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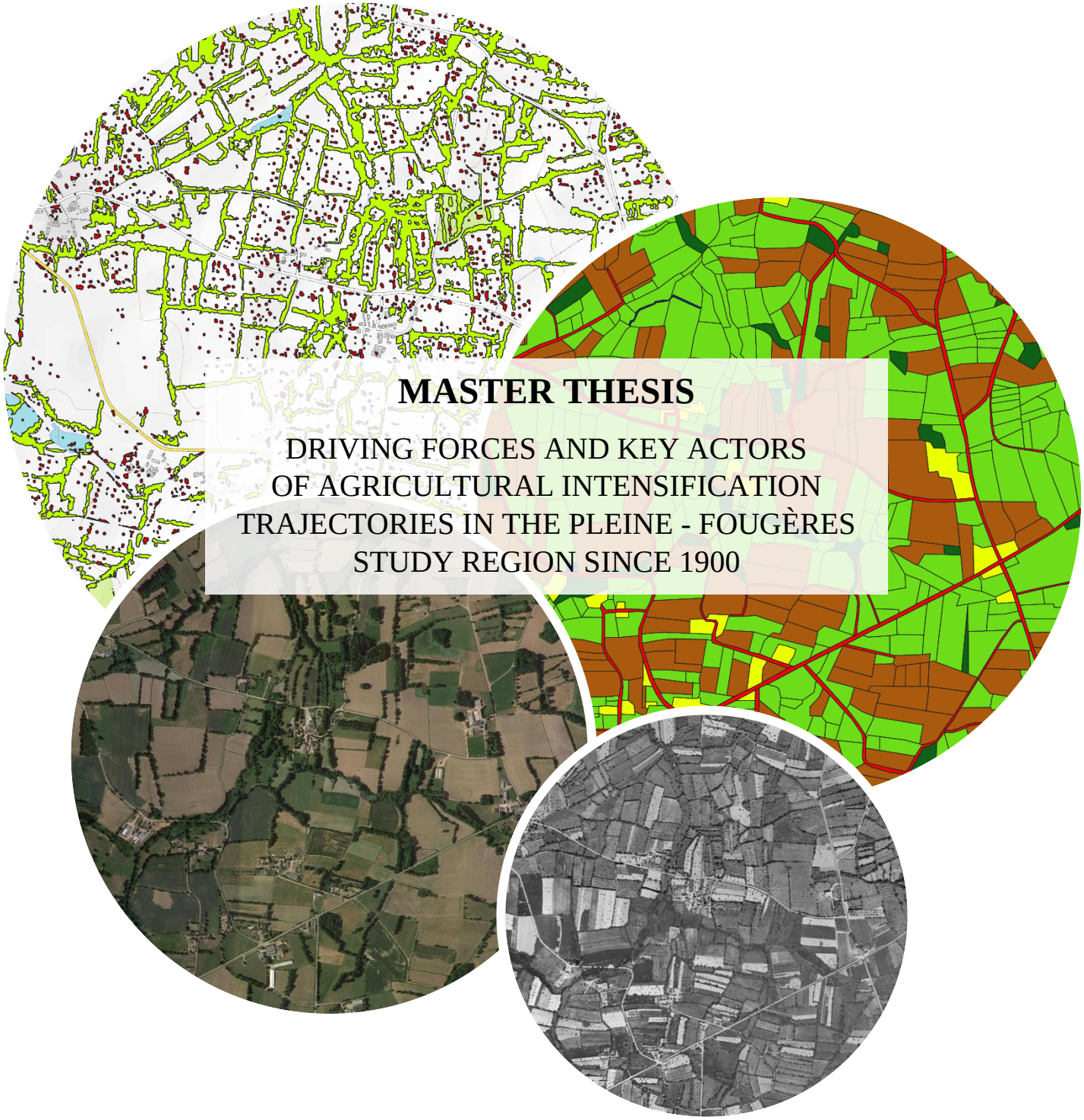

MASTER THESIS

DRIVING FORCES AND KEY ACTORS OF AGRICULTURAL INTENSIFICATION TRAJECTORIES IN THE PLEINE - FOUGÈRES STUDY REGION SINCE 1900

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Abstract

The unprecedented growth of the world's population with increasing food demand was accompanied by a substantial increase in agricultural production in the 20th century. In many European regions, this development was characterised by an intensified use of resources such as soil and water and significant landscape changes. However, as agricultural intensification progressed, the adverse effects of this development, such as degradation of soil quality, perturbation of natural water cycles or decrease in biodiversity, became apparent.

The concept of Sustainable Intensification (SI) addresses possible pathways for agricultural intensification with simultaneous preservation of the natural, economic social production bases. For this purpose, profound knowledge about the main driving forces of intensification processes and landscape changes is essential. In this Master's thesis, the agricultural and landscape trajectory during the 20th century in a case study region near Pleine-Fougères in the French department of Ille-et-Vilaine was investigated. In this area strongly characterised by agriculture, former farmers were interviewed in oral history interviews as witnesses of the development processes during the past century. The data were combined in a mixed-methods approach with a GIS-based landscape development analysis and an analysis of statistical records.

The study revealed a significant trend of agricultural intensification in the 20th century. This intensification was in particular characterised by a continuous increase in the size of farms with a decreasing number of holdings. In addition, regional specialisation in dairy farming could be observed until the 1980s, before a diversification trend began again. In the course of this process, a substantial increase in the degree of mechanisation and motorisation was also observed. An active rural society, which played an essential role in disseminating new agricultural methods in this environment, accompanied this process. The intensification trajectory can also be read in the landscape through a considerable change in the traditional *bocage* landscape since the end of World War II. The economic and institutional drivers were significant foundations of the identified changes. However, natural, structural and cultural forces have also been found to be important drivers of the development in this agricultural area's history.

Acknowledgement

The present thesis represented for me a many-faceted challenge. On the one hand, the research work has enabled me to deal with an interesting and, in my opinion, important research topic within the framework of a cross-border project. On the other hand, the cooperation with all the partners in the research area has greatly enriched me, both personally and professionally. As a result, I ended this work with a sharpened eye for complex interrelationships between economy, landscape, politics and society. I consider this contribution to acquiring a differentiated viewpoint particularly valuable for my future path. However, there were many hurdles to overcome along the path. I would never have been able to cope without the support of a multitude of people.

I wish to take this opportunity to thank Franziska Mohr and PD Dr Matthias Bürgi from the WSL, as well as Prof. Dr Chinwe Ifejika Speranza from the University of Bern, for guiding me through my thesis. I was able to rely on their continued patience and professional expertise at all times. I would also like to thank Claudine Thenail and the other collaborators of the Zone Atelier Armorique for their valuable help in preparing and carrying out the field visits. I would also like to thank all the interview partners in the study region for their openness, the interesting conversations and the culinary experiences. Not to forget, my host family gathered around Yvette Leport, whose kind welcome made me feel very comfortable from the first day of my stay in Brittany. Their generous sharing of their network and knowledge of the local area were indispensable in finding the right people to talk to in the limited time available. My mother, Michelle Bulloch, also played a big part in the success of this work, once again offering me an open ear at all times and ensuring the written quality of my contribution with her linguistic skills – words cannot express my appreciation. Finally, I would like to thank my brothers, my father, and the many friends who motivated me with their encouragement throughout this project.

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CAP	Common agricultural policy
CETA	Centre d'etudes techniques agricole
CNJA	Cercle national des jeunes agriculteurs
CUMA	Coopérative d'utilisation de matériel agricole
EARL	Exploitation agricole à responsabilité limitée
FDSEA	Fédération départementale des syndicats d'exploitants agricoles
FNSEA	Fédération nationale des syndicats d'exploitants agricoles
GAEC	Groupement agricole d'exploitation en commun
GVA	Groupement de vulgarisation agricole
JAC	Jeunesse agricole catholique
LTSER	Long term socio-ecological research
LU	Livestock unit
LULC	Land use, land cover
OHI	Oral history interview
SAFER	Société d'aménagement foncier et d'établissement rural
SI	Sustainable intensification
SIPATH	Sustainable intensification pathways in Europe
UAA	Utilised agricultural area
WSL	Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft

1 Introduction

1.1 General Problem Statement

The supply of a population with primary products like timber or food, the regulation of environmental qualities such as hydrological and bio-chemical cycles, the maintenance of biodiversity or benefits through recreation-landscapes can be associated with a wide range of landscape functions and ecosystem services (Kienast et al. 2009). Over history, most landscapes have been shaped to a large extent by agricultural activities (Ellis et al., 2013; Plieninger et al.; 2016; Antrop, 2005). In addition, anthropogenic interventions, such as forest clearing or wetlands drainage, contributed to developing a cultural landscape (Marguerie et al., 2003). Through these human actions, the land became usable for agricultural production to meet the food demands of a growing population (Roth et al., 2011). It is estimated that the agricultural use of the soil in today's world has affected around 75% of the ice-free surface (Levers et al., 2016). Since the onset of industrialisation in the 18th century, new cultivation methods, rapidly increasing productivity, and progressive mechanisation, especially on the European continent, have characterised the agricultural development (Historisches Lexikon der Schweiz, 2011). In the aftermath of the Second World War and the accompanying economic growth, agriculture experienced exceptional production intensification in many European regions. Significant changes in landscape patterns accompanied the transformation process of agriculture in the 20th century (e.g. Matasov et al., 2019; Canévet, 1992; Jepsen et al., 2015; Reger et al., 2007).

In many regions, the adverse effects of this agricultural intensification on landscape functions and ecosystem services have become apparent. In addition to a growing degradation of soil quality and water bodies, adverse effects on biodiversity and ultimately on human health are also observed (e.g. Levers et al., 2016; Canévet, 1992; Rudbeck Jepsen et al., 2015; Temme & Verburg, 2011). Furthermore, it is estimated that about one-quarter of greenhouse gas (GHG) emissions are caused by land clearing, crop production and fertilisation (Tilman et al., 2011), which have a direct impact on global warming (Stavi & Lal, 2013). At the same time, the effects of climate change and increasing competition for production resources such as soil, water, and energy challenge agricultural productivity (Garnett et al., 2013).

A need to increase agricultural crop production to meet the demand for food can be anticipated, considering the tendency to a further increasing world population in the coming decades (Tilman et al., 2011). An essential factor in ensuring this function of agricultural landscapes will depend on how we use the available resources for food production (Weltin et al., 2018). García-Martín (2021) points out that besides ecological aspects, sustainable land management also needs to integrate economic and social aspects.

Research into alternative intensification pathways that allow an increase in agricultural productivity while thus preserving the necessary factors of production is a major challenge of the upcoming decades (Godfray & Garnett, 2014). Garnett et al. (2013) situates these considerations in the concept of sustainable intensification of agriculture (SI).

1.2 Research Context

The prospect of extending food production and, at the same time, reducing related environmental consequences seems tempting. However, researchers, policymakers and practitioners challenge the paradigm of SI for different reasons.

On the one hand, there is a well-described lack of consistency in the scientific definition and application of the term SI. This issue is related to the heterogeneous perception of sustainability and intensification in the broad scope of disciplines involved in SI research, ranging from agricultural and biological sciences to economic and social sciences (e.g. Weltin et al., 2018; Petersen and Snapp, 2015; Struik et al., 2014; Pretty, 1997). Another challenge of SI tackles the lack of contributions to provide practice-oriented and context-sensitive guidelines, especially on regional and landscape levels (Weltin et al., 2018). Buckwell et al. (2014) demonstrate the need to elaborate SI practices depending on specific regional settings and current land-use practices. Thereby, agricultural production is related to specific location factors such as accessibility and availability of infrastructure, labour supply, climatic conditions, soil quality, topography, socio-cultural norms, and the structure of institutions (Bürgi et al., 2018; Xie et al., 2019). Canévet (1992) points out that the course of intensification processes is thereby closely related to the motivation and actions of direct intervening actors and groups of actors. A further task to close the gap between science and practice involves considering regional networks and coordinated action between relevant actors in further research. Dedeurwaerdere et al. (2015) point out that it is necessary to address collaborative networks of state and non-state collective actors to reach the goals of a more sustainable agri-environmental management besides a policy of economic compensation payments. However, such approaches for regional integration of SI measures remain in the minority. This point will be crucial in discussing how relevant actors can be incentivised to adopt SI practices (Weltin et al., 2018).

An essential requirement in the formulation of SI policy thus lies in a deeper understanding of the contextual, regionally differentiated conditions. Against this background, a retrospective approach is proposed here, as the historical development of agrarian landscape structures has contributed to the current situation factors and hence determines future pathways to a large extent (Bürgi et al., 2018; Hermy and Verheyen, 2007; Tappeiner et al., 2021). Following Plieninger et al. (2015), past interactions of populations with their biophysical environment can thus be read out in existing landscape structures.

Even though Plieninger et al. (2015) highlight that most studies about landscape change and their drivers assessed only one case study area, comparative studies on long-term landscape change remain in the minority. In order to understand how similar driving forces and actor constellations could lead to different effects in the landscape, an essential challenge for SI research remains thus in comparing different regional settings by investigating the mechanisms of landscape change (Jepsen et al., 2015).

This Master thesis contributes to the interdisciplinary research project "What is Sustainable Intensification? Operationalizing Sustainable Agricultural Pathways in Europe (SIPATH)", funded by the Swiss National Science Foundation. SIPATH addresses the described issues of the operationalisation of sustainable intensification. Participation of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), the Swiss Centre of Competence for Agricultural Research Agroscope and the Free University of Amsterdam (VUA) provide the opportunity to draw on the expertise of various disciplines, reaching from land-use history, agronomy, and spatial human-environment modelling. SIPATH aims to operationalise the concept of SI and to identify regionally differentiated potential pathways of SI in Europe. Thereby, three main objectives are formulated: Firstly, to understand the mechanisms of agricultural development in Europe since 1900. Secondly, to assess future mega-trends with potential impact on the future of European agriculture. Thirdly, in this context, to identify possible pathways of sustainable agricultural intensification. SIPATH's structure comprises four work packages (WP) to achieve these goals, whereby WP 1 addresses the development of a conceptual framework for SI and seeks specific indicators applicable throughout all activities conducted. WP 2 addresses the reconstruction of past dynamics and trajectories of agricultural development and their driving forces, while WP 3 focuses on identifying decisive mega-trends of tomorrow's European agriculture. WP 4 finally projects possible future pathways of sustainable intensification. The present Master thesis is embedded in WP 2 of SIPATH.

In order to address the diversity of location factors throughout Europe, SIPATH carries out case studies in a set of 14 different study regions distributed all over Europe. On the one hand, the choice of study sites intends to reach broad representativeness regarding their bio-geographical situation, thus enabling regions in boreal, continental, Atlantic and Mediterranean areas to be investigated. Furthermore, the choice of the study regions ensures the consideration of various socio-economic conditions over the continent. The present Master thesis will carry out a case study near Pleine-Fougères, Ille-et-Vilaine department in the French region of Brittany.

1.3 Research Goals and Questions

The research goals of this thesis are based on the described general problem statement and the research context. On the one hand, the study aims to document mechanisms of agricultural intensity change and landscape changes in the case study region. On the other, it should identify key actors of these mechanisms. Furthermore, this study aims to identify essential driving forces and assess their impact on agricultural intensification trajectories and landscape structure. This work applies to a retrospective approach. All research objectives and questions refer to the developments that occurred in the Pleine-Fougères case study region during the 20th century.

The research objectives are as follows:

G1: Document trajectories of agricultural productivity, management intensity and landscape structure.

G2: Identify key actors that affected trajectories of agricultural productivity, management intensity and landscape structure.

G3: Identify the major driving forces that affected agricultural intensity and landscape structure changes

Based on these goals, the following research questions are addressed:

RQ A: How did land-use intensity and landscape evolve?

RQ A1: How did farm characteristics alter?

RQ A2: How did agricultural intensity on regional and farm scale develop?

RQ A3: How did the landscape structure change?

RQ B: What were the key actors and drivers for changes in land-use intensity and landscape structure?

RQ B1: Which actors were perceived as decisive in mechanisms of agricultural intensity change?

RQ B2: What underlying drivers for mechanisms of intensity change can be identified?

2 State of the Art

This research aims to reconstruct – through a case study – the course of agricultural intensity and landscape changes in the study region during the 20th century. With this in mind, section 2.1 first introduces common concepts in current research regarding the definition of land-use intensity. In addition, possible indicators that can be used to describe change processes are discussed. Another intention of the case study is to identify the driving forces behind the described change processes. Chapter 2.2 then deals with considerations on how to structure different drivers and proceed with analyses in this area. The literature highlights land consolidation as an essential mechanism of intensification processes in European agriculture. In this context, Chapter 2.3 intends to provide an overview of common mechanisms of this practice in the European and study region context. As mentioned in the introduction, practitioners and researchers criticise the lack of embedding SI approaches in existing local social structures, leading to limited chances of success. Chapter 2.4 discusses the characteristics of social capital in general and its importance in the agricultural context.

2.1 Land-Use Intensity

Since agricultural activity has largely shaped landscapes, examining agricultural transformation pathways is closely related to Land Use and Land Cover (LULC) research. Turner and Meyer (1991) indicate differences and point of contact between the two study topics. Thereby, Land Use is primarily related to the human employment of land and is thus primarily a concern of the social sciences, historically speaking. Following the OECD's definition, Land Use can be defined as the functional dimension of land for different human purposes or economic activities. In this context, Land Use categories include, for instance, cultivation, pasture, recreation, or settlement, whereby this enumeration could be further supplemented and differentiated. Land Cover refers to the physical state of the land; this could include categories such as cropland, grassland, forest, water. Land Use and Land Cover are thereby connected, enabling human Land Use to be mirrored in the properties of Land Cover. Considering Land Use of an area as a proximate driver of Land Cover changes, the intensity of agriculture as a function must therefore be included in the assessment of Land Use (Bibby, 2009). However, Erb et al. (2014) emphasise that an analysis of intensification processes cannot be achieved by observing Land Cover alone since remote sensing data cannot capture specific intensification processes. Suitable indicators to assess agricultural intensity are needed to evaluate impacts on the environment and establish effective policies. However, different approaches are available to express the intensity and intensification of agricultural Land Use on a landscape level.

Erb et al. (2014) document the fragmented attempt to determine measurable indicators for assessing Land Use intensity. In a traditional approach, the definition of intensification follows a paradigm of

efficiency and is described in a binary composite through increased use of inputs (e.g. land, labour, capital) to gain more outputs (products) per unit of land at a given time (Brookfield, 1972; Turner and Doolittle, 1978). Hence, many approaches to measuring agricultural Land Use intensity consist of assessing input to or output from an agricultural production system or combinations of both aspects. In the context of sustainability research, input intensity is often determined by relevant indicators for their effect on the environment – for example, by influencing water, air, and soil quality – or through impacts on biodiversity. Such indicator sets usually refer to individual fields or holdings (Erb et al., 2013; Herzog et al., 2006; Lambin et al., 2000; Temme & Verburg, 2011).

Erb et al. (2014) point out the complexities of measuring the output of a system. On the one hand, there is the question of the correct unit of measurement (e.g., dry matter, fresh weight, energy, nutritive value, or monetary value), and on the other hand, there is the question of the method of measurement, considering an entire production system that should also include temporary fallow land. Another challenge in assessing intensity is the availability and robustness of data. Table 1 provides an overview of possible proxies per unit area and time referring to Erb et al.; 2013, Herzog et al., 2006 and Temme & Verburg, 2011, which could be further differentiated and completed with other indicators.

Table 1: Proxies of Land-Use Intensity

Input Intensity Proxies	**Output Intensity Proxies [per unit area and period of time]**
Chemical/Organic fertilizer application	Calorific or protein value of production
Pesticide application	Monetary value of production
Retardant application	Food tonnage of a variety of crops
Livestock density	Fibre and other non-food products
Degree of mechanisation	
Irrigation, Amount of water	
Cropping frequency, rotation length	
Use of energy	
Amount of workforce	
Technique Skills	
Capital	

Erb et al. (2013) emphasise that in the context of Land Use research, the effects of Land Use intensity on ecological patterns and processes should be considered. The above-mentioned binary conception of agricultural intensification should be completed by measuring changes in ecosystem properties. Possible

proxies, therefore, are nutrient cycling, biodiversity, carbon storage, net primary production of biomass, water quality and water retention capacity. These system properties can be decisive for the overall dynamics of a land system. However, measuring changes in system properties has proven to be complex since the appropriate indicators often cannot be measured directly; they result from a combination of different indicators. Moreover, existing monitoring systems are usually not designed to collect such information (Haines-Young et al., 2012).

A further approach to assessing Land Use intensity can be related to landscape composition and elements (Baessler & Klotz, 2006; Herzog et al., 2006), as intensification processes often also imply interventions at the landscape level (Helfenstein et al., 2020). Landscapes present complex spatial patterns in the distribution of resources that vary over time. Quantifying these patterns and their dynamics is the purview of landscape pattern analysis (McGarigal, 2013). The habitual procedure consists in measuring, analysing, and interpreting spatial patterns to quantify particular heterogeneity (Uuemaa et al., 2009). Possible proxies to assess intensification trajectories may then be, for instance, field size (Herzog et al., 2006; Tieskens et al., 2017), the abundance of trees or the length of hedges in a given area (van der Zanden et al., 2016).

A current framework to assess the trajectories of Land Use intensity indicators lies in the concept of agricultural intensity change mechanisms. Diogo et al. (submitted) develops mechanisms operating in European agriculture and identifies farm attributes used to describe them. This approach also enables a description of de-intensification processes. Thereby it should be considered that these mechanisms are usually observed in complex combinations. This means, in particular, that some of the same indicators can be used for different intensification mechanisms. The following list reviews the different mechanisms of intensity change. This focus on categories helps compare the intensification pathways of different case study regions.

- **Land Management Intensity**
  Adjustment of land management practices (e.g. livestock density, length of the grazing period or crop rotation cycles) and frequency of field management operations (e.g. soil tilling, grassland mowing, mechanical weeding).

- **Capital intensity**

  Investments in goods such as buildings (e.g. silos, stables, greenhouses), infrastructure (e.g. roads, bridges, drainage), machinery and equipment (e.g. milking robots, mechanic seeder, automatic feeder), permanent crops (e.g. tree orchards) as well as the livestock herd size or land reclamation through permanent drainage of wetlands, for instance.

- **Input-use intensity**

  Adjustment of the use of consumable inputs such as fertilisers, plant protection products, animal feed and health inputs, seeds, water and energy.

- **Labour-intensity**

  Adjustment of labour inputs, considering both family and hired labour.

- **Farm consolidation**

  Increased agricultural productivity is achieved by increasing the size of the farm (e.g. by buying or renting land from other farms) or by restructuring the land to make it more manageable. This can be achieved, for example, by land consolidation or removal of landscape elements such as rows of trees or hedges.

- **Farm specialisation/diversification**

  Adjustment of the diversity of crops or livestock species, breeds, and stages of animal development. Agricultural productivity gains are achieved through concentration on a limited number of production skills and the abandonment of certain production branches. Diversification is achieved through integrating complementary activities, integrating new livestock in the production system or cultivating complementary crops.

- **Income Diversification**

  Economic productivity gains are achieved by combining agricultural activities with non-agricultural activities (e.g. methane and energy production, agritourism), off-farm employment or government-supported environmental programmes.

- **Regional specialisation and concentration**

  Agricultural productivity gains are achieved by pursuing particularly distinctive branches in the region (e.g. clusters of dairy industry or vegetable production). Respective regions are characterised by industrial and logistic hubs for processing, transporting or marketing agricultural products.

- **Vertical integration**

  Transaction costs and risks are reduced by integrating more production/value chain stages into economic activities.

- **Knowledge intensity change**
  Acquiring additional knowledge and skills through additional training and/or involving external consultants.
- **Improved information management**
  Adjustment of agricultural and economic processes through the use of information and communications technology (ICT).
- **Crop/product change and product differentiation**
  Increased agricultural productivity is achieved by switching the farm to particularly high-yielding varieties and products or added-value niche markets.
- **Cooperation**
  Economic gains based on social capital, by sharing or co-managing certain factors of production such as labour force, knowledge or machinery.

2.2 Driving Forces

Historically speaking, agricultural intensification processes have been a significant factor in landscape change. The European landscape convention (2000) defines the landscape as the prime sphere where the combined effects of society and nature become visible. An essential aspect of the concept of landscape is the dimension of human perception. Thus, a landscape is usually understood as a coherent space due to a specific character as a cultural unit (Hauck et al., 2016). Landscapes are, therefore, the expression of the dynamic interaction between natural factors and human actions in the environment (Antrop, 2005; Bürgi et al., 2017). The term cultural landscape is usually used in the sense of this interplay of natural factors, human activities and the constant renegotiation of values related to these landscapes. As societies and nature are dynamic, change is an inherent characteristic of landscapes (Bürgi et al., 2005). Today's landscapes are always the result of processes that lie in the past. Therefore, a historical perspective of the underlying processes is of considerable importance for understanding today's landscape structures. However, defining the driving forces of landscape change and appropriately modelling them is a major challenge due to the complexity of the systems under investigation. Numerous dependencies, feedbacks and parallel processes at different temporal and spatial scales express this complexity.

As a framework to analyse causes, processes and outcomes of landscape and Land Use changes, the concept of driving forces has proven to be a consistent approach in various studies (Santana-Cordero et al., 2017; Plieninger et al., 2015; Jepsen et al., 2015; Matasov et al., 2020). Bürgi et al. (2005) define driving forces as processes that cause observed landscape changes and affect a system at different institutional, temporal and spatial scales. Geist and Lambin (2002) distinguish proximate and underlying drivers of change. Proximate drivers are understood to mean direct human action at a local level.

Fundamental social processes, such as demographic development or implementing agricultural or environmental regulations at a higher level, are classified as underlying forces. Identifying a driving force depends on the purpose of the research question and the three named axes of the system under study. The right balance between generalisation and specification is crucial for designing a case study to correctly consider a system's complexity.

Five major types of driving forces are identified: economic, political/institutional, technological, natural/structural, and cultural (Schneeberger et al., 2007; Bürgi et al., 2005). The economic drivers are particularly perceptible in the economic framework conditions of a system under study. Examples of economic drivers are, for example, a change in demand or the market trend for certain agricultural goods. It is a fact that the economy at all levels is strongly related to political decisions, laws, and agreements. There is, therefore, a strong relationship between these two categories. The way agriculture is practised and, ultimately, the landscape is shaped is also largely influenced by technological possibilities. The level of infrastructure, which ensures access to markets and labour markets, or the level of development of mechanical tools are obvious examples. Development in a particular location is also dependent on natural conditions. In addition to local characteristics such as topography or soil conditions, natural disturbances should also be mentioned. These can be acute, such as floods or droughts, or continuous, such as changes in oceanic or atmospheric circulation. Local characteristics are usually stable in the short term but may change in the long term. Categories such as personal convictions, values or social traditions are, assigned to cultural driving forces (Schneeberger et al., 2007). A society's lifestyle and the associated needs with spatial effects are also mentioned (Hersperger & Bürgi, 2009). Disagreements exist regarding the classification of demography as the driver of changes. While Bürgi et al. (2005) also assign it to cultural drivers, van Vliet et al. (2015) and Geist and Lambin (2002) consider demographic developments as a driver category in their own right. In conclusion, it can be said that in comparing the dimensions of the driving forces previously mentioned, the definition but also the detection of cultural drivers remains vague. Interdependencies and overlaps between the various driving forces are frequent. Within the main categories, the driving forces can be categorised even further according to temporal, spatial, and institutional scales.

Standard procedure of Driving Forces Assessment

Bürgi et al. (2005) propose a standard procedure to study the driving forces of landscape change that includes three major steps: system definition, system analysis and system synthesis.

- In the **system definition** phase, the spatial and temporal boundaries of the system of interest must be determined. Within the framework of the system definition, the institutional dimension is also determined. The latter can partly coincide with the spatial dimension if the study perimeter is chosen alongside administrative borders. The right level also depends on data availability for the specific case study area, as it is more difficult to gather statistical data for earlier periods. Therefore, a temporally nested approach, where certain aspects are analysed further back in time than others, can be more appropriate.

- The **system analysis** focuses on three subsystems: change and persistency of landscape elements, actors and institutions within a system of interest, and the driving forces. In this step, the relationships between driving forces, institutions, and actors should be reached by linking them to each other and to the major land change processes for a study area. The relevant elements of these subsystems can be identified, for instance, through aerial image analysis, interviews, and the review of local literature (Santana-Cordero et al., 2017). Actors and institutions can be located inside or outside the system of interest.

- With the **system synthesis**, actors, institutions, and driving forces are linked in causal relationships, and their impact on the landscape elements under study is determined to understand the land cover changes in the study sites. The synthesis of the Driving Forces Assessment benefits thereby from graphical visualisations. For example, the connection between the identified change mechanisms and the identified driving forces can be pictured in an organisational chart (see for instance Plieninger et al., 2016; Loran et al., 2017; Geist and Lambin, 2002). In the context of interdisciplinary studies of landscape changes, Bergeret et al. (2015) suggest establishing chrono-systematic timelines to structure and visualise events, actors and driving forces over time. Depending on the specific setting in a system of interest and the research question, changes and persistency can also be characterised by distinct land-management regimes (Matasov et al., 2020).

2.3 Land Consolidation

Land consolidation in various forms is regionally often a significant LULC change process. At a spatial level, its effects can usually be seen in the changing structure of cultural landscapes (Périchon, 2004; Veršinskas et al., 2020; Philippe & Polombo, 2010). Early forms of land consolidation practices have already been known in Europe since the Middle Ages (Lambert, 1963; Philippe & Polombo, 2010). The term now defines a standard process on the European continent since about the turn of the 20th century (Gamperl, 1955). During the agricultural intensification of the 20th century, land consolidation was a significant process of rural development (Veršinskas et al., 2020). However, through the division of Europe after the Second World War, substantial differences appear in the organisation between Western and Eastern Europe; in some former socialist states, for example, the legal framework for land consolidation has yet to be developed (Neubauer, 2016).

Land consolidation as a series of activities aimed at reorganising plots in a given farm area through their regrouping, as well as providing them with a more favourable shape and access, was an essential part of agrarian policy in European countries (Jacoby et al., 1959; Vitikainen 2004; Wójcik-Leń et al., 2018). Land consolidation comprises policies and measures designed to reallocate a fragmented rural agricultural area. However, the objectives and procedures of land consolidation differ according to the country (Vitikainen, 2004; Veršinskas et al., 2020). Since historical trends, culture, and the legislation of each country have influenced the development of land consolidation, precise objectives and procedures vary from country to country. The following list gives an overview of possible land consolidation objectives.

- Improvement of agricultural land division
- Reallotment of leasehold areas
- Enlargement of farm size
- Improvement of road network in the land consolidation area.
- Implementation of environment and nature conservation projects.
- Improvement of drainage network in the land consolidation area.

In most developed countries, land consolidation is nowadays based on legislation dating back to the 1970s or 1980s; such is the case in France (AGTER, 2012:2). In that phase of the 20th century, quick changes in the land consolidation environment (e.g. technical possibilities, need to enhance productivity, effects on the natural environment) made new regulations necessary. In European countries, two main

models of land consolidation can be named. A common form of land consolidation execution is the committee model, where a panel committee carries the responsibility; this model is also applied in France. Depending on the country, authorities at various administrative levels can nominate this committee. Besides administrative authorities, landowner representatives, usually gathered in an association, can complete the committee. Another model comprises the "cadastral surveyor model", whereby a cadastral surveyor implemented by the authorities is responsible for lands consolidation projects. In both models, additional experts are called upon if needed (Vitikainen, 2004).

2.4 Social Capital

The definition of social capital is associated with a certain fuzziness due to its limited measurability (Grootaert et al., 2002). However, most approaches refer to the benefits and the value that arises from social networks for individuals and communities (Ostrom, 2009; Paldam, 2000). Social networks describe connections between individuals that create the basis for collective action and social cohesion. These social networks can have a formal character, such as being organised in clubs, or informal, such as relationships between neighbours or friends (Freitag, 2014).

