of customers the company has.

The online questionnaire that was created in SurveyGizmo was posted onto an online community group in Leicester, where the cheese is sold in the supermarkets locally and aimed for a target population of people who just ate this case study's particular cheese. However, to increase the response rate it was formulated for cheese eaters in general. One of the questions asked which brands of cheese the respondent ate or bought regularly. The data for respondents who replied that did not buy the cheese from this case study was simply excluded from the dataset for this project. In total 169 consumers filled in the online survey and 85 of these were Wyke Farm cheese consumers. The third case study, I gave out the questionnaire to their customers in their farm shop, which resulted in a 8 questionnaires being filled in and returned.

The questionnaire was 13-14 questions long depending on the case study and was centred on their cheese buying habits, how they stored the cheese and their thoughts about sustainability. Again, the sampling strategy used was purposive as the target population for the questionnaire was only customers who were buying the specific cheese in each of the networks. It was also opportunist, as it was decided that the best way to approach the target population would be as they were buying it, otherwise there would be no way of knowing if they had bought the cheese in question.

A questionnaire was also used at the second case study as they had over 200 people in employment. It would not have been possible to interview every employee, although it was felt that it was still important to establish what their views and thoughts on sustainability were in general and at the business they worked. Therefore, a short questionnaire was handed out to employees for them to fill in. The questionnaire for the employees and the customer can be found in Appendices 4 and 5 respectively. The response rate for the employee questionnaire was poor, only 4 responses were received, so it was converted to an online questionnaire using SurveyGizmo, and again, the link for the survey was then emailed to the gatekeeper for distribution to staff.

The plan was to trace and then interview as many different actants as possible across the cheese actor-networks including farmers, cheesemakers, retailers and consumers. This research sought to speak to a retailer (a large supermarket chain) that the sustainably intensive case study supplied. Unfortunately, this was not possible as the supermarket retailers did not allow access. This didn't stop the actor-networks from being mapped as it was possible to find out the identity of the supermarket retailers from the cheesemaker. It was frustrating however, as the sustainability discourses within the network were explored and it would have been valuable to speak to someone. In the research conducted by Schmitt *et al.* (2016), they only marginally took retailing into account because of limited access to data which is the issue that this study had.

With the network mapped using a range of techniques and information gathered from different actants in the network, it was then that the discourses of sustainability within the network could be explored.

3.2.2 Explore the different discourses of sustainability within the actor-networks and explore the connections to notions of sustainable intensification and eco-localism

When thinking about sustainability it is often thought important to consider the discourses of sustainability and this is touched briefly upon in Chapter 2. However, a much bigger project would be needed to explore all the discourses of sustainability, so instead this research considers the discourses of sustainability within the network. The discourse of sustainability is investigated within the networks because discourse is a part of the actor-networks. Each actants notion of sustainability is itself an actant along the network. As well as the sustainability immutable mobiles that form part of the sustainability discourse such as texts, printed materials, websites and leaflets.

To do this a discourse analysis was applied to the data collected from the interviews and questionnaires. Discourse analysis "emphasises the way versions of the world, of society, events and inner psychological worlds are produced in discourse." (Potter, 1997 as cited in Bryman, 2016, pp.146). Bryman (2016) also describes what a discourse analysis does: "Language is depicted in discourse analysis as constituting or producing the social world; it is not simply a means of understanding that world" (Bryman, 2016, pp.528). Gill (2000), describes four themes

in discourse analysis: discourse is a topic; language is constructive; discourse is a form of action; and discourse is rhetorically organised.

As previously mentioned, interviews and questionnaires were used to collect the data for the discourse analysis. The main questions that were analysed to ascertain the discourses of sustainability within the network were:

What do you understand by the term sustainability?

Also was examined:

Do you think adopting sustainability policies is important?

Other sources, such as websites and sustainability policies, were also examined to ascertain the discourses of sustainability within the network. NVivo was mainly used to analyse the discourses of sustainability within the network thematically. NVivo is software for qualitative data analysis, it enables unstructured data to be understood easier (QSR International, 2017).

3.2.3 Look at the interactions between actants that link to sustainability

Discourse analysis was also used to achieve this objective of looking at the interactions between actants that link to sustainability. The participants' thoughts and views of sustainability from across the different actor-networks were compared to the embedded sustainability of the business. The embedded sustainability of the business was agreed as being the practices they employ and have in place, and the visual aids they have such as websites, logos and brand.

3.3 Problems and solutions in realising sustainability for cheese actor-networks

After the cheese actor-networks had been mapped and the discourses of sustainability within the network had been explored it was possible to identify problems and solutions for sustainable cheese actor-networks. This was achieved by looking in more depth at the information gained from the interviews. This research also proposed a system development methodology that used interdisciplinary approaches, which could then have the potential to help identify additional problems and solutions for sustainable cheese actor-networks along with the qualitative data gathered in the interviews.

3.3.1 Identify problems in the sustainable cheese networks

As part of the research and as a contribution to the third aim - problems and solutions in realising sustainably for cheese actor-networks - the problems had to be identified within the cheese actor-networks. This was done in the interviews that were conducted with different actants across the network. Actants were asked a series of questions relating to problems. They were asked about specific problems facing the area they worked in, such as:

From a financial perspective what are the biggest problems/challenges facing the business?

Further questions were also asked about more general problems facing the whole business like the question below:

Are there any more general problems that you can think of that the company is facing?

Problems facing sustainability for cheese actor-networks were also established through ethnographic observations and also through the literature. The problems were coded in the qualitative analysis software NVivo. The i* diagrams, which are explained later in this chapter, were also looked at to establish sustainability vulnerabilities within the actor-networks. The problems were collated and can be found in Chapter 6.

3.3.2 Establish and evaluate suitable solutions

Once the problems for sustainable cheese within the actor-networks were established, possible solutions had to be investigated. Potential solutions to the identified problems were discussed in the interviews with the different actants along the cheese actor-networks. The problem questions were followed up by the question:

What possible solutions can you think of to solve any of the mentioned problems?

This allowed for the actants themselves to identify potential solutions and to discuss the feasibility of them. Solutions were also identified from the literature.

3.3.3 **Develop and critically assess a suitable system development methodology**

This research proposed to consider a system development methodology as part of its interdisciplinary focus, exploring whether this methodology could then have the potential to help identify additional problems and solutions for sustainable cheese actor-networks, as well have the capacity to make ANT more practical. This section gives a description of what a system development methodology is and then investigates a series of system methodologies that were assessed as to their suitability for modelling cheese networks in this research. The system methodologies that were investigated are waterfall, agile, soft systems methodology (SSM), goal question metric (GQM), test driven development, search based software engineering and GOAL modelling (more specifically the i* framework).

Designing systems that actually meet peoples' needs is a sizeable challenge for many requirements and systems engineers. This is mainly attributable to the fact that effective requirements are notoriously difficult to pin down (Yu *et al.*, 2011). This section assesses different system development methodologies and their ability to successfully produce requirements and/or develop or redevelop a system. The section then goes on to consider the methodologies' aptness for real world systems modelling and problem solving. But first, it is important to ascertain what a methodology is. To describe a methodology, Wilson (2001) first describes what it is not, argued that it is not a method or a technique. A method or a technique is prescriptive and if followed through correctly will produce a defined outcome, whereas with a methodology you are not necessarily guaranteed a result (Wilson, 2001). According to Wilson (2001) "a particular methodology is a set of guidelines which stimulate the intellectual process of analysis".

A software or system development methodology is a way to implement the software development life cycle (SDLC) (Crookshanks, 2013), being seen to refer to the framework that is used to structure, plan, and control the process of developing an information system. Development methodologies exist because of the complicated chaos that software development entails (Pressman, 2010) and they are commonly used by organisations and individuals who design software (Crookshanks, 2013). A selection of system development methodologies and system analysis methodologies have been chosen, reviewed and compared for their suitability to model the real world.

A series of system development methodologies was considered, with the first being the waterfall method. This is a sequential approach to software development where stages cascade from one into another. Each initiated stage must be completed before the next one is started (Sommerville, 2007; Pressmen, 2010). The main stages of a waterfall model are: requirements definition; system and software design; implementation and unit testing; integration and system testing; and operation and maintenance, as shown in Figure 3.6 below.

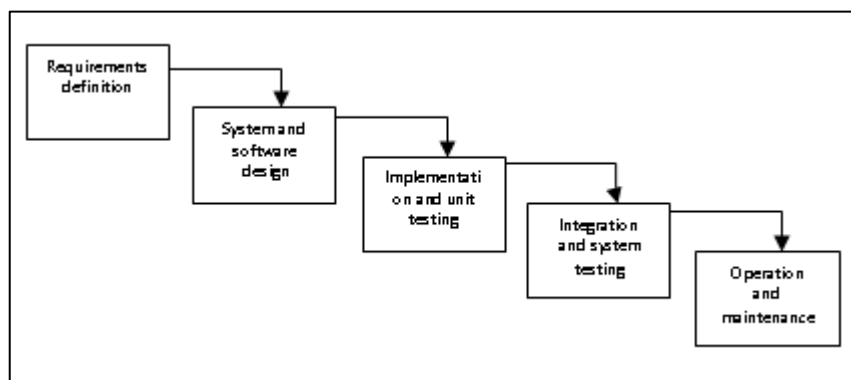


Figure 3.6- The Waterfall Model taken adapted from Somerville (2010).

The waterfall model can be applied if the requirements for a problem are clear and succinct. This is often the case when adaptations or adjustments are made to an existing case (Pressmen, 2010). Due to the strict linear process of the waterfall model, iterations can often be very time-consuming and costly. Because of this after a small number of iterations, development is often frozen and problems can be ignored. This could lead to the system not being what the user wanted (Sommerville, 2007). The waterfall method was deemed not suitable for modelling this research, as the problems for sustainable cheese are not necessarily clear and succinct.

The next to be considered were agile methods. This system development methodology is typically used to deliver useable, working software as quickly as possible to the user who can then suggest new requirements for later iterations. Agile methods first came to light in the 1990s as a response to being dissatisfied with the waterfall method that dominated the software process (Sommerville, 2007). According to Pressman (2010), agile software engineering is an amalgamation of a set of development guidelines and a philosophy. The main principles of agile software are defined by the Agile Alliance, which is an organisation that is devoted to enhancing agile development both in principle and practice. The 12 principles are outlined below in Table 3.1 (Agile Alliance, 2014):

Table 3.1 - Agile Principles (Agile Alliance, 2014).

1. Customer satisfaction.	2. Welcome changing requirements.
3. Deliver working software frequently.	4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals.	6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.	8. Agile processes promote sustainable development.
9. Continuous attention to technical excellence and good design enhances agility.	10. Simplicity.
11. Self-organizing teams.	12. Regular reflection on how to become more effective.

Sommerville (2007) identified the following as the key principles of agile methods: customer involvement; incremental delivery a focus on people not process; an embrace change and a concern to maintain simplicity. One of the most interesting principles for this research is Agile Alliance's principle number 8; agile processes promote sustainable development. More information on agile approaches can be found in Appendix 6.

Crookshanks (2013) argues that any method used to implement the software development life cycle falls loosely into waterfall or agile development category; there is no other category but these two have lots of different variations. So the eventual chosen system development methodology was bound to have some elements of agile development but this was not chosen as the specific system development methodology for this research.

The next system development methodology that was considered was Soft Systems Methodology (SSM). This is a 7-Stage approach that was first devised by Checkland (1993). The main outcome of SSM is a way of using systems ideas to solve problems. It is a step by step approach, the first stage of which involves defining an area of interest. A 'problem' is not identified as such at this stage, it is just the situation that needs to be defined and as much data as possible collected about the situation. The second stage involves the creation of a rich picture that includes structures, processes, climate, people, people's issues and conflicts. Sutrisna and Barrett (2007: 171) applied rich picture diagrams to model case studies of construction projects. One of their rich pictures can be seen in Figure 3.7. There are similarities between a rich picture and an ANT diagram. Parallels can certainly be drawn between the one shown in Figure 3.7 and the ANT diagrams that were produced in Chapter 5.

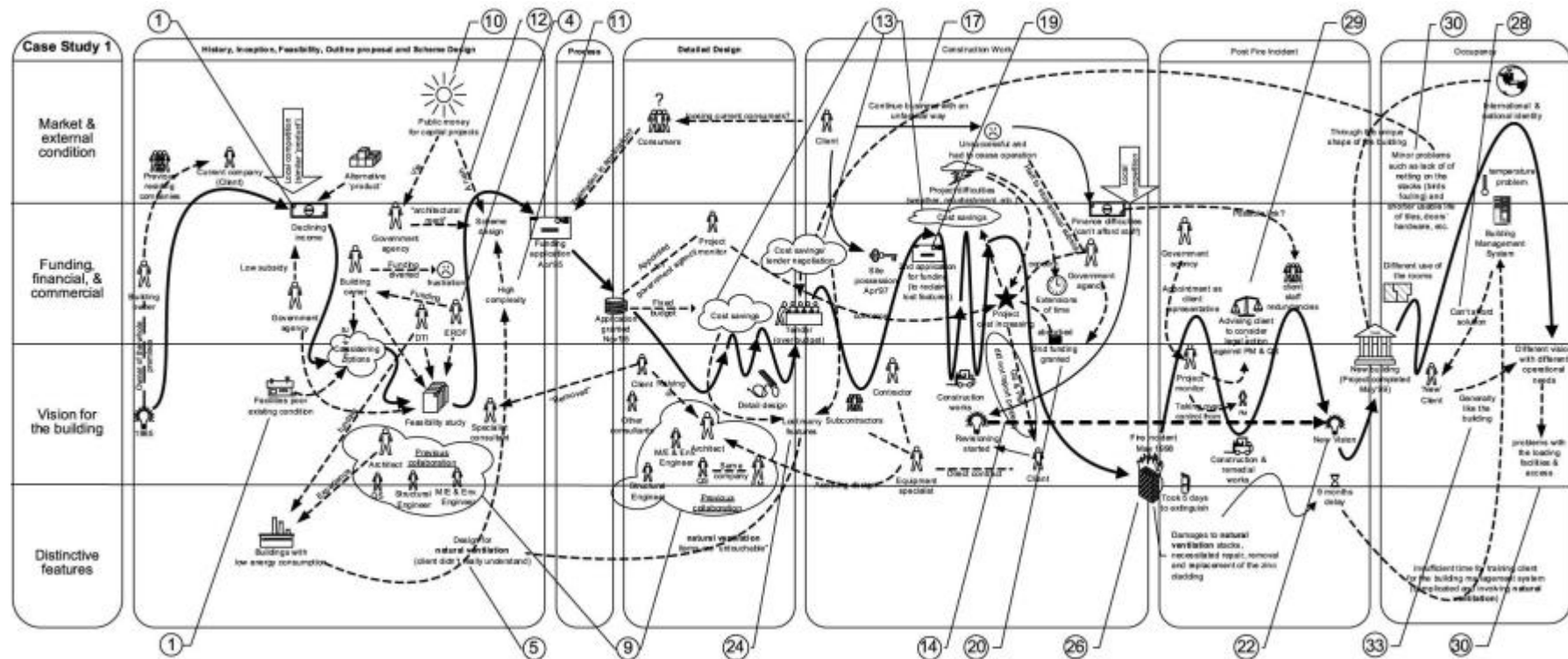


Figure 3.7 - An example of a rich picture diagram (Sutrisna and Barrett, 2007: 171)

The next stage of SSM, Stage 3 according to Checkland (1993), is called the 'root definition' where the move is made out of the real world and into systems thinking. The focus here is to understand and interpret different perspectives of the rich picture and draw them out - Checkland (1993) calls these 'holons'. These perspectives are then put through a model development process developed by Checkland and known as CATWOE (Checkland, 1993). Stage four involves developing a conceptual model and using systems conventions is drawn up, while Stage 5 compares the models with the real world. Stage 6 involves making any feasible changes to the model and Stage 7 is actually acting upon any changes that could improve the real world situation (Checkland, 1993). The different stages can be seen in Figure 3.8 (Checkland, 1993; Wilson, 2001).

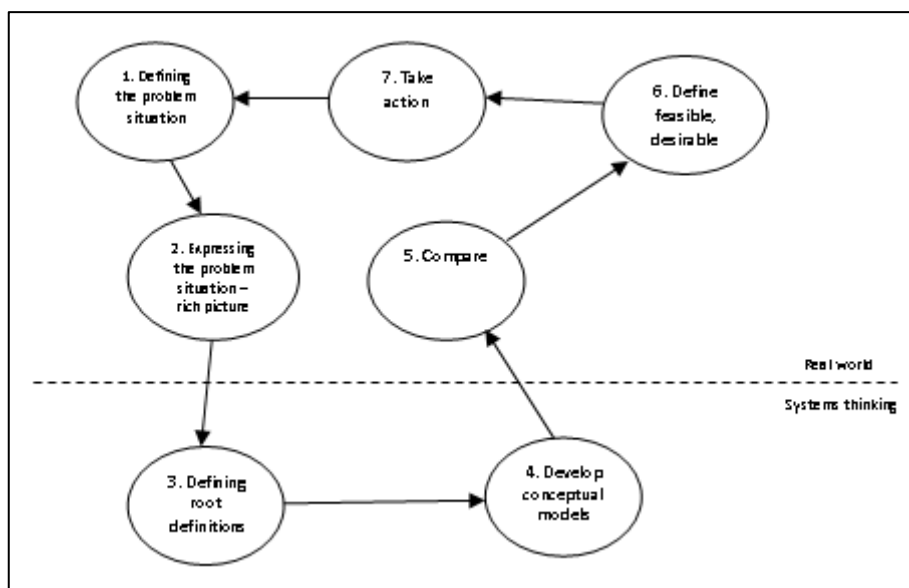


Figure 3.8 - The Checkland SSM methodology adapted from Checkland (1993) and Wilson (2001).

The SSM system development methodology was considered to have many useful attributes that could help in the decision-making process for sustainable cheese research. However, a lot of the steps in the methodology would almost happen naturally when thinking about problems for sustainable cheese, therefore this methodology was not chosen to be applied in full to this research, although certain attributes were applied alongside the chosen system development methodology. For example, the actor-network diagrams that were produced that can be seen in Chapter 5 are similar to the 'rich pictures' that Checkland (1993) advises modellers to produce to express the problem.

The next system development methodology that was considered is the Goal, Question, Metric Paradigm. This quite self-explanatorily consists of goals, questions and metrics and is a goal-

orientated software measurement approach. The goals, questions and metrics are in a hierarchical structure (Figure 3.9), with the approach working from the top down in terms of defining elements and bottom up after measuring to interpret the results (Koziolek, 2008).

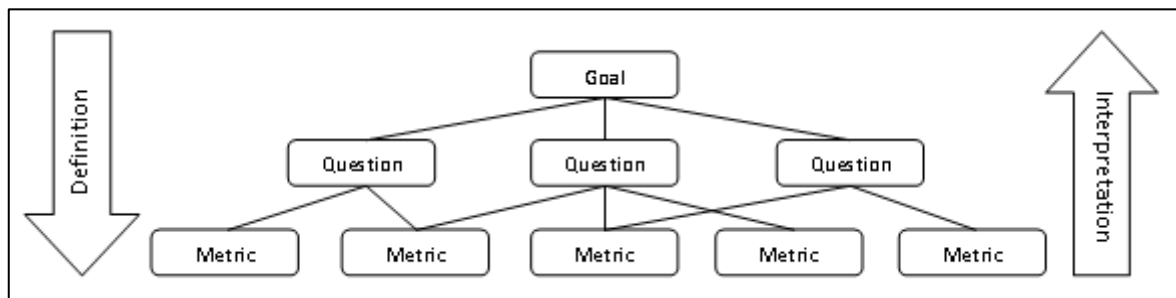


Figure 3.9 - The GQM Paradigm adapted from Koziolek (2008).

According to van Solingen and Berghout (1999) this approach was originally developed by V. Basili and D. Weiss and has four phases (Figure 3.10): planning, definition, data collection and interpretation.

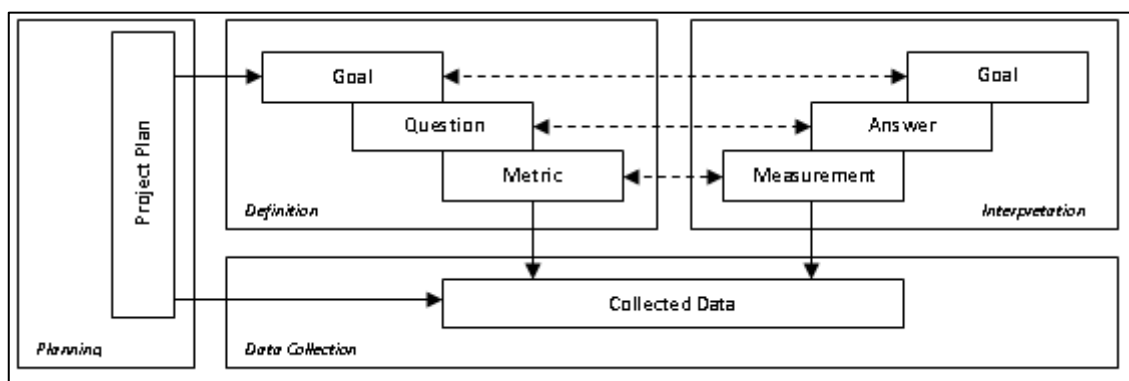


Figure 3.10 - The four phases of GQM (van Solingen and Berghout, 1999).

van Solingen and Berghout (1999) argue that after applying GQM you have “the specification of a measurement programme targeting a particular set of issues and a set of rules for the interpretation of the measurement data” (van Solingen and Berghout, 1999, pp. 23). As can be seen from Figure 3.9, GQM defines a goal which is split into questions. Metrics are then devised which are capable of providing measurables that can provide answers to the questions and thereby evaluations as to whether the goal has been achieved or not (van Solingen and Berghout, 1999). GQM were identified as being useful but not as a whole methodology, so elements of it were definitely used, though possibly without realisation.

Test Driven Development (TDD) and Search Based Software Engineering (SBSE) system development methodologies were also reviewed but they were viewed as being unsuitable for

this research. Information about them can be found in Appendix 6. The final system development methodology that was reviewed for this research was decided upon; i* modelling which is discussed in the next section, it being considered that this was the most appropriate system development methodology for this study.

3.4 Introduction to i*

The i* framework encompasses both goal modelling and agent-based modelling. Goal modelling is a response to traditional requirements approaches which lead to systems that do not understand the user because they misunderstand the requirements (Rolland and Salinesi, 2005). van Lamsweerde (2001) [ENREF 49](#) offers many reasons as to why goals are needed, including that they help to achieve requirement completeness, avoid irrelevant requirements and assist in explaining the requirements to stakeholders.

The approach that this research is interested in is i* as Yu *et al.* (2011) believe that in order to be able to build a system, you need to consider, examine and understand the relationships among social actors. It is a social approach to early requirements engineering often providing the possibility of producing information in an early phase of the software engineering process. i* modelling is an agent-orientated approach that uses the strengths associated with goal orientation but also considers how goals are initiated by many different actors and recognises that the relationship between the actors is extremely important (Yu *et al.*, 2011). The evolution from goal-orientated modelling to agent-orientated modelling happened because it was established that goals emanate from different actors and it is the relationship between these actors that is important, whereas goal orientated modelling just has the one viewpoint which is the requirements analyst (Yu *et al.*, 2011). The term i* is actually named to reflect its focus on so-called “distributed intentionality” (Yu, 1995).

3.4.1 The i* Framework

It has been argued that there are two models of i*, namely a Strategic Dependency (SD) model and a Strategic Rationale (SR) model. The SD model is used to describe a configuration of dependency relationships between actors and the SR model shows the rationale of actors for embracing one configuration or another (Yu, 1995). The two models correspond to different abstraction foci, the SD model denoting a focus on the level of intentionality and the SR model denoting a concern with the rationale level (Grau *et al.*, 2005; Grau, 2008). Intentionality and

rationale in these models applies to the intentionality and rationale of actors in the system. The next section explores the importance of actors.

3.4.1.1 The importance of actors

The SD model illustrated that Intentionality is an important factor in i^* . It is viewed as representing the deliberateness of the actor, is an important factor in i^* . This with intentionality being conveyed through goals, beliefs, abilities and commitments. Actors seeking to achieve goals that are complicated or seemingly impossible for them to achieve individually will rely on other actors to accomplish them, making the actor vulnerable if let down by other actors in the process of achieving a goal (Grau, 2008). In i^* notation actors are represented as circles but can also be further classified as agents, roles and positions using IS-PART-OF and IS-A relationships (Grau, 2008). When applying i^* the term actor can be seen to encompass any unit which has intentional dependencies, with the actor not necessarily having to be human. When there is a complex social actor the notions of role, agent and position might be used.

A role is viewed as an “abstract characterisation of the behaviour of a social actor” (Yu, 1995: 29), while an agent is “an actor with concrete physical manifestations, such as a human individual” (Yu, 1995: 29). An agent is “an actor with concrete physical manifestations, such as a human individual.” (Yu, 1995, pp.29). As already mentioned, an agent is not restricted to having a human form, with the word ‘agent’ being used to maintain this generality. Often within i^* , non-human actors are viewed as hardware or software reflecting the nature of the socio-technical systems under investigation. This issue is discussed further in the ANT and i^* section of this chapter. A position is in between a role and an agent, it is considered to be “a set of roles typically played by one agent” (Yu, 1995: 29). To clarify, Yu (1995) adds that an agent would occupy a position and a position would cover a role. The i^* notations for actor, agent, position and role can be seen in Figure 3.11.

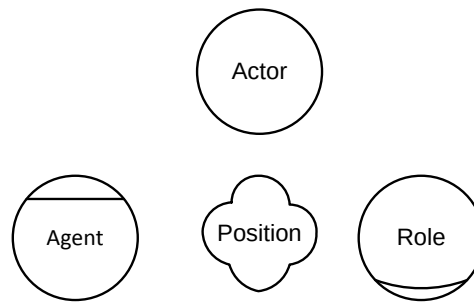


Figure 3.11 - i* notation for actor, agent, position and role.

3.4.1.2 The Strategic Dependency model

The SD model is used for “describing a particular configuration of dependency relationships among organizational actors” (Yu, 1995: 16) it being argued that it is possible to identify the different stakeholders involved in a situation and realise what their stakes are. As well as analyse opportunities and vulnerabilities. The model is composed as having a set of nodes and links. The nodes are actors and the links between them are known as dependums, which represent the relationships among the actors, for example, the relationship of one actor (the depender) relying on another actor for something (the dependee) in order to achieve the dependum or some other objective.

There are four types of dependencies: resource dependency, task dependency, goal dependency and softgoal dependency (Yu, 1995; Grau, 2008). Decisions are seen as being impacted by these dependencies and by whether you are the depender or the dependee. If the situation is a goal dependency, then the depender depends on the dependee to produce a certain state. The dependee is free to make whatever decisions are needed to achieve the goal as the depender does not care how the dependee achieves the goal. For a resource dependency, the issue of who makes the decisions does not arise, as a resource is the product of a deliberate action where the dependee assures the depender of the availability of an object, whether that be a physical object or an informational object. For a task dependency, the dependee has some freedom of choice but the depender will have already made a decision as to how the task should be achieved. For a softgoal dependency, the dependee has to meet a non-functional requirement. For the depender, the criteria for accomplishing a softgoal are not distinct (Grau, 2008; Yu, 1995). The i* notations for a goal, softgoal, resource and task are an oval, cloud, rectangle and hexagon respectively, as seen in Figure 3.12. With their corresponding dependency links, the i* notations would look as they do in Figure 3.13.



Figure 3.12 - i* notation for goal, softgoal, resource and task

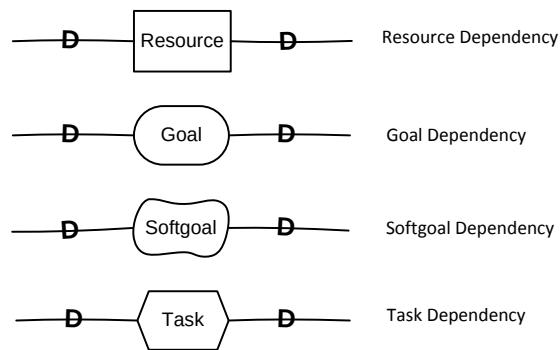


Figure 3.13 - i* notations for different dependency links

There are also varying degrees of strength of dependencies; with the positions of open (O), committed (unmarked) and critical (X) being identified on the basis of whether strength lies on the dependers side or it it's on the dependee's side, it being argued that it is likely that the dependee will make a greater effort to achieve the dependum (Yu, 1995; Grau, 2008). Below, Figure 3.14 shows a strategic model (Yu, 1995: 34) which shows the different features that have been discussed.

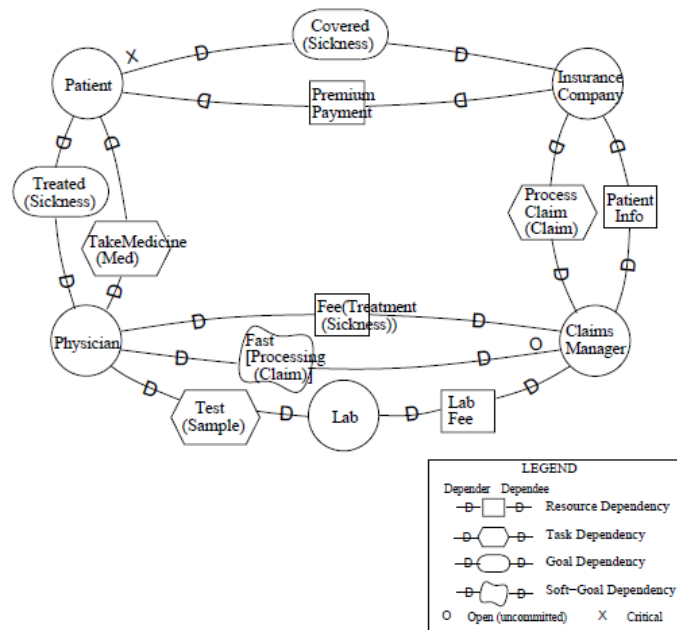


Figure 3.14 - Example of a Strategic Dependency model from the health care domain (Yu, 1995: 34)

The figure above shows some relationships between five actors in a healthcare domain. Namely patients, physicians, labs, claims managers and insurance companies. There can be seen to be a goal dependency between the patient and the physician, as the patient (dependor) depends on the physician (dependee) to accomplish the goal of treating them for sickness (dependum). There is also a task dependency between the physician and the patient, but in this case above, the physician (dependor) depends on the patient (dependee) to complete the task of taking the medicine (dependum) (Yu, 1995: 34). In the SD model above, four out of five of the actors are human. The actor 'lab' is, in this case, testing equipment, though there are more than likely, but not necessarily, human actors within the lab running the testing equipment.

3.4.1.3 The Strategic Rationale model

The SR model is used for “describing rationales that actors have about adopting one configuration or another” (Yu, 1995: 16). Again, it is a graph that has several nodes and links. The SD model is refined with reasoning means, the reasons behind decisions can be explored which allows for the intentionality to be visualised into the boundary of an actor (Grau, 2008). These nodes and links interact to present a representational structure for showing the rationales behind processes. The nodes this time, however, are not actors but goals, tasks, resources and softgoals. There are two main different types of link; means-end links and task decomposition

links. A means-end link is a link between an end and a means for attaining that end. For example, there could be a link between a goal and a task to achieve that goal meaning that it is mainly a task as it requires completing something to achieve a goal which is the end (Yu, 1995; Grau, 2008).

The task decomposition link, connects a task node to its component nodes. There are four different types of task decomposition links: subgoals, subtasks, resources, and softgoals. For (Yu, 1995), these relate to the four different nodes. Grau (2008) also mentions contribution links which are means-end links with a softgoal as the end and the contribution of the means towards the end (softgoal) can be classified as either a positive or negative contribution. The i* notations for the SR model can be seen below Figure 3.15.

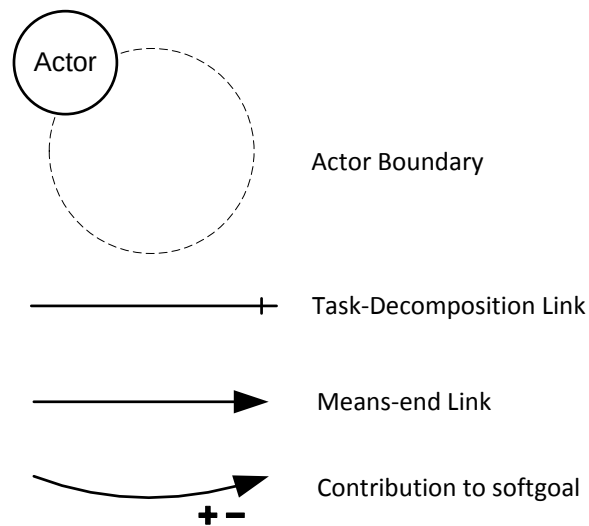


Figure 3.15 - i* notation for elements used in the SR model

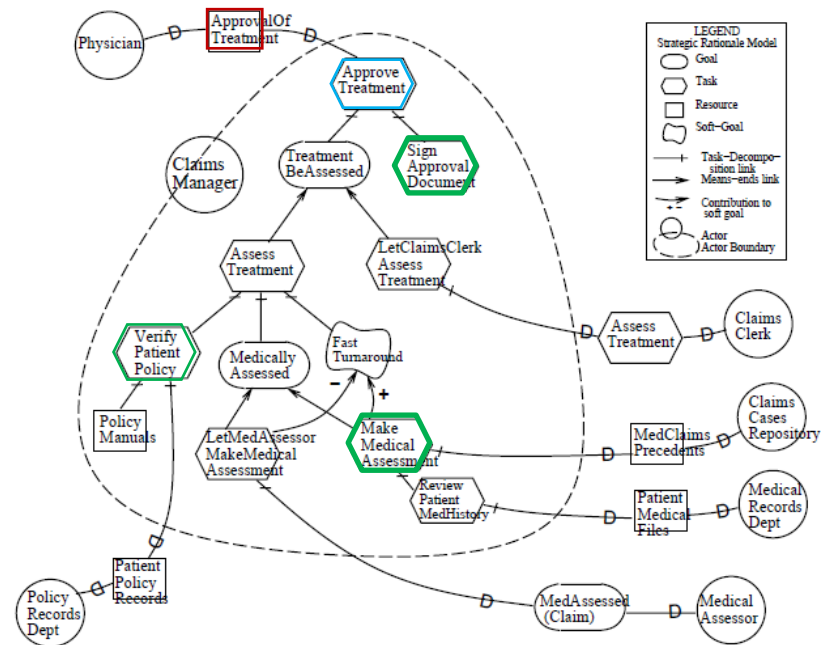


Figure 3.16 - A Strategic Rationale model – insurance claims manager example (Yu, 1995: 48).

Figure 3.16 shows a SR model for an insurance claims manager, from looking at the diagram it can be seen that the claims manager can produce the resource *ApprovalOfTreatment* (highlighted in red in Figure 3.16) by completing the *Approve Treatment* task (highlighted in blue in Figure 3.16). Yu (1995) says that the model in Figure 3.16 could be described as having just three steps or tasks, namely the task *VerifyPatientPolicy*, the task *MakeMedicalAssessment* and the task *SignApprovalDocument* (these tasks are highlighted green in Figure 3.16). Looking, at this example, these three tasks do not take into consideration the why and the how of what is happening, nor do they consider the rationale behind the process or indeed intentionality, and they do not inspire the contemplation of alternatives. However, the model is much more than that. The task *Approve Treatment* has two components; the subgoal *TreatmentBeAssessed* and the subtask *SignApprovalDocument*, which are connected through task-decomposition links, because these tasks have two components. It can be argued that this model has connections to the 'unpacking' or 'opening' of the black box in ANT. The other types of link that can be seen in the diagram are means-end links and contribution to soft goal links. These are just a few examples of what is happening in the SR model (Yu, 1995: 48). In SR models, elements of reasoning are called routines, rules and beliefs. A routine is one course of action to attain the goal of an actor amid all other alternatives (Grau, 2008).

3.4.1.4 Advantages

Strengths of i* include it being an agent-orientated approach and that it considers the relationship between the different actors, with the primacy of social actors being recognised. Actors are viewed as having intentionality; and thereby as having goals, beliefs, abilities and commitments. These issues are seen to be largely omitted from other systems analysis methods which endeavour to remove the human aspect of systems (Yu, 2009). Instead of the usual focus on activities and information flows, questions asked include: what does each actor want?; how do they achieve what they want?; and who do they depend on to achieve what they want? (Yu, 2009: 100). Grau (2008), states that i*'s successes include it being visually useful and it provides reasoning capabilities. These reasoning capabilities mean that i* can provide an important test of the system boundary, because projects will identify if an element (e.g. goal, softgoal, task) has been achieved by an actor and that therefore the actor is part of the socio-technical system, but if it is deemed that it does not matter if the element is achieved or not, then the actor is not part of the system (Maiden *et al.*, 2011). Perhaps the framework's biggest strength lies in its stimulating considerable interest in a socially-motivated approach to systems modelling. In turn, i* is being used in a number of different contexts and, it is widely applicable (Yu, 2009). The applicability of i* is discussed in more detail in this chapter.

3.4.1.5 Disadvantages

There are many disadvantages or constraints of i* that are identified in the literature. Maiden *et al.* (2011) and Grau *et al.* (2005), for example, explain how the complexity of i* can be an issue, even though i* has a graphical modelling notation that is simple to use with only five process elements. These elements, however, can be used in combination in many different ways and the relationships between different elements can be hidden as the forms of relationship are not obvious, resulting in even the most non-trivial models growing rapidly (Grau *et al.*, 2005). A user that has not had previous experience, may therefore find it to be confusing.

Ayala *et al.* (2005) i* framework is analysed using criteria proposed by Meyer (1993), namely in terms of noises, silences, contradictions and ambiguities. Noises are the existence of irrelevant or useless information while silences are features that exist but about which there is no information and as a result they are not explained. Contradictions are viewed as the presence of more than two elements defining a feature in the text but whose definitions are incompatible. Ambiguity is where it is feasible to understand or interpret a feature in more than one way. Ayala *et al.* (2005) did not find any contradictions in the i* framework. They did however, find

some noise, silence and ambiguity. Noise that was detected when analysing the i* framework included the IS-A relation. This has been used in numerous examples although is not actually defined in the i* language or guides. The concept of routines is also noise to a certain extent, as it is defined in the description of SD models but its use is only seen in SR models, which adds to confusion. There were a number of silences detected including that it is not clear if a dependum can be related to more than one depender and whether an actor can decompose into other actors by means of an IS-PART-OF relationship (Ayala *et al.*, 2005). An ambiguity that was discovered was centred around the strength of a dependency and how that dependency is interpreted differently whether it is defined on the depender or dependee side, suggesting that a dependency can have different importance for each actor involved. However, Ayala *et al.* (2005) could not find anything to clarify this. There are clear ambiguous and indistinct pieces of information in the i* framework which can make it difficult to use.

Another problem with the i* framework is that it is not always clear how to start i* modelling because it is used in many different contexts (Maiden *et al.*, 2011). Grau (2008) confirms this, stating that the construction of i* models is rarely addressed and there is also not a single definition of the language, making it difficult to know where to start. Also, most of the proposals on i* assume prior knowledge of building i* models, so if i* is a new concept to the user, it can be extremely difficult.

Maiden *et al.* (2011) suggest that composing a context diagram can help as it provides an image of the overall system. They describe a context diagram as a prototype for the SD model. However, a context diagram does not help with identifying the actors in the first place. In addition to a context diagram, Maiden *et al.* (2011) suggest that it is useful drawing on the idea of adjacent systems. i* modelling is a good way of displaying actor dependencies but it is difficult to discover and express actor dependencies in the first place, which can be a setback of the framework. Maiden *et al.* (2011) recommend making a list of dependers and what actors they depend on and what they depend on that actor for. Having this in a tabular version first eases the modelling of i* later.

Dalpiaz *et al.* (2016) have critiqued the i* modelling language, producing what they describe as a more usable version of it, known as iStar 2.0. Their main critique of the language is that unless you are an expert in the i* community, the likelihood is that i* will not have been spread amongst other groups. For example, it is hard to learn if you are a beginner, because teachers do not have a shared body of knowledge to teach and so they are unlikely to use it.

3.4.1.6 i* based modelling methods

There are a number of versions of the i* language that have been customised by different groups of researchers. This is because i* does allow for degrees in its use, so that the language can be interpreted in different ways. Grau (2008) in her doctoral thesis identified a number of i* based modelling methods and techniques. These were including: the ground breaking proposal of the i* framework (Yu, 1995); the TROPOS methodology (Bresciani *et al.*, 2004); the goal-based business modelling orientated towards late requirements generation method (Estrada *et al.*, 2003); the RESCUE process (Jones and Maiden, 2005); a methodology for mapping activity theory diagrams into organizational models based on i* (Cruz Neto *et al.*, 2005); a methodology for building i* models from BPEL process descriptions (Schmitz *et al.*, 2004); and the RiSD methodology (Grau *et al.*, 2005).

As already mentioned i* can be complex and it can be difficult to know where to start, so this study investigated the RiSD methodology as presented in a paper by Grau *et al.* (2005). The main reasoning behind producing this methodology is because there are disadvantages with the initially proposed i* framework that have been identified. These disadvantages that Grau *et al.* (2005) identified are that there is an absence of a methodology for producing i* models and that the models can be extremely complex, as was identified in this research in the *Disadvantages of i** sub-section. Therefore Grau *et al.* (2005) proposed a methodology that produces reduced i* SD models for software systems so they are not as complex and a set of specific questions to provide a guide through building the models. RiSD has two distinct phases to guide the modeller through the development process by a series of specific questions. It was the first phase of RiSD that this research is interested in as it deals with the construction of a social system model without software, focussing on the stakeholders' needs, which is what this research has done. The second phase constructs the socio-technical system (with software) (Grau *et al.*, 2005). Although RiSD was meant to provide a set of clear instructions that were easy for the user to follow, this was not the case and the instructions did not make starting the i* diagrams any easier, so this methodology was not applied.

