

Sustainability Assessment of Bread Production

The Case of Artisan Bakeries in Germany

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Declaration

I hereby declare that this thesis has not been previously published or written by another person; neither has it been submitted nor accepted for any other academic award. It is the result of my original work carried out at Brandenburg University of Technology Cottbus, Germany, within the framework of the Ph.D. Programme 'Environmental and Resource Management'. All materials from other sources have been duly and adequately acknowledged.

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List of Abbreviations and Acronyms

CAS	Complex adaptive system
CI	Confidence interval
CIRT	Center for Innovation in Research and Teaching
CPI	Corruption Perceptions Index
DPA	Data Protection Act
Ecolabel	Ecological label
EMAS	Eco-Management and Audit Scheme
EU	European Union
EUR	Euro
FAO	The Food and Agriculture Organisation of the United Nations
GHG	Greenhouse gases
GSDS	German Sustainable Development Strategy
IHK	Industrie- und Handelskammer (Chamber of Industry and Commerce)
KfW	Kreditanstalt für Wiederaufbau (Reconstruction Bank)
MDG	Millennium Development Goals
OLS	Ordinary Least Squares
OR	Odds Ratio
PDO	Protected Designation of Origin
PGI	Protected Geographical Indication
SAFA	Sustainability Assessment of Food and Agriculture Systems
SD	Standard deviation
SDGs	Sustainable Development Goals
TSG	Traditional Specialty Guarantee
UN	United Nations
UNESCO	The United Nations Educational, Scientific and Cultural Organisation

Abstract

Background

Food sustainability is becoming increasingly important for the achievement of sustainable development goals, especially in light of recent global challenges of climate change, geopolitical conflict and the increasing vulnerability of food systems. The world is emphasising the importance of holistic approaches to agriculture and food systems to tackle these challenges. Germany's Sustainable Development Strategy for 2030 associates SDGs 2, 3 12 and 15 with sustainable agriculture and food systems as crucial elements to achieve these goals. However, with the lack of knowledge in this area, and the scarcity of tools to monitor and assess food sustainability, it has become crucial to investigate potential holistic approaches and frameworks to assess the sustainability of food systems.

Purpose

This study uses the national framework of Sustainable Development Goals (SDGs), as the only available valid holistic framework, to explore the sustainability of the bread system in Germany. It operationalises the SDGs to bakery level to identify significant indicators that could, potentially, be used to assess the sustainability of artisan bakeries, and identify to which SDGs the bakeries contribute.

Methods

This study utilises a mixed-methods research design to address the multi-disciplinary nature of the food sustainability concept. It critically evaluates the SDG framework and identifies a set of indicators, which are expanded with further indicators to address the cultural dimension of bread as a cultural heritage. To collect data, a 26-item questionnaire was issued to 586 artisan bakeries with a response rate of 8.8% ($n = 52$); the 52 bakeries own 562 branches. This was followed by interviews with an acceptance rate of 19% ($n = 10$). Descriptive and inferential statistics were used to analyse the quantitative data, while the interviews were transcribed from German to English and coded using NVivo 11.

Results

Sustainable bread is redefined from a holistic perspective encompassing theory, policies and artisan bakeries. The results confirm that bakeries positively contribute to bread sustainability in Germany, as well as towards achieving the national SDGs. Progress areas include energy efficiency, sustainable packaging, local procurement, heritage promotion, waste reduction and ecolabels. Interestingly, individual bakeries appear to be slightly more sustainable than chains due to their flexibility in adapting to new practices and their use of organic products; however, chain bakeries are slightly less sustainable, but are proven to be more efficient in terms of productivity and market reach.

Zusammenfassung

Hintergrund: Die Nachhaltigkeit von Nahrungsmitteln nimmt immer mehr an Bedeutung zu, wenn die Nachhaltigen Entwicklungsziele erreicht werden sollen, insbesondere wenn man die neueren globalen Herausforderungen wie Klimawandel, geopolitische Konflikte und die zunehmende Vulnerabilität von Nahrungsmittelsystemen berücksichtigt. Weltweit wird die Bedeutung eines ganzheitlichen Ansatzes für Landwirtschaft und Nahrungsmittelsysteme hervorgehoben, um diese Herausforderungen zu bewältigen. Die Deutsche Nachhaltigkeitsstrategie für 2030 berücksichtigt nachhaltige Landwirtschaft und nachhaltige Nahrungsmittelsysteme vor allem in ihren Nachhaltigkeitszielen 2, 3, 12 und 15, und benennt sie als kritische Elemente für die Erreichung der Ziele. Dennoch, mit fehlendem Wissen auf diesem Gebiet, und mit wenigen Instrumenten zur Kontrolle und Beurteilung von Nahrungsmittelsystemen, wird es umso wichtiger, potenziell ganzheitliche Ansätze und Rahmenwerke zu untersuchen, um die Nachhaltigkeit von Nahrungsmittelsystemen zu erfassen.

Untersuchungszweck: Diese Studie hat das Ziel, das nationale Rahmenwerk der Nachhaltigen Entwicklungsziele SDGs als einzig verfügbares valides ganzheitliches Rahmenwerk zu nutzen, um die Nachhaltigkeit des Brotsystems in Deutschland zu untersuchen. Die Studie wird die SDGs auf Bäckerei-Ebene operationalisieren, um signifikante Indikatoren zu identifizieren, die potenziell dazu genutzt werden können, um den momentanen Stand der Nachhaltigkeit bei Handwerksbäckereien zu untersuchen, und um festzustellen, zu welchen SDGs die Bäckereien beitragen.

Methoden: Die Studie nutzt ein gemischtes Untersuchungsdesign, um die Multidimensionalität von Nahrungsmittelnachhaltigkeitskonzepten zu adressieren. Sie evaluiert das SDG-Rahmenwerk kritisch und identifiziert eine Reihe von brauchbaren Indikatoren. Diese Indikatoren werden um weitere Indikatoren ergänzt, um die kulturelle Dimension von Brot als Kulturerbe zu erfassen. Ein Fragenkatalog mit 26 Fragen wurde an 586 Handwerksbäckereien verschickt. Die Antwortrate lag bei 8.8% (n = 52). Diese 52 Bäckereibetriebe haben ein Netzwerk von 562 Niederlassung/Filialen. Darauf folgte ein Interview mit der Akzeptanzrate von 19% (n = 10). Deskriptive und inferentielle Statistik wurde genutzt, um die quantitativen Daten auszuwerten. Die Interviews wurden von Deutsch nach Englisch übersetzt und mit Nvivo 11 kodiert.

Ergebnisse: Nachhaltiges Brot wird von einer holistischen Perspektive neu definiert, die Theorie, politische Grundsätze und Handwerksbäckereien umfasst. Die Ergebnisse bestätigen, dass Handwerksbäckereien positiv zur Nachhaltigkeit von Brot in Deutschland beitragen, und ebenso zur Erreichung der SDGs. Fortschrittsbereiche sind unter anderem Energieeffizienz, nachhaltige Verpackungen, lokaler Wareneinkauf, Promotion von Brot als Kulturerbe, Reduzierung von Abfall und Öko-Label. Interessanterweise erscheinen individuelle Betriebe leicht nachhaltiger als Bäckereiketten, weil sie sich in Vergleich zu Bäckereiketten flexibler an neue Methoden anpassen können, und weil sie vergleichsweise mehr Bioprodukte nutzen, während Bäckereiketten vergleichsweise weniger nachhaltig sind, dafür aber vor allem bei Produktivität und Marktreichweite effizienter sind.

1. Introduction

1.1. Background

With a constantly growing world population, reaching 7.7 billion people in 2020 (World Bank, 2019) and expected to reach 10 billion in 2050 (Ranganathan, Richard Waite, Tim Searchinger, & Craig Hanson, n.d.), the question of ‘How to feed the world?’ became a major global challenge. The deteriorating conditions in some of the poorest countries are alerting the whole world about what could happen if humanity fails to find a permanent solution for the increasing food demand and limited capacity of our planet (Global Food Security, n.d.).

During the last three decades, and more specifically since the Earth Summit in 1992 and the United Nations Conference on Environment and Development (UNCED, n.d.), the world has been strategising its development for the future with the environment a main global concern. Food has been a key factor in the formulation of global development strategies because it is immanently related to the environment and the use of natural resources, such as land and water. It is at the centre of our socio-economic systems, and is related to human health; people, simply, want to be healthy, fit and live longer.

However, back in 1992, the world’s population was 5.4 billion (World Bank, 2019), and the 42% increase in only 28 years, together with its associated challenges and conflicts, were not efficiently projected, nor incorporated within the so-called development agenda. Eventually, this led to many objectives not being achieved and additional challenges being faced (United Nations, n.d.). Growth in the global population, and the increasing need for food and natural resources, are causing pressure factors that decelerate the progress of the world towards achieving its envisioned development goals (Bongaarts, 2016).

This learning created the need for a revised strategy, one that is more comprehensive with dynamic goals and realistic targets; food was, again, an important influencing factor of what could be globally agreed and to what extent. However, once again, the world found itself confronted with unpredictable challenges and conflict such as the 2008 food prices and the financial crisis.