In the context of agricultural change processes, Lucas et al. (2014) highlight the importance of collective action through social networks dating back to the Neolithic. Essential aspects of agriculture such as storage, production, land allocation, the management of shared resources, like soil and water, as well as risk management were the subject of a collective organisation between farmers and external actors, whether under the influence of authorities or in an informal manner. Finally, in the course of intensification processes during the 20th century, regional social networks were seen as an important tool during the transition to productivist agriculture in the 1960s and 1970s (Canévet, 1992; Houet, 2006). As Dedeurwaerdere et al. (2015), Grootaert et al., (2002) and Weltin (2018) point out, the participation of local networks can also play a central role in the implementation of policies in the sense of sustainable intensification. Ostrom (2010) emphasises that the success of translating environment protection goals into concrete actions depends on a backing up at national, regional and local levels. The local level has a central role since relevant governance tasks such as spatial planning, land consolidation or water distribution are carried out locally. The cooperation between different actors, i.e. farming and non-farming actors at a regional level can enable communication channels to be opened, raise awareness and trust in a region and thus facilitate the diffusion of knowledge and novel practices (Tilly, 1976; Hirschi, 2010). The development – and ultimately also the application – of regional implementation plans for overarching policies in the sense of sustainable intensification thus begins with a careful stakeholder analysis (Hauck et al., 2016). In addition to establishing a general inventory of all actors and assessing their influence on change processes, it is also of particular interest to ascertain the existing links between the actors.

3 Material & Methods

3.1 Case Study Site

3.1.1 Geographic Situation and Extent

The study perimeter near the town of Pleine-Fougères in the French department of Ille-et-Vilaine was chosen related to its representativeness for marginalised remote rural areas in the Atlantic region (Bürgi et al., 2018). The study site is situated about 40 km northeast of Rennes, the prefecture of Ille-et-Vilaine. The study area contains both cleared areas and zones that remain in the typical *bocage* structure, the traditional hedgerows network landscape in western France (Thenail & Baudry, 2004). To the east, the study area covers a part of the Forêt de Villecartier, a forest covering about 1000 hectares. The distance to the Baie du Mont-Saint-Michel in the north, a bay in which the name-giving and touristically well-known Mount is located, is about twenty kilometres. Larger towns in the region are St. Malo in the northeast, about 35 kilometres away, and Fougères to the southeast, about the same distance. The perimeter used for the analysis of landscape development, according to Chapter 3.5, spans over parts of the four municipalities of Cuguen, Broualan, Trans-la-Forêt and Bazouges-la-Pérouse and covers an area of approximately 25 km2. The delimitation of the area results from the study regions defined within the framework of SIPTAH. Figure 1 shows how this study perimeter is located within the four municipalities mentioned above.

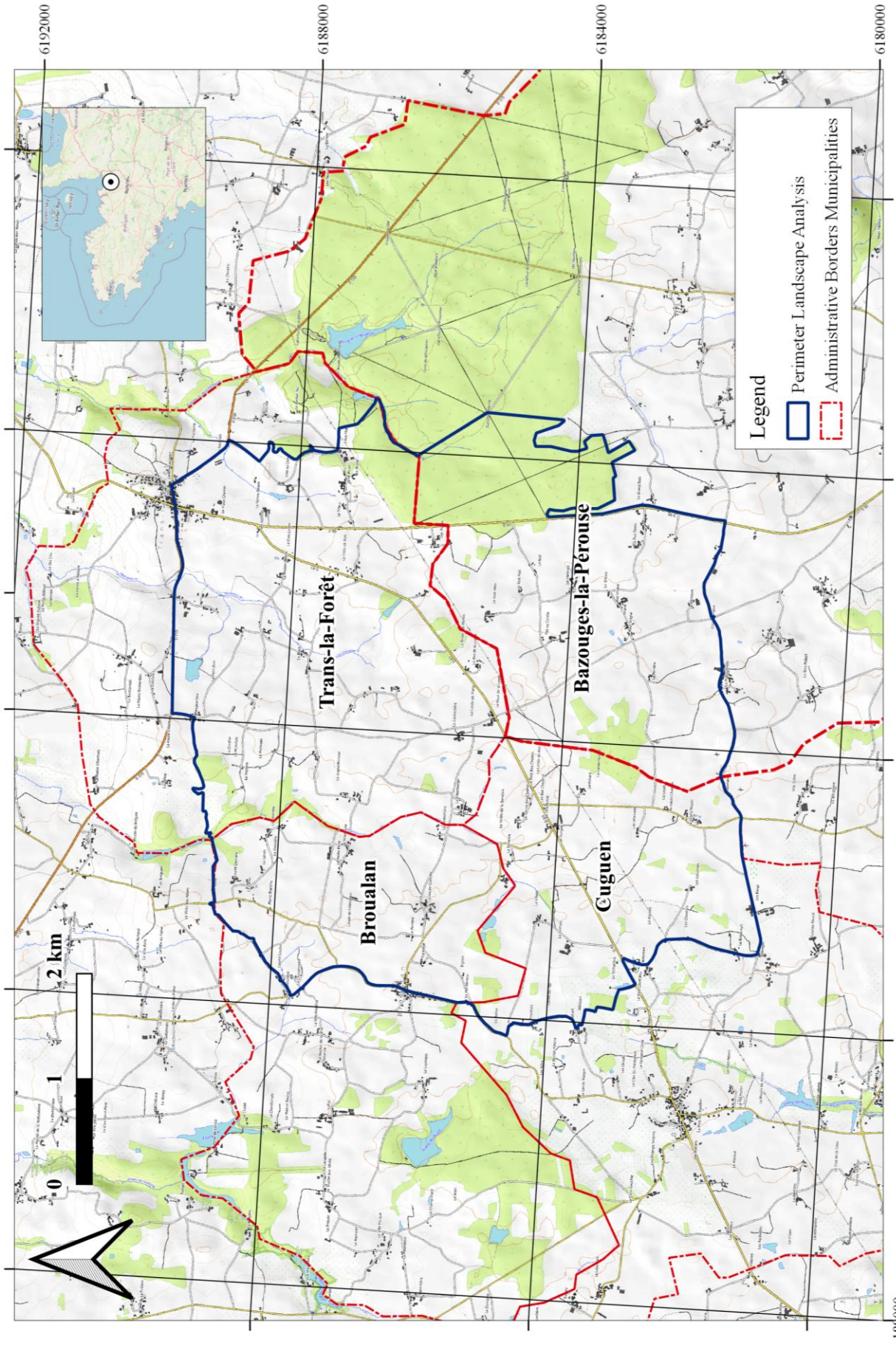

Figure 1: General study perimeter

The delineation of the perimeter for the landscape development study formed the basis for further methodological considerations. As can be seen in Figure 1, the study perimeter of the landscape study only follows the municipal boundaries in a few places. In some cases, these boundaries extend far beyond the study area. However, since the data of the statistical collection defined in Chapter 3.4 summarise values per municipality, there is a certain deviation here regarding the spatial extent of the study area. In addition, the study area was also extended to the neighbouring municipalities of Epiniac, Trémeheuc and Noyal-sous-Bazouges for the oral history interviews presented in Chapter 3.3. Figure 2 shows how the different perimeters of the study areas differ according to the various methods and locates them in the immediate vicinity.

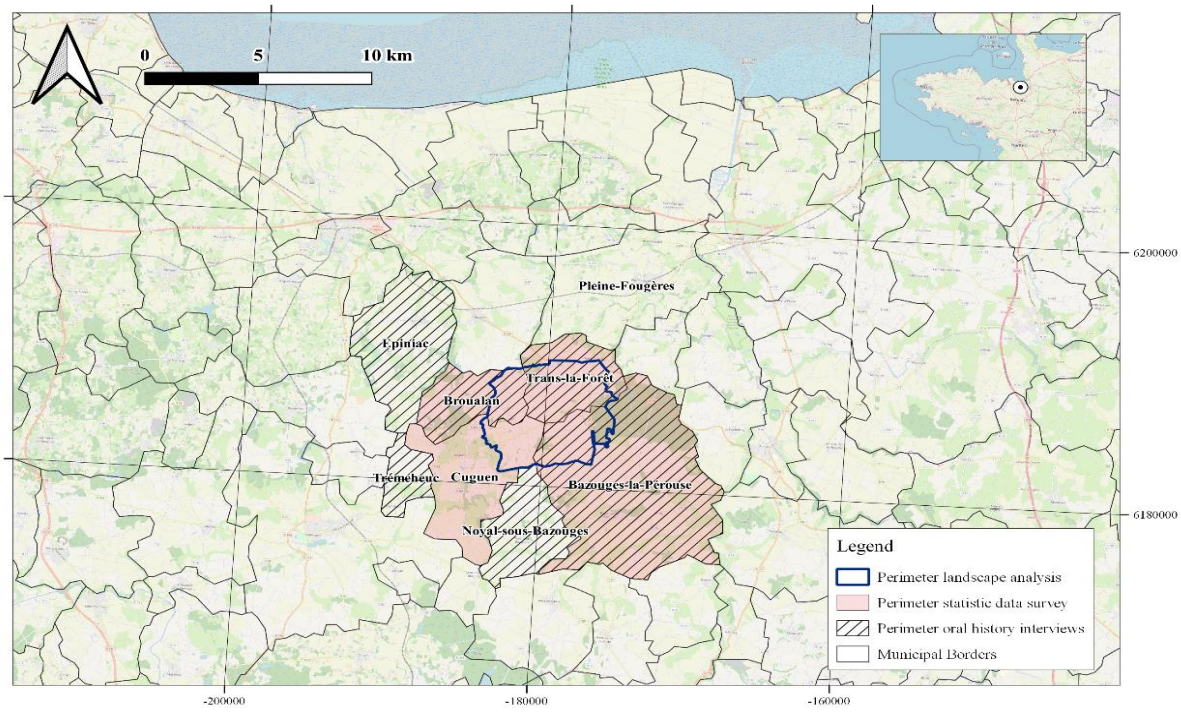

Figure 2: Different study perimeters depending on research method

The study area is in a temperate climate zone with oceanic influence (Meteo France, 2020). Within Brittany, the case study site is situated within an area with a more continental character, which experiences cooler winter and warmer summer. From 1981 to 2010, Meteo France (2010) lists 694 mm of annual precipitation in Rennes, distributed over an average of 114 rainy days. A slight maximum is observed from October to February. The average minimum temperature in the same period is 7.9° C, whereas the average maximum temperature is 16.4° C (OEB, 2021). The average annual temperature is around 11° C, with 30 - 40 heat days recorded annually and as many frost days.

The study area has an altitude between approximately 75 and 110 m.a.s.l. and is characterised by a gentle hilly landscape. Figure 3 shows the typical landscape in the study region. Granitic bedrock, interspersed with sedimentary material, dominates in the geological subsoil (Géoportail, 2021). It is not rare for the granitic subsoil to appear at the surface (Javelle, 2007). The geological structure thus clearly stands out from the somewhat lower-lying landscape around Pleine-Fougères in the north, which is characterised by a schistose subsoil. The dominating soil type is brown earth (Géoportail, 2021). The estimated soil erosion in the study area is relatively low (OEB, 2021).

Figure 3: Typical landscape in the study region

3.1.2 Administrative Structure

The administrative structure of the French state comprises different levels with different competencies. At the highest level, the study area belongs to the region of Brittany, one of 13 regions of *France Metropolitaine*, which designates the French territories in continental Europe plus Corsica. At the next level, the area is in the department of Ille-et-Vilaine, one of 96 French departments of *France Metropolitaine*. Within the department, France has different forms of administrative organisation. On the one hand, Ille-et-Vilaine is divided into cantons, which constitute an electoral district for the election of the departmental parliament (Insee, 2021). The study area is situated in the border region between the three cantons of Combourg, Dol de Bretagne and Val-Couesnon. On the other hand, the

Intercommunalités des communes (CC) are public establishments of inter-municipal cooperation with their own tax status. Their purpose is to pool together specific public tasks such as spatial planning, protection of the environment or waste disposal for several municipalities. The extent of the CCs only partly corresponds to that of the cantons and partly combines areas of several cantons. The four municipalities in the study area are integrated in three different CCs, the CC Bretagne Romantique, the CC Couesnon Marches de Bretagne and the CC Pays de Dol et de la Baie du Mont Saint-Michel (Ille-et-Vilaine, 2021). Within the study perimeter of the present research, the boundaries of the cantons and the CC coincide.

3.1.3 Demography

The study area is demographically characterised by three villages with a relatively small number of inhabitants, Broualan, Cuguen and Trans-la-Forêt, and a larger town, Bazouges-la-Pérouse. Continuous data series regarding population development have been available since 1876, whereby no significant changes were observed until the turn of the 20th century. Figure 4 provides a detailed overview of population development from 1901 to 2019.

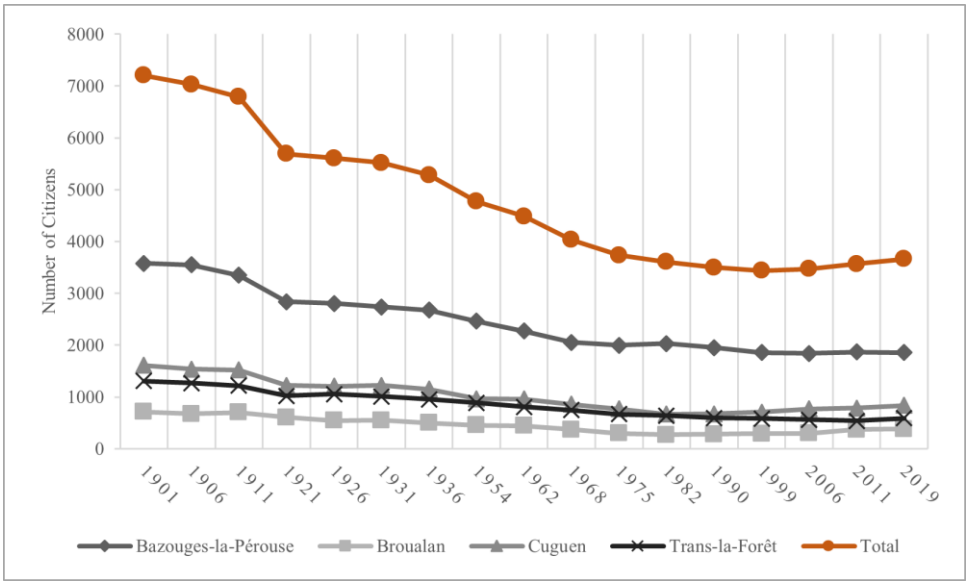

Figure 4: Demographic development in the study region (Data source: INSEE, 2021)

The first significant dip in the population curve occurred during the First World War around 1915. After an interim stabilisation phase, a further population decline followed from the end of the 1930s and lasted until the turn of the millennium. Since then, a slight population increase has again been observed in all four municipalities.

3.1.4 Zone Atelier Armorique

To foster long-term multidisciplinary research on socio-ecosystems, a network of fourteen workshop regions called *Zones Ateliers* (ZA) was established in France and two specific regions abroad. The ZA network is affiliated with the French National Centre for Scientific Research (CNRS), an interdisciplinary public research organisation placed under the administrative supervision of the French Ministry of Higher Education and Research. Furthermore, the ZA network is also part of the European Long-term Ecosystem Research Network (LTER) and the international LTER network (LTSER France, 2021). The perimeter of the present master thesis is integrated into the *ZA Armorique* (ZAAr), which encompasses the whole department of Ille-et-Vilaine. Within the *ZAAr*, the region around Pleine-Fougères has been designated as a separate test site since 1993 with regard to the *bocage* structure as a typical landscape entity; the study area of the present work is located within this perimeter. Figure 1 shows the location of the test site "*site atelier agricole*" in both the *ZAAr* and the department of Ille-et-Vilaine.

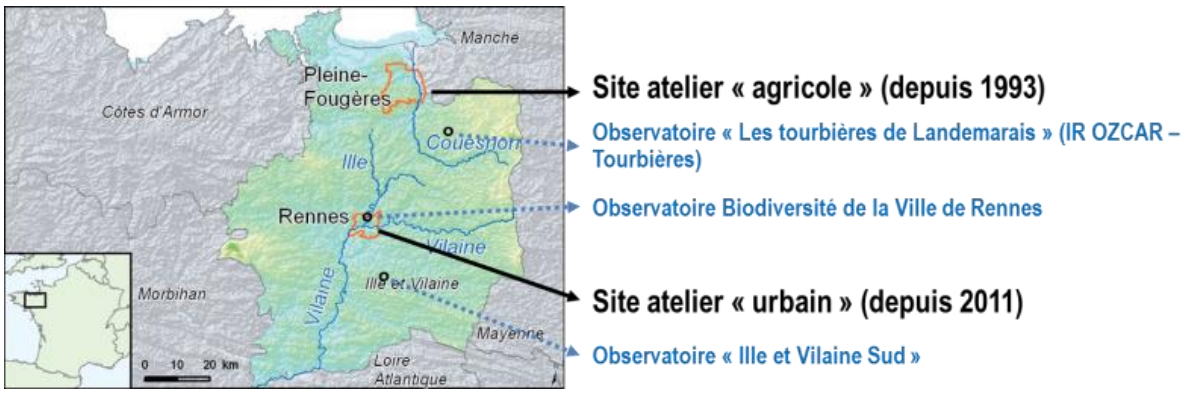

Figure 5: Perimeter of the Zone Atelier Armorique and workshop sites (LTSER France, 2021)

The ZAAr setup aims to enable research about the complex relationships between human activities and the functioning of ecosystems in nested scales of time and over different spatial entities. Therefore, the ZAAr is directly in contact with local stakeholders such as farmers and policymakers. The University of Rennes and the French National Research Institute for Agriculture, Food and Environment (INRAE) share the governance of the workshop region. Within the ZAAr, three observatories and two test sites – one urban and one agricultural – have also been designated. This case study will proceed within the agricultural test site.

The study region of the present thesis was already a landscape test site in the EU-commissioned research project "Vulnerability of biodiversity in the agro-ecosystem as influenced by green veining and land-use intensity - GREENVEINS" with contribution from Agroscope (Herzog et al., 2006). Furthermore, since Agroscope is also a research partner in the SIPATH project, it was possible to refer to existing

connections with researchers within the ZAAr. This background facilitated the preparation of field research and access to various data sets, in particular regarding the study of landscape changes.

3.1.5 General Trajectory of Breton Agriculture

This chapter offers a general historical background in the 20th century of the study perimeter. This retrospective outline of agricultural and landscape development intends to build a certain amount of basic regional knowledge and thus improve the classification of the results. For this purpose, the general course of the well-described agricultural development in Brittany as a whole is used.

At the beginning of the 20th century, a large part of the population in Bretagne was still actively engaged in agriculture. The Bretagne was then characterised as a peripheral and economically marginal region with limited equipment and access to markets. Compared with other European rural regions in England or the Netherlands, Brittany was considered a somewhat underdeveloped area. In the first half of the 20th century, mixed farming (crops, livestock) with a high level of self-sufficiency (Canévet, 1992) characterised the traditional farming system. However, against the background of the World Wars and an economy marked by war and reconstruction needs, the entry of capital and technological innovation in agricultural activity remained low. As a result, production intensity was described as somewhat low with a high labour input (Houet, 2006; Javelle, 2007). Furthermore, agriculture showed a modest degree of motorisation and mechanisation. Consequently, land-use intensity and capital intensity were relatively low (Houet, 2006). Even if the traditional *bocage* landscape was subject to changes in the first half of the 20th century against the background of modernisation, the typical agricultural landscape in Brittany was still characterised by a relatively dense network of hedgerows and a large number of fruit trees in the fields (Périchon, 2005). Against the background of the absence of regulation of a pension system in agriculture, ageing farm management could be observed in many farms; in addition, many succession arrangements led to considerable fragmentation of the farms (AGTER, 2012:1).

In post-war France, France and Brittany's demographic and economic development underwent a dramatic shift (Canévet, 1992; Javelle, 2007). In the 1950s, along with the rapid population growth and economic expansion, highly mechanised and productive agriculture began to be established, accompanied by substantial development in the agro-industrial sector (Canévet, 1992; Jennequin, 2005). The introduction of the "*lois d'orientation agricole*" in 1960 and 1962 laid an essential basis for the era's structural changes. These laws provided the authorities with better tools for improving the organisation of agricultural land. Furthermore, the "*indemnité viagère de départ*" (IVD), introduced in the same course, was aimed to enable older farmers to take early retirement, thereby liberating agricultural areas. At last, economic and educational requirements for the occupation of agricultural land increased significantly (AGTER, 2012:1). As a result, Brittany became in the 1960s and 1970s one of the most

productive agricultural regions in Europe, producing for both the domestic market and international trade.

During this evolution, the traditional *bocage* landscape in Brittany underwent significant changes, with a rapid decrease in hedge density and the number of field trees to fulfil the requirements of an intensive production system (Houet, 2006). In many Breton municipalities, official land consolidation was carried out at the request of landowners, elected municipal representatives or farmers. Drainage projects and major land exchanges were planned and implemented by municipal commissions with the involvement of relevant stakeholders (AGTER, 2012:2). The average surface used per farm increased to the same extent as the decrease in the number of farms (Canévet, 1992).

A key pillar of the described development of this time in the Brittany region lies within the high degree of organisation of the rural population's formal and informal social networks. Various member-strong syndicalist and cooperative-type organisations (e.g. CNJA, FDSEA) were committed to far-reaching modernisation in the society and agricultural practice. They also made a significant contribution to the diffusion of knowledge and technology and advocated at various political levels for the interests of the farming community (Houet, 2006). In addition to the trade unions and cooperative movements, rural youth associations (*Jeunesse Agricole Chrétienne* JAC) complemented the range of formal social networks in rural Brittany. The diffusion of knowledge was primarily supported through farmer organisations, which are mainly cooperatives aimed at the use of agricultural equipment (*Coopératives d'Utilisation de Matériel Agricole*, CUMA), Technical Agricultural Study Centres (*Centres d'Etudes Techniques Agricoles*, CETA) and Agricultural Advisory Groups (*Groupements de Vulgarisation Agricole*, GVA). In addition to the local and international agro-industrial companies, the numerous emerging cooperatives in Brittany also played an essential role in the local trade of agricultural goods (Canévet, 1972).

The following period, covering the years 1982 to 1984, again represented a clear break in development (Canévet, 1992). Depending on the region, hors-sol chicken and pork production or dairy production had established themselves as the dominant production sector by the end of the 1970s. Overproduction of milk and other agricultural products such as eggs or poultry had become evident since the late 1970s on a pan-European level. At the same time, Breton and European agriculture was increasingly challenged by international competition (Canévet, 1984). Against the background of steadily growing milk surpluses, milk quotas were introduced at the European level from 1982-83 onwards (Bruneau, 2013). In the backlash of this production regulation, an infra-regional specialisation of production systems manifested itself, with a large number of farms turning to other branches of production (Canévet, 1992). Economic developments of the time were accompanied by further expansion of the

farm size; simultaneously, the importance of agricultural organisations eroded in terms of membership and ability to manoeuvre (Canévet, 1992; Houet, 2006).

Until 2000, Brittany was the most productive region in France in various sectors such as dairy or poultry production and the agro-alimentary industry. In a constantly diminishing agricultural area, a decreasing number of farms have been practising increasingly intensive agriculture (Houet, 2006). The trend of farm enlargement continued towards the end of the 20th century, with more and more farms merging together. On the institutional level, the European Community's Common Agricultural Policy reform finally shaped the landscape in the last decade of the 20th century. In terms of environmental protection, the obligation of temporary fallowing and water protection through grass strips is prescribed (Javelle, 2007). At this time, re-parcelling was no more a decisive instrument for farm expansion. Instead, expansion of farm structures was performed through alterations of parcels between farms or the acquisition of surfaces liberated thanks to the farmers retiring without successor. Individual action then was then the primary driver of "*debocagement*" at this time (Houet, 2006).

3.2 Study Design

The systematic literature research on the general problem and the regional context of the study region made it possible to narrow down the field of action of the present study. Therefore, it seems appropriate to use a combination of qualitative and quantitative research approaches in terms of data collection and analysis. Hence, a mixed-methods case study framework approach was chosen. Kuckartz (2014) emphasises that the mixed-methods approach offers the advantage that combining both approaches of one method can contribute to a more holistic understanding of the topic of interest. The present study deals with past processes of change in land use with the aim to reconstruct the trajectory of agricultural intensity, identify the underlying drivers and show the interaction of different actors in these processes in a regional context. The application of different complementary methods considers the complex interrelationships in the context of agricultural and landscape transformation processes.

On the one hand, perceived changes in the investigated period were gathered by people directly involved in these processes. For this purpose, oral history interviews were conducted; this procedure is discussed in chapter 3.3. This method was also used to gather information on the driving forces behind the transformation processes. The data collected through the oral history interviews are primarily of a qualitative type. In order to better embed the information collected during the interviews in an overall context, a statistical data collection of selected indicators concerning agricultural intensity was also carried out. For details of this method, see Chapter 3.4. As explained in the previous chapters of this thesis, agricultural and landscape changes are closely related. Therefore, changes in landscape structure can be used as an indicator of agricultural development. In this sense, a GIS-based long-term analysis of landscape development was carried out. The details of this method are described in chapter 3.5.

The methods listed above complement each other and should enable the reconstruction of an overall picture of complex transformation processes. Because of this complementarity, the implementation of qualitative and quantitative methods is not carried out sequentially but rather in a concurrently or parallel timeframe. Parallel mixed-method studies are characterised by the fact that the different strands are basically not interdependent and can therefore be planned in a very flexible way (Kuckartz, 2014). However, it should be mentioned that the different methods implemented are related to each other. For example, the implementation of the interviews could be sharpened with initial findings from the landscape analysis concerning the specifics of the study area. In turn, the further focus of the landscape analysis could be narrowed thanks to findings gained during the field visit.

Finally, it must be taken into account that the data collected by the different methods cover time periods that only partially coincide. The concerned time periods are indicated in Table 2, which lists which methods aim to answer which research questions.

Table 2: Research Methods		
Method	**Time period**	**Addressed Research Question**
Statistic Data Collection	1970 - 2010	RQ A
Oral History Interviews	1931 - 2021	RQ A; RQ B
Landscape Development Analysis	1952 - 2000	RQ A

3.3 Oral History Interviews

Technical possibilities, political and societal conditions and the environmental situation influence many aspects of land use. Eventually, development in land-use practice is predominantly implemented at the farm level through individual decision processes. Considering the historical perspective of this master thesis, some aspects of agricultural intensity are not identifiable through literature study, image analysis or statistic data collection. Schaffner (1988) emphasises that the inclusion of oral sources allows identifying change and continuity of everyday living conditions on an individual level. Such information is available only to a limited extent through written sources. Thus, it is crucial to gather information from directly involved people on a farm level.

Wierling (2003) defines Oral History as a method within historical sciences where contemporary witnesses are consulted as sources. Oral History Interviews are a type of narrative interview, which are particularly appropriate when researching historical events and processes from the perspective of contemporary witnesses (Strübing 2013). Particular attention has to be paid to ethical issues in the search for potential interview partners, a trustful relationship between researcher and interviewee and the prevention of biased questions (Wierling, 2003).

3.3.1 Interview partners

The choice of interview partners was based on the following criteria:

Number of Interviews

Due to various aspects, the number of interviews that a researcher can conduct for a study is limited. On the one hand, the search for interview partners, and the implementation and evaluation, including transcription, are associated with considerable time resources. On the other hand, the researcher's ability to adequately consider different people in a complex context is limited. Wierling (2003) lists a sample size of 10-15 people as an example of a regionally limited case study, although this depends on the complexity and logistical possibilities of the study. Based on these methodological considerations, the targeted scope of this master's thesis and the background situation prior to the field stay, with no possibility to fall back on an existing network, ten oral history interviews were scheduled with retired farmers within the study region. This number is considered sufficient to make a consolidated statement and corresponds to SIPATH's practice for long term investigations. During the fieldwork, ten interview partners were initially found. However, one interview had to be cancelled at short notice; no replacement could be found. For this reason, a total of nine interviews were carried through. As the increasing size of the sample already manifested some patterns in the answers to the questions asked and the search for

further partners was no longer feasible for logistical reasons, the slightly reduced size of the sample size was nevertheless considered sufficient for the representativeness of the data set for the present study.

Age of the interview partners

The present study aims to reach contemporary witnesses of agricultural structural change over as large a time span as possible. In particular, the phase of the early post-war period, where the most significant changes are to be expected, as described in the introduction and the general trajectory of Breton agriculture, are of particular interest. In this sense, the search for interview partners should include both quite elderly and experienced people who have been retired for some time and younger, recently retired people. Although the field visit had to be postponed several times against the background of the covid pandemic, the search for such people turned out to be relatively uncomplicated, as this type of person was flexible in terms of time and took time for more extended conversations during the day. Consequently, the set of interview partners covered a broad time span, with the age of the interviewees ranging from 64 to 90 years. In this way, information could be gathered from about 1930 to the present, in other words, over almost one hundred years.

Location of the farm

When choosing the interview partners, the focus was on achieving the highest possible congruence with the perimeter for the analysis of landscape development according to chapter 3.5 of this thesis. The study area was thus initially limited to parts of the municipalities of Broualan, Cuguen, Trans-la-Forêt and Bazouges-la-Pérouse. Finally, the perimeter had to be extended to the neighbouring municipalities of Noyal-sous-Bazouges, Epiniac and Trémeheuc. Furthermore, no suitable interview partners could be found during the field visit in the municipality of Cuguen. However, the locations of the farms managed by the interviewees are so close to each other that a uniform landscape and agricultural development can be assumed. Therefore, the information collected on the development of land-use intensity and the perceived driving forces should also be related to the perimeter of the landscape development analysis. Possible differentiation due to different geological or administrative starting points must be considered accordingly in the analysis.

Availability

The search radius was extended for several reasons. Early organisation of the search for possible interview partners during the run-up to the field visit proved to be impractical. On the one hand, there was no current database of suitable people to fall back on. Furthermore, trust was an essential factor for the success of establishing contact. In the search for possible interview partners, it was beneficial to

draw on the network of previous interviewees. Thus, the set of interview partners was continuously compiled during the field stay using snowball sampling, according to Flick (2009). In this sense, arranging contacts through existing intermediary partners was a suitable solution to reach the required sample size during a time-limited field stay. The consequence of this approach was thus to also interview partners outside the originally envisaged study perimeter. Finally, it must be taken into account that this approach has a negative impact on the representativeness of the sample.

Function on the farm and in rural society

The choice of interview partners focused on people active as independent farmers at the farm level. The interview was conducted with the primary farm management in each case. A strong work-sharing between husband and wife, where both spouses shared the work equally, characterised the majority of the surveyed farms. Five of the nine interviews were conducted with a married couple. In three cases, the interview was conducted with a man alone; in one case, with a widowed woman who had run the business with her husband.

Due to the particular research interest regarding the role of the key actors in the development process, it was also of particular interest to meet interview partners who played an active role in rural social networks beside their farming activities. As already mentioned, the network of people already interviewed was beneficial in searching for interviewees. This approach also offered the possibility of explicitly searching for people who either had a function in municipal politics, associational activities or were involved in labour union activities. It was possible to talk to former trade union members, mayors, or assistants in this sense. On the other hand, the specialisation of the agricultural enterprise did not play a role. As a result, diversity characterises the range of farms surveyed. Additional information on the farms visited can be found in Table 4, which summarises the farms surveyed in Chapter 4.2 of this present thesis.

3.3.2 Questionnaire

For the SIPATH Project, a standardised questionnaire was set up; it is listed in Annex 8.1. This standardisation should make it possible to compare and transfer the results from the different study regions of SIPATH. Furthermore, in addition to specific questions regarding agricultural practice and landscape changes, general information about the interview situation and the persons was also recorded. Such information can help to contextualise the statements made in the later evaluation.