The methodologies that have been reviewed throughout this section clearly all have advantages and limitations when developing software. This accounts for why there are a large number of them, because new approaches are being found that address some of the limitations of earlier approaches. The methodologies also have their advantages and limitations when applying them

to human systems. The methodologies that I found least appropriate in their application were the Waterfall Methodology and the Test-Driven Development. The nature of human systems is regularly unsystematic, so it was difficult to apply the Waterfall model which is opposite in its nature. Test-Driven Development's disposition as a trial and error methodology when applied to a human system could be very time-consuming, as one might begin with a completely irrelevant test. As for choosing the most appropriate, this method, is a difficult task as there are a few that are clearly more suitable for applying to human systems. The i* framework can be viewed as being especially useful as it brings social understanding into the system engineering process and considers the relationship between actors as well as the rationale behind their actions, which is extremely important when considering human systems. However, when producing the i* diagrams I found I was continually referring to the GQM model and SSM model, as the GQM easily identifies metrics and the SSM model easily identifies goals. Agile development draws on very valuable principles that I feel should be prevalent in most system engineering, particularly principles 1) customer satisfaction; 2) adaptable to changing requirements; and 8) promote sustainable development.

Taking into consideration all the methodologies that have been reviewed and evaluated, this research proposed that not one single methodology should be used for the development of a cheese actor-network but, that a combination of many should be applied to human systems. These methodologies include: Agile Development, SSM, and the i* framework. The amalgamation of these methodologies allowed for a greater understanding of the requirements and the actors involved. The i* framework has constraints, therefore this research used Soft Systems Methodology (Checkland, 1993) to help get started with the i* diagrams and the Agile Development principles (Table 3.1) were also applied. SSM understanding was applied to create ANT diagrams (rich picture) for the identification of actors in this research, SSM for the identification of the actors' goals and then the use of i* framework to create i* models. More information on the system development methodologies can be found in Appendix 6.

3.4.2 Integration of i* and Actor-network Theory (ANT)

As already discussed in Chapter 2 Actor-network Theory (ANT) is being applied to this research but as highlighted there are critiques of ANT. The bulleted list below summarises the critiques of ANT that this research has found:

- ANT provides very little analytical insight
- ANT does not reflect the socio-natural world in reality

- Too descriptive and therefore not practical enough
- Inability to provide explanations of social processes

Despite these critiques the research still decided to use ANT as an underlying theory instead of any other theory, the main reason as highlighted in Chapter 2 is because of the similarities that were identified with the i* framework. Not only were similarities established which are discussed in this section but i* provides ANT with the tools to become more practical.

This research has decided to integrate ANT and i* because there are many parallels between the two concepts. ANT has been discussed in great detail already so this section attempts to draw on the key concepts of ANT and how those key concepts relate to i*. The main connecting feature of ANT and i* is that they are both concerned with actors or actants within a network and they both look at the interactions and relationships between these actors/actants. Neither ANT nor i* attempt to explain why the networks or system exist, but they are interested in how the network/system is formed and how they can fall apart. ANT is extremely descriptive and can be used to examine the social relationships between actants in a network and i* attempts to bring social understanding into the system engineering process. Both approaches view social and technical problems simultaneously. Cressman (2009) writes that we should not limit ourselves to one perspective if we wish to understand the sociotechnical world. This is what ANT and i* are attempting to do by acknowledging the sociotechnical world. They both allow for both human and non-human actants within the network; although it is common in i* for hardware and software to be an actor in the system. Latour (2005) writes of having “to follow the actors themselves”. The actors must be able to make their own decisions and make their own way and i* models what actors intend to do and their motivations. They both allow for the black boxing of certain elements in order to not overcomplicate the model or diagram and as mentioned earlier, SR models allow for the black box to be unpacked. ANT and i* are both networks that display aligned interests between people, organisations and standards.

Bearing these similarities in mind i* accounts for the rationale and the conscious behind translating and enrolling actants into the network and forming associations. i* diagrams can be created from actor-network maps. Cruz Neto *et al.* (2005) used activity theory diagrams to identify the activities for their i* models. This research has produced actor-network diagrams and then used these diagrams to identify the actants in the system to then be able to produce i* models, as identifying the actors is the first step for the i* models. Actor-network maps used in conjunction with i* diagrams can show the rationale of actants and is able to unpack, ‘open the black box’, investigate further the actants within the network. In doing so this provides some

analytical insight that ANT alone lacks and goes further in reflecting the socio-technical world in reality. The combination of the two also means that the descriptiveness of ANT is taken further and made more practical by the i* diagrams. One of the disadvantages of i* models is that it can be difficult to know where to start, creating the actor-network maps prior to creating the i* models provides you with the actants and the associations and therefore facilitates the starting point for the i* models. This allows for both the human geography and informatics aspects of this research to come together. The outcome of using actor-network maps and i* can be seen in Chapter 6.

3.4.3 Sustainability and i*

i* modelling is being used in a number of different contexts which include business process design, business redesign, information systems requirements engineering, analysing the social embedding of information technology and the design of agent-based software systems (Yu, 2009). i* has also been applied in areas such as healthcare, security analysis, eCommerce (Dalpiaz *et al.*, 2016), and also to air traffic management (Maiden *et al.*, 2004; Maiden *et al.*, 2005), as well as, more relevant to this study, to decision support in agriculture (Perini and Susi, 2004) and to model food chain traceability (Siena *et al.*, 2008). Some of applications of i* have been used to promote or achieve sustainability (e.g. Cabot *et al.*, 2009).

Throughout the literature there are many papers on supporting sustainability in software engineering research and practice and many of those are highlighted in the systematic literature review carried out by Penzenstadler *et al.* (2012). Many of the papers however, refer to how to improve the software itself by making it more sustainable and do not apply sustainability to the wider socio-technical system (e.g. Albertao *et al.*, 2010; Naumann *et al.*, 2011; Nguyen, 2013).

Siena *et al.* (2008) in their paper evaluated the effectiveness of an extension of i* modelling called normative i* modelling, which they proposed. They implemented this analysis on a project that aimed to improve the traceability of food chains in Europe. The project produced i* SD and SR models as well as normative i* models establishing actors in the dairy food chain. In order to develop different models, they used knowledge of current processes and workflows in the dairy industry as well as one to one interviews with different actors. This paper was more focused on the effectiveness and efficiency of the proposed normative i*, rather than how it can help food chain traceability. Some parallels between the research conducted by Siena *et al.* (2008) and this study are that they both focused around a case study in the dairy industry and although Siena

et al. (2008) do not mention sustainability as such, they do examine traceability which has been identified as an important element within sustainable food chains.

Cabot *et al.* (2009), did use i* to improve sustainability. They investigated how they could help the organisers of a conference to go green and cut down the eco-footprint of the conference. Feedback from their i* models was positive and it was concluded that the i* models were a useful way of presenting the rationale of sustainability related decisions. In the Cabot *et al.* (2009) paper they treat sustainability as a 'softgoal', because they claim it makes more sense for sustainability to be a quality that is striven towards. It is worth noting here that in the iStar 2.0 Language guide presented by Dalpiaz *et al.* (2016), which is an update from the initial i* modelling language that aims to consolidate a key set of concepts from the language so that it is easier to understand, softgoals are referred to as qualities. Sustainability in terms of a softgoal or quality does not really explain what should be achieved and there is a need to break it down into other elements that can be achieved. Cabot *et al.* (2009) broke the sustainability softgoal down into a taxonomy of softgoals. They did this by first breaking the sustainability softgoal into the three softgoals that are widely associated with sustainability; - reduce, reuse and recycle, - and then these were themselves broken down into more fine-grained subgoals (Cabot *et al.*, 2009). The taxonomy of sustainability-related softgoals presented by Cabot *et al.* (2009) is shown in Figure 3.17. This is a predefined taxonomy that Cabot *et al.* (2009) envisage being adopted to design a range of sustainable systems.

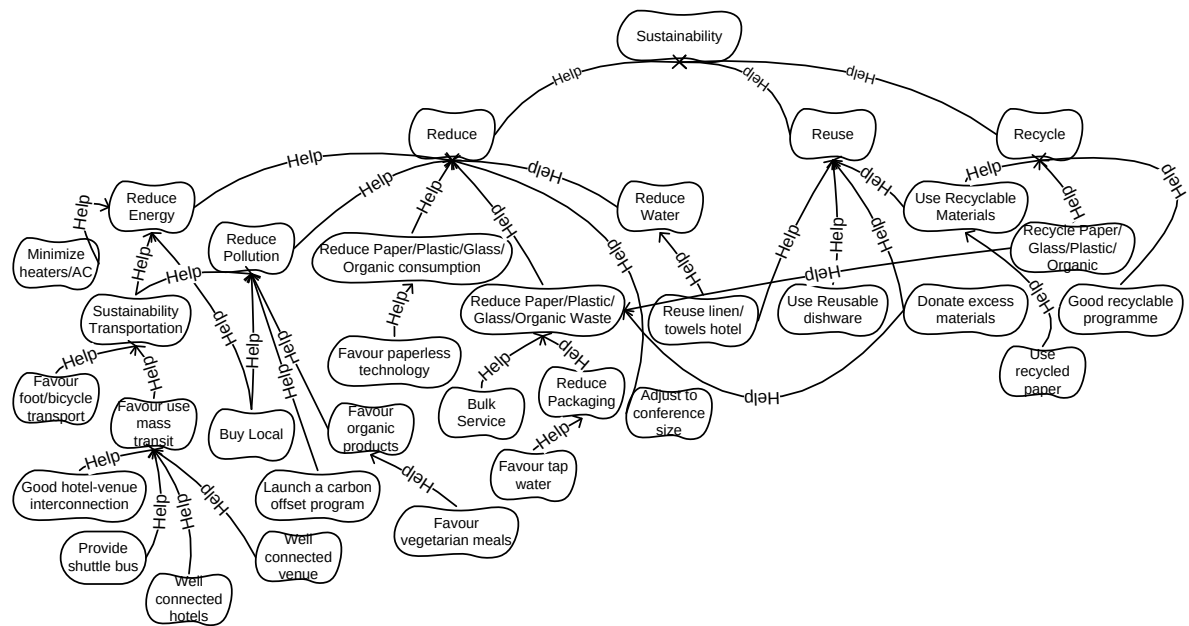


Figure 3.17 - Copy of the taxonomy of sustainability goals presented by Cabot *et al.* (2009)

The taxonomy presented by Cabot *et al.* (2009) is a useful idea for modellers to be able to follow and consider when thinking about designing sustainable systems, though this can also be problematic as each system is entirely different. As can be seen from looking at the taxonomy presented (Figure 3.17), when thinking about the ‘system’ in this research (a sustainable cheese network) the softgoals are going to be different. Cabot *et al.* (2009) do recognise in their paper that the diagram shown in Figure 3.17 is driven by the needs of their case study and therefore it is not a general model for sustainability goals at this stage. This research proposes its own taxonomy to consider when applying i^* to a real world food network and in some cases the goals are specific to cheese. This taxonomy can be seen in Chapter 6. The softgoals were identified from the literature and the data collected from the interviews with the participants.

3.5 Methodological Framework

This methods chapter has been arranged by aims so that it is clear what methodological approaches were used for each part of the research. The steps that were taken accumulate to form a methodological framework that is a particular methodology that allows for the construction and interpretation of the i^* and ANT models. The approach is a two-phase approach that combines elements of the widely adopted theory in human geography research, ANT and the computer science framework, i^* . The specific steps that need to be completed to construct these models can be seen below:

Phase 1:

1. Identify case studies
2. Collect data – follow the ‘thing’
3. Identify the actants
4. Create actor-network maps
5. Explore the discourse
6. Identify the sustainability problems and solutions
7. Identify the sustainability goals

Phase 2:

8. Use actor-networks maps as a rich picture
9. Choose a goal to model
10. Create i* SD models
11. Create the i* SR models
12. Revise and reiterate the model

1. Identifying the case studies is a straightforward step, the networks that are going to be investigated need to be chosen. As it was for this research, three were chosen from the sustainable intensification – eco-localism continuum and a flat ontology of actor-network theory was applied. Once the actor-networks were identified the data needed to be collected.

2. Collect data, a rich collection of data needs to be collected from all aspects of the actor networks by ‘trail sniffing’ or ‘following the ‘thing’’. For this research the cheese was followed, the entry point to the network was the cheese which allowed for the identification of actants. A range of techniques were used to collect the data; ethnographic observations, semi-structured interviews, questionnaires and an online survey.

3. Identify the actants, the cheese was followed from the cheesemaker and the dairy to eventually the consumer. And the cheese was followed back through the network to the milk, the cow, the grass and many any other lines of associations and actants which allowed for the creation of the actor-network maps.

4. Create the actor-network diagrams using the identified actants from the previous step and trace the associations between actants. For this research the limits of the actor-network were as far as the eye could see. Actor-network diagrams were created for each case study network.

5. Explore the discourse, as mentioned previously in this chapter it is important to examine the discourse as it can cause 'technopolitics', therefore the discourse of sustainability within the networks were examined. The discourse is an actant in the network so had to be addressed. The discourse could be examined from the rich data that was collected in Step 2.
6. Identify the sustainability problems and solutions, using the actor-network maps, from the discourse analysis and the rich data collected in Step 2 it should be possible to spot the weak associations within the actor-networks and therefore the sustainability issues. A list of problems should be compiled. From the literature and the rich data collected solutions should be identified for the problems.
7. Once the solutions for the sustainability issues are identified it is possible to distinguish the goals. The relationship between solutions, sustainability problems and goals, are that the sustainability goals should be ways to achieve the solutions and overcome the sustainability problems. If the goals are difficult to determine at this stage and the project is based on sustainable food, you can refer to Figure 6.2 for guidance as they are the goals for sustainable cheese that were identified in this research.
8. The next step is to create a rich picture as this helps to aid the construction of the i* diagrams but in the context of this research the actor-network maps created in step 4 can be used as a rich picture.
9. Step 9 is to choose a goal to model, not all the goals can be modelled in the same i* diagram as they would get extremely complicated.
10. Create the i* SD models for the chosen goal in order to be able to identify the different stakeholders involved in a situation and realise what their stakes are.
11. Create the i* SR models, from the SD model a SR model can be constructed that shows the rationale between actants decisions, it has the potential to 'unpack' some of the black boxes found in the SD models.

12. Revise and reiterate the model, once the SR model has been constructed it is possible to perform the last step. The SR model is evaluated using the concepts proposed by Yu (1995) ability, workability, viability, and believability. This is explained further in Chapter 6.

This 12 step process allows for the integration of ANT and i* that can be used to assess a real world sustainability system. The purpose of collating the steps into a methodological framework is that the approach can then be applied in theory to other sustainability research and in other industries.

3.6 Ethics and Access

As with all research, there were ethical considerations to take into account, especially as the fieldwork involved people as research participants. The first thing that was considered was privacy, some of the fieldwork involved going into businesses and in one case, research participants' home and asking questions about the business and people's lives. Therefore, the audio files, interview transcripts and questionnaires were all stored in a password-protected folder and any hard copies or field notes were stored in a lockable drawer. The worry that I encountered the most from research participants was that the recipe for their cheese, which had quite often been passed down from generation to generation, would be revealed to the public. To stop this from happening when implementing the i* models and ANT diagrams, the specific ingredients that were added to the different recipes were not added to the diagrams and the usual requirements were applied to the field notes that were taken.

Confidentiality of the research participants was also important if they did not wish to be identified. All three case studies did not mind the business being revealed in the research, however individual people were kept anonymous.

Informed consent was needed from participants, which was achieved with an information sheet (Appendix 7) that went out to the participants who undertook interviews and for those who filled out the initial exploratory questionnaire. Attached to this information sheet was a consent form for willing participants to sign. For the customer and employee questionnaires, an information paragraph was included at the start and end of the questionnaires which clearly stated that they were consenting to taking part in the research by handing back the questionnaire. As already mentioned, the ethnographic methods that were applied were overt so there was no deception involved.

Access was a subject to careful consideration when undertaking the research of this project, because as Van Maanen and Kolb (1985) affirmed, “gaining access to most organizational settings is not a matter to be taken lightly but one that involves some combination of, strategic planning, hard work, and dumb luck.” This research was undertaken in some closed settings, and therefore the support of someone had to be gained from within the organisation to be able to get interviews and visits arranged. Bryman (2016) calls this person, the sponsor, because they are likely to champion you and your research. The sponsors in this research were achieved by sending emails with initial questionnaires to the cheesemakers, an information sheet was also attached which gave a clear explanation of the methods and what was expected of them if they agreed to take part. At the end of the questionnaire respondents were able to opt in to further research, which it was explained would entail visits and interviews. The cheesemakers acted as a gatekeeper to the network and a rapport had to be established with them as they were then crucial to the collection of data and carrying out the remainder of the research. It was extremely useful to have gatekeepers at each of my study sites but it also restricted communication. At one of the sites, the gatekeeper arranged all of the interviews with different members of staff meaning they could have chosen people who solely support the sustainability of the business. This is investigated to a certain extent however, when the different discourses of sustainability within the network are examined.

3.7 Interdisciplinary Reflection

Considering methods to display the interdisciplinary nature of this research was one of the hardest parts of the research. Suitable methods had to be chosen that were complementary. Human geography and computer science methods have completely different approaches. For example, in computer science it is expected that the model produced, such as the i* diagrams, should be evaluated by tests or other means, whereas in human geography this does not necessarily have to be the case. The discovery of the similarities between i* and ANT integrated the two disciplines together.

3.8 Chapter Summary

The following table (Table 3.2) summarises the aims and objectives of the research along with their associated methods:

Table 3.2 - A summary of the thesis aims and objectives and the methods used to achieve them.

Research Question: Can sustainably intensive or eco-localist approaches produce sustainable cheese?		
Aim	Objective	Associated Methods
Aim 1: Identifying eco-local and sustainably intensified cheese networks	Objective 1.1: Identify cheesemakers in England with an interest in sustainability	Web based investigation
	Objective 1.2: Establish and create criteria for sustainably intensive and eco-localist cheese	Criteria formulation
	Objective 1.3: Identification of sustainably intensive and eco-localist cheesemakers	Questionnaire Quantitative data analysis in Excel
	Objective 1.4: Selection of case study cheese actor-networks	Quantitative data analysis in Excel Questionnaire
Aim 2: Understand the dynamics of the actor-networks	Objective 2.1: Map the actor-networks	Ethnographic methods
	Objective 2.2: Explore the different discourses of sustainability within the network and explore connections to the notions of eco-localism and sustainable intensification	Ethnographic methods Interviews Questionnaires Discourse analysis
	Objective 2.3: Look at the interactions between actants that link to sustainability	Qualitative data analysis using NVivo
Aim 3: Problems and solutions in realising sustainability for cheese actor-networks	Objective 3.1: Develop and critically assess a suitable system development methodology	RiSD and production of i* models
	Objective 3.2: Identify problems in the sustainable cheese networks	Interviews Qualitative data analysis using Nvivo
	Objective 3.3: Establish and evaluate suitable solutions	Interviews Literature

As explained throughout this chapter, different data gathering techniques were employed at the different case studies because of the type of setting that they were. The table below gives a summary of the data collected per case.

Table 3.3 - A summary of the data collected at each case study.

Case Study	Data collected
Middle Campscott	• Ethnographic observations. • Semi-structured interview data from interviews conducted with the farmer and the cheesemaker. • Questionnaire data collected from customers at a farmers' market. • Quantitative data relating to water, gas and electric consumption.
Wyke Farms	• Ethnographic observations. • Semi-structured interview data from interviews conducted with a Director/Farmer, Cheesemaker, Green Team Manager, Biogas and Water Treatment Plant Operator, Commercial Director, Finance Team member, Farm Shop employee, Marketing Coordinator, Brand Manager and Packaging Manager. • Questionnaire data collected from customers using an online survey. • Questionnaire data collected from Wyke Farm employees. • Quantitative data relating to water, gas and electric consumption.
Plaw Hatch Farm	• Ethnographic observations. • Semi-structured interview data from interviews conducted with a farmer and a cheesemaker. • Questionnaire data collected from customers in the farm shop. • Quantitative data relating to water, gas and electric consumption.

There were challenges with the methods that were encountered from the fieldwork element of the research, including a failure to find a large number of willing case studies or research participants; too complicated questionnaires; and not getting the required information needed for the research from the interview data. Obtaining research participants or case studies was a worry and this did turn out to be a problem as one of the three cheesemakers was chosen at the start of the research to form a case study had to pull out for personal reasons. It took a long time to find a replacement case and this did set the research timescale back. Thankfully, eventually a third case study was found but because it was late in the data collection stage, I do not feel that I was able to spend quite as much time at that site as I would have liked to. It was also a struggle to find customers in the supermarket to fill in the questionnaires as it was not convenient for the shoppers at the time. Therefore, as mentioned an online questionnaire had to be produced to improve the response rate and this was successful.

A pilot study was conducted before fieldwork commenced, which allowed for the interview schedule to be tried and tested. The pilot was conducted at an eco-localist cheese maker. The trial revealed that although the interview schedule did acquire some of the information required for the research, it was not enough so it was decided that more follow-up questions were needed in order to generate more information with a higher level of detail. It was also decided that some of the questions needed to be rearranged in a different order so that the interview had more fluidity. These points were considered and the interview schedule was altered to reflect this, the pilot study was an insightful and useful activity for the research.

To summarise the steps that created the methodological framework for this research is one of the more novel aspects of this work. This is the first time that the parallels of ANT and the i* framework have been recognised and because of this, the two approaches were used in tandem. i* rightly addresses many of the ambiguities that are thrown up by actor-network diagrams as well as actor-network diagrams providing a starting point for the i* models which are notoriously difficult to start. The approach has two main phases and 12 steps in total. The first phase uses an established conceptual framework (Actor Network Theory), widely used within Geography, to map human and non-human cheese actors networks for three different sustainable cheese producers, including associated sustainability discourses. The second phase is to apply a Requirements Engineering approach from Software Engineering (i*) to refine and enhance the actor network maps. This two-phased approach compliments the interdisciplinary aspect of this research perfectly.

The main research question of this study is 'Can sustainably intensive or eco-localist approaches produce sustainable cheese?'. A range of methods to achieve the answer of this research question have been outlined in this chapter. By combining both human geography and computer science elements it is intended that a journey for blending these two disciplines can be explored and developed. The next chapter, Chapter 4, discusses the findings from employing these methods in order to identify eco-localist and sustainably intensive cheese actor-networks.

4 Identification of cheese actor-networks

The main purpose of this chapter is to address Aim 1 and the corresponding objectives.

Aim 1: Identifying eco-localist and sustainably intensified cheese actor-networks

Related objectives:

- 1.1 Identify cheesemakers in England with an interest in sustainability
- 1.2 Establish and create a criteria for sustainably intensified and eco-localist cheese
- 1.3 Identify sustainable intensive and eco-localist cheesemakers
- 1.4 Select case study cheese actor-networks

This chapter attempts to identify eco-localist and sustainably intensified cheese networks in England by first identifying cheesemakers in England and then establishing whether they are eco-localist or sustainably intensified cheesemakers. This was done by determining cheesemakers who have an interest in sustainability, then establishing a criteria for both eco-localist and sustainably intensified cheese networks, identifying these networks and selecting those most suitable to act as case studies. The satisficing of this aim corresponds to Step 1 in the methodological framework. Case study networks were chosen from a sustainable intensification – eco-localism continuum, as a flat ontology was applied to this research, neither sustainable intensification nor eco-localism was seen as being hierarchical. They were viewed as having the same influence.

Identifying eco-localist and sustainably intensified cheese networks is important for this study as already previously discussed in Chapter 2, this research is looking at the two differing approaches to sustainability. Sustainable intensification and eco-localism have in the literature primarily been applied to farming or dairy production, however, this research seeks to explore their applicability to the study of the production, distribution and consumption of cheese, thereby moving beyond the farm gate. Therefore specific criteria had to be formulated to use across the whole network in order for it to be directly applicable to cheese, as there was no set standard to follow.

4.1 Identify cheesemakers in England with an interest in sustainability

In order to establish which cheesemakers had an interest in sustainability, first of all cheesemakers had to be identified. As mentioned in Chapter 3, this was achieved by obtaining a list of dairy establishments from the Food Standards Agency. However this list alone did not

identify the cheesemakers, as the list contained all the establishments in England who have permission to handle dairy products. The list was voluminous in length and contained 821 establishments. Out of the establishments listed, 254 of these were identified as definite cheesemakers. This was done by Google-ing the establishment in order to find out if they were a cheesemaker or not. From the list of 821, those establishments that were not cheesemakers were a number of other establishments including dairy farmers, ice-cream parlours, butter makers and dairy distributors. It is important to note though that some dairy farmers were also cheesemakers and they did make the list of cheesemakers. The limitations of Google-ing the dairy establishments is that there are some establishments who might not have had an online presence and therefore information was not attainable on whether they made cheese or not. Unfortunately, there was no way around this as there was no other information on the list provided by the Food Standards Agency, other than name and area location. From the 254 establishments making cheese, 34 were ascertained as having an interest in sustainability and the location of these establishments can be seen below in Figure 4.1. These locations are not confined to a certain area of England. In order to establish whether the cheesemakers had an interest in sustainability, as referred to in Chapter 3, website data was inspected to see if there was any mention of terms associated with sustainability and a content analysis was conducted. A disadvantage of inspecting website data though, is if a cheesemaker does not have a website or online presence, then information may have been missed or cheesemakers may have just decided to not include their approaches or thoughts to sustainability on their websites. Therefore the cheesemakers identified only have an advertised interest in sustainability.

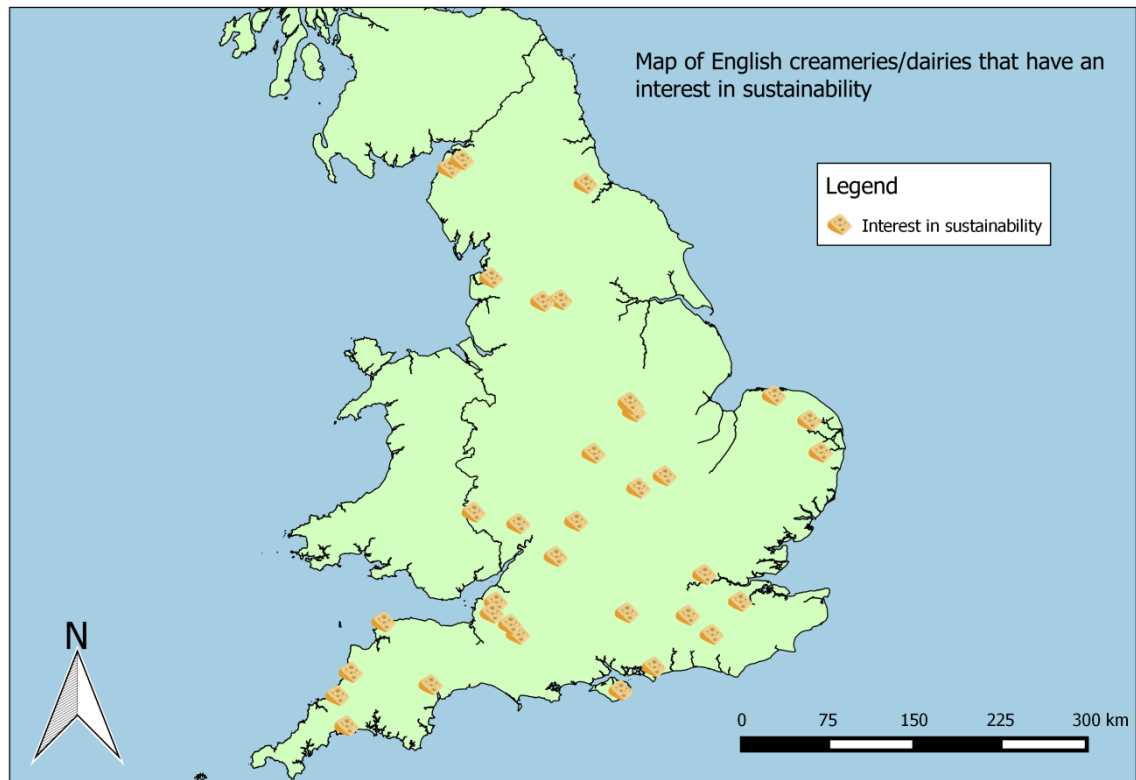


Figure 4.1 - Map of English creameries/dairies that have an interest in sustainability (Author's own map, the UK map outline was obtained from ONS).

Once the cheesemakers who have an interest in sustainability were identified, it was important to find out if they met a criteria of sustainability and also importantly for this research, to find out whether the creameries/dairies associated with these cheesemakers are part of a sustainably intensified network or an eco-localist network. Therefore a criteria for sustainable and intensification and eco-localism had to be formulated.

4.2 **Establish and create a criteria for sustainable intensification and eco-localism**

A criteria was created for both an eco-localist cheesemaker and a sustainably intensive cheesemaker. The criteria was based on suggestions for sustainable farming by Underwood *et al.* (2013). These suggestions were then expanded upon and adapted to fit a sustainable intensification or an eco-localist approach using the eco-localist literature (e.g. Curtis, 2003; North, 2010) and the sustainable intensification literature (Garnett and Godfray, 2012; Garnett *et al.*, 2013; e.g. Godfray and Garnett, 2014). The areas of sustainable animal agriculture stated by Underwood *et al.* (2013) as being important for animal agriculture include the management of grasslands and croplands, change in land use, livestock management, energy use and water

use (Underwood *et al.*, 2013, pp. 27). The criteria which was determined can be seen below in Table 4.1 and Table 4.2.

Table 4.1 - Sustainable Intensification Criteria (the blue points are only applicable if they produce the milk on their own farm).

<u>Sustainable Intensification Criteria</u> • Process a large volume of milk (more than 1,000,000 litres a year) • Large no. of employees (more than 100) • Annual turnover greater than £500,000. • Have adopted any of the following farming systems: Precision farming, Agroecology, Conservation Agriculture. • Adjusting dietary intakes or feeding techniques to maximise production • Artificial insemination of dairy animals • Using of artificial fertilisers • Increasing fertiliser use • Using smart technology for fertiliser application • Protecting or restoring natural or semi-natural grassland. • Restoring or establishing landscape features (e.g. hedges, treelines, woodland patches, terraces, ponds, stone walls) • Using wind power or solar power • Using anaerobic digestion • Have sustainability/environmental policies in place • Reducing amount of packaging • Have a waste recycling scheme • Have a water recycling scheme • Use renewable energy produced on site in your cheesemaking • Use heat exchange technologies in your cheesemaking • Use any other energy conservation practices in your cheesemaking • Sell usually to supermarkets and wholesalers
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The sustainable intensification criteria had to be adapted to fit animal agriculture as it is normally more applicable to arable farming. It also had to be applied to the whole cheese network. A number of the criterions had to be engineered towards the farming/milking area of the network but parts of the criteria had to also be focused on the cheesemaking and location

of the selling point of the cheese network. The criteria are targeted towards the cheesemaker as they were the gatekeepers to the network and they provided information on the rest of the network that was gathered by the initial questionnaire (Appendix 1) so that assumptions could be made about the rest of the network.

The sustainable intensification criteria includes a criterion that you would associate with large production including large volumes of milk, large number of employees and a high annual turnover. The criteria in blue are only applicable to the cheesemaker if they produce their own milk on their own farm. Precision farming, agroecology and conservation agriculture are all concepts related to sustainable intensification (Garnett and Godfray, 2012). On a farm that is practicing sustainable intensification, they will likely be doing what they can to maximise the milking potential of the animal, which for example, could include adjustments to the animal's diet. A diet that has a high intake of dry matter for example, would in turn mean a higher nutrient intake, which can improve the milk yield (Oba and Allen, 1999). Maximising the milk yield is a typical sustainable intensification approach as it maximises production but in turn lessens the environmental impact because the higher the yield the fewer amount of cows needed to produce the milk, therefore reducing the methane emissions from each cow because of the reduction in rumen fermentation, but also the amount of slurry accumulated (Agriculture and Horticulture Development Board, 2016). You would expect a sustainably intensified establishment to have recycling schemes in place for waste and water and to have an interest in renewable energy as these are all ways of reducing environmental impact whilst increasing production. Reducing the amount of natural fertiliser, as well as stopping the use of artificial fertilisers and the application of smart technology to apply it are all associated with the sustainable intensification of agriculture. If a company is practicing sustainable intensification and they were on a large scale you would expect to see them sell to supermarkets as the network would be larger and they would want to distribute to as many customers as possible.

Table 4.2 - Eco-localist Criteria (the blue points are only applicable if they produce the milk on their own farm).

<u>Eco-localist Criteria</u> • Process a small volume of milk (less than 35,000 litres a year) • Small no. of employees (less than 10) • Annual turnover less than £15,000 • Source their milk from within 6 miles of their location • Practice organic farming or biodynamic farming • Stocking rare breeds • Reducing fertiliser use • Decreasing grazing density • Use traditional methods of cheesemaking • Sell usually only at farmers' markets, their own farm shop or local delis, restaurants and pubs
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As described in the literature review (Chapter 2), you would expect an eco-localist cheesemaker to be on a much smaller scale compared to a sustainably intensified cheesemaker. Therefore the criteria for an eco-localist setting reflects that by processing a small volume of milk, having a small number of employees which would in turn result in a lower annual turnover. Curtis (2003), writes how the central argument of eco-localism is a local self-reliant community therefore the criterions 'Source their milk from within 6 miles from their location' and 'Sell usually only at farmers' markets, their own farm shop or local delis, restaurants and pubs' were added to the list because this implies that they are relying on the community around them. Farmers' markets are a common eco-localist occurrence (Curtis, 2003). Organic and biodynamic which is a described as 'deep organic' (Biodynamic Association, 2016) farming have been included in the eco-localist criteria as they are farm forward approaches that are in keeping with the natural environment. An eco-localist farm is more likely to stock rare breeds, reduce fertiliser use and decrease grazing density because these are all methods that are not ensuring maximised production which would be sustainably intensified.

4.3 Identification of sustainably intensive and eco-localist cheesemakers

The criteria established above was so that eco-localist and sustainably intensive cheesemakers could be identified from the list of cheesemakers with an interest in sustainability that had already been collated. As described in the methodology (Chapter 3) a questionnaire was used to gather the information from the cheesemakers to establish which criteria they fitted best.

The key data obtained from the questionnaires, which were distributed to 34 cheese makers identified in Figure 4.1, is displayed throughout this chapter.

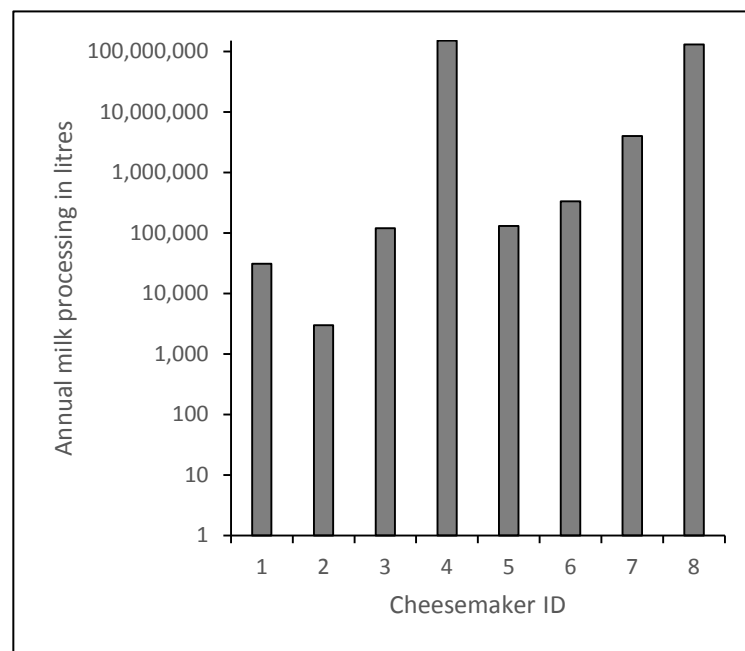


Figure 4.2 -Bar graph showing the annual milk production in litres on a logarithmic scale for each cheesemaker (1-8)

Figure 4.2 shows the annual milk production in litres on a logarithmic scale for the 8 cheesemakers that returned the questionnaire. The annual milk production has been displayed on a logarithmic scale because Cheesemakers 4 and 8 process significantly more milk than the other 6 cheesemakers. A large amount of milk being processed is congruent with sustainably intensified cheesemakers and contrasts a small amount of milk being processed annually associated with an eco-localist cheesemaker.

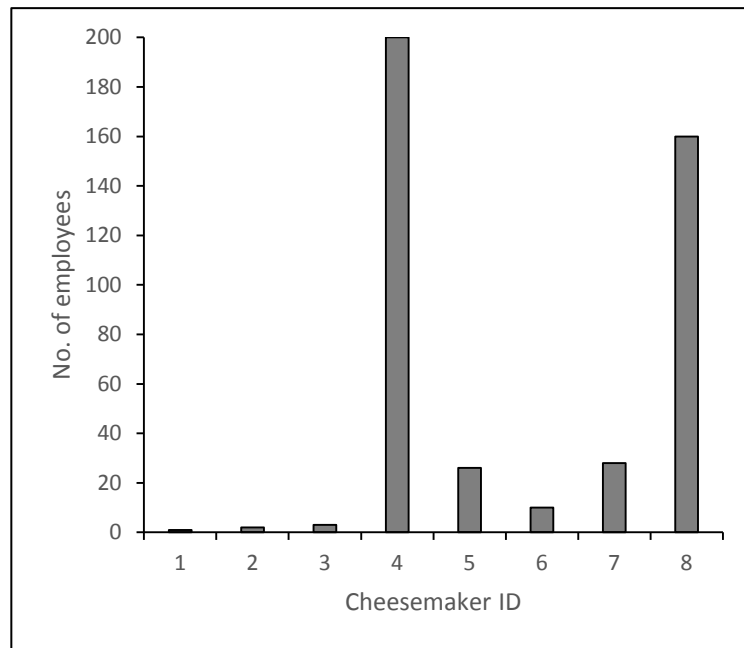


Figure 4.3 - A bar graph showing the number of employees at each cheesemaking setting (1-8)

Figure 4.3 shows the number of employees at each cheesemaking setting. Cheesemakers 4 and 8 again have substantially more employees than the other 6 cheesemakers. A sustainably intensified cheesemaker would have a larger number of employees and an eco-localist cheesemaker would have a smaller number of employees. As seen in the graph, cheesemakers 1, 2 and 3 have a particularly small amount of employees.

Another line of enquiry that was investigated from the questionnaire and the criteria is the annual turnover of the business, as displayed in Table 4.3. Cheesemakers 1 and 2 have a low annual turnover which is linked to an eco-localist setting.

Table 4.3 - Table showing which bracket of annual turnover each cheesemaker setting (1-8) fits into

Annual Turnover	Cheesemaker ID
Less than £15,000	2
£25,001 - £50,000	1
£100,001 - £500,000	3
Over £500,000	4, 5, 6, 7, 8

The location of the place of sale of the cheese was also included in the criteria and the results from the questionnaire, of where each cheesemaker sells their cheese, can be seen below in Table 4.4. Cheesemakers 4, 7 and 8 have an export product implying that they are sustainably intensified. Selling to a national supermarket chain is also indicative of being sustainably intensified and cheesemakers 3, 4, 7 and 8 sell to a national supermarket chain.

Table 4.4 - Table showing the location each cheesemaker setting (1-8) sells their produce at

	Cheesemaker ID							
Sell to/at...	1	2	3	4	5	6	7	8
Own farm shop	No	No	No	Yes	Yes	No	Yes	Yes
Farmers markets	No	Yes	Yes	Yes	No	No	No	Yes
Local delis and independent stores (within 30 miles)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Non-local delis and independent stores (beyond 30 miles)	Yes	No	Yes	Yes	No	Yes	Yes	Yes
Local pubs, restaurants and other eateries (within 30 miles)	Yes	No	Yes	Yes	No	No	Yes	Yes
Non-local pubs, restaurants and other eateries (beyond 30 miles)	No	No	Yes	Yes	No	No	Yes	Yes
Local supermarket branch	No	No	Yes	Yes	No	No	Yes	Yes
National supermarket chain	No	No	No	Yes	No	No	Yes	Yes
Wholesalers	No	No	Yes	Yes	No	Yes	Yes	Yes
Other		Mail order		Export			Export	Export

All the data that was collected in the questionnaires was analysed and it was decided which criterion each cheesemaker setting satisfied. Table 4.5 shows a complete list of the criteria for both the sustainable intensification criteria and the eco-localist criteria. For each criterion the table shows which cheesemaker establishment satisfied it and if so a 'Y' for 'yes' is shown in the corresponding box. If the establishment did not meet that particular criterion then the box was left blank and a 'N/A' for 'not applicable' was used for the criteria specific to the farm if the cheesemaker setting did not have their own farm.

Table 4.5 – Table showing how well each establishment fits the sustainably intensified and eco-localist criteria using data collected from the initial questionnaires.