Furthermore, conflicts and wars broke out in Iraq, Afghanistan, Syria, Yemen, Libya, Ethiopia and, recently, Ukraine, leading to the worst global political crisis since World War II and, consequently, the weaponisation of food, energy and natural resources (Kemmerling, Schetter,

& Wirkus, 2022). The coronavirus pandemic in 2020 had severe consequences on the world's economies and supply chains, causing global disruption and shortages (Barman, Das, & De, 2021). The growing conflicts in dry areas over access to freshwater for agriculture and food production is putting the lives of millions of people at risk, such as the conflict over the Nile River (Stephan Roll, Tobias von Lossow, & Luca Mieke, 2020). The wildfires and livestock production in the Amazon rainforests and other monocultures on forest lands around the world are threatening ecosystems and leading to deforestation on a global scale (Worldwide Fund for Nature, n.d.). Moreover, 33% of the earth's topsoil, where 95% of our food comes from, is now degraded and that degradation might increase to 90% by 2050 (FAO, 2022). As a result, severe food crises loom ahead, and action is needed before it is too late. The United Nations warned that the number of people facing hunger, which is currently above 800 million, will increase dramatically (United Nations Press, 2022). These symptoms reveal that current sustainable development is far from resilient; achieving the development goals by 2030 is not possible with current trends, and the outcomes of global food strategies confirm the negative trend in that area.

Parenthetically, it is essential to distinguish between food security and food sustainability. Food security, in principle, is a historical and an ongoing social concern. Humans have always suffered from food scarcity, conflicts over food resources, and, most recently, two world wars and their devastating consequences on humanity and food supplies (Pilcher, 2012; Toussaint-Samat, 2009). The need for food, primarily, and for other resources such as water for agriculture, has always driven humans to act instinctively, and many tragic, historical events could be listed in this context. However, global food security has significantly improved since the Industrial Revolution (1760–1840), and the rise of conventional production systems has led to an abundance of food resources and has, eventually, helped to reduce hunger (Koning et al., 2008).

Yet, food sustainability is a relatively new topic and has only become known during the last few decades, since sustainable development was officially introduced as a global agenda (Berry et al., 2015; United Nations, 2022). Food sustainability implies that our methods of unsustainable production and consumption must be changed in line with our planet's limitations; however, these changes can affect our fragile food security. For instance, in the context of sustainability, conventional food systems, which are essential for mass production to maintain food security, are seen as major contributors to one-third of global greenhouse gas

(GHG) emissions. GHG emissions can increase global warming and, subsequently, accelerate climate change and its devastating consequences on global food systems (Vermeulen, Campbell, & Ingram, 2012). The question of ‘Security or sustainability first?’ initiated a global debate on the future of food strategies with little consensus on ways to move forward.

Given that the world is divided between developed and developing countries, it is important to differentiate between two major trends in national development strategies. On the one hand, economically and socially developed countries have started to prioritise their environmental concerns and the transition to greener economies. The main purpose was to meet the target of limiting the global temperature increase to well below 2 degrees Celsius (UNDESA, 2015). On the other hand, developing countries have had to address social, economic and environmental concerns simultaneously, while contributing towards meeting global targets. Partnerships between developed and developing countries have become crucial to achieving global progress, but the funding gap remains a major challenge.

As for food strategies, developed countries have begun to strengthen and improve their so-called secure food systems in line with their revised development strategies (i.e. becoming more sustainable), while many developing countries with unresolved chronic problems and fast-growing populations have struggled to secure their food systems in the first place, and food sustainability is far from achievable within their circumstances (Shaw, 2007). Thus, it can be observed that, nowadays, food security and food sustainability are major concerns for governments and policy makers, and sometimes, one is prioritised over the other, depending on the national context (Berry, Dernini, Burlingame, Meybeck, & Conforti, 2015b). Security and sustainability, however, have both become prone to the accelerating climate change and its impact on food systems and yields as a major driver of change. In other words, countries have been confronted with the double challenge of securing their food systems, while attempting to make them more sustainable, so they can be resilient to shocks and overcome current and future challenges.

Nevertheless, research on the security of global and/or national food systems is different from research on the sustainability of food systems; this is because they mostly examine two different contexts: ‘security and sustainability’, or, in other words, ‘needs and limitation’s (Berry et al., 2015b). It is of utmost priority that humans satisfy their needs for food; only then can they start to think about the limitations of our planet, as believed. However, a new concept has recently emerged, which considers that security and sustainability are intrinsically

interconnected (Sonnino, Faus, & Maggio, 2014). A food system must be sustainable to pave the way for resilient security. Sustainability is not entirely seen as a luxury anymore; it is seen more as a means for future stability.

Nowadays, most food systems are interconnected and interdependent as a result of globalisation. Production and consumption of developed and developing countries have become interrelated and interconnected. To understand these relationships, it is important to explore current global food production and consumption patterns. In 2021, the world produced nearly 3.75 billion metric tonnes of food: one-third was wasted, and two-thirds were consumed by 7.7 billion people, providing an average of 2,800 kcal per capita per day (FAO, n.d.-b); a quarter of this food comprised bread and cereals (Statista, 2022). However, the volume of available agri-food resources in global markets is mainly supplied by countries with high agricultural productivity levels; this is due, in part, to the size of their agricultural land area (e.g. Canada), and/or their production capacity (e.g. the Netherlands). Yet, several countries continue to fail to produce a sufficient food supply to meet the needs of their own populations. Rich countries with low agricultural productivity are easily shifted to imports (e.g. Qatar), while poorer countries have had to adapt to a low-calorie diet, mainly below the daily minimum of 1,800 kcal per capita, a number recommended by the Food and Agriculture Organisation (FAO) as a minimum dietary requirements (e.g. Sierra Leone). The global food trade figures in Table 1 (European Commission, 2016) show the key players in the global food systems:

Table 1 Top world agri-food exporters and importers

Exporting country	EUR billions	Importing country	EUR billions
EU	129	EU	114
USA	128	USA	110
Brazil	67	China	98
China	46	Japan	49
Canada	40	Canada	31
Argentina	30	Mexico	24

While large food exports might indicate a country's output levels beyond local needs, large food imports in today's context do not necessarily mean a country needs them to survive. Global imports are influenced by a range of factors, such as the growing demand for diet diversification (the need for a wider range of products that cannot be locally produced). Affordability is a key factor in this case, and some of the biggest exporters are also importers. Large food imports also exist, out of necessity, but on a lower scale compared to the figures in Table 1. There are currently 34 countries that cannot produce their own food and depend on imports from other countries; in 2050, half of the world's population is expected to shift to that category of dependency (Cago, 2017).

One of the most important factors to consider when exploring global food systems is food culture. Globalisation has brought enormous changes to human lifestyles, but only a slight change to food culture around the world. One reason for this is that humans tend to preserve food culture as part of their identity (Boutaud, Becuț, & Marinescu, 2016). Thus, recent growth in the global food trade can be attributed to the growing affordability of increasing urban populations, such as the demand for meat in Asia; and, in some cases, to immigrant communities introducing their food cultures to hosting countries and creating new markets, mainly in urban centres. Thus, while urban food cultures have started to become more diverse, especially in industrialised countries, the rest of the world has maintained its food habits despite climatic, political and economic changes (Boutaud et al., 2016). Food is not only a source of nutrients and calories, but is also an element of a complex socio-cultural, economic, environmental and nutritional system.

One product that has remained almost unchanged across the world is bread. Bread is an important element of several food cultures, such as Middle Eastern and North African (MENA region). The region was once called the breadbasket of the Roman Empire, due to its historical wheat supplies (Johns Hopkins Centre for a Liveable Future, n.d.). However, its wheat production failed to evolve in line with its population growth. While demand for bread grew significantly, triggered by growing need, wheat supply fell short, due to several limitations including the shift of farmers towards other cash crops, which led to a supply gap. That growing gap gradually led the MENA region to shift towards imports, with some countries importing around 80–90% of their bread wheat, such as Lebanon and Egypt, respectively (World Bank, 2021). Replacing bread with another local staple simply did not occur, due to the strong bread culture in these countries, which caused a lack of flexibility in the population to shift to another

locally produced food type. The low affordability of these populations drove their governments to subsidise wheat supplies to make bread affordable, and these subsidies increased financial burden (Kemmerling et al., 2022). Similar examples can be seen across the world, where many countries found imports to be the only source to satisfy needs for specific foods that could not be locally supplied, in particular food staples with a strong historic footprint and cultural significance.

Potential limitations that can also lead to an increasing need for food imports include agricultural land area, population size, climate, infrastructure and productivity levels. The notion of ‘food sovereignty’ became a synonym for whether a country has control over the mechanisms and policies of production, distribution and consumption of its food systems or not (Patel, 2009). A food system dependent on imports can only make the quest for its sustainability more complex.

1.2. The Concept of Food Sustainability

The notion of food sustainability informally emerged with the introduction of sustainable development, but there has never been a universally agreed definition of this term (Clancy, 2022). Alternatively, the notion of a ‘sustainable food system’ was officially defined by the FAO in 2014 as: *‘a system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised’* (FAO, n.d.-c). While food sustainability might refer to food in general, a sustainable food system refers to a specific food (e.g. bread system). However, in this dissertation, both terms might be used interchangeably when relevant.