The questionnaire is divided into two main parts. In the first part of the interview, open-ended questions were asked, making it possible to gather insights into the perceived changes in landscape and agriculture from the interviewees' point of view. In the second part, questions were primarily based on the main

mechanisms of agricultural intensity change in Europe already described in chapter 2.1. The aim here was to assess the intensification processes and identify their driving forces. Therefore, in addition to practical questions about the farmers' occupation and business, the interviews also focused on the motivations and contexts of the decisions concerning adjustments to farming practices or changes in landscape elements at the farm level, which should provide new insights into driving forces.

Since there are sometimes considerable differences between the various study regions regarding the prevailing agricultural system, it was possible to modify the questionnaire in certain sections. In Brittany, for example, there was no need to ask about crop irrigation, as the climatic conditions allow farming without irrigation. Depending on the background of the interview partners, the questionnaire was also adapted, for example, to gain a better insight into different forms of rural organisation such as agricultural labour unions, associations or machine circles. As the number of interviews increased, it was also possible to go into the interviews with more in-depth prior knowledge, which meant that more precise questions adapted to the field of study could be asked from the outset.

Particular attention had to be paid to the appropriate translation of the questionnaire from English into French. Furthermore, in order to ask the right questions, the questionnaire was adapted several times to the corresponding agricultural vocabulary with the help of the local research partners of the LTSER *Zone Atelier Armorique*, the research setup described in chapter 3.1.4 of the present study.

3.3.3 Interview procedure

All interviews were conducted in face-to-face meetings at the interviewees' homes. Most of the interviewees still lived on the farm they had managed during their active life as farmers. This situation created a familiar atmosphere for an informal conversation. Prior to the interviews, a informed consent form was signed by each partner. This document is attached to this paper in Annex 8.2. This consent form is based on the European Union's General Data Protection Regulation and was drawn up in close cooperation with the French research partners. By signing the consent form, the farmers agreed that the collected statements could be analysed, stored and shared with research partners for the purpose of this study. At the same time, the researcher of this study undertook to anonymise the data used to protect the interview partners' personal rights.

The interviews lasted between 75 and 135 minutes and were recorded using an audio recorder. This technique had the advantage that few notes had to be taken during the interviews, making it possible to respond directly to the interviewees and react flexibly depending on the course of the conversation.

3.3.4 Evaluation

Transcription

The recorded interviews were then transcribed literally in French using the software MAXQDA Plus 2022. In addition to the interview partners' statements, the interviewer's questions and remarks were also transcribed. A particular challenge in this step was the transcription of interviews with two people, as the interviewees often completed each other's sentences, making a verbatim transcription difficult. In this context, the statements had to be simplified in some cases. However, since the interest in the interviews relates to the perceived aspects in connection with the research questions, the quality of the interview transcripts nevertheless corresponds to the research goals. In a second step, the transcripts were translated into English.

Coding & Qualitative Aggregation

A standardised evaluation of interview transcripts requires a structurisation of the gathered statements. In this sense, a classification of the contents based on predefined categories according to Strick (2009) was considered suitable. On the one hand, it was necessary to identify land-use intensity change and landscape structure statements. On the other hand, decisive driving forces of the described changes had to be determined. The transcripts were coded using MAXQDA as well.

The coding of the interviews regarding mechanisms of agricultural intensity change was based on the categories according to Diogo et al. (submitted) described in chapter 2.1, so that the mechanisms of agricultural intensity change could be determined at the farm level but also at a regional level . The coding of the interviews concerning the driving forces of the described mechanisms was done according to the five driving forces dimensions described in chapter 2.2 of this thesis. The entire volume of statements in the transcripts was checked for their relevance to the different categories of intensification mechanisms and driving forces and marked accordingly. It must be pointed out that individual statements were sometimes assigned to more than one category, as they could not be clearly assigned to one or the other. The categorised text passages were then exported as a coherent text document to make them available for further processing.

In a second step, a first range of possible subcategories of trends of agricultural intensity change was drawn up, same was done for possible drivers of change. In terms of trends of intensity change, the definition of main categories resulted from the perceptions of the interviewed farmers, on the evidence from statistical records and the landscape development analysis. The definition of the subcategories of drivers mainly resulted from the perceptions of the interview partners and was supported by the prior knowledge about the transformation processes in Brittany’s agriculture (see also Chapter 3.1.5). Using

inductive content analysis, according to Mayring (2000), the text snippets were then again checked for mentions of the possible subcategories as trends and drivers of change processes. By repeating this step with feedback loops, the definitive subcategories which turned out to be especially relevant were then aggregated qualitatively.

3.4 Local statistical data

To support the evidence collected through Qualitative Oral History Interviews, a collection of local statistical statistics data was carried out regarding indicators considered relevant for describing the intensification processes according to Diogo et al. (submitted). Therefore, proxies of interest concerned mechanisms of agricultural intensity change, according to chapter 2.1 of the present thesis. Records were available, particularly regarding farm concentration, whereas time series were also available to describe land management intensity and farm specialisation and diversification. There remains a gap concerning capital intensification; therefore, no data for the machinery available on the farms could be used. The combination of different indicators also made it possible to determine additional parameters.

For the records, the online services of the French Ministry of Agriculture and Food Agreste were used. This service enables municipality-specific filtering of the required data. To a lesser extent, the data collection is supplemented by data provided by the French national institute of statistics and studies Insee and other sources. Most of the indicators collected were available for the period stretching from 1970 to 2010, and in some cases, from 1988 onwards only. Evaluations and representations of the statistical data sets were carried out using Microsoft Excel 2010. Table 3 provides an overview of the indicators used and lists the corresponding source. The complete tables with detailed values can be found in Annex 8.4.

Table 3: Proxies for Mechanisms of Agricultural Intensification

Indicator	Administrative Level	Time Period	Source (All sites were visited in March 2022)
Population	Municipality	1876 - 2019	INSEE URL: < https://www.insee.fr/fr/statistiques/3698339 > (Date of access: 10.6.2022)
Annual work units in agriculture	Municipality	1970 - 2010	Agreste URL: < https://agreste.agriculture.gouv.fr/agreste-saiku/?plugin=true&query=query/open/G_2005#query/open/G_2005 > (Date of access: 10.6.2022)
Number of farms	Municipality	1970 - 2010	Agreste URL: < https://agreste.agriculture.gouv.fr/agreste-saiku/?plugin=true&query=query/open/G_2003#query/open/G_2003 > (Date of access: 10.6.2022)
Utilised agricultural area	Municipality	1970 – 2010	Agreste URL: < https://agreste.agriculture.gouv.fr/agreste-saiku/?plugin=true&query=query/open/G_2003#query/open/G_2003 > (Date of access: 10.6.2022)
Average farm size	Municipality	1970 – 2010	Combination of number of farms and utilised agricultural area.
Farms by utilised agricultural area (UAA)	Municipality	1970 – 2010	Agreste URL: < https://agreste.agriculture.gouv.fr/agreste-saiku/?plugin=true&query=query/open/G_2047#query/open/G_2047 > (Date of access: 10.6.2022)
Annual work units per farm	Municipality	1970 – 2010	Combination of number of farms and annual work units per farm.
Technical and economic orientation of farms (OTEX)	Municipality	1988 - 2010	Agreste URL: < https://agreste.agriculture.gouv.fr/agreste-saiku/?plugin=true&query=query/open/G_2002#query/open/G_2002 > (Date of access: 10.6.2022)
Cultivated crops	Municipality	1970 – 2010	Agreste URL: < https://agreste.agriculture.gouv.fr/agreste-saiku/?plugin=true&query=query/open/G_1013#query/open/G_1013 > (Date of access: 10.6.2022)
Drained areas in the UAA	Municipality	2010	Agreste URL: < https://stats.agriculture.gouv.fr/cartostat/#bbox=319591,6850078,745455,50425&c=indicator&i=cult1.saudrai10&t=A02&view=map1 > (Date of access: 10.6.2022)

3.5 Landscape Development Analysis

In accordance with chapter 2.1 of this study, an analysis of landscape development was carried out to characterise mechanisms of agricultural intensity change in the 20th century. The analysis consists of two main approaches. On the one hand, the change in land cover during the study period was analysed. On the other hand, the occurrence of landscape elements – in this case, individual trees and linear vegetation structures consisting of rows of trees and hedges – was used as an indicator of agricultural intensity.

3.5.1 Material

The spatial data were processed using software QGIS, Version 3.10.9. Quantitative evaluations and representations of the spatial data sets were achieved using Microsoft Excel 2010. Aerial photographs from 1952, 1974, 1985 and 2000, provided by The French National Institute of Geographic and Forest Information (IGN), serve as the basis for the landscape analysis. The recourse to these four different aerial images enables the reconstruction of landscape developments in approximately the same period as the data from the interview statements and statistics. For the year 1952, an online mosaic of the whole of Brittany was made available. It could be integrated into the project via a WMS connection. For the aerial photographs of 1974 and 1985, georeferenced aerial photographs were available from the LTSER *Zone Atelier Armorique* (see chapter 3.1.4). The aerial photograph of the year 2000 was not yet georeferenced, so it was georeferenced manually by defining a dozen pass points and thus made usable for the present work.

As a basis for the two analysis strands described in the introduction of this chapter, it was possible to fall back on data sets that the LTSER *Zone Atelier Armorique* also provided. The perimeter of the data sets corresponds to the perimeter of the "site atelier Agricole" introduced in chapter 3.1.4. Both data sets were generated using the aerial photographs described above.

Concerning the development of the land cover, vector layers that record the land cover in the study perimeter in the years 1952, 1974, 1985 and 2000 could be used. A distinction was made between built areas, wooden areas, arable land, grassland, water and streets. These data sets were compiled using the photo interpretation method, according to Bariou (1978). Since this procedure was not carried out in the context of this research, a detailed description will be omitted in this paper.

Regarding the landscape elements, raster data sets that record the *bocage* structures in the study perimeter in the years 1952, 1974, 1985 and 2000 could be used. This binary raster data set distinguishes all areas covered by trees and hedgerows. A convolutional neural network (CNN) was used to detect these structures. The application of this deep learning algorithm corresponds to the work of Ahlswede

et al. (2021). Since this procedure was not carried out in the context of this research, a detailed description will be omitted in this paper as well.

In order to compare the development between the different municipalities of the study perimeter, the administrative boundaries of the municipalities were used based on the Open Street Map (OSM), which the French authorities have made available as open data (Etalab, 2022). The vector layers with the municipalities were checked for accuracy, transformed into the projection of the QGIS project and tailored to the perimeter boundaries. This operation enabled the basic relative analyses per municipality.

3.5.2 Methods

Land Cover Development

The first step of landscape analysis was to determine how the land cover in the farm parcels of the study perimeter has changed in the indicated time span. The procedure in this sense essentially comprised the following work steps, which are also visualised in Figure 6.

1. Clip the vector layer on the study area of interest for SIPATH. Check for errors; troubleshoot if necessary.
2. Set symbology according to land cover classes.
3. Recalculate parcel size, export attribute table.
4. Quantitative analysis: share of land cover categories over time and parcel size over time, differentiated per municipality.

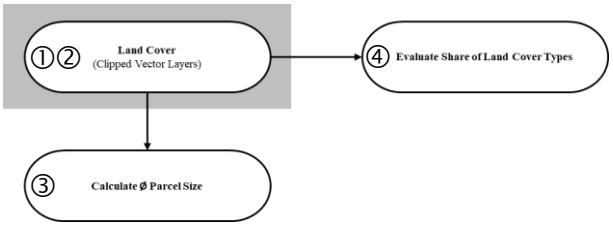

Figure 6: Workflow land cover development analysis

Numerical Development of the Landscape Elements

In addition to the land cover development, the analysis of the occurrence of different landscape elements was used as an indicator of agricultural intensity. In accordance with chapter 2.1, individual trees and hedges should be used as proxies. Forest surfaces were not considered for this thesis. The procedure in this sense essentially comprised the following work steps, which are visualised in Figure 7.

1. Clip the raster layer on the study area of interest for SIPATH; Check for errors; troubleshoot if necessary.

2. Only those elements located on the croplands, grasslands or accompanying adjacent roads and paths should be considered, as these can be used as a proxy for land-use intensity. The selection from the land cover vector layers was first limited to the land cover categories mentioned above using the query function. Forest areas and vegetation within the settlement were removed. All remaining polygons were merged into a single polygon vector layer for a better overview.

3. The existing raster layer representing the landscape elements of the different time steps was clipped with the generated vector layer from step 2 with the corresponding year.

4. Transformation of the generated raster layer from step 3, with landscape structures of interest, into a vector layer. All areas that were not assigned to the landscape elements were filtered out.

5. Calculation of the area of the landscape-elements polygons.

6. Differentiation between punctual and linear elements through the surface of the polygon. By comparing aerial images with the generated landscape-element layers from step 4, the threshold of 140 m^2 proved to be an appropriate value over all time steps. Other thresholds were also tried. Depending on the time step, a slightly higher threshold seemed more appropriate according to qualitative evaluation. This observation is supposed to result from the quality of the different images and the different recording times of the aerial images. For reasons of comparability, however, the same threshold was applied everywhere.

7. Quantitative landscape analysis: Count the number of trees and the surface of linear elements over time, differentiated per municipality.

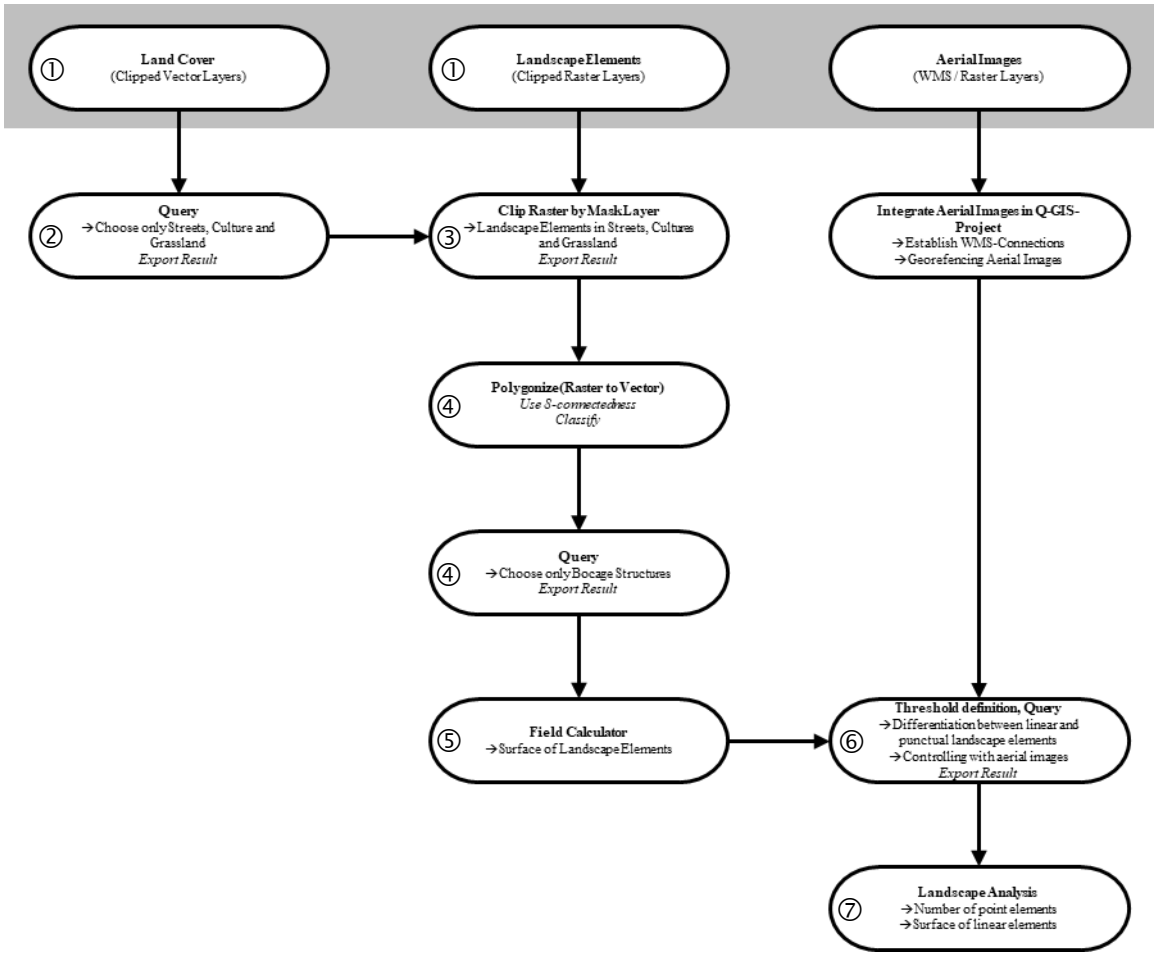

Figure 7: Workflow landscape elements development

4 Results

This chapter aims to reconstruct the agricultural intensification trajectory of the study region in the 20th century. To this end, Chapter 4.1 first presents the most important actors in the course of the change processes. Then, in chapters 4.2 and 4.3, the essential mechanisms of agricultural intensity change are traced, based on the interviews conducted, the statistical data analysis, and the landscape development study. Finally, chapters 4.4 and 4.5 link the most important mechanisms with the relevant actors and the driving forces identified. Figure 8 provides a chronologic overview of the active careers of the interviewees, the intensity changes identified and the related driving forces, which will be described in this chapter.

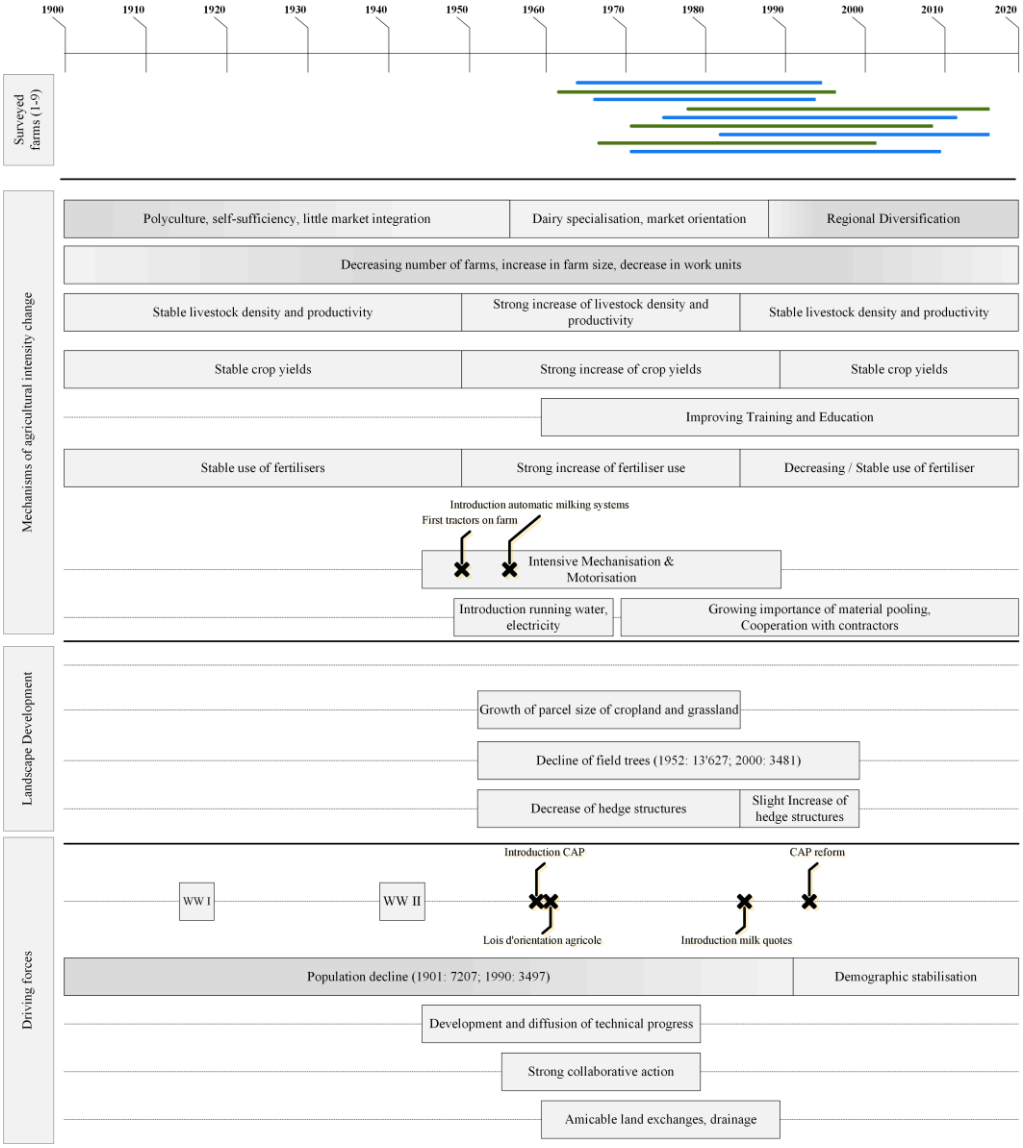

Figure 8: Time line with farmers carreers, main trends of agricultural intensity change and related driving forces

4.1 Actors

4.1.1 Surveyed Farms and Farmers

Farm 1: The woman interviewed was born in 1931 in a neighbouring village. She grew up in a family with eight siblings on another farm. Even though her father was not called up for military service during World War II, she remembers the German occupation as a difficult time marked by sacrifice and hard work. As a child, she and her siblings had to perform various tasks on the farm, such as herding the cows. She attended school until the age of 13. She later followed some correspondence courses with her sisters, where farm management and housekeeping basics were taught. Together with her husband, she took over a farm in 1964, which they ran until the mid-90s. The farm was mainly oriented toward the production of milk. At the same time, a variety of by-products were produced, which primarily served self-sufficiency. None of their children pursued an agricultural career or continued to run the farm. The land was taken over by expanding farms.

Farm 2: The interviewed farmer was born in 1935 and grew up on a farm with seven siblings. He came into contact with agricultural work as a child, as he had to do various jobs on the farm. From 1956 to 1958, he was called up for military service in Algeria. According to his statement, the farmer did not intend to become a farmer himself but wanted to learn another profession. However, when he returned from military service, his father was already widowed, and most of his siblings had already left the farm. Against this background, he stayed on and took over the farm with his wife in 1966, when his father retired. According to his statement, he learned the farming profession through practice. However, he took some correspondence courses to learn the basics of agriculture. The farm was mainly focused on dairy production. In 1995, he handed over the farm to one of his sons, who now runs the farm with his own son.

Farm 3: The woman interviewed was born in 1939, the husband in 1931. Both come from farming families, one in the same village and the other in a neighbouring village. The husband states that he and his seven siblings were already helping with milking and herding the cows at the age of six, mainly because his father died shortly after his birth, as did his mother's later husband. The interviewed couple remembers that French and German forced labourers were subsequently employed on the farm during the war. Schooling was not always guaranteed during the war years and finally ended at the age of twelve to fourteen. In 1966, the couple was able to take over the farm from the man's mother. In addition to milk, the farm also produced in the beginning veal calves and fattening pigs. However, with a growing family, the latter branches of the farm were given up again to have more time for the family. The training consisted of correspondence courses and a more in-depth course in Rennes for the husband. In 1994, the farm was handed over to a son, who still runs the farm today.

Farm 4: In the interviewed couple, the husband is 67, and the wife is 64. While the husband comes from a farming family, the wife grew up in a family of merchants and workers. In 1977, when the husband's father died, the couple was able to take over the dairy farm previously run by the husband's parents. Neither the husband nor the wife received any agricultural training but learned the profession empirically. However, the value of the CETA, the Chamber of Agriculture and the dairies themselves is emphasised. In addition, knowledge could be expanded through discussions and courses. The husband always ran the farm full-time, while the wife worked part-time as a secretary in an agricultural insurance company for a while before turning to a full-time occupation on the farm. In 2014, the farm was handed over to a young successor outside the family, as no family succession plan could be found. It was important for the couple that the farm could be handed over in this way and not just absorbed by a larger farm.

Farm 5: The interviewed couple ran the farm together after establishing themselves on the farm in 1973. The husband (72) has already grown up on this farm. His wife (71) comes from a farm in a village about 10 kilometres away. The farmer completed an agricultural certificate in Rennes. Originally specialised exclusively in milk production, the product range was expanded over time to include meat production, coupled with an increasing agricultural surface. In the mid-90s, the couple formed a GAEC with a son. They worked together for a while on the existing farm from then on. Around 2005, the farm was finally handed over to the son.

Farm 6: The interviewed farmer, born in 1945, ran the farm from 1970 to 2007. From the age of 14 to 17, the farmer completed a professional agricultural certificate in Dol-de-Bretagne. He then worked on his parents' farm, where he had grown up. A few years later, he could take over the farm definitively with his wife. The farm was initially specialised in milk production but soon switched to meat production against a background of brucellosis epidemic. After retirement, the couple handed over the farm to a son. He still runs the farm today but has a job as an employee in the agro-alimentary sector alongside his farming activities. The interviewed farmer still goes to work on the farm every day.

Farm 7: The interviewed farmer is 67 years old, his wife 63. They established themselves in 1980 on the farm of the husbands' parents. The wife is from a village 5 kilometres away. The farmer had been working since the age of 18 in an agricultural company that provided services to farms and got an agricultural certificate after two years of training. The wife has retired from farming due to health problems and has taken a job in a nearby car factory until retirement. The farm was characterised by a great variety of productions, ranging from milk and meat to tobacco production. After the couple retired in 2014, nobody took over the farm since their children were not interested in facing all the constraints

and the immense responsibility. Larger farms in the surroundings took over the agricultural surface. Nowadays, the couple no longer has any active involvement in agriculture.

Farm 8: The interviewed farmer is 80 years old and took over his parents' dairy farm with his wife in 1965. The couple had a strong will to develop and enlarge the farm. The farmer was active for a long time in leading positions at various levels in the FDSEA/FNSEA, the largest agricultural trade union. As such, he was involved in land consolidation processes, organisation of demonstrations, and training of other farmers. In addition to his trade union activities, he was also active in local politics and associations like the JAC. Together with his wife, he has expanded the dairy farm over the years to include a large pig farm. Since his retirement, he no longer lives on the farm and is no longer active on the farm, which was passed on within the family.

Farm 9: The interviewed farmer is 75 years old and affirms that he has always been a farmer since he started working on the farm when he was 14. He and his wife have both completed a professional agricultural certificate. They worked for the husband's parents until 1969 when they took over the parental farm. In addition to meat production, salads were also produced for some time, making it economically possible for the son – who entered the business in 1997 – to take over. For a while, both generations were involved in the business structured as a GAEC. The parents then withdrew during the 1990s. To the present day, the interviewed farmer works almost every day on his son's farm and participates in cattle breeding. The animals are presented at cattle shows in the region.

4.1.2 Farm environment

Based on the statements obtained and the literature study carried out beforehand, an inventory of the relevant actors in the operating environment of the surveyed farms is drawn up. Actors can be either organisations, informal groups, or individuals. The actors are divided into different categories that can be meaningfully distinguished from each other. These categories are: a) economic actors; b) labour unions and associations; c) institutional actors; d) affiliated individuals. It should be noted that overlaps between the categories are also possible in some cases; the farmers were connected to the organisational structures listed above because of their relationship to individuals acting within them. Figure 9 provides an overview of all the actors whome the farmers interviewed described as relevant in their actions. The development of farms visited is presented in chapter 4.2.

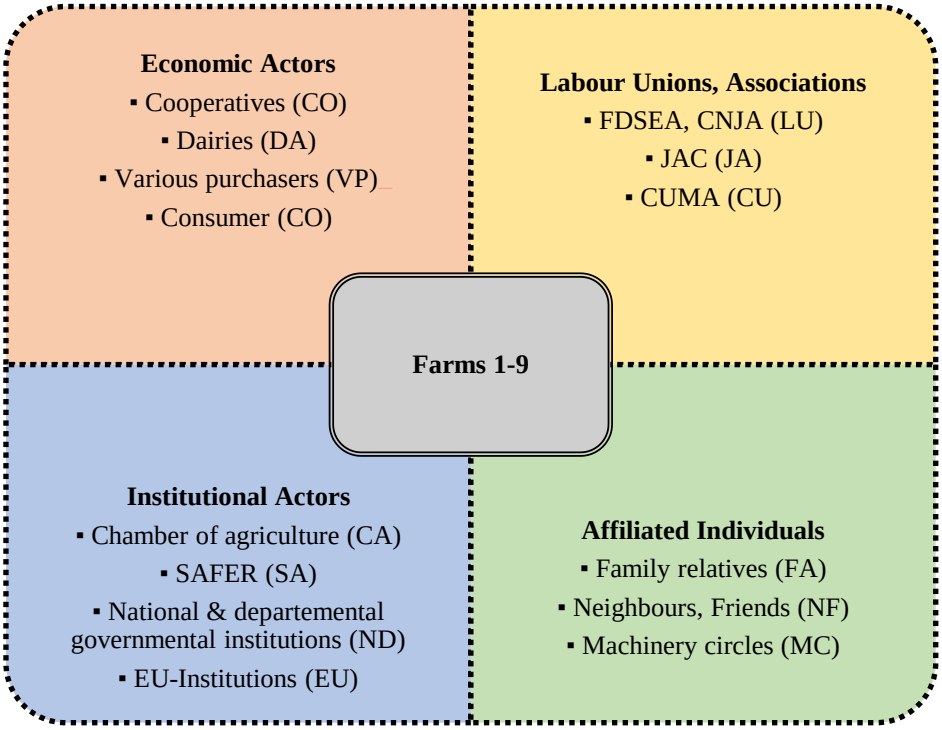

Figure 9: Key actors in farm environment

Economic Actors

- Dairies are described as the main customers of the farm production during the active period of the interviewed dairy farmers. These dairies were said to be in Brittany and neighbouring Normandy. The interviewees' statements cannot deduce the extent to which these were cooperatively organised structures. Representatives of the dairies also acted as consultants for production methods.

- According to the statements collected from the dairy farmers, cooperatives primarily act as suppliers of seeds, seedlings and fertilisers. In some cases, the cooperatives were also described as suppliers of tools and machinery. Representatives of the cooperatives also acted as advisors for cultivation methods.

- During the meat producers' active years, cooperatives were described as the principal customers of the farm production. Representatives of the cooperatives also acted as advisors for breeding strategies.

- To a lesser extent, labels or specialised butchers were also mentioned as meat buyers.

- In addition to regional farms as direct buyers, independent cattle merchants who resold the animals were also mentioned as buyers of suckler cows.

Trade Unions an Associations

- The FDSEA, the departmental branch of the largest national trade union FNSEA, was the main active trade union in the region. Seven of the farmers interviewed stated that they were members of the union at least some of the time. Their organisation for the youth CNJA was also active in the study area. However, the membership of the interviewed farmers in this latter organisation could not be reconstructed. Another active movement in the region was the *Paysan travailleur*, which was active in the 1970s.

- The youth organisation JAC was present in the municipalities of the study area. The JAC showed organisational proximity to the parish. Two of the interviewed farmers stated that they had been active in this organisation. According to one statement, many people active in the JAC were later leading figures in the trade union movement.

- According to the farmers interviewed, there were CUMAs in most municipalities. It is not easy to reconstruct when they were founded, but it is mentioned that new ones were founded in the 1960s and 1970s. According to one statement, it was also common for CUMAs to be founded by trade unions, and there were sometimes several CUMAs per municipality if different trade unions were

active within the municipality. Several people interviewed stated that they had belonged to a CUMA during their active period. Currently, official CUMAs are only listed in Bazouges-la-Pérouse.

- A CETA is a group of active farmers who pool their experience and financial resources in the hope to improve their farms technically, economically and sustainably. A significant action area for CETAs includes joint training. Only one person stated that he had been a member of a CETA.

Institutional Actors

- The Chamber of Agriculture is an organisation with a public character. The Chamber of Agriculture's structure is based on the levels of the French State and is thus organised at a national, regional and departmental level. At the departmental level, the Chamber of Agriculture is composed of elected members who represent active and former farmers, landowners and employees working in the agricultural sector. Its main tasks are to represent farmers' interests and support them with information, training, and project management.