	Establishment							
	1	2	3	4	5	6	7	8
<u>Sustainable Intensification criteria</u>								
Process more than 1 million litres of milk per year				Y			Y	Y
Large no. of employees (over 100)				Y				Y
Annual turnover greater than £500,000.				Y	Y	Y	Y	Y
Have adopted any of the following farming systems: Precision farming, Agroecology, Conservation Agriculture	N/A		N/A				N/A	Y
Adjusting dietary intakes or feeding techniques to maximise production	N/A		N/A	Y			N/A	Y
Artificial insemination of dairy animals	N/A		N/A	Y	Y		N/A	Y
Using of artificial fertilisers	N/A		N/A				N/A	Y
Increasing fertiliser use	N/A		N/A				N/A	
Using smart technology for fertiliser application	N/A		N/A				N/A	Y
Protecting or restoring natural or semi-natural grassland	N/A	Y	N/A		Y	Y	N/A	Y
Restoring or establishing landscape features (e.g. hedges, treelines, woodland patches, terraces, ponds, stone walls)	N/A	Y	N/A	Y	Y	Y	N/A	Y
Using wind power or solar power	N/A	Y	N/A	Y		Y	N/A	Y
Using anaerobic digestion	N/A		N/A	Y			N/A	
Have sustainability/environmental policies in place				Y				Y
Reducing amount of packaging	Y	Y	Y	Y	Y	Y	Y	Y
Have a waste recycling scheme		Y	Y	Y	Y	Y	Y	Y
Have a water recycling scheme		Y		Y		Y		Y
Use renewable energy produced on site in your cheesemaking		Y		Y		Y		

Use heat exchange technologies in your cheesemaking			Y	Y			Y	Y
Use any other energy conservation practices in your cheesemaking		Y		Y	Y	Y	Y	Y
Sell usually to supermarkets and wholesalers			Y	Y		Y	Y	Y
<u>Eco-localist criteria</u>								
Process less than 35,000 litres of milk per year	Y	Y						
Small no. of employees (less than 10)	Y	Y	Y			Y		
Annual turnover less than £15,000		Y						
Source their milk from within 6 miles from their location	Y	Y			Y		Y	
Practice organic farming, biodynamic farming	N/A	Y	N/A		Y		N/A	
Stocking rare breeds	N/A	Y	N/A			Y	N/A	
Reducing fertiliser use	N/A	Y	N/A	Y			N/A	Y
Decreasing grazing density	N/A	Y	N/A		Y		N/A	
Use traditional methods of cheese making	Y	Y	Y		Y	Y	Y	Y
Sell usually only at farmers' markets, their own farm shop or local delis, restaurants and pubs	Y	Y			Y			

Table 4.5 is summarised by the percentage of criteria which each establishment satisfies, both sustainable intensification and eco-localism, which can be seen in Table 4.6.

Table 4.6 - table showing the percentage of criteria each establishment satisfies for both sustainable intensification and eco-localism.

<u>Establishment</u>	1	2	3	4	5	6	7	8
Percentage of criteria satisfied for Sustainable Intensification	9	38	36	76	33	48	64	86
Percentage of criteria satisfied for Eco-localism	83	100	33	10	50	30	33	20

The percentages were worked out based on a score out of 21 for sustainable intensification and out of a score of 10 for eco-localism and this was dependant on the number or criterions in each criteria (if the establishment did not have their own farm the scores were out of 11 and 6 for sustainable intensification and eco-localism respectively). A better representation of the results shown in Table 4.6 can be seen below in Figure 4.4.

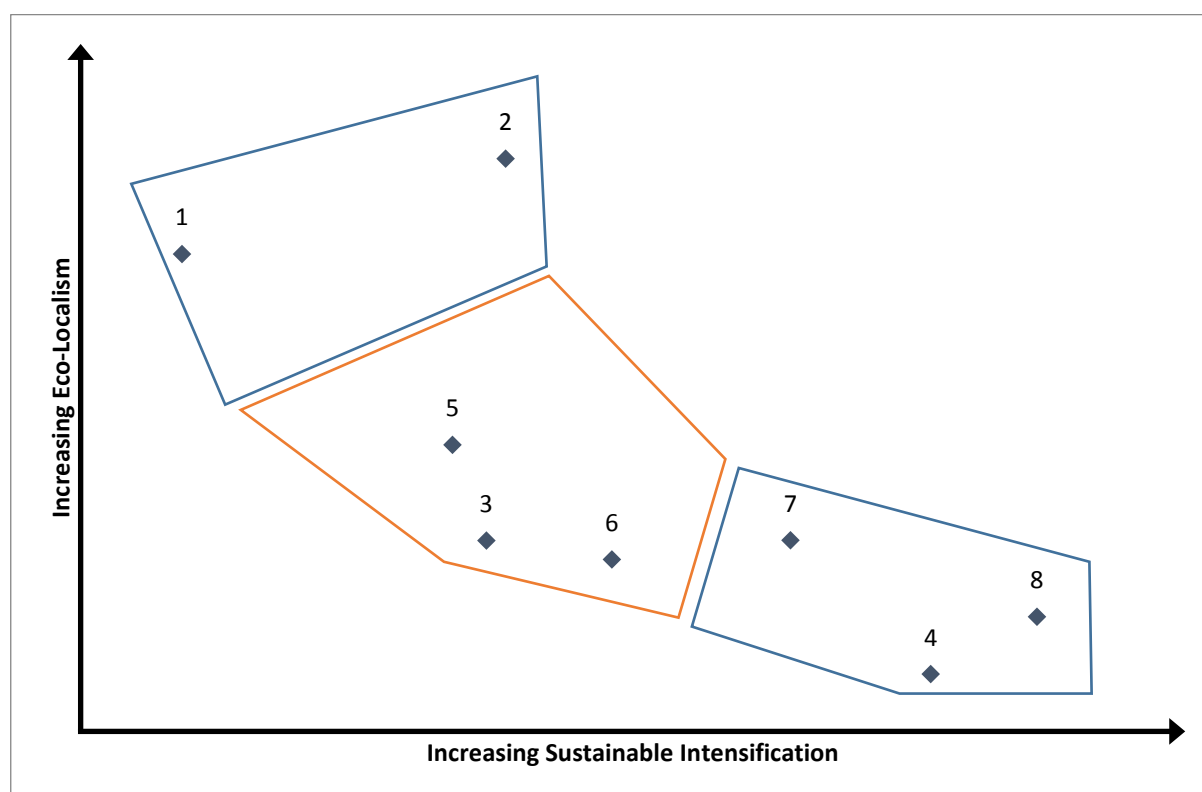


Figure 4.4 - Graph plotting the percentages of criteria satisfied for both sustainable intensification and eco-localism for each establishment (numbered 1 - 8).

Figure 4.4 shows each establishment's percentage of criteria satisfied for sustainable intensification against eco-localism and it produces a horn like shape. This is to be expected, the greater the percentage of criteria for one approach the lesser the percentage of criteria for the other. The three establishments that displayed the strongest sustainable intensification characteristics are establishments 7, 4 and 8, the two establishments (4 and 8) with the highest percentage of satisfying sustainable intensification have the lowest percentages of criteria satisfied for eco-localism. As the graph indicates, sustainable intensification and eco-localism are not discrete categories as some establishments can show characteristics of both. Sustainable intensification and eco-localism can be seen as being on a continuum and Figure 4.5 indicates this below.



Figure 4.5 - Visualisation of eco-localism to sustainable intensification continuum.

When thinking of sustainable intensification and eco-localism as on a continuum, this explains the three establishments outlined in red on the graph in Figure 4.4 (establishments 5, 3 and 6). These establishments show that there can be characteristics of both sustainable intensification and eco-localism displayed by a cheesemaker. These three establishments still follow the general pattern that the higher the percentage of criteria satisfied for one approach the less for the other. The eco-localism end of the continuum shows that there are two establishments that are clearly eco-localist, these being establishments 1 and 2. The shape of the graph is horn like (wider at the top of the curve than the bottom) because the establishment with the highest percentage of criteria satisfied for eco-localism (establishment 2) does not have the lowest percentage of criteria satisfied for sustainable intensification. This is because places showing strong eco-localist characteristics are likely to have an interest in other areas of sustainability. Looking at establishment 2 in Table 4.5, it can be seen that the sustainable intensification criteria that they satisfied are restoring or establishing landscape features, using wind power or solar power, reducing amount of packaging, have a waste recycling scheme, have a water recycling scheme, use renewable energy produced on site in your cheesemaking and use any other energy conservation practices in your cheesemaking. All these characteristics show a deeper commitment to other areas of sustainability, even though the establishment is a small network and you would not normally expect to see this level of commitment at an eco-localist scale.

However, with regards to the waste and recycling schemes, they may not actually be tangible schemes in place but just a moral obligation to reduce the amount of waste produced and water used and therefore a misinterpretation of the term 'waste and recycling' scheme. The sustainable intensification end of the 'horn' is always likely to be narrower than the eco-localist end as establishments this size are unlikely to fulfil all or a lot of the eco-localist criteria. For example, it would be almost impossible to source their milk from within 6 miles of their location when they are processing over 1,000,000 litres of milk a year and having to assemble the milk from many different farms.

The location of the 8 establishments that have been classified as sustainably intensified, eco-localist or intermediate can be seen below in Figure 4.6.

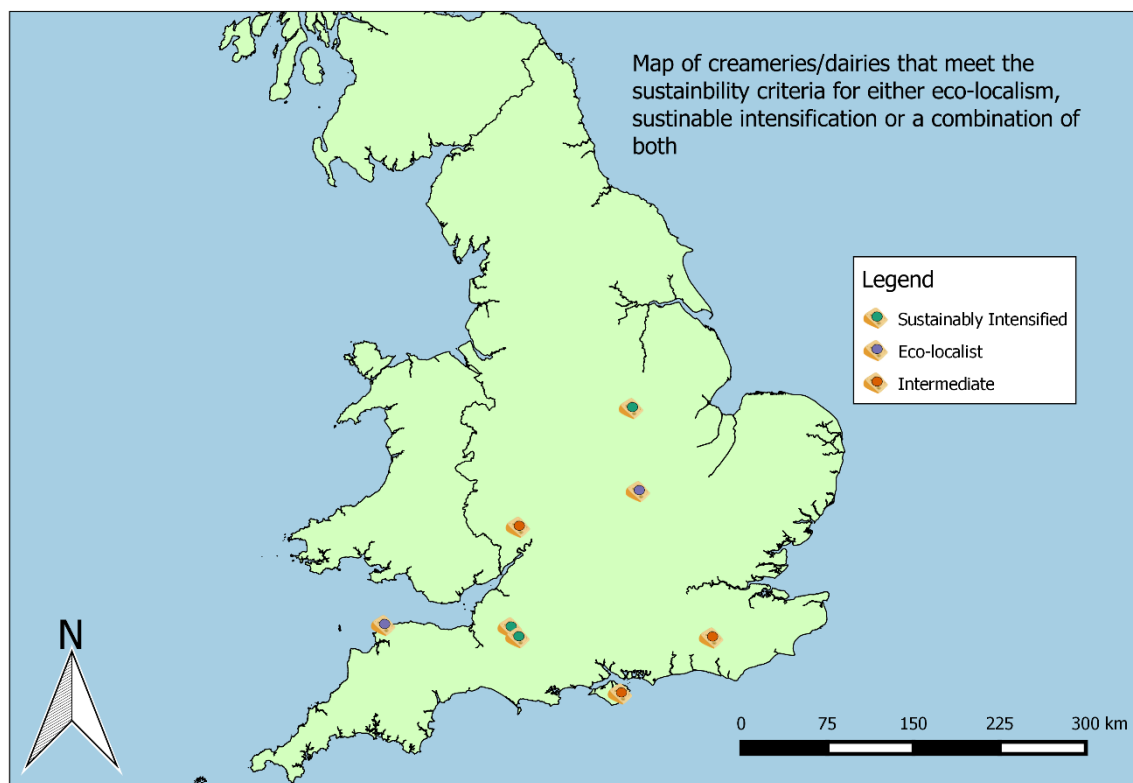


Figure 4.6 - Map of creameries/dairies that meet the sustainability criteria for either eco-localism, sustainable intensification or a combination of both.

Unfortunately as referred to above, only 8 of the 34 cheese makers returned the questionnaire which is only a 23.5% response rate and a higher response rate was hoped for. There could be a number of reasons for the low response rate including the fact that the cheesemakers could be genuinely not interested in sustainability even though they have mentioned it on their website. To explore this further a list of sustainable cheese buzzwords was compiled and then the

frequency of these words recurring throughout the sustainability section of their websites was recorded. A list of the sustainable cheese buzzwords can be seen below in Table 4.7.

Table 4.7 - table showing a list of sustainable cheese buzzwords that were used to establish the cheesemaker's interest in sustainability

Sustainable cheese buzzwords

- | | |
|-------------------------------------|------------------------------|
| • Animal welfare/health | • Greenhouse gases |
| • Biodegradable | • Handmade |
| • Carbon capture/neutral/offsetting | • Local |
| • Carbon footprint | • Low-input |
| • Climate change | • Natural |
| • Conservation | • Organic |
| • Eco friendly | • Recycle |
| • Ecological footprint | • Reduce |
| • Emissions | • Renewable energy |
| • Energy efficient | • Reuse |
| • Environment | • Soil association |
| • Environmentally friendly | • Solar energy/panels/power |
| • Ethical | • Sustainable |
| • Food miles | • Waste management/reduction |
| • Grass-fed | • Wildlife |
| • Green | • Wind energy/turbine/power |

The total number of buzzwords used by each establishment on their website can be seen below in Figure 4.7. The data revealed that establishment 4 had the most number of buzzwords when talking about sustainability. However, establishments 10 and 13 (shown in red) also had full sustainability reports of which the buzzwords were not counted for so those two establishments total buzzword count would be a lot higher. This is to be expected as establishments 4, 10 and 13 are large cheddar producers in the UK. The columns in green show the establishments that replied to the questionnaire; however, there is not a correlation between the number of buzzwords and which establishments replied. Establishments 25 and 28 have since removed or edited their webpages. The establishments that didn't reply to the questionnaire and those that have a low count of buzzwords could be because they don't have an actual interest in sustainability.

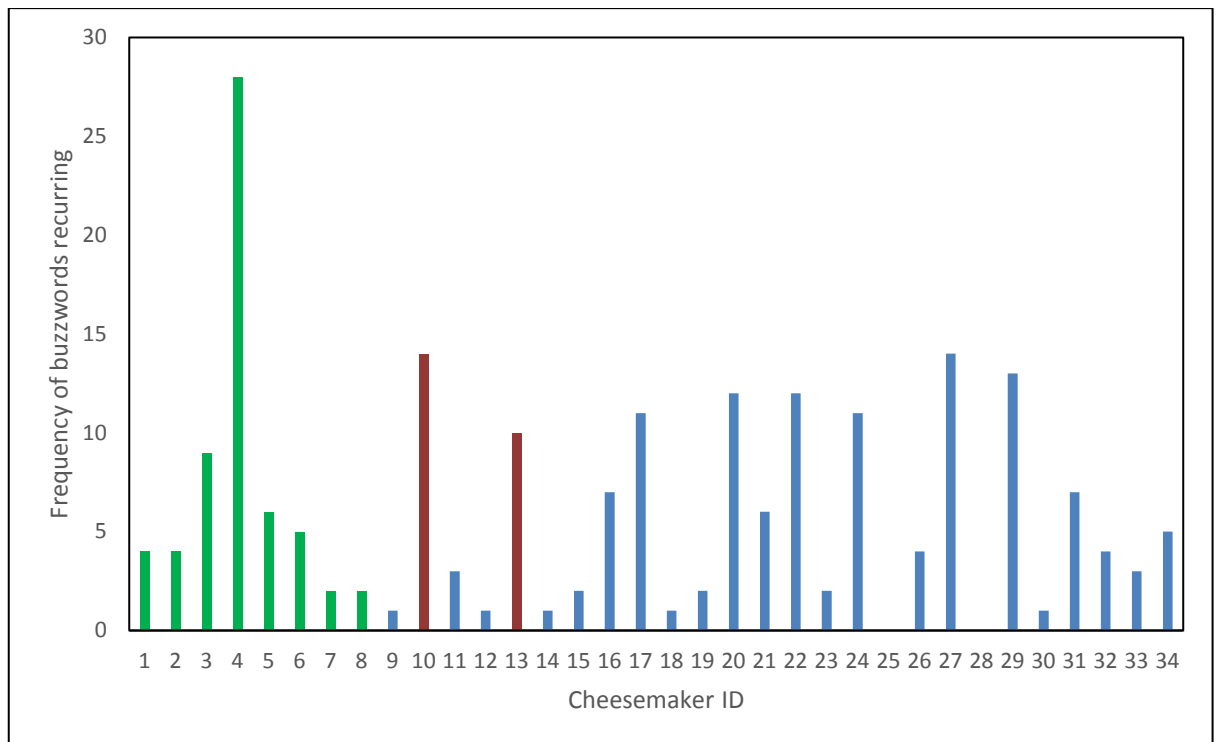


Figure 4.7 - graph showing the frequency of buzzwords used by each cheesemaker setting on their website

Other reasons why only 8 establishments replied could be because some may have found the questionnaire to have been too long or complicated and this may have put cheesemakers off responding or the questionnaire may have not been received by the right person. For example, for the bigger establishments it might not have gone to the right department.

4.4 Selection of case study cheese actor-networks

An establishment with strong eco-localist characteristics was wanted for the first case study and therefore Establishment 2 was chosen because they are strongly eco-localist and they satisfy all criteria for eco-localism, but they are also very interested in other areas of improving sustainability (whilst remaining a small business) such as renewable energy and reducing amounts of packaging, waste and water use. For the second case study an establishment with formidable sustainably intensive characteristics was required to offer a comparative to case study 1 and Establishment 4 was chosen as the sustainable intensification case study, as it is apparent they strongly fit into this category. Establishments 3, 6, 7 and 8 did not want to take part in further research.

Initially it was thought that the research would only require two case studies but it was decided that a third case study would provide a richer depth of information on sustainable cheese

networks. Therefore because of this and because the eco-localist case study would be a small network it was decided that a third case study would be feasible. Looking at the continuum the first two case studies are situated at either end, therefore the third case study was to be from the intermediate category. Case Study 3 can be seen on the continuum located in between the Case Study 1 and Case Study 2 and this can be seen below in Figure 4.8.

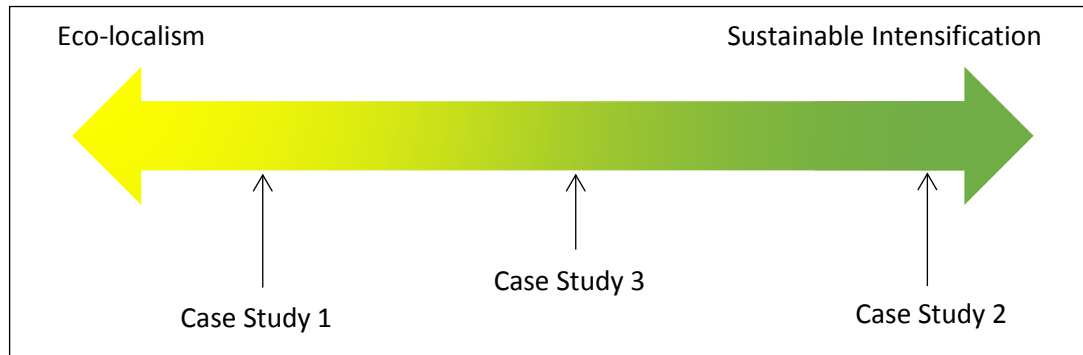


Figure 4.8 - Visual continuum of eco-localism to sustainable intensification with the perceived locations of the case studies on the continuum.

Establishment 5 is an interesting network as they are a cooperative business, which implies eco-localism, however, they have an annual turnover of over £500,000 and artificially inseminate animals and consequently they show characteristics of both eco-localism and sustainable intensification which is also displayed in the graph in Figure 4.4 and therefore establishment 5 was chosen as case study 3. Establishment 1 was determined as having strong eco-localist characteristics and was also the closest location to Leicester, therefore because of the size of the network and its close proximity, it was selected as the pilot study. The pilot study was located in the East Midlands, Case studies 1 and 2 are located in the South West of England and Case study 3 is located in the South of England. The Case Study locations and the pilot study can be seen on the map in Figure 4.9.

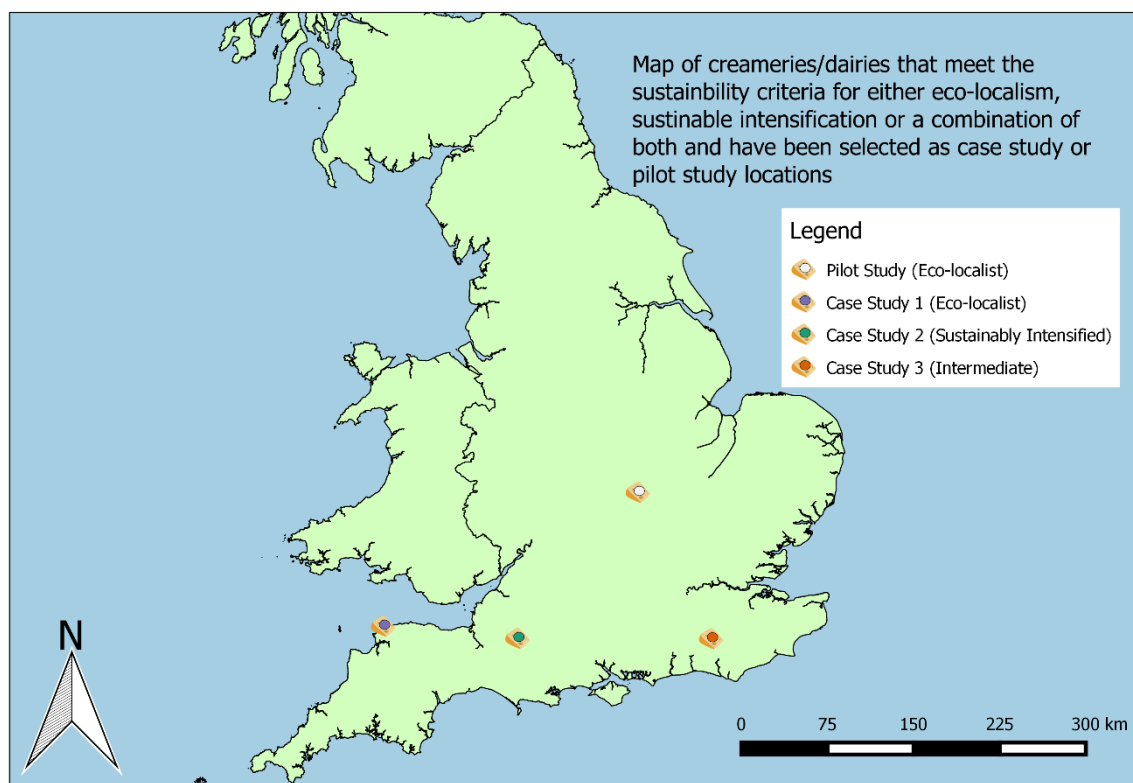


Figure 4.9 - Map of creameries/dairies that were selected for either the pilot study or as case study locations.

4.4.1 Introduction to Case Studies

This section introduces information about the case studies although some of the characteristics have already been discussed in this chapter and a further detailed description of the different case studies can be found in Chapter 5.

Case study 1: Middle Campscott Farm has been chosen as the eco-localist case study. The farm is an organic farm covering 34 hectares located in Lee near Ilfracombe on the North Devon coast. They produce a sheep cheese which they make using milk produced on their own farm by their own sheep. They are a small business with an annual turnover of less than £15,000 and they process 3,000 litres of milk a year to produce 500kg of hard ewes' milk cheese. There are two people running the farm and dairy, and they rely on regular volunteers throughout the year to help with the workload.

Case study 2: Wyke Farms has been chosen as the sustainably intensive case study. The farm and dairy are a large business on three different sites. The farm covers 610 hectares located in Wkye Champflower near Bruton in Somerset. They produce a cheddar cheese which they make

using milk produced on their own farm as well as milk from 90 supplier farms in the local area. They are a large business with an annual turnover of more than £500,000 and they process 150 million litres of milk a year to produce 15,000 tonnes of cheddar cheese. The business has 200 employees across the three different sites including a board of directors and managers.

Case study 3: Plaw Hatch Farm has been chosen as the intermediary case study. The farm is a biodynamic farm covering 83 hectares located in Sharpthorne near East Grinstead in West Sussex. The farm is part of a bigger cooperative, the Tablehurst and Plaw Hatch Community Farm. They produce four different cheeses: a cheddar, a crumbly cheese, a halloumi and a Gouda-type cheese which they make using milk produced on their own farm by their own cows. They have an annual turnover of more than £500,000 and they process 130,000 litres of milk a year to produce 4,217kg of cheese and the business has 26 employees.

4.5 **Chapter Summary**

This chapter has taken steps to tackle the first aim and its corresponding objectives which can be seen below

Aim 1: Identifying eco-localist and sustainably intensified cheese networks

Related objectives:

- 1.1. Identify cheesemakers in England with an interest in sustainability
- 1.2. Establish and create a criteria for sustainably intensified and eco-localist cheese
- 1.3. Identify of sustainable intensive and eco-localist cheesemakers
- 1.4. Select case study actor-networks

The aim of identifying eco-local and sustainably intensified cheese networks has been achieved in this chapter. Cheesemakers with an interest in sustainability were identified, given that 34 cheesemakers across England have a known interest in sustainability. As already mentioned some cheesemakers may have been missed if they do not have an online presence and also if they do not outwardly advertise their views or interest in sustainability meaning they will not have been recognised to fulfil the requirements to be included in the list of 34 cheesemakers with an interest in sustainability. A criteria was successfully established and created for both sustainably intensified and eco-localist cheese. There was not a criteria for sustainably intensified or eco-localist cheese in previous literature so this can provide a criteria for further

research to work from and build upon, along with studies such as Schmitt *et al.* (2016) who have also provided a criteria for cheese.

The formulation of the criteria allowed for the 34 identified cheesemakers to be categorised as either eco-localist or sustainably intensive based on responses to the initial questionnaire. As mentioned earlier in this chapter only 8 responses were received from the initial questionnaire, which was a disappointing response rate and there are any number of reasons why this could have occurred as discussed, which included the questionnaire being too long or the questionnaire never reaching an actor to answer it. However, from the 8 responses that were received from the cheesemakers, 2 were categorised as eco-localist, 3 were categorised as being sustainably intensive and 3 were categorised as neither but as an intermediary category. This intermediary category allowed conclusions to be drawn that eco-localism and sustainable intensification are not discrete entities and can therefore be thought of as existing on a continuum which is visualised earlier in the chapter in Figure 4.5. When the categories of sustainable intensification and eco-localism that each establishment satisfied was interpreted in graph form (Figure 4.4) a horn shaped emerged and from this, the research was able to conclude that this is because an eco-localist setting which has an interest in sustainability is also likely to satisfy some sustainably intensive criteria, such as having a recycling and water scheme. This is because they have an interest in sustainability and they are able to execute these at a small scale. However, it is unlikely that a sustainably intensified cheesemaker would satisfy many eco-local criteria because of the scale and breadth of the business.

The final part of this chapter successfully identified four case studies from the eight that responded to the questionnaire to participate in the research. One eco-localist case study: Middle Campscott Farm, one sustainably intensive case study: Wyke Farms, and one intermediary case study: Plaw Hatch Farm.

The next chapter goes on to address the second aim and its related objectives.

5 Understanding the dynamics of cheese actor-networks

The main purpose of this chapter is to address Aim 2 and the corresponding objectives.

Aim 2: Understanding the dynamics of actor-networks

Related objectives:

- 2.1. Map the actor-networks.
- 2.2. Explore the different discourses of sustainability within the actor-networks and explore connections to notions of eco-localism and sustainable intensification.
- 2.3. Look at the interactions between the actants that link to sustainability.

Therefore, this chapter seeks to understand the dynamics of the actor-networks by mapping the networks using notions from the initial questionnaire data and then interviews which provided richer detail on the networks themselves. Next, the different discourses of sustainability within the network are explored and discussed, with connections to sustainable intensification and eco-localism investigated along with the interactions between actants that link to sustainability. The satisficing of Aim 2 and the corresponding objectives completes steps 2-5 of the methodological framework that was identified for this research. Rich data needed to be collected in order to identify the actants. Once the actants are identified the actor networks can be mapped and the discourse explored. The discourses of sustainability are important actants within the networks.

5.1 Mapping the network

When using ANT, as previously mentioned in Chapter 2, it is often descriptively focused and can be used to examine the relationships between actants in a network. To develop its description of the three food networks studied in this research, visual actor-network diagrams were developed to map the networks. As already discussed in Chapter 3, my own interpretation of their cheese actor-networks was shown to the participants in diagrammatic form, who were invited to comment on them in order to illicit more detailed information about the network. These cheese network diagrams were then expanded upon by adding more actants and detail that was gained in the interviews and from observations, to map the actor-networks to give an expressive view of each network.

For each actor-network diagram, the actants were arranged in lines of association that were identified as occurring along the network so that the diagrams were comprehensible. There

were many actants and associations present within even the smallest eco-localist network, therefore the diagram was extremely busy so it was arranged to make it simpler to read. The main lines of association that were identified along cheese actor-networks were farming, milking, cheesemaking, maturation, packaging, and selling. These lines of association were identified as being main lines of association because this is where the strongest associations between actants exist, for example the association between the farmer and the milk, the association between the cheesemaker and the cheese. Not every network had all these lines of association, but they had variants of them. It is important to note at this stage that these network diagrams are by no means complete representations of actor-networks as it is not possible to display every actant, as there are often other actants involved in each actant's actor-network. For example, animals have been included in the diagrams, but the inner workings of the animal or the complex relationships that comprise the animal are declared invisible. This would include all the organs, bones, blood and many other components within the animal, as animal and human bodies themselves are actor-networks. Animals as well as many other actants along the network have therefore been black-boxed to reduce the complexity of certain actants to just their inputs and outputs. It would be almost impossible to include everything and there had to be limits to the network in some way. Therefore the limits to the actor-networks that were chosen in this study are what the researcher can see by ethnographic techniques. Other actants have been added to the cheese actor-networks and they are actants that came up in the interviews. The actants that the researcher could see are shown in the diagram as yellow.

5.1.1 Eco-localist case study: Middle Campscott

The eco-localist cheese actor-network can be seen in Figure 5.5. Even though this is the smallest actor-network of the three produced, which is what you would expect from the eco-localist case study, the actor-network is still quite extensive. The lines of association that were identified for Middle Campscott's cheese actor-network are farming, milking, cheesemaking, maturation and selling. The farm and buildings (a farmhouse, a dairy, a milking parlour and two barns) are located on land in North Devon, just up from Lee Bay, and the farm and surrounding area is home to many different types of wildlife. At the time of the first visit, the farm contained 96 sheep, with approximately 84 of these being milked once a day by the farmer. The sheep are a more than human actant and the farmer is a human actant; the association between these two actants is a strong association, and as a result a key association within the network because the actant milk is enrolled at this stage of the network. The sheep have a diet of grass (a natural actant) which they graze on, hay and silage that is grown on the farm, and also an animal feed

that is supplied by an external supplier (Mole Valley Farmers). This translates the external feed supplier actant into the Middle Campscott network. The sheep also have straw for bedding, which is supplied by a local farmer in Woolacombe Bay. Any manure produced by the sheep is sprayed back onto the fields. The manure is translated into the network firstly by problematization; the fields need manure to grow well so interessement locks the manure into the network. It is then further enrolled into the network as the fields and manure interests align to grow the grass. Other animals living on the farm, grazing on the grass and living in the farmhouse were 12 cows, two pigs, a number of ducks and chickens, five border collies and six cats. The manure is a natural actant within the network and the animals are more than human actants.



Figure 5.1 - Montage of photos from the farming line of association in the Middle Campscott actor-network (author's own photos).

The sheep come in from the fields twice a day: once in the morning to be milked and then again in the evening to bring the lambs in, with the lambs being kept in the barn overnight so that they do not drink their mothers' milk in order that the mother has milk for milking in the morning. The sheepdogs bring the sheep in from the fields on instruction from the farmer. The farmer milks the sheep in the milking parlour (key association as mentioned). The sheep enter the milking parlour and walk straight onto a milking table, with eight sheep being milked at one time. The farmer attaches milking clusters to the sheep's udders, with suction being used to take

milk from the sheep. Prior to attachment, a wet wipe is used to clean any mud from the teat. Once the sheep is dry, the milking clusters are removed and an iodine based teat spray is sprayed onto each teat to prevent infections, such as mastitis. The sheep can then make her way back outside to see her lamb and return to the fields. Once the sheep have been milked they exit the milking table down a different ramp to the one they entered back out in to the yard, and the lambs are released so that they can join their mothers' in the fields. The relationship between the sheep and the teat spray is a key association as the teat spray prevents the sheep from getting an infection, helping to ensure that the sheep can continue to be translated within the network. The milk is moved through the milking system and is collected in the milk receiver, and then passed through a filter. The milk is collected in old ice cream tubs and is either put in the refrigerator that is in the dairy for cheesemaking that week, or it is stored in the freezer for cheesemaking at another time. Middle Campscott's annual milk production is 3,000 litres.



Figure 5.2 - Montage of photos from the milking line of association in the Middle Campscott actor-network (author's own photos).

Cheesemaking at Middle Campscott is carried out once a week, with an annual cheese production of approximately 500kg. Cheesemaking was identified as a key line of association as this line of association is where the cheese is made for maturation. It is in the milking line of association where there are many technological actants. To make the cheese, the milk is retrieved from either the freezer or the refrigerator and deposited into the vat, which holds a maximum of 300 litres of milk. Heat provided by an immersion heater is used to warm up the

vat and the milk inside. Starter culture is added to the milk that is obtained from Orchard Valley Dairy Supplies (located in Tenbury Wells), who are then translated into the network with aligned interests of providing ingredients in exchange for money. Vegetarian rennet is added which is also obtained from Orchard Valley Dairy Supplies. The vegetarian rennet for this research has been decided as a more than human actant, as even though the enzymes collected from fungi are naturally occurring, they are collected and fermented by a human actant. Once the milk has set to a curd, which is what the rennet activates, the curd is cut with curd cutters; the curd is cut when the set milk reaches 24 degrees Celsius. This separates the curd and releases whey. The curds and whey are then stirred for 30 minutes by the cheesemaker running their hand through the curds and whey, breaking up the bigger pieces of the curd into smaller pieces. Once this has been achieved the plug at the bottom of the vat is removed, draining the whey through a drain in the bottom of the vat through a hose. This is then collected in a series of churns.

Once most of the whey has been drained off, the curd is left to pitch. This is where the curd settles at the bottom of the vat. The whey is given to the animals to eat. The now bonded curds are cut into large chunks and turned over and left for an hour. After an hour, the curds are broken up into chunks by the cheesemaker's hand and put into cheese moulds, which are lined by cheesecloth. Curd is packed in by the cheesemaker all the way to the top of the cheese mould and then a lead weight is placed on top to keep tension on the curds. The curds are then left for two hours. After which they are flipped and the weight is added to the now topside of the mould. The next day they would then be flipped again. At this stage, the cheeses are moved into the cheese store where the refrigerator is set to 13 degrees Celsius, and instead of using a humidifier, a small amount of water is poured onto the floor of the store to keep it humid. Cheese mites are also an actant (natural) in the actor-network as they devour the cheese when it is maturing. There are many strong relations that exist in the cheesemaking line of association, as the cheese is an integral actant in the network. The technological actants in the cheesemaking association include the vat, curd cutters, cheese moulds, and lead weights.



Figure 5.3 - Montage of photos from the cheesemaking line of association as well as one photo of the maturation store in the Middle Campscott actor-network (author's own photos).

The cheeses mature in the cheese store and are taken to farmers' markets in the car by the cheese maker, along with the co-product of yoghurt. The farmers' markets that are attended by Middle Campscott to sell their cheese are Barnstaple Pannier Market on every Tuesday and Friday, Ilfracombe Farmers' Market the first Saturday of every month, Braunton Farmers' Market the fourth Saturday of every month and the Real Food Market the second Sunday of every month. The cheese and market actants have a strong association in the actor-network as the cheese is only sold at farmers' markets. At each market there are a variety of other stallholders and a Market Management Team runs each market. Ranges of different customers visit and buy cheese from the Middle Campscott stall and money is exchanged. The cheese is not pre-packaged but at market the cheese is wrapped either by a plastic sheet or wax paper

and put into a brown paper bag for the customer to carry home, which are obtained from external suppliers MK Products, Booker Wholesale and NJ Products respectively.



Figure 5.4 - Montage of photos from the selling line of association in the Middle Campscott actor-network (author's own photos).

At the market, Middle Campscott also sells meat and wool produced on the farm. Prior to their arrival at the market as meat, lambs and cows from the farm travel to Coombe Martin abattoir in a Land Rover or an often-attached trailer. After slaughter, meat is returned to the farm for the meat to go to market for sale, whilst skins go to a skin curer and then also return to the farm for sale at farmers' market. Wool from the sheep goes from the farm to a spinner to be spun, before returning to the farm to be sold at market. The wool is also sold at a wool show, Unravel in Surrey.

Middle Campscott have a website and a Facebook page that they use to promote when they are attending markets and on what days, and to keep in touch with the wider community. There are updated by the farmer. Also, for promotional purposes, Middle Campscott distribute yellow paper bookmarks when a product is bought so that customers have their contact details and can visit again. The yellow paper bookmarks are a literary inscription, which is circulated to enrol more customers and therefore actants into the network. At Barnstaple farmers market, it is not uncommon for tourists to attend the market. The bookmark supplies the contact details of

Middle Campscott, and in many cases tourists at the market have become mail order customers. This is because they have liked the taste of the cheese and wanted to remain customers, but they do not live in the area so order the cheese to be delivered to their home address.

Middle Campscott also use Facebook to maintain contact with volunteers that work and have worked on the farm. Volunteers are used instead of paid staff, as Middle Campscott are a small farm with a small income; their approximate annual income is £25,000. The volunteers are recruited from the volunteering websites Active X and WWOOF. Volunteers participate in farm activities, milking, and occasionally the cheesemaking. A sharing of knowledge occurs between the people at Middle Campscott and the volunteers. This sharing of knowledge occurs because often the volunteers are veterinary or agricultural college students; they bring their knowledge to the farm and Middle Campscott share knowledge of their cheesemaking and low input lifestyle.

Water, electricity and heat is needed for many lines of association occurring at Middle Campscott, their energy is sourced from the National Grid and they feed back to the grid from solar panels installed on the farmhouse roof. A stove, which burns waste cardboard and excess building site timber, is used to heat the water for the farmhouse. Members of a wider community, such as the local pub, often donate waste cardboard to the farm to be burned in the stove. The water used at Middle Campscott comes from a hillside spring. The main spring is intercepted and held in a holding tank where an aerator pumps air bubbles through it to prevent the water from being as corrosive. The water passes through a coarse and fine filter to remove any debris and an ultraviolet light to remove any bacteria. The water is then pressurised so that it will circulate around the water pipes. Wastewater enters a septic tank where it is treated and goes through perforated pipes back into the ground.

Glass and tins are recycled at Middle Campscott: the glass jars were usually taken to market and given to somebody who would make use of them, e.g. with jam making. There is also a compost bin, and food scraps are given to the pigs. What little waste that is not used is put out for refuse collection. Middle Campscott are farming to organic standards under the licensing inspection of the Soil Association, which costs approximately £650 per year. Environmental Health officers also have to make regular visits to the farm and across the actor-network government legislation impacts.

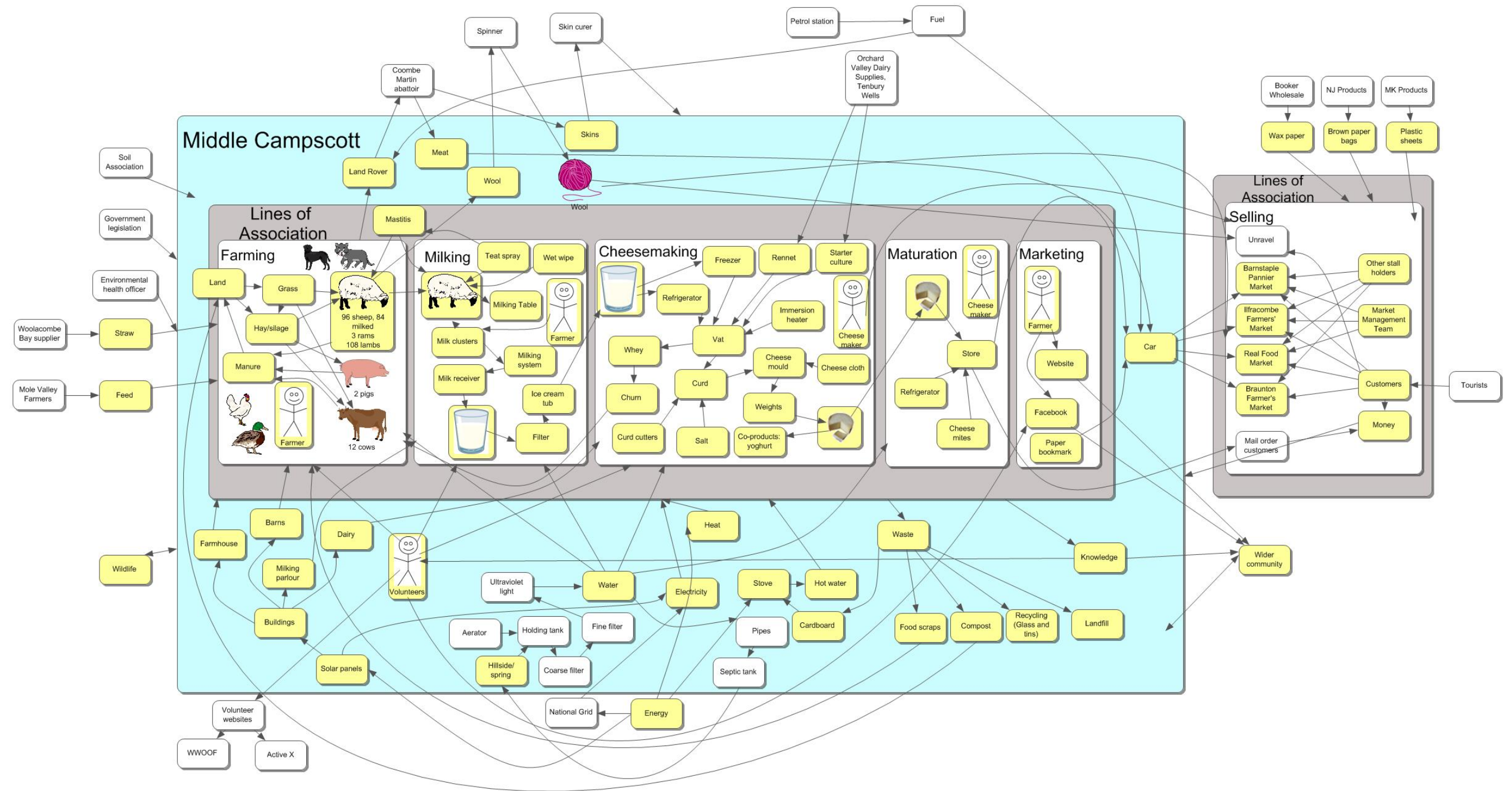


Figure 5.5 - Middle Campscott eco-localist cheese actor-network. The yellow actants are the actants that the researcher could physically see. The actants are arranged in lines of association.