Theoretically, a food system is *‘a complex web of activities involving the production, processing, transport, and consumption’* affected by internal and external drivers (Oxford Martin Programme on the Future of Food, n.d.). Therefore, a sustainable food system, in practice, can be described as a value chain that provides a sufficient food supply without negatively affecting the planet, or the ability of natural resources to regenerate, therefore, continuing to provide for future generations. However, with the global challenges and trends discussed above, global food strategies are undergoing a process of revision, and focusing on food security alone is no longer the best approach (Berry et al., 2015b).

The latest global development strategies were translated in the ‘2030 Agenda for Sustainable Development’ of the United Nations, or what is commonly known as ‘2030 Agenda’. It was

set in 2015 with 17 Sustainable Development Goals (SDGs) to be achieved in subsequent 15 years or so (UNDESA, 2015). The 17 SDGs include targets to be achieved within specific timeframes to mark milestones in a long development process. Member States, who adopted the 2030 Agenda, tried to align their national development strategies accordingly, either by adopting the new framework, or by committing to it as part of their own strategies.

Therefore, progress towards sustainability in today's context, from a policy perspective, can be observed and monitored on two levels: global and national. Global progress is monitored through the use of 148 indicators across the agreed 17 global SDGs, using input data from Member States on a yearly basis (UNDESA, n.d.). National progress is generally monitored using indicators from national strategies.

In Germany, the German Sustainable Development Strategy (GSDS) adopted the global SDG framework, but with 75 indicators instead of 148, mainly focusing on energy and resource conservation. The targets of the 75 indicators reflect how Germany monitors its progress in line with the European Union strategy and that of the United Nations. However, Germany's strategy has been updated several times to address rising challenges and changing circumstances affecting the country, while trying to remain aligned with the 2030 Agenda.

In the latest update of the GSDS in 2021, food is mentioned 304 times, food security 58 times and sustainable food eight times (compared to 115, 0 and 0, respectively, in the 2002 version). Production and consumption of food and non-food products are addressed mainly by SDG 12 'Responsible Production and Consumption with three targets:

1. Promoting sustainable food production through reporting, mainly via the Eco-Management and Audit Scheme (EMAS)
2. Promoting sustainable consumption with publicly managed ecolabels (i.e. organic/bio), and by aiming to reduce the impact of global/national household consumption on the environment
3. Promoting sustainable procurement for the public sector as an exemplary practice for the private sector

Moreover, in the same update, a new holistic approach to sustainable agriculture and food systems emerged in line with the latest scientific work in this area; it associated food with

SDGs 2, 3, 12 and 15, targeting food security, health and nutrition, production and consumption, and biodiversity, respectively. The holistic approach aims to create a balance between healthy biodiversity and a healthy population.

Since food security and sustainability are both embedded within national strategies, individual monitoring of these areas is not equally straightforward. Food security, on the one hand, benefits from an available framework with universal indicators for monitoring and assessment on a national level; the Global Food Security Index (GFSI) is an example that uses a scoring system developed for that purpose. Food sustainability, on the other hand, does not have a universal framework for monitoring and assessment as it is a relatively new field. In 2014, the FAO developed the Guidelines for Sustainability Assessment of Food and Agriculture Systems (SAFA), which adopted a benchmarking approach to help food systems adopt best practices and encourage reporting. The SAFA framework inspired several initiatives, such as the Sustainability Monitoring and Assessment Routine (SMART), which became an important tool for several food supply chains across Europe. However, the knowledge regarding systematic, holistic approaches to monitor and assess food sustainability requires further scientific contributions to fill the gaps.

1.3. Rationale

This research contributes to the knowledge on food sustainability in a secure food context, precisely on the sustainability of the artisan bread sector in Germany from a holistic perspective, combining policymakers and artisan bakeries as key stakeholders. It aims to investigate the current status of sustainability of the artisan bread sector in Germany.

This study uses the case of artisan bread as an important staple and a traditional food. Bread is seen as a universal food product with cultural significance and an important element of both global and national food systems. Bread makes up a significant portion of the daily food consumption worldwide of people in both developing and developed countries; it represents a very unique opportunity to learn how a basic food can be sustainable.

Germany has a very strong bread culture, inscribed by UNESCO as an Intangible Cultural Heritage (German Commission for UNESCO e. V., 2014). Germany achieved top rankings in food security and in its progress towards sustainability: it was ranked 4th worldwide in its progress towards achieving its SDGs (Sachs, Kroll, Lafortune, Fuller, & Woelm, 2021) and 11th on the GFSI (The Economist, n.d.). Germans are amongst the top consumers of bread

worldwide with nearly 53kg per household per year, with the majority coming from artisan bakeries; bread represents around 18% of their daily calorie intake.

This research will refer to the national SDGs as a valid and relevant sustainability framework, deriving from the universally agreed SDGs of the UN and aligned with the EU strategies. The national SDGs provide a view on sustainability from the holistic perspectives of policymakers and features scientifically valid indicators for sustainability on a general national level, as well as targets that Germany wants to achieve to increase its overall sustainability. The national framework will enable this research to contextualise bread sustainability by building on an established knowledge system.

Artisan bakeries are chosen because they are major stakeholders of the bread system in Germany. They existed long before the concept of food sustainability became part of the political agenda; yet, their perspective on the sustainability of the bread system remains unknown. Artisan bakeries supply 60% of national bread (The Federation of Bakers, 2022), and they are holders of the breadmaking culture; their role in the bread system transformation, in line with national strategies, is very important.

Basic bread contains flour and water (and yeast and salt as conditioners), and worldwide preparation methods are, by some means, similar. Therefore, this study can potentially be replicated to improve bread sustainability elsewhere. Several lessons can be learnt from the study of how the German bread system is transforming in line with sustainable development, and how artisan bakeries are contributing to that change. This is one of the least explored areas.

1.4. Research Problem

The GSDS was first implemented in 2002, and has been updated on a regular basis since. Major updates took place in 2016, shortly after the Paris Agreement, and again in 2021, shortly after the COVID-19 pandemic; the next update is expected in 2023/2024. The updates reflect the commitment to continuous improvements to overcome the increasing challenges and achieve the transformation goals.

The latest approach of the strategy towards food sustainability emphasises the importance of addressing agriculture and food systems holistically. The strategy provides a relevant framework for that purpose, particularly by associating SDGs 2, 3, 12 and 15 with sustainable agriculture and food systems.

While the new policy approach could address typical food systems (e.g. milk), special considerations are necessary in the case of a traditional food with cultural significance such as German bread. There is a knowledge gap on how a system can become sustainable while preserving its important cultural aspects; these aspects are, nowadays, a German heritage.

Artisan bakeries are key stakeholders of the artisan bread sector in Germany; however, there is a lack of knowledge on how they perceive sustainability, and how their practices, which are derived from a centuries-old breadmaking culture, contribute to the sustainability of the bread system in today's context.

1.5. Research Hypothesis

To understand the sustainability of the bread system in Germany from a holistic perspective, it is imperative to address bread-specific dimensions together with generic policy dimensions. Therefore, it becomes necessary to expand the SDG framework, which focuses on environmental and human needs, to include the cultural dimension to achieve a better understanding of sustainable bread. The current definitions and policy frameworks provide a good foundation, but there is a need to consider the artisan bakeries' perspective.

Artisan bakeries are key stakeholders in the transformation of Germany's bread system towards sustainability; they maintain a culture that avoids the conversion of bread into a culturally neutral product available on every supermarket shelf. They have made significant progress in that area, especially with the inscription of bread culture as a UNESCO heritage. Moreover, a recent pilot study, conducted by the Federal Institute for Vocational Training (*Das Bundesinstitut für Berufsbildung – BIBB*) to develop and implement sustainable aspects in the profession of artisan bakers, also revealed that the preservation of artisanal traditions are key factors in shaping that sector sustainably. Therefore, if we incorporate the artisan bakeries' perspective into the current SDG framework, then we can achieve higher holistic sustainability of the bread system in Germany.

1.6. Research Objectives

This research has the following objectives:

1. Explore the various perspectives, including literature, policymakers and artisan bakeries to achieve a broader understanding of sustainable bread.

2. Examine Germany's bread system and evaluate the role of artisan bakeries with a focus on sector-specific dimensions.
3. Conduct primary research to investigate artisan bakeries' perspectives towards sustainable bread and their current state of sustainability with regard to national SDGs.
4. Analyse the data and relate to the wider context for the purpose of future research.

1.7. Research Questions

The following three research questions were developed to guide this study:

- RQ1: What is sustainable bread?
- RQ2: What is the role of artisan bakeries in promoting bread sustainability? How do they contribute towards achieving the national SDGs?
- RQ3: What influence does the changing artisan bakery sector have on bread sustainability?

1.8. Scope of the Research

This dissertation will investigate the concept of sustainable bread from three perspectives: literature (i.e. theories of food/bread system), policy and artisan bakeries. It will analyse the bread system within Germany on a macro level using secondary data. It will evaluate the role of artisan bakeries in promoting bread sustainability. Industrial producers and supermarkets/discounters will not be considered in this study, as they are not legally classified as bakeries. This research will critically evaluate Germany's SDG framework to understand what sustainability is from a policy perspective. It will then investigate how it applies to the bread system and artisan bakeries. The exploration of holistic sustainability dimensions will help identify the dependent variables of this study, while the independent variables will comprise the characteristics and practices of bakeries within these dimensions.