- The SAFERs originated in the early 1960s and are organised on a regional basis. They were mentioned as an important actor in land consolidation by three of the interviewed farmers. They are anonymous non-profit *sociétés anonymes* under the supervision of the Ministry of Agriculture and were initially set up to promote a better farm organisation in terms of higher productivity and the rejuvenation of farms. The SAFERs intervened in the land market through their land acquisitions and accompanied the dialogue regarding land reorganisation. The areas of responsibility have expanded over the decades, especially regarding environmental and landscape protection.

- The discussions repeatedly pointed out the importance of legal foundations at the national or European level. The farmers interviewed primarily characterised the departmental, national and European institutions as bodies that shape from the outside the framework conditions for development. As a legislative body, they were described as little tangible and, for the politically active among the interviewees, were primarily portrayed as an actor against whom one stood up in demonstrations.

Affiliated Persons

- In addition to the CUMAs mentioned above, there are also descriptions of farmers forming private communities to share agricultural tools and vehicles. These machinery circles usually included 3-4 neighbouring farmers.

- Neighbours, friends and family members were mentioned by most of the interviewed farmers within the context of personal decision-making in the role of reference persons. It was mentioned that both familiar life situations and advice from the close entourage were included in the decision-making process for farm-related projects.

4.2 Mechanisms of Agricultural Intensity Change

Table 4 below provides an overview of agricultural transformation at the farm level. In combination with the statistical data collected, the statements presented are used in the following chapters to address research question A ("How did land-use intensity and landscape evolve?").

Due to the incomplete quantitative significance of the statements obtained, numerical comparison of the farms visited is only possible to a limited extent. Where numerical values could be collected at the time of farm takeover and farm handover, these are listed accordingly. For farms where no quantitative information could be obtained but where the respondents perceived a qualitative development over the time of the farm activity, the indicators are characterised by a tendential increase (↗), no perceived change (→) or a tendential decrease (↘). In cases where no information could be obtained, an N.A. (not answered) indicates the lack of data. A complete overview of the farm characteristics can be found in tabular form in Annex 8.4.

Subsequently, the statements collected in the OHIs are summarised, referring to the different agricultural intensity change mechanisms. Individual quotations support the significance of the respective overviews. Finally, statistical data matching the various categories supplement the summaries. Table 3 in Chapter 3.4 contains the references to the statistics.

Table 4: Mechanisms of Intensity Change on the Surveyed Farms										**Legend**: ↗: Growth trend; →: No changes; ↘: Declining trend; n.A.: not Answered
Indicator		**Farm 1**	**Farm 2**	**Farm 3**	**Farm 4**	**Farm 5**	**Farm 6**	**Farm 7**	**Farm 8**	**Farm 9**
Farm Size [ha]	1	15	4	23	20	26	45	40	30	18
	2	15	35	33	55	80	75	60	n.A.	125
Δ, Trend		0	+31	+10	+35	+54	+30	+20	n.A.	+107
Share of Cropland	1	1	0	Minority	5	0	n.A.	25	n.A.	n.A.
	2	1	10	20	30	n.A.	Min. 30	n.A:	n.A:	n.A.
Δ, Trend		0	+10	↗	+25	↗	↗	↗	n.A.	n.A.
Trend Yield per Area		n.A.	n.A.	n.A.	→	n.A.	→	↗	n.A.	→
Livestock (Adult Animals)	1	3	4	14	25	n.A.	n.A.	20	18	12
	2	16	25	52 dairy cows, 100 pigs	40	50 dairy cows, 20 limousine cattles	32 calves, 56 sows	45	60 dairy cows, 800 pigs	135
Trend Animal Productivity		↗	↗	↗	↗	↗	↗	↗	n.A.	↗
Trend Frequency of Use (mowing & grazing) of Grasslands		→	→	→	→	→	→	→	n.A.	n.A:
Trend Fertiliser Use		↗	↘	↗	↗	n.A.	↗	→	n.A.	↗
Drainage		No	n.A.	Yes	Yes	Yes	Yes	Yes	n.A.	Yes
First Tractor on Farm		1975	1963	Ca. 1950	1964	1958	1952	Before 1960	1963	1952
Trend number of Tractors		↗	↗	→	→	→	↗	n.A.	n.A.	→
Workforce per farm	1	2	2	3	1.2	2	3	2	2	2
	2	2	2	2	2	2	2	1.2	2	2

4.2.1 Land Management Intensification

Increase in Livestock Density and Productivity

According to the interview partners, a specialisation in dairy farming characterised the research area. The composition of the livestock also reflects this. Typical breeds for milk cows were *Bretonne pie noir* or *Normande*. Furthermore, certain species were bred for meat production, partly also as a strategy to develop additional sources of income. Typical meat animals were pigs for fattening and piglets, fattening calves, veal and bullocks (*taurillons*). *Limousine* or *Charolais* cows were quoted as typical breeds for suckling cows. Poultry, rabbits and pigs were also kept to a lesser extent on many farms, but these were primarily intended for home consumption.

All the interviewees have increased their herds during their professional careers, although to different degrees. At the beginning of the survey period, between 1960 and 1980, the livestock numbers of the surveyed dairy cow farmers ranged from 2 to 15 animals. The number of livestock was then continuously increased during the farmer's career. The interviewed farmers testified that until the middle of the 1980s, the maximum size of cowherds reached 40 to 60 animals. The heifers, which ensured the continuity and growth of the herd on the farm itself, must also be added here. It was generally stated that about as many young animals were kept as adult cattle. In the subsequent period, from the mid-1980s onwards, stagnation or decline of the size of dairy herds is then described. The reduced number of cattle was partly compensated by establishing additional herds. These usually consisted of suckling cows or temporary rearing of young animals for meat production.

The productivity of the dairy cows could only be reconstructed to a limited extent with quantitative trends. However, eight of the farmers interviewed stated that revenue per animal had tended to increase in the course of their careers. The quantitative statements range from a doubling (farm 2) to a tripling (farm 5) or even a quadrupling (farm 3) of the annual revenue per dairy cow.

Increased Cultivation of Rotational Crops, Decrease of Grassland

According to the interviewed farmers, rotational crops played a minor role in the agriculture of the study area until the middle of the 20th century. A large part of the UAA was kept as permanent grassland and used for grazing or hay production. To feed the cattle and partly for the farmers' own consumption, beetroots, cabbage, and potatoes were cultivated to a small extent. Cultivation of these crops has been on the decline since the 1950s. Five of the interviewed farmers who took over the farm between 1961 and 1977 stated that they had mainly cultivated grassland at the beginning of their careers. During those farmers' professional activities, an increase in the proportion of land used for rotational crops is described. Fodder maize, wheat depending on the farm, and to a lesser extent, barley and oats, and sweet maize for sale were particularly mentioned by the interviewed farmers. The cultivated cereals were generally primarily intended for sale rather than animal feed. Other crops that were produced to secure fodder for the farmers' livestock – and to a lesser extent, for commercialisation – include rapeseed, sunflowers or flax, although these tended to be of minor importance.

Accordingly, a decrease in the share of grassland is reported. Ryegrass and, to a lesser extent, lucerne were mentioned as being typical grass varieties in pastures. However, lucerne was increasingly avoided because the cows noticeably preferred other varieties due to the intense taste. The interviewed farmers stated that they could not detect any noticeable changes over the years regarding the first mowing or the start of the grazing season. Also, precise quantitative statements regarding the number of uses are only possible to a limited extent. In general, it can be said that since the beginning of the agricultural activity of most respondents, the frequency of use for both pasture and hay and silage production was estimated to be stable.

The development described by the interviewed farmers is also visible in the corresponding statistical data, which are graphically represented in Figure 10. From 1970 to 2010, a decreasing proportion of the UAA was used as permanent grassland throughout the municipalities of Bazouges-la-Pérouse, Broualan, Cuguen and Trans-la-Forêt.

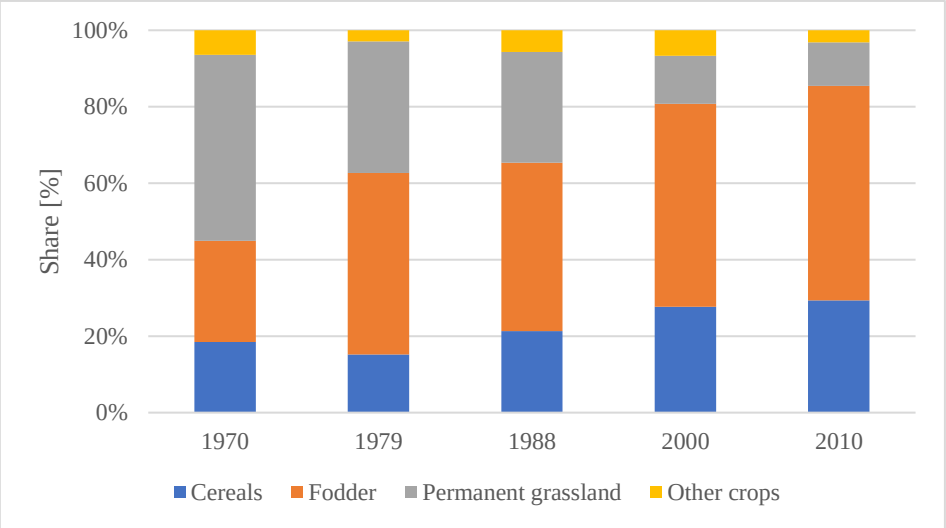

Figure 10: Share of different cultures in total UAA (Data source: Agreste, 2022)

Specific nuances between the different communes are discernible. However, the general trend is that the proportion of UAA devoted to fodder production has increased considerably. The proportion used for the cultivation of cereals has also increased, although at a somewhat lower level.

Increased Crop Yields

On the basis of the conducted interviews, it was not possible to make a quantitative evaluation of changes in crop yields. However, on the farms where it was possible to obtain statements regarding this aspect, it was noted that crop yields tended to increase during the course of the farmer's career. No suitable local statistical values could be used to verify these statements.

Minor Drainage Activities

Quantitative statements on the extent of drainage measures on the surveyed farms, based on the statements obtained, are not possible. On six farms, however, the retired farmers indicated that certain areas had been drained during the course of their careers but that no large areas had been affected. For those interviewed farmers where a more specific temporal statement could be obtained, these measures were located temporally in the 1970s and 1980s. The interviewees also mentioned that the drainage of further areas was no longer practised in the following decades. In general, drainage does not seem to have played a significant role in the intensification process. Concerning this aspect of land-use intensity, it is worth looking at the current statistics related to the proportion of drained land in the UAA, listed in table 5; they are all at a low level (Agreste, 2022).

Table 5: Share of drained areas in total UAA

Level	Share [%]
Bazouges-la-Pérouse	1,5
Broualan	2,7
Cuguen	4,6
Trans-la-Forêt	0,2
Ille-et-Vilaine	14.8

4.2.2 Capital Intensification

Increased Motorisation

Regional agriculture between 1930 and 1950 – which represents childhood time for most respondents – is generally characterised by the interviewees as poorly equipped. Most of the fieldwork was carried out by hand or using horses. However, there were already horse-drawn specialised tools used, for instance, for mowing or potato harvesting. Subsequently, most of the respondents remember the introduction of the tractors. This breakthrough is described by all interviewees from the study area as a decisive change, as the following statement summarises:

> *"We saw the combine harvesters with a small tractor [arrive], […], well that was an incredible breakthrough. It wasn't the same, because threshing was a big party [before], there were 30 or 40 people, it was huge." (Farm 5)*

The motorisation of the farms is dated around 1945 at the earliest, and mainly in the 1950s and 1960s. Depending on their age, the interviewees were present as farmers' children, grandchildren or even active when the first tractor arrived on the farm, and they still remember this event. Therefore, most of the respondents were used to working with tractors since the beginning of their careers.

The interviewed farmers stated that in the course of their agricultural activity, some of the tractors were replaced when they could no longer meet the technical requirements. Over the decades, investments were thus made in increasingly high-performance vehicles. However, on most of the farms surveyed, no increase in the number of tractors was described. Besides, CUMA or agricultural contractors provided an increasing part of the fleet as motorisation of the tasks progressed. Further information regarding this aspect can be found in chapter 4.2.6. The use of machines that can combine different tasks, such as grass seeders, fertiliser and corn drills, harvesters, slurry tankers, cow trailers or hay balers, was directly related to the arrival of tractors in local agriculture. In addition to fieldwork, the tractors were also used in farm logistics to transport animals, fertiliser, seeds and crops.

Increased Mechanisation and Investments in Infrastructure

The older interviewees stated that they could still remember that the cows had to be milked by hand during their childhood. The arrival of the first mechanised milking machines can be traced back to the 1950s. From the late 1960s onwards, entire milking parlours were installed, making it possible to simplify the work processes by transferring the milk directly to a central reservoir. The mechanisation of milking is described as an important further development, as illustrated by the following statement:

> *"I don't remember the year I got the milking machine, but I got it very late. […] It took a lot of pressure off my arms. Because of all the manure and all that was taken to the fields, everything was done by hand. We had to put the manure around the fields like that. We had to get up at two o'clock in the morning to do this [milking] before the children went to school. We had no choice." (Farm 1)*

The installation of automated milking systems was particularly dependent on the farm's connection to the electricity grid. This date cannot be reconstructed for all farms but is usually estimated to be in the

1950s and 1960s. The arrival of running water is not reconstructible for all farms either. However, some farms were not connected to the water supply until the 1960s. Another advantage mentioned concerning the connection to running water is the improved possibility to give water to the cows in the fields. Before that, animals could only be supplied with water in the evening when they were led back into the stable.

In this context, the investment in infrastructure required for the farm expansion, such as slurry pits, stables and feed silos, should also be mentioned. However, only a few statements were collected regarding this aspect of capital intensification. There are also descriptions of larger jobs being taken on by contractors. One interviewee explained the advantages of such an approach as follows:

> "*The contractor has recent, high-performance, low-cost equipment, and if we had done it as individuals we would have had to invest as much. We preferred to leave it to a contractor, and we were left to look after our herd and do the work.*" (Interview 4)

Improved Training & Education

The older interviewees, especially those born between 1930 and 1950, stated that they had basically learned the agricultural profession "*by nature*" (farm 2) since childhood and have "*always been a farmer*" (farm 9), starting to help on the parental farm before finally taking over the exploitation. The agricultural education of the previous generation was characterised as primarily "*empirical knowledge*" (Farm 4). With regard to the generation of the farmers' parents, it is generally described that only a few people have received professional training in a school specialised for this purpose.

In general, the people interviewed described a development that led aspiring farmers to be increasingly trained in appropriate schools in the region. Hence, most of the interviewed farmers have completed some training in the agricultural sector. Until the 1960s, education was described as being likely achieved through correspondence courses. According to the descriptions, modern agricultural training became established mainly from the 1980s onwards. It was also stated here that the receipt of agricultural aid for setting up a business depended on completing specific training.

In addition to the conventional training paths at agricultural training institutions, several of the interviewed actors also stated that they had made use of additional training opportunities that had been created. These were organised, for example, by the Chamber of Agriculture, the FDSEA labour union, cooperatives and dairies, or within the CETA framework. To a lesser extent, personal training through specialised journals was also mentioned.

4.2.3 Input Use Intensification

Variable Use of Fertilisers

From the statements of the interviewed farmers, it can be seen that mineral fertilisers were already used in agriculture during the first half of the 20th century. However, it is emphasised that the use of mineral fertilisers played a rather subordinate role in the overall composition of fertilisers, as can be gathered from the following statement:

> *"There was none or very little. It started after the war. I remember at my parents' house, we had small harvests." (Farm 3)*

Most of the fertiliser was provided by organic manure produced on the farm. While a large part of the fertilisation is still described as organic fertiliser from farm production, the statements of the interviewed farmers generally indicate increasing use of mineral fertiliser in the second half of the 20th century. Since the 1980s, a decreasing trend is reported.

Decreasing Workforce Development

The farmers interviewed stated that they had not noticed any significant changes in the amount of work during their careers. This situation is also expressed through a mostly stable to slightly decreasing number of workers employed on the farms, whereby it was stated that the farms were usually managed by married couples working together. A reduction in the number of working units on the surveyed farms was mainly attributed to the abandonment of auxiliary workers. Instead, the interviewed farmers stated that the amount of work in hours was basically the same, but that the type of work had changed with regard to the increasing motorisation and the improved equipment. In this sense, the interviewees described, in particular, the time of their childhood when more physical work had to be done due to a lack of equipment. The following quotation underlines this development:

> "*Yes, compared to earlier, people now work less. We had more trouble, and the work was more physical. Today they have work, but it's different. The straw was in small bales, and it was done by hand. The bags of fertiliser were 50 kilos, now they are big bags, with the tractor. We worked more physically."* (Interview 6)

However, this description of stable development of the work units employed only refers to the individual farms. Based on available statistics, a significant decrease in the absolute number of people working in

agriculture can be observed on a regional level. Figure 11 shows the trend for each municipality of annual work units in agriculture in the study area since 1970. By the year 2000, the absolute number of annual work units had fallen to about one-third of their original value. Since the turn of the millennium, the decline in the labour force has slightly slowed down.

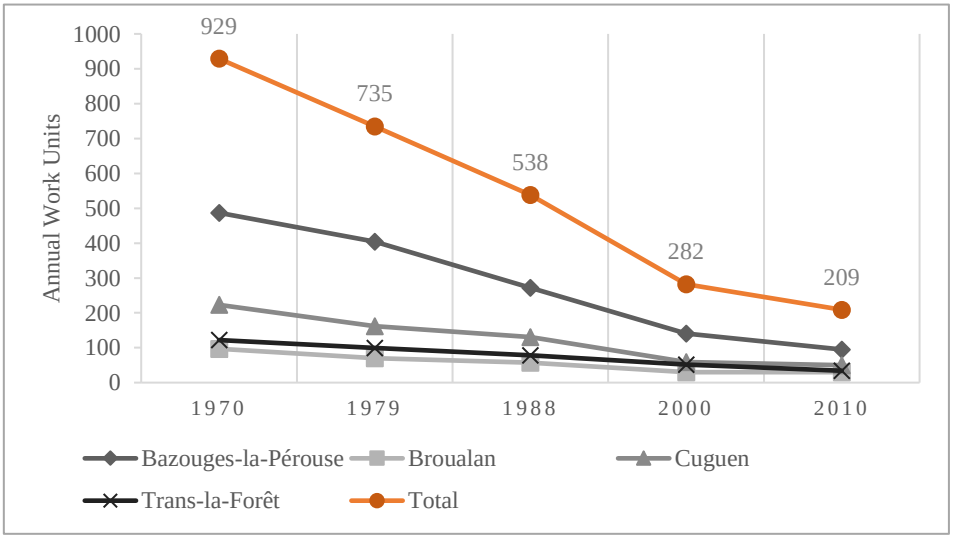

Figure 11: Absolute number of annual work units from 1970 to 2010 (Data source: Agreste, 2022)

Combining this dataset with the number of farms in the study area allows the reconstruction of the number of annual work units per farm within this period. Figure 12 shows that after a decline from 1.55 in 1970 to 1.32 in 2000, the average annual work units per farm have risen again since the turn of the millennium. In the year 2000, around 1.6 annual work units per farm in the study area were recorded. This statistical trend is somewhat consistent with the stable development of the number of people employed on the farms, as described by the farmers interviewed.

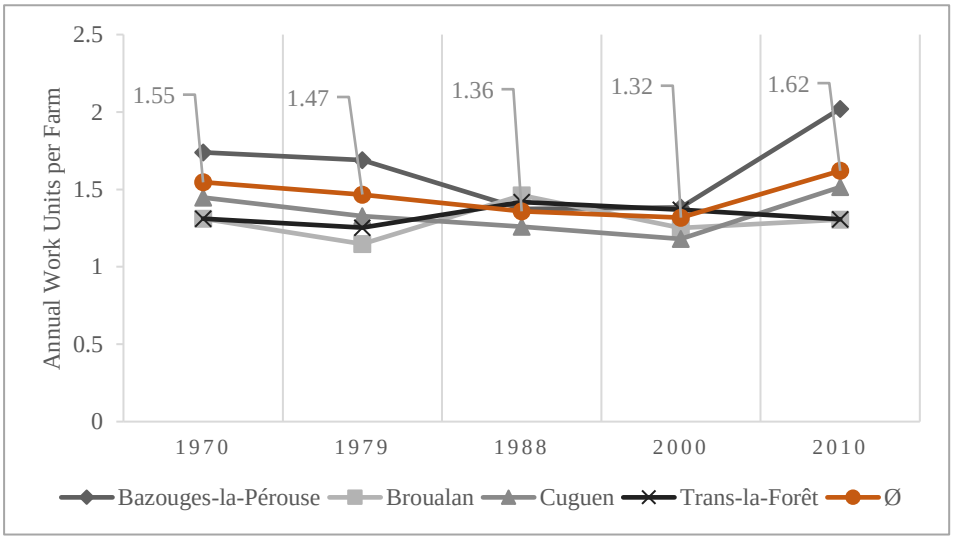

Figure 12: Annual work units per farm from 1970 to 201 (Data source: Agreste, 2022)

4.2.4 Farm Concentration

Reduction in number of farms

The statements made by the farmers interviewed describe a significant decline in the number of farms during the 20th century. Based on the statements, the decline can mainly be traced back to the 1960s, although no quantitative statements could be collected. This farm concentration process was characterised by one interviewee in a broader sense as follows:

> "W*e started in 1977, and we finished in 2014. So we were active for 37 years. We started with a large and diversified agriculture and at the end of the course we arrived with a much smaller number of farmers. Many farms have disappeared with specialised production.*" (Farm 4)

The disappearance of farms had particularly continued at the time of the respondents' retirement. This was approximately in the period between 1990 and 2010, as can be gathered from the following statement:

> "*There aren't many farms left in Trémeheuc, eh? Because almost all the people of our age, when they left, well, it was too small, so the farms were basically abolished.*" (Farm 1)

These descriptions are also supported by the statistics available from 1970 to 2010, which are presented in Figure 13. In all municipalities of the study perimeter, the number of farms has decreased by at least half during this period. A major decrease in the number of farms between 1988 and 2000 can be observed, particularly in the municipalities of Bazouges-la-Pérouse and Cuguen.

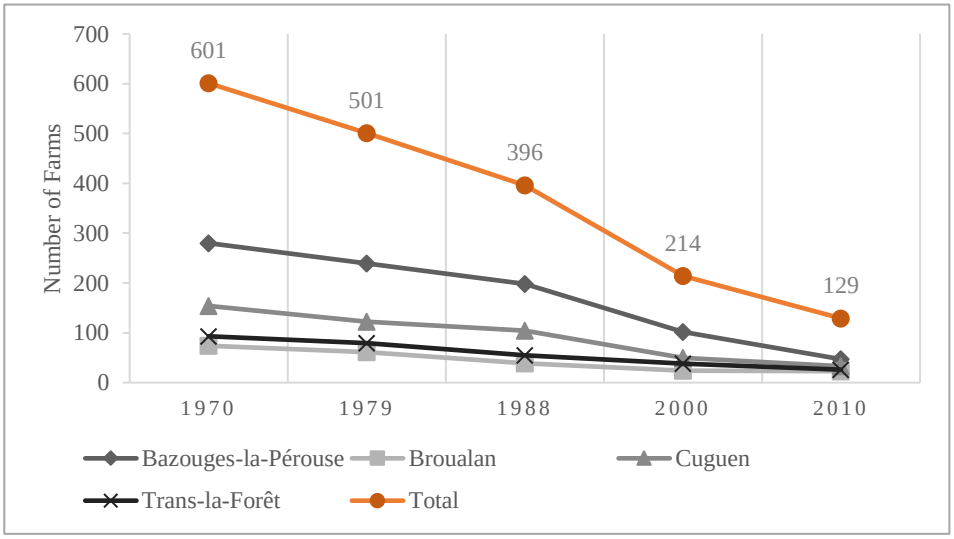

Figure 13: Number of farms between 1970 and 2010 (Data source: Agreste, 2022)

Expansion of the farm area

The total area of the UAA in the study area has remained relatively stable between 1970 and 2010, as can be seen in the statistical data. Only minor deviations can be detected, with an intermediate low point in 1988, as shown in Figure 14. The development is comparable in all municipalities.

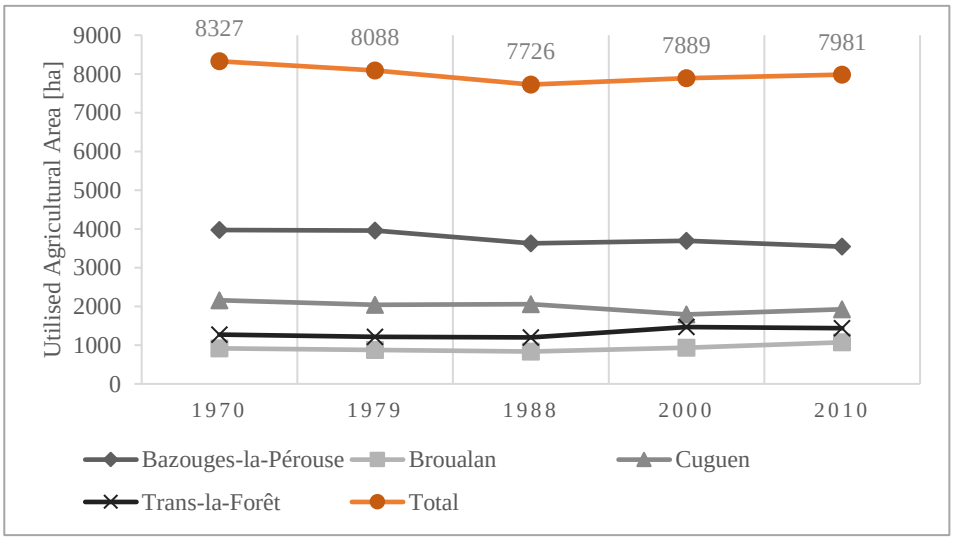

Figure 14: Total utilised agricultural area between 1970 and 2010 (Data source: Agreste, 2022)

Parallelly to the described development of the decrease of the absolute number of farms, the statements of the interviewed farmers reveal a somewhat significant expansion of the cultivated UAA per farm. Eight out of nine farmers interviewed stated that they have increased their UAA in the course of their activity. The eight farms for which quantitative data could be recorded have all increased by around 35 hectares on average throughout the farmers' careers. This corresponds to an average growth rate of around 150%. This development was exemplified by one interviewee as follows:

> "*We started with 26 hectares, then we took over all the small farms around where there were 3 or 4 cows, so 3 or 4 hectares, 4 or 5 hectares, and we ended up with 80 hectares. And then we set up a GAEC with the son. He took over two farms as well, he took over a farm from a neighbour, and then he took over the other farm from his brother-in-law. And he ended up with 130 hectares.*" (Farm 5)

Combining statistical information regarding the number of exploitations and utilised agricultural surface, it is possible to calculate the development of the average size of farms between 1970 and 2010, which is presented in Figure 15. In 1970, an average farm in the study area cultivated about 14 ha of land. In 2010, the average farm size was about 60 ha. A sharp increase in farm size can be observed since 2000.

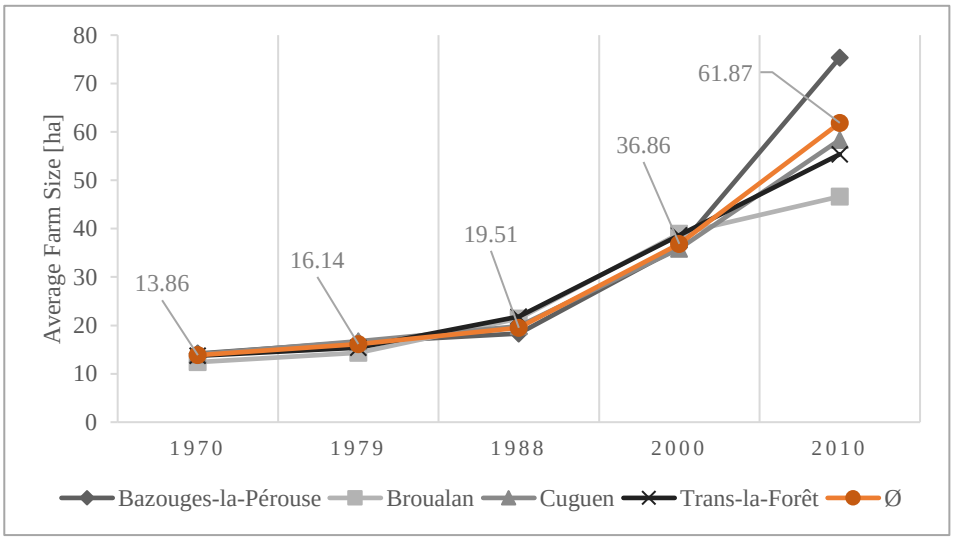

Figure 15: Average farm size between 1970 and 2010 (Data source: Agreste, 2022)

4.2.5 Farm Specialisation & Diversification

Regional dairy specialisation

The interviewees describe quite diversified agriculture until the 1950 and 1960s, which in most cases corresponds to the time of their childhood and youth. The predominant farming system is characterised as crop-livestock production. In addition to the farming of dairy cows, the interviewed farmers also emphasised that the production of a wide range of different agricultural products was suited to self-sufficiency. This applies in particular to goods such as eggs, poultry, rabbits or garden crops such as potatoes or beans. A common practice on most farms also involved the production of apple-based beverages such as *cidre*, *pommeau* or *calvados*. The diverse farm production is exemplified in the following statement:

> "*We used to get money from a little bit of everything. People from the city came to the farms […], and we gave them merchandise, either milk, butter or pork, beef, meat […]*" (Farm 3)

The statements indicate that this production diversity changed during the post-war period. The majority of the farms were described as specialising in milk production, which peaked in the 1980s. Eight of the interviewed farmers stated that when they took over their farm between 1960 and 1980, they were already running a farm that specialised mainly in dairy farming. The interviewees characterise this specialisation in milk production by the expansion of the infrastructure (see Chapter 4.2.2) and the corresponding production of fodder (see Chapter 4.2.1).

Recent Diversification

Among the eight investigated farmers who specialised in dairy farming when they took over the farm, seven stated that they had expanded their farm in the course of their career with additional production branches. The diversification of the farms in this phase was particularly oriented towards meat production, as can be gathered from the trajectory described in the following statement:

> "*[…] at the beginning of the 1980s, […] we had a lot of heifers, which we were forced to sell at very low prices. […] So, with the sale of these animals, we set up a suckler herd alongside, so as not to lose the whole herd. We changed herd, we went to Limousin cattle, and set up a herd of Limousin cattle next door*." (Farm 5)

However, a broadening of the range of varieties planted was also mentioned. For example, on one farm, it was stated that blond tobacco was cultivated in parallel with milk production for about ten years. According to several farmers, this was a local speciality that some practised during a period ranging from roughly the late 1980s to the early 2000s. One farm had also specialised in the production of lettuce in an intermediate period.

The described trend of a certain diversification of farms in the study area towards the end of the 20th century is also supported by the available statistics on farms' technical and economic orientation (OTEX). The trend from 1988 onwards, aggregated across all municipalities and shown in Figure 16, indicates that the proportion of farms concentrating on dairy farming tended to decline up to 2010, while an increasing number of farms specialised in beef production, hors sol breeds such as chickens or pigs, and other productions. However, dairy farms still dominate in the region.