Figure 5.5 shows the many actants and associations that make up the Middle Campscott actor-network. As already established, there are some associations within the network, which have a stronger relationship than others. The association between the farmer and the sheep is a strong association as the milk is integral to the actor-network. The associations between the actants in the cheesemaking line of association are also strong associations as this is when the cheese is produced. One of the other really strong associations between actants in the Middle Campscott actor-network is the association between the cheesemaker and the cheese. The cheesemaker is the actant who helps the cheese to nurture and develop. The cheese to the maturation store is an important association as the cheese matures in the maturation store ready for customer consumption. Other key associations exist between the consumer and the farmers' market as they buy cheese and money is exchanged, so there is a strong association between money and the cheesemaker who sells the cheese, as money is needed to sustain their lifestyle.

The next section maps the actants and associations that are present in the sustainably intensive actor-network, Wyke Farms.

5.1.2 Sustainably Intensive case study: Wyke Farms

The sustainably intensive cheese actor-network can be seen in diagrammatic form in Figure 5.9. This is the most extensive and complicated network of the studies. It is for this reason that it is also the network most likely to be incomplete as actants will have been overlooked and not added to the diagram. There may have been actants that were not apparent from the observations, or they may have not been mentioned in interviews and therefore will not be featured in the actor-network diagrams. The different lines of association that were identified for the Wyke Farms actor-network are farming, milking, cheesemaking, selling and marketing, water recovery, anaerobic digestion, maturation, packaging, distribution and selling. The land and buildings of Wyke Farms are situated in the Somerset countryside; surrounded by many different types of wildlife, across three separate sites. Two sites are located in and around Wyke Champflower, and the other site is in Wincanton. There is a board of directors, with an overall Managing Director and in total there are two hundred employees spread across the three sites. The employees were added to the diagram as one actant because the diagram would have been too complex and busy if the employees were added individually.

The lines of association that have been identified at the Wyke Champflower site are farming, milking, cheesemaking, selling and marketing, and water recovery. A Biogas Plant is located just

down the road from the main site and Wincanton is responsible for the lines of association of maturation and packaging. Wincanton is an actant; a place can be an actant where its inner workings are 'black boxed' and therefore Wincanton is a complex actor-network in itself, and as a result Wincanton is unpacked in the ANT diagram to a certain extent in Figure 5.9.

At the time of the first visit on the farm at Wyke Farms, they had one thousand cows producing milk, split into three herds, which are milked twice a day. The first herd had 460 cows, the second 360, and the third 180 cows. There was also a replacement herd of 800 cows aged from a week old to twenty-six months (the age at which they return to the herd). A replacement herd is a herd of cows that can be used to replace the cows from the current milking herd; the herd replacement rate is 23%. The male calves are taken to two farms for veal rearing or another farm for beef rearing. In winter the cows live in cowsheds in their three different herds, and in summer they are out in fields grazing on grass. In the cowsheds is sawdust and lime, which soaks up any bacteria. The cows have a diet of 40% grass silage and 40% maize silage. A soya, beet and straw blend makes up the other 20%. In summer the cows' diets are more grass based so the winter diet is reduced accordingly. The blend is bought in from Countrywide, who are an external supplier, and the grass and maize silage is grown on site. The cows have straw for their bedding, which is supplied by a local contractor on the Salisbury Plain. Any manure produced by the cows is taken to a silo via a tractor to be eventually deposited into the anaerobic digesters. A bi-product of anaerobic digestion is digestate this is used as a fertiliser and sprayed onto the fields. Artificial fertiliser is also sprayed onto the fields, usually in April, as the land is too soft to access with the big tanks carrying the digestate. Artificial fertiliser use is small, and totals approximately 20 tonnes annually. On the farm there are fifteen employees.



Figure 5.6 - Photos from of the farm in the Wyke Farms actor-network. Images sourced from (Farms, 2015a) and (Farms, 2014) respectively.

The cows are milked twice daily; with the cows entering the collecting yard as a herd. The cows in this actor-network are also more than human actants. Artificial insemination is a practice that occurs in this actor-network so from an ANT perspective, they could be 'more' more than human than the sheep in the eco-localist actor-network as humans have more control over the animals in this actor-network. From the collecting yard they enter into the milking parlour. On entrance to the parlour, the cows are washed with water, and then milked. Between 20 and 42 cows are milked at a time, depending on which herd they are in. A farmer puts the milk clusters on the cow, and the milking system uses suction to take milk from the cow. These clusters are automatic clusters so once the cluster has detected low milk flow, the cluster comes off. Once the cow has been milked, an iodine based teat spray is sprayed onto each teat to prevent infections, e.g. mastitis. Once a cow has been milked she can make her way out to the feedlot. The cows wear electronic collars for identification so if need be they can be identified as they pass through the gates and be put in a separate pen. The milk makes its way through the milking system and is collected in the milk receiver. It then passes through a filter and is transported through pipes to a bulk tank ready for cheesemaking. Wyke Farms' annual milk production is approximately eight million litres, with each cow producing on average of 8,000 litres of milk a year. However, Wyke Farms process a total of approximately 150 million litres of milk annually. Wyke Farms obtain milk from 95 other external farms within a 35-mile radius. Milk is transported from these farms via milk tankers and the milk is pumped into a bulk tank at the Wyke Champflower site ready for cheesemaking.



Figure 5.7 - The cowsheds that house the cows in the Wyke Farms actor-network. Image sourced from: (Wyke Farms, 2015b).

Cheesemaking in the Wyke Farms cheese actor-network occurs at the Wyke Champflower site on a daily basis. Their approximate annual cheese production is 18,000 tonnes. Similarly to Middle Campscott, it is in the cheesemaking line of association where there are many technological actants, although the technological actants in the Wyke Farms actor-network are much more high-tech. In the literature review (Chapter 2), there was a discussion of high-tech being more associated with sustainable intensification and low-tech more eco-localist. All the cheesemaking happens inside a factory. The milk is transferred from the bulk tank into the pasteuriser (the pasteuriser is a high-tech actant), where all the milk is pasteurised. Heat from an electrical source is used to raise the temperature of the milk to 71.1 degrees Celsius for at least 15 seconds. Some of the milk will pass through a centrifuge (high-tech actant) to allow for cream to separate from the milk to produce semi-skimmed milk. For cheesemaking, however, only the full mat milk is used so the milk is not centrifuged, and instead travels from the pasteuriser into the vats. There are six vats located in the factory; four of the vats hold 5,000 gallons of milk and the other two hold 4,000 gallons. 22 vats of milk a day are processed and made into cheese. Heat from an electrical source is used again at this stage of the actor-network to raise the temperature of the milk inside the vats to 30 degrees Celsius. Starter culture is added to the milk, which is grown by Wyke Farms themselves and then vegetarian rennet is added which is obtained from CHR Hansen, located in Hungerford, Berkshire. The aligned interests of CHR Hansen and wanting to provide rennet, which is needed for cheesemaking, enrolls the external ingredient supplier into the Wyke Farms actor-network. CHR Hansen is an actant that has been 'black boxed' because CHR Hansen are not an individual but a place that is made up of many other actants including people, machinery, and ingredients; it is an actor-network in itself.

Once the milk has set to a curd, which is what the rennet activities, the curd is cut by curd cutters in the vats and electronic stirrers to keep them separate continually stir the separated curds and whey. Heat is still applied to scald or cook the curd. The curds and whey are then transferred to the 'cheddar belt' (high-tech actant) where the curd is left to set on the belt and whey off occurs. The whey off is the where the whey drains away from the curds so that they are fully separated. The bonded curd is cut into strips and then cut again, after which the curd is salted and milled in a mill. The curds then travel along the machinery to the block formers and the curds are pushed into a block of cheese. At the bottom of the block former, the blocks of cheese are put inside a vac-pack and travel along a conveyer belt where the vac-packs are sealed. The blocks of cheese in the vac-packs are then put into wooden maturing boxes and transferred by an

employee to the cold store on site. There is only one cheese cold store on the Wyke Champflower site. The temperature inside the store is set to five degrees Celsius. The cheese only spends 48 hours in this cold store, after which it gets transferred to the Wincanton site for maturation. There are 60 employees working in the factory at the Wyke Champflower site.

The whey permeate produced in the cheesemaking stage of the actor-network is put through filters and some of the whey will then go to Barber's. Barber's are another cheesemaker in Somerset who are enrolled into the actor-network as Barber's and Wyke Farms have aligned interests. The whey is taken for processing into whey protein powder. This association allows for Wyke Farms to support other cheesemaking businesses in the area. Wyke Farms takes the rest of the whey once it has been filtered. The whey goes through a clarifier to remove any non-milk solids, then through a separator. Finally, the whey will be put through a pasteuriser and filtered again. The whey protein that is left from filtering is dried and forms whey protein concentrate. Some whey protein will be used as animal feed for the cows. The water component of the whey, which is produced from the filtering process, is used to wash down the factory. There are five co-products produced in the Wyke Farms cheese actor-network: yoghurt, butter, cream, milk powder and the already mention whey protein powder. Milk powder processing and organic milk processing also happen on the Wyke Farms factory site for Cadburys and OMSCo respectively.

The maturation line of association takes place at the maturation store in Wincanton, which is approximately seven miles from the main site in Wyke Champflower. The cheese at Wyke Farms comes in five different varieties of cheddar: 'Mature and Creamy', 'Extra Mature and Delicious', 'Vintage and Scrumptious', 'Ivy's Vintage Secret Recipe', and 'Smoked Beautifully Balanced'. The main reason for the different cheddars is the amount of time that the cheeses are matured for in the maturation store. The mature cheddar is matured for six months, the extra mature for twelve months, the Vintage and Ivy's Vintage for fifteen months, and the Smoked for 12 months. After the smoked cheddar has been matured for 12 months, it then goes to a smokehouse to be smoked for 16 hours. The oak woodchips that are used to smoke the cheese are dampened with Thatcher's Heritage Somerset Cider. The maturation store has a refrigerator and a humidifier to regulate the temperature and humidity. Once the cheese has been matured for its required length of time, the cheese is cut and packaged. The cheese is cut using a cheese-cutting machine. Once cheese orders come in from retailers, the employees who work in the packaging at the Wincanton Site can order in the film from YPAC. The cheese is packaged in the film by a

packaging machine. The film they are packaged in is laser perforated and a zip is added so that the packet can be easily ripped into and then re-sealed again. Different coloured film is used for the different types of cheeses: red for mature, purple for extra mature, green for vintage, orange for smoked, and black for Ivy's vintage. The smoked cheese and Ivy's Vintage are cut in to a smaller size (200g) and are then packed into a smaller film, which is sealed without being laser perforated. Whereas the mature and extra mature are cut into 370g sizes, vintage is cut into 320g blocks. The individual cheese packets are stacked into open cardboard trays, which are put straight on the supermarket shelf.

Distribution companies, either Culina or Peter Greens, in their lorries to supermarket distribution warehouses, export the cheese. The individual supermarkets that stock Wyke cheese then distribute themselves to their stores. The supermarkets that stock Wyke branded cheese are Budgens, Lidl, Sainsbury's, Asda, Waitrose and Tesco stores in the South West of the country. Customers visit these supermarkets and exchange money for the cheese that they buy. Likewise, the supermarkets exchange money with Wyke Farms for the cheese they stock on their shelves. Wyke Farms do not just supply cheese under their own brand; approximately 30% of the overall cheese production undertaken is for retailers to use under their own brand. Asda, Co-op, Morrisons, Lidl, Spar and Tesco all stock Wyke Farms cheddar under their own brand. For example, Wyke Farms make the Valley Spire Cheddar for Lidl and the Deli Cheddar in Morrisons. Wyke Farms also cut the mature, extra mature and vintage cheeses into 200g sizes so that they can be sold as an export product, which they supply to 106 countries. The wholesaler Costco is also supplied with Wyke Farms cheddar.

Selling also occurs at the Wyke Champflower Site, as well as marketing and brand management. There is a farm shop that sells cheese as well other fresh and dried products, some of which are supplied by external suppliers. Three employees work in the farm shop. The farm shop provides lunches such as sandwiches, omelettes, and salad boxes that the employees can come in and buy, and also any passing trade people or visitors who are hungry. There are refrigerators in the farm shop that hold all the supplies. The farm shop supplies cheese to local pubs, delis and restaurants, with a farm shop employee delivering the cheese in a van once or twice a week. The wider community also uses the farm shop to buy provisions, with it being open 9am to 5pm Monday to Friday all year round and Saturday mornings 9am to 12pm from April to September. Wyke Farms have a website where customers can also buy cheese from the online shop. The website is also used as part of the Wyke Farms brand, with it informing the users about the

business and their green promises. The website was designed by external designers but with input from employees and the board of directors from Wyke. Wyke Farms have a strong presence on social media and are active on Instagram, Facebook and Twitter, where they make regular contact with their customers and the general public. There are regular competitions to win cheese hampers or a year's supply of renewable energy. The presence on social media is part of their advertising strategy. They also advertise in magazines and support local wider community groups, e.g. the St Margaret's Hospice who they fundraise for and the sponsorship of local sports teams.

Water, electricity and heat are needed for many lines of association occurring at Wyke Farms. The majority of their energy is sourced from their own Biogas Plant. Across the anaerobic digestion lines of association, there are many non-human technological actants that are high-tech occurring in the network. This can be seen in the following paragraphs. At the time of the visit, there were two anaerobic digesters. Since visiting, a third has been installed. The digesters are fed with a mixture of waste products. Whey/permeate from the cheesemaking factory is pumped down in pipes, however, this only happens when there has been an error in the cheesemaking. Whey/permeate also comes in on tankers from Barber's cheese factory. The whey/permeate is stored in a silo and a set amount is pumped into each digester gradually throughout the day and night. Pig slurry is also fed into the digesters that continually flow into the lagoon through pipes. Cow slurry from the farms is also brought to the slurry lagoon by tractors. Irish permeate is also bought in and pumped into the slurry lagoon by tankers as it has a higher sugar and solids content. The mixture of liquids is gradually pumped into each digester throughout the day and night.

Solids are fed into the Peecon feeder by the JCB loader. The solids are mixed up of straw, silage and maize, which are brought in by a tractor from the farm and other local farms that supply milk to Wyke. Bread waste from local supermarkets also makes up some of the solids mixture along with apple pomace, which is waste from local cider makers during the cider-making season. The Peecon feeder can be filled up to twice a day to be able to feed the digesters and can hold up to 25 tonnes when full. The Peecon feeder mixes all of the solid waste materials. The mixture then passes through a RotaCut, which cuts up the waste materials and removes any stones before the mixture is passed through pipes to the digesters. The digesters are heated to 39°C. Each digester has 5 agitators positioned around the walls of the digester which propel the mixture inside, improving the anaerobic digestion process by mixing the solids and liquid. Each

digester also has a flare, which burns off any excess gas so that the gas levels in the digester do not get too high. Gas levels rarely get too high, but if the flares were not there, the gas would continue to build up to bursting point. If this happened, the gas would not be able to be sent to the grid or the CHPs. Gas is produced by methanogenic bacteria and is then stored in the hoods of the digesters. The gas is pumped out of the digesters to power two CHP (Combined Heat and Power) units. One of the CHP units is located at the biogas plant and the other is located at the Wyke Champflower factory site. The CHP units contain V12 engines that make electricity and heat. Extra gas that is produced is sold back to the National Grid. To do this, many associations must exist.

The biogas passes through a gradient of fine filters to clean the gas, including an activated carbon filter to remove Hydrogen Sulphide (H_2S) from the gas stream, which helps to prevent corrosion of upstream machinery. The gas is upgraded to natural gas by removing the carbon dioxide (CO_2) from the biogas. Passing the gas through a membrane does this. Next, water is removed from the biogas by cooling to remove condensate and then leading the biogas through a desiccant to absorb the water. The gas is then compressed and the Elster Unit adds propane to the now biomethane in order to reach the right calorific value that the grid requires, as well as adding an odorant to give the gas a smell. Wyke Farms also sell their gas to Sainsbury's, who use it to power a local store.



Figure 5.8 - Anaerobic digesters at the Biogas Plant in the Wyke actor-network. Image source from (BBC, 2016).

Digestate is a bi-product, which is produced in the production of biogas from the digesters. This digestate is rich in nutrients, such as ammonium, potash and phosphate. The digestate is drilled to combine it and then spread onto the fields where the cows graze, improving the productivity of the grass and helping to reduce erosion. Digestate is also shared with the local farms that supply milk to Wyke Farms for the farmers to spread on their land. This reduces the need for inorganic fertilisers that require a large amount of carbon dioxide to produce them.

Even though the CHP units produce electricity, some still has to be imported from the National Grid, although relatively small amounts. The Wincanton Site is powered from electricity from the National Grid. The other sites get power from the National Grid when not enough power is produced from the CHP towers. Wyke Farms also produce their own energy by having solar panels on the cow shed roofs. This power is valuable because when the milk comes out of the cow at body temperature it needs to be cooled rapidly using ice water and heat exchangers. The cooling plants have to work harder in the summer to build ice and the solar panels produce the most power on hot sunny days.

Water at Wyke Farms is sourced from mains water and a borehole, while all wastewater that is produced across the different lines of association at the Wyke Champflower Site enters a water recovery plant. This plant allows for Wyke Farms to recover up to 95% of the site's wastewater and saves up to 850,000 litres of water per day. Before the water is reused, it is put through a membrane filtration system. The water that is not reused is high quality wastewater that is produced for discharge to the river. Wyke Farms have a commitment to sustainability and have a 100% green energy statement. The 100% green energy is a 'literary inscription' that does have the power to translate further actants into the network. Those actants interested in the statement may enrol in the Wyke Farms actor-network as retailers or consumers for example. It is not just human actants that have been enrolled into the Wyke Farms actor-network, non-human actants have also been enrolled because of the literary inscription that is the 100% green energy statement. For example, the solar panels and the anaerobic digesters have been translated into the actor-network by aligning their interests of providing renewable energy to eventually achieve 100% green energy. They also have three electric cars that a number of the staff use to get from one site to another.

Different amounts of waste are produced along the different lines of association that occur at Wyke Farms. Animal waste and factory waste, as already mentioned, is deposited into the

anaerobic digesters, whilst wastewater enters the water recovery plant. The majority of the waste is packaging waste, which eventually ends up at landfill. Environmental Health officers have to make regular visits to the farm and across the actor-network government legislation impacts, for example legislation on TB and fallen livestock impact upon the actor-network.

Wyke Farms also have a Sustainable Energy Visitor Centre at their Biogas Plant where a sharing of knowledge can occur. The wider community is able to visit, including local school groups, the Young Farmer's Club and other groups. This sharing of knowledge allows Wyke Farms to educate their customers and consumers on their views and values of sustainability.

Figure 5.9 shows the many actants and the associations that make up the Wyke Farms actor-network. There are some associations within the network, which have a stronger relationship than others. The relationships that occur in the cheesemaking line of association are strong associations as without the cheese there is not a cheese actor-network. The relationships between Wyke Farms and their supplier farmers are an important association because without the supply of the milk from those farmers, Wyke Farms would not be able to produce as much cheese as they currently do. The relationships between the farmer and the cows are a strong association, as the cows need to be looked after and kept healthy to produce usable milk for cheesemaking.

5.1.3 Intermediary case study: Plaw Hatch Farm

Plaw Hatch Farm cheese actor-network can be seen in diagrammatic form in Figure 5.12. This actor-network shows traits of being both eco-localist and sustainably intensified, as indicated in Chapter 4. The lines of association that were identified for Plaw Hatch Farm's cheese actor-network are farming, milking, cheesemaking, maturation, packaging, and selling and marketing. The farm and buildings are located on land in Sharpthorne, West Sussex, near East Grinstead. Many different types of wildlife surround the farm and the local areas. Wildlife is a black box actant as there are many different types of wildlife present in the actor-network. For ease, wildlife has been grouped as one natural actant. Plaw Hatch Farm is part of the larger cooperative Table Hurst and Plaw Hatch Community Farm, which encompasses two farms that are biodynamic. As explained in Chapter 2, biodynamic is similar to organic farming but is based on the esoteric ideas of Rudolf Steiner. The farms are a limited company owned by the local community, and a board of directors is responsible for the cooperative. Plaw Hatch Farm has a board of four internal directors and one external director, six more managers and 25 employees. The community initiative was founded in 1995 following a community led campaign that raised £150,000 to purchase the stock and business assets of Tablehurst Farm from Emerson College. Community ownership and responsibility lies at the heart of the initiative. 400 individuals who have paid £100 each for a share in the co-operative. A committee who are elected at an AGM governs the co-op. The farm management teams make all the day-to-day decisions, with the committee being involved in the long-term agenda for the co-op.

The farm does not own the land and the buildings located at Plaw Hatch Farm but instead by a trust, St Anthony's Trust; the land was transferred from Emerson College to St Anthony's Trust. St Anthony's Trust is a charity that is dedicated to training and research in biodynamic farming and horticulture. The trust is the landlord of Tablehurst and Plaw Hatch Community Farms. At the time of the visit, Plaw Hatch had 36 cows, 27 of which were being milked, plus 31 sheep, three pigs and 360 laying hens. An

Animal Husbandry Manager is responsible for the overseeing the rearing of the animals. This is a good example of a mix of different types of actants within the network as there are many animals that live on the farm which are more than human actants, and there is a human actant that oversees looking after the animals. This is why the animals have been classified as more than human actants even though they are natural they are looked after by a human. There is one bull on the farm, but he does not breed with the dairy cows, as he is not a dairy bull himself. Artificial insemination with a dairy bull is used to breed replacement cows. The cows have a diet of grass fodder and silage, which is grown on the farm. They are also fed oats and field beans, which are grown on the farm whilst they are in the milking parlour. Other additional nutrients that the cows consume include salt that is spread on the fields, seaweed and iodine, the latter being added to the water the cows drink. The straw for bedding for the cowsheds has to be bought in from conventional, non-biodynamic farmers because Plaw Hatch does not produce enough straw and there are no local biodynamic producers of straw in the area. Crops such as wheat and maize are also grown on the farm. The only fertiliser used is cow manure. Male calves and other animals for meat are taken to Southern Traditional Needs abattoir in Henfield, West Sussex to be slaughtered and then returned to the farm for meat produce.

The cows come in from the fields twice a day to be milked in the milking parlour. The cows are held in a milking pen before entering the milking parlour where they stand on a milking platform, six abreast. The farmers attach milking clusters to the cows' udders. Prior to that a wet wipe is used to clean any mud from the teat. The milking system uses suction to take milk from the cow. When the cow is dry the farmer will remove the milking clusters from the cow. Once the cow has been milked, an iodine teat spray is sprayed onto each teat to prevent infections. The cows then make their way back outside and return to the fields. The association between the teat and the iodine spray is a strong relationship as this prevents the cow from getting an infection; if the cow were to get an infection they would not be able to produce usable milk. The milk makes its way through the milking system and is collected in a milk receiver. It then passes through a filter and is collected in a bulk tank. Plaw Hatch Farm's annual milk production is 130 thousand litres.

Cheesemaking at Plaw Hatch Farm occurs in the dairy. The Dairy Production Manager oversees the running of the dairy. They are also a cheesemaker. There are two more cheesemakers and four more other employees working in the dairy. The approximate annual cheese production for Plaw Hatch is 4,217 kilograms. Four different types of cheese are made: cheddar (which comes in mild, mature, extra mature, vintage and smoked), crumbly cheese, Halloumi, and Dutchman (a Gouda-type cheese). This section focuses on the actants and associations that are involved in the making of the cheddar

cheese. The milk is pumped from the bulk tank into the vat via pipes. A hot water system is used to heat up the vat and the milk inside. Starter culture is added which is obtained from CHR Hansen (different starter cultures are used for the different cheeses), which is located in Hungerford, and then vegetarian rennet is added, which is also obtained from CHR Hansen. Once the milk has set to a curd, which is what the rennet activates, the curd is cut with curd cutters. This separates the curd and releases whey. The curds and whey are then stirred by the cheesemaker running their hand through the curds and whey, breaking up the bigger pieces of the curd into smaller pieces. Stirring is for a set amount of time, varying from cheese to cheese. Once the curd has been broken up, the plug at the bottom of the vat is removed. The whey is removed through a hose using a pump to pump it out. It is collected in a series of whey containers. Once the whey has been drained off the curd is left to pitch. The now bonded curds are then cut into large chunks and turned over, before being left for a set amount of time, which is called cheddaring. The curd is milled with a hand mill to break them up into smaller pieces and then finally the curd is put into cheese moulds and pressed. Once the cheeses have been pressed they are moved to the cheese store for maturation. The whey that is drained off is fed to the animals. Co products that are also produced at Plaw Hatch are yoghurt, raw milk and kefir cream. They are often sold to local independent stores.

The maturation period is different for the different cheeses. The cheddar matures from anywhere between three and twenty-four months depending on how strong it is. The Dutchman is matured for two to three months and the crumbly cheese from one to two months, depending on the strength. The halloumi is packed the next day. The maturation store is refrigerated and there is a humidifier inside. The cheddar that is smoked is sent to the smokehouse on the farm before maturation. It is smoked with oak apple woodchips. The smoked cheese will then be sealed in a vacuum pack with a vacuum sealer. The vacuum packs are sourced from World Packaging Supplies. The packaging process includes cutting the cheese into smaller pieces by a cheese slicer first and then packaging the cheese. Some are sealed in vac-packs and others are packaged in wax paper that is sourced from Neal's Yard Dairy.



Figure 5.10 - Cheese maturation store in the Plaw Hatch Farm actor-network
© Plaw Hatch

The selling of Plaw Hatch Farm cheeses happens at their on-site farm shop and at the farm shop located on the other cooperative farm, Tablehurst. The cheese is kept in refrigerators. The co-products mentioned earlier are also sold in the shop along with meat, fruit, vegetables, eggs and organic yarn, all of which are produced at Plaw Hatch. The cheese and other produce are taken to Tablehurst in a van or car. Produce such as pasties, meats and vegetables are also brought back from Tablehurst to sell in the Plaw Hatch farm shop. Produce doesn't just come from Tablehurst but also other organic and biodynamic suppliers in the area. A lot of the dried food sold in the farm shop comes from Infinity Foods. Plaw Hatch also imports a wider variety of biodynamic and organic products from overseas. Customers who come and visit the farm shop buy the produce and they exchange money for the produce they are buying. This is a strong association between money and the farm, as they need income to sustain the farm. The association between the customer and the cheese is also an important association because the customer needs to enjoy the taste provided by the cheese in order to continue buying it. There is also an online shop but only wool is available to buy online. Plaw Hatch Farm has an annual income of approximately £1,015,000.



Figure 5.11 - Images of the farm shop in the Plaw Hatch Farm actor-network © Plaw Hatch

Plaw Hatch have a website, Facebook and Twitter that they use to promote their farm, way of thinking and their produce, employees at Plaw Hatch update them. The main users of the website and the social media sites are the customers and the wider community. Plaw Hatch normally has two to three volunteers at any one time. They participate in day-to-day farm activities, and are either from biodynamic agricultural colleges or the wider community. A sharing of knowledge occurs between the people at Plaw Hatch and the volunteers. Plaw Hatch also has school groups that visit the farm to learn about biodynamic and sustainable farming so again a sharing of knowledge and a wider education occurs.

Water, electricity and heat are needed for many of the lines of association occurring at Plaw Hatch Farm. Their energy is sourced from the National Grid. The water used on the farm is sourced from a spring and a borehole. Any wastewater, such as parlour washings, cow manure and cow urine, and rainwater, is collected in drains. It travels through pipes to a settling tank where the solids are removed. It is then transferred into a lagoon, which holds the water so that during the summer months, when it is dry, the water can be sprayed onto the fields. Glass, paper, tins, soft plastics and hard plastics are recycled at Plaw Hatch and some of the glass is reused, e.g. the glass bottles that the raw milk is sold in. There are also three landfill skips that collect the rest of the waste. Plaw Hatch Farm are farming to organic and biodynamic standards under the licensing inspection of the Soil Association and Demeter, with the annual certifying costs for the two being £1,248. Environmental Health officers also have to make regular visits to the farm but Plaw Hatch see this as a partnership to deliver results that are good for the environment which everyone values just as much also across the actor-network government legislation impacts.

Throughout this last section actants and associations have been discussed in detail for Plaw Hatch Farm's actor-network, Figure 5.12 shows this diagrammatically. As already established, there are some associations within the network that have a stronger relationship or association than others.

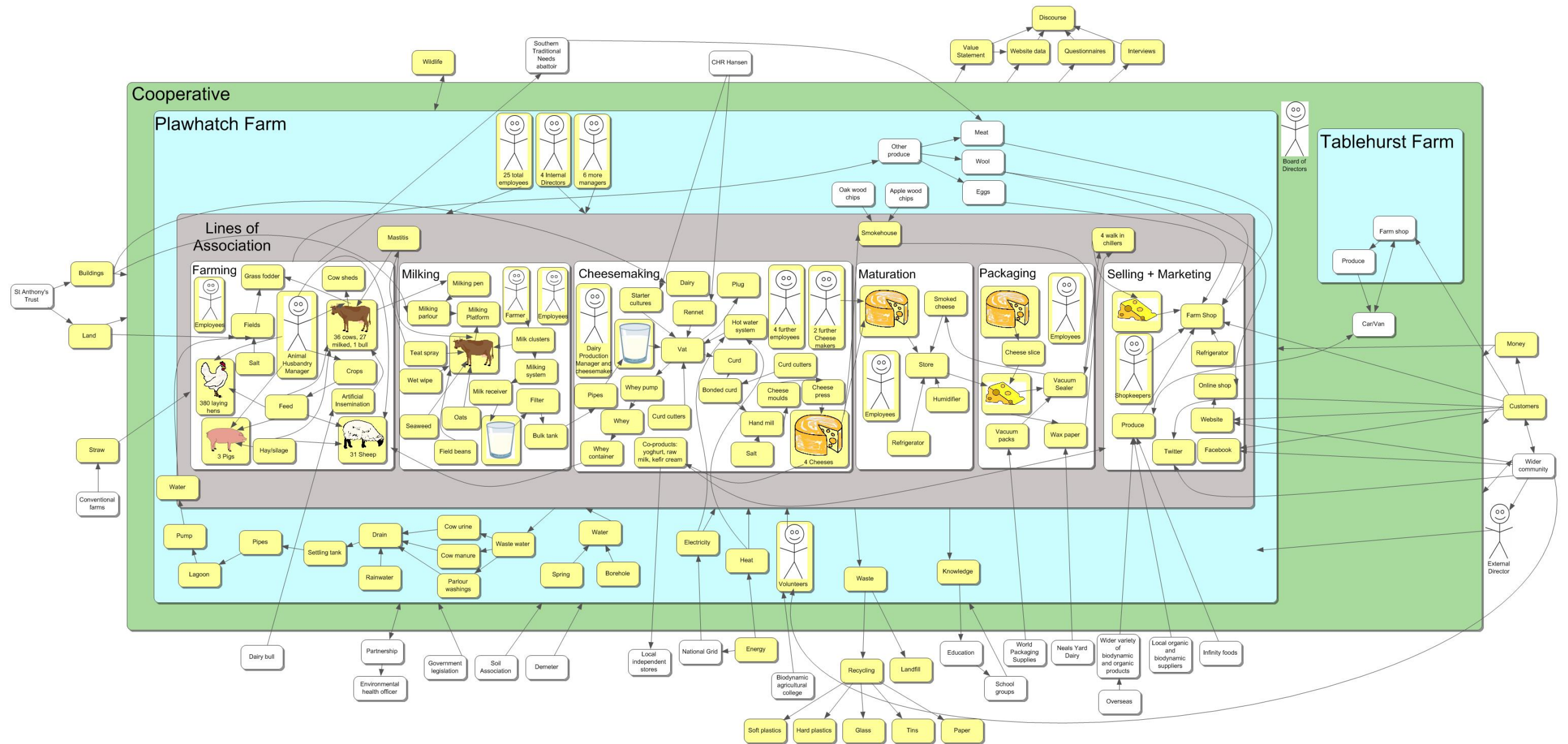


Figure 5.12: Plaw Hatch Farm intermediary cheese actor-network. The yellow actants are the actants that the researcher could physically see. The actants are arranged in lines of association.

Again like the other actor-networks, the association between the farmer and the milk is an important association as milk is crucial for the cheesemaking line of association. The association between the cheese and the cheesemaker is also an important relationship that occurs in the Plaw Hatch actor-network; however, the cheesemaking at Plaw Hatch is secondary to other products such as raw milk, yoghurt and kefir.

5.1.4 **Summary**

The three cheese actor-networks have now been mapped in detail and an extremely descriptive insight, which is the nature of ANT, has been provided. The actants in the actor-networks have been identified and the associations/relationships between the different actants have been established. There are a number of associations within the cheese actor-networks that are a stronger association than others, as discussed throughout the previous three sub-sections. However, the associations between actants that are important or most strong differ depending on the actor-network. The association between the human actant, the cheesemaker, and the more than human actant, the cheese, is an important association that is featured throughout the three cheese actor-networks that were studied. However, the association is strongest in the Middle Campscott actor-network; this is because the cheesemaker uses traditional, handmade methods to create the cheese. This is different to the Wyke Farms actor-network because although the cheesemaker is involved in the cheesemaking line of association, technological actants have an important role in enrolling the cheese into the network. However, the cheesemaker at Wyke Farms does turn on and oversee the machinery. The association between the cheesemaker and the cheese at Plaw Hatch is a strong association but again, it is not as strong as the same association in the Middle Campscott actor-network. This is because the cheesemaking at Plaw Hatch Farm only occurs if there is enough milk left over from enrolling cream, yoghurt and kefir into the network. Therefore the association between the cheesemaker and the cheese by-products is a stronger association than with the cheese.

There was mention of many technological actants in the Wyke Farms actor-network of a high tech nature. Wyke Farms have enough capital to enrol high-tech actants into the actor-network, e.g. the anaerobic digesters. Middle Campscott, the eco-localist actor-network, cannot enrol high-tech solutions into the actor-network because they do not have the capital to do so. Middle Campscott enrol volunteers into their actor-network instead as they do not have to pay volunteers, but they get valuable skills and labour. Wyke Farms could not enrol volunteers into

their actor-network to assist with the cheesemaking as the high-tech equipment that is used needs exhaustive training to be able to know how to use it.

The Wyke Farms actor-network is able to enrol supermarkets into their network as a lot of cheese is enrolled into the network, which in turn enrolls the supermarket as Wyke Farms produce enough cheese to be able to supply them cheese in bulk. The eco-localist network is not able to enrol supermarkets into the network, as they do not produce enough cheese. They do enrol a farmers' market, whereas a sustainably intensive network wouldn't. The next section looks at the sustainability discourses within the network and how they differ across the actor-networks.

5.2 Exploring the sustainability discourses throughout the network

The discourses of sustainability operating through the actor-networks were explored. This was to get an insight of how sustainability differed between the different actants and to gain a sense of general thoughts and understandings of sustainability. Discourses of sustainability throughout the actor-networks were investigated because discourse is a part of the actor-networks as mentioned in Chapter 3.

The chapter assesses whether the farmers', consumers' and employees' thoughts were reflective of the discourse presented by the cheesemakers themselves in their sustainability policies and statements. As already mentioned in Chapter 2, there are many different discourses of sustainability and different senses of the term discourse, Peterson and Norton (2007) point out that the ambiguity of its definition is both its greatest strength as well as its biggest weakness. The term sustainable development implies that if a community/individual/organisation wants to embrace sustainable development it has to embrace both sustainability and development, but as Peterson and Norton (2007) point out, communities/individuals/organisations will often create their own operational definition of sustainability. It is for this reason that multiple definitions of sustainability exist, as those promoting sustainability have rooted it in their own agendas. Business interests have colonised sustainability and sustainable development for use in marketing and furthering business plans, this section investigates this for the sustainable cheese actor-networks under scrutiny.

Sustainable food has different meanings for different stakeholders, Friedberg (2014) argues how it is important to understand what is meant by sustainable food by the

company/person/organisation using the term, if the best possible decision about the broader impacts are to be made. Defining what is meant by a term especially in a sustainable food context can become extremely political if based on its footprint according to Friedberg (2014). For this she coined the term 'footprint technopolitics', Friedberg (2014) believes that the footprinting of food (which is the use of quantitative methodologies such as LCAs to assess sustainable food) are unable to capture the "breath of 'political situations' in which measures of sustainable food are contested" (Friedberg, 2014: 151). Kirwan et al. (2017) in their paper, because of the 'footprint technopolitics' surrounding the contested meanings of food supply chains, argued the need to adopt a more inclusive and multi-dimensional view of food supply chain performance in order to facilitate effective sustainability assessment and appraisal. This allowed for the discourses to emerge from a wide range of perspectives and contexts. This is what this research strived to do, by undertaking a multi assessment of sustainability by not just collecting quantitative data but gathering qualitative data for the discourse of sustainability within the network to emerge from a wide range of perspectives and contexts.

In order to consider the discourses of sustainability within the networks, every actor within the network who participated in the research, whether that was through means of an interview or questionnaire, was asked 'What do you understand by the term sustainability?'. This was an open question and it was stressed that there was no right or wrong answer. In total 115 individuals were asked about their understanding of sustainability, three failed to answer the question and six did not know what was meant by the term 'sustainability'.

Two key perspectives emerged from the data; they were an environmentalist perspective and a productionist perspective. The two perspectives emerged from the data, when the data was analysed thematically using NVivo, a qualitative analysis software package to identify the relevant fields for sustainability. Palmer (2003) also found that these two perspectives prevailed on his study of peoples' understandings of sustainability. In total there were 67 references that adopted an environmentalist orientation and there were 31 references that alluded to a productionist orientation.

5.2.1 Environmentalist and productionist perspective

There were 67 references referring to the environment, ten of these references however were from the cheese maker websites, one was from a value statement and seven were from a green strategy statement. This meant that 50 of the references with an environmentalist orientation

were individuals' understandings of the environment, which was 44.6% of the total individuals who answered. The environment or an environmentalist perspective did therefore feature quite prominently in peoples' perceptions of sustainability. Exploring this perspective further there were, some key sub themes that emerged from within this perspective. The first of these sub themes was 'minimising or minimal impact to the environment' and the second sub theme was 'looking after or being good to the environment'. There were 31 individuals who commented on minimising or minimal impact to the environment with responses such as:

Q1: *"Minimal environmental impact" – Consumer*

Q2: *"I guess it's just making sure that we're not too harmful on the environment, making sure especially in this industry that our primary focus is making sure the environment is looked after" – Wyke Farms employee*

Q3: *"Not being harmful to the environment" – Farmer*

The word harm or harmful was used seven times, this could indicate that some actors' perceptions of sustainability are that to not be sustainable is hurting the environment. The second sub theme was 'looking after or being good to the environment', actors were not focused on the negative aspects of impacting the environment but they spoke of looking after or being good to the environment. Instead of perceiving sustainability as minimising the bad impacts on the environment these actors saw sustainability as being good to nature or the environment, nine people discussed this, examples can be seen below.

Q4: *"If you look after nature then nature will look after you" – Employee at a cheesemakers*

Q5: *"Nature, animals and humans are looked after." – Consumer*

Q6: *"Taking care of the environment" - Consumer*

The other main theme was of a productionist perspective. There were 31 references of a productionist perspective, 29 of which were comments made by individual actors. Responses that were given had some mention of an element of production or a product in them

Q7: *“Production at levels that can be maintained - a continually
perpetuating cycle” – Consumer*

Q8: *“Something that can be produced without harming future production” –
Consumer*

In Q8 above sustainability is perceived as a product that can be produced. Within this productionist orientation, production was often linked to other themes, for example four of the responses featured a reference to economic sustainability, this is highlighted in the two quotes below (Q9 and Q10).

Q9: *“How it's produced, how it's brought to market in an economically
sensitive way.” – Consumer*

Q10: *“The product has a future economically and ethically.” – Consumer*

All the productionist perspective references to sustainability were by consumers of the cheese. When asked their understanding of sustainability no farmer or cheesemaker employee made any mention of production. One productionist reference to sustainability in particular made by a customer mentioned ‘maximising production’. It might be expected that increasing or maximising production was mentioned through comments made by Wyke Farms employees, as Wyke Farms were interpreted as practising sustainable intensification. The main focus of sustainable intensification according to Godfray and Garnett (2014) is “more food with less environmental impact” (Godfray and Garnett, 2014, pp.6). Yet no employees at Wyke talked about more food or more production. This might be because they were asked about the understandings of sustainability generally and not directly relating to food, but also their personal perspective of sustainability could be entirely different to Wyke Farms’ sustainability promises. It may not be that surprising after all as Wyke Farms brand identity plays to notions and imagery commonly associated with small-producers. i.e. farmhouse cheddar and photos of barns. But there is a disconnect here with the realities of most sustainably intensified production. Other examples of this include Tesco’s fictitious farms such as the name Boswell Farms or the term “natural” ingredients that is often found on packaging.

It was not expected for just consumers to be mentioning production or product; the individuals who work in an environment where a product (the cheese) is being produced were expected to mention it in terms of sustainability.