Data collection took place between July 2020 and February 2021. The population included all registered bakeries (or Bäckerei in German) within the Central Association of the German Bakery Trade (Zentralverband des Deutschen Bäckerhandwerks) representing the body of German artisan bakeries, which holds 60% of the market share.

1.9. Research Outline

This research has the following structure:

- Chapter 1 provides a background to this dissertation, as well as an introduction to challenges affecting the global food systems and strategies, with a focus on the emerging holistic approach to food sustainability in Germany. It also introduces the rationale, research problem, hypothesis, objectives, research questions and scope.
- Chapter 2 provides an overview of the history of food and the role of bread and will explore how food systems and bread production have evolved from early history to the present day. It will serve as an epistemology background to understand how our food/bread knowledge and beliefs have been shaped.
- Chapter 3 explores the concept and theories of a food system, and the empirical approaches to study food sustainability.
- Chapter 4 analyses the current bread system in Germany and the role of artisan bakeries. It also identifies the specific sustainability dimensions of bread.
- Chapter 5 discusses and justifies the methodology for this dissertation, including why and how the SDGs are operationalised in this study, and the relevance of the mixed-methods design, sampling strategy, instruments, data collection and analyses.
- Chapter 6 presents a detailed critical evaluation of the SDGs while operationalising them to a bakery level for the purpose of identifying suitable holistic indicators. This chapter is an integrated part of the methodology, but due to its length, it was separated.
- Chapter 7 presents the results and discussions of the study.
- Chapter 8 provides a conclusion and discloses the limitations and recommendations for future research.

2. Overview of Food History and the Role of Bread

2.1. Introduction

This chapter provides an overview of the history of food and how global food systems have evolved as a result of major changes during the major historical transitions. Moreover, it examines the role of bread, and how it has remained almost unchanged during the last millennia. This chapter helps the reader to understand how humans shaped their knowledge and beliefs about food and bread, before proceeding to Chapter 3 to explore food sustainability theories. Current food systems are the result of developments that took place over millennia as explained in this chapter; major changes have been dictated by climate and innovations, but very rarely by the ecological responsibility needed today. The need for food has always been the main driver.

2.2. The Neolithic Revolution

The Neolithic Revolution, the Neolithic Demographic Transition or simply the Agriculture Revolution – the wide-scale transition and evolution of food acquisition that took place during the Neolithic period – marked the end of the era during which humans relied predominantly on hunters and gatherers (Pilcher, 2012). The cultural ecology of the hunter–gatherer had evolved from a period of climate change, following the ice ages and droughts, and when humans began to use animal tissues for various purposes to conserve energy. The hunter–gatherer also saved considerable time, as one day of successful foraging could last a man and his family many days (Svizzero, 2016). Furthermore, anthropologists have found evidence that, even as early as the hunting and gathering period, humans were intermixing agriculture with foraging and domestication practices, living an agrarian lifestyle that afforded them better health due to their diverse diets (Pilcher, 2012). Thus, while the Neolithic era marked an end to the foraging lifestyle, it did not introduce agriculture.

Scholars tend to agree that the transition from foraging practices to an agrarian lifestyle was predicated by climatic changes (Svizzero, 2016; Vermeulen et al., 2012). Specifically, this change occurred mostly between the final identified ice age, the Pleistocene, to what is known as the beginning of the modern climatic era, the Holocene, which is widely believed to have begun around 9,700 BCE (Pilcher, 2012). Much evidence to support this comes from proof of rice cultivation and domesticated grains found in the Fertile Crescent in Mesopotamia around 10,000 and 9,000 BCE as well as in India, China and parts of the Americas (Pilcher, 2012).

The climatic conditions that followed the end of the last Great Ice Age – which would have ended approximately 12,000 years ago – even ensured that specific crops and plants would flourish better than others, such as wild cereal plants, which were able to grow in abundance; however, it would take some time for civilisations to understand what tools were necessary to cook, prepare and develop foods (Toussaint-Samat, 2009).

Crop agriculture played a major role in early human settlements; it brought humans together as there was a need for greater labour to increase production. Human culture was also changing from hunters and gatherers in continuous motion, to agriculturists who settled down (source). Simultaneously, humans started to acquire food preservation skills so they could extend the ‘shelf-life’ of certain foods harvested during times of abundance. Drying, fermentation, salting and other techniques gradually emerged. Wheat varieties such as einkorn and emmer, barley and pulses were perfectly suitable for sun-drying and became a significant source of nutrition during times of scarcity (Balossi Restelli, Barbaro, Lemorini, Mori, & D’Errico, 2017). Moreover, animal domestication flourished in parallel and provided a supply of dairy foods and animal protein.

It was believed that bread first appeared in Mesopotamia during the agricultural transition, but the latest evidence of charred remains of flatbread found in North-Eastern Jordan revealed that it predates the agricultural revolution by four millennia (Glorfeld, 2018). That discovery brought additional evidence of the importance of bread in human history. Grain acquisition, processing and bread baking appears to be the earliest food system known to humans, one that could develop to provide nutritional supply independent from seasonality. However, ancient bread was unleavened and thick and mostly baked on stone. Sourdough bread, or bread with semi-domesticated yeast, was first known in Ancient Egypt and it was baked surrounded by heat rather than on a stone, but scholars argue that it was also known to Mesopotamians together with other food innovations (Fantozzi, 2022). However, while these developments emerged in the Old World, other areas were still relying on hunting and gathering.

2.3. Early Empires to Medieval Times

From the Neolithic era onwards, from practices in Egypt and Greece to the Roman Empire, where bread became an essential food, regional food systems were continuously in conflict. However, the first globalisation of food systems can be attributed the Roman Empire as they conquered distant areas and started shipping food resources across these regions. The clash of food culture came to a head when the Roman Empire began its attempts to control as much

territory in the region as possible; as the Greeks and Romans operated on a diet of wine, bread and fish (de Angelis et al., 2020), their conflicts with nomadic, foraging tribes and cultures from the Classical civilisations marked a synthesis of the two diets; it is believed that bread was introduced to Germanic tribes during that period. The synthesis triggered a shift toward meat and game, which were popularised during the medieval and Renaissance period (J. Pilcher, 2012). The rise of a new wealthy class with sophisticated food preferences also created a demand that was not only influenced by need, but also by habits and behaviour (i.e. food culture). Political and economic forces during the reigns of monarchs shaped innovation and technology, but dietary regimes, in general, evolved with limited flexibility (Pilcher, 2012). During these eras, food became a commodity more than it had ever been before, with food and bread becoming a source of wealth, and the control of food equating to the acquisition of power (Standage, 2009). However, while royal families and the wealthy controlled access to food and bread, this power was not tempered with any social or environmental responsibility.

2.4. Colonialism

As various civilisations emerged and grew across the world, food helped to connect civilisations, regions and cultures. Food trade routes in what would later come to be known as Indochina saw spices traded in abundance, and other cross-cultural fertilisations occurred when religious and cultural practices were shared through these international networks, all due to the need for access to food (Pilcher, 2012; Standage, 2009).

Eventually, Europe would circumvent trade routes, such as the Arab spice monopoly, and this would lead to the discovery of the New World, where European nations established their first colonial forts or outposts (Standage, 2009). Much like the Roman Empire had ushered in the synthesis of foraging and agriculture practices in the medieval age, borrowing from agrarian examples in the Middle East, Africa, and Asia and hunting tactics of the nomadic cultures they extinguished, the establishment of the dominion and influence of European nations over food systems, in which a global empire was achieved by extension, were ushered into the next era of human history.

As Europe controlled much of the maritime trade routes between the Old World and the New World, Europe specifically gained a position of power to influence food system transitions. As Europeans settling in the New World discovered that the Native American feasts, which were important to reinforce social positions and hierarchies, featured a diverse spread of meats, vegetables and grains, the colonists began to learn from the Native American tribes, who helped

them settle and successfully carry out food practices (Freedman, 2007; Pilcher, 2012). The influence of Native Americans would become central to the development of food processes. While ethnicities such as the Germans, Dutch and Swedish introduced specific foods to the colonies, such as waffles and bread, the Native Americans introduced foods, such as squash and corn, to the Europeans (Pilcher, 2012).

The mass plantation of these crops ultimately led to the discussion of how best to harvest them to preserve resources. The production of sugar in the West Indies was a prototype of industrial processes; however, this industrial process was reliant on slave labour (Standage, 2009). Meanwhile, the increasing commodity of food in the Old World increased the pressure on Europe to make food production and trade more efficient. Distributed ownership of food systems by colonisation extended food systems to a new scope. The invention of steam engines underpinned the coming Industrial Revolution, which would lead to economic development, in part, by allowing for the further weaponisation of food (Lang, 2003).