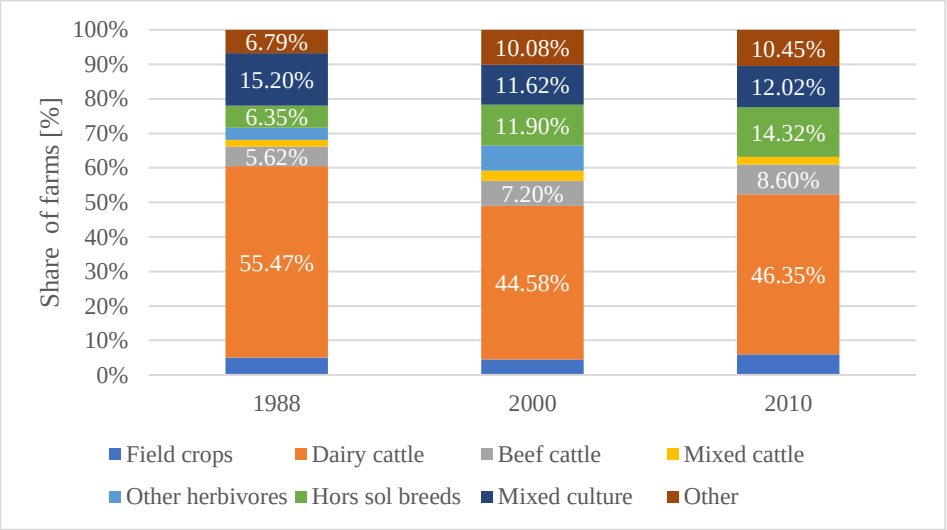

Figure 16: Share of different farm specialisation types between 1988 and 2010 in all municipalities of the study perimeter (Data source: Agreste, 2022)

4.2.6 Cooperation

Increased Pooling of Resources

Cooperation between farmers at the time of childhood, adolescence, or the beginning of their careers is characterised by the interviewed farmers primarily through labour pooling for labour-intensive work, such as sowing and harvesting fodder maize. The following statement exemplifies this type of mutual help:

> "*[…] during the silage period, we had to help each other. But it was only during silage time. But it was for mutual aid, and it was everyone's turn once.*" (Farm 3)

Several farmers believe that this mutual help has decreased in the later course of the 20th century. In general, mutual assistance is described as having moved more towards sharing vehicles and tools. Some interviewed farmers have thus indicated that they have helped out each other with specific vehicles for

certain labour-intensive activities. Furthermore, on five surveyed farms, it was stated that the farmers had joined with neighbours to form a machinery circle to acquire specific tools such as a harvester, grass-seeder or a fertiliser drill. In one case, a farmer had also joined with other farmers to share an auxiliary worker, who helped out on a different farm each day.

In the 1960s and 1970s, CUMA still had little significance, according to the statements of some farmers. As already introduced in chapter 4.2.2, the use of equipment provided by such organisms only started to increase significantly in the 1970s and 1980s. More machines such as tractors and trailers were obtained, especially for mowing and threshing. For other activities such as ploughing, sowing, silage or harvesting, increased use of agricultural contractors is described.

4.3 Landscape Development

Correspondingly with Chapter 3.5, this section lists the results of the landscape development analysis. First, changes in land cover are discussed, with a particular focus on the grassland and cropland development. Subsequently, it is shown how the occurrence of individual trees and linear landscape elements has changed during the study period.

4.3.1 Land Cover Development

The examination of land cover changes in the study area shows that a major share of grasslands has been converted to cropland since the early 1950s. About three-quarters of the total area of the study perimeter was covered with grassland in 1952. The most significant change in land use occurred in the early post-war period between 1952 and 1974. The share of grassland further decreased to about 45% by 1985 and moved back to about 50% by 2000. During the same period – towards the end of the 20th century – a reduction of the agricultural area used as cropland is again recorded. Although minor changes are recorded regarding settlement and road area, an increase of about three percentage points is recorded regarding the area occupied by forest. Figure 17 shows the respective shares of the different land cover categories in the total area of the study perimeter.

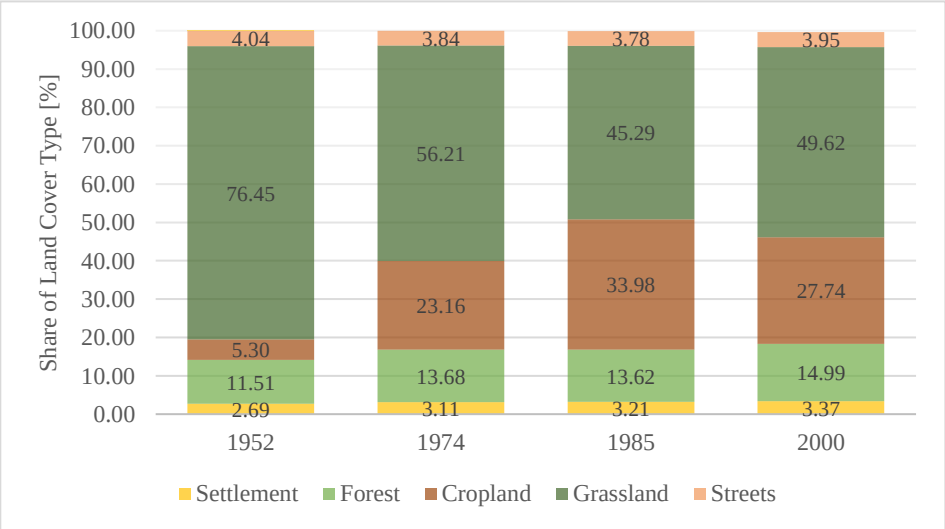

Figure 17: Land cover development between 1952 and 2000 (Data source: LTSER ZAAr)

With regard to the total utilised agricultural area, the landscape analysis also shows that the area used as grassland or cropland has slightly decreased over the study period. Whereas in 1952 2098 hectares were still used as arable or grassland, in 2000 the number was around 4 percent lower at 2011 hectares.

An examination of the plot size development in the study perimeter, illustrated in figure 18, shows a general increasing trend over the whole study period. At the beginning of the observation period in 1952, the average plot sizes of grassland and arable land were at a comparable level of 0.48, respectively 0.56 hectares. Subsequently, the increase in plot size is more pronounced for cropland and becomes even more pronounced between 1985 and 2000, eventually reaching an average area of 1.44 hectares. The development of plot sizes for grassland is less steep and peaks in 1985 at around 0.7 hectares. Subsequently, a slight decrease can be observed between 1985 and 2000. This observed trend coincides with the perception of the interviewed farmers, shown in figure 10.

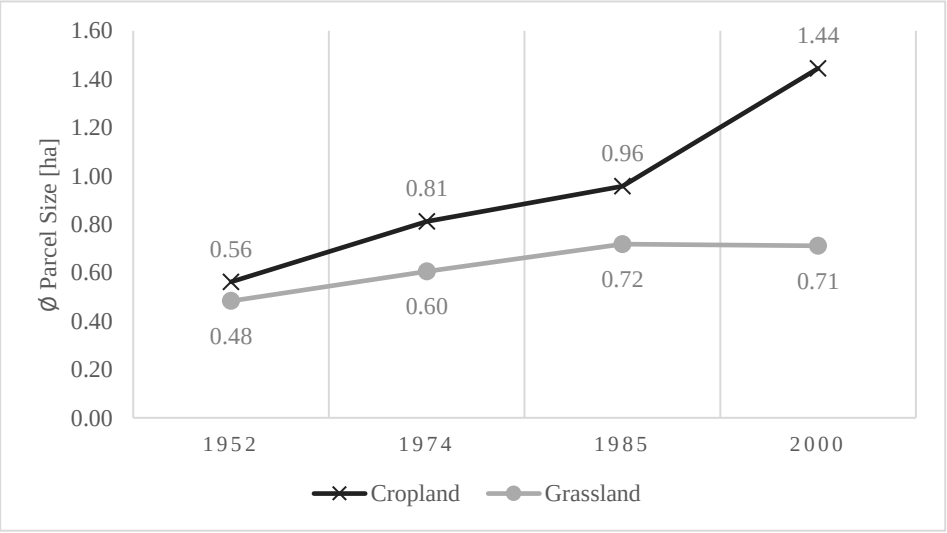

Figure 18: Development of average parcel size between 1952 and 2000 (Data source: Agreste, 2022)

The following figure 19 provides a cartographic overview of the development of the land cover during the study period.

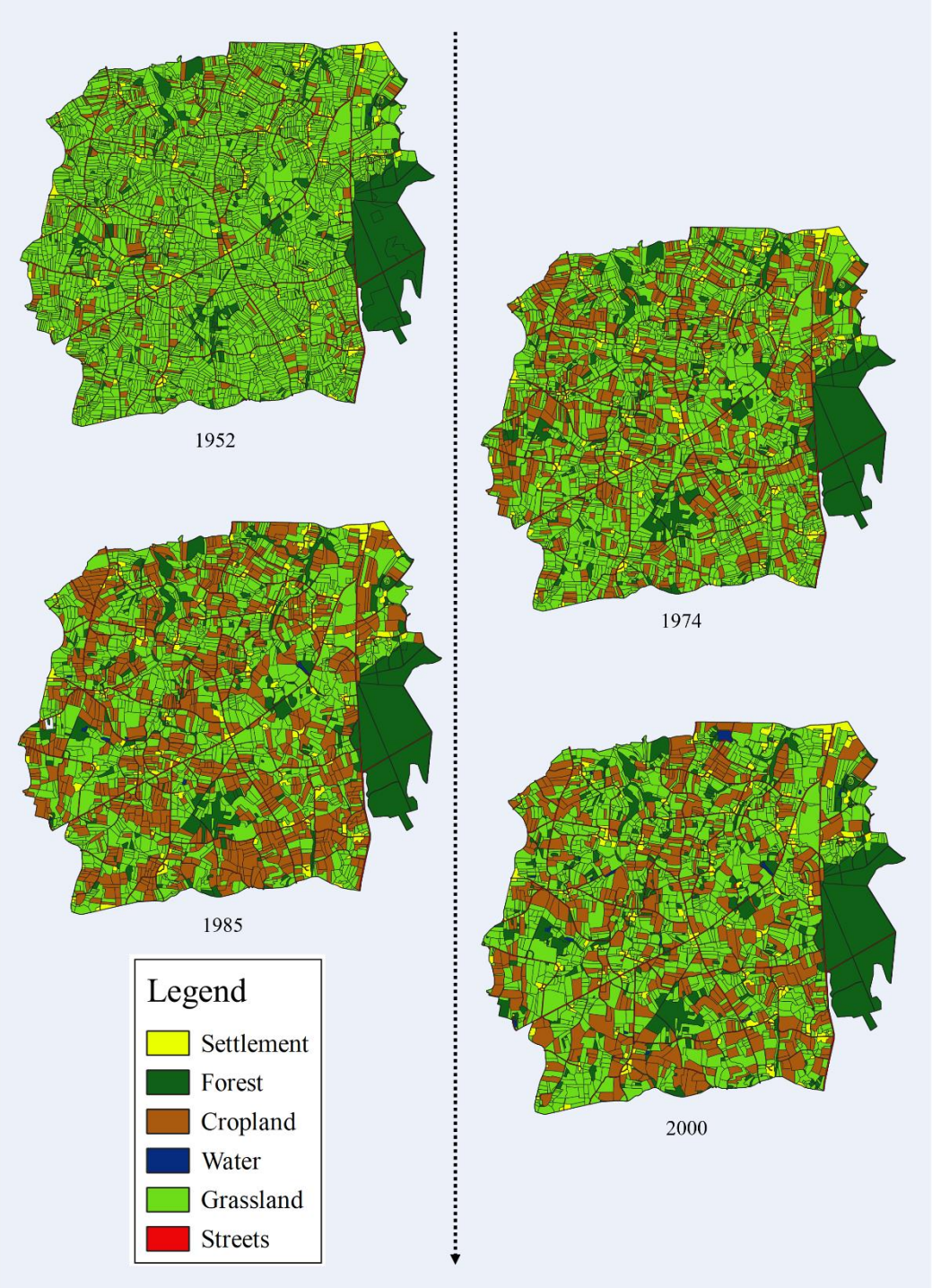

Figure 19: Land cover development from 1952 to 2000 (Data source: LTSER ZAAr)

4.3.2 Landscape Elements

The landscape analysis records the elements defined as trees or hedges in the areas relevant to agriculture, i.e., the arable and grass areas, whereby the elements along the roads are also considered. Over the entire study perimeter, a reduction in the number of trees from 13,627 in 1952 to 3,481 in 2000 was recorded. This corresponds to a decline of 74% in just under fifty years. In relation to the area, this development means a decrease in tree density from 6.59 to 1.62 trees per hectare of crop and grassland in half a century. By calculating an annual rate of change within the different time periods based on the original tree population in 1952, a slowdown in tree decline can be observed from 1985 onwards. While the annual decline rate in the periods 1952-1974 and 1974-1985 was at a similarly high yearly level of -1.88 and -1.79%, respectively, an annual rate of -0.94% can still be recorded for the period between 1985 and 2000.

The analysis does not reveal any significant differences between the municipalities in the study perimeter. While Bazouges-la-Pérouse, Broualan and Cuguen show very similar rates over the entire period, with respective declines of -76%, -77% and -79%, Trans-la-Forêt ranks a few percentage points lower with a decline of -69%. Figure 20 provides a graphic overview of the overall development of the tree population in the study perimeter from 1952 to 2000.

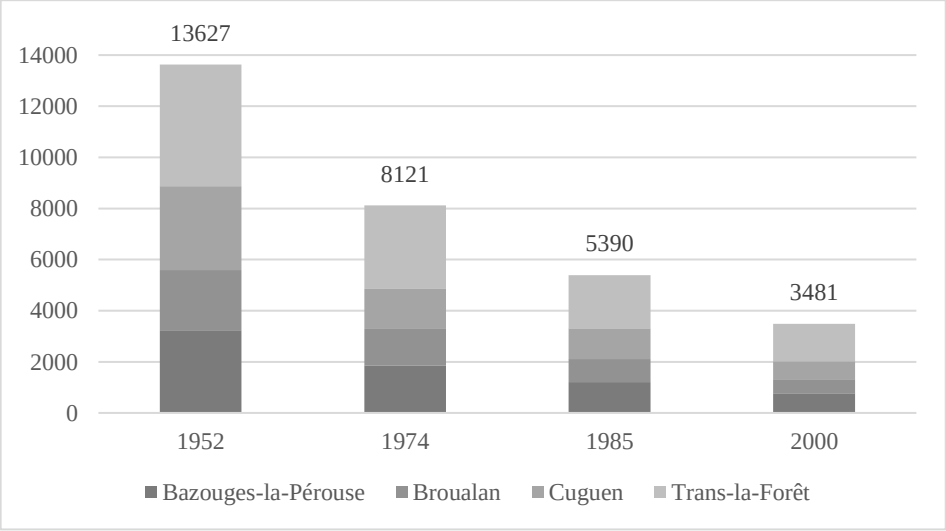

Figure 20: Single tree population development from 1952 to 2000 (Data source: LTSER ZAAr)

The linear elements of the landscape were studied separately from the individual trees. The total area occupied by these landscape elements in the study perimeter was used to indicate their development over the second half of the 20th century.

Between 1952 and 1985, a significant decrease in the area covered by hedgerow structures can be observed. Whereas in 1952 around 485 hectares were covered by hedges and similar structures, in 1974 the figure was just under 300 hectares, before falling to a low of around 160 hectares in 1985. Thus, in just over thirty years, the area occupied by hedge structures had been reduced to about one-third of the initial stock. Starting from the initial stock, this development corresponds to an annual decline of about 7.3% between 1952 and 1974; in the period between 1974 and 1985, the clearing of the *bocage* even accelerated somewhat, with an annual rate of about 8.6%. In the last period studied, before the turn of the millennium, the area covered by hedges in the study perimeter again increased by about 20% to around 200 hectares. The analysis of the hedge structures does not reveal any significant differences between the municipalities in the study perimeter. Figure 21 shows the development of hedge structures in the entire study perimeter.

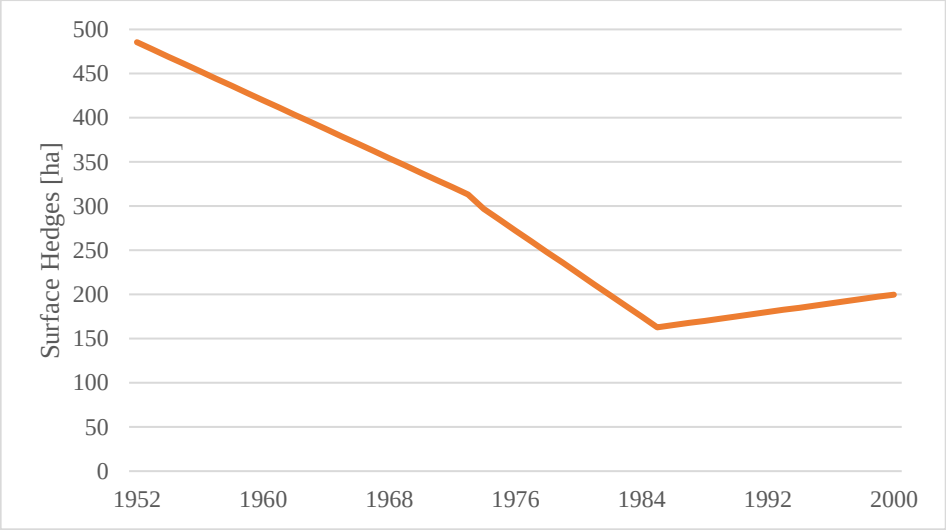

Figure 21: Hedge structures development from 1952 to 2000 (Data source: LTSER ZAAr).

In the detailed view, the above-described development of a recent increase in the hedgerow structures towards the end of the 20th century is expressed in the growth of individual elements, whereas recently, the emergence of new hedges or the widening of already existing structures can be noticed. Figure 22 illustrates an exemplary evolution of the hedge structures. On the one hand, it shows how the hedge population of 1952 compares to that of 1985. In addition, it shows how the hedge population of 1985 compares to that of 2000 at the same location. Continuing landscape elements are shown in green, removed elements in red, and emerged elements in yellow.

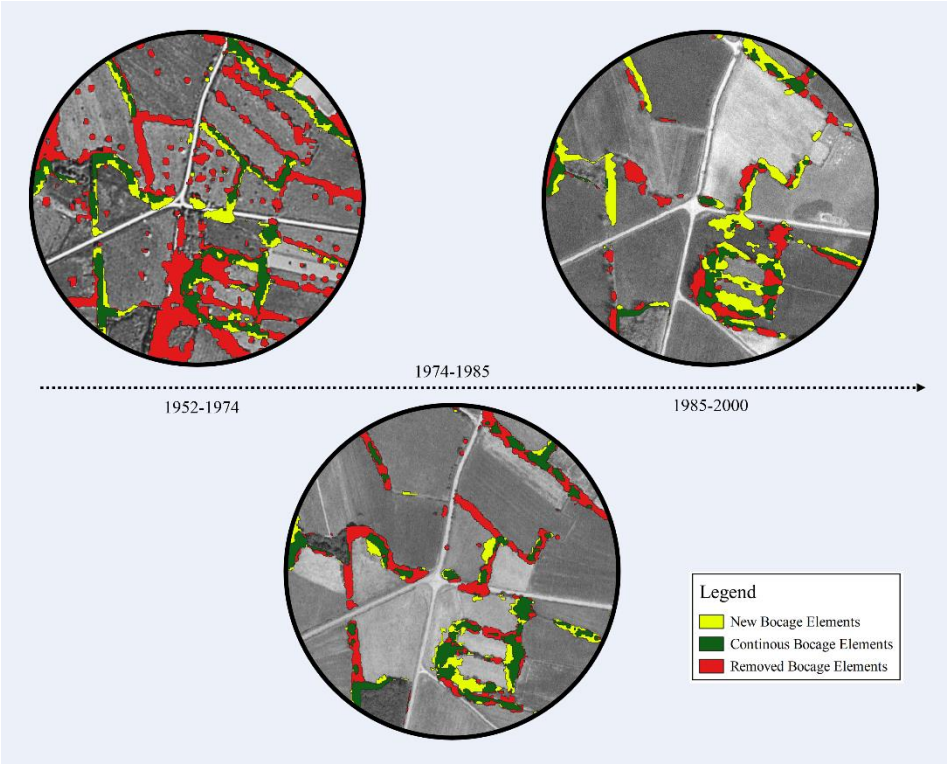

Figure 22: Detailed view of single trees and hedgerows structure development from 1952 to 2000 (Data source: LTSER ZAAr)

Figure 23 provides a cartographic overview of the existing stock of individual trees and hedge structures in the different time steps.

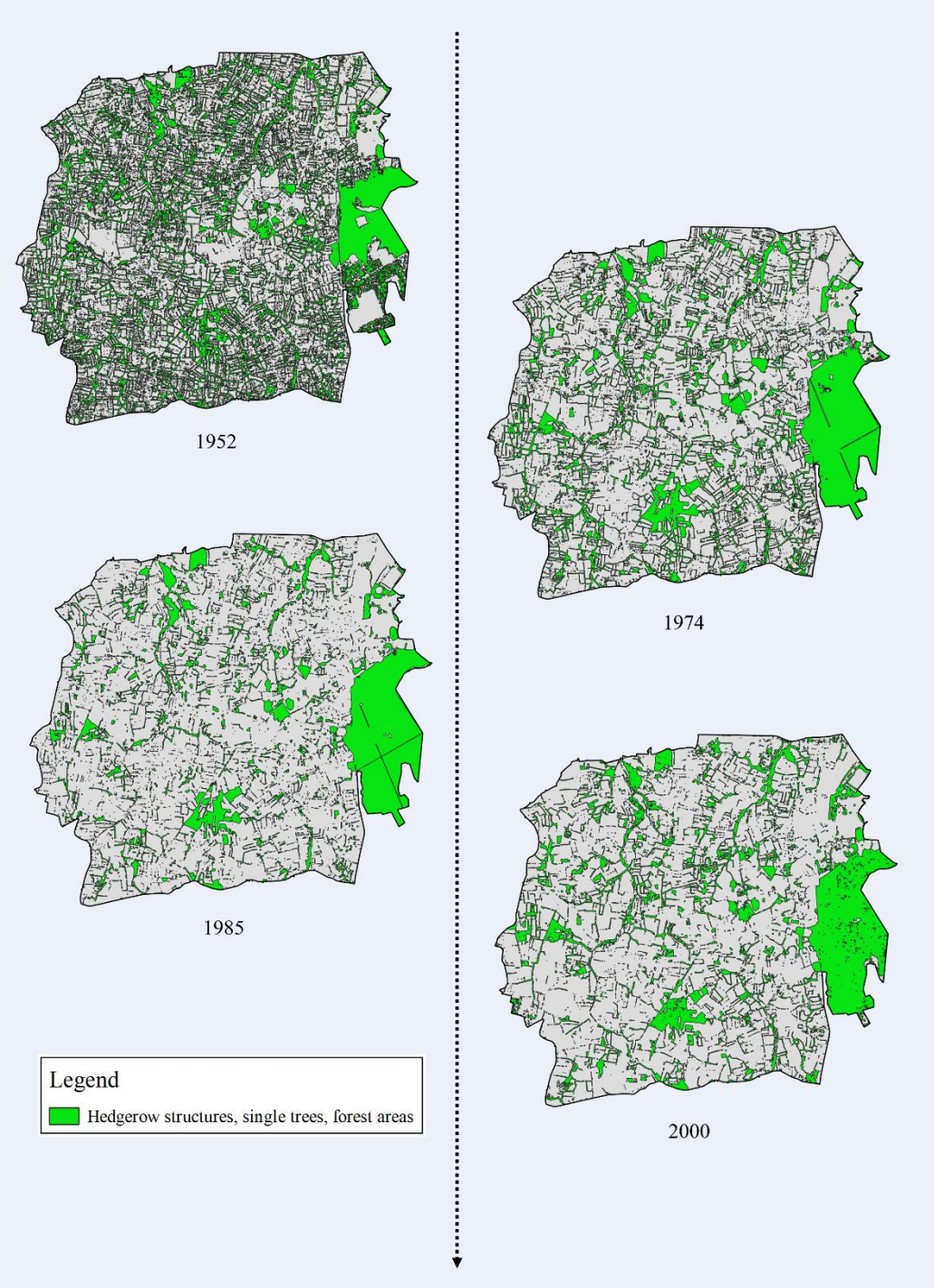

Figure 23: Development of hedgerow structures, single trees and forest areas from 1952 to 2000 (Data source: LTSER ZAAr)

4.4 Driving Forces of Agricultural Intensity Change

After reconstructing the development of agricultural intensity and landscape structure in the last century, the present chapter will focus on the driving forces investigated during the oral history interviews. As landscape structure is also a function of agricultural intensity, the influence of the driving forces on the landscape development will also be discussed. All the driving forces identified according to the procedure described in chapter 3.3.4 in the OHIs, are summarised in table 6. Based on the considerations of Schneeberger et al. (2007) and Bürgi et al. (2005), the drivers were divided into five thematic dimensions: socio-economic, institutional, technological, natural-structural and cultural drivers. Furthermore, the driving forces were divided according to spatial criteria according to Schneeberger et al. (2007). The highest category includes drivers that had an influence on a national, and in some cases also on an international level. Further, the region of Northern France was identified as an appropriate spatial level. This scale was chosen because the interviews revealed a certain degree of interdependence across departmental borders in the regions of Brittany and Normandy. This level is thus an appropriate unit of analysis, especially for economic and natural/structural drivers. The drivers were then categorised at a landscape level, which corresponds more or less to the study perimeter of the landscape development analysis, and finally at a farm level. It should be noted at this point that specific drivers can also be operating at different spatial levels and thematic dimensions, so the allocation to a category is to some degree selective. In some cases, same drivers were also assigned to different scales. The allocation was carried out with a focus on those effects that had the most evident influence on the case-specific mechanisms of agricultural intensity change. In a second step, the driving forces identified as particularly influential are explained in more detail and underpinned with quotes from the interviews. A crucial factor for the definition as a particularly influential driving force was the ability to support it through the statements of the interviewed farmers. These driving forces are highlighted by underlining in Table 6.

Table 6: Driving Forces of Agricultural Intensity Change				
Level **Driving Forces**	**National** (& International)	**Regional** (North of France)	**Landscape** (Study perimeter, Municipality)	**Individual** (Farm level)
Socio-economic Drivers	▪ Incentives / Premiums for specific practices ▪ Access to credits / loans ▪ Market Potential	▪ Presence of agro-industrial companies	▪ Presence of agro-industrial companies	▪ Wealth ▪ Degree of education
Institutional Drivers	▪ Agricultural laws ▪ Environmental laws ▪ Educational requirements	-	▪ Land consolidation measures	▪ Embedding in municipal structures
Technological Drivers	▪ Technological progress	-	-	▪ Investment in machinery and infrastructure ▪ Consultancy & Information ▪ Connection to electricity and water network ▪ Predisposition
Natural and structural Drivers	-	▪ Extreme weather events (droughts / rainy periods, storms)	▪ Topography ▪ Soil conditions ▪ Incisive landscape / infrastructure elements	▪ Topography ▪ Soil conditions ▪ Animal / Plant diseases ▪ Access to farmland ▪ Extent of the area when taking over the farm
Cultural Drivers	▪ Demographic development ▪ Position of agriculture in society ▪ Globalisation ▪ Environmental awareness	▪ Collective motivation to develop and modernise	▪ Collective motivation to develop and modernise ▪ Social Cohesion	▪ Personal motivation to develop and modernise ▪ Family situation ▪ Health situation

4.4.1 Socio-Economic Drivers

Market Potential

As the interviewed farmers pointed out, the development of the respective farm strategy largely depended on the potential perceived on the market for the various products. On the one hand, this concerns the demand for certain goods and, on the other, the price that could be achieved. The spatial level of this driving force can be defined as the national and international levels. Thus, as the process of intensification progresses, substantial supra-regional market integration is described for Breton agricultural production.

An example of the effect of this driving force is noted in connection with the diversification processes described towards the end of the 20th century. The choice for new breeds or the diversification of crops to include maize, tobacco or salads was also a strategy that was pursued to supplement the primary source of income, usually milk or, to a lesser extent, meat. This shows a certain dependence on market dynamics, as two farmers explained, referring to sometimes relatively low meat and milk prices. Such is particularly evident in the case of the two farms that have placed their meat production under a specific label. The farmers stated that they could sell their products under these conditions at favourable prices. Therefore, a certain degree of security was possible in terms of sales and price development.

Also, regarding the identified trends of farm concentration and land management intensification – and in a broader sense also for input-use intensification – the connection with the market potential of production was referred to in the conducted interviews, as reflected in the following statement:

> "*If we had been paid our fair labour price, farms would not have increased. We had to increase all the time to have a minimum.*" (Farm 9)

Several farmers mention the decline of fruit trees in connection with the demand for apple-based beverages. While there was still a relatively high demand for cider or calvados – which apples were processed into – shortly after WWII, the demand for the products mentioned above was described as declining rapidly in the following decades. As a result, the labour-intensive fruit cultures lost their economic appeal. Therefore, the clearing of these trees should also be seen in the context of this fluctuation in demand.

Central actors that should be emphasized are, in particular, the dairies and cooperatives as the main buyers of the farm production and individual consumers, in a broader sense, as the final product buyers of the products.

4.4.2 Institutional Drivers

Agricultural & Environmental Laws

The legal framework in the agricultural sector, and later also in the environmental sector, was repeatedly mentioned by the interviewed farmers as an influential driving force directly related to land management intensification and farm concentration. In a broader sense, capital and input use intensification were also considered dependent on the legal framework.

Effective policies were already identified at the beginning of the 1960s, and therefore preceding most careers professional line of the interviewees. At an international level, this corresponds to the introduction of the European CAP. The price stability thus ensured by the State promoted the substantial expansion of livestock density and productivity as well as the increase in field yields. This, in turn, led to an intensification of fertiliser use and an expansion and modernisation of the infrastructure and tool park. At a national level, the effects of the *lois d'orientation agricole* on-farm concentration are emphasised. It was described that this legislation had a strong impact, especially on the size and number of farms, because premiums were paid for the early retirement of older farmers. This resulted in smaller farms merging into larger ones and being taken over by a new generation of farmers. In the same context, the consolidation of plots for the best possible access and modern, mechanised cultivation was promoted.

Against the background of the widespread dairy farming in the study perimeter, all dairy farms also mentioned the introduction of milk quotas in 1984 in the States of the European Economic Community as an important turning point, which slowed down a further intensification of milk production, as one interviewee revealed with the following statement:

> "*When quotas were introduced, they slowed down production. But thanks to the development that we had done before […] we had a reasonable quota for most the farms.*" (Farm 8)

According to several statements, this has particularly further advanced the process of farm concentration. Thus, it is described how the introduction of milk quotas was a particular issue for farms that had not yet significantly expanded their production in the past decades. These often relatively small

farms have been increasingly integrated by larger farms under the influence of limited production quantities and the associated lack of profitability. Therefore, those farms were somewhat less affected in terms of land management intensification. However, they were limited in further expansion of their milk production, and their growth possibilities were somewhat slowed down. Against this background, the promotion of farm diversification is simultaneously described:

> "*There were quotas at the beginning of the 1980s, and we had a bad time because we had a lot of heifers, which we were forced to sell at bad prices. We didn't have a big quota, and then a year later, we would have a decent quota. So, with the sale of these animals, we set up a suckler herd alongside to not lose the whole herd*." (Farm 4)

Finally, the impact of the revision of the Common Agricultural Policy in the early 1990s was perceived as decisive for further farm concentration by the interviewed farmers. Thus, subsidies were no longer based on State intervention in market prices but instead on the cultivated area at the farm level. As can be gathered from the following statement, this formed an additional incentive to increase the farm area:

> "*Well, we didn't really realise it before, because the subsidies were hidden under the products. When we sold a litre of milk there was a part that was subsidised. And for crops too, instead of paying per product, we were paid per hectare, which is a considerable difference, because whatever the yield, we get money. So, this obviously encouraged the race for premiums. This is also what encouraged expansion.*" (Farm 4)

Another connection was described between increased environmental requirements and the degree of land management and input use intensity. The farmers interviewed stated that during the 1990s, when most of the interviewees were towards the end of their careers, they had to pay more attention to environmental aspects in general. In terms of input use intensity, this changed legal framework led to a reduction in the use of fertilisers and pesticides. Furthermore, the interviewed farmers explained that they had to plant winter crops to cover bare surfaces and keep a defined area along streams free from cultivation with grass strips.