There were two main perspectives that were identified as mentioned: environmentalist and productionist. Some of the references to understandings of sustainability encompassed both productionist and environmentalist thinking. The focus of the comments was both on production but also on minimising the impact on the environment or another theme from the environmentalist orientation. Examples of these comments can be seen below:

Q11: *“Produced in a way not detrimental to the environment.” – Consumer*

Q12: *“Able to be made without a negative impact on the environment; so product can be sustained indefinitely” – Consumer*

Q13: *“A product or way of doing something that has minimal impact on the natural and social environment that product or activity is done. There is also an element of regeneration and renewal if the activity causes damage to the area it is done/produced in.” - Consumer*

The references to sustainability that incorporate a productionist perspective but respective of the environment are in line with sustainably intensive thinking, however, as mentioned, no comments specifically eluded to increased or maximised production. The environmentalist perspective that is present in many references could be seen as being in line with eco-localist thinking. Some of the productionist comments could be seen as having a ‘business as usual’ approach and Wyke Farms’ business model is selling an ever increasing quantity of cheese on a finite planet.

5.2.2 **The three pillars of sustainability**

There are other key themes that were identified in the references to understandings of sustainability; some of the comments come under environmentalist and productionist perspectives as well as being mentioned independently as a separate theme. The other themes that were identified are economic sustainability and social sustainability. Although, not many comments showed understanding of the interrelationships between environmental, social and economic sustainability or, if they did they, did not articulate themselves well. There are three comments out of 112 that encompass elements of all three elements of sustainability these quotes can be seen below (Q14, Q15, and Q16).

Q14: "Taking into account environmental, economic and social factors to not only help generations now but help future generations." – Wyke Farms employee

Q15: "A product which is responsibly produced, minimising the impacts on the manufacturer and the consumer in terms of environment, economy and health" – Consumer

Q16: "Sustainability is about meeting present needs without compromising the ability of future generations to meet their own needs. It's having a regard for the environment as well as ensuring people and the economy benefit." – Consumer

Quote 14 (Q14) is similar to the definition of sustainable development highlighted in the Brundtland report (World Commission on Environment and Development, 1987) as quoted in the literature review. This employee quote talks about not only helping generations now, but helping future generations too, which is what the Brundtland report also highlights although Q14 doesn't specifically refer to needs. However, Quote 16 (Q16) is closer to the well-known definition of sustainable development as it addresses the needs of now and future generations and talks about the pillars of sustainability. Quote 15 (Q15) by a consumer refers to the environment, economy and health that is a social factor but also talks about sustainability as a product (a productionist perspective).

More comments expressing awareness of the overlap of environmental, economic and social sustainability were expected, as the three pillars are a key element of sustainability. The World Commission on Environment and Development (1987) explains how sustainability should involve the protection of the environment and the provision of social and economic welfare. Agyeman (2002) defines sustainability as something that "...cannot be simply a 'green', or 'environmental' concern, important though 'environmental' aspects of sustainability are. A truly sustainable society is one where wider questions of social needs and welfare, and economic opportunity are integrally related to environmental limits imposed by supporting ecosystems." (Agyeman, 2002, pp 78), basically where the needs of all can be met within the means of the planet. However, it is important to remember that just because that is this research's understanding of sustainability does not mean that it is everyone's. Walshe (2008) discovered in her study of the understandings of sustainability that individuals also failed to understand the

interrelationships between environmental, economic and social sustainability. There were only three comments that connected all three elements of sustainability, but there were, however, other attempts to link two of the concepts together. For example, the following comments link environmental and social sustainability together:

Q17: *"[Sustainability is] beneficial to all its parts so I think yeah that applies to the environment, that applies to the people, applies to the community around, it's something that will still be wanted."* – Plaw Hatch employee

Q18: *"Where things are replaced and not just taken. Nature, animals and humans are looked after."* – Consumer

Q19: *"having no bad impact on humans, nature, the planet"* – Consumer

Quote 17 (Q17) reflects that sustainability should be beneficial to the environment, people and the community, it has a strong emphasis on social sustainability but there is no mention of economic sustainability. This could be because an employee at Plaw Hatch Farm provided the quote, they are part of the actor-network, which displayed both eco-localist and sustainably intensive characteristics. As mentioned in the *Section 5.1.3*, Plaw Hatch Farm are a cooperative but they are also a community supported agriculture (CSA), a strong sense of community was observed here by this study, even though Pole and Gray (2013) believe that the sense of community in CSAs is declining. The interactions that were observed between the employees, directors and consumers there was a real sense of community. Insufficient data was collected to confirm this in its entirety as it wasn't the focus of the research, but the following quote from the same Plaw Hatch employee when asked about the relationship with the customer alludes to a sense of community.

Q20: *"I mean I feel like you know there is this focal point which is clearly the food but they are our community really, they are the people you will see out and about, I find that I am known all over the place where I didn't expect to be."* – Plaw Hatch Employee

It could be that, instead of the employees at Plaw Hatch Farm being economically minded, they are more concerned for community cohesiveness and therefore social sustainability elements. This research would also expect Plaw Hatch to have an emphasis on the environment as treating the environment well and keeping a closed loop are all key aspects of biodynamic farming. Also

a biodynamic farm with many eco-localist characteristics, you would expect that the emphasis would not be on money or indeed economic sustainability. However they do have an extremely high annual turnover (approx. £1,015,000) for an establishment that has some eco-localist characteristics.

Links were also made by some actors to the pairing of environmental sustainability and economic sustainability, but not to social. Quote 21 (Q21) makes references to continued economic growth and success, but the emphasis is still on the environment.

Q21 *“Continued economic success but with environmental concerns on the forefront. So basically how to make sure environmental renewal can occur while sustaining economic growth.” – Consumer*

There were some understandings of sustainability that just referred to the one pillar of sustainability. There was just the one reference to purely social sustainability and three references to purely economic sustainability and 32 references to just environmental sustainability, this is reflective of the environmental focus that is prevalent in the sustainability literature which was mentioned in Chapter 2.

5.2.3 Future, long term and continuity

The future, long-term and continuity dimensions of sustainability was another key theme that was prominent from the interviews and questionnaires. Some of the comments were made alongside the environment-orientated perspective but some were in a standalone discourse. This was also a key theme in the research conducted by Pole and Gray (2013) when they asked people with an interest in rural life, agriculture and agricultural products who had attended the National Field Days what their understanding of sustainability was.

From the group of 50 comments with an environment perspective 14 of them mention the future, long-term and continuity aspect of sustainability. To be more specific 9 referenced sustainability as being able to continue or cyclic whilst still mentioning the environment some examples can be seen below:

Q22: *“Being able to continually produce something without significant impact on the environment.” – Consumer*

Q23: *"A system where waste from the production of a produce can be returned to the farm or other place to not create waste, to make a life cycle"* – Consumer

Three comments mention the future but specifically they noted future generation and how the environment should be considered for them and two actors referenced the long-term. Examples of these can be seen in the quotes below respectively:

Q24: *"Something that can last for generations. It supports itself with no negative impact. In popular use, it refers to environmental sustainability which includes the preservation (and improvement) of the environment for future generations."* – Consumer

Q25: *"Products are made using machinery/materials/ingredients which are sustainable. They can be produced en masse without causing too much harm to the environment and can be produced long-term with these sustainable ingredients."* – Consumer

However, there were 28 instances of individuals talking about the future, long-term and continuity dimensions of sustainability as a standalone theme, which is 25% of the individuals who answered the question. Again, they were specifically talking about the continuation of sustainability, its ability to not stop (9 references), the future or future generations (13 references) and the long-term (6 references). Some examples of these can be seen below (Q26, Q27, Q28).

Q26: *"a system that can carry on running on as little input as possible."* – Middle Campscott

Q27: *"Meeting the needs of the present generation without compromising the needs of future generations."* – Consumer

Q28: *"consistent, long-term, beneficial in the long run, forwards thinking, step ahead"* – Consumer

Quotes 26 and 27, are both from the eco-localist case study, Middle Campscott, and both quotes consider the future, long-term continuity dimension of sustainability. This isn't eco-localist specific as this theme was mentioned across the different networks but what is interesting about Q26 is the reference to how the system should continue to run on as little input as possible, this is an eco-localist perspective as they are small-scale and have a low annual turnover so don't have the money for multiple inputs.

5.2.4 **Additional themes**

Resource efficiency came up as a theme, 23 references were made to sustainability being about resource efficiency. De Koeijer *et al.* (2002) concluded in their study resource efficiency has the potential for improving the sustainability. The following quotes show the references to resource efficiency when considering understandings of sustainability (Quotes 29 and 30).

Q29: *"that you aren't using too many of the resources, outside your ability or availability."* – Middle Campscott

Q30: *"Working in sympathy with available resources and at an appropriate scale."* – Consumer

Other themes that were concurrent included: animal welfare, ethicalness, localness, organic. Animal welfare was mentioned by 4 individuals, and animal welfare features heavily in the sustainable intensification discourse (e.g. Godfray and Garnett, 2014) because it is often assumed that if you are maximising production then you are sacrificing the welfare of the animals by using methods such as factory farming. However, Wyke Farms in the sustainable intensive actor-network have not installed robotic milkers at the farm as they are concerned for their cows and they see the cows as being part of the family, they have a big emphasis on animal welfare so it was interesting to note that none of the employees, directors or farmers at Wyke Farms referenced this. The four actors who mentioned animal welfare were all consumers who could perhaps be conscious of where their food is coming from, this links into the traceability of food and the Red Tractor farm to fork assurance scheme. On a similar note four people mentioned ethics as part of their understanding of sustainability and all four actors talk about it in a sense of 'ethically produced' or an 'ethical product'.

The last two themes mentioned were local and organic, both terms you would associate with an eco-localist setting or network. Four individuals mentioned local and two mentioned organic, and Wyke Farms' consumers made all the references to the local or organic. This is surprising as Wyke Farms are thought to be practicing sustainable intensification and are not thought as local and they are not organic. However, Wyke Farms have a wide customer base who are bound to have a wide selection of views and thoughts of understandings of sustainability. The area that I sampled for consumers of Wyke Farm cheese was Clarendon Park in Leicester as the Sainsbury's Local stocks Wyke Farm cheese. Clarendon Park, however, is an affluent area with a good selection of local suppliers on their doorstep so this could account for this.

5.2.5 **Summary**

The discourses of sustainability throughout the three actor-networks have been explored. Several themes were identified in the understandings of sustainability discourse. The two most prominent themes were identified as being environmentalist and productionist perspectives. Environmentalist perspectives included references to not harming the environment and looking after or protecting the environment, which are in line with eco-localist thinking. The productionist perspective mentioned notions of a production and even thinking of sustainability as something can be produced and could be compared with Pretty's (1997) 'business as usual' school of thought. There were some understandings by actors' that combined the two perspectives and this displays features of sustainable intensification (i.e. production with less impact on the environment).

Another theme that were apparent when actors' understandings of sustainability were deliberated included the discussion of sustainability with all its parts: social, economic and environmental. Although only three actors across all the actor-networks discussed sustainability in accordance with its three pillars. This could be because not many people are aware of the Brundtland definition. The future and long term aspects of sustainability were also referenced as well as resource efficiency, animal welfare and organic.

The next two sections explore the understandings of sustainability actor-network by actor-network. The information and writings of sustainability that are presented in public for the different cheesemakers (i.e. websites) are compared to the actors' understandings of sustainability within the network.

5.3 Looking at the interactions between the actants that link to sustainability

This section explores and compares how sustainability is embedded differently in the eco-localist actor-network and the sustainably intensive actor-network for the different cheesemakers in the forms of the literary inscriptions that were mentioned in *Section 5.1* of this chapter (i.e. websites). As food businesses frequently make claims about their sustainability and the overall sustainability of their product. Questions have, however, often been raised about the validity of these claims and the degree to which agribusinesses are taking responsibility for these claims and acting to embed sustainability into the actual practices of food production and the characteristics of the commodities produced. A recent high-profile example of a potential failure to take responsibility over promotional materials was Tesco's use of fictitious farm identities (Figure 5.13). Such concerns provide the context of this section, which seeks to explore the embedment of sustainability discourses in cheesemaking at Middle Campscott and Wyke Farms.

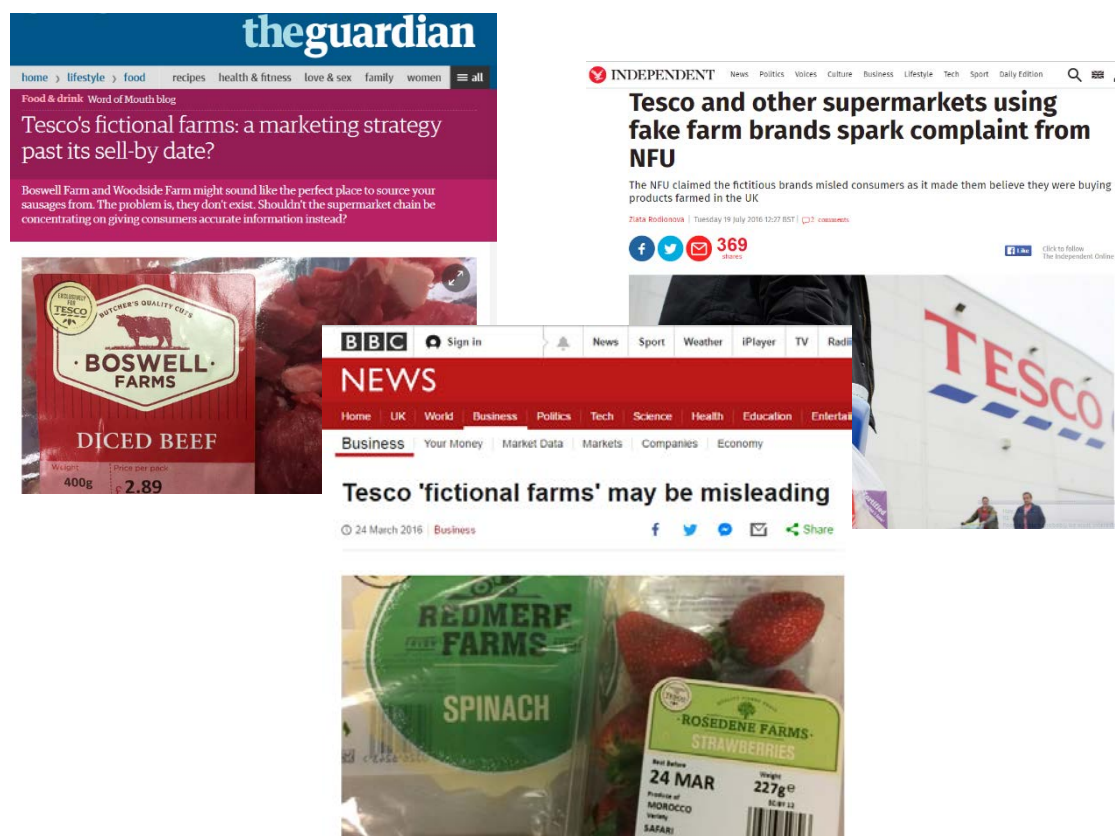


Figure 5.13 - Fictitious agri-food identities, Tesco and their fictional farms. Screenshots of websites obtained from

This section of the chapter therefore attempts to look at how sustainability is embedded at the different actor-networks and how this embedded sustainability compares to the actors' understandings of sustainability within the network.

5.3.1 Embedded sustainability in the Middle Campscott actor-network

The embedded sustainability at Middle Campscott uses terms like organic, local, traditional methods and animal welfare. This can be seen in Figure 5.14, a screenshot taken from the Middle Campscott website as well as in *Section 5.1.1* of this chapter where the actor-network is described in detail along with the pictures as visual aids.

Q31: *"Our cheeses are handmade on the farm in North Devon, exclusively from the milk produced from our own flock of milking sheep" – Middle Campscott*



Figure 5.14 - An example of embedded sustainability at Middle Campscott on a screenshot taken from their website. © Middle Campscott

That their website points out that their animals are happy grazing staring out across the Atlantic Ocean, suggests some consideration of animal welfare. Middle Campscott do not have any written sustainability policies, official sustainability policies committed to writing are more associated with a sustainably intensive setting as the criteria displayed, but they state that their main sustainability policy is to:

Q32: “import as little as possible” – Middle Campscott

Middle Campscott are aware that they have some unsustainable practices. Their most unsustainable practice being vehicle use; sometimes going out in the car or the Land Rover cannot be avoided but Middle Campscott try not to go out unless there is more than one specific reason for leaving the farm. This shows an awareness of sustainability and shows an effort of trying to strive towards it. As already mentioned, their understandings of sustainability fell under the future, long-term continuation discourse of sustainability and resource efficiency. Middle Campscott both agree that adopting sustainable practices is important, when asked why adopting sustainable practices was important, Middle Campscott responded with the following quotes (Q33 and Q34).

Q33: “you then have a workable cycle that should be renewable without continuing using up things or having to import things.” – Middle Campscott owner

Q34: “Well, if we erm manage to erm run a sustainable system at our scale, it contributes to a larger whole and hopefully moves towards a sustainable way or conducting agriculture in the UK.” – Middle Campscott owner

Quote 33 fits into the theme that has already been discussed the continuation of sustainability, something that is cyclic. Quote 34, however, is interesting; it is the notion that even though they are a small business, Middle Campscott can practice sustainability and are contributing to a larger whole. It is rooted in the literature of the role of individuals for change agents of sustainability (e.g. Van Der Grijp *et al.*, 2005; Smith and Stirling, 2010; Spaargaren and Oosterveer, 2010). If one person or in this case two people are practicing sustainability it can inspire, motivate and empower others to do so too.

Middle Campscott consumers have similar understandings of sustainability as is embedded in the business. The references made to sustainability by Middle Campscott consumers all fall into either the environmentalist perspective, future, long-lasting theme, the continuation theme or the resource efficiency theme which fits with the embedded sustainability of Middle Campscott. However, there is no reference to any specific characteristics of eco-localism by any of the Middle Campscott consumers, no one mentions wanting to buy their cheese locally in their understanding of sustainability, and this could be because their notion of sustainability has nothing to do with the cheese being local. When asked 'Is it important that your cheese is made locally?' only two people out of five found it to be very important so this could be the case.

Middle Campscott's embedded sustainability does not make direct mention to 'sustainability'. The website does not really mention sustainability, it is just seen as something that should be done anyway in an 'organic', 'handmade' way with their 'own farm' and their 'own sheep'. Sustainability is a kind way, a way of continuing to run. Sustainability is their whole livelihood and they rely on the farm and their cheesemaking to live, it is a way of life. Both owners of Middle Campscott, as can be seen in their quotes (Q33 and Q34), are engaging with sustainability and their thoughts are reflective of the embedded sustainability at the farm. The next subsection looks at the embedded sustainability at Wyke Farms.

5.3.2 Embedded sustainability in the Wyke Farms actor-network

The embedded sustainability at Wyke Farms is very different to that at Middle Campscott, telling a story of technology and money. Wyke Farms' website encompasses many of the different sustainability themes that were discussed in the *Section 5.2* and more. Sustainability features heavily across the Wyke Farms' website and they have a "100% green strategy". The 100% green strategy statement alludes to Wyke Farms practicing sustainable intensification. The opening paragraph of the 100% green strategy statement incorporates the three pillars of sustainability (Q35):

Q35: "We wish to make prize winning cheddar in a way that has minimal impact on the Somerset environment and to create a truly symbiotic relationship with the countryside that provides our food, our income and our home." – Wyke 100% Green Strategy Statement

The website mentions many things that you would expect from a company who is trying to be sustainable, including social sustainability (engaging with the community, sharing of knowledge) traceability of food or transparency and animal welfare, but there is also text about topics you may not expect. They have a section on craft and provenance which is all part of their brand, where the following quote appears;

Q36: *“And although the cheese-making process isn’t as labour intensive now, the traditional methods used by our ancestors haven’t been lost in the gleam of stainless steel.” – Wyke website*

This is an unusual quote to find on a website of a business who has been characterised as sustainably intensive as the use of traditional methods is usually associated with an eco-localist setting. The website assures that traditional methods haven’t been lost in the ‘gleam of stainless steel’. However, the factory is a modern factory with high-tech actants operating (as described in *Section 5.1.2*) and it is difficult to see where the traditional methods come into play, maybe the recipe is an element of the traditional methods but from observations the site is very much more modern than traditional. The website includes strong elements of the environmental and social sustainability themes, however there is less feature on the economic sustainability discourse. Although the 100% Green strategy statement does feature economic sustainability and productionist discourse that you would expect from a sustainably intensive setting as seen below:

Q37:

1. *Produce all of our own energy from renewable sources. Produce surplus energy to offset our supplier energy usage*
2. *Save energy through investment and changes in working practise*
3. *Recover and measure heat wherever possible*
4. *Filter and re-use 90% of our water*
5. *Maximise the use of organic nitrogen on our own farms and our neighbouring farm in order to reduce the use of artificial Nitrogen in the region*

6. *Minimise and recover waste where possible*
7. *Actively encourage wildlife within the Brue valley through conservation schemes and good farming practices*
8. *Knowledge share and encourage others to work in more sustainable ways – Extract from Wyke Farms 100% Green Strategy Statement*

The embedded sustainability on the Wyke Farms' website is not just located in the text but also in the images they display, there are background images of luscious fields which could be indicative of their interest in the environment. There are also images relating to the technology that they have employed such as the electric car and the anaerobic digesters, this can be seen from the screenshots taken from the Wyke Farms website show below in Figure 5.15.



Figure 5.15 - An example of embedded sustainability at Wyke Farms from screenshots taken from their website. © Wyke Farms

This paragraph investigates who at Wyke Farms is engaging with this embedded sustainability and explores what the Wyke Farms' employees think of the 100% green strategy. Four employees thought that the 100% green was to make the business more environmentally friendly and similarly one employee thought that it was to become self-sufficient. One employee mentioned it was trying to offset all the carbon emissions. The official line from Wyke Farms and those that came up with the 100% green strategy is shown below in Quote 38:

Q38: "Wyke Farms 100% Green' is a strategy committed to environmental leadership in our sector and the use of environmental best practise in all of

our operations. Our target by 2020 is to reduce our CO2 emissions by 20 million kilos of CO2 per year, eliminate waste where possible and recover 90% of water each year.” - Extract from Wyke Farms 100% Green Strategy Statement

The 100% green strategy is not a commitment to becoming 100% green, it is a strategy committed to environmental leadership, even if Wyke were to accomplish the reduction of carbon emissions by 20 million kilos by 2020 and their other pledges stated it will still not make them 100% green. The commitment to environmental leadership is not a bad thing, it again is situated in the literature surrounding change agents of sustainability (e.g. Van Poeck *et al.*, 2017). However it could be seen that the 100% green strategy is misleading Wyke Farms' employees, customers, and consumers as it is not clear from the name of the 100% green strategy that it is a commitment to environmental leadership. One Wyke Farms' employee picked up on this when asked 'what does 100% green mean to you?':

Q39: *“that they’re stretching the truth [laughs].”*

Wyke Farms 100% Green strategy statement is certainly misleading even if the promises they set out to do are good things to strive towards. Two employees mentioned that they think 100% Green is a way to market or promote the business, Ferrell and Hartline (2011) highlighted in their study how green labelling has dramatically increased product sales and a recent study by Maniatis (2016, pp.225) concluded that “green consumers choose green products by virtue of their consciousness about environmental benefits, economic benefits, green reliability, and green appearance of the product.” This is often known as green-washing, which is a marketing strategy used to deceptively convince people that they are sustainable.

Not everyone is engaging with the 100% green, when asked about their understandings of sustainability, no Wyke Farms' employees mentioned the 100% green strategy and very few employees related their understanding of sustainability back to cheesemaking. The understandings of sustainability from the employees' perspectives were centred on the environment and production orientations, resource efficiency, the future and the three pillars of sustainability which is similar to the discourses of sustainability provided by Wyke Farms across their website and strategy. However, it is what's not there that speaks more about the discourses of sustainability, which is part of the notion of discourse. Ten Wyke Farms employees

were interviewed for this study and a further four employees filled out and returned a questionnaire. However, that means there are approximately 186 people that this research did not get to investigate their understandings of sustainability. This could be for any number of reasons, but it could be because some employees are not engaging with the embedded sustainability of Wyke Farms and not interested in sustainability but they just happen to be working for a sustainable company. Alternatively it could be because the questionnaire was not distributed to all employees.

5.3.3 **Summary**

The embedded sustainability has been investigated for both the Middle Campscott and the Wyke Farms' actor-networks. This research believes that both the eco-localist actor-network (Middle Campscott) and the sustainably intensive actor-network (Wyke Farms) embed sustainability. However, they both embed sustainability in very different ways. The above discussion mentioned that Wyke Farms could be green-washing with their 100% green energy statement. However, this research believes that Wyke Farms are not green-washing as they are trying to do many things as described in *Section 5.1.2* to improve upon their sustainability but certainly not everyone is engaging with the 100% green strategy. Middle Campscott don't advertise their sustainability but they still embed sustainability, it is seen as something that should just be done anyway – it is their way of life. This Chapter finishes by discussing if 'sustainable cheese' is a fictitious agri-food identity; this research believes that 'sustainable cheese' is not a fictitious agri-food in the actor-networks that have been studied in detail for this study as the cheesemakers are doing many things to make their cheese more sustainable. However, there are sustainability issues that arise when making cheese and these are discussed in the next chapter (Chapter 6) along with potential solutions.

5.4 **Chapter Summary**

This chapter has taken steps to tackle the second aim and its corresponding objectives which can be seen below:

Aim 2: Understanding the dynamics of actor-networks

Related objectives:

- 2.1. Map the actor-networks.

- 2.2. Explore the different discourses of sustainability within the actor-networks and explore connections to notions of eco-localism and sustainable intensification.
- 2.3. Look at the interactions between the actants that link to sustainability

The actants in the actor-networks were identified along with associations/relationships between the different actants. These cheese actor-networks were displayed in actor-network diagrams. The nature of ANT is that it is not an actant who is strong or more important in the actor-network but it is the association between the actants that is the focus. There are a number of key associations within the cheese actor-networks that are seen as essential to the network and therefore a stronger association than others. The key associations that were picked out in the actor-networks include the farmer to the milk and the farmer to the animal (sheep for the Middle Campscott actor-network, cows for the Wyke Farms and Plaw Hatch actor-networks). These associations are seen as strong because the milk is crucial for cheesemaking. The key associations differed for the different networks.

Once the actants and the associations between the actants were mapped, the discourses of sustainability within the actor-networks were explored. Actors were engaging with sustainability in different ways. Two main themes were identified in the understandings of sustainability discourse. They were environmentalist and productionist perspectives. Environmentalist perspectives which could be thought of as in line with eco-localist thinking included references to not harming the environment and looking after or protecting the environment. The productionist perspective mentioned notions of production and even thinking of sustainability as something that can be produced and could be compared with Pretty's (1997) 'business as usual' school of thought. There were also other themes that did emerge from the understandings of sustainability within the network including sustainability as being cyclic, the three pillars of sustainability and sustainability being something that is considered for the future. Only 3 actors incorporated all three elements of sustainability together like sustainability is defined in the Brundtland Report.

When thinking about the notion of embedded sustainability, this research believes that both the eco-localist actor-network (Middle Campscott) and the sustainably intensive actor-network (Wyke Farms) embed sustainability. The message that comes across from their websites and other media are that both cheesemakers are both very interested in sustainability and sustainability is important to them. However, they both embed sustainability in very different

ways. The above discussion mentioned that Wyke Farms could be green-washing with their 100% green energy statement. However, this research believes that this is not the case but just that not every employee is necessarily engaging with the 100% green energy statement.

6 Problems and Solutions in realising sustainability for cheese actor-networks

The main purpose of this chapter is to address Aim 3 and the corresponding objectives.

Aim 3: Problems and Solutions in realising sustainability for cheese actor-networks

Related objectives:

- 3.1.1. Identify problems in the sustainable cheese networks
- 3.1.2. Establish and evaluate suitable solutions
- 3.1.3. Develop and critically assess a suitable system development methodology

Therefore, this chapter attempts to realise the sustainability problems and solutions for the three cheese actor-networks, that this research has studied. The problems were firstly identified by referring to the rich data that was collected at different case study locations, as well as examining the actor network diagrams and results from the discourse analysis. Solutions were then investigated by again referring to the rich data, but also to the literature. The final part of this chapter investigates a potential system development methodology, the system development methodology that is proposed is the two phased approach of using the two approaches actor-network maps (which are produced using the underlying theory for this research, ANT) and models created using the i* framework. Once Aim 3 and the related objectives have been satisfied, steps 6 – 12 of the methodological framework presented by this research will have been completed.

6.1 Identify problems and establish and evaluate suitable solutions in sustainable cheese networks

The cheese actor-networks with an interest in sustainability have been identified, the actor-networks have been mapped and the discourses of sustainability within the chosen networks have been explored. This chapter now explores the problems that have been identified as being an issue for achieving sustainability in relation to the cheese actor-networks. These problems were identified in the interviews and questionnaires that were carried out across the different actor-networks and through ethnographic observations that were recorded when on location. Problems were also identified in the literature. The solutions to the problems of achieving

sustainability are then discussed. The solutions that have been suggested are initially solutions that were proposed by the different interviewees and then the literature was explored to ascertain the feasibility of these possible solutions.

The problems identified varied across the from cheese actor-networks. However, some problems experienced were similar across the networks as identified below. Problems also varied within the network depending on the area of the network (i.e. the farm, the dairy, the consumer). Unfortunately, as mentioned in Chapter 3, although the plan was to trace problems across the whole network the research did not manage to get agreement from supermarket retailers. Therefore, the problems from the view of supermarket actants are not included in this chapter. The chapter looks at the sustainability problems and solutions across the actors in each of the cheese actor-networks. Across all networks, the main sustainability problems in relation to the cheese actor-networks observed were energy and water usage, plus waste, these problems are discussed first in detail below and then other sustainability problems that the different networks have experienced are highlighted.

6.1.1 Energy, Water and Waste

From observations at the case study sites, three main sustainability problems for all three cheese actor-networks were: energy, water and waste. Farming and cheesemaking are energy and water intensive and there is a large amount of waste and waste water associated with these processes (Aguirre-Villegas *et al.*, 2011; Hamerschlag, 2011; Garnett, 2011).

Energy usage as outlined in the literature review in Chapter 2 is used intensively in the dairy and the dairy processing industry, with energy consumption for the heating and cooling being particularly significant as these appear throughout the cheesemaking process as water is heated to heat the milk and then the milk is cooled. There is also high energy involved with the cheese production and maturation of the cheese. Other high-energy intensive activities include, lighting, transport, machinery and refrigeration (Garnett, 2011). The size of the farm and dairy is an important factor in how much energy is consumed for these activities. Middle Campscott's energy consumption was said to be approximately 100 kWh (kilo watt hours) per day, which tends to be the same throughout the winter and summer. In winter they are not running the milking pumps but they are opening the freezers more frequently to get milk out for cheesemaking. Plaw Hatch Farm have provided detailed readings for energy consumption in the dairy: annually they use 132,480 kWh of electricity and 70,880 kWh of oil to run the dairy. Daily

this is equivalent to 362.96 kWh of electricity and 194.19 kWh of oil which altogether is 557.15 kWh of energy consumed. Unfortunately a figure for Wyke Farms' energy consumption was not obtained. These figures are shown in tabular form in Table 3.1.

Table 6.1 - table showing annual energy consumption for the three actor-networks and how much energy is needed to make 1kg of cheese

Actor-network	Annual cheese production (kg)	Annual energy consumption (kWh)	Energy consumption per kg of cheese (kWh)
Middle Campscott	500	36,500	73
Plaw Hatch Farm	4,217	203,360	48.22

There are ways to reduce the annual energy consumption on the farm and in the dairy and some ways have already been implemented within the cheese actor-networks. Potential solutions are discussed below.

Renewable energy is a significant way of reducing energy consumption and the supply of clean, affordable energy that does not cause negative societal impacts is seen as important on the route to sustainability (Kothari *et al.*, 2010). Energy such as solar radiation, wind, wave and tide are renewable and therefore relatively sustainable in the long run (Kothari *et al.*, 2010). Middle Campscott have installed solar panels on the roof of their farmhouse but they would like more solar panels and have investigated installing them on the dairy roof. They also have a solid fuel stove which they use to heat the water in the farmhouse. Middle Campscott (when Middle Campscott is speaking it is the farmer and the cheesemaker together) would like a more economical way of heating the water in the dairy, such as a solar heating system, because currently water is heated using an immersion heater that is expensive to run in terms of electricity used.

Wyke Farms are also implementing renewable energy. As described in previous chapters, they have installed solar panels on their cowsheds and are investigating increasing the size of their solar array and installing a heat recovery system. Wyke Farms also have a biogas plant with anaerobic digesters that supply power to CHP towers, powering the biogas plant and the cheesemaking factory site. Waste and biomass fuels are seen as sustainable energy resources, when waste is used to make energy forms such as biohydrogen, biogas and bioalcohol; it is

known as a waste-to-energy technology (Kothari *et al.*, 2010). There are advantages of using anaerobic digestion over other waste treatments including it being able to deal with wet wastes (Mata-Alvarez, 2002), it having minimal odour emissions (Smet *et al.*, 1999), and the digestate it produces being an improved fertiliser for plants (Tafdrup, 1995). Battini *et al.* (2014) confirm that biogas from manure is a successful option for greenhouse gas mitigation. However there are also disadvantages of anaerobic digestion and it is not a solution for everyone, not least because it requires significant capital and operation costs to install a biogas plant the size of Wyke Farms', as well as the machinery traffic that delivers the waste for anaerobic digestion (Monnet, 2003). Smaller scale anaerobic digestion is possible and Holm-Nielsen *et al.* (2009) feel that both small-scale and large scale biogas plants have brought forward huge steps for economic sustainability of a business.

Plaw Hatch Farm have added a thermal store to their new boiler in the hope that it will make it more energy efficient. A thermal store is a way of retaining renewable heat until it is needed and can be used as a renewable technology with a conventional boiler. The Energy Saving Trust (2017) confirm that a thermal store will enable a heating system to work more efficiently. It will also reduce the need to buy fossil fuels to meet on-demand hot water. Kalaiselvam and Parameshwaran (2014) promote thermal energy storage for its capacity to provide a spectrum of benefits for achieving a sustainable future.

Particular actors in Middle Campscott and Plaw Hatch actor-networks have consciously reduced the number of trips that they take and have implemented other measures across their actor-networks to reduce their overall energy. Middle Campscott try to only leave the farm if they have several reasons to make a journey, in order to cut down on fuel use. When they leave the farm to go to market, for instance, they also seek to undertake a series of other activities whilst they are at the market, such as visiting a bank.

Q40: *"I don't think that I actually go out without some sort of business reason..."* – Cheesemaker, Middle Campscott

They also do all their own food shopping in the market so that they don't need to undertake a separate trip to buy food, also viewing it as a way of supporting their fellow stallholders. Such actions can be seen as being important for sustaining farmers' markets.

The cheesemaker at Plaw Hatch Farm identified the use of fossil fuels as an unsustainable practice and an overall sustainability problem for the business. When asked about solutions to reducing or ceasing use of fossil fuels, this cheesemaker disclosed that they were trying to move away from the use of fossil fuels, albeit doing this in small steps, as is illustrated in the following quote (Q41):

Q41: “Mostly in small steps, it’s very difficult, especially in agriculture, but we’re looking at getting solar thermal for the dairy water because we use a lot of hot water and we have looked at getting a biomass boiler...” –

Cheesemaker, Plaw Hatch Farm

This cheesemaker was also conscious that all their tractors are run on diesel, although they stated that they were trying to minimise the number of trips needed in a tractor and investigating whether implements attached to the rear of the tractor could reduce the amount of times they have to go over an area of land, thereby reducing compaction. Reducing the number of trips needed in a car and travelling shorter distances was also seen as a key way of contributing to sustainability (Banister, 1997). Reducing the number of resources used and using less input is a key component of eco-localist ideology (Curtis, 2003). Plaw Hatch Farm are going further to explore energy saving opportunities, as at the time of interview they had arranged for the Carbon Trust to come in to do an energy survey, in the hope that it would bring new insights as to where they can conserve energy.

Four Wyke Farm employees, mentioned their concern for emissions, such as the greenhouse gas emissions emitted from factory and farm machinery, and two others talked specifically about the emissions from vehicles and the fuel needed to power these vehicles. Wyke Farms are trying to overcome this problem with electric cars to travel from site to site and they are investigating the cost of electric powered milk tankers. However as one Wyke Farms employee pointed out in the following quote:

Q42: “...we all drive round like in our BMs and Range Rovers...” – Employee, Wyke Farms

You could argue that employees of a business who are trying to be the forerunners of green cheesemaking and sustainability should take more responsibility for their own personal carbon

emissions. On the other hand, Wyke Farms as a business is clearly considering energy use and emissions.

Smith *et al.* (2007) and Garnett (2011) suggest five broad mitigation techniques for reducing greenhouse gas emissions in farming, namely enhancing carbon removals, optimising nutrient use, improving productivity (increasing the yield), managing and benefiting from waste outputs (biomass: composting and anaerobic digestion) and reducing the carbon intensity (energy efficiency improvements and alternative fuels). All three actor-networks studied include actors who are doing some of these to reduce their greenhouse gas emissions. Wyke Farms are implementing aspects of the first two, including restoration of degraded lands and precision dosage and timing of fertiliser application. Smith *et al.* (2007) feel that the best way to reduce greenhouse gases in the food chain is to stress the importance of increased productivity but with minimised land requirements and greenhouse gas emissions. As Garnett (2011) points out this is essentially sustainable intensification. Sustainable intensification is not possible for all food actor-networks as they are on a smaller scale and do not have the money to invest in such technologies. Even so Plaw Hatch Farm and Middle Campscott are already investing in renewable technologies and are interested in adopting other measures to reduce their energy consumption and reliance on fossil fuels.

Garnett (2011) also identify measure for mitigating greenhouse gas emissions beyond the farm gate, including increased energy efficiency, cleaner and renewable fuels, and resource efficiency. Energy efficiency includes only using equipment when necessary and use of the cleanest transport option possible (Garnett, 2011). Plaw Hatch and Middle Campscott both only use equipment when necessary and, as mentioned above, Wyke Farms have electric cars and are investigating electric milk tankers. Cleaner renewable fuels includes biomass, solar, wind, purchased green energy and combined heat and power (Garnett, 2011). Wyke Farms have solar, anaerobic digestion and CHP towers. Resource efficiency includes reducing unnecessary use of products and equipment. Middle Campscott are managing this beyond the farm gate because, as mentioned earlier, they have reduced the number of off-farm vehicle trips.

Water usage is also a huge sustainability problem for cheese actor-networks because, as highlighted in Chapter 2, high water intensity activities are needed for a block of cheese to be made. The food and drinks industry is reliant on freshwater for its raw material and processing needs (FDF, 2011). According to Lundqvist *et al.* (2008) agriculture is the largest human use of water, and the *Food and Drink Federation* feel that all food manufacturing businesses share a

responsibility to cut down water usage in the food supply chain along with their suppliers and customers (FDF, 2011). Again, the size of the farm and the dairy affects water consumption. Middle Campscott uses 90 litres of water per day, on a day where they are both milking and making cheese, while Wyke Farms use approximately 4,500,000 litres per day in their cheesemaking factory and Plaw Hatch Farm approximately 500 litres per day, although this figure is for the dairy alone and doesn't include the amount of water used on the farm. A table of water consumption for the three actor-networks can be seen below (Table 3.2). The extent to which the networks see water as a problem and the solutions they are implementing to use less water are discussed below.

Table 6.2 – table showing annual water consumption for the three actor-networks and how much water is needed to make 1kg of cheese

Actor-network	Annual cheese production (kg)	Annual water consumption (l)	Water consumption per kg of cheese (l)
Middle Campscott	500	32,850	65.70
Wyke Farms	15,000,000	1,642,500,000	109.5
Plaw Hatch Farm	4,217	182,500	43.28

It was evident that Middle Campscott did not regard themselves as consuming water, as is illustrated in the quote below:

Q43: *“...we don't regard it as consumption of water as the water that we use runs out of the hillside above the farm, we hijack it and use it for things and then we put the waste water back into the hillside below the farm and so the only water that gets taken away is what evaporates or gets sold wrapped up in lump of cheese or carcass of a lamb, well the carcass of the lamb has mainly got its water from the streams and the wet grass that its eaten anyway.”* – Farmer, Middle Campscott

The water that Middle Campscott use is intercepted, as explained in Chapter 5, and then their waste water is cleaned and released back into the stream. However, Middle Campscott are still

mindful of about not using too much water and the water that they use to flush through the milking system after use is the water that they use to clean down the milking area.

Wyke Farms' solutions to reduce the amount of water they are using include installing a water recovery plant at the factory site. The water recovery plant allows them to produce drinking water for re-use and they also extended their waste water treatment plant so they can discharge more water back into the river. Wyke Farms are now able to recover 95% of their factory waste water.

Plaw Hatch Farm is seeking to reduce their water use through finding a way to recycle the water used to heat the vats back to the boiler and to be able to reuse the heat as well. In terms of what they are already doing at Plaw Hatch Farm, they have a waste water system where the water goes through a settlement tank and then into a lagoon and they are hoping to be able to pump the water from the lagoon in the summer months onto the fields.

The *Food and Drink Federation* suggest a number of things that should be done to improve the use of water in a food supply chain, including: 1) addressing water security concerns by managing availability, access and use; 2) considering the impact of water when creating a new product; 3) applying sustainable sourcing principles to procurement practices; 4) reducing, reusing and recycling water to eliminate waste and inefficiency; 5) preventing water pollution; 6) communicate to customers and consumers in the importance of being water efficient; and 7) engage with communities at catchment level and consider local ecosystems (FDF, 2011). Middle Campscott are engaging with 1), 2), 3), 4), and 5), Wyke Farms are engaging with 1), 2), 3), 4), 5), and 7), Plaw Hatch Farm are engaging with 1), 2), 3), 4), 6) and 7). Lundqvist *et al.* (2008: 4) feel that "reducing food loss and wastage lessens water needs in agriculture." This is because if you make the food chain more efficient you save water that is used to make unused products. This is why the next few paragraphs discuss waste.