2.5. The Industrial Revolution

Along with the Neolithic Revolution, the Industrial Revolution was one of the most influential and fundamental transformations in human history and was directly linked to the dramatic growth of the world population (Bongaarts, 2016). During that era, science and technology were major drivers of change in food system transformation. By this time, modern human society had adapted to a lifestyle wholly removed from a strictly foraging existence. Regardless of one's geographical location, humans lived a primarily agrarian way of life prior to the start of the Industrial Revolution, which only changed when people were drawn to major cities, particularly to port cities, where plants and mills were opening to afford work opportunities and supplies (Hudson, 2014). The Industrial Revolution also created a middle class, which developed influential consumption preferences. The emergence of city states boosted that influence and became a significant driver of change in urban food cultures. As Hudson (2014) asserts, global populations had nearly tripled from 1750 to 1850, but the majority of families in modernised countries were still fed from home production, except for their bread.

By this time, owners of industrial plants were looking for inexpensive ways to feed their workers and found that sugar and potatoes, a higher calorie 'staple' food, capable of producing higher volumes of crops with less land space, provided an adequate solution. Events such as the Irish Potato Famine of 1845 swiftly negated a rising notion that the global economy could be improved with agricultural production. When the Irish Potato Famine occurred, an

acceleration in agriculture production had already begun as economists in countries such as Britain saw agriculture and not the industry as the future of economic prosperity (Hudson, 2014; Standage, 2009). Instead, shifts to larger fields and farms for agricultural production in the late eighteenth century, as opposed to the previous smaller farms, yielded no great increase in overall food production, as experts believed (Hudson, 2014).

It has been argued by scholars such as Hudson (2014) and O'Brien (1985) that agricultural production practices, which were able to provide sufficient amounts of food to 'allay large-scale starvation and [prevent] a mortality crisis' were already developed by 1750 (Hudson, 2014). As the urban population expanded and human lifespans increased over time – due, in part, to the focus on medical and environmental health improvements in the age of science and technology – the processes of food production simultaneously evolved and benefited from industrial advancements (Lains & Pinilla, 2008).

Agricultural production, and the mechanisation of planting and harvesting, became intensified with less need for human labour. Animal and disease control enabled better yield management. Canning, freezing and refrigeration were breakthrough inventions and led to a substantial change in global food systems. Increasing supply and reducing the cost of food became popular national priorities in industrialised countries.

This emergence of the Industrial Revolution, as a primary force evolving food systems, subsequently evolved the production of bread as a low-cost food, as well as other foods, into a commodity withstanding transport, a longer shelf-life and undergoing greater processing (Rosell, 2011; Rubel, 2011).

The Industrial Revolution and advances in agriculture had a slight impact on Germany, where, by the 1800s, labour productivity for the whole German economy was little more than half the efficiency of Britain, including the entire United Kingdom, but was still an improvement on the previous century (Lains & Pinilla, 2008). By WWI, Germany managed to catch up with Britain in terms of industry productivity; however, Germany's aggregate labour productivity levels failed to reach those of the United Kingdom. While both Germany and America attempted to improve labour productivity relative to agriculture and saw success, Germany was unable to match the international competition, so the governing body made efforts to limit foreign interference.

Part of the reason for Germany's failed attempts to reach higher agricultural production levels was the country's lack of adequate resources. For example, even by 1939, when WWII raged

in Germany, resources included only six tractors per every thousand agricultural workers, as opposed to nearly 100 tractors per every thousand agricultural workers in the United Kingdom (Lains & Pinilla, 2008). As Lains and Pinilla (2008) explain, one factor that reduced Germany's historical capability to take full advantage of industrial advances was the isolation Germany experienced in the interim period between WWI and WWII. Since then, Germany has seen a decline in the importance of agriculture relative to the 1800s, yet the Industrial Revolution impacted one element of food production critical to Germany: the baking of bread (Gerschenkron, 1989; Hannon, 2011; Rubel, 2011).

Although the United Kingdom and the Americas may have seen greater production rates than Germany, this was partly due to government actions taken to protect German interests and to compete with those regions (Pierenkemper & Tilly, 2004). Germany's agricultural production has, historically, been linked to population growth, and agriculture dominated the German economy until the 1850s; however, competition from the Americas and Australia caused Germany to shift away from grain production and to place greater emphasis on animal production by 1913 (Pierenkemper & Tilly, 2004). However, this strategy was in opposition to protectionist interests, such as tariffs that reduced foreign competition and eased the burden of German farmers.

Meanwhile, innovations of the Industrial Revolution were affording humans the ability to gain a tighter grasp over their dominion of agriculture. This directly led to practices that helped modern humanity better control food processes, such as bread production.

One of the critical implications of modern industry, technology and innovation is that humans are consistently attempting to control their environment and, ultimately, their own biology and the biology of the environment, or rather the biology of nature. As Pollan (2013) remarks, *humans are always making concessions for their lack of control; during ancient times, hunters and gatherers brought their kills home and either they or the women of their households would handle and prepare the dead meat* – our modern notion of “cooking” stems primarily from the use of fire which not always available (Toussaint-Samat, 2009). Substances such as plants and vegetables, while not “dead”, are pliable raw materials that respond in certain ways. A material such as bread, however, is a biological substance which reacts to biological processes just as plants do, only bread is unpredictable. After the Industrial Revolution, the availability of commercial yeast afforded bakers control over biological processes they had not previously been able to predict with certainty (Pollan, 2013).

Regardless of technological inventions that make the production of bread easier, the invention of technology that increases the availability of flour, the most desirable and affordable ingredient, is crucial to an economy that has much weight in agricultural production. For several hundreds of years, rye has been the second-most popular bread grain in Europe after wheat; it remains a very popular grain in Germany and is used to make numerous breads (Rubel, 2011). As Gerschenkron (1989) asserts, the price of agricultural machinery fell between 1860 and 1890 while the cost of rye was the lowest between 1894 and 1896 and wages were their highest between 1890 and 1913. It was during this low-cost-rye period when the Bülow tariff, a protective measure, was passed, which would tax agricultural imports. While protective measures often hindered the agricultural industry's ability to expand on animal production, due to political and economic relations, this created room for the skill of breadmaking to flourish well into the 1900s.

The Industrial Revolution also brought about a rise of global innovations that caused an abundance of food as well as increased knowledge, which improved food practices that adapted in light of the modern conceptions of health and the environment (Lang, 2003). Countries that benefited from industrialisation, and succeeded in increasing agricultural productivity beyond their needs, began to export agri-food products to international markets, leading to higher availability (Jideani et al., 2020). Simultaneously, the global markets witnessed a growing demand triggered by the dramatic increase in world population and increasing affordability of consumers (Hudson, 2014). Also, the developments in transportation, infrastructure, food processing and refrigeration led to a revolution in the global food trade (Jideani et al., 2020; Teker & Koc, 2019). These inventions reduced transportation time and improved processing and storage conditions, prolonging food shelf-life and enabling access to distant markets. As a result, a new era of international food trade emerged that allowed for the further globalisation of food systems; however, the impact on bread was particularly exceptional.

The globalisation of bread remained limited to the supply of its raw material: grains/flour (Dutta, Levine, Papageorge, & Wu, 2018). Grains have a longer shelf-life than flour, and they are more convenient to ship and store; therefore, their cost is lower. Cheap bread had always been a necessity for low income and poor households. Ultimately, bread baking remained a local culture, despite the fact that it could be easily made to withstand transport and perishability. Fresh, basic bread remained a universal favourite food; its role appeared to be rooted in local culture beyond simply being a source of nutrition (German Commission for UNESCO e. V., 2014; Rubel, 2011; WWF, 2018).

2.6. WWI, WWII and the Recovery

By the time wheat became the top global food commodity, many countries had also become dependent on imports and, therefore, were exposed to the risks of shortages, price volatility and geopolitical conflict. Maintaining that balance required a global agreement that was not always present (Barrett, 2021).

WWI, the Great Depression and WWII, consecutively, marked the first half of the twentieth century with the death of millions of people, global scale destruction, hunger, poverty and devastated economies. Global food systems equally suffered from these events, and many countries were hit by starvation. During that time, food was scarce; limited quantities implied stronger rationing systems to ensure minimum food supplies reached soldiers and civilians in several countries (Cebula, 2020; Kesternich, Siflinger, Smith, & Winter, 2014). Rationing was the last resource a country sought to implement to avoid starvation, but bread was mostly the first food to be rationed.

After WWII, the victorious allies, together with other countries, established the United Nations with the aim of *'maintaining international peace and security, developing friendly relations among nations and promoting social progress, better living standards and human rights'* (UN, n.d.). Restoring global food security was a main concern, and it was mandated to the FAO which aimed to tackle global hunger and improve the resilience of food and agriculture systems in suffering countries (FAO, n.d.-a). However, hunger, poverty and other problems appeared to be more complex issues and a global collaboration was crucial to achieving solutions.

After WWII, food was urgently needed in many parts of the world. Many food products, such as canned food and soup cubes, previously used as food supplies during the war, continued to be popular afterwards and were used to alleviate hunger. The long shelf life of these products made them popular supplies that could be distributed less frequently.