With regard to the transformation of the landscape, the importance of the premiums for the clearing of hedges and field trees was emphasised:

> *"They started by cutting down the apple trees, by giving subsidies to cut down the acid apples in the years 1962 and 1963. We received incentives for cutting down apple trees."* (Farm 2)

The agricultural laws revised during the 1960s promoted the expansion of farms and increases in productivity, as previously outlined in the discussion regarding the driving forces of agricultural intensity change. In this sense, the change in cultivation, with increased use of tractors and other technical aids, necessitated an increase in the size of plots. This was achieved through the increased clearing of individual trees and hedge structures. In addition, the intensification of land management intensity, promoted against the background of the legal framework, also influenced the growing share of land used as cropland.

The CAP reform described at the beginning of the 1990s – according to which State support for agriculture is no longer implemented through market interventions but through area-related premiums – was also mentioned in the interviews as a driving force for further clearing. One interviewed farmer specifically explained that the associated motivation to have as large a farm area as possible led to further clearings, as areas occupied by hedges could not be counted.

Land Consolidation

It was described that no official land consolidations with the installation of a respective commission were carried out in the municipalities within the study perimeter. Several interviewed farmers stated that it was not so much a top-down land consolidation but rather processes organised at a local level. In this context, part of the farmers reported a friendly exchange of plots, as can be deduced from the following statement:

> "*In Bazouges, I did it amicably. That is to say, by mutual agreement. That is to say that I invited all my neighbours in a certain sector, saying, "Could we do a land exchange together?" But how to do it? Afterwards, we took on a technician, a surveyor. We tried to share the plots of land between the neighbours in an amicable way. It took a year, meetings, meetings, meetings. And then we had to carry out analyses of the land. And we did some nice things at Bazouges-la-Pérouse without breaking too much."* (Farm 8)

In this sense, the local community and the direct reference persons such as neighbours, friends, and family members were crucial actors for the interviewed farmers. In some cases, it is also described that support funds and services of the *société d'aménagement foncier et d'établissement rural* (SAFER) could be used to foster land consolidation intentions:

> *"[…] So, we received incentives, so afterwards, when we arrived with the SAFER, if it was a small piece of land that was close to another piece of land in another property, they prioritised taking over the piece of land. That way, there were no small plots everywhere. So, we bought, the embankments around were abolished to be able to expand, to be able to put a combine harvester in there. Without that, there would have been half of the land; the combine harvesters and the forage harvesters would not have gone in."* (Farm 2)

As explained in the previous statement, land consolidation – resulting in an increase in the average plot size – was made possible, particularly with the modernisation and motorisation of agricultural practices. Subsequently, this also enabled a more systematic use of fertilisers and plant protection products and the cultivation of larger areas by fewer workers.

In terms of landscape development, land consolidation was described as a driving force for both plot enlargements and the decreasing populations of individual trees and hedge structures. The landscape changes brought about in the course of land consolidation measures were exemplified by the following characterisation by one interviewee:

> "*And then when we started, we were at 90 plots, and we stayed at five times less. We cut down embankments, we made beautiful plots of land, land consolidation and amicable exchanges too*." (Farm 9)

4.4.3 Technological Drivers

Technological Progress

As already explained above, based on land management and capital intensification, most respondents characterised the provision of rural areas with infrastructure and technological tools as very modest until around the middle of the 20th century. The following statement exemplifies the associated effects in everyday rural life:

> "*We had no equipment. It was just handwork. We worked a lot, a lot. Every day, seven days a week, it was like that. […] When they came with the equipment, they did the work in an hour that we did in a week, even more*." (Farm 1)

All interviewees described how, during their active careers or even earlier during their childhood, work processes and the degree of land management intensity had changed considerably due to significant technological progress.

Thus, the dissemination of motorisation in agriculture should be highlighted here. With the the arrival of tractors on farms, the use of increasingly powerful tools that could be used with the tractors, made it possible to carry out many tasks that previously had to be done by hand or with horses. In this sense, technological progress has also contributed to reducing the required labour force. Furthermore, it was described that it was possible to manage much larger and more widely spaced plots of land. In the context of improved technological conditions, the interviewed farmers implied, in particular, the intensified cultivation of arable land and grassland, for example, in terms of ploughing, sowing and harvesting and the associated increase in yields. The significant advances in technological possibilities thus also directly impacted the input-use intensity with the increasing use of fertilisers and plant protection products.

Apart from the apparent impact of tractors, other technological advances with an impact on intensification mechanisms are to be mentioned. Two interviewees pointed out that the connection to the electricity and water network was a significant turning point. On this basis, the installation of efficient automated milking systems led to a significant increase in the production volume.

In addition, the interviewees refer to optimised production conditions at various levels regarding increased crop and livestock production yields. This includes, for example, genetic selection of breeds and better possibilities to improve animal health. Increasingly effective varieties were also used for the cultivated crops.

Beside of being a crucial driving force for land management intensification, the increased possibilities with growing technological progress were also a reason for the change in landscape structures, as can be gathered from the statement of an interviewed farmer:

> "*The embankments around were abolished to be able to expand, to be able to put a combine harvester in there. Without that, there would have been half of the land; the combine harvesters and the forage harvesters would not have gone in*." (Farm 2)

In conclusion, technological progress has significantly impacted land management, capital and input use intensification, resulting in a substantial increase in crop yields and animal productivity. In addition, improved technical equipment in agriculture has also promoted farm concentration.

Consulting and Information

The following statement points to another influencing driver of different agricultural intensification mechanisms, which needs to be considered in addition to the technological progress itself, namely the process of making farmers aware of new varieties, cultivation techniques and technologies:

> "*And we took advantage of the agricultural technician who was very competent. He helped us a lot*." (Farm 3)

In these terms, most interviewed farmers emphasised the growing influence on the farms of external advisors from various organisms from about the 1960s. This mainly concerns dairies and cooperatives as suppliers of seeds and additives and as the primary purchaser of farm production. To a certain extent, advisors from the Chamber of Agriculture or the trade unions were also mentioned. It is also evident that a high degree of trust was placed in the advisors. The farmers interviewed clearly indicated that there was little questioning regarding the methods proposed by the advisors, which, in retrospect, was also judged somewhat ambivalently, as the following statement reveals:

> "*And the corn was treated a lot […] And that's perhaps what caused a lot of pollution in the rivers. Because we didn't have any stream limits. But for me, the culprits were those who were selling. Because they told us that we had to use so many litres per hectare, so much of this per hectare and so on. And we were so ignorant*." (Farm 2)

According to the statements, the advice of experts was influential throughout the entire farm production chain. In milk production, the advice received ranged from genetic selection and feed composition to quality control. In arable farming, the choice of crop varieties, type and quantity of fertilisers and plant protection products, as well as soil analyses, are frequently mentioned areas where farmers increasingly sought advice.

On the other hand, the Chamber of Agriculture and the trade unions were more influential in areas such as the implementation of legally binding requirements in terms of environmental legal constraints or the economic organisation of the farm. In these terms, consultancy has rather to be understood as an institutional driving force.

4.4.4 Natural & Structural Drivers

Weather

Interestingly, most farmers interviewed said they had not perceived any significant climatic changes that would have impacted agricultural practice. In this sense, no connection can be made between agricultural intensity change and climatic driving forces. Instead, the respondents attributed greater importance to singular weather events. In particular, the interviewed farmers mentioned on several occasions a prolonged hot and dry phase in 1976, which led to short-term fodder shortages in the animal supply. However, they stated that these singular events had not affected the farms' general orientation and that their consequences had been of a more short-term nature.

Topography and Soil conditions

The topography and the soil structure characteristics were emphasised as a significant driving force of development for the specialisation of the farm and the degree of land-use intensification at the farm level. In this context, it was explained that most farmers saw their expansion possibilities as being limited by factors that they could only change to a limited extent. The possibilities of deciding whether an area should be used as grassland or arable land were placed by several farmers in a context with the natural conditions. Among other things, it was stated that due to topographical conditions, certain areas could only be used as grassland because tractors could not operate within. Another important influencing factor was also attributed to the soil conditions; areas with rather wet soils were, therefore, reserved for mowing. These specific initial conditions ultimately also had an impact on the strategy of the farms:

> "*We have a lot of land that gets wet, and also with rocks. So it's not suitable for cultivation, it's more suitable for grass. Well, as we were stuck, there was no question of growing crops, the land didn't enable that. So that's why we set up a suckler herd.*" (Farm 5)

In the areas that are now suitable for arable farming – considering the premises described above – the interviewed farmers also placed the farm-specific cultivation strategies in a context with the

characteristics of the subsoil. Depending on the composition and thickness of the soil, other crops were preferred. In some cases, it was also mentioned that heterogeneous conditions on the farm scale influenced the plot structure so that the harvests could be as homogeneous as possible.

At the landscape level, several interviewed farmers stated that the natural preconditions were a significant factor for a relatively moderate farm concentration. Due to the numerous small streams and the topography as well as the granitic subsoil, the possibilities for large-scale agriculture, especially arable farming, would have been limited. In this context, a farmer in the commune of Bazouges-la-Pérouse established a connection between the topographical and pedological conditions and the regional dairy specialisation. Thereby, he observed that the higher part of the commune, characterised by a stony subsoil, is dominated by grassland, mainly intended for pasture, while cropland dominates in the lower part.

Additionally, several interviewed farmers described that the natural preconditions were a major limiting factor why the landscape in the study perimeter had undergone a relatively moderate change in terms of *bocage* structures. Due to the numerous small streams and the topography as well as the granitic subsoil, the possibilities for large-scale agriculture, especially arable farming, would have been limited:

> "[…] *You can't expand the plots as you like here. It's hilly and there are streams*." (Farm 7)

4.4.5 Cultural Drivers

Individual and Collective Motivation

According to the interviewed farmers, it was noticeable that significant parts of the rural population were driven by a common and widely recognised motivation to develop and modernise agriculture and the rural way of life. The investigated farmers thereby placed this aspiration in the general context of post-war society's attitude. The following statement also exemplifies the associated spirit of change:

> "*We were waiting for that! It's true that when we were young, France was behind, we had no courage, no equipment, no electricity to milk the cows and all that.* (Farm 3)"

In this context, the main emphasis was on the demarcation of ways of life and agricultural practices that were perceived as outdated. This collective consciousness characterised by the will to modernise and improve living conditions was reflected in the farmers' personal motivation. In this context, the increase

in productivity through new breeding methods, for example, or the change towards mechanised and motorised agriculture with the possibility of higher field yields, were considered desirable goals.

Social Cohesion

On the basis of the statements obtained, in combination with the above-mentioned collective motivation, attention should also be given to the defining role of local associations, trade unions and other social networks in the region. Most of the interviewees stated having been integrated into association structures in some form or another. As a result, a high degree of social cohesion in the region can be discerned from these diverse societal interconnections. This helped shape and promote the development processes described above in the century's second half.

Several mechanisms are described, how the mentioned structures have contributed to the establishment and diffusion of this broadly supported development motivation in society. Three of the interviewed farmers explicitly mentioned that they had been members of the youth organisation JAC. A farmer from Trans-la-Forêt estimated that in the 1950s and 1960s, about half of the young adults in the community were members of the youth organisation. This allowed them to meet with their contemporaries regularly and pursue joint activities, thus providing platforms for intensive exchange. In this context, the emergence of a new consciousness in terms of orientation within farming and rural society was highlighted. Another central point of discussion referred to the diffusion of a modernist agricultural orientation, as is expressed in the following statement:

> "*[The aim was] the improvement of the exploitation of the parents or of those who were settling. You got on the train with the JAC, it was a way of opening up. There were meetings that were also there to train us.*" (Farm 9)

The values embodied in the JAC were carried forward in the union's activities, which had a substantial membership at the time of the most significant agricultural intensification. So, seven of the nine farmers interviewed were members of the communal branch of the largest French trade union FNSEA at least some of the time during their active period. In addition to the classic representation of interests at various political levels – which will not be further discussed here – reference was made to other activity levels offered in union structures. Discussion platforms and further education were offered within the framework of events and educational trips, and protest actions contributed to cohesion in the agricultural community.

It was emphasised that the modernisation intentions pursued in the trade unions had a significant impact on developing the agricultural structure at a regional and local level. This concerns the farm concentration and the dissemination of new breeding and cultivation methods that were implemented in the course of land management intensification. However, this role of the labour unions has also been assessed ambivalently and critically in some cases, as emphasised in the following statement:

> "*So, the unionisation rate was high, I think. At that time, the larger producers, in general, were not unionised; they felt they didn't need anyone. The medium and small farmers tended to unionise. When we started, there was the majority union FNSEA and what we called the working farmers. So, their role was... [reflects a little] It's ambiguous. It's ambiguous because they said they were going to protect small and medium-sized farms, and in the end, the opposite happened*." (Farm 4)

4.5 Systemic Overview

In the precedent chapter, it was described how the perceived driving forces and key actors are related to the identified main trends of agricultural intensity change and the dominant landscape changes. Figure 24 summarises the interrelationships in a systemic overview. In the context of this systemic overview, it is considered that the driving forces have influenced the trends of agricultural intensity changes through the actions of the various identified actors. In this sense, they are assigned to the driving forces categories. The most evident connections based on the given statements are illustrated through arrows. They show that the institutional driving forces, in particular, have directly influenced almost all the agricultural intensity changes identified. Thus, agricultural and environmental policy can be linked to land management, capital and input-use intensity, and dependencies can also be found on farm concentration and regional specialisation in dairy farming up to later diversification. Land consolidation measures have contributed to farm concentration and catalysed landscape change. Technological progress and increased extension services have particularly impacted the observed land management, capital, and input-use intensification. In addition, this has also promoted the expansion of farms and thus farm concentration. As the figure shows, there is little evidence of linkages between intensification trends and natural and structural drivers. This indicates that the natural conditions in the study region must be regarded more as a restraining driving force than as favouring intensification. The individual and collective motivation as a cultural driving force can be related, in particular, to the increased land management intensity, which is reflected in an increase in livestock numbers and their productivity and an increase in field yields.

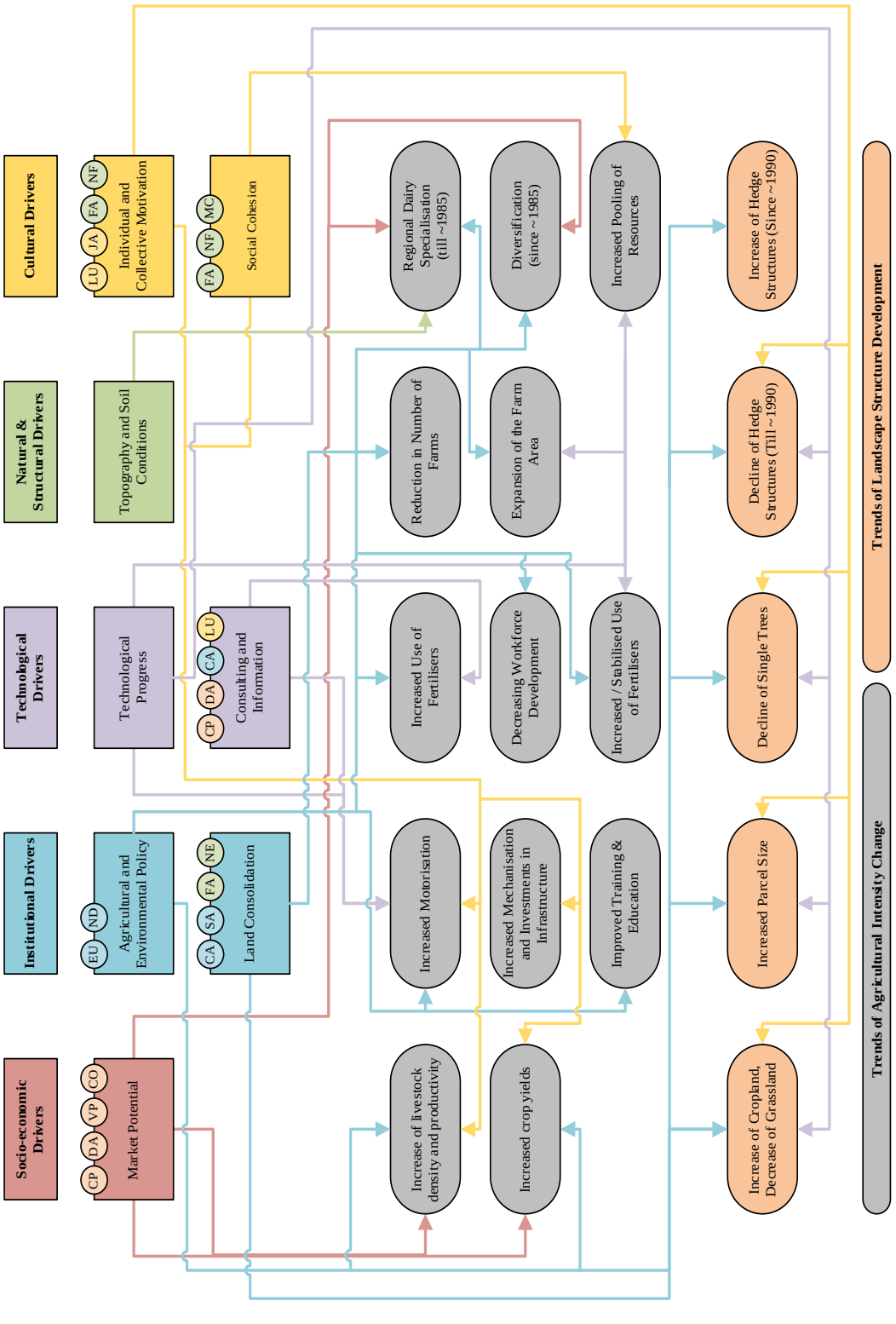

Figure 24: General view of relations between driving forces, key actors trends of intensity change.

5 Discussion

The present case study addressed the past trajectory of agricultural structural change in the research area near Pleine-Fougères. On the one hand, the aim was to identify which mechanisms of intensity change according to Diogo et al. (submitted), which are discussed in chapter 2.1, can be observed in the course of the 20th century. For this purpose, various indicators were used by applying a mixed-method approach. An apparent intensification of various agricultural aspects could be identified through the statistical data collection, spatial analyses, and the collection of statements from contemporary witnesses. At the same time, moderate regime shifts were observed regarding aspects such as specialisation or the use of fertilisers.

Against the background of modelling future development scenarios, the claim made is that the formulation of concrete instructions for action must be tailored to locally differentiated framework conditions (Hermy & Verheyen, 2007; Bürgi et al., 2018; Weltin et al., 2018). In this sense, a deeper understanding of historical processes is central. Therefore, the present work aimed to identify the driving forces that contributed to the change in intensity and assess their influence. A further core interest consisted of identifying the key actors of the change processes and assessing their connection with the mechanisms of agricultural intensity change to place the agricultural trajectory in a local context. To identify driving forces in all dimensions introduced in chapter 2.2 of this thesis, the statements of contemporary witnesses were decisive.

This chapter discusses the trends of agricultural intensity change in the 20th century in the study region and the related driving forces. The role of the identified main actors is set in the context of the driving forces and mechanisms of intensity change. In line with the research questions raised at the beginning, the results of the present study will be compared with the findings of related studies. In doing so, it will also be clarified to what extent the findings of the locally limited study can be applied in a superordinate spatial context. Finally, the limitations of the case study will be pointed out.

5.1 Mechanisms of Agricultural Intensity Change

In chapter 4.2, the trends of agricultural intensity change are described in detail based on the oral history interviews. Statistical data sets largely support the statements made in the field. Table 7. shows how the trends relate to the mechanisms of agricultural intensity change defined by Diogo et al. (submitted).

Table 7: Trends of Agricultural Intensity Change

Identified Trend in the Study Region	Mechanism of Agricultural Intensity Change
Increase of livestock density and productivity	Land management intensification
Increased crop yields	
Decreasing workforce development	
Increased motorisation	Capital intensification & input-use intensification
Increased mechanisation and investments in infrastructure	
Improved training and education	Knowledge intensity change
Increased use of fertilisers (until ~1990)	Input-use intensification
Stabilised use of fertilisers (since ~1990)	Input-use deintensification
Reduction in number of farms	Farm concentration
Expansion of farm area	
Regional/Farm dairy specialisation	Regional/Farm specialisation
Diversification	Farm diversification
Increased pooling of resources	Cooperation

The overview shows that the developments in the Pleine-Fougères study region cover almost all mechanisms of agricultural intensity change according to Diogo et al. (submitted). As expected, they occur in a complex combination. The dominant trends are land management, capital and input-use intensification, and farm concentration. Together, these mechanisms have significantly shaped the course of agricultural intensity in the study region. However, no convincing statements could be made regarding vertical integration and income diversification of farms.

Until the early post-war period in the 1950s, the results show an agricultural structure characterised by numerous relatively small and diversified farms in the crop-livestock model with a high degree of self-

sufficiency. From the 1960s onwards, in particular, a continuous increase in animal productivity and field yields and an increasing specialisation of farms can be observed. Thus, the agricultural development of the study region essentially fits into the general agricultural history of the particularly productive Brittany in the 20th century (Canévet, 1992; Houet, 2006). With regard to the cropping pattern, the role of the regionally particularly pronounced specialisation in milk production should be emphasised at this point. In this respect, the proportion of land managed as cropland, which grew in the 20th century, makes sense. The interviewed farmers pointed out that this was needed to manage the growing demand for fodder in intensive livestock production. In particular, the cultivation of fodder maize was a central pillar of the strategy. With prairie farming, which dominated until the 1950s, this supply could not be secured.

The increasing number of cows (milk and meat production) on the farms studied, which increased without exception throughout the investigated careers, also fits into the post-war productivist trend described by Canévet (1992); it is also within the framework of the increase in livestock described in this context between 1950 and 1990. Interestingly, no indications were found showing that the permanent and temporary prairies had experienced a significant increase in productivity during these intensification processes. Therefore, the question as to whether the additional demand for fodder could also have been partly covered by more intensive management of the grasslands remains open. As already pointed out by Javelle (2007), the production of cereals and other crops for marketing played a somewhat minor role in the study region near Pleine-Fougères. In the light of the spatial analysis and the OHI, it cannot be clarified conclusively to what extent the cropland was also used for purposes other than fodder production. However, the findings of Aviron et al. (2005) document a relatively significant share of around 20% of the UAA in the study region dedicated to the production of cereals and other cash crops at the beginning of the 2000s. This suggests that cropland was increasingly cultivated for marketing, at least towards the end of the 20th century.

The results show a decrease in the number of farms in the study region from 1970 to 2010 by about 75%. Parallel to this, the average farm size has increased in approximately the same proportion during the same period. The general trend is thus in line with the description offered by Canévet (1992), who documents a steady decline in the number of farms in Brittany throughout the 20th century. A comparison with statistical data also shows that the development of the study area corresponds to the situation at the departmental level and in Brittany over the same period (Agreste, 2010). During the fieldwork, it was noticeable that the interviewed farmers perceived this development as a drastic change

in their living environment. Therefore, the sharp decline in the number of farms and the total number of people working in agriculture has also significantly impacted rural life in professional and cultural terms.

The relatively stable size of the UAA in the study area can be understood by taking into account various aspects, which are described by Yvon et al. (2010), for example. According to these, it must be noted that the study area is not located in the immediate proximity of large urban centres such as Saint-Malo or Rennes, and the tourist attractions on the coast are somewhat further away. Therefore, there is no significant pressure regarding urbanisation processes in this sense. Also, the study perimeter comprises no significant protected areas or afforestation areas that could have competed with agricultural land, thus preventing a significant decrease in UAA.

The statistical data available for the period between 1970 and 2010 regarding the average active labour force per farm shows only a moderate decrease. This suggests that the basic division of labour on farms, where a farming couple does most of the work together, has remained largely the same. This characterisation also corresponds to the descriptions obtained on the farms, which show that work had not become less but different. In this context, the reference to the increasing bureaucratic activities that had to be carried out was particularly striking. Furthermore, the increase of the farm size, with a stable development of the number of workers per farm, leads to the increasing degree of mechanisation and motorisation described on all the farms visited as an essential part of the modernisation trend observed in the second half of the 20th century. The sharp increase in the use of tractors and other technical aids fits in with the post-war trend observed throughout Brittany (Canévet, 1992; Houet, 2006; Javelle, 2007). The increase in motorisation also correlates with the increases mentioned above in farm productivity until the 1990s.

Pollet (2014) establishes a significant connection between the increase in productivity and the substantial increase in fertiliser use, although only qualitative evidence could be found concerning the study region. However, the increase in fertiliser use and the described peak in fertiliser use during the 1990s can be assessed as plausible with regard to national and regional developments. One statement, which could not be quantified at the farm level, concerns the stagnation of crop yields, described after the peak in fertiliser use. However, with regard to the national context, this correlation can also be classified as plausible (Baschet, 2011).

The regional specialisation in milk production in the post-war period was accompanied by strong development of the manufacturing industry, as Canévet (1972, 1991, 1992) or Lossouarn (2020) have demonstrated thoroughly. Concerning dairy farming, this symbiosis manifests itself through the high density of large dairies in Brittany compared to national standards. Here, the broader context can also be applied to the study region, as the close links with the nearby dairies described by the farmers testify. As a characteristic of this cooperation, the description highlights, in particular, that the equipment of the farms with modern milking systems in cooperation with the dairies and the regular collection by the dairies were essential pillars of the intensive production system.

During the 1980s, a tendency towards diversification was described on the farms visited. An examination of the statistics also confirms this development at the end of the 20th century. The broadening of the product range towards meat production or cash crops represents a development that has already been observed in other regions with a primarily strong specialisation in milk production. Houet (2006), for example, mentions the reorientation of dairy farmers towards meat production in the French departments of Morbihan and Côtes d'Armor. Here, the connection is drawn, in particular, with changed institutional and economic framework conditions.

The pooled purchase of material by different farmers described by some respondents is not surprising, as similar developments have already been described in detail in other comparable studies (e.g. Cocaud, 2006; Goulet et al., 2008; Canévet, 1992; Houet, 2006). However, it is striking with regard to the present study that the interviewed farmers attributed relatively little importance to CUMAs, which are widespread in Brittany. Instead, cooperation between farmers was characterised more as mutual help among farmers or as an informal association, mainly to acquire specific machines and equipment. At this point, an in-depth study on this topic would be interesting to see whether this organisation form effectively played a subordinate role in the region and, if so, to question the background of this circumstance.

In conclusion, it can be said that the study region is a relatively typical example of an agricultural area specialising in dairy farming. However, concerning the intensification trends observed on the farms visited, a more in-depth quantitative survey of key data on appropriate indicators would be helpful. Comparison with other similar case studies could thus help to strengthen the reliability of the results.

5.2 Landscape Development

The case study results show an evident change in the landscape in the second half of the 20th century. This landscape change is characterised by a substantial erosion of the typical *bocage* structure in northern France. Thus, between 1952 and 1984, the hedge structures were reduced to about one-third of the original inventory. They later experienced a slight increase in the last 15 years of the 20th century. This development is basically in line with developments observed throughout Brittany (e.g. Flatrès, 1979; Canévet, 1992; Javelle, 2007). In the course of the field visits, however, attention was repeatedly drawn to the relatively well-preserved hedgerow landscape, both in the interviews and in informal conversations. A quantitative comparison with other regions is difficult regarding hedge structures, as other comparable studies tend to record hedge density in terms of length per hectare, whereas, in this study, the area occupied by linear structures was used as an indicator. Furthermore, a qualitative comparison of the landscape development with the surrounding terrain chambers in the north and south of the study perimeter supports the description that the study perimeter still has a relatively dense hedgerow landscape.

In terms of field trees, a decline to about one-quarter of the original number can be observed in the 50 documented years of the landscape development analysis. This decline of individual trees continued until the turn of the millennium; however, a slight development deceleration has been observed since 1985. Other landscape changes that could be identified by the case study concern the significant increase in average plot sizes. Here, the comparison of the development of use and area development is interesting. It can be observed that in the first phase of substantial intensification, the areas used as cropland increased considerably. However, the increase in the size of the plots was slightly delayed. This suggests that when switching to this cropping system, the advantages of larger cultivated areas in terms of machinery use were only recognised later and therefore, a somewhat looser plot structure was the aim. With regard to the number of plots kept as grassland, however, stagnation can be observed between 1985 and 2000 at a value of about 0.7 ha. A further increase in arable land can be observed in the same period. The general trend of landscape change was expected in view of other studies carried out in the region; Javelle (2007) and Houet (2006), for example, have already described mostly identical developments in Brittany.

Finally, it should be mentioned that the investigation of the landscape structure between 1900 and 1950 could also have contributed interesting added value to the present study. Unfortunately, however, no statements can be made for this first half of the 20th century due to the lack of aerial photographs and

mapping. Nevertheless, based on general observations in northern France (e.g. Flatrès, 1979; Périchon, 2005), it can be assumed that the density of the *bocage* landscape would have reached its peak in the 1920s and 1930s, after which it probably experienced the first declining changes.

5.3 Driving Forces of Agricultural Intensity Change

As shown, the observed mechanisms of agricultural intensity change in the study region are mostly consistent with the intensification trajectories in other comparable European agricultural areas. The substantial decline of landscape elements as an expression of these change processes also fits into the significant structural changes observed, particularly in the whole of northern France. As expected, on the basis of theoretical assumptions (Bürgi et al., 2005; Geist & Lambin, 2002; Plieninger et al., 2015), it was possible to identify overarching driving forces that shaped the course of these changes. The analysis of these driving forces makes it possible to place the structural changes identified in a spatial, social and historical context. It should be said at this point that the definition of the driving forces presented in the results is subject to a certain subjecticity. Other factors that have shaped landscape and agricultural development could also be defined as driving force categories. The driving forces used in the frame of this work are primarily derived from the interviews with the farmers, whereby these driving forces have been explicitly or implicitly accentuated as essential aspects. The main driving forces are now discussed and reflected in the current state of research.

5.3.1 Socio-Economic Drivers

Kristensen et al. (2015) and Plieninger et al. (2015) already described in a broader European context that economic factors emerged in the second half of the past century as a significant driving force for agricultural intensification. Corresponding mechanisms could be revealed in the framework of this case study. The difficulty of distinguishing between socio-economic and institutional drivers, such as described by Schneeberger et al. (2007), was also confirmed in this context. This results from the close interplay between agricultural policies and economic frameworks. Milk prices, which are important at the farm level, can be cited as an illustrative example of this phenomenon. These are subject to intense state regulatory influence. The institutional driving forces are discussed in the following section 5.3.2.

Several key actors can be highlighted in terms of economic influence on agriculture. At the regional level, reference must be made to the strong presence of the food processing industry in Brittany from the 1950s onwards. The development of this industry is described in detail by Canévet (1988), for example. It comprises private enterprises and cooperatively organised organisms and can be summarised

as an agro-alimentary sector. Dairies turned out to be the most important actors of the farm environment in the highly specialised study region. Lossouarn (2020) already identified support in setting up efficient milking equipment and daily collection as an essential component of production intensification. Especially with regard to meat production, other purchasers, such as animal merchants, were important actors for the farms. Finally, in a broader sense, the production consumers are important stakeholders, as their demand ensures the sale of the production. In this sense, reference must also be made to the demographically induced growth of sales markets in the post-war period. Here, with reference to the high market integration of Breton agricultural production, both the French and the international market must be considered (Canévet, 1988, 1992). In addition, reference has already been made to the relatively modest economic conditions in the study region during the first half of the 20th century. Subsequently, the interviewed farmers described the will to improve the economic situation, which undoubtedly contributed to the intensification of agriculture in the study region. However, this aspect is assigned to the cultural driving force of individual and collective development motivation and is dealt with in chapter 5.3.5.