Waste is also an issue for cheese actor-networks as there are a lot of processes involved and waste can accrue at any stage. According to Lundqvist *et al.* (2008: 36) "as much as half of all food grown is lost or wasted before and after it reaches the consumer." However as Parfitt *et al.* (2010) point out, waste is more readily thought of as accruing at the retail and consumer stages of a food supply chain because the output here is more easily defined as food.

Middle Campscott make an effort to minimise their waste as much as possible, as can be seen in the following quote:

Q44: “...almost all the organic matter either gets consumed by a creature or composted or burned.” – Farmer, Middle Campscott

All organic matter is consumed by animals on the farm or it is composted, whilst waste that is non-recyclable is burned in their multi-fuel stove that heats the hot water for the house. They recycle all their glass and tins, with their glass jars being taken to a local jam maker at the market so she can reuse them. The only waste item that Middle Campscott feel is a sustainability problem for them are the polystyrene boxes that they transport their meat to market in. They use these polystyrene boxes to keep their meat cool, and although they do reuse them as much as they can, once they have become overused and in a bad condition they are forced to take them to landfill.

The main issue of waste for Wyke Farms is at the packaging stage. They started to use cardboard crates that were 100% recycled to stack the cheese for supermarket distribution. However, the performance of the cardboard boxes was problematic as they could not support the cheese. Consequently, the cardboard that Wyke Farms are currently using cannot be recycled so it does go to landfill. Supermarkets also dictate packaging requirements for their private-label cheese. If a supermarket decides to change their packaging when they still have some of the old film left then the old film just goes to waste because the supermarkets have requested the new film.

Plaw Hatch Farm recycle all their plastics, glass, paper and tins. The rest of their waste gets sent for energy recovery, waste is turned into energy by burning it at a high heat.

One of the most prevalent waste problems associated with cheesemaking is the whey that is produced in the cheesemaking process. However, the three cheese actor-networks studied did not have an issue with whey as it did not go to waste. Middle Campscott and Plaw Hatch feed their whey to their animals, whilst Wyke Farms break down their whey, with some of it being dried to create whey protein powder, whilst some of it is used for animal feed and the water component is used to wash down the factory. However, whey disposal did present itself as a problem for the cheesemaker that was interviewed for the pilot study that was conducted for this research. This cheesemaker was located on an industrial estate and not on a farm. The whey had to be carried down a corridor and out of the building where the cheese was being made

before being deposited in the cheesemaker's vehicle who then drove the whey to a friend who kept pigs. This was a source of frustration as evidenced by the quote below (Q45):

Q45: *"Yeah it's a bit of a chore, lugging it in and out basically the physical labour that's involved, disposal of the whey is a massive problem..."* –

Cheesemaker, Pilot Study

Furthermore, if this cheesemaker didn't have a friend who keeps pigs, then they would have to pay for the whey to be removed.

With regards to waste along the network, the biggest waste issue is arguably at the consumer end (Parfitt *et al.*, 2010; Evans, 2011). The consumer in these actor-networks will be discussed later in this chapter rather than here. The next three sections look at other sustainability problems for the cheese-actor-networks beyond energy, waste and water.

6.1.2 **Middle Campscott cheese actor-network**

There were a number of sustainability problems that were highlighted by Middle Campscott beyond energy, waste and water. The nature of an eco-localist network means that economic sustainability of the business is of repeated concern to the actors as they are very concerned about whether there will be sufficient income to live (Curtis, 2003). Sustainability is hence often framed in terms of whether there will be enough money coming into the business for it to be possible to sustain what is being presently done. This concern was echoed by both the farmer and the cheesemaker involved in this actor-network, as they said the following quote simultaneously.

Q46: *"Well we've got to earn enough to keep this going haven't we"* – Farmer
and Cheesemaker, Middle Campscott

The main way they try to overcome this issue is to limit their outgoings, by being careful with their expenditure, only purchasing items when they perceive there to be a clear need, as this quote highlights:

Q47: *"I think we do most things just trying to be careful because it's more economical, because as soon as you use a vet or you use something, you've*

got to pay for it, so generally we just try not to spend money if we can manage it ourselves and do it ourselves.” – Cheesemaker, Middle Campscott

Another problem identified that related to money and economic sustainability of the business, as well as to environmental sustainability, was the price of professional advice. As already mentioned in the *Energy, Water and Waste* section of this chapter, Middle Campscott wanted to increase the amount of renewable energy that was produced on site and to do this they felt that they needed professional advice in order to make the right decisions for their business and the environment. However, they were reluctant to pay for this advice, not only because it can be expensive, but also because they had nearly got “fraudulently stung” over a wind turbine in the past

Q48: “...we’re reluctant to fork out for professional advice on how and what to do, we nearly got very badly fraudulently stung over some, over a wind turbine...” – Farmer, Middle Campscott

This is a difficult problem to find a solution to, because the price for professional advice on matters such as renewable energy can be expensive and if you have placed trust in advice before and the trust has been misplaced, it can be difficult to move on from this. Another issue that ties into this last problem was the cost of being organically certified: at the time of interviewing it was approximately £650 per year to be certified as organic, which is a large cost outlay for a small business. Being organic was part of their identity and so both the farmer and the cheesemaker felt that they had to find the money to pay this. In addition, for their wool side of the business they had to pay a further £100 for the Global Organic Textile Standard (GOTS) to certify the wool as organic. One solution to such problems that has been identified in the literature is to form a producer group or cooperative and then apply for the certification as a group rather than as individual producers (Barrett *et al.*, 2002; Barrett *et al.*, 2001; Harris *et al.*, 2001). Middle Campscott had not considered this as an option.

A further sustainability issue that was found within both networks that have eco-localist characteristics was the problem of old infrastructure and equipment which affects the efficiency of the business.

Q49: “would make life easier...just better equipped, I mean there is equipment that’s about falling to bits you know... and washing down,

cleaning up, it's all graft isn't it, there's not much else you can do to, other than having easier to clean surfaces." – Farmer, Middle Campscott

The simplest, most obvious solution to this sustainability problem would be to update the infrastructure but this is not always feasible, as there has to be money available for such actions. Old infrastructure can be an issue affecting the sustainability of the business because energy efficiency has improved over time, so old equipment is likely to have a poor energy efficiency and thus wasting energy but as stated new equipment and buildings are expensive. There is a trade-off between environmental sustainability and economic sustainability.

For Middle Campscott, many sustainability problems were perceived as arising from governmental regulations, especially on the farm side of the business. Two regulations were seen to be particularly significant because of the costs associated with them. The first was that Middle Campscott had to pay for a lorry to come and collect fallen livestock for disposal. If livestock dies on the farm it must be collected, identified and transported from the farm, because the burial or burning of livestock is banned to prevent the risk of diseases spreading to the soil, groundwater and air (DEFRA, 2012). Middle Campscott are a small business and the cost of having to take away fallen livestock is a significant cost as well as having to deal with the financial cost of having to lose the animal. Middle Campscott felt it is a cost that they shouldn't have to pay as they keep a closed herd. The quote 50 below highlights:

Q50: "...because I keep a closed herd and a closed flock, the animals on my farm, eat my farm, they shit on the farm, they live on the farm and they die on the farm, well some of them die on the farm, and if they die on the farm, I can't see what disease that isn't already on the farm they are going to spread to any of the stock... I have to pay for a lorry to come here laden with dead stock from other farms which all have died from diseases that I don't necessarily have on the farm and load up the carcass and take it away using diesel for the road and diesel or whatever ever they use to burn the carcasses, I regard that as being absolutely stupid and a waste of my money and a waste of everybody's money, I don't see why I can't recycle the nutrients from an animal that I've raised on the farm on my own farm." – Farmer, Middle Campscott

There isn't a solution for this problem as it is a precautionary measure that is used to stop the spread of disease, apart from a reduction in the cost of fees for collection so that it is more affordable for smaller businesses. The other cost related issue of government regulations is the electronic ear tags that are required for the sheep. These ear tags cost £1 per sheep which is expensive for a small business who have around 200 sheep, as every sheep needs to be tagged including wethers. Middle Campscott used to put plain ear tags in that cost 18 pence per sheep, the farmers' thoughts on them can be seen in the quote below:

Q51: "They're a waste of time for us, we don't need to have electrically read tags in our sheep...our sheep don't go off with mass flocks to go through the countryside and in any case the trading standards officer that came and inspected our ear tagging system said they're absolutely hopeless, they give them readers, you point the reader at one sheep and it reads the one beside it, you have a race at the market and you drive forty sheep down the race, it reads 38 ear tags, you then have to go and read every individual ear tag to see which ones it missed and so it's a total waste of time, we nevertheless have to pay for these chips, ear tags" – Farmer, Middle Campscott

The quote above highlights how unnecessary Middle Campscott think the electronic ear tags are and according to this farmer they are not that effective. In the following quote the farmer compares the size of the farm and their network to an industrial scale and how he understands why they are needed at a larger scale:

Q52: "I can see that they're necessary for industrial scale agriculture but we're a tiny farm and we don't send our animals far away, if we did I'd be quite happy to put the requisite tags and so on, but we don't, they're are not going, the ones that get killed are only going ten miles down the road, two at a time, one at a time." – Farmer, Middle Campscott

Again, because this is a government requirement, it is difficult to see how there could be a potential solution to this other than for the government to relax the rules for small farms.

As discovered in Chapter 5, Middle Campscott use volunteers to help them with the workload on the farm, they mainly do this for economic reasons because they can't afford to pay anyone to do the work but also seek to share their knowledge with the volunteers. Many of the

volunteers are agricultural or veterinary students who want hands on farm experience. This set up works well for both parties but sometimes there are drawbacks of using inexperienced people. An issue that was identified by Middle Campscott was that on occasions a volunteer has milked a sheep with mastitis which has resulted in extraneous matter getting into the cluster. Once this has happened the milk collected can then not be used for cheesemaking and is fed to the animals instead. Possible solutions to overcome this problem is for better training of the volunteers so they know how to spot a sheep with mastitis and also to make sure the sheep is sheared regularly so that it is easier to spot the teats that have mastitis. Volunteers really benefit from working at Middle Campscott and their time with them is usually a placement towards their studies. The ones that I spoke too clearly expressed that they had enjoyed working on the farm and in the dairy, plus had really valued the skills that they had learnt.

Another potential issue that was identified on the farm which wasn't a problem at the time of my research but it could be in the future was the local organic abattoir that was used by Middle Campscott. This was a small abattoir that only did contract killings. If this local, organic abattoir were to close then Middle Campscott claim that it wouldn't be worth them selling meat as they would have to travel further to an abattoir and they are larger abattoirs that only do killings for supermarkets. Also, if Middle Campscott were going to travel further to an abattoir then they would have to take more than their usual two lambs at a time, as they would have to make the journey worthwhile. The lack of local organic abattoirs is not necessarily a direct sustainability problem for cheese but it is a problem for the overall sustainability of the business and the sustainability of small scale farming in general because if they were not selling meat, it is quite likely that they would not be able to make enough money to continue to just sustain the cheese side of the business.

Q53: "...we rely on the abattoir for our continuance of our meat enterprise and the meat enterprise also supports the cheese and the wool enterprises so if one leg went the others would be tested..." – Farmer, Middle Campscott

A solution to stop this problem from occurring suggested by the Middle Campscott farmer would be for the government to support small, local abattoirs and to not give them as many requirements to meet. The Middle Campscott farmer described the loss of small abattoirs as being disastrous for sustainable farming:

Q54: “...the loss of small abattoirs has really been disastrous for sustainable farming in the countryside, it forces everybody to send their animals to supermarket controlled abattoirs who will only buy stuff, they won't give you back your own...” – Farmer, Middle Campscott

The number of slaughterhouses in the UK has been in decline over the last century, in the 1950s there were over 5,000 slaughterhouses in the UK and in 2007 this figure had decreased to 285 operational abattoirs (Palmer, 2008; Tricks, 2016). For red meat, a very large abattoir can handle 100,000 ELU (EU Livestock Unit) a year, with one ELU being one cattle beast, two calves, five pigs or ten sheep. A 'large' abattoir can handle 30,000 – 100,000 ELU, a 'medium' abattoir can handle 5,000 – 30,000 ELU, a 'small' abattoir is less than 5,000 ELU and 'very small' is anything less than 1,000 ELU per year (Palmer, 2008; Tricks, 2016). In 2007 there were 145 'small' or 'very small' abattoirs in the UK compared to 11 'very large' abattoirs, however, the 'small' or 'very small' abattoirs only contributed 2.8% of the throughout share. It is these 'small' and 'very small' premises that service the small-scale farmer for them to be able to sell their meat. The demise in the smaller abattoirs is a threat to small scale farming, it threatens the least intensive livestock farms (Palmer, 2008; Tricks, 2016) such as the farm at Middle Campscott.

Another problem that was mentioned in relation to the farm was TB restrictions. There is extensive testing that needs to be carried out for the presence of TB, if the animals fail the test they are known as a reactor animal and have to be removed from the herd by slaughter. Unfortunately, there are not many solutions to this as the restrictions are strict in order to reduce the risk of spread within the herd. This was also mentioned as an issue for Wyke Farms.

Most of the problems described above are problems that Middle Campscott have identified as sustainability problems for the farm. Attention will now turn to considering problems that have been recognised for the cheesemaking process and the selling of cheese. The biggest sustainability problem for the cheesemaking process is controlling the cheese this was brought up by the cheesemaker in an interview. Cheese is a living organism and is notoriously difficult to standardise especially when unpasteurised milk is being used. The Middle Campscott cheesemaker says this can be a problem and on occasions it has put customers off the cheese, although Middle Campscott's regular customers are said to be aware that the cheese is always changing and they like this characteristic of it. The solution to this particular aspect of controlling the cheese would be to standardise the milk but that would entail pasteurising the milk before cheesemaking, which would dramatically alter the taste of the cheese.

A second aspect of controlling the cheese which was a sustainability issue in terms of waste was cheese mites. Cheese mites can devour a whole maturation store of cheese if undetected. There are a few solutions to this problem as detailed by the Middle Campscott cheesemaker who suggested that the big dairies fumigate the cheese. The Middle Campscott cheesemaker also indicated that vac-packing the cheese would solve the problem of the cheese mites but would also alter the taste of the cheese, which they do not wish to do that. A simple solution that has been suggested to them is to try metal shelves in the maturation store. Apparently cheese mites don't like metal shelves but currently in the maturation store Middle Campscott has wooden shelves that are covered in a plastic cladding. The replacement of shelves could potentially be costly so for now the cheesemaker at Middle Campscott is dealing with the issue by steaming the maturation store and hovering/vacuuming. According to Wilkin (1979), cheese mites come hand in hand with the storage and maturing of cheese, they start to eat the cheese and open up holes which allows mould to grow in the cheese.

The solutions that the Middle Campscott cheesemaker identified to combat the cheese mites, some of them are used but not all of them. The big dairies did use to fumigate the cheese to kill the mites but due to EU regulations banning Methyl Bromide, fumigation was no longer an option, resulting in a decline of vintage cheddars as the mites were ruining the older cheeses (The Courtyard Dairy, 2013). One cheesemaker in the UK swears by a vacuum cleaner and hovers the cheese every couple of weeks, another has built a dust blower that blasts the cheese with air removing the mites (The Courtyard Dairy, 2013). Some cheesemakers rub Diatomaceous Earth on to the cheese which is a soft white sedimentary rock which microscopic sharp edges, the mites eat the Diatomaceous Earth and it damages their digestive tracts and kills them (Wolfe). However, some cheesemakers believe that this will dry out the cheesecloth lifting it off and letting in more cheese mites. Even with all these approaches, they do not remove the mites indefinitely, just for a period of time, so whatever procedure the cheesemaker adopts for mite removal must be repeated (Wilkin, 1979).

Perhaps one of the biggest sustainability concerns in relation to cheese for Middle Campscott is the decline of farmers' markets. Middle Campscott solely sell their produce at farmers' markets so they are a huge factor in ensuring they acquire an income. Middle Campscott sell their produce at Barnstaple Pannier twice a week every week and also on three weekend days a month, they also sell at Ilfracombe farmers' market and Braunton farmers' market once a month. Their most local farmers' market, Ilfracombe, the local government, Devon County

Council used to provide a “splendid market hall”, the Lantern, but then they stopped providing it as the building was sold. So instead they had to rely on the benevolence of the local church who let them hold the farmers’ market inside the church once a month. However, the church is not located in a central location and is up a hill so not ideal for passers-by and it also does not hold as many customers. This resulted in not many customers coming through the door, this could also be reflective of the decline in popularity and number of visitors to farmers’ markets. Barnstaple Pannier market is a big market but it is not what it once was, there have been a decline in customers since they first started selling their produce there. Some days they will have no customers that buy any cheese which is detrimental to their economic sustainability. At Braunton farmers’ market, I witnessed for myself how difficult it is to sustain a farmers’ market when the customers are dwindling. On one of the occasions that I was there during the market, the market organiser came over and handed Middle Campscott a piece of paper announcing that this was to be the final Braunton farmers’ market because it was not worthwhile to keep the market running.

The decline of farmers’ markets is obviously a massive issue for Middle Campscott as this is how they make a living. Profit is not important to them, they just wish to make enough to sustain what they are doing. The advantage that Middle Campscott hold is that they supply organic produce and the interest in organic food has grown significantly in recent years (Hughner *et al.*, 2007). There was a 4.5% growth in organic food and drink sales in 2015 despite a decline in the overall UK food and drink sector (Ethical Consumer, 2016). Throughout 2015, £1,744 billion was spent on organic produce (Ethical Consumer, 2016). Hopefully Middle Campscott will be able to continue to capitalise on this, however organic food and drink market is still a niche market, it accounts for just 1.4% of the entire UK food and drinks market (Ethical Consumer, 2016). Ueasangkomsate and Santiteerakul (2016) has said this increase in demand for organic goods mirrors the rise in income and the growing public concerns of conventional food production (Van Loo *et al.*, 2013).

6.1.3 Wyke Farms cheese actor-network

There were many problems identified for sustainable cheese by people who work for Wyke Farms that were interviewed. The problem that came up the most and arguably one of the most challenging problems for Wyke Farms is the milk price. The milk price is an issue, it costs more for a farmer to produce a pint of milk than the amount they receive for it. Wyke Farms source their milk from 90 other farms including their own farms so there is a need to get this right and

to keep the support of their supplier farms so that they can continue to make cheese. Wyke Farms do pay a premium to their farmers that are working in a sustainable way, the premium is an extra 0.02 pence per litre. Working in a sustainable way is taken to include actions such as installing a mini AD plant, solar panels, taking digestate from Wyke to spread on their fields or owning a green vehicle. Profit is extremely important to a business like Wyke and whilst it might be expected that they would wish to pay the minimum for milk, it was clear that they sought to balance price with other criteria, such as getting a regular milk, which means that they are also concerned that their suppliers remain in business. A problem that is tied into the issue of the milk price is milk supply. The supply of milk is exceeding the demand which is mainly because of Russia banning imports of dairy and China demanding less milk. By one Wyke Farm employee they were described as external threats to the business.

Q55: "External threats...on the external market so you've got the milk price, you've got global milk supply, you've got demand China and Russia has dried up so Russia have got the bans on dairy, China not demanding so much dairy produce." – Wyke Farm employee

Milk supply and milk price both impact the economic sustainability of Wyke Farms, the milk price also affects the social sustainability of Wyke Farms. Another issue that is associated with the global market place is the competitiveness of the market, cheese is a difficult market. In recent years the strength of Aldi and Lidl is having a direct impact on the cheese industry which is described by one Wyke Farm employee as the 'discounters effect' which they describe as being the effect of stores like Lidl and Aldi doing well with not that many brands and smaller stores, and how larger supermarkets have seen their success and want to compete with this can be seen in the below quote (Q56):

Q56: "...the discounters effect so Lidl and Aldi have obviously grown quite well and they've done it on a really neat nice simple plan so they don't have too much selection, there's not too much brands, the stores aren't too big so Tesco and Asda and everybody is noticing this saying our stores are massive, our overheads are too big, we want to try and look at their model and kind of emulate it..." – Wyke Farm employee

Piercy *et al.* (2010) describe this effect as the 'flight to frugality' effect, consumers search out very low prices and migrate their business to the extreme discounters. So the bigger stores such

as Tesco and Asda are trying to reduce their overheads by cutting the number of brands they have in their stores so that they don't get stuck in the middle between the extreme discounters (Aldi and Lidl) and the quality based stores such as Sainsbury's and Waitrose (Piercy *et al.*, 2010). This is difficult for Wyke because they are not the biggest cheddar brand in the UK, Cathedral City are known as the leading cheddar brand as they are the biggest so they fill the number one brand spot for cheese in supermarkets. Supermarkets then need a competitor for Cathedral City to fill their shelves with and their biggest competitor is Pilgrim's Choice as they produce similar volumes of cheese. This means that there is then a fight for that third-place brand spot which supermarkets are likely to fill their shelves with. Wyke Farms are therefore trying to fill that spot. Wyke Farms' solution to be accepted as the UK's third placed cheddar brand is to play to their strengths to set them apart from other cheddar producers. Those strengths are highlighted below by a Wyke Farm employee:

Q57: "...provenance, the green route, the tradition, the family heritage plus our, I'm probably biased but, our cheese is pretty good quality so compared to a lot of the other brands our cheese has won a lot of awards, it's probably got the most flavour so we try and go down that route and come in as probably the third brand going into the supermarkets..." – Wyke Farm employee

Wyke Farms very much market their product as having a strong family history and provenance. This should stand them in good stead as Piercy *et al.* (2010) points out the consumers who are not as low price focused but quality orientated are purchasing from Sainsbury's and Waitrose on the basis of provenance. Wyke Farms also now have their 100% green angle which they have moved to the front of pack to target the consumers who are interested in sustainability. Brach *et al.* (2017) and Luchs *et al.* (2010) believe that consumers' attitudes to sustainable products are generally positive but these attitudes have not translated into current behaviours. Carrington *et al.* (2010: 141) states that "ethically minded consumers do not always walk their talk" this could be because of any number of potential factors including price, performance/quality, availability, convenience (Brach *et al.*, 2017). Lombardi *et al.* (2017) feels that information for the consumer can overcome problems such as price. In their study of 'climate neutral' milk they found that the importance of price declined after consumers were informed about the impact of their choices on climate change risks. Wyke Farms bringing their label to the front of the pack makes it more noticeable to the consumer and there is extensive information about their 100% green strategy on their website which consumers could look up

for themselves which has the potential to promote more ethical purchasing. Wyke Farms will have to continue to fight for the third brand of choice until there is less of a competition.

The choosing of which brands they want to stock their shelves with is not the only problem that supermarkets cause for Wyke Farms. Globally sourcing supermarkets have a lot of power in a food supply chain (Booth and Coveney, 2015), and when Wyke Farms provide cheese for a supermarket under the supermarket's own brand the supermarket can dictate whatever packaging they want on the cheese and Wyke have to comply or risk losing the contract. One of the Directors of Wyke Farms describes one of the biggest issues with dealing supermarkets is getting the Wyke Farms story across to them as some of them don't want to listen.

Sustainability problems for cheese have been identified on the farm, at the start of the cheese network, they are: methane emissions, climate/weather, government restrictions (particularly TB restrictions), the mix of technology and the environment, and speed and staffing cost of milking. Methane emissions are a major sustainability problem associated with the meat and dairy industry and Wyke Farms are aware that it is a problem for themselves:

Q58: *"We just don't want methane going up into the atmosphere, not good for anybody or anything."* – Director, Wyke Farms

Wyke Farms' solution to their own methane emissions is that in the winter the slurry in the cowsheds is collected quickly because that is when it has the most gas potential and it is going straight to the AD plant to be processed.

The weather can affect and impact the timings of certain events on the farm. If it is too wet to take the digestate tankers onto the fields then they spray fertiliser instead, which has an impact on the environment. A wet spring can also delay when the cows can be turned out back into the fields and likewise a wet autumn can mean the cows come into the cowsheds early, which can dramatically reduce their grazing time so the weather can have an impact on the happiness of the cows. The weather can also affect the crops, for example, by delaying the planting of crops and, on occasions, destroying a crop. Unfortunately, there are no solutions for controlling the weather but perhaps an alternative method of distributing digestate could be in part a solution.

Farm assurance schemes can be a difficulty for Wyke Farms' according to one of their farmers. The farmer described how the farm assurance scheme can be hard work in the farming area and

it requires spending a lot of money and effort to keep up with it, as described in the following quote:

Q59: *“...health and safety on a farm is very, very difficult and as you’re well aware it’s accidents waiting to happen out there, in a factory environment is quite different. When you’re out on the farm there is so much more that could go wrong but we do, we do, have a very strict health and safety program on the farm and we can get round it but it is very difficult.” –*

Farmer, Wyke Farms

The Red Tractor Scheme is a food standards scheme, the largest in the UK that covers areas such as animal welfare, food safety, traceability and environmental protection (Red Tractor Assurance, 2017). There are many critiques of the Red Tractor Scheme (e.g. Sustainable Development Commission, 2005), it often being questioned whether a third party is needed to establish whether food is legally compliant. According to the Sustainable Development Commission (2005) the Red Tractor Scheme doesn’t actually tell the consumer anything, and the logo certainly doesn’t mean that the food product is a ‘sustainable food product’, although it does help British farmers to provide some reliable assurance to customers.

In another interview, a farmer who supplies Wyke Farms said that the Government do not support farmers. This could be related to another problem that has been recognised, namely TB restrictions given that the farmer who was interviewed their animals had, only a month before, had TB for two years. TB restrictions were also mentioned by the Middle Campscott farmer who viewed them as very restricting, although as discussed earlier, there is no obvious solutions to this situation given that that the restrictions are set by the Government.

Another problem identified by a Wkye Farms farmer was possibly a direct consequence of them trying to be sustainably intensive, namely establishing a use of technology within the demands of an outdoor environment, as highlighted in the following quote (Q60):

Q60: *“Sometimes it’s a job to mix technology with, or the hardware if you like, with the dirty environment and they’ve come along way now, manufacturers with dealing with that but it does suffer with the environment, yeah and the damp.” – Farmer, Wyke Farms*

The technology used includes GPS on the tractors for field applications of the digestate. This technology allows the farmer to be more accurate with their digestate application, which by reducing the quantity of inputs, makes the process more sustainable. Pretty (1997: 248) argues that low-input agriculture “can be highly productive, provided farmers participate fully in all stages of technology development and extension.” Wyke Farms are attempting to engage with the technology, but as mentioned in the quote above, some natural elements get in the way. Technology that Wyke Farms has decided to not engage with is robotic milkers, this is discussed below.

An additional detected problem is the speed and staffing cost of milking. It is a time consuming process, one that could be easily sped up by robotic milkers. Meijering *et al.* (2004) in their study identified three social reasons for farmers investing in automatic milking system, these were increased labour flexibility, improving social life and health concerns. However robotic milkers do have their drawbacks (Q61):

Q61: “...you’ve got to bear in mind that that would change things for the cows as well, because if we’re tied to robot milkers they wouldn’t really be able to go out to graze so much. That’s the problem with it and we like to get the cows out, it really boosts them, they so look forward to going out in April, they’re looking out of the gates, ready to go, and they so look forward to it, it’s for their health and their feet as well, their feet they come off that concrete and go into that grass and it cleans them up...” – Farmer, Wyke Farms

Wyke Farms have chosen the welfare of the animals over the ease of operation and reduction of operational costs.

There were also sustainability problems recognised in the cheesemaking factory, the main problem is related to equipment failures. Breakdowns do not occur often in the cheesemaking factory, but when they do occur it can be disastrous because all the milk that is already in the vats then goes to waste as it has nowhere to go. Solutions to this issue are to make sure that the maintenance checks are regular, which they are, and when there is an equipment failure, Wyke Farms don’t let the spoiled milk go completely to waste because they let it go down to the anaerobic digester.

The seasonal changes of milk is also a sustainability issue according to a Wyke Farms' farmer. Kefford *et al.* (2009) argue that seasonality impacts milk composition due to its influence on lactation, feeding levels and diet. Milk tastes different in different seasons depending on the diet of the cows and the cheese is a living product, so adjustments have to be made as every day is different. Adjusting the recipe so that it accounts for the seasonal changes solves this problem, in spring the cheese can be very acidic as the cows are back out in the fields grazing so the recipe has to be adjusted for this. The last issue that was identified by a cheesemaker was a social sustainability issue, employees in the factory currently have to manually stack palettes of vac-packed cheese which could potentially have an impact on employee health so Wyke Farms are looking to solve the issue by adding robotic stackers to the cheesemaking factory.

The final problem that was mentioned by a member of the green team who was a Wyke Farms employee is that they often have issues with gaining planning permission, it is one of the biggest restrictions on the expansion of the biogas plant. Improving the relationship with the local community so there are less planning objections and to strengthen ties with the local council so they know exactly what they plan to do could solve this.

6.1.4 Plaw Hatch cheese actor-network

The two main problems that were presented by the one of the Plaw Hatch farmers is that the milking is back-breaking work and the equipment and buildings are old. Milking is undertaken using a milking system that does not have automatic cluster release, which means that milking was both taking a long time and was a process that was having an impact on their health as it is meant having to continually bend to attach and detach clusters. The farmer believed that automatic take-off would solve the issue of milking being back-breaking work because it would half the amount of bending in the milking parlour as you wouldn't have to bend to remove the clusters just to put them on. The farmer also pointed out that with automatic take-off clusters it would be easier to have less experienced people in the milking parlour because it is a learned art as to when the cluster needs to come off. The equipment and buildings being old is a problem to sustainability again because of time factors: the longer something takes to do the longer you have to pay someone for that role, which effects economic sustainability and also the social sustainability of the business.

Upgrading the milking parlour would solve both the problems identified, however this would be an expensive upgrade and it could also potentially encroach on much needed space. Again, this would suggest a trade-off between economic and social sustainability.

One of the cheesemakers at Plaw Hatch Farm identified a plethora of problems for sustainability both for the cheesemaking itself and for the Plaw Hatch actor-network as a whole. The problems encountered by the cheesemaker in the cheesemaking process included ancient equipment, unstable milk yields, difficulties in training new staff and limitations imposed from Environmental Health and Demeter, Demeter is the biodynamic certifying body. The vat used to hold and heat the milk in the cheesemaking process is “*ancient and leaky*”, this presents issues of waste, as the milk is leaking from the vat. The obvious solution again for this is to update the machinery and equipment that is used in the dairy. The cheesemaker admitted that they would like a more efficient, improved water heating system to heat the vat because the current one is temperamental and they also would like a platform for the vat so that it is easier to reach inside. This particular cheesemaker at Plaw Hatch Farm describes unstable milk yields as being the most challenging problem in Quote 62.

Q62: “...the fact that the milk yield is so unstable throughout the year so you know in April, May we get the sudden flush of milk which is triple the amount in sort of the lowest point in winter so things like staffing and that is difficult...” – Cheesemaker, Plaw Hatch Farm

As can be seen from the quote above one of the issues with unstable milk yields is that it can be difficult to staff the dairy accordingly, but it also affects the production of the cheese. At Plaw Hatch Farm the milk that is used for cheesemaking is what is left after enough raw milk has been produced as well as kefir and yoghurt. Therefore, there can be periods of a few months where cheese is not being made. This leads into a further problem, because it is difficult to train up cheesemakers when cheese is not always being made, as well as cheesemaking being a skill that can be hard to master and can be hard to pass on to a trainee. The cheesemaker outlined the issues as follows in Quote 63:

Q63: “I think sort of some of the scientific things can be quite difficult to get your head around but I think it’s really marrying up the science with the feel of it and the kind of intuition. I think actually that makes it quite difficult as I’m quite intuitive about it and sort of yeah, its quite difficult, because I think

they, I think sometimes it seems like it doesn't really matter if you mill here or if you mill it there, because sometimes I'm milling it at this acidity and sometimes at this acidity, and sometimes it's a longer time or a shorter time, but there's a reason for that but I just find it really difficult sometimes to explain or to make it make sense if I did explain..." – Cheesemaker, Plaw Hatch Farm

Another problem the cheesemaker identifies specifically to the cheesemaking process is the limitations set upon them by *Environmental Health* and *Demeter*. The cheesemaker reveals that they would like to make a variety of different cheeses and to be more creative with ingredients to suit customers' requests. However, this has to be negotiated with Environmental Health and Demeter. Although the cheesemaker admits that Plaw Hatch Farm's relationships with Environmental Health and Demeter are good and they are very supportive, it can just be a hassle to negotiate especially after extensive microbiological testing. This could impact the sustainability of the network as if customers are not getting the cheese that they want then they may not return and this could affect the overall economic sustainability of the business and the relationship with the customers

The cheesemaker that was interviewed also identified one general sustainability issue for the cheese actor-network. This was a tight financial budget, which impacted wages and updating of old infrastructure. Even though the business is making a profit, there is so much renovating and updating needed that the list of things to do is too long. This quote seems to show that the financial situation has improved in the last year:

Q64: "...we've got a lot of old infrastructure and systems you know I think until relatively recently the farm was working on a you know on a very tight budget so things for the future weren't really getting done you know and maintenance wasn't really getting done..." – Cheesemaker, Plaw Hatch Farm

The cheesemaker identified that wages were a huge sustainability issue, until recently. As some people live on the farm and some people live off the farm, the wages were OK if you lived on the farm as you got accommodation as part of the deal. However, if you lived off the farm then the wages were not enough to sustain living.

Q65: *"...historically the wages were not very good especially for people living off the farm, because some of live us on the farm and some of live off the farm, and I think if you live on the farm and then you've got quite a lot of security and it's not so difficult, you know. But if you live off the farm then you've got to pay rent and rates and all of these things, then that's more difficult. So in a sort of human sense, I don't think it was very sustainable and we brought the wages up quite a bit in recent years..."* – Cheesemaker, Plaw Hatch Farm

This is a problem that can drastically affect the economic and social sustainability of the business. The next section identifies sustainability issues found at the consumer.

6.1.5 **Sustainability and the consumer**

There are also sustainability issues at the consumer end of the actor-network. These issues included food waste, refrigeration, and travel to buy food. There can be issues of food waste at the point of consumption, with LEI (2015), for example, finding that 31% of food waste across the supply chain occurs in the consumer households, compared to just 14% waste in trade and catering. Parfitt *et al.* (2010) identify that dairy, because it is a perishable, is one of the most wasted types of food, along with fresh vegetables, fresh fruit and bakery items. When cheese has mould present that is not supposed be there then it is possible that instead of chopping off the piece with mould, the whole piece of cheese is thrown away. However, of the customers surveyed, only 7% said that they would throw away the whole piece of the cheese in the bin. In those 7%, there were no Middle Campscott or Plaw Hatch Farm customers. Of the customers from Middle Campscott (7 in total) and Plaw Hatch (8 in total) that were surveyed, all said they would either cut the mouldy piece off or just eat it anyway. A solution for not letting the cheese go mouldy would be to freeze it. Cheese can be grated and then stored in the freezer to be used when needed. The 7% of consumers who would throw the whole piece of cheese in the bin were all consumers of Wyke Farms' cheddar, this could mean that consumers of a big brand of cheddar are less concerned about food waste than those who would support a smaller, local cheesemaker. Aschemann-Witzel *et al.* (2015) suggests that there is no one single action but only a combination of actions that can trigger change when it comes to household food waste. Actions that Aschemann-Witzel *et al.* (2015) suggest as triggers for change include addressing consumer household management behaviour, expectations and perceptions. Consumer household management behaviour could incorporate meal planning for the week, investigation

of left-over recipes, and daily purchasing of food for meals. Consumer behaviour and expectations concern knowing when and when not to pay attention to food features such as date labels. If a food product is past its 'best before date' then being able to judge when a food product can still be eaten is advantageous and less wasteful. Granted the consumer is not solely responsible according to commentators such as Stuart (2009), supermarkets have a lot of responsibilities here and date labelling needs to be reassessed (Newsome *et al.*, 2014; Aschemann-Witzel *et al.*, 2015).

This potential sustainability issue for cheese at the consumer level is that consumers don't feel that it is important that their cheese is made sustainably. When asked the importance level of their cheese being made sustainably, only 2.4% of Wkye consumers felt it was very important and 25% felt it was important, whereas 29.4% felt it was not at important at all.

Another potential sustainability issue identified at the consumer level is that consumers often travel to get their cheese travelling by car. This causes an environmental impact by greenhouse house gas emissions being released into the atmosphere. For the smaller, more local cheese actor-networks of Middle Campscott and Plaw Hatch, the majority of customers drove to get their cheese. There is not a suitable solution for this because these cheesemakers sell in rural areas and their customer's only option is generally to drive to buy their cheese and other produce.

6.1.6 **Summary**

The sustainability problems across the actor-networks have been established and the solutions to some sustainability issues have already been implemented in the actor-networks. Other solutions have been found in the literature and presented above. The table below summarises the specific sustainability problems that have been identified for each cheese actor-network (Table 3.3).

Table 6.3 - A summary table showing the specific sustainability issues that were identified for each cheese actor-network

Middle Campscott (eco-localist) actor-network	Wyke Farms (sustainably intensive) actor-network	Plaw Hatch Farm (intermediary) actor-network
General energy consumption	General energy consumption	General energy consumption
Heating water	Petrol/diesel consumption	Petrol/diesel consumption
Petrol/diesel consumption	Water usage	Water usage
Waste: polystyrene boxes	Waste: cardboard crates	Milking is backbreaking work
Enough income to live	Milk price	Old infrastructure
Cost of professional advice	Milk supply	Ancient equipment
Cost of organic certification	Discounters' effect ('flight to frugality effect')	Unstable milk yields
Old infrastructure	Power of supermarkets	Difficult to train new staff
Government regulations: fallen livestock	Methane emissions	Limitations imposed by Environmental Health
Government regulations: TB restrictions	Climate/weather	Limitations imposed by Demeter
Experience of volunteers	Government regulations: TB restrictions	Tight financial budget
Decline of small abattoirs	Technology in the environment	Fair wages
Decline of farmers' markets	Equipment fails	Consumer waste
Consumer waste	Seasonal changes of milk	
	Planning permission	
	Consumer waste	

The list of sustainability issues that have been identified is in no way an exhaustive list of all sustainability problems for the actor-networks. The problems identified are the problems that emerged from interviews, questionnaires and observations at a specific time when the fieldwork was being undertaken.

There are some sustainability problems that occur for more than one actor-network such as energy consumption, petrol consumption, water usage, waste, TB restrictions and old infrastructure. There are also problems that occur solely for one of the actor-networks studied. Specific problems that are a sustainability issue for Middle Campscott actor-network that is associated with the actor-network being eco-localist are: having enough income to live, experience of volunteers, decline of small abattoirs and decline of farmers markets, cost of professional advice and cost of organic certification. Some of these problems are entwined with another: for example, being able to afford organic certification and professional advice is dependent on the having enough income to live first. An eco-localist network is small and every actant in the network is reliant on the other, Middle Campscott is reliant on the farmers markets to sell their produce and make enough income to live, they are also reliant on the small abattoir to do their killings so that they can continue to sell their meat and to support the cheese side of the business.

Sustainability problems that have been identified for the Wyke Farms actor-network that are concurrent with issues associated with the sustainably intensified nature of the network include milk supply, discounters' effect, power of supermarkets, and technology in the environment. A sustainably intensive network is trying to maximise their production, therefore they need an outlet for selling a maximised production and that naturally is supermarkets.

The next section provides a series of goals for sustainable cheese in the hope that the goals suggested will help to overcome the problems outlined in Table 6.3. A system development methodology is also used to goal model and investigate alternative iterations.

6.2 Develop and critically assess a suitable system development methodology

This chapter to date has identified the sustainability problems and solutions for the cheese actor-networks. This section proposes a system development methodology that can show the relationships between the different actants and identify sustainability vulnerabilities within the network. The selected system development methodology plans to combine interdisciplinary approaches as discussed in the methodology chapter, and specifically explore the potential links between ANT and the system development methodology, i* framework. As discussed in Chapter 3, this research is seeking to investigate whether i* can be a suitable way of making ANT more practical as one of ANT's biggest criticisms is that it can be too descriptive. Therefore this research is implementing the proposed methodological framework that is outlined in chapter 3 that uses ANT and i* in tandem to better define sustainability problems and solutions for cheese

actor-networks. The steps 1- 6 have been completed and displayed in Chapters, 4, 5 and the start of this chapter.

As outlined in Chapter 3, a system development methodology can be used to structure, plan, and control the process of developing an information system. In this case, I am looking for a framework that can be used to structure, plan and control a real-world system, namely sustainable cheese actor-networks. A number of system development methodologies were assessed for their suitability to do this, it being determined that a single system development methodology was not appropriate for this research but several methodologies could be applied in combination. Specifically it was decided to employ Agile Development, although it was assumed that it was applied intrinsically as Crookshanks (2013) writes that all system development methodologies have elements of either waterfall and agile, alongside Soft Systems Methodology (SSM) and the i* framework.

One of the biggest struggles for this research, was that the i* framework itself can be extremely complex especially as there was no prior knowledge of the i* framework before the research began. This meant the literature had to be engaged with and the concept understood prior to starting the drawing of i* frameworks diagrams. Therefore parts of SSM, presented by (Checkland, 1993), were drawn on, as well as the i* framework presented by Yu (1995).

The parts of SSM that were applied were the first two steps of the methodology, namely of, first, defining an area of interest, and second, of creating a rich picture. The system development methodology was only applied to the first case study which is the eco-localist sheep cheese actor-network, Middle Campscott. The reasons for choosing Middle Campscott to construct the i* diagrams for was because it was, first, the smallest network, which was significant because i* diagrams can become extremely complex, but also, second, was the network for which a richer level of information had been obtained, reflecting the longer amount of time that was spent in this network. The two stages of SSM for the Middle Campscott actor-network can be seen below.

Stage 1: defining an area of interest or expressing the problem situation. It was decided that the area of interest is 'to produce sustainable cheese'.