However, during the 1960s and 1970s, a counterculture emerged (Larkin, 2015). It sought to obtain food from outside of the mainstream system and had political, social and environmental influences. In fact, some of today's food trends such as granola, tofu, organic agriculture, ethnic cuisine, and more widespread concern for ecology, have roots in this counterculture. It is believed that traditional foods started to regain their popularity during that period, and food culture started to regain its importance. Food culture can be defined as the attitudes, beliefs and practices that surround the production and consumption of food (Boutaud et al., 2016). The counterculture period was shortly followed by healthism, which was triggered by an increasing

awareness that foods high in fat, cholesterol, and sodium are linked to disease. Living long and healthy became a major driver of change in food system transformation.

2.7. The Sustainable Revolution

During this period, food science and technology evolved greatly. Breaking individual products into sub-ingredients enabled the expansion of global food systems with more specialised products. Global food systems became systems of food and food ingredients, such as animal products and animal ingredients, plant products and plant ingredients, etc. Planting and harvesting machinery became automated and more efficient. Food processing equipment, chemicals and packaging also evolved and expanded food varieties to include semi-cooked and fully cooked frozen meals and breads. Feed to fertilisers, vaccines and pharmaceuticals became key elements in maintaining the health of modern agri-food systems; food safety standards also became regulatory requirements across the world.

However, the second half of the twentieth century was also characterised by a global development movement aiming to redefine the relationship between humans and the environment by setting new policies. Meanwhile, global food systems continued to develop, with these policies causing very limited impact, as they were mainly driven by corporate culture and profitability (Adams, Donovan, & Topples, 2022).

During that period, discussions on the future of development and environment emerged in the United Nations with the first Conference on the Human Environment (UNCHE) in 1972 (United Nations, 1972), which introduced the environment as a new factor in global policies. Later, in 1987, the concept of sustainable development emerged with 'Our Common Future', or what is known as the Brundtland Report (United Nations, 1987), which introduced the social, economic and environmental pillars of sustainable development. A few years later, in 1992, the Earth Summit was held in Rio de Janeiro, which presented the first declaration on sustainable development: the legally non-binding Agenda 21, which was adopted by 173 Heads of State (Grubb, Koch, Thomson, Munson, & Sullivan, 2019). Later, in 2000, the United Nations introduced the 8 Millennium Development Goals (MDGs) set for 2015. These were eventually replaced by the 17 SDGs with targets set for 2030 or, what came to be known as, the 2030 Agenda. The concretisation of the concept of sustainable development into an actionable plan with clear goals and specific targets took nearly three decades (Swilling, 2019); however, new drivers of change continued to emerge along with new risks and challenges.

Although it is sometimes labelled as the ‘sustainable revolution’, the series of global actions for sustainable development greatly invested in setting new trends and policies rather than actual changes. Part of this can be linked to power conflicts and lack of agreement (R. Kumar & Roy, 2018). The United Nations, somehow, provided a platform for Member States to negotiate a common vision towards the future of our planet rather than enforcing development agendas (Lin, 2021). In fact, none of the development agreements were legally binding, except for the 1997 Kyoto Protocol and the reduction of GHG emissions.

As for the 2030 Agenda, 193 Member States committed to it, but their progress was not equally consistent. While several countries made significant progress in certain goals, many fell behind. This slow progress was generally linked to social and economic factors, such as the lack of resources and flexibility (Leal Filho et al., 2020). Thus, sustainable development, as a global policy, emphasised the importance of the three pillars: social, economic and environmental. One cannot be achieved without the other two. National sustainable development was mandated to each Member State as a matter of sovereignty; elements of global food systems, which fell below national jurisdictions and standards, had to abide by these rules rather than by the global agenda (UNDESA, 2015). Globally, the International Laws together with bilateral agreements between Member States, implied how joint food systems could operate.

2.8. The Role of Bread

To understand bread from a broader, historical perspective, it is a universal, basic and essential food, and is one of the oldest known foods to humans. However, until the Industrial Revolution, the production of bread had less of a cultural impact than either of the food systems involving meat or vegetables had on agricultural transitions. From a historical perspective, the importance of the anthropological findings of loaves and rolls in Egyptian tombs, and wheat in ancient human settlements, helps us to understand the level of importance this food had in ancient human societies in terms of uniting men as communities (Balossi Restelli et al., 2017). Mesopotamians first baked bread approximately 10,000 years ago in the Fertile Crescent, when both wild and domesticated wheat and barley were hulled into glume structures and threshed before being pounded with a mortar and pestle (Rubel, 2011). These grains were types that were believed to have the capacity to trap gases, and were harvestable like the grains we use today; the goal being to create a thick dough capable of trapping the gases to create an aerated crumb.

Just as the evolution of food processes throughout history is intrinsically linked to politics and shifting power, the presence of bread throughout history provides a narrative of this concept. From Egyptian times to the rise of the Roman Empire, the composition of bread did not change drastically. In fact, Rubel (2011) notes that Roman bakeries were filled with bread similar to what is offered today, for example, loaf bread. However, the power structure or power struggles between the wealthy and the poor were ever-present, even in bread production. For instance, the poor were forced to eat dense whole grain bread that was full of peas, fava beans, pulses, acorns and other nuts, seeds, and grains, which were inexpensive but filling (Balossi Restelli et al., 2017; Rubel, 2011). As Europe turned to industrialisation to make agricultural practices more efficient, fewer workers were tilling the land and milling grain. Thus, while industrialisation could make the flour easier to produce, the revolution's effect on baking was not as positive as it could have been.

2.9. Chapter Summary

This chapter presented wheat and bread in their historical context. The Neolithic Revolution marked important turning points in the development of food systems and human settlements. The cultivation of wheat was developed in Mesopotamia before expanding into the ancient empires of Egypt, Greece and Rome, where the human diet mainly became based on bread, fish and wine. The Middle Ages saw a slight merge of classic food diets with game and meat obtained from tribes, but bread remained present. Colonisation witnessed the development of novel farming systems such as plantations, and marked the dominion of Europe over global food systems. The Industrial Revolution marked the most significant milestone in food production and increasing human population. After the industrialisation, an economic competition took place between the great powers of Germany and Great Britain, in the last third of the nineteenth century until WWII left its marks on the efficiency of agriculture and, subsequently, the shape of global food systems. This sustainable development brought new ideas on how global food systems could balance between our needs and our planet's capacity. Table 2 summarises the main food system transitions and their impact on bread.

Table 2 Summary of the main historical food system transformations (created by the researcher)

Era	Drivers of change	Impact on Food systems	Impact on bread
Ice Age to Neolithic Revolution	Climate Agriculture Domestication Knowledge	Stable food supply Independence from seasonality	Baking of unleavened bread
Ancient Empires to Medieval Times	Political powers Geographic expansion	Expansion Commodification	Bread introduced to new areas
Colonialism	Expansion New resource acquisition	Innovative farming systems Control of Europe over food systems	
Industrial Revolution	Machinery Inventions Population increase	Mass production Globalisation	Discovery of yeast
World Wars I & II	Political conflicts Wars	Disruptions of supplies Hunger and poverty	
Recovery	New strategies	Restoration of global food systems	
Sustainable Revolution	Development of sustainable policies	Reformation of global food systems	

3. The Concept of Food Sustainability

3.1. Introduction

This chapter will explore the concept of a food system, from a theoretical point of view, to understand the study approaches. It will also explore the empirical approaches to investigate food sustainability from different perspectives, levels and scopes. This chapter will help the reader understand what a sustainable food system is from a theoretical perspective; this will be followed by a critical analysis of the bread system in Germany in Chapter 4.

The term ‘sustainability’ in its basic, linguistic definition means ‘the ability to be maintained to a certain level’ (Merriam-Webster, n.d.). Sustainability, as a concept of development, which was introduced 50 years ago, represents the main objective for development; sustainable development, in this sense, can be perceived as the process towards maintaining our world as it develops. The epistemology of sustainability, which was shaped by major historical changes discussed in Chapter 2, has undergone several changes as a result of growing knowledge on that topic and the gradual addition of sustainability pillars and dimensions over time.

There are now more than 300 definitions of sustainability and sustainable development; the ambiguity of the concept itself resulted from the different schools of thoughts in this topic and the difficulty in achieving a common perspective (Clancy, 2022). However, sustainability’s research philosophy is mostly positivist and normative, which means it relies on empirical scientific evidence and, at the same time, aims to establish the norms that best fit the needs of society (Oxford Reference, n.d.). Norms are the controversial parts, especially on a global level, due to a lack of agreement regarding these. The notion of ‘food sustainability’ is commonly used to refer to the sustainability of food systems. Food sustainability in this sense, is a theoretical construct that cannot be reduced to one metric because it is associated with a continuously evolving complex adaptive system (CAS) i.e. the food system (Holland, 1992). One of the main characteristics of a CAS is that it has a memory; in the case of food systems, this is food memory or ‘food culture’ – an integrated aspect of current food systems.

3.2. The Theory of the Food System

According to Clancy (2022, p. 17), *‘the global food system is composed of large-scale interconnected systems of systems that include ecosystems; climate; food processing, distribution and retail networks; data and information systems; social-economic systems; and other elements’*. The same applies to regional, national and local food systems, but on a

narrower scope, respectively. In other words, a food system on its own is a complex paradigm that involves input resources, supply chain, consumption, and outputs all managed by various stakeholders and influenced by a range of internal and external factors, including culture.