As shown in the results, the main overarching economic driving force is the market potential of agricultural production, which influences the farms' profitability. Against the background of the correlations between the course of intensification history and the economic potential of agriculture, listed by Canévet (1992) or Jennequin (2005), this finding was basically to be expected. In all evidence, the farmers interviewed had an economic motivation in designing their farm strategy, which was shaped by market mechanisms. This concerned, for example, the breeding and cropping pattern, and the extent of production to ensure prosperity. In this sense, state-guaranteed milk prices contributed significantly to expanding production. Furthermore, investments in farm infrastructure can also be linked to market mechanisms. This aspect can also be related to the diversification of farms observed towards the end of the 20th century, as market potential was often the basis for decisions. There is also an overlap with the introduction of milk quotas in 1984. Thus, the limited expansion of production against the background of capped demand led to a certain compulsion to look for new business opportunities.

Interestingly, the interviewed farmers did not consider direct payments to be a significant economic factor. More important in this sense was access to credit when taking over a farm or for expansion projects. As already explained in the discussion of institutional drivers based on Canévet's (1992) statements, this seems by and large plausible. However, a specific evaluation of the direct aid to the farms would have been helpful in order to provide an overall picture, but this was beyond the scope of the present work.

5.3.2 Institutional Drivers

As described by Kristensen et al. (2015) and Plieninger et al. (2015) in a broader European context, institutional drivers represent a decisive driving force of agricultural transformation processes. The institutional framework was also identified as a key driving force in the region investigated in the case study. Since ensuring food security is a core interest of national governments and agriculture is thus an economic sector with a high public interest, the relatively strong influence of the state is understandable. The principal actors to be highlighted in this context are the institutional decision-makers at European and national levels as legislators and, to a lesser extent, the decision-makers at regional and departmental levels in charge of implementing the policies.

The introduction of the European Common Agricultural Policy at the beginning of the 1960s and the Lois d'orientation Agricole at the national level is a decisive moment (Houet, 2006). The undertaken measures, such as the support of production through protectionist market interventions or the introduction of the Lifetime Retirement Allowance (Indemnité Viagère de Départ IVD), have decisively shaped the significant intensification of agriculture in almost all sectors. Another milestone at the institutional level can be found in the introduction of milk quotas in 1984. The further promotion of farm concentration, on the one hand, and the partial compulsion to diversify farms on the other are effects that are not surprising given similar analyses (e.g. Houet, 2006; Eynaudi, 2010; Codron, 2006). However, this institutional framework is not specific to the study region around Pleine-Fougères but is more general at the national level. Moreover, as Canévet (1992) points out, agricultural production in Brittany was subsidised below average compared to other French regions at the time of the strongest intensification processes. This suggests that other factors played a decisive role in the intensification trajectory of agriculture.

A particular feature of the study region concerns the way reorganisations of plot structures were carried out for more efficient management. As the interviewed farmers clearly pointed out, overarching land consolidation programmes, such as those described by Philippe & Polombo (2010), played a minor role. This description is also supported by Pauchard et al. (2016) in a study of the history of land consolidation in Brittany and Normandy. In the Ille-et-Vilaine department, municipalities that have carried out such land consolidation are mainly concentrated in the south and around the town of Fougères. It should be noted that such measures had to be applied with the involvement of a commission, whereby municipal decision-makers and the chambers of agriculture, which are usually active in this area, would have been decisive actors in the implementation. However, according to the statements of the interviewed farmers, there was generally no great willingness to do this, nor any apparent necessity. It can be assumed that this also reflects the local population's attitude. According to Vitikainen (2004), this does not mean that no land consolidation measures were carried out to fulfil objectives such as improving agricultural land division or other purposes. According to the interviews, bilateral solutions in the neighbourhood or known circle without the involvement of institutional actors were more likely to be sought. This is also in line with Pauchard's (2016) observation that alternative models, which tend to occur informally between individuals, have always been used to achieve the desired land consolidation.

The effects stressed by Houet (2006) and Pollet (2014), linked to the CAP reforms at the beginning of the 1990s, coincided with the farmers' statements. On the one hand, the change in the basic principle of state support should be emphasised; this includes the decoupling of CAP subsidy payments from production goals to calculate premiums according to the size of the area cultivated and the size of the livestock. Thus, the farm concentration that continued towards the end of the 20th century, with growing farms and plot sizes, can be placed in an institutional context. On the other hand, the tighter regulation of agriculture in terms of environmental protection should be considered (Lossouarn, 2020). The described restrictions on the use of fertilisers and pesticides correspond to the quantitative surveys of Le Souder et al. (1998), which document a significant decrease in the use of nutrients in northern Brittany from the mid-1990s onwards.

The effects of the institutional framework conditions, which have forced an increase in farm productivity, can also be clearly seen in landscape development. As Houet (2006) and Canévet (1992) described, the reorientation of European and French agricultural policy at the beginning of the 1960s had a decisive influence on farm consolidation processes. For example, the introduction of the Lifetime Retirement Allowance (*Indemnité Viagère de Départ* IVD) and the implementation of the SAFER

should be highlighted. These measures, that favoured the expansion of farms while the total number of farms decreased, fostered the rapid expansion of land parcels, which was partly realised through the clearing of hedge features.

5.3.3 Technological Drivers

The case study was able to show that technological progress played a significant role in the identified intensification mechanisms during the study period. Thus, the development fits into the general context of agricultural intensification processes in Europe (e.g. Santana-Cordero et al., 2017; Jepsen et al., 2015; Geist & Lambin, 2002). Furthermore, the influence of technological progress identified in the case study fits into the influence of technological progress documented for Brittany as a whole. As already described by Canévet (1992) or Houet (2006), this promoted the change from small-scale, diversified farms to more extensive and highly specialised enterprises. For example, the gradual replacement of muscle power by motorised vehicles and increasingly customised tools opened up a much more intensive land management intensity. As a result, all cropping and livestock-related activities were considerably simplified. In this context, significantly larger areas could be farmed with the same number of workers, and the arrangement of the land was less tied to the location of the farm itself. This also highlights a clear connection between technological progress and the significant farm concentration in the region.

In addition, the importance of advice and information on technical possibilities should be mentioned, as they have contributed decisively to the rapid diffusion of new possibilities. Economic actors such as cooperatives and dairies, the Chamber of Agriculture as an institutional actor and the trade unions played a decisive role in the developments. Lossouarn (2020) and Canévet (1992), for example, have already referred to the importance of the organisations mentioned above in the diffusion of technical aids in their explanations.

There is an apparent relationship between the increased technological possibilities and the decline of landscape elements, as motorisation made it possible to cultivate larger plots of land profitably. Concerning the decline of hedgerow structures, one has also to consider the changing value of hedgerows in the agricultural production system. For example, as Marguerie et al. (2003) explain, the hedgerows were used, among other things, for herding livestock and for the production of firewood needed to heat the dwellings. However, with the arrival of barbed wire from the 1960s onwards and later electric wires and oil-fired heating, hedgerows lost their function in the rural system, catalysing the rapid

decline. Concerning the decline of fruit trees, Périchon (2012) also refers to clearing premiums and a sharp drop in demand for cider and calvados from the 1950s onwards.

5.3.4 Natural drivers

The field study results seemingly suggest that the natural conditions of the study region can only be counted among the drivers of intensification to a limited extent. In fact, during the interviews, the natural conditions were instead described as an inhibiting factor for further agricultural development. The relatively hilly topography and the numerous small rivers running through the landscape were mentioned. In addition, the development possibilities were limited by relatively nutrient-poor soils and numerous places where the granitic subsoil appears. This results in a smaller-scale landscape with a higher density of landscape elements. This small-scale differentiation with regard to the geologically different starting positions was already determined in the natural characterisation of the study area (see Chapter 3.1.1), so for the adjacent landscape area in the north of the study area, the topography is significantly flatter, and the subsoil consists of sedimentary bedrock. A relatively moderate land-use intensification also seems plausible against the background of Javelle's (2007) findings in the study region. However, it cannot be conclusively interpreted from the results whether, as described in the cited study, the smaller-scale initial situation has also affected the willingness to cooperate with regard to land consolidation measures. In addition, it should be emphasised at this point that without the corresponding natural framework conditions, the observed expansion of field yields and animal productivity would not even have been possible.

Concerning the structural driving forces, it would have been expected – on the basis of the theoretical assumptions – that traffic accessibility, in particular, would have been highlighted as an important driving force. However, no statements could be obtained regarding the expansion of transport infrastructure as a possible factor in agricultural intensification. Nevertheless, if one follows the statements of Lossouarn (2020) or Canévet (1992), the expansion in street infrastructures has contributed to better linking Brittany to the entire French and European economy. In addition, better access to production factors such as fertilisers and tools can be expected.

5.3.5 Cultural Drivers

Based on the results, it can be said that cultural driving forces also influenced the history of agricultural development in the study region. On the one hand, the pronounced motivation for economic development and improvement of living conditions should be emphasised as a significant driver which influenced the history of development both at the individual level and in the local and superordinate context. In addition, various intensification trends such as increased land-use management or input use intensity can be placed in a context with pronounced social cohesion at the local level. Social cohesion in the region is expressed in particular in the context of various formal and informal social networks, according to Freitag (2014). The strongly organised trade unions and the JAC should be mentioned as formal networks, whereas the informal level consists of the family and friend environment and the machinery circles in a mixed form.

In disseminating a collective vision of agricultural development, previous studies have already pointed to the crucial role of rural associations, especially the JAC and the large labour unions (Canévet, 1988; Canévet, 1992; Périchon, 2004). It was pointed out, for example, that a rational and productivist narrative towards agricultural development was cultivated within the framework of meetings, training programmes and discussion groups. This subsequently provided an essential basis for Brittany's particularly pronounced agricultural intensification. This starting point was confirmed to a certain extent in the case study, as several of the farmers interviewed emphasised the attitudes conveyed by these organisations as having a formative influence on their decision-making. However, it should be emphasised that not all farmers interviewed belonged to the organisations mentioned above and instead understood further development as a necessity in the post-war period to put themselves in a more privileged economic and social position. This attitude of questioning established structures and thought patterns is also emphasised, for example, in Lossouarn's (2020) remarks in the context of the history of Brittany's agricultural development and could be expected in this sense. The determinant role of beliefs and values in the farmers' decision-making processes has been documented in depth in other works (e.g. Ostrom, 2009; Paldam, 2000; Brown et al., 2021).

The case study reveals the close connection between individual and collective motivation and the solid regional social cohesion in the 20th century. These two driving forces influenced each other. In this sense, development motivation was, on the one hand, the basis for strengthening social cohesion through the expansion of social networks. At the same time, as described above, these social networks contributed to the spread of a productivist narrative. Interesting, at this point, is the connection with the

increased mechanisation and investments in infrastructure. For example, informal relationships in the circle of friends, neighbourhood or family have been identified as conducive to acquiring agricultural equipment, as evidenced by the example of machinery circles. However, the results did not reveal a significant role of CUMA's, as would have been expected based on other regionally related studies (Lucas et al., 2014; Cocaud, 2006; Houet, 2006). In summary, it can nevertheless be stated that social networks provided a framework for individual and collective opinion building and disseminating knowledge necessary for agricultural intensification.

Finally, the case study also confirmed the difficulty in detecting and evaluating cultural driving forces already described by Bürgi et al. (2005). This is expressed here by the fact that the delimitation of driving forces in this case study remains vague to a certain degree.

5.4 Limitations and Weaknesses

The present study aimed to reconstruct agricultural and related landscape development on a limited perimeter in a case study. Even if some conclusive linkages could be identified based on the conducted surveys, the results have some limitations and have to be relativised under consideration of various aspects.

On the one hand, the used statistical data series refer to the second half of the 20th century only, which means that statements regarding the period stretching from 1900 to 1950 were impossible. On the other hand, it is also to be pointed out that the definition of the study perimeter was not ideal for the acquisition and interpretation of data. It must be taken into account that the municipal boundaries do not coincide with those of the perimeter of landscape development analysis. This induces a lack of clarity which negatively affects the analyses' validity.

With regard to the landscape development analysis, it should be underlined once again that the data basis used was not compiled independently. In this sense, it was not precisely tailored to the analyses carried out and had to be processed again beforehand. This results in a certain lack of clarity, especially regarding the quantitative evaluations. Therefore, the absolute values determined for the number and area of the various landscape elements only correspond to a limited extent to the actual conditions. However, it should also be noted that this bias applies equally to all snapshots, and therefore the evaluation of trends over the entire study period can still be considered reliable.

As mentioned in the methodology part, the interview partners were mainly organised through a snowball technique. This procedure entailes the risk that similar people tended to be interviewed, and thus, no representative picture could be gathered. A random selection would have tended to minimise the risk in this sense. Furthermore, the following must be taken into account: the statements of the oral history interviews are based on personal experiences and describe developments that are partly limited to individual perception. Moreover, the interviews were conducted with senior farmers, some of whom began their agricultural careers up to 60 years ago. Some of the described memories of events before their careers date back even further. As a limiting factor, it must therefore be emphasised that the reliability of the statements can be somewhat biased by the long-time spans. This restriction concerns quantitative information – related, for example, the size of the farm or the number of animals – but may also concern qualitative information on specific historical events on the farm or in the region.

Another limiting factor is to be located on a linguistic level. Since the partly very technical interviews had to be conducted in French, in-depth questions which would have been necessary to specify further the data were limited. This would have required additional knowledge of agriculture-related technical terms, acquired only during the field stay and its evaluation. It should also be noted that the translation of the transcripts necessary for the analysis may have resulted in minor alterations in the literal meaning of the statements, which then may have found their way into the results.

As can be seen from the discussion, the classification of trends in agricultural intensity change and driving forces is somewhat vague. Therefore, the list should not be regarded as exhaustive. It could be supplemented by other trends and driving forces or further subdivided.

6 Synthesis

6.1 Conclusion

Considering the research objectives set at the outset, it was possible to achieve conclusive findings within the case study's framework for the second half of the 20th century. It was possible to trace the course of agricultural productivity and management intensity of the farms and the landscape structure in the study region near Pleine-Fougères. The study also enabled the identification of key actors and driving forces behind agricultural and landscape change processes in the 20th century. Using a mixed-method approach, which included interviews with contemporary witnesses in the study region, the evaluation of statistical data sets and a GIS-based investigation of landscape change, it was possible to trace the history of a relatively strong intensification of agriculture and drastic landscape changes in a retrospective perspective.

The most characteristic intensification trends include an evident decrease in the number of farms with growing cultivated areas, an initially strong regional specialisation in dairy farming with later diversification tendencies and, simultaneously, a substantial increase in the use of technological aids, fertilisers and plant protection products. In this context, it also appeared that the acquisition of materials and machinery was increasingly pooled in various forms of organisation. It should also be emphasised that there has been a significant increase in agricultural management intensity, which is reflected in higher crop yields, an increase in livestock numbers and a rise in animal productivity. The intensification of agriculture has also left clearly recognisable traces in the landscape structure. The main change is the sharp decline in field trees and hedgerows. This was accompanied by a significant increase in plot sizes, which were also increasingly converted from grassland to cropland. As drivers of the documented changes, overarching legislation at the European and national levels proved to be particularly influential. From an economic point of view, the market mechanisms shaped by demand and price development exerted a particularly noticeable influence on the agricultural intensification of farms, whereby close interlocking with the institutional framework conditions could be identified. In addition, the rapid progress in agricultural technology and the intensive training and counselling of farmers were essential fundamentals for intensifying the local production system. Finally, a cultural factor that should not be underestimated in the history of agricultural intensification in the 20th century is the strong motivation for modernisation and economic progress in the study region and the social cohesion of the local population. However, the natural foundations of the study region could instead be identified as a limiting factor for a more profound intensification, whereby the geological and topographical characteristics of

the landscape between Broualan, Cuguen, Trans-la-Forêt and Bazouges-la-Pérouse are to be mentioned in particular. In summary, it must be emphasised that the identified driving forces have acted in a complex interplay regarding both the mechanisms of agricultural intensity change and landscape development.

However, the case study was not conclusive regarding the first half of the 20th century. Neither an investigation of landscape development nor an analysis of relevant statistical indicators could be carried out. Therefore, findings for this phase are based exclusively on the statements of contemporary witnesses who experienced this period as children or adolescents. This description, obtained during the interviews, draws a picture of a poorly developed agriculture which, under the influence of the political, social and economic realities of the world wars, shows a low degree of intensification.

The agricultural intensification trajectory and landscape development of the study region reconstructed in this case study show many similarities with the agricultural histories of other comparable regions in Brittany in the 20th century, as revealed through a comparison with statistics and the relevant specialised literature. This indicates the high effectiveness of the overarching agricultural and environmental policies and the widespread attitude towards modernisation and innovation throughout Brittany. As an individual characteristic of the study region, the geographic characteristics can be emphasised, whereby a significant influence on the pronounced specialisation in dairy farming can be assumed. The *bocage* structure typical of northern France can still be clearly read in the study area in relation to other comparable regions. Here again, a limiting influence of the natural starting position can be assumed. In addition, a culturally conditioned renunciation of far-reaching land consolidation measures can also be supposed.

6.2 Outlook

The studies carried out within the SIPATH project are intended to facilitate the modelling of realistic scenarios of future agricultural development and the formulation of practical recommendations for action concerning sustainable agricultural intensification. In addition, a deeper understanding of past mechanisms between actors, driving forces and trends of agricultural intensity change can serve as a guideline.

This case study has shown that farmers' general attitude and motivation towards change processes play a significant role. Future efforts in the sense of sustainable intensification should give high relevance to this circumstance. Accordingly, further research should address the search for ways to promote motivation. On the basis of the discussions held on the sidelines of the interviews, a certain alienation between the agricultural and broader society was, for example, highlighted; this had a negative impact on motivation. Therefore, bringing these social groups closer together through a better understanding of their individual needs could be a valuable approach.

It has also been underlined that overarching legal frameworks and economic incentives can considerably influence the development of agriculture. Therefore, a carefully developed formulation and implementation of appropriate measures will continue to play a significant role in the further trajectory of agricultural development. Finally, it must be emphasised that development in the sense of sustainable intensification cannot be achieved through improved farming methods alone. Parallelly to efforts to achieve resource-efficient agriculture and food security, issues of consumption, distribution and the value attributed to food in society must also be addressed.

7 Declaration of Originality

According to Art. 30 RSL Phil.-nat. 18

Leo Müller

13-105-903

Master of Science in Geography

Driving Forces and Key Actors of Agricultural Intensification Trajectories in the Pleine-Fougères Study Region since 1900

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I hereby declare that I have written this thesis without any help from others and without the use of documents and aids other than those stated above. I have mentioned all used sources and cited them correctly according to established academic citation rules. I am aware that otherwise the Senat is entitled to revoke the degree awarded on the basis of this thesis, according to article 36 paragraph 1 letter o of the University Act from 5 September 1996.

Luzern, 10 June 2022

Signature:

8 Annex

8.1 Questionnaire

Données sur les conditions de l'entretien

Veuillez noter les informations suivantes pour chaque entretien. Elles serviront à nouveau de préambule à la transcription

Intervieweur:	Leo Müller
Code de la personne interrogée :	
la date et l'heure de l'entretien:	
Site de l'entretien:	
Type d'entretien:	□ Face à face □ Autre: _____
Durée de l'entretien:	
Remarques sur la situation de l'entretien (atmosphère, perturbations, autres observations):	
Sexe de la personne interrogée:	□ Féminin □ Masculin □ Autre □ Pas de réponse
Age de la personne interrogée:	
Fonction, Rôle dans l'agriculture (écrire le terme que la personne interrogée utilise pour elle-même) :	
Type d'exploitation agricole:	□ Exploitation de grandes cultures □ Exploitation mixte élevage(s) et grandes cultures □ Exploitation spécialisée en élevage laitier □ Exploitation spécialisée en élevage de granivores (porcs et/ou volailles) □ (Autre)_____

Première partie : Questions ouvertes concernant la perception des agriculteurs sur les changements dans l'agriculture *

A: Pourriez-vous décrire votre vie liée à l'agriculture ?

- *Comment la profession d'agriculteur a-t-elle évolué entre le moment de la reprise de l'exploitation et aujourd'hui?*
- *Objectif : avoir un éclairage sur différentes étapes de la vie de la personne interrogée : par exemple, aider dans l'exploitation agricole des parents, créer sa propre exploitation agricole, expériences dans des entreprises agricoles /syndicats, grands changements de carrière, etc.*

B: Dans quelle mesure la vie agricole vous a-t-elle satisfait?

- *Cette satisfaction a-t-elle évolué au fil du temps ?*
- *Qu'est-ce qui était satisfaisant ?*

C: Quels ont été les moments particulièrement stressants ou faciles pour vous en ce qui concerne l'exploitation agricole?

- *Quelle était la cause de ce stress ? / Quel a été son impact sur vous ?*
- *Ce stress a-t-il évolué au fil du temps ?*
- *Mots clés : Facteurs économiques, contraintes financières, charge de travail, …*

D: Dans quelle mesure était-il facile de vivre de l'agriculture?

- *Comment cela a-t-il évolué au fil du temps ? / A quel moment cela a-t-il changé ?*
- *Quelle est la cause de ce changement ? / Pourquoi est-ce que c'est resté constant ?*
- *Les revenus ont-ils beaucoup varié d'une année à l'autre ? Si oui, pourquoi?*

E: Quelles ont été les principal évènements marquants (positifs ou négatifs) (p.e de nature environnementale, politique, sociale ou économique) que votre exploitation a connu ?

- *Quand et pourquoi ?*
- ***De quelle facon avez-vous réagi dans ces moments cruciaux ?***
- *Exemples pour des événements marquants négatifs :* arrêt d'une filière, fin de la régulation des prix / effondrement du marché, restriction réglementaire, départ de personnes, problèmes d'équipements*, nouvelles politiques, effondrement du système politique, calamités naturelles tels que des inondations, des années de chaleur accompagnées de sécheresse ou l'érosion des sols, épidémies végétales et animales, etc.*
- *Exemple pour des événements marquants positifs : ouverture d'une filière, aides publiques, libéralisation, nouvelles politiques, expansion de l'infrastructure, ouverture d'un site de formation, etc.*

F: Sur votre territoire, quels sont les types de soutien sur lesquels les agriculteurs pouvaient compter? (p.e. autres agriculteurs/villageois/autres)

- *De quelle facon et pour quelle raison ceci a changé ?*
- *Le soutien peut inclure par exemple: Échange de biens, de services (aide à la ferme), d'informations, etc..*
- *Ce soutien a-t-il eu lieu entre des fermes voisines ou plutôt au niveau municipal ou même régional ?*

G: Avez-vous eu l'impression que la société estimait le travail agricole?

- *Cela a-t-il changé depuis que vous avez commencé à travailler dans l'agriculture ? Si oui, pourquoi ?*
- *Cela a-t-il eu un impact sur votre façon de pratiquer l'agriculture ?*
- *Est-ce que cela se reflète dans la façon dont le gouvernement a soutenu l'agriculture ?*

* Les questions en italique peuvent être posées, si l'agriculteur n'élabore pas trop par lui-même.

Deuxième partie : Questionnaire sur les changements dans l'exploitation (ou les exploitations)

1	Biographie et informations générales

1.1. En quelle année avez-vous commencé à travailler dans l'agriculture ?

1.2 Comment êtes-vous devenu agriculteur ? (Enseignement professionnel, maîtrise professionnelle, diplôme universitaire, autre)

1.3 Détails concernant l'exploitation agricole

F.1.3.0 De quel type d'exploitation s'agit-il ?

- *SCEA/GAEC/EARL/SEP Type à préciser et souligner au cours de la conversation.*

F 1.3.1 Quand avez-vous commencé à travailler dans la ferme et quand avez-vous commencer à mener l'entreprise ?

F 1.3.2 Quelles étaient vos activités, responsabilités ?

Question a poser en dépendance de la forme de l'exploitation

F 1.3.2 Si un changement de ferme est mentionné en A : En quelle(s) année(s) avez-vous changé d'exploitation ?

F 1.3.3 Quand avez-vous (ou prévoyez-vous de) remis la ferme dans d'autres mains ?

F 1.3.4 Aviez-vous (ou avez-vous) un successeur ?

F 1.3.5 Quelle est votre relation avec le successeur (familiale, externe) ?

1.4 Quel est votre lien actuel avec l'exploitation agricole / l'agriculture ?

2	Spécificités de l'exploitation agricole

2.1 Taille de la ferme

2.1.1 Quelle était la taille de l'exploitation en ha quand vous avez commencé et quand vous avez arrêté d'y travailler ?

2.1.2 Le cas échéant : Quand et pourquoi la taille de l'exploitation a-t-elle changé ?

2.2 Utilisation des terres

2.2.1 Quelle était la part de la surface agricole utilisée pour les grandes cultures/ les pâturages / les cultures permanentes / les surfaces forestières lorsque vous avez commencé **et** cessé de travailler dans l'exploitation ?

2.2.2 Le cas échéant : Comment et pourquoi ces proportions ont-elles changé ?

2.3 Régime foncier

2.3.1 Quelle était la superficie des terres agricoles dont vous étiez propriétaire / locataire / usager de terrain communaux (%) lorsque vous avez commencé et cessé de travailler dans l'exploitation ?

2.3.2 Le cas échéant : Quand et pourquoi cela a-t-il changé ?

2.3.3 Le type de régime foncier a-t-il influencé la manière dont les terres étaient utilisées ?

2.4 Questions supplémentaires concernant le régime foncier

2.4.1 Terrain en propriété : Comment êtes-vous entré en possession de la terre ?

2.4.2 Terrain loué : De qui avez-vous loué (personne privée, succession, commune, réserves foncières des communes, etc.) ? Quand et pourquoi cela a-t-il changé ?

2.4.3 Comment fonctionne / a fonctionné la gestion de terrains communaux

2.5 Évolution du nombre d'exploitations

2.5.1 A votre avis, Pourquoi le nombre d'exploitations agricoles a-t-il diminué ?

2.5.2 Qu'est-il arrivé aux parcelles des agriculteurs qui ont cessé de cultiver ? / Cela a-t-il changé au fil du temps ?

2.5.3 Quelles sont les caractéristiques des exploitations qui existent encore par rapport à celles qui ont abandonné ?

3 Terres arables

3.1 Rotation des cultures

3.1.1 Quelles étaient les cultures typiques (y compris le %) dans la rotation des cultures lorsque vous avez commencé **et** cessé de travailler dans l'exploitation ?

3.1.2 Pourquoi et quand cela a-t-il changé ?

3.2 Rendement des cultures par surface

3.2.1 Comment le rendement par surface de la culture principale a-t-il évolué ?

3.2.2 Le cas échéant : Quand et pourquoi le rendement par surface de la culture principale a-t-il changé ?

4 Animaux d'élevage

4.1 Nombre et genre d'animal

4.1.1 Combien d'animaux de chaque type aviez-vous lorsque vous avez commencé et cessé de travailler dans l'exploitation (*si possible, également noter les unités de bétail (UB*))

4.1.2 Le cas échéant : Pourquoi et quand le type / nombre d'animaux a-t-il changé ?

4.2 Alimentation des animaux

4.2.1 Quelle était la composition (*par exemple, herbe sur pied (pâture), foin, ensilage, produits concentrés*) de l'alimentation animale (en %) lorsque vous avez commencé **et** cessé de travailler dans l'exploitation ?

4.2.2 Comment la quantité de produits concentrés a-t-elle évolué au fil du temps?

4.2.3 D'où proviennent les aliments pour animaux (*y compris les fourrages de base et les produits concentrés*) (*produits à la ferme / locaux / nationaux / mondiaux*) en % ?

→ *Distinguer les différents animaux dans la discussion.*

4.2.4 Le cas échéant : Quand et pourquoi la stratégie en matière de fourrage et/ou la stratégie en matière de concentrés a-t-elle changé ?

4.3 Productivité animale (par exemple : Rendement laitier / lactation pour les vaches laitières, âge moyen à l'atteinte du poids d'abattage pour les animaux à viande, nombre d'œufs / âge attendu pour les poules pondeuses)

4.3.1 Comment la productivité des animaux a-t-elle évolué pendant la période où vous avez travaillé à la ferme ?

4.3.2 Le cas échéant : Qu'est-ce qui a changé, quand et pourquoi ?

5 Prairie

5.1 Genre d'utilisation

5.1.1 Comment les prairies ont-elles été utilisées lorsque vous avez commencé **et** cessé de travailler à la ferme ? (Pâture seule, pâture et fauche, ou fauche seule)

5.1.3 Le cas échéant : Quand et pourquoi le genre d'utilisation a-t-il changé ?

5.2 Fréquence d'utilisation (*coupes / fréquence de pâturage*)

5.2.1 Quel était le type de conduite de prairie lorsque vous avez commencé **et** cessé de travailler dans l'exploitation ? (p.e. 2 fauches/1 pâture courte)

5.2.2 Le cas échéant : Quand et pourquoi le nombre d'utilisations a-t-il changé ?

5.2.3 La date de mise en pâture/première fauche a-t-elle changé depuis votre installation ?

5.3 Si cela est valable pour la région : Avez-vous également utilisé des pommeraies et bosquets ? Cela a-t-il changé ? / Pourquoi ?

6 Cultures permanentes

6.1 Genre de cultures permanentes

6.1.1 De quel type étaient vos vergers de pommier lorsque vous avez commencé **et** cessé de travailler à la ferme ? (Basse tige/haute tige)

6.1.2 Le cas échéant : Quand et pourquoi le type de cultures permanentes a-t-il changé ?

6.2. Nombre / superficie des arbres

6.2.1 Combien d'arbres y avait-il / quelle était la taille de la zone quand vous avez commencé et quand vous avez arrêté de travailler à la ferme ?

6.2.2 Le cas échéant : Quand et pourquoi le nombre d'arbres / la la superficie boisée ont-ils changé ?

7 Apports

7.1 Engrais

7.1.1 Est- ce que vous savez quand les premiers engrais minéraux ont-ils été utilisés dans l'exploitation ?

7.1.2 D'après votre propre expérience, l'utilisation d'engrais (*organiques et minéraux*) a-t-elle augmenté / diminué / est restée constante pendant les années où vous avez travaillé dans l'exploitation ?

7.1.3 Comment la composition des engrais *(% de fumier, lisier, engrais minéraux, etc*.) a-t-elle évolué pendant les années où vous avez travaillé dans l'exploitation ?

7.1.4 Pourquoi et quand la composition et la quantité d'engrais ont-elles changé ? (*Si la réponse n'est pas connue, demander si le contexte politique et/ou l'augmentation des coûts des additifs ont eu un impact*)

7.2 Additifs *(antibiotiques, herbicides, fongicides, insecticides*)

7.2.1 Quand les premiers antibiotiques ont-ils été utilisés dans votre exploitation ?

7.2.2 Comment l'utilisation des antibiotiques a-t-elle évolué (*plus / constant / moins*) ?

7.2.3 Quand est-ce que les premiers herbicides **et** fongicides **et** insecticides ont été utilisés dans votre exploitation ?

7.2.4 Comment la quantité d'herbicides **et** de fongicides **et** d'insecticides utilisée a-t-elle évolué (*plus / constant/ moins*) ?

7.2.5 Quelles étaient les raisons de l'augmentation ou de la diminution de la quantité d'additifs ? (Si l'agriculteur ne connaît pas la réponse, demandez-lui si les politiques et/ou l'augmentation des coûts des additifs ont eu un impact)

7.3 Irrigation

7.3.1 Quelle proportion [%] de la surface était irriguée quand vous avez commencé **et** quand vous avez arrêté de travailler à la ferme ?

7.3.2 Le cas échéant : Quand et pourquoi la superficie irriguée a-t-elle changé ?

7.4 Drainage

7.4.1 Le cas échéant : Quelle proportion [%] de la surface était drainée lorsque vous avez commencé **et** cessé de travailler dans l'exploitation ?

7.4.2 Le cas échéant : Quand et pourquoi la surface drainée a-t-elle varié ?

8 Innovation & Investissements

8.1 Nombre de tracteurs

8.1.1 Quand est-ce que le premier tracteur a-t-il été acheté dans l'exploitation ?

8.1.2 Combien de tracteurs y avait-il dans l'exploitation, quand vous avez commencé et quand vous avez cessé de travailler à l'exploitation ?