Stage 2: Rich picture: a rich picture was created to express the problem situation

A rich picture as indicated in Chapter 3, is similar to an ANT diagram. A rich picture is meant to capture the actors and detail of the situation. It is thought that a diagram and pictures

encourages detail that words cannot (Checkland, 1993). An actor-network theory diagram showcases actants in the network, both human and non-human, and therefore there is also a large amount of detail in an ANT diagram. Consequently, it was decided that the ANT diagrams could be viewed as constituting the rich pictures for this research. The ANT diagram (rich picture) for Middle Campscott that was displayed in Chapter 5, but can be seen below Figure 6.1. Rich pictures can often also show issues and conflicts (Checkland, 1993). The rich picture allowed for the actants to be displayed and then using the problems that were discerned from the rich data collection in step 2 of the methodology framework the solutions that are show in the above section were able to be found. From the solutions this study was able to produce a taxonomy of goals for sustainable cheese like the goals Cabot *et al.* (2009) produced for a 'green Conference' Chapter 3. The taxonomy of goals for sustainable cheese actor-networks is displayed in Figure 6.2.

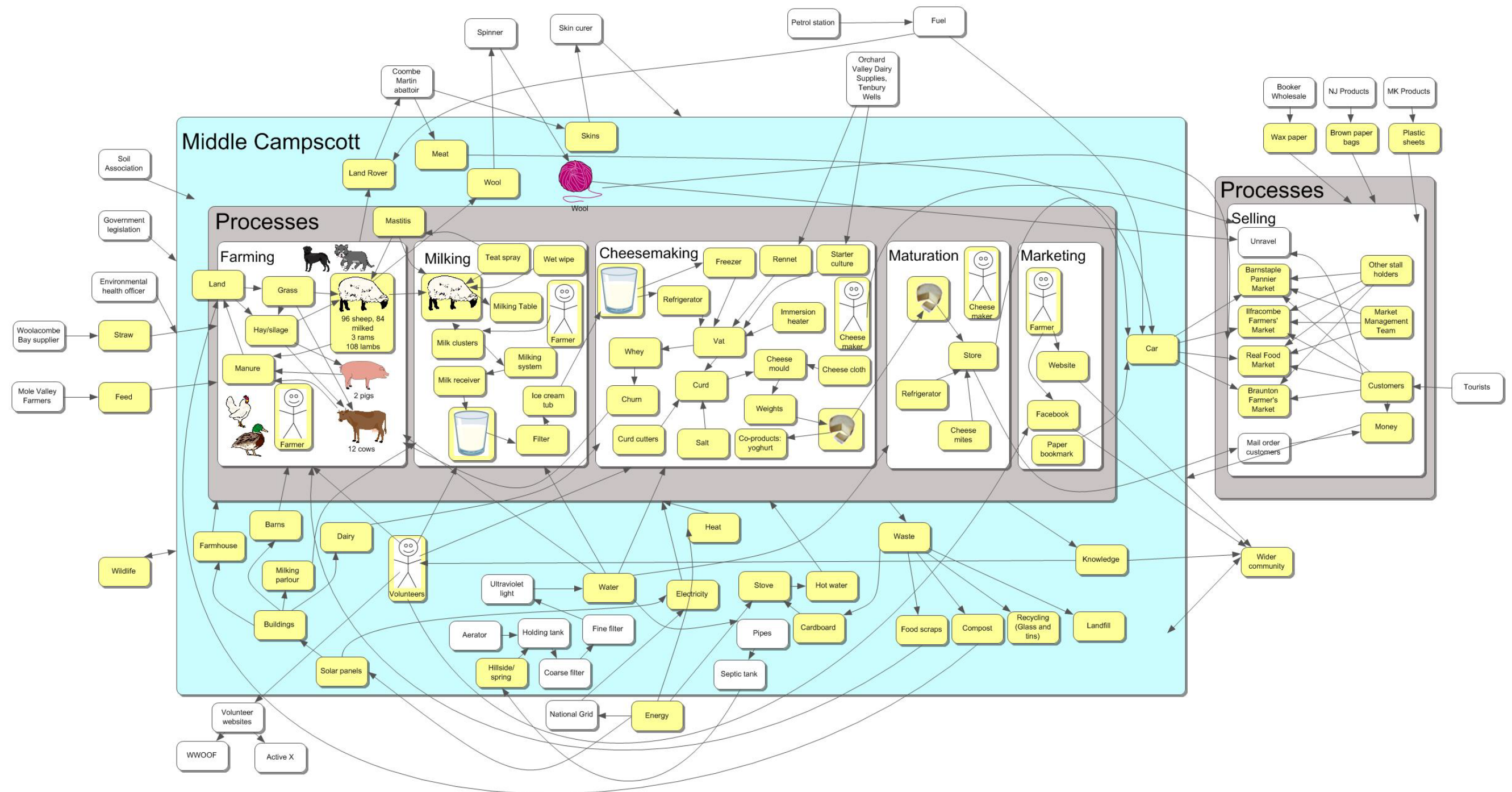


Figure 6.1 -Middle Campscott actor-network diagram that is being used as a rich picture for stage 7 of the soft systems methodology

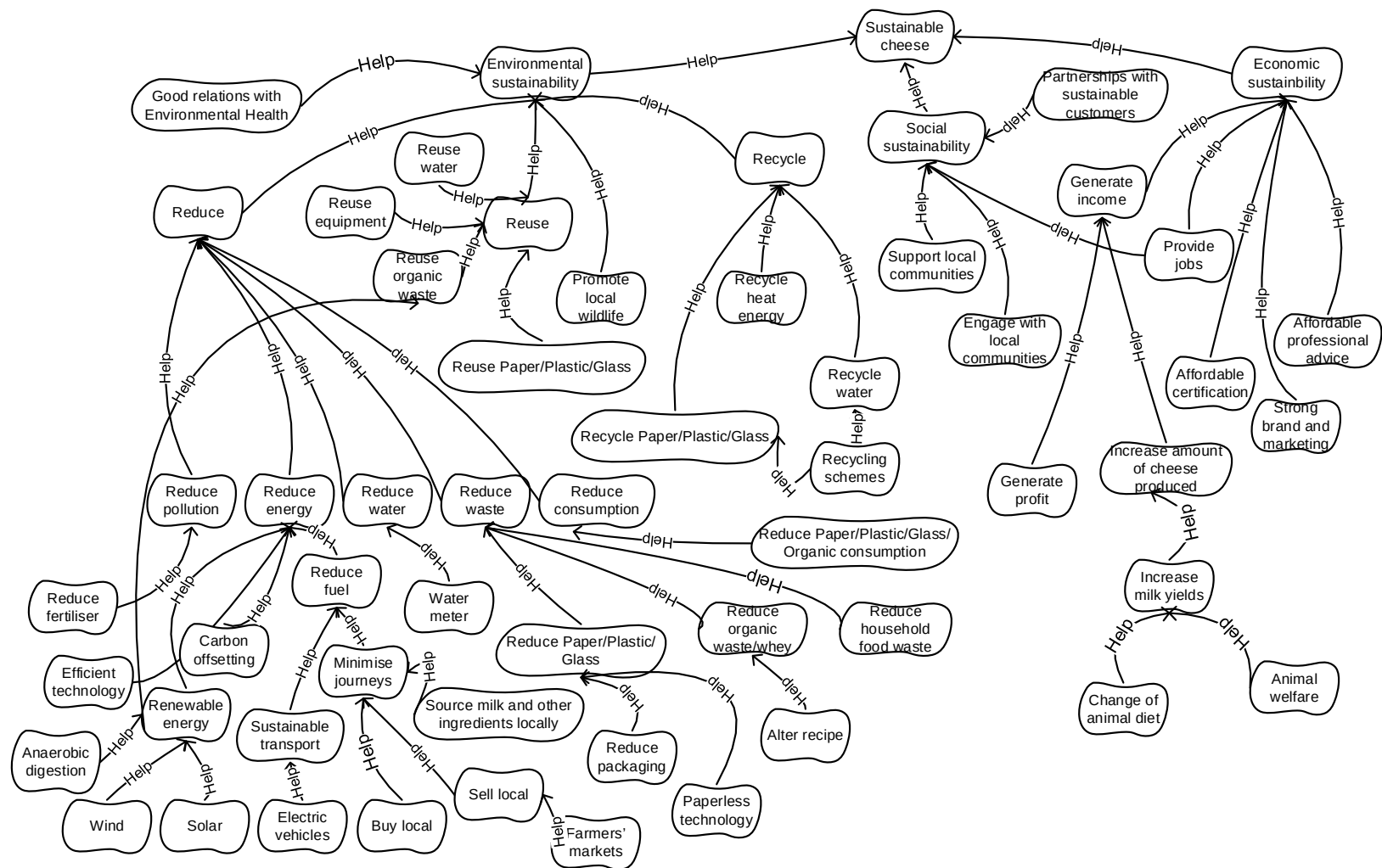


Figure 6.2 - Goals for a sustainable cheese actor-network

The taxonomy of goals is based on Cabot *et al.*'s (2009) although the taxonomy of goals produced for this research (Figure 6.2) differs from Cabot *et al.*'s (2009) taxonomy of goals because they only focused on environmental goals for a 'green conference'. The taxonomy produced in this research considers the three pillars of sustainability that, as discussed in Chapter 2, were taken as an understanding of sustainability for this research. These goals were identified from using the rich picture and also from the sustainability issues that were identified in the interviews, questionnaires and through observations that are discussed earlier in this chapter.

Once the goals were established the i* diagrams could be drawn for the Middle Campscott actor-network. The first diagram that was drawn was the strategic dependency (SD) model. As outlined in Chapter 3, the SD model is a set of nodes and links that make up a network. Each node in the network is an actor and the links between the actors indicates what one actor depends on another for the former to achieve a particular goal (Yu, 1995). According to Yu (1995) the SD model is used to convey intentional, strategic relationships among actors in a network but it does not illustrate the internal rationale behind these dependencies. The SD model for Middle Campscott can be seen in Figure 6.3.

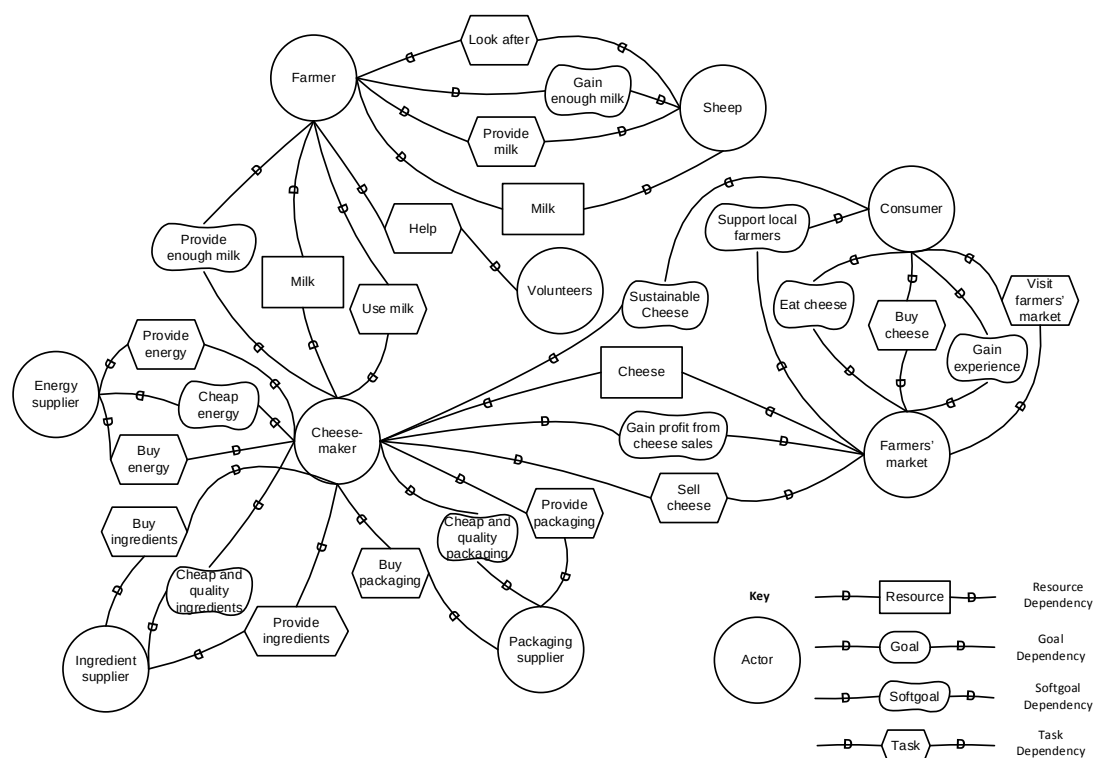


Figure 6.3 - strategic dependency model for Middle Campscott

There are 9 nodes in this SD model, with the nodes representing the following actors: farmer, sheep, volunteers, consumers, energy supplier, cheesemaker, farmers' market, ingredient supplier and packaging supplier. There are four different types of dependency links linking the nodes. These include dependency links where, for example, the actor 'Cheesemaker' is dependent on the actor 'Farmer' for the resource of 'Milk', the 'Farmer' is dependent on the 'Volunteers' for the task of 'Help' and the 'Cheesemaker' is dependent on the 'Ingredient supplier' for achieving the softgoal of 'Cheap and quality ingredients'. In this last case, the dependency link requires the 'Ingredient supplier' being dependent on the 'Cheesemaker' for the task of 'Buy ingredients', while the 'Cheesemaker' is dependent on the 'Ingredient supplier' for the task 'Provide ingredients'. This SD diagram shows the intentional, strategic relationships amongst the actors in the Middle Campscott actor-network.

Once the SD model had been drawn it was possible to draw a strategic rationale (SR) model. A SR model is still a graph with nodes and links but there are several different types of nodes and links. These nodes and links work together to form a representational structure that conveys the rationales behind the dependencies (Yu, 1995). The actors that were shown in the SD model were 'opened up' in the SR model, with their specific intentions being explored (Yu, 1995). In the SR model there are four different types of node which are based on the same distinctions as the dependency links in the SD model: goal, task, resource and softgoal. The links that join the nodes in the SR model are means-ends links, task decomposition links and contribution links (Yu, 1995). A SR model for Middle Campscott can be seen in Figure 6.4.

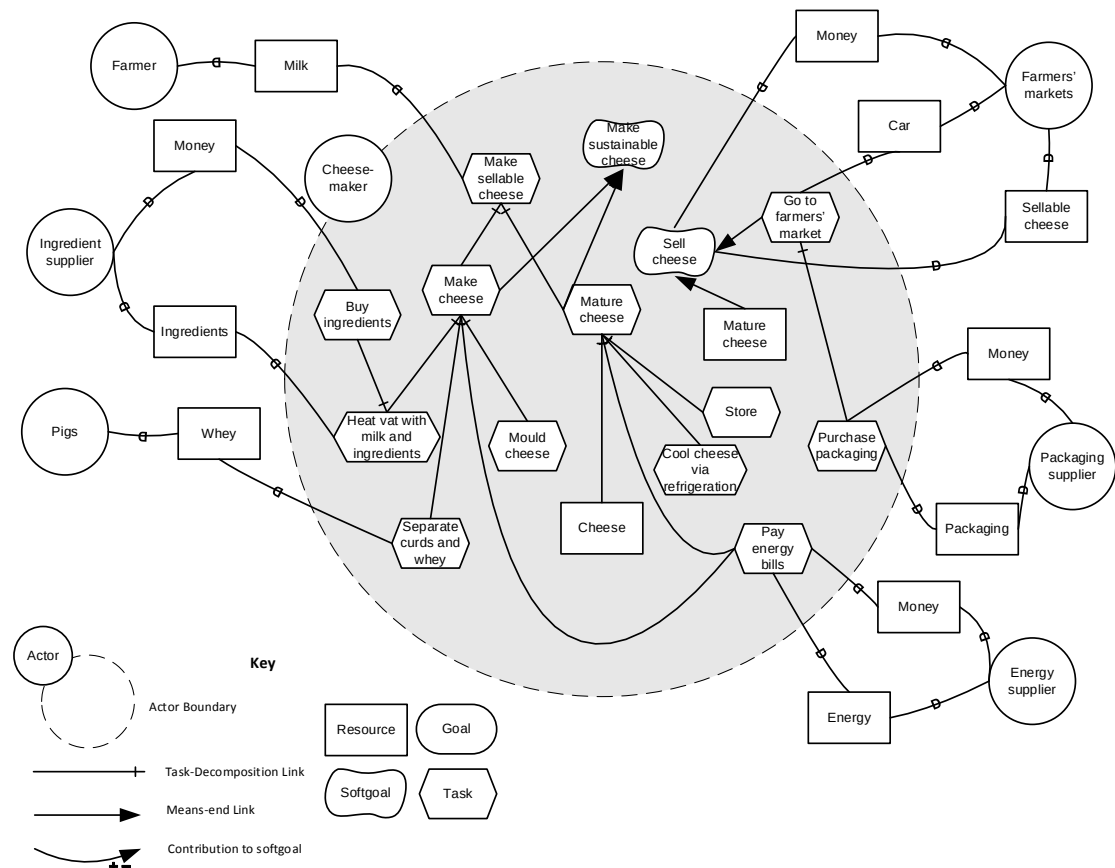


Figure 6.4 - Strategic rationale model for Middle Campscott

The SR model above has 'opened up' the 'Cheesemaker' actor to show the internal elements of the 'Cheesemaker'. With the 'Cheesemaker' opened up it can be seen that there is a number of tasks, resources and softgoals that influence the analysis of the fulfilment of the dependencies that the 'Cheesemaker' has with the other actors.

Looking at Figure 6.4 in more detail, it can be seen that the task 'Make sellable cheese' is split into two sub-tasks by task-decomposition links, these two sub-tasks are 'Make cheese' and 'Mature cheese'. The 'Make cheese' sub-task is again split into four further sub-tasks before it can be achieved these four sub-tasks are 'Heat vat with milk and ingredients', 'Separate curds and whey', 'Mould cheese' and 'Pay energy bills'. To be able to fulfil the sub-task 'Heat vat with milk and ingredients', the 'Cheesemaker' is reliant on an 'Ingredient supplier' to supply the resource 'Ingredients'. The 'Ingredient supplier' and the resource 'Ingredients' are outside the actor boundary for the 'Cheesemaker'. It can be seen from looking at the SR model that the 'Cheesemaker' is reliant on 6 other actors to fulfil their softgoal of making 'Sustainable cheese'. The sub-tasks 'Make cheese' and 'Mature cheese' are connected to the softgoal 'Make

sustainable cheese' by means-end links. The 'end' is the softgoal and the 'means' to that 'end' is by the tasks 'Make cheese' and 'Mature cheese'.

The SR model compared to conventional process model displays the 'why' and the 'how', the means-ends links element of the SR model allows for a goal-orientated view of the processes and with the SD elements (the elements in Figure 6.4 outside the actor boundary) the i* framework allows for the detection of where these intentional forces are coming from and where they are directed at (Yu, 1995). It allows for the analytical support at the level of nodes and links as well as actors. It asks questions such as: what resources does a task need, what are the softgoals for a task and so on.

This is not all i* models can be useful for, they can go beyond their initial creation. After a model has been created, quite often it is useful to know that an actor's goals and dependencies are satisfied and what effect the different elements have on another. Analysis can be performed on them so that they can answer high-level design questions, the answers to these questions are at the very heart of the i* framework as it tries to support the reasoning and rationale behind informed design decisions (Yu, 1995). They have the potential to point out areas of the model that can be improved through iterations so the model quality and the solution can be improved (Yu, 1995). There are a set of analysis concepts, proposed by Yu (1995), which aim to help aid i* analysis. These concepts are: ability, workability, viability, and believability. Ability refers to "Does the actor have a process for accomplishing a goal?" (Yu *et al.*, 2011: 64). A routine that is set out to fulfil a goal, ability does not mean that the actor has to accomplish the goal alone, degrees of delegation and external dependency can be involved. Workability is "the process going to work?" (Yu *et al.*, 2011: 64), but goes beyond ability because an actor can have a routine and they can know what needs to be done but they may not believe that the routine is achievable. Yu *et al.* (2011: 65) also describes workability as referring to something which "the actor believes that it can successfully carry it out or achieve it." Therefore, all the elements of a subroutine have to be workable for a routine to be workable. Viability is the third level of assessment, viability is "How well will it work?" (Yu *et al.*, 2011: 64).

Viability is a finer grained level of analysis than workability, a routine is said to be viable if all the softgoals are satisfied. Believability is "What evidence is there to confirm or disconfirm that it will work?" (Yu *et al.*, 2011: 65). This is because the SR model relies on judgement and assumptions when it is constructed.

The concepts described above can be used when building a model by asking a series of questions. The SR model presented in Figure 6.4 can be analysed in terms of ability, workability, viability, and believability from the cheesemaker's perspective. The cheesemaker would analyse its practices to see whether and how well they meet the objectives of making a sustainable cheese and then selling it.

- Ability: Do they have the routine for making a sustainable cheese? And selling a sustainable cheese?
- Workability: Do they have the skills and resources to address all the elements in the routine for making a sustainable cheese and selling it?
- Viability: Are the softgoals identified for making sustainable cheese satisfied?
- Believability: is it really possible to make a sustainable cheese?

Using the above questions, it was possible to analyse the SR model. Middle Campscott had the ability to make a sustainable cheese, while its task was to 'Make sellable cheese' and the following sub-tasks 'Make cheese' and 'Mature cheese' provide an able routine to make a sustainable cheese that can be sold. Middle Campscott did not necessarily have the workability to establish a sustainable cheese. For example, it could be argued that for this to happen, renewable energy would need to be used to make a sustainable cheese, therefore all the resources are not there to address all the elements for making and selling a sustainable cheese. The SR model is also not viable because not all the softgoals are satisfied. Finally, the believability of the model, the underlying assumption that cheese can be sustainable. This is a higher-level question that is integral to the system, and a question that has implications for the whole of this research. This research has discovered that there are steps that can be taken to make a cheese actor-network more sustainable than it was, such as satisfying the criteria that was laid out in Chapter 4. A cheese actor-network can be sustainably intensive or eco-localist, which are sustainability transitions, and they are therefore attempting to make the network more sustainable. Also sustainability problems have been identified, many by actants in the actor-networks and solutions have already been implanted or thought about which in turn is making the actor-networks more sustainable. However, it is not known when sustainability has been reached or achieved, which is why sustainability is a softgoal but does this question the believability of the model?

Yu (1995) admits that even though the analysis concepts of ability, workability, viability and believability can be useful for a model, they are often difficult to assess especially when the model is complex. In answering these questions, the model can quite often be changed until it is able, workable, viable and believable. The whole process is supposed to be iterative and the model would keep changing until routines for all goals have been found and the model is believable (Yu, 1995). There is a whole evaluation process that can be followed to assess the analysis of the i* framework, including general algorithm, convergence, termination, and human judgement (Horkoff, 2006; Amyot *et al.*, 2010; Horkoff and Eric, 2010; Horkoff and Yu, 2011).

ANT and i* are both networks that display aligned interests between people, organisations and standards but, as mentioned previously throughout this thesis, this research intended to assess the use of the i* framework for making the very descriptive ANT more practical. The i* framework does go some way to doing this, the i* framework does allow for non-human actors much like ANT does but it also allows non-human actors to have goals and softgoals attributed to them so non-human actors have as much agency as human actors in the model. For example, the cheese can want to be sustainable and sellable as well as the cheesemaker wanting to be able to make and sell a sustainable cheese, although some assumptions are being made about what the cheese wants. However, a non-human actor can quite often be seen as a resource that human actors can use. In both the SD and the SR models, all the elements that have been assigned as an actor are human whereas the cheese, a non-human actant has been assigned as a resource so this implies that the agency is not necessarily equal across the different model. Otherwise the models could have been constructed wrongly. Although there has been an actor included in the models, which is not necessarily just human. The actor 'Farmers' market' is made up of many actors including stalls, stallholders, management team, produce, and customers.

The i* framework allows for the opening of black boxes. Black boxes are quite common in ANT as networks can be complex and for ease and better understanding elements are black boxed. The SR model within the i* framework investigates these black boxes and looks at the inner workings of the element. As outlined in Figure 3.4, the task 'Make sellable cheese' is broken down into a series of subtasks and resources which make up a routine in order for the task to be achieved. Given that neither ANT nor i* attempt to explain why the networks or systems exist but instead interested in how they are formed and can fall apart, plus the inclusion of non-human actors and the opening of black boxes, i* does appear to have strong tendencies for making ANT more practical.

Although as discussed in Chapter 3 and earlier in this chapter, i* can be viewed as a complex system development methodology that is often difficult to follow, ANT is also often criticised for being too complex and confusing especially when the network is large. Also with i* it is difficult to know when the model is correct and all the elements and links are used in the correct way. It is because of these complexities that this research doubts the i* framework's ability to make ANT more practical. However, if the i* framework was continued to be used in interdisciplinary projects with interdisciplinary teams featuring people who have substantial knowledge of both ANT and the i* framework, then the i* framework definitely has the potential to allow ANT to be more practical when they are used in conjunction.

6.3 **Interdisciplinary Reflection**

It was in this chapter that the interdisciplinary element of this research was most prominent. This chapter had to identify the sustainability issues and solutions for the cheese actor-networks and then develop a system development methodology. The identification of the problems and solutions was definitely contributing to more of the human geography aspect of this research but the use of the system development methodology was much more of the computer science aspect of the study. These two elements had to come together and work alongside each other to form this chapter. The problems had to be identified along with the solutions to form the goals for the cheese actor-networks as well as the identification of the actors to allow for the goal modelling using the i* framework. Luckily for this research the similarities between ANT and the i* framework were noticed early on in the research and it integrated the two disciplines extremely well for this research.

6.4 **Chapter Summary**

This chapter has taken steps to tackle the first aim and its corresponding objectives which can be seen below:

Aim 3: Problems and Solutions in realising sustainability for cheese actor-networks

Related objectives:

- 3.1.1. Identify problems in the sustainable cheese networks
- 3.1.2. Establish and evaluate suitable solutions

3.1.3. Develop and critically assess a suitable system development methodology

This first part of this chapter has discussed the sustainability issues that have occurred across the cheese actor-networks. There is a range of sustainability problems that are encountered from farm to fork. The main problems discovered throughout the actor-networks were energy consumption, water consumption and waste. The sustainability problems that were experienced differ for the eco-localist actor-network and the sustainability intensified network. The actors within the cheese actor-networks have already considered solutions to many of the sustainability issues encountered and this chapter has explored further potential solutions.

The second part of this chapter identified a set of goals that actors within a cheese actor-network could adopt to make the network more sustainable. The system development methodology, i* framework, was then used to explore the different actors and their goals within the cheese actor-networks. The SR model allowed for the opening of black boxes within the ANT diagrams to explore the roles and responsibilities of the cheesemaker to achieve the goal of making a sustainable cheese. Using i* framework analysis of: ability, workability, viability, and believability it was decided that currently the goal of making a sustainable cheese is not workable, viable or believable for Middle Campscott. The use of renewable energy could help Middle Campscott for achieving their goal of producing a sellable sustainable cheese. However, as discussed, the i* framework analysis concepts are all subjective and it is also not known when sustainability is achieved. Therefore, on reflection the goal for cheesemakers should be to make a 'more' sustainable cheese as sustainability can always be improved on and it is not a definitive point that can be reached. The i* framework was assessed for its ability to make ANT more practical, this study has decided that i* and ANT have many similarities and parallels and because of this the i* framework has the potential to make ANT more practical and to take it out of the descriptive sphere. However, the complexity of the i* framework could have limitations for its use for making ANT more practical. It took this research a long time to understand the i* framework and produce the diagrams seen in this chapter (Figure 3.3 and Figure 3.4). Although for use in an interdisciplinary project with both ANT and i* framework experts it would definitely be a way of making ANT more practical.

The next chapter is the final chapter, the conclusion. The findings that were found and discussed throughout the thesis are brought together. Also in this chapter is a final interdisciplinary discussion, limitations of the study, some points for further research and final closing remarks.

7 Conclusion

The aims of this study were to identify eco-localist and sustainably intensified cheese actors-networks, understand the dynamics of these cheese actor-networks, and to realise problems and their corresponding solutions for cheese sustainability whilst deciding on a system development methodology to aid this process. This research has explored these three aims and presented its findings across the six previous chapters.

This study's three aims had corresponding objectives which highlighted the gaps in the research and the barriers that needed addressing for sustainable cheese. The objectives along with the aim they fulfil can be seen below:

Aim 1: Identifying eco-localist and sustainably intensified cheese actor-networks

Related objectives:

- 1.1. Identify cheesemakers in England with an interest in sustainability
- 1.2. Establish and create a criteria for sustainably intensified and eco-localist cheese
- 1.3. Identify sustainable intensive and eco-localist cheesemakers
- 1.4. Select case study cheese actor-networks

Aim 2: Understanding the dynamics of actor-networks

Related objectives:

- 2.1. Map the actor-networks
- 2.2. Explore the difference discourses of sustainability within the actor-networks and explore connections to notions of eco-localism and sustainable intensification.
- 2.3. Look at the interactions between the actants that link to sustainability

Aim 3: Problems and Solutions in realising sustainability for cheese actor-networks

Related objectives:

- 3.1. Develop and critically assess a suitable system development methodology
- 3.2. Identify problems in the sustainable cheese actor-networks
- 3.3. Establish and evaluate suitable solutions

Chapter 1 initially outlined the aims and objectives above and introduced the research, chapter 2 put the aims and objectives and the research as a whole in context with the wider literature. Chapter 3 showed how the aims and objectives were going to be achieved and proposed a methodological framework, chapters 4, 5 and 6 presented and discussed the findings from the

research. This concluding chapter summarises what has been presented throughout the rest of the thesis, the aims and objectives are addressed in turn and it is considered how well they have been addressed and what any final implications of the research are. This chapter also addresses the interdisciplinary aspect of the research with a final interdisciplinary reflection, some contributions to knowledge of the research, and some limitations of the research. As it is natural with research it often raises more questions to be answered even though questions have been answered throughout the research. Therefore the penultimate part of this chapter is a section with some considerations for further research and finally some closing remarks to finish the thesis.

7.1 Research story

This research was always interested in sustainable food not only because the funding was for a project that was focused on sustainable food but also from a personal interest perspective. I am conscious of what food I am buying as a consumer and always try to buy sustainably. This thesis could not look at sustainable food in general as it would have been too big a project. This research from the beginning, because of the reasons displayed in Chapter 2, decided to use ANT as a theoretical framework for this work. Mainly because ANT was prevalent in food studies and I was also inspired by the ANT lectures provided by a social science lecturer. Therefore I was interested in networks and wanted to investigate food from farm to fork. The milk crisis that was occurring in the UK at the start of this research project meant that many dairy farmers were turning to cheesemaking to diversify and add value to their milk. Therefore cheese actor-networks were chosen as a focus for the PhD research. At the time of starting the PhD, the research did not intend to suggest its own methodological framework. The idea was to use a system development methodology that was already widely applied in computer science. However early on in the research stage, after being inspired to try and apply ANT to this research, I realised there were parallels and similarities between ANT and i*. Also it was noted that the areas where i* and ANT differed, they could contribute and add to the approach of the other. The creation of the two phased, 12 step approach is one of, if not the biggest contribution of this thesis. A reminder of the proposed methodological framework can be seen below:

Phase 1:

13. Identify case studies
14. Collect data – follow the ‘thing’
15. Identify the actants
16. Create actor-network maps

17. Explore the discourse
18. Identify the sustainability problems and solutions

Phase 2:

19. Identify the sustainability goals
20. Use actor-networks maps as a rich picture
21. Choose a goal to model
22. Create i* SD models
23. Create the i* SR models
24. Revise and reiterate the model

Phase 1 relates to the human geography element of the research and uses the flat ontology of ANT, this phase consists of 6 steps. The case studies had to be identified, the data had to be collected, the actants identified, the actor-network maps created, the discourse explored and the sustainability problems and solutions identified. Phase 2 relates to the computer science element of this methodological framework which draws on the i* framework which is a system development methodology used in requirements engineering. Steps 7-12 complete the second phase of the approach. The sustainability goals had to be identified from the solutions, the actor-maps had to be used as a rich picture for the starting point of the i* models, a goal to be modelled had to be chosen. The SD model then had to be completed and followed by the SR model and finally the SR model could then be revised and reiterated.

The structure of the rest of this section looks at the phases 1 and 2 of the two phased approach and how the aims and objectives once completed were able to form the steps for the methodological framework and builds up the argument for the use of ANT and i* in tandem as a methodological framework.

7.1.1 Methodological framework: Phase 1 – ANT

The aim of identifying eco-localist and sustainably intensified cheese networks was achieved and is displayed in Chapter 4. Cheesemakers with an interest in sustainability were identified, 34 cheesemakers in England were identified as having an interest in sustainability. Although, there is a likelihood that some cheesemakers with an interest in sustainability, could have been missed off the finalised list. This is because the web-based investigation did not account for cheesemakers without a website. Criteria were established for both sustainably intensive and eco-localist cheese, to date there was no criteria for sustainably intensive and eco-localist

cheese. The criteria was based upon a report by 'Options for sustainable food and agriculture in the EU' by Underwood *et al.* (2013) and the sustainable intensification and eco-localist literature (especially Garnett and Godfray, 2012; Garnett *et al.*, 2013; Godfray and Garnett, 2014; Curtis, 2003; North, 2010). There was not a criteria for sustainably intensified or eco-localist cheese in previous literature so this can provide a criteria for further research to work from and build upon, along with studies such as Schmitt *et al.* (2016) who have also provided a criteria for cheese.

The criteria allowed for the effective identification of sustainable intensive and eco-localist cheesemakers. Of the 8 cheesemakers who returned the questionnaire, the criteria qualified 2 as eco-localist, and 3 qualified as sustainably intensive. The response rate was disappointing for the research and as discussed in Chapter 4, there could be any number of reasons for a poor response rate which included the questionnaire being too long or the questionnaire never reaching an actor, to answer it. If this research was to be undertaken again perhaps the questionnaire could be more persistently followed up or the form of the questionnaire could have been changed, maybe an email questionnaire with an embedded link to an online survey site would have been more effective. There were 3 cheesemakers that were not classified as eco-localist or sustainably intensive, it soon became apparent that even though they did not strictly qualify as either category the cheesemakers still showed characteristics of both. Therefore, the 3 cheesemakers were qualified as intermediary because they satisfied elements of the criteria for both sustainably intensive and eco-localist. Sustainable intensification and eco-localist are clearly not discrete entities and therefore, this research decided they could be thought of as existing on a continuum. This is because the flat ontology that was considered for this research, ANT does not believe that anything is more hierarchical than the other. There is no clear distinction between the two approaches. The relationship was not seen as strictly simple between the two elements either, when increasing eco-localist characteristics qualified, was plotted against increasing sustainably intensive characteristics qualified, a horn-like shape was produced. This horn shape led the research to believe that some eco-localist qualified cheesemakers also occasionally display some strong sustainably intensive characteristics. The most likely explanation for this is because eco-localist cheesemakers already have an interest in sustainability and they may have employed measures such as recycling and, or water schemes that they are able to execute at a small scale. The horn is unlikely to feature the other way round and the reason why it is so thin at the sustainable intensification end is because, it is unlikely that a sustainably intensified cheesemaker would satisfy many eco-local criteria because of the scale and breadth of the business.

Overall this research believes it made a good attempt to achieve Aim 1 and its corresponding objectives, not as many eco-localist and sustainably intensified cheesemakers were identified as would have liked but it still provided the opportunity to select four different case study cheese actor-networks for further research. Two eco-localist case study cheese actor-networks were chosen; one for the actual study and one as a pilot study, one sustainably intensive cheese actor-network was chosen as well as one intermediary. The identification of the actor-networks meant that case studies were chosen which completes step 1 for the methodological framework.

The three different cheese actor-networks that were chosen were, Middle Campscott (eco-localist), Wyke Farms (sustainably intensive) and Plaw Hatch Farm (intermediary). These actor-networks were mapped in detail which allowed for the descriptiveness of ANT to shine through the research. In order to map the actor-networks rich data was collected using a variety of techniques including ethnographic observations, semi-structured interviews, questionnaires and an online survey. This combination of techniques did provide a bountiful amount of rich data. On reflection it would have been more ideal to spend longer with Wyke Farms and Plaw Hatch Farm networks in order to gain a richer insight into the networks but this was not possible. However the time that was spent embedded in these actor-networks was enough time to allow for the following of the cheese through the networks. In following the cheese through the network, step 2 in the methodological framework was achieved.

With the rich data that was collected the actants in the actor-networks were identified which meant that step 3 in the methodological framework was achieved. Using the identified actants, associations could be identified between actants and therefore the actor-networks were mapped and the result was detailed actor-network diagrams which satisfied step 3 in the methodological framework. Different lines of associations were identified within the networks such as farming, milking, cheesemaking, maturing, and selling. The term 'lines of association' was deemed more appropriate than 'processes' as the actor-networks are a series of associations. The actants in the different actor-networks were identified and the associations noted between the different actants. There were a variety of different actants established in the actor-networks including both human and non-human actants. In the Wyke Farms actor-network there were many more high-tech actants than there were in the other two actor-networks. This is because there is a strong association between Wyke Farms and money so they therefore have the capital to enrol high-tech actants which an eco-localist actor-network is not able to do. When Middle Campscott enrol money into the actor-network, it is used to sustain

their current living standard. Instead Middle Campscott are able to enrol volunteers, which is not something that the Wyke Farms actor-network can easily achieve. One of the strongest associations in the Middle Campscott actor-network is between the cheesemaker and the more than human actant, cheese, this is because the cheesemaker uses traditional, handmade methods to create the cheese. This is the same in the Plaw Hatch actor-network but they only make cheese if there is enough milk after producing raw milk, yoghurt and kefir. Therefore, the association is not as strong as the same association in the Middle Campscott actor-network. Fulfilling this objective completes step 4 in the methodological framework.

The discourses of sustainability were also explored for the three actor-networks as mentioned in Chapter 3, the discourse was explored because the sustainability discourse is part of the network, what actants think about sustainability, signs, websites, texts are all discourse elements of the actor-networks. Several themes were identified in the understandings of sustainability discourse. However, there were two prominent themes identified these were an environmentalist perspective and a productionist perspective. Eco-localist thinking could be seen as being a kin with the environmentalist perspectives as it included references to not harming the environment and looking after or protecting the environment. The productionist perspective is much more in the line of thinking of Pretty's (1997) 'business as usual' school of thought. Notions of production and sustainability as something that can be produced were referenced. This research believes that these two perspectives came through as main themes because as discovered in the Chapter 2 many sustainability studies are biased towards the environmental aspect and this research believes that so are actors' understandings of sustainability. This research believes that the productionist perspective was prominent because even though a general question of 'what do you understand by the term sustainability?' was asked, this was asked to actors in a cheese actor-network and cheese or food more generally as pointed out in Chapter 2 is sometimes seen as a commodity or a product, so it's no surprise that some actors would see sustainability with a productionist perspective. Other themes that were apparent when actors' understandings of sustainability was deliberated included, the discussion of sustainability with all its parts: social, economic and environmental, the future and long-term aspects of sustainability as well as resource efficiency, animal welfare and organic.

The embedded sustainability in the eco-localist and sustainably intensive actor-networks discourse was also explored. This research believes that both Middle Campscott and Wyke Farms are embedding sustainability but they are doing it in different ways. Wyke Farms' embedded sustainability is rooted in money and technology. For example, they enrolled £13

million pounds to build a high-tech biogas plant to produce their own power, they also spent lots of money on the water recovery plant. Sustainability is also mentioned all over the Wyke Farms' website. Whereas, Middle Campscott on the other hand embed sustainability without really mentioning the term, their embedded sustainability is much more in the 'local', 'handmade methods', and 'organic' approaches. Sustainability at Middle Campscott is just seen as something that should be done. There was a discussion in Chapter 5 about whether Wyke Farms are 'greenwashing', so appearing to adopt all these sustainable approaches but actually just interested in increasing the sale of the product and therefore capital. However, this research believes that Wyke Farms are not green-washing as they are trying to do many things to improve upon their sustainability. There is the issue in the Wyke Farms actor-network that not all the employees are engaging with the 100% green strategy so even though they work for a 'sustainable business' they not be necessarily interested in sustainability themselves. The last thing Chapter 5 attempts to address is whether 'sustainable cheese' is a fictitious agri-food such as Tesco's fake farms. This research does not believe that 'sustainable cheese' is a fictitious agri-food for the cheese that is enrolled in the actor-networks featured in this research. This does not mean that every cheesemaker who claims to be sustainable is necessarily sustainable but the cheesemakers who were studied in this research are very much doing what they can to improve on their sustainability to make the cheese they produce 'more sustainable'. The successful exploration of the sustainability discourse within the actor-networks meant that step 5 in the methodological framework was completed.

Overall this research believes it has made a successful attempt to achieve Aim 2 and its corresponding objectives, the level of detail that was obtained from the ethnographic methods was extremely rich and allowed for a thorough assessment of the discourses of sustainability within the network.

The aim of gaining problems and solutions in realising sustainability for the cheese actor-networks was successfully achieved using the information gathered from observations, interviews, questionnaires and more. A range of sustainability problems that are encountered from farm to fork were discovered. The main problems discovered throughout the actor-networks were energy consumption, water consumption and waste. Other sustainability problems that were experienced differed across the actor-networks. There were sustainability problems that occur for more than one actor-network such as energy consumption, petrol consumption, water usage, waste, TB restrictions and old infrastructure. Specific problems that are a sustainability issue for the Middle Campscott actor-network that are associated with the

actor-network being eco-localist are: having enough income to live, experience of volunteers, decline of small abattoirs and decline of farmers markets, cost of professional advice and cost of organic certification. Sustainability problems that have been identified for the Wyke Farms actor-network that are concurrent with issues associated with the sustainably intensified nature of the network include milk supply, discounters' effect, power of supermarkets, and technology in the environment. Solutions were identified for the discovered sustainability problems and they are discussed throughout Chapter 6 in some cases the actors in the actor-networks were already implementing the solution(s) but in other cases the solutions had not been thought of. The completion of the identification of sustainability problems and the corresponding solutions satisfied the completion of step 6 in the methodological framework and also brings to a close phase 1.