Food systems in this connotation are, by nature, multi-faceted and involve multidisciplinary quantitative and qualitative knowledge; yet they remain difficult to predict because they continuously evolve and adapt. Moreover, factors influencing them, such as climate, natural forces and human activities, are also unpredictable. In addition to their nutritional role, food systems are strongly cultural, consumerist, social, environmental and economic; the same applies to a food product that results from a food system (Marsden & Morley, 2014). The ability to maintain and preserve all these aspects in light of current and future changes is what food sustainability aims to achieve. However, the application of this principle in scientific research is a very complex and challenging task, according to several scholars (FAO, n.d.-c; Marsden & Morley, 2014; Meybeck & Redfern, 2013; Moscatelli, el Bilali, Gamboni, & Capone, 2016).

Scientifically, a system is a network of multiple elements that are connected through causal relationships – a change in one variable causes a change in another (Zhang, Zhan, Wu, & Zhang, 2021). Because each food system is unique, the most common approach to studying food systems is through the use of models, or modelling of the chosen system; this involves mapping the elements of the system and their causal relationships.

According to Peters and Thilmany (2022, p. 5), food systems can be modelled and studied in four orientations (see the supply chain lens, the linkages lens or the sector-specific lens; however, the overall food system lens (i.e. holistic) involves all three lenses, including inputs and consumption, which are not, usually, considered elements of the supply chain (Peters & Thilmany, 2022)).

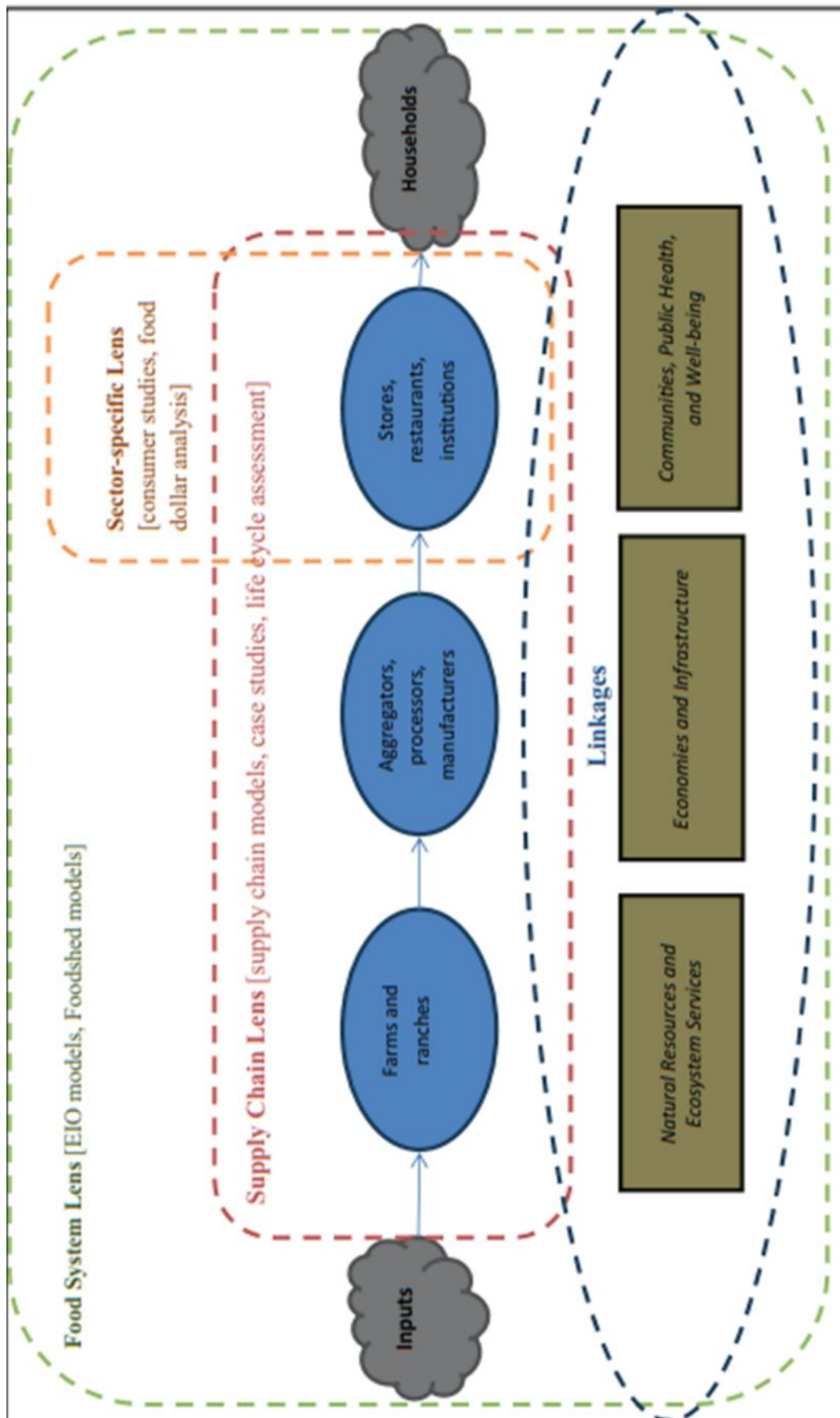


Figure 1 Peters and Thilmany's food system modelling (Peters & Thilmany, 2022)

Furthermore, detailed models illustrating the causal relationships among food system elements can also be presented as a detailed ‘food system map’ (figure2), such as the one developed by the Nourish Initiative (Nourishlife.org, n.d.).

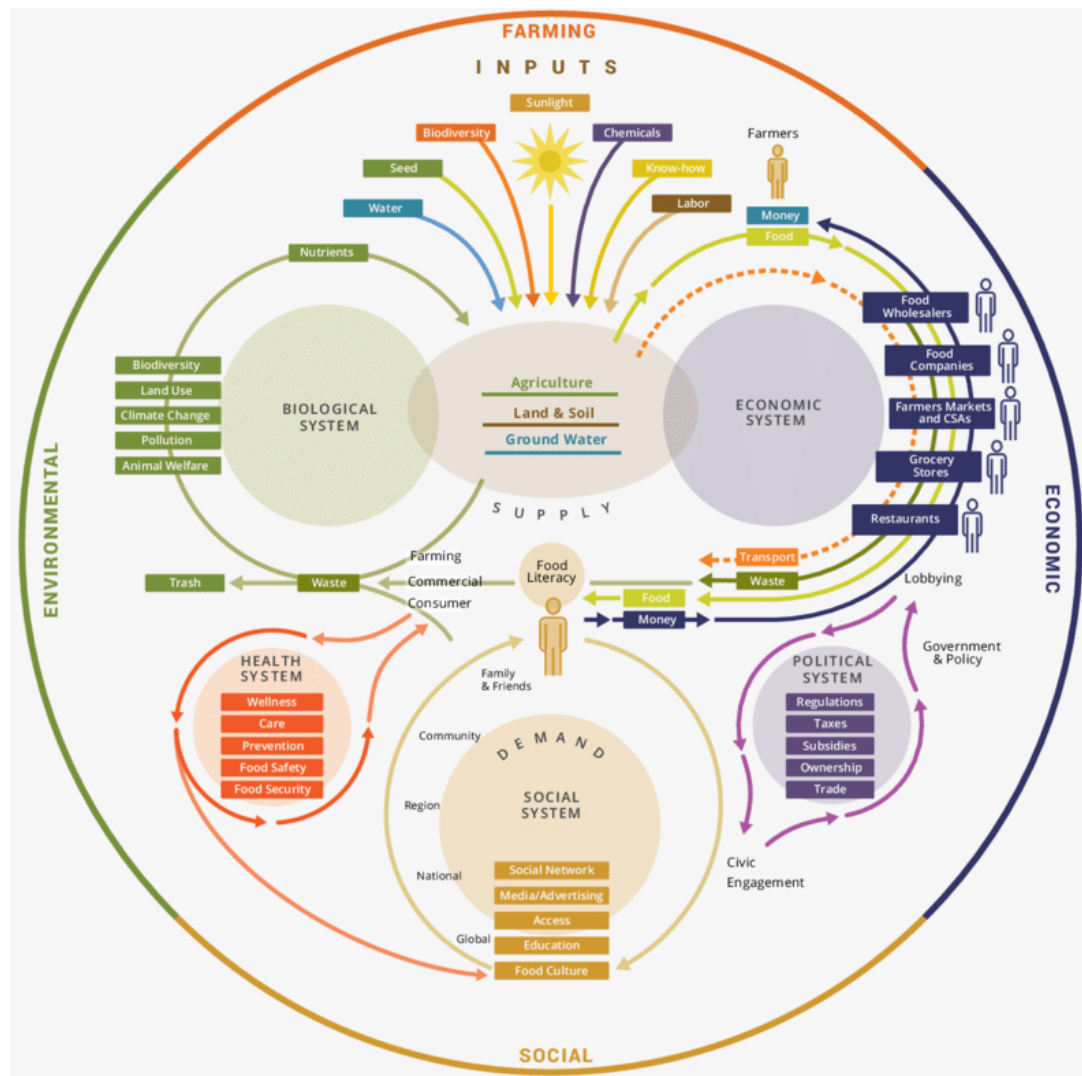


Figure 2 A food system and its subsystem (Nourishlife.org, n.d.).