8.2 Mécanisation

8.2.1 Quelles autres machines *("**qui ont fondamentalement changé les processus de travail dans l'exploitation**") ont été achetées pendant la période où vous travailliez dans l'exploitation ? Attention : concerne la mécanisation sur le terrain et dans l'étable (par exemple, les machines à traire, les machines à nourrir*).

8.2.2 Quand et pourquoi de nouvelles machines (*y compris les tracteurs*) ont-elles été introduites ?

8.3 Location de services / machines

8.3.1 Quelles machines avez-vous louées / quel travail a été effectué par des contractants (machines + opérateur) lorsque vous avez commencé **et** cessé de travailler dans l'exploitation ?

8.3.2 Le cas échéant : Quand et pourquoi avez-vous commencé à louer plus / moins / d'autres machines ou contractants ?

8.4 Infrastructure / Innovation

8.4.1 Avez-vous investi dans d'autres infrastructures ou des nouvelles technologies pendant que vous travailliez dans l'exploitation ? Si oui, quoi et quand ? (*par exemple, stabulations, serres, silos, routes*)

8.4.2 Quelle était la motivation pour ces investissements ?

8.5 Contexte de la prise de décision

8.5.1 D'où provenaient les informations relatives aux nouvelles machines / technologies / apports ? Cela a-t-il changé au fil du temps ? (*par exemple, journaux, salons du machinisme agricole, représentants d'entreprises, formation, syndicats, coopératives*) ?

8.5.2 Avec qui (*c'est-à-dire la famille, les amis, les voisins agriculteurs, les syndicats, les coopératives*) avez-vous discuté de l'achat de nouvelles machines ou du changement de pratiques ? Cela a-t-il changé au fil du temps?

9	Main d'œuvre

9.1 Travailleurs à l'année

9.1.1 Combien de personnes (si possible l'unité de travail annuel UTA) ont travaillé à l'exploitation pendant toute l'année lorsque vous avez commencé à travailler **et** lorsque vous avez cessé de travailler dans l'exploitation?

9.1.2 Si cela n'est pas déjà mentionné au point 9.1.1 : Quel était le rôle des membres de la famille (*partenaire/conjoint, parents, enfants*) ? / Comment cela a-t-il changé ?

9.2 Travailleurs saisonniers / de récolte

9.2.1 Combien de travailleurs saisonniers / de récolte étaient employés quand vous avez commencé **et** quand vous avez cessé de travailler à la ferme ?

9.2.2 Pour quel travail et pour quelle période les travailleurs saisonniers / de récolte sont-ils employés ? Comment cela a-t-il changé ?

9.2.3 D'où venaient les travailleurs saisonniers / de récolte (*par exemple, de la municipalité / du pays / de l'étranger*) ? S'ils n'étaient pas locaux, par quels canaux / réseaux ont-ils été-engagés ?

9.3 Charge de travail

9.3.1 Quand et pourquoi le nombre de personnes (*travailleurs à l'année, saisonniers et ouvriers agricoles*) a-t-il changé ?

9.3.1 Le temps consacré au travail a-t-il changé pour vous au fil des ans ? Si oui, quand et pourquoi ?

9.3.2 Avez-vous pu prendre des vacances ? Si oui, à partir de quand, comment cela a-t-il changé ?

9.4 Revenu hors exploitation

9.4.1 Quelle part [%] du revenu du ménage a été générée par des activités non agricoles lorsque vous avez commencé à travailler et lorsque vous avez cessé de travailler dans l'exploitation ?

9.4.2 Le cas échéant : Quand et pourquoi cela a-t-il changé ?

10	Stratégies

10.1 Lucrativité des activités

10.1.1 Quelles sont les activités de l'exploitation agricole qui ont été les plus lucratives financièrement lorsque vous avez commencé et cessé de travailler à la ferme ? (*y*

compris les activités comme l'agrotourisme, la location d'appartements, la dégustation de vin)

10.1.2 Quel pourcentage du revenu agricole a été généré par ce(s) produit(s) lorsque vous avez commencé **et** cessé de travailler dans l'exploitation ?

10.1.3 Le cas échéant : Quand et pourquoi cela a-t-il changé ?

10.2 Certifications et labels

10.2.1 Quelle était l'importance des labels / de la certification pour l'exploitation ? Comment cela a-t-il changé ?

10.2.2 Le cas échéant : Quel a été le coût (monétaire ou organisationnel, par exemple) de leur acquisition ?

10.2.3 Quelle était la motivation (ou non) pour obtenir un label ?

10.3 Marché de vente

10.3.1 Quels étaient les marchés de vente importants pour la ou les principales productions lorsque vous avez commencé et cessé de travailler à l'exploitation?

10.3.2 Le cas échéant : Quand et pourquoi les marchés de vente ont-ils changé ? (*Où avez-vous obtenu des informations sur les marchés alternatifs ?*)

11 Contexte politique

11.1 Selon vous, quelles sont les réglementations les plus marquants qui ont été mises en place par les autorités au cours de votre trajectoire professionnel ? Pourquoi étaient-ils importants (si d'autres règlements importants (point de vue de l'enquêteur) ne sont pas mentionnés, veuillez demander leur importance).

11.2 Comment ont-ils influencé le développement de l'exploitation ?

11.3 Si elle n'est pas mentionnée : Comment l'importance des paiements directs pour la rentabilité de l'exploitation a-t-elle évolué ? Comment les paiements directs ont-ils influencé l'orientation de l'exploitation ?

12 Paysage et environnement

12.1 Changement du paysage

12.1.1 Comment, quand et pourquoi le paysage autour de votre ferme a-t-il changé au fil des ans ?

12.1.2 Sur la base de cartes / images aériennes, nous avons observé les changements suivants : _____. Pouvez-vous nous faire part de vos observations à ce sujet ? Pourquoi et quand cela a-t-il changé ? (**Les changements observés pourraient être la**

taille des champs, des haies, des arbres isolés ou d'autres éléments caractéristiques du paysage).

12.2 Comment la diversité des oiseaux, des papillons / insectes et des fleurs / herbes sauvages a-t-elle changé depuis que vous avez commencé à travailler dans l'agriculture ?

12.3 Au fil de votre trajectoire professionnel, est-ce que vous avez connu des processus de dégradation des sols ?

12.4 Si oui : Quelles mesures avez-vous mises en œuvre pour éviter la dégradation des sols ? Comment cela a-t-il changé ?

Questions finales

- Souhaitez-vous ajouter quelque chose à notre conversation d'aujourd'hui ?
- Si nous avons encore des questions de suivi, pouvons-nous vous contacter par téléphone ?
- Souhaitez-vous être informé des résultats de l'étude ?

8.2 Consent Form

Demande d'autorisation de collecte de données sur votre exploitation agricole et d'utilisation de ces données dans un cadre de recherche scientifique

Projet/protocole de recherche: dispositif Zone Atelier Armorique / projet SIPATH

Responsable(s) de la collecte et de l'utilisation des données: Leo Müller, Claudine Thenail

Coordonnées des responsables:

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La Zone Atelier Armorique est un dispositif de recherche à long terme qui rassemble des scientifiques de plusieurs unités de recherche (Université de Rennes 1, INRAE, Université de Rennes 2). Elle a pour objectif d'étudier les liens entre les acteurs et activités au sein des territoires locaux (pratiques agricoles, aménagement du territoire), le paysage et la biodiversité (faune, flore, micro-organismes du sol) afin de comprendre les évolutions qui sont à l'oeuvre. Travaillant sur des gradients paysagers agricoles et urbains, le suivi des usages agricoles constitue un des piliers des activités scientifiques de la Zone Atelier Armorique.

L'agriculture d'aujourd'hui est soumise à une énorme pression. D'une part, la productivité devrait augmenter pour nourrir une population mondiale croissante ; d'autre part, l'agriculture devrait devenir plus durable dans toutes les dimensions. Le projet SIPATH de l'Institut fédéral suisse de recherches sur la forêt, la neige et le paysage WSL (Suisse), Agroscope (Suisse) et l'Université libre d'Amsterdam (Pays-Bas) étudie comment ces deux objectifs peuvent être combinés dans l'agriculture actuelle et future.

Une partie du projet se concentre sur l'évolution passée de l'utilisation des terres afin de mieux comprendre ce qui a influencé les changements dans la gestion des terres. Pour cela, nous étudions comment l'agriculture et l'organisation de la vie quotidienne dans l'agriculture ont changé dans 14 territoires locaux en Europe. En collaboration avec les collègues chercheurs de la Zone Atelier Armorique, en particulier de l'INRAE (UMR BAGAP), nous voulons mener environ 10 entretiens avec d'anciens agriculteurs et travailleurs agricoles dans les alentours de Pleine-Fougères.

Au cours de l'entretien, nous souhaitons vous poser des questions sur l'évolution de votre exploitation agricole depuis que vous avez commencé votre activité : productions, modes d'utilisation des terres, fonctionnement de votre exploitation, vie sur l'exploitation. Vos réponses nous aideront à comprendre l'évolution passée de l'agriculture sur votre territoire, les défis rencontrés et les choix pour y faire face.

Code :……

Pour garantir vos droits à la vie privée, nous vous demandons de bien vouloir donner votre consentement explicite (entourer les mentions correspondantes dans le texte en bleu):

❶ Dans le cadre de ce projet, **les données personnelles qui seront collectées auprès de vous sont** vos noms et prénoms, coordonnées personnelles (adresse, numéro de téléphone), ainsi que les coordonnées géographiques de vos parcelles. Egalement, nous souhaitons pratiquer auprès de vous un entretien ouvert qui fera l'objet d'un enregistrement vocal, ce qui constitue une donnée personnelle en soit. Les données portant sur vos pratiques et caractéristiques d'exploitation relèvent, indirectement, des données personnelles car il est possible de vous identifier en les croisant. **Nous avons besoin de ces données (coordonnées et enregistrement vocal)** afin de bien analyser et comprendre vos points de vue et logiques, les liens entre vos pratiques et caractéristiques d'exploitation et les structures paysagères et de les remettre en perspective avec le contexte local. Egalement, vos coordonnées personnelles nous permettent de vous faire retour sur ces recherches, individuellement (envois de document) ou collectivement (envoi d'invitation à séminaire autour d'un repas).

❶ J'ai pris connaissance des informations sur le dispositif Zone Atelier Armorique et le projet SIPATH, mentionnées ci-dessus. J'atteste avoir obtenu les réponses à mes questions sur les finalités du/des projets et les finalités de la collecte de mes données personnelles :

OUI **NON**

❷ Les données personnelles et l'ensemble des autres données collectées sur votre exploitation (données techniques sur votre exploitation, observations de faune / flore, etc.) seront collectées puis conservées pendant toute la durée du projet de recherche et de sa valorisation (5 à 10 ans en tout), en assurant les **conditions de confidentialité et de sécurité** suivantes. La mention de vos données personnelles sera faite une seule fois et réservée dans un tableau à part ; un identifiant (pseudonyme) vous sera attribué à la place de vos noms-prénoms/coordonnées pendant toute la collecte et le traitement des données. Lors des présentations des résultats, nous ne donnerons pas de précisions géographiques ou de spécificités permettant de vous identifier. Des mesures pour éviter le piratage informatique des données sont prises (accès avec code). Le tableau à part de vos coordonnées sera utilisé seulement pour vous faire un retour individuel (envois de documents) ou collectif (envoi d'invitation pour séminaire).

❷ J'atteste avoir obtenu les réponses à mes questions concernant le traitement et la sécurisation de mes données dans le cadre du projet SIPATH. J'accepte que l'ensemble des données collectées dans le cadre de ce projet soient traitées et présentées / publiées dans le cadre de confidentialité et de sécurité garanti ci-dessus :

OUI **NON**

❸ Le projet SIPATH est mené **en collaboration avec plusieurs unités de recherche européennes** (WSL, Agroscope, Université libre de Amsterdam, Université de Berne…) **soumises au même règlement européen de protection des données personnelles vous concernant en tant que citoyen français.** Dans ce cadre, les données sont collectées et/ou analysées entre équipes, et donc partagées. L'objectif de ce partage est de pouvoir comparer des situations entre pays européens, en les replaçant bien dans leurs contextes locaux. **Le protocole pour la protection des données personnelles sera le même** pour toutes les équipes européennes concernées, de la collecte à la conservation des données jusqu'à la valorisation des résultats du projet (5 à 10 ans).

❸ J'ai pris connaissance des informations sur le partage des données me concernant, avec des équipes de recherche européennes respectant le règlement européen de protection des données personnelles. J'atteste avoir obtenu les réponses à mes questions sur les finalités de ce partage et sur le traitement et la sécurisation de mes données dans ce cadre. J'accepte que mes données soient partagées dans le cadre de confidentialité et de sécurité garanti ci-dessus :

OUI **NON**

❹ **A l'issue de la durée de réalisation et valorisation du projet (5 à 10 ans), les données collectées seront archivées dans nos laboratoires sur serveurs et/ou dans des locaux dédiés et sécurisés (10 à 50 ans).** Nous avons besoins d'archiver vos données, afin d'être en capacité de les réutiliser plus tard pour suivre et comprendre des changements dans les relations entre agriculture, paysage et biodiversité. La recherche publique dispose d'une dérogation permettant à nos instituts une conservation plus longue de données personnelles pour remobilisation à de strictes fins scientifiques. Dans la perspective d'un **nouveau projet de recherche mobilisant vos données passées**, nous vous en informerons autant que possible. Dans le cas de collaborations avec des équipes de recherche d'autres pays européens, **l'archivage des données personnelles (au-delà de 10 ans) sera exclusivement opéré dans nos services** (dans les équipes collaboratrices européennes, les données seront détruites ou complètement anonymisées).

❹ J'ai pris connaissance des informations sur l'archivage et la possible remobilisation de mes données dans le cadre d'un projet ultérieur. J'atteste avoir obtenu les réponses à mes questions sur les finalités et garanties de cet archivage, et sur les modalités pour reconduire l'agrément des chercheurs :

OUI **NON**

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❺ Conformément au règlement européen relatif à la protection des données personnelles (RGPD) qui élargit la loi Informatique et Libertés, **vous bénéficiez d'un droit d'accès, de rectification, d'opposition, d'effacement des informations qui vous concernent**. Si vous souhaitez exercer ces droits et/ou obtenir communication des informations vous concernant, veuillez-vous adresser à Leo Müller ou Claudine Thenail. Vous pouvez également solliciter directement la Commission Nationale Informatique et Liberté (CNIL) chargée de l'application du RGPD en France (https://www.cnil.fr/).

❺ J'atteste avoir obtenu les réponses à mes questions concernant mes droits. J'ai noté que je pouvais retirer mon/mes consentement(s) à tout moment en recontactant le ou les responsable(s) du projet mentionné ci-dessus, et ai compris comment procéder :

OUI **NON**

Formulaire de consentement en conformité avec le RGPD fait en deux exemplaires originaux, dont un remis en main propre au volontaire pour cette enquête. Merci d'avoir accepté d'y participer.

Date :

Nom, prénom de l'enquêteur : Nom, prénom du volontaire :

Signature : Signature :

8.3 Table sheets Local Statistical Data

Table 8: Share of different cultures in total UAA (Data Figure 10)																				
Municipality	**Bazouges-la-Pérouse**					**Broualan**					**Cuguen**					**Trans-la-Forêt**				
Year	**1970**	**1979**	**1988**	**2000**	**2010**	**1970**	**1979**	**1988**	**2000**	**2010**	**1970**	**1979**	**1988**	**2000**	**2010**	**1970**	**1979**	**1988**	**2000**	**2010**
Cereals	0.23	0.16	0.24	0.38	0.45	0.16	0.16	0.18	0.22	0.21	0.18	0.16	0.21	0.26	0.28	0.18	0.13	0.23	0.25	0.23
Fodder	0.29	0.58	0.47	0.4	0.4	0.26	0.38	0.46	0.58	0.63	0.22	0.5	0.43	0.64	0.62	0.29	0.43	0.41	0.5	0.59
Permanent grassland	0.42	0.25	0.24	0.13	0.09	0.51	0.41	0.28	0.13	0.12	0.53	0.31	0.32	0.05	0.08	0.48	0.41	0.32	0.19	0.17
Other crops	0.06	0.02	0.04	0.1	0.06	0.07	0.04	0.08	0.06	0.03	0.07	0.03	0.05	0.05	0.02	0.05	0.03	0.05	0.06	0.01
Total UAA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 9: Absolute number of annual work units (Data Figure 11)					
Year / **Municipality**	**1970**	**1979**	**1988**	**200**	**2010**
Bazouges-la-Pérouse	487	404	272	141	95
Broualan	97	70	57	30	30
Cuguen	223	162	131	59	50
Trans-la-Forêt	122	99	78	52	34
Total	929	735	538	282	209

Table 10: Average work units per farm (Data Figure 12)					
Year / **Municipality**	**1970**	**1979**	**1988**	**2000**	**2010**
Bazouges-la-Pérouse	1.74	1.69	1.37	1.38	2.02
Broualan	1.31	1.15	1.46	1.25	1.30
Cuguen	1.45	1.33	1.26	1.18	1.52
Trans-la-Forêt	1.31	1.25	1.42	1.37	1.31
Ø	1.55	1.47	1.36	1.32	1.62

Table 11: Number of Farms (Data Figure 13)					
Year / **Municipality**	**1970**	**1979**	**1988**	**200**	**2010**
Bazouges-la-Pérouse	280	239	198	102	47
Broualan	74	61	39	24	23
Cuguen	154	122	104	50	33
Trans-la-Forêt	93	79	55	38	26
Total	601	501	396	214	129

Table 12: Total Utilised Agricultural Area (Data Figure 14) [ha]					
Year / **Municipality**	**1970**	**1979**	**1988**	**2000**	**2010**
Bazouges-la-Pérouse	3972	3955	3629	3693	3542
Broualan	919	875	836	935	1073
Cuguen	2159	2041	2061	1793	1926
Trans-la-Forêt	1277	1217	1200	1468	1440
Total	8327	8088	7726	7889	7981

Table 13: Average Farm Size (Data Figure 15) [ha]					
Year / **Municipality**	**1970**	**1979**	**1988**	**2000**	**2010**
Bazouges-la-Pérouse	14.1857143	16.5481172	18.3282828	36.2058824	75.3617021
Broualan	12.4189189	14.3442623	21.4358974	38.9583333	46.6521739
Cuguen	14.0194805	16.7295082	19.8173077	35.86	58.3636364
Trans-la-Forêt	13.7311828	15.4050633	21.8181818	38.6315789	55.3846154
Ø	13.86	16.14	19.51	36.86	61.87

Table 14: Share of different specialisations (Data Figure 16) [%]			
Year / **Municipality**	**1988**	**2000**	**2010**
Field crops	5.06%	4.45%	6.00%
Dairy cattle	55.47%	44.58%	46.35%
Beef cattle	5.62%	7.20%	8.60%
Mixed cattle	1.92%	3.00%	2.27%
Other herbivores	3.58%	7.17%	0.00%
Hors sol breeds	6.35%	11.90%	14.32%
Mixed culture	15.20%	11.62%	12.02%
Other	6.79%	10.08%	10.45%

8.4 Evaluation of Visited Farms

Table 15: Evaluation of Visited Farms									
Farm	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Takeover of the farm, further described as (1)	1964	1961	1966	1977	1973	1970	1980	1965	1969
Retirement, further described (2)	ca. 1995	1995	1994	2014	2010	2007	2014	2000	2008
Succession. Options: Familiy, External, None	None	Family (son)	Family (son)	External	Family (son)	Family (son)	None	n.A.	Family (son)
Farm type (1)	Dairy	Dairy	Dairy	Dairy	Dairy	Dairy	Dairy	Dairy	Mixed
Farm type (2)	Dairy	Mixed	Mixed	Dairy	Mixed	Mixed	Mixed	Mixed	Beef
Legal organisational form (1)	Individual	n.A.	n.A.	Individual	n.A.	Individual	n.A.	n.A.	Individual
Legal organisational form (2)	Individual	n.A.	n.A.	EARL	GAEC	n.A.	n.A.	n.A.	GAEC
Area [ha] (1)	15	4	23	20	26	45	40	30	18
Area [ha] (2)	15	35	33	55	80	75	60	n.A.	125
Composition [ha] (1)	ca. 14 grassland, ca. 1 cultures	4 grassland	Mainly grassland	15 grassland, 5 cropland	26 grassland	n.A.		n.A.	n.A.
Composition [ha] (2)	ca. 14 grassland, ca. 1 cropland	ca. 25 grassland, ca. 10 cropland	ca. 20 maize, ca. 13 grassland	30 cropland (15 cereals, 3 corn, 12 silage maize), 25 grassland	Permanent grassland about 30 ha , rotational meadows and cropland. Share n.A.	Mainly cropland (wheat, maize 30, barley)	25 cropland, 35 grassland	n.A.	n.A.
Land tenure (1)	15 property	4 property	23 property	4 property, 16 leased	25 leased	Mixed land tenure	n.A.	n.A.	n.A.
Land tenure (2)	15 property	30 property, 5 leased	29 property, 4 leased	11 property, 44 leased	Mainly property, some parts remain leased	Mixed land tenure	17 property, 43 leased	n.A.	n.A.
Crops (1)	none	Cereals (wheat, barley, oats), little potatoes/beet roots/rapeseed	n.A.	n.A.	None	Maize, wheat, little barley		n.A.	Beetroots, cabbage
Intermediate crops	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.	Blonde tobacco (1995 - 2005), sunflowers, flax, potatoes, beetroots	n.A.	Salads
Crops (2)	Little wheat, little maize	Maize, cereals (mainly wheat & barley), little potatoes/beet roots/rapeseed	Maize	Cereals, corn, silage maize	Maize, wheat, barley	Maize, wheat, little barley		n.A.	Cereals, corn, maize and wheat
Trend yield development	n.A.	n.A.	n.A.	Stable	n.A.	Stable	Slightly increased	n.A.	Stable
Livestock type (1)	dairy cows (Normande), little pigs/poultry/ rabbits for own consumption	dairy cows (Normande), little pigs/poultry for own consumption	Dairy cows	Dairy cows	Dairy cows (Normande)	Dairy cows, a little sows	Dairy cows	Dairy cows, pigs	Dairy cows
Intermediate livestock types	n.A.	n.A.	Fattening calves, bullocks	n.A.	Suckler cows	n.A.	Piglets, suckler cows	n.A.	Bullocks, veal calves
livestock types (2)	Dairy cows, chicken/pigs for own consumption	Dairy cows (Normande), little pigs/poultry	Dairy cows, pigs,	Dairy cows	Dairy cows (Austènes), Limousine cattles	Bullocks, farrow-to-finish sows (since 1978)	Dairy cows	Dairy cows, pigs	Suckler cows

Table 15: Evaluation of Visited Farms									
Farm	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		for own consumption							
Livestock Units (1)	3	4	14	25	n.A.	n.A.	20	18	12
Livestock Units (2)	16	25	52 + 17 (100 fattening pigs)	40 (+ ca. 30 heifers)	50 (+ca. 20 heifers), ca. 20 limousine cattles	32 calves, 56 sows	45	60 dairy cows, 800 pigs	135
Composition animal feed (1)	Grass (summer), hay (winter) from own production, potatoes & acorns (for pigs)	Grass (summer), hay grass & maize silage (winter) from own production	Mainly grass (summer), hay (winter) from own production	Grass (summer), maize silage, Straw, hay (winter) bought from neighbours	n.A.	Grass, maize silage, hay from own production	Grass, maize silage, hay from own production, little food concentrates	n.A.	Grass
Composition animal feed (2)	Grass (Summer), hay (Winter) from own production, potatoes & acorns (for pigs) little maize silage from own production	Grass (summer), hay, grass & maize silage (winter) from own production	Grass (summer), maize silage (summer and winter) from own production, maize silage from other farms	Grass (summer), Straw, hay (winter) bought from neighbours, maize silage from own production, concentrated products	Grass, hay (summer), maize silage, hay (winter), soya- or equivalent, rapeseed-, oilcake to balance the maize, alfa-alfa	Maize silage from own production, soya to balance the ration, concentrated products for sows from off-farm production	Grass, maize silage, hay from own production, little food concentrates	n.A.	Grass, hay, grass silage, wrapping, straw,
Animal Productivity	Increase of milk production	Increase of milk production (x2)	Major increase of milk production (x4.5)	Increase of milk production (x3)	Increase of milk production (x3)	Increase of meat production	Slightly increased	n.A.	Increased
Trend first usage of grassland from (1) to (2)	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.
Number of usages grassland (1)	Minimum 2x	2 - 3 times	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.
Number of usages grassland (2)	Minimum 2x	2 - 3 times	2 - 3 times	n.A., but stable	n.A., but stable	n.A. but stable	n.A., but stable	n.A.	n.A.
Permanent Crops (1)	None	n.A.	n.A.	None	None	None	None	n.A.	n.A.
Permanent Crops (2)	None	Orchard with 20 apple trees	A few sour apple trees in a corner of a field	None	None	None	None	n.A.	n.A.
First use of mineral fertilizers on the farm	Before takeover	Before takeover	A little before takeover	Before takeover	Before takeover	Before takeover	Before takeover	n.A.	Great evolution between 1959 and 1969
Quantitative Trend: Use of fertilizers	Increased	Decreased	Major increase	Increased	n.A.	Increased with a peak around 1980	Stable	n.A.	Increased with peak around 1980
Composition Fertilizer (1)	Mainly maure	Mainly manure, supplement with mineral fertilizers	Liquid manure, use of mineral fertilizers to complete manure	Manure, mineral fertilizers	Manure, mineral fertilizers, Potash	Mainly manure	Mainly manure, mineral fertilizers	n.A.	Mainly manure, completed with mineral fertilizer
Composition Fertilizer (2)	Mainly manure	Mainly manure, supplement with mineral fertilizers	Decrease of mineral fertilizer, increased availability of manure	Increase of manure, decrease of mineral fertilizers	Manure, mineral fertilizers	Manure, slurry, mineral fertilizers	Mainly manure, mineral fertilizers	n.A.	Mainly manure, completed with mineral fertilizer
Use of antibiotics on the farm	Yes	Yes	Yes	Yes	Yes	Yes	n.A.	n.A.	Yes
Quantitative Trend: Use of antibiotics	n.A.	n.A.	Stable	n.A	n.A.	Stable	n.A.	n.A.	n.A.
Use of pesticides on the farm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	n.A.	Yes

Table 15: Evaluation of Visited Farms									
Farm	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Quantitative Trend: Use of pesticides	n.A.	decreased	Stable	Slightly decreased	Increased	Decreased	Stable	n.A.	n.A.
Use of fungicides on the farm	Yes	Yes	Yes	Yes	n.A.	n.A.	Yes	n.A.	Yes
Quantitative Trend: Use of fungcides	n.A.	n.A.	Stable	Slightly decreased	n.A.	n.A.	Slightly increased	n.A.	n.A.
Use of insecticides on the farm	n.A.	Yes	Yes	Yes	n.A.	Yes	Yes	n.A.	n.A.
Quantitative Trend: Use of insecticides	n.A.	decreased	Stable	Slightly decreased	n.A.	Decreased	Slightly increased	n.A.	n.A.
First use of growth regulators on the farm	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.	Yes	n.A.	n.A.
Quantitative Trend: Use of growth regulators	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.	Increased	n.A.	n.A.
Drained area [ha] (1)	None	n.A.	None	None	None	None	n.A.	n.A.	n.A.
Drained area [ha] (2)	None	n.A.	Drainage was executed	Drainage was executed	Drainage was executed	15	3	n.A.	Drainage was executed
Year of drainage meausres	-	-	n.A.	1981	n.A.	1981	n.A.	n.A.	n.A.
Year of the first tractor on the farm	1975	1963	ca. 1950	1964	1958	1952	Before 1960	1963	1952
Number of tractors (1)	0	0	1	1	1	1	n.A.	n.A.	1
Number of tractors (2)	1	2	1	1	1	2	n.A.	n.A.	1
Other fundamental machines and year of introduction	Milking machine (ca. 1975), tedder	Milking machine with transfer (ca. 1968), tedder, reaper	Tools for tractor, own construction	Silo unloader, loaders	Milking parliour (1974), combine harvester	n.A.	Milking parliour	Milking machine (1970)	Improved forage harvesters,
Rented machines (1)	None	None	None	CUMA equipment	None	n.A.	CUMA equipment	n.A.	CUMA equipment
Rented machines (2)	None	None	None	more CUMA equipment	None	Silage harvester, Combine harvester	CUMA equipment	n.A.	CUMA equipment
Contracted services (1)	None	n.A.	n.A.	n.A.	n.A.	n.A.	Harvesting, baling, maize silage	n.A.	Harvesting
Contracted services (2)	None	To cut down embankments	Harvesting	Ploughing, partly sowing, baling, silage, harvesting	n.A.	Silage, threshing, maize planting	Harvesting, baling, maize silage	n.A.	n.A.
Other investments	Electricity (1975), running water (ca. 1990)	n.A.	Electricity (1958), running water (1967)	Filter basins	n.A.	Electricity, running water (1955)	None	n.A.	Slurry pits (1973), Silos, Stables for Bullocks (1972), house renovation
Shared machines, tools with other farmers	n.A.	Trailer	Grass seeder, fertiliser drill, corn drill, silage harvester, slurry tanker	silage teams in the beginning with more importance	Forage (maize) harvesters, slurry tanker, cow trailer, chopper, cultivator	Hay baler	None	n.A.	n.A.
Background for decision making	Discussions with neigbours, consultation by retailers	Information by companies and retailers, discussions with neighbours	Consultation from technicians	Neighbours, chamber of agriculture, CETA, specialised press,	Technicians from cooperatives,	Technicians, specialised press	Discussions with neighbours, chamber of agriculture, technicians,	n.A.	Chamber of agriculture, technicians from cooperative,

Table 15: Evaluation of Visited Farms									
Farm	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
				journeys abroad			Specialised press		
Annual work units (1)	2	2	3	1.2	2	3	2	2	2
Annual work units (2)	2	2	2	2	2	2	1.2	2	2
Seasonal workers (1)	0	0	0	0	0	0	0	n.A.	n.A.
Seasonal workers (2)	0	0	0	0	0	0	2 for tobacco harvesting and drying	n.A.	Mutual help for sald harvesting
Trend workload during carreer	Slightly decreased	n.A.	Stable	Stable	n.A.	Less physical	n.A.	n.A.	n.A.
Share of external income	0%	0%	0%	Minority part of the income (wife worked in an insurance)	0%	0%	Minority part of the income (wife worked in a factory some years)	n.A.	n.A.
Opportunities to make Holidays	No	No	Yes	n.A.	n.A.	Yes, one week per year	n.A.	n.A.	n.A.
Financially most rewarding activity (1)	Milk production	Milk production	Milk production	Milk production	Milk production	Milk	n.A.	n.A.	Milk production
Share of complete farm income	about 100%	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.	n.A.
Financially most rewarding activity (2)	Milk production	Milk production	Milk production	Milk production	Milk production, meat production	Beef	n.A.	n.A.	Beef
Share of complete farm income	About 100%	n.A.	n.A.	n.A.	60% vs. 40%	n.A.	n.A.	n.A.	n.A.
Labels	No	No	No	No	Limousine label		no	n.A.	Breed certification (Charolaise)
Sales markets (1)	Regional dairies	Regional dairies	Regional dairies (Brittany)	Dairy cooperative in normandy, other regional cooperatives for cereals	Regional dairy	n.A.	Local cooperatives	n.A.	n.A.
Sales markets (2)	Regional dairies	Regional dairies, local cattle merchants	Regional dairies (Normandy)	Dairy cooperative in normandy, other regional cooperatives for cereals	Regional dairy, specialised butchers for the meat	Cooperatives	Local cooperatives, Germany for tobacco	n.A.	n.A.
Direct payments	None	None	None	n.A.	Little subsidies for fallow fields	None	Yes, premiums for tobacco	n.A.	n.A.
Subsidies on agricultural Credits/Loans	Yes	Yes	Yes	n.A.	To build stable	For building construction	Yes	n.A.	Loan to diversify production

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