7.1.2 **Methodological framework: Phase 2 – i* framework**

The second phase of the methodological framework starts with step 7, the identification of sustainability goals. Chapter 6 also identified a set of goals that actors within a cheese actor-network could adopt to make the network more sustainable. To identify the goals the solutions that were identified in step 6 were used. The relationship between goals and solutions are that goals are a way of achieving the sustainability solutions. This was a tricky step as the goals were not always obvious, this research drew on the goals provided by Cabot *et al.* (2009) on their work on 'green conferences'. It is hoped that the goals for sustainable cheese that were distinguished for this research will benefit other researchers when investigating sustainable food goals.

Once the goals for sustainable cheese were established the actor-network diagrams that were created in step 4 of the methodological framework were used as a rich picture. The connection of actor-networks maps to a rich picture is another novel concept to this research. The i* framework, in conjunction with the actor-network diagrams were used to explore the different actors and their goals within the cheese actor networks. The SR model allowed for the opening of black boxes within the ANT diagrams to explore the roles and responsibilities of the cheesemaker to achieve the goal of making a sustainable cheese. The i* framework was assessed for its ability to make ANT more practical and for ANT to provide a starting point for creating i* models, this research has decided that i* and ANT have many similarities and parallels and because of this the i* framework has the potential to make ANT more practical and to take it out of the descriptive sphere. However, the complexity of the i* framework could have

limitations for its use for making ANT more practical. It took this research a long time to understand the i* framework and produce the diagrams seen in this chapter (Figure 6.3 and Figure 6.4). However the creation of the methodological framework provides a step by step account for researchers to use the two phased approach in their own research.

Overall this research believes it has made a successful attempt to achieve Aim 3 and its corresponding objectives, the problems and solutions were explored for sustainability in the cheese actor-networks and the use of i* as a practical solution to ANT is an interesting comparison that has not been made before.

7.2 Conceptual and methodological contributions

The point of this section is to emphasise the contributions of the research and to link the research to wider research. First and foremostly this research truly believes that its most novel and substantive contribution is the proposal of the two phased approach that combines ANT and the i* framework. The first phase uses an established conceptual framework (Actor Network Theory), widely used within Geography, to map human and non-human actants. This research has used actor-network diagrams to display actants and associations of three different sustainable cheese networks, including associated sustainability discourses. The second phase is to apply a requirements engineering approach from computer science discipline (the i* framework) to refine and enhance the actor network maps. The actor-network diagrams also provide a starting point for the i* models. They both enhance and facilitate the other. This is a novel aspect of the research as the links between ANT and the i* framework have been undiscovered until now. It is hoped that with the enumerated approach, following steps 1-12 successively will enable others to apply this approach in other industries.

ANT has been used as a theoretical framework throughout this research. There are a number of reasons why ANT was used for this research as discussed in Chapter 2, firstly I was always interested in the food network never just one part of the network so networks were a feature of the research from very early on. ANT is prevalent in past food studies so it was an obvious choice to begin with. However there were other relational geography approaches that could have been applied to this research, namely assemblage theory, especially as there are many critiques of ANT. Critiques of ANT as highlighted throughout this thesis, include that it is extremely descriptive and not practical enough. It is also argued that ANT's language does not contribute anything more than conventional sociology does and therefore provides very little analytical insight. ANT is accused of not truly representing reality as it reduces the real world to

a series of relations, networks and associations and reality is much more than that so it is not a true depiction. With these critiques in mind, this research still used ANT instead of assemblage theory. Assemblage theory is itself not without its critiques, also there was an aspect of linearity about the networks studied, the networks that were traced went through similar lines of association such as farming, milking, cheesemaking, maturation, marketing and selling. ANT has an element of linearity to it so in that sense it was the more appropriate theory to use as a theoretical framework. Another reason ANT was used instead of assemblage theory is because ANT has a more concrete approach to empirical work than assemblage theory. ANT offers a more concrete method, for example throughout this research 'follow the thing' was used to trace the actor networks. The cheese was followed through the network to establish the different actors and associations in the actor-networks that were studied.

The main reason that ANT was chosen over assemblage theory as mentioned in Chapter 2 is because of the parallels that ANT shares with the system development methodology, the i* framework. Not just the parallels but also what they both contribute to the other. ANT is very descriptive and doesn't attempt to explain why the networks exist, whereas combined with i* it does, i* provides the analytical tools to look at the networks in more detail and to 'unpack' the black boxes. ANT also contributes to i*, as one of the critiques of the i* framework is that it is often difficult to know where to start creating the i* models, whereas the actor-network maps identify the actants for the model and so provide a starting point. The methodological framework that is proposed in this thesis also suggests more steps that if followed will provide a concrete starting point for constructing the i* models. The i* framework also addresses a critique of ANT, in ANT there is a no a priori distinction between humans and materials so therefore it is not possible for ANT to reflect the complex relations of reality. However humans are capable of intentions. The i* framework considers that humans are capable of intentions and therefore overcomes that critique of ANT.

In Muller and Schurr's (2016) paper they suggest a cross-fertilisation of both ANT and assemblage thinking. They believe that the two theoretical approaches have much more to say to each other and gain from each other than they do individually, the best of both worlds. This research did not apply both ANT and assemblage thinking, John Law believes that they are much the same thing, there is little difference between the two, as explained in Chapter 2, Law (2009) believes that 'agencement' is the same as 'actor-network'. Therefore this research believes that a merge of the two theories will offer no more for this research than ANT already has done. ANT

was ultimately chosen because of the parallels with the i* framework and the same connections between i* and assemblage are not as prominent.

This research can also contribute to the sustainability transitions literature, sustainability transitions are ways of addressing the complex problems affecting food systems via essential processes of social change (Maye and Duncan, 2017). Sustainable intensification and eco-localism are both sustainability transitions. Sustainable intensification is highly criticised as a sustainability transitions, this is because sustainability transitions are meant to transform mainstream practices (Werbeloff *et al.* 2016; Maye and Duncan, 2017). There are some critics who believe that sustainable intensification is too close to neoliberal models of provisioning that already exist and that sustainable intensification actually fails to address and transform the weaknesses that are associated with these existing neoliberal models (Loo *et al.* 2014; Marsden 2016 and Maye and Duncan, 2017). This research could contribute to that literature as it has studied an actor-network where it has been established they are practicing sustainable intensification successfully. Wyke Farms are producing large amounts of cheese but at the same time being very mindful of their impact on the environment and implementing measures that are much different to existing neoliberal models of food provision, such as the large anaerobic digester plant that deals with their waste and produces their own gas. Maye and Duncan (2017) state that emerging 'alternative' practices are often overlooked as a sustainability transition, this research does not overlook the alternative as an eco-localist cheese actor-network was investigated which is definitely challenging existing neo-liberal models of food provision.

Other contributions that this thesis achieves are a list of sustainability goals for sustainable cheese, it is hoped that actants within other cheese actor-networks and food actor-networks more generally will be able to work towards some of these goals to make their area of the actor-network more sustainable.

7.3 Interdisciplinary reflections and contributions

As discussed in the interdisciplinary discussion in Chapter 1 and throughout the thesis, this research has been an interdisciplinary study. This has made it an interesting study but also extremely difficult in places. As also previously mentioned in the interdisciplinary discussion my background is geographical so there was bound to be an overwhelming social science element. With the use of ethnographic techniques and the wealth of food literature the research project was definitely more social science based than initially intended. However this research can

contribute to the interdisciplinary literature. The struggles and benefits of undertaking interdisciplinary work are discussed openly throughout the thesis and this has the potential to help others undertaking interdisciplinary work. One of the main points to take away from this research is a result of the interdisciplinary nature of this work, the methodological framework that is proposed in Chapter 3. It is the combining of two disciplines' approaches that forms the methodological framework. ANT, that is frequently used in the social sciences and often in human geography and food studies, is used in tandem with the i* framework, a method used by computer scientists in the requirements engineering phase. This methodological framework has great potential to facilitate other interdisciplinary research of this nature.

7.4 Limitations of the study

The most limiting factors to this research were the time and money constraints, however this is common in research. I would have liked to spend more time within the cheese actor-network but this was not feasible in terms of time and money. Not just my own time constraints as I had a set amount of time to complete my PhD but also the time constraints of the actors who participated in my study.

There were other limitations to the study and these are discussed in the following paragraph. As the case studies were found initially from a list provided by the food standards agency and a web based investigation, then it is certain that if the cheesemaker did not have an online presence then they would not have been identified. This is a limitation as there could have been any number of cheesemakers without an online presence that have an interest in sustainability and they therefore would have been missed from the study. Unfortunately as there were so many establishments in the list to investigate there was no other way apart the web based investigation to find out information about the establishments quickly. The nature of the web-based investigation means you can only see what the website displays. Therefore a business may have had an interest in sustainability but didn't mention it on their website and therefore they will have not been selected as a cheesemaker who has an interest in sustainability. To get round this a question could have been sent via email to find out if the cheesemaker has an interest in sustainability but that would have required finding 254 contact email addresses and then sending 254 emails. This was considered to be too time consuming as the web-based investigation had already taken a significant amount of time to conduct.

Bearing these limitations in mind, the next section looks at ways in which the research can be taken further.

7.5 Further work

It is clear from the above discussion from limitations of the study and the findings displayed throughout the thesis that there is scope to take this research further. More research is needed to understand the intricacies of the problems experienced by cheese actor-networks and how technology can help improve these sustainability issues. A by no means extensive list for point for further work can be seen below:

- Explore more of the mapped networks – unpack some of the black boxes and go beyond the current set limits of the actor-networks.
- Focus groups – to evaluate and discuss the found solutions for the sustainability issues that the actors in the actor-networks are not yet implementing.
- Expand on the sustainable goals – expand on the sustainable goals for cheese actor-networks so that it is a more complete list

Future work that is needed in this area and could be conducted that goes further then the current research would entail:

- Apply i* and ANT to a range of different contexts using the current methodological framework presented in this thesis.
- And therefore contribute to the critiques of ANT and present a solution for overcoming some of the critiques.
- Also to contribute to the critiques of the i* framework and present a solution for overcoming some of the critiques.
- Work on various elements of the sustainable intensification – eco-localism continuum and the positions within the continuum, investigating the continuum and specification for areas outside of cheese.
- Investigation of the effect of Brexit on the three cheese actor-networks as well as how Brexit will affect sustainable food networks more generally.

7.6 Closing remarks

One of the last things to do for this thesis is to reflect on the study's research question. 'Can sustainably intensive or eco-localist approaches produce sustainable cheese?'. This study believes that cheese can be made demonstrably 'more' sustainable by both eco-localist and sustainably intensive approaches. This is because 'sustainable cheese' was clarified as not being a fictitious agri-food in Chapter 5. Also both eco-localist and sustainably intensive cheese actor-

networks are doing many things to improve their sustainability, by addressing the sustainability issues they have in the actor-networks by viable solutions. One of the main reasons the research question can be answered is because the methodological framework that is proposed in Chapter 3 allows for the sustainability of a network to be assessed and improved. The integration of ANT and i* in this thesis has resulted in a methodological framework to be produced that allows the sustainability of a network to be investigated. The sustainability problems are identified and then the networks are improved using the i* models as they allow for the actor-networks to be unpacked and the intentionality and rationale of the actants are considered for reaching set goals.

However, the issue does come back to the thread, which has been running through this thesis, that is 'can sustainability ever be truly achieved?' Determining if a product/actor-network is truly sustainable in all three spheres is inherently difficult to quantify. Therefore, the answer to the research question is, sustainably intensive and eco-localist approaches can contribute to improving to the sustainability of cheese. They can do anything in their means to make the cheese 'more' sustainable. For this research eco-localism and sustainable intensification were looked at equally in line with ANT, a flat ontology. Therefore, this research is not saying that eco-localism or sustainable intensification is more powerful than the other and this research is not privileging global over local or vice versa.

This study aimed to be an interdisciplinary project that explored the discourses of sustainability and the sustainability problems for sustainable cheese actor-networks in the South of England. It aimed to consider two different approaches to food sustainability, sustainable intensification and eco-localism. As an individual study it cannot address every barrier or answer every question relating to the sustainability of cheese but it starts to document specific sustainability problems that may be experienced by other cheese actor-networks and lessons could be learned. A methodological framework is proposed that outlines specific steps to follow that can be used for other researchers considering the sustainability of a network. Much work is needed to address and overcome sustainability issues in the food system especially the problems facing cheese actor-networks, I hope research continues to progress towards making cheese actor-networks more sustainable. I hope this area of research will feature more studies and those of interdisciplinary nature. Hopefully this study has been one step further in studies contributing to sustainable cheese.

8 Reference List

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9 Appendices

9.1 Appendix 1 - Initial Investigatory Questionnaire

Questionnaire for cheesemakers

I would like to better understand the current practices in cheese making and understand more about the sustainability issues in cheese making. You can help me to do this by filling out this initial questionnaire below. The questions cover topics relating to the characteristics of your business, your milk supply and the characteristics of any farms you run, and cheese making and the adoption of sustainability practices. *If you are part of a large company or group of companies, please fill out the information for either the part of the company or the subsidiary company that handles cheese production only. If you need any assistance regarding this contact me at hb110@leicester.ac.uk.*

Section 1: Characteristics of your business

1. What types of cheese do you produce?

Click here to enter text.

2. How much milk do you process? (please specify units and the time period in the drop down menus)

Click here to enter amount. Choose a unit of measurement. Choose a time period.

If 'other' unit of measurement please specify: Click here to enter text.

3. How many employees do you have at your company?

Click here to enter text.

4. What was your annual turnover for the last year?

- | | |
|------------------------|--------------------------|
| a. Less than £15,000 | ☐ |
| b. £15,000 - £25,000 | ☐ |
| c. £25,001 - £50,000 | ☐ |
| d. £50,001 - £100,000 | ☐ |
| e. £100,001 - £500,000 | ☐ |
| f. Over £500,000 | ☐ |

Section 2: Source of milk

5. Where do you source your milk from? (tick all that apply)

- a. Own farm ☐
- b. Other farms ☐
- c. Dairy ☐
- d. Other source ☐

If Other, please specify: [Click here to enter text.](#)

If you have **ONLY** ticked **c or d**, please proceed to **Q12**.

If you have **ONLY** ticked '**a. Own farm**' go to question **8**.

If you have ticked '**b. Other farms**' please continue to question **6**.

6. How many (other) farms do you source your milk from?

[Click here to enter text.](#)

7. How far away are the farms you source your milk from (in miles)?

[Click here to enter text.](#)

If you **ONLY** source your milk from other farms please go to question **12**

Section 3: Your farm

8. How many of the following dairy animals do you own for producing milk?

Cows: [Click here to enter the number of cows.](#)

Goats: [Click here to enter the number of goats.](#)

Sheep: [Click here to enter the number of sheep.](#)

Other: [Click here to enter the number of other animals you own for milking.](#)

If Other, please specify: [Click here to enter text.](#)

9. How much land does your farm cover? (please specify the unit of measurement from the drop down menu)

[Click here to enter number.](#) [Choose a unit of measurement.](#)

10. Have you adopted or are you thinking of adopting any of the following farming systems? (tick all that apply):

	Already doing	Planning to in the near future	Not doing	Did in the past	Not heard of
a. Agroecology	☐	☐	☐	☐	☐
b. Biodynamic farming	☐	☐	☐	☐	☐
c. Organic farming	☐	☐	☐	☐	☐
d. Conservation agriculture	☐	☐	☐	☐	☐
e. Precision farming	☐	☐	☐	☐	☐

11. Do you undertake any of the following practices or intend to in the near future (tick all that apply):

	Already doing	Planning to in the near future	Not doing
a. Adjusting dietary intakes or feeding techniques to maximise production	☐	☐	☐
b. Artificial insemination of dairy animals	☐	☐	☐
c. Stocking rare breeds	☐	☐	☐
d. Taking action to improve animal health and welfare	☐	☐	☐
e. Using of artificial fertilisers	☐	☐	☐
f. Reducing fertiliser use	☐	☐	☐
g. Increasing fertiliser use	☐	☐	☐
h. Using smart technology for fertiliser application	☐	☐	☐
i. Protecting or restoring natural or semi-natural grassland.	☐	☐	☐
j. Restoring or establishing landscape features (e.g. hedges, treelines, woodland patches, terraces, ponds, stone walls)	☐	☐	☐
k. Decreasing grazing density	☐	☐	☐
l. Using wind power or solar power	☐	☐	☐
m. Using anaerobic digestion	☐	☐	☐

Section 4: Cheesemaking

12. What is your annual cheese production? (please specify the unit of measurement from the drop down menu)

[Click here to enter number.](#) [Choose a unit of measurement.](#)

13. Do you package your own cheese? YES ☐ NO ☐

14. Where do you sell your cheese to? (tick all that apply)

- | | |
|--|--------------------------|
| Own farm shop | ☐ |
| Farmers markets | ☐ |
| Local delis and independent stores (within 30 miles) | ☐ |
| Non-local delis and independent stores (beyond 30 miles) | ☐ |
| Local pubs, restaurants and other eateries (within 30 miles) | ☐ |
| Non-local pubs, restaurants and other eateries (beyond 30 miles) | ☐ |
| Local supermarket branch | ☐ |
| National supermarket chain | ☐ |
| Wholesalers | ☐ |
| Other | ☐ |

If Other, please specify: [Click here to enter text.](#)

15. Do you have any sustainability policies in place for cheesemaking? YES ☐ NO ☐

If YES, please give details below, or if you would prefer to simply send copies of these policies, please attach or enclose them when returning the questionnaire, indicating your intention to do so here: ☐

[Click here to give details.](#)

16. Do you undertake any of the following practices, or intend to in the near future? (tick all that apply)

Already doing	Planning to in the near future	Not doing	Did in the past
------------------	---	--------------	--------------------

- | | | | | |
|---|--------------------------|--------------------------|--------------------------|--------------------------|
| a. Use traditional methods of cheesemaking | ☐ | ☐ | ☐ | ☐ |
| b. Reducing amount of packaging | ☐ | ☐ | ☐ | ☐ |
| c. Have a waste recycling scheme | ☐ | ☐ | ☐ | ☐ |
| d. Have a water recycling scheme | ☐ | ☐ | ☐ | ☐ |
| e. Use renewable energy produced on site in your cheesemaking | ☐ | ☐ | ☐ | ☐ |
| f. Use heat exchange technologies in your cheesemaking | ☐ | ☐ | ☐ | ☐ |
| g. Use any other energy conservation practices in your cheesemaking | ☐ | ☐ | ☐ | ☐ |
| h. Use smart computing in your creamery/dairy | ☐ | ☐ | ☐ | ☐ |
-

Section 5: Further research

I am going to be conducting further research on sustainable cheesemaking. If you are interested in taking part in further research or would like to know more about my project, please tick below:

☐ Yes, interested in taking part in further research

☐ Yes, I would like more information

If you have answered 'Yes' to any of the above, please fill out your details below.

Name: [Click here to enter text.](#)

Company Name: [Click here to enter text.](#)

Address: [Click here to enter text.](#)

Preferred point of contact: PHONE ☐ EMAIL ☐

Phone No. [Click here to enter text.](#)

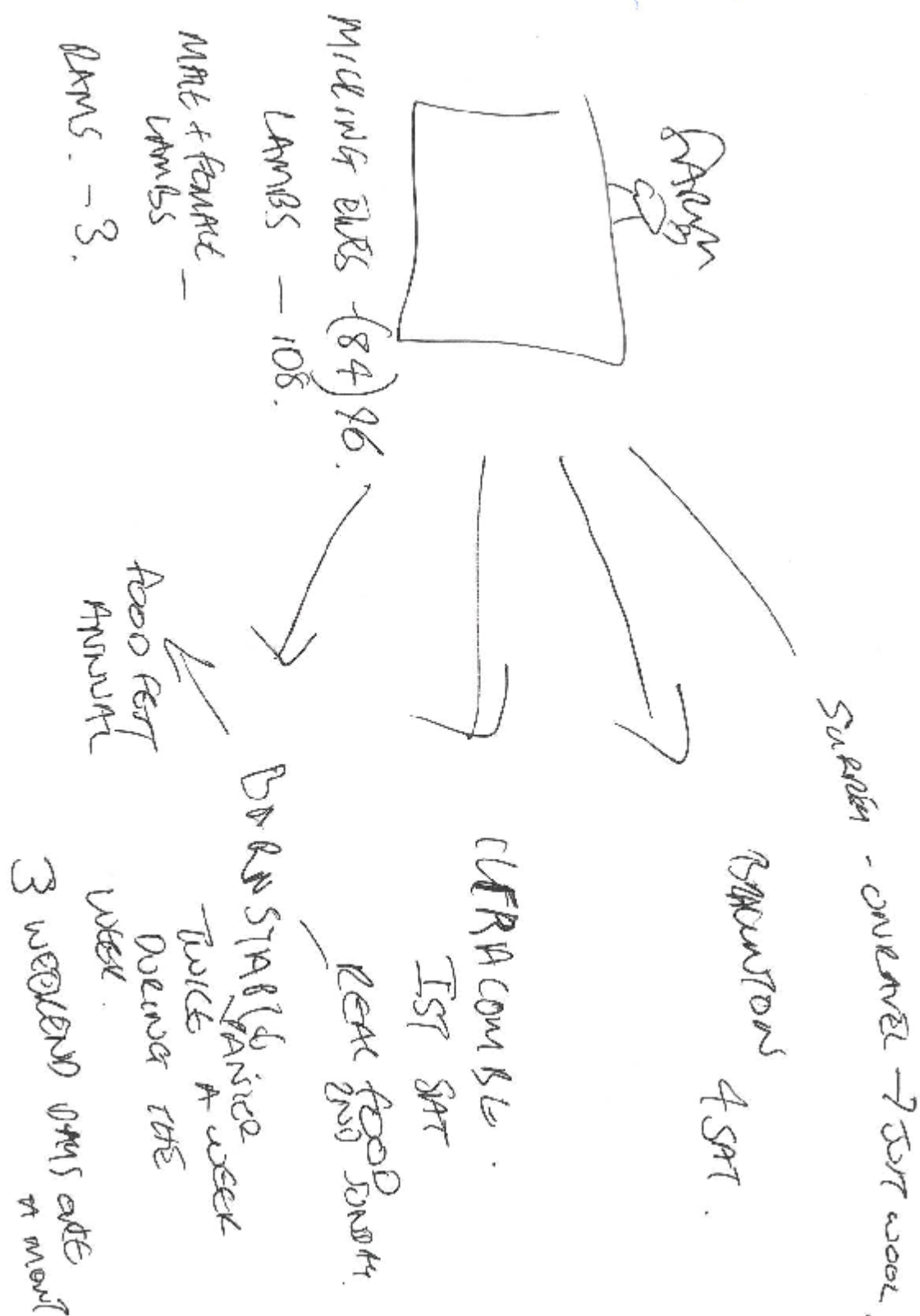
Email Address: [Click here to enter text.](#)

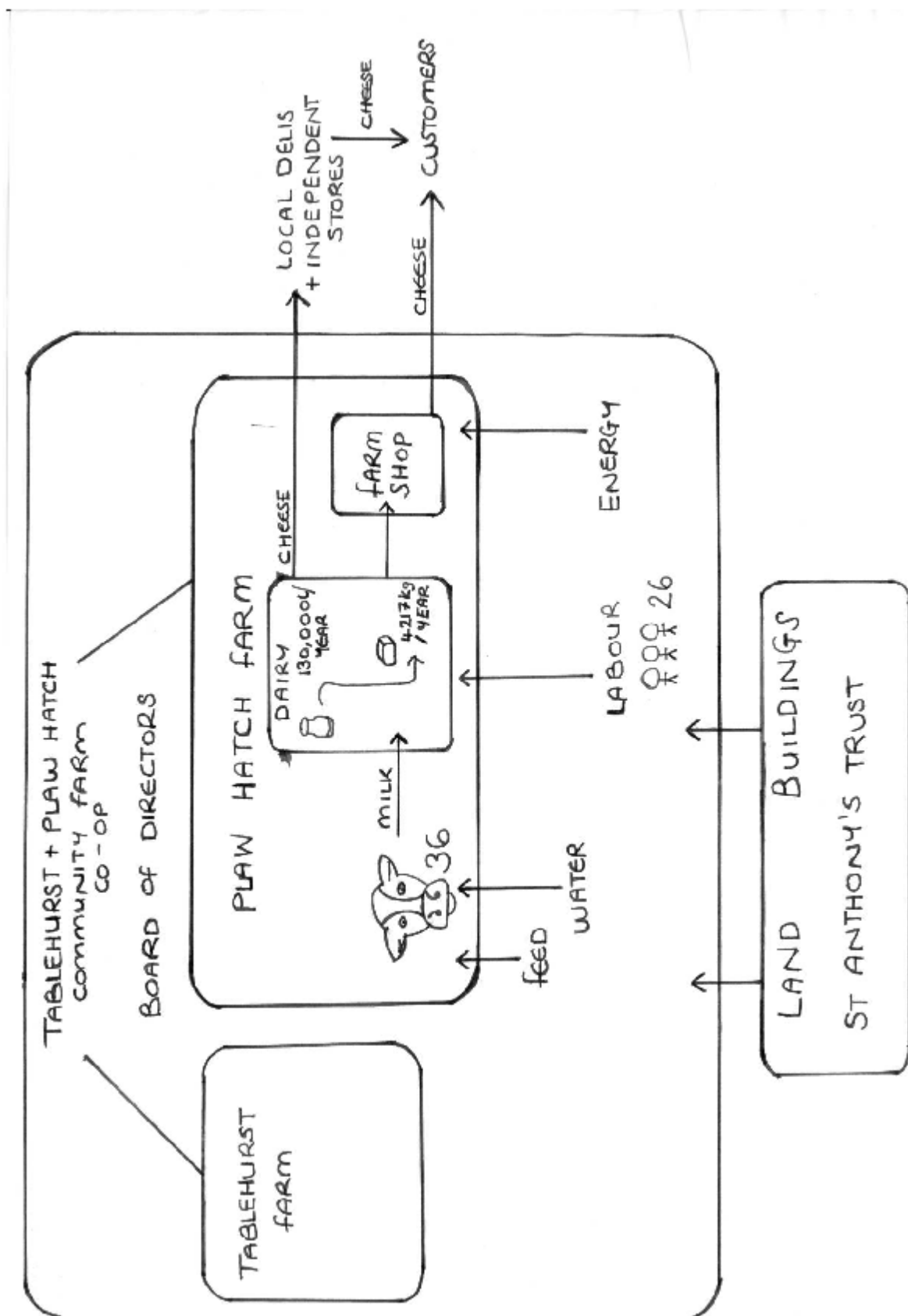
Even if you don't wish to take part in any further research, I am very grateful in the time you have taken to complete this questionnaire. Please return the questionnaire by email to hb110@leicester.ac.uk or alternatively return by post to:

Hannah Brooking
Department of Geography
University of Leicester
University Road
Leicester
LE1 7RH

Also if you've ticked that you intend to send your sustainability policies for question 15, please don't forget to attach the document to the email or send a photocopy by post. Thanks.

Please Note: By returning this questionnaire, you are confirming that you have read and understood the information sheet you were provided with and you are consenting for me to use the information contained in this questionnaire for my research.





9.4 Appendix 4 - Questionnaire for the Employees

Questionnaire

I am Hannah Brooking, a PhD student at the University of Leicester, who is researching cheese making and consumption. My research involves looking at the production and distribution of cheese from farm to fork. The questionnaire covers topics relating to sustainability and your role in the company, it should take around 3 minutes to complete.

Here are the important points you need to know:

- *Participation is voluntary but I would love if you could spare me some of your time*
- *The information gathered will be used for my own research purposes to complete my project thesis and possibly academic papers and will not be shared with any other third parties. The information collected will be kept in a secure place for at least seven years.*
- *The questionnaire will be anonymised and there is no need to provide any personal information.*
- *This research project was approved in accordance with the University of Leicester's research ethics procedures.*
- *If you have any questions/concerns you can contact me by email on: hb110@leicester.ac.uk*

If you have read all the information and you are happy filling out the questionnaire please continue and hand it back in the envelope provided to Christie when finished. Returning the questionnaire will be taken as indication that you are willing for the information contained in it to be used for the purposes outlined above. If you do not wish to continue then there is no pressure to and I thank you for your attention.

1. What is your role within the company?
2. Who do you report to?
3. What hours do you work?
4. How far have you travelled to get to work today? (i.e. where have you come from?)
5. And how did you get here?
☐ By foot ☐ By Car ☐ By bicycle ☐ Other
If **Other**, please specify _____
6. How long have you worked here?

7. What do you understand by the term sustainability/sustainable? (There is no right or wrong answer).
8. Do you think any of the following are important for the business? (please tick as appropriate)
- ☐ Renewable energy and reduction of greenhouse gas emissions
 - ☐ Profit of the business
 - ☐ Supporting communities
 - ☐ Recycling and waste management
 - ☐ Provision of jobs
 - ☐ Sharing of knowledge
 - ☐ Water re-usage
 - ☐ Encouraging wildlife
9. How important do you think adopting sustainable practices is? (please tick)
- ☐ Very important
 - ☐ Quite important
 - ☐ Indifferent
 - ☐ Not very important
 - ☐ Not important at all

Please explain your view:

10. Do you think there are any ways the company could be more sustainable? Please outline...
11. Do you think there are any unsustainable practices in the company? Please outline...
12. What does 100% Green mean to you?
13. What is it like working here?
14. Where do you see yourself in a year's time?

15. Where do you see yourself in five years' time?

Thank you for taking the time to fill out this questionnaire, it is much appreciated.

Please Note: By filling in this questionnaire, you are confirming that you have read and understood the information overleaf and you are allowing consent for me to use the information contained in this questionnaire for my research. On completion please put the questionnaire in the envelope and return to Christie.

9.5 Appendix 5 - Questionnaire for the Middle Campscott Customers

Questionnaire

I am Hannah Brooking, a PhD student at the University of Leicester, who is researching cheese making and consumption. My research involves looking at the production and distribution of cheese from farm to fork. The questionnaire covers topics relating to sustainability and your cheese buying practices, it should take around 3 minutes to complete.

Here are the important points you need to know:

- *Participation is voluntary but I would love if you could spare me some of your time*
- *The information gathered will be used for my own research purposes to complete my project thesis and possibly academic papers and will not be shared with any other third parties. The information collected will be kept in a secure place for at least seven years.*
- *The questionnaire will be anonymised and there is no need to provide any personal information.*
- *This research project was approved in accordance with the University of Leicester's research ethics procedures.*
- *If you have any questions/concerns you can contact me by email on: hb110@leicester.ac.uk*

If you have read all the information and you are happy filling out the questionnaire please continue and hand it back to me when finished. Returning the questionnaire will be taken as indication that you are willing for the information contained in it to be used for the purposes outlined above. If you do not wish to continue then there is no pressure to and I thank you for your attention.

1. What types of cheese have you bought today?

2. Have you bought or are intending to buy the Campscott cheese?

☐ Yes

☐ No

If **No**, go to question 5

If **Yes**, why have you/are you buying it? (tick all that apply)

☐ For the taste

☐ It is good value

☐ It's sustainable

☐ It's a local cheese

☐ Because it is available at a farmers market

☐ Other (**please specify**) _____

3. Do you regularly buy this cheese?

☐ Yes

☐ No

If **Yes**, how often do you buy this cheese?

4. In what ways do you consume this cheese (tick all that apply)?

☐ Cheese on its own

☐ Cheese and biscuits

☐ Cheese in sandwiches

☐ Cheese in cooking

- ☐ Sprinkled on pasta or other hot food
- ☐ In any other way

5. What other cheese do you regularly buy?

6. Do you buy cheese regularly from any of these outlets?

- ☐ Farm shops
- ☐ Farmers markets
- ☐ Local delis and independent stores (within 30 miles)
- ☐ Non-local delis and independent stores (beyond 30 miles)
- ☐ supermarket
- ☐ Other (**please specify**) _____

7. How far have you travelled to get here today? (i.e. where have you come from?)

8. And how did you get here?

- ☐ By foot
- ☐ By Car
- ☐ Other

If **Other**, please specify _____

9. Have you come here just to buy cheese or is your visit tied into other purposes as well?

- ☐ Cheese only
- ☐ Other purpose as well (**please specify**) _____

10. What do you understand by the term sustainable?

11. How important is it for you that your cheese is:

a) Made sustainably?

- ☐ Very important
- ☐ Important
- ☐ Mildly important
- ☐ Not at all important
- ☐ No opinion

b) Made locally?

- ☐ Very important
- ☐ Important
- ☐ Mildly important
- ☐ Not at all important
- ☐ No opinion

12. How many times have you eaten cheese in the last week?

- ☐ Once or twice
- ☐ 3-4 times
- ☐ 5-7 times
- ☐ More than 7 times

13. If there is mould on your cheese what do you do?

- ☐ Throw the cheese in the bin
- ☐ Cut off the mould off the cheese
- ☐ Eat the cheese and not worry about the mould
- ☐ Other

14. And finally, what's your favourite cheese?

Thank you for taking the time to fill out this questionnaire, it is much appreciated.

Please Note: By filling in this questionnaire, you are confirming that you have read and understood the information overleaf and you are allowing consent for me to use the information contained in this questionnaire for my research.

9.6 **Appendix 6 – Additional information on system development methodologies: agile methods, Test Driven Development (TDD) and Search Based Software Engineering (SBSE)**

Agile Methods

There are several agile approaches including Scrum, Crystal, adaptive software development, DSDM, and Feature Driven Development. The most featured approach in the literature is Extreme Programming (XP), that uses practices of agile development such as iterative development and customer involvement (see also Table 3) that takes them to high or ‘extreme’ levels. For example a new version of the software could be built several times a day and then incrementally delivered to the customer every two weeks (Sommerville, 2007). The XP programming release cycle is shown below:

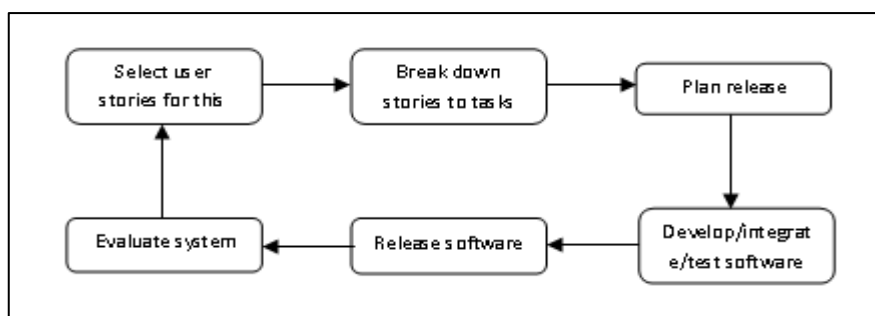


Figure 9.1 - The XP release cycle taken from Somerville (2010).

Table 9.1 - XP practices (Sommerville, 2007).

Incremental development	Customer scenarios or stories (on story cards) are the basis for the planning and there are small frequent releases of the system.
Customer Involvement	The customer is engaged full-time with the development team.
People not process	Pair programming is used, a sustainable development process that involves reasonable working hours.
Change	Regular system releases and test-first development
Simplicity	Improving code quality by constant refactoring and simple designs.

Test Driven Development

Another system design methodology that was assessed for the purposes Gupta and Jalote (2007) describe TDD as being an incremental way of developing programs by first writing tests and then writing code that suits. A test must fail before new functional code is written, it is becoming increasingly popular with agile software developers as a way of developing the application source code (Ambysoft Inc, 2013). Test-driven development (TDD) is often seen as just a testing method but Janzen and Saiedian (2005) believe that TDD has the ability to affect many aspects of a software development methodology and Siniaalto and Abrahamsson (2007), believe that it is much rather a development technique than at testing technique. Janzen and Saiedian (2005), suggest that by breaking down Test-driven Development into its three parts it alludes to much more. The 'test' part is not just testing but also the creation of automated tests of a program's individual units, the 'driven' part Janzen and Saiedian (2005), relates to how "TDD leads analysis, design and programming decisions." (Janzen and Saiedian, 2005, pp.44) while the 'development' aspect refers to TDD's ability to be used to aid constructing software. TDD alone is not a software development methodology but it has the ability to be used as a micro process within different software development methodologies (Janzen and Saiedian, 2005). It is often a corresponding approach to Agile Model Driven Development and together they can provide an effective software development process (Ambysoft Inc, 2013), or XP, or even as a standalone practice (Rafique and Misic, 2013). A diagram showing the steps of Test-driven Development can be seen below:

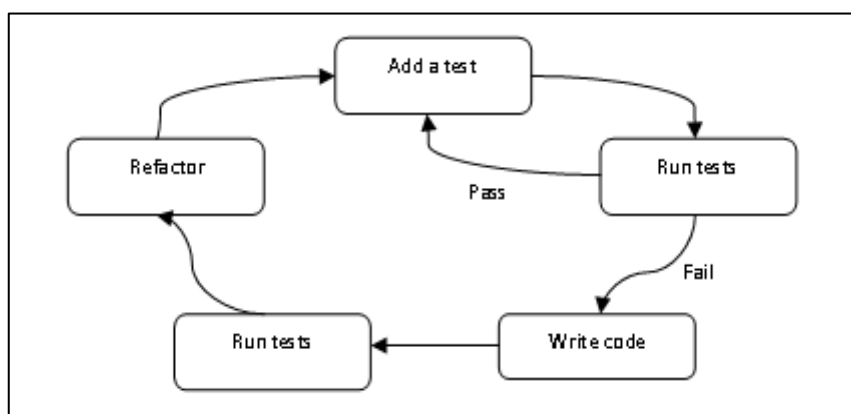


Figure 9.2 - Test-driven development diagram (own interpretation).

As TDD is not a system design methodology as a standalone it was decided not to use it. However the continual testing of the system could have been extremely beneficial.

Search Based Software Engineering

Search Based Software Engineering (SBSE) is essentially the name that is given to the field of Search Based Optimisation (SBO) in software engineering. The term 'search' in this case is not to be confused with textual searching (Harman *et al.*, 2012b). A 'search' in SBSE according to Harman *et al.* (2012a) is used to refer to the metaheuristic SBO techniques that are used, "a search problem is one in which optimal or near-optimal solutions are sought in a search space of candidate solutions, guided by a fitness function that distinguishes between better and worse solutions." (Harman *et al.*, 2012a, pp.2). As Harman *et al.* (2012b) point out in software engineering there are often questions that are usually phrased where an optimisation-based solution would be very fitting. For example, 'What is the best way to....?' or 'what is the best....?'. For SBSE you need two components: the choice of the representation of the problem and the definition of the fitness function (Harman *et al.*, 2012a; Harman *et al.*, 2012b). There are several techniques that have been used within SBSE for search and optimisations, those that are most widely used are: local search, Simulated Annealing (SA), Genetic Algorithms (GAs), Genetic Programming (GP) and Hill Climbing (HC) (Harman *et al.*, 2012a). According to the Harman *et al.* (2012a) study, 54% of past SBSE literature is related to testing although SBSE can be applied in many areas including requirements/specifications and Design Tools and techniques. In requirements engineering SBSE can be used to optimise choices among requirement and prioritise requirements (Harman *et al.*, 2012a).

9.7 **Appendix 7 - Information Sheet with Attached Consent Form**

Participant Information Sheet for Interviews

Dear _____,

I am Hannah Brooking, a PhD student at the University of Leicester, who is researching sustainable cheese making. My research involves looking at the production and distribution of cheese from farm to fork. To better understand the current practice in cheese making and find ways of improving it, I intend to gather information from people by interviewing them and also by observing the different processes that happen today (e.g. cheesemaking, dairying, packaging), my research hopes to compare two different cheese networks. The research aims to identify ways in which the cheese making process could be made more efficient, less costly, and friendlier to the environment.

You have been invited to take part as you are a key actor in the UK cheese making industry and I would love to hear about your views and ideas. I would like to talk to you about your role in the cheese system, the processes that occur at your setting, sustainability and how you think the sustainability of cheese can be improved. Interviews will vary in length depending on how much you have to say but will probably last around half an hour. To help my observations I would like to take photos. The information I collect will go towards completing my PhD thesis and academic articles and papers.

Here are the important points you need to know:

- Participation is voluntary but I would love if you could spare me some of your time
- If you do decide to participate but change your mind at a later date, you can withdraw your information at any time until the submission of my thesis.
- If you decide to participate, it will mainly involve an interview, where I will ask you questions relating to my research and I will need to record your answers on a written sheet and with a Dictaphone.
- If you decide to take part in the study, identity of individuals, firms and also locations can be kept anonymous at your wish.
- In rare circumstances it is possible for anonymity to be compromised as certain characteristics of the firm or an individual, for example could make you identifiable. However everything will be done to try and minimise this risk.
- Personal and commercially sensitive information that is recorded throughout the interviews will be kept confidential, the data will not be shared with any third parties. The interview transcripts and other data recorded from the research will be kept in a secure place for at least seven years, transcripts will be available on request.

- The information collected will be used to complete my project thesis and possibly academic papers. It will be possible to see the finished articles on request.
- If you have any questions/concerns, during or after the research, you can contact me in the following ways:
 - o Ring me on: 07791034126
 - o Email me on: hb110@leicester.ac.uk
 - o Write to me at: Hannah Brooking, Department of Computer Science, University of Leicester, Leicester, LE1 7RH

This research project was approved in accordance with the University of Leicester's research ethics procedures. If you have any further questions or need any further information about the project you may contact my supervisor:

Professor Martin Phillips

Department of Geography

University of Leicester

Email: mpp2@le.ac.uk

Tel: 0116 252 3886

If you have read all the information and you are happy to continue with the research study, you will be asked to sign a consent form to confirm this. If you do not wish to continue then there is no pressure to and I thank you for your attention.

Consent Form

- ☐ I have read and understood the information sheet and consent to taking part in the interviews
- ☐ I consent to the interview being recorded
- ☐ I consent to photographs being taking during your visit

Name

(printed): _____

Signed: _____ Date: _____