The detailed map of a food system can help visualise how its different elements are interconnected, and/or interdependent, from a holistic perspective. First, it involves the biological system and input resources, which are both being economically exploited for the benefit of human health and nutrition. Second, there are legal, regulatory and information networks, which control the interactions and processes among the various elements. Third, there is a framework for the so-called ‘sustainable development’, which represents the environmental, social and economic constraints relevant to contemporary strategies. These constraints can equally affect the elements, the stakeholders and their interactions. Eventually, all systems and subsystems are influenced by internal and external factors (i.e. drivers of

change), including factors that are unique to each subsystem. In the case of the German bread system, a unique factor is the strong bread culture empowered by consumers' food culture and artisan bakeries.

3.3. Empirical Research Approaches

When comparing Peters and Thilmany's modelling approach to the Nourish Initiative's detailed food system map, one can begin to observe that there are two perspectives from which to study food sustainability: focused versus holistic. While each of the perspectives can have its own advantages and disadvantages, it is important here to highlight that the holistic perspective normally requires more resources, more time and a multidisciplinary knowledge; however, its results can help develop strategies. The holistic approach is recommended by the FAO, EU, Germany and several other countries (Moscatelli et al., 2016). Alternatively, the focused perspective requires more specialised knowledge and can generate stronger evidence, but its results are less generalisable due to the uniqueness of each food system. The focused approach is normally used to gain in-depth knowledge on a specific area of high significance for the investigator. Bread systems worldwide share common characteristics, because bread ingredients, preparation and production methods are, somehow, similar; therefore, potentially, both focused and holistic approaches can be replicated.

Given that the size and level of complexity of a food system is greatly based on the size and length of its value chain (FAO, n.d.-c), there are four geographical scopes through which to study food sustainability: global, regional, national and local. This categorisation is mostly based on the geographical distribution of the food system and the main factors influencing it:

- **Global scope:** global food systems involve cross-national inputs, supply chains and consumption, in addition to multidimensional stakeholders and factors. Globally, food systems are interconnected and interdependent (Koning et al., 2008); therefore, they are more exposed to international risks and challenges beyond the control of one single country, such as price volatility, supply disruption and political conflicts (Kemmerling et al., 2022). Global food systems are mainly operated by corporates driven by profitability; however, at the same time, they are regulated by governments aiming to maintain food security and ensure compliance with regulatory requirements and sustainability, where possible. Countries with disproportionate population growth in low-resource areas are the most vulnerable on a global level.

- **Regional:** regional food systems are, generally, the result of an extended national food system operating across a region rather than within a country. Operations, logistics and movements operate under a set of rules and regulations allowing the system to expand beyond national borders. The EU is a good example of how regional food systems operate (Millard et al., 2022); the EU institutional framework facilitates the movement of people, goods and money under a homogeneous set of rules for the benefit of EU countries and relevant stakeholders.
- **National scope:** national food systems involve the inputs, supply chains and consumption of a mainly national, geographical scope with either security or sustainability being prioritised, depending on the national context. There are two common scenarios: developed countries and developing countries. On the one hand, developed countries have slow growing populations, strategies focusing on the optimisation of their well-established food systems, and the transformation toward sustainability (BMEL, 2015). On the other hand, developing countries have fast-growing populations and more vulnerable food systems, depending on imports in several cases (Global Food Security, n.d.). National food systems have a significant impact on the outlook of the global food context.
- **Local scope:** local food systems involve inputs, supply chains and consumption mainly of a local geographical scope in the form of a small economic cycle. This is where the system mostly adapts to local capacity and need (Enthoven & van den Broeck, 2021). Highly productive local food systems are very important in sustaining national and global food systems; yield excess is normally diverted as an input stream into national or global food systems.

However, due to globalisation, it has become difficult to characterise a food system as ‘purely local’ or ‘purely national’. It is very common to find global elements or factors affecting national and local systems, such as energy (Monforti-Ferrario et al., 2015). In this case, the causal relationships within a local/national food system have become vulnerable to global factors such as global energy price changes. An example of extreme exposure to global factors is the national bread system in Lebanon (Tohmé Tawk, Chedid, Chalak, Karam, & Hamadeh, 2019). Historically, it shifted from using purely local input resources (wheat and wood) to becoming totally dependent on foreign inputs; 80% of its wheat from Ukraine and 100% of its fuel energy from Gulf countries. Globalisation made it nearly impossible to make a food system

more sustainable without addressing global factors and elements of exposure. Recent anti-globalisation movements are calling for the reduction of dependency by promoting the resilience of national/local food systems (Enthoven & van den Broeck, 2021).

In addition to the four geographical scopes explained above, food sustainability is a multidisciplinary topic with several dimensions. It can be investigated as a whole (holistic sustainability) or by focusing on a specific dimension (de Olde, Bokkers, & de Boer, 2017). Thematic scopes mainly include:

- **General sustainability:** also, sometimes referred to as ‘holistic sustainability’, in which all three dimensions of environmental, social and economic (and sometimes governance) are covered. In the case of food, nutrition and culture are sometimes included as additional dimensions (Marsden & Morley, 2014). Examples of holistic sustainability include studies on corporate social responsibility (CSR) and sustainability reporting in the food sector. Holistic sustainability normally adopts a multidisciplinary approach to address diverse dimensions.
- **Environmental:** where the environmental impact of a specific activity, system or product is emphasised (Moscatelli et al., 2016). Examples include carbon footprint studies and environmental Life Cycle Assessments (LCAs). Environmental studies aim to quantify or model environmental impact using a range of tools and techniques; therefore, it is mostly quantitative.
- **Social:** where social sustainability is emphasised with the human factor at the core. Examples include social network analysis (SNA) and community intervention studies (BMUB, 2018). Social sustainability normally investigates sustainability from a social perspective using statistics and analyses to understand the role of the human factor.
- **Economic:** where food systems are being modelled as economic systems for the purpose of economic development. Examples include input–output analysis and market analysis. These normally aim to optimise a system by looking at it from an economic perspective (Sala, Ciuffo, & Nijkamp, 2015).
- **Governance:** where the focus is mostly on how sustainability is being institutionalised, coordinated and disseminated across stakeholders. Examples include governance assessment and evaluation reports. Governance studies are mostly used as an additional

pillar alongside environmental, social and economic ones, especially in the development of policies (Lang, 2003).

- **Multidisciplinary:** where a mix of two or more themes are adopted, depending on the topic being investigated and the theme of concern. Examples include combination modelling, carrying capacity and participatory approaches, which involve the combination of two or more elements of a different nature (Moscatelli et al., 2016). The difference between multidisciplinary and general sustainability is that the latter should incorporate the three dimensions: social, environmental and economic.

Significant advances have been achieved within the above themes; however, several areas of food sustainability remain vague and could have multiple interpretations, particularly regarding quantification and assessment methods. The empirical research approaches to studying food sustainability are summarised in Table 3. For the purpose of clarity, this research will look at bread sustainability from a holistic perspective, using the bread system approach; this has a national geographical scope and will focus on general sustainability rather than a specific theme.

Table 3 Empirical research approaches to food sustainability and the selected ones for this study
(created by the researcher)

Perspective	Approach	Geographic Scope	Thematic Scope
Holistic	Food system	Global	General sustainability
Focused	Supply chain	Regional	Environmental
	Linkages	National	Social
	Sector-specific	Local	Economic
			Governance
			Multidisciplinary

3.4. Food Sustainability Assessment Principles

According to the Oxford Dictionary (n.d.), an assessment is '*an opinion or a judgement about somebody/something that has been thought about very carefully*'. The sustainability of a food system can, therefore, be seen as an opinion or judgement about a food system in the context of sustainability. However, due to the lack of consensus on sustainability in general, assessment tools and metrics are mostly developed as elements of a context-specific approach (Lyytimäki, Salo, Lepenies, Büttner, & Mustajoki, 2020), especially those of general sustainability.

In practice, the sustainability assessment, regardless of its theme, emerged as a tool to help understand where we are/were, and where we want to be. Therefore, the suitability of an assessment method depends on its ability to produce clear results. The objectives of a sustainability assessment could be, for instance: to decrease input resources; to reduce waste; to improve productivity and efficiency; to reduce GHG; to reduce environmental impact; to improve social or economic aspects; or, to simply maintain an existing food system (Waas et al., 2014).

The need for food sustainability assessment is also justified by the necessity to assess our existing food systems and seek improvements and adaptations on a constant rhythm (Sala et al., 2015). Food sustainability assessment in this sense, can be seen as an exercise to mark our food activities from an environmental, social or economic point of view and draw recommendations for adjustments based on the society needs and environmental changes.

Assessments or judgements normally require points of reference, such as baselines, targets or both. However, gathering baselines and identifying targets for a food system is a very complex task. This can be easier at a stakeholder or product level, where data can be gathered and targets can be set. Hence, food sustainability assessments are evolved at stakeholder and/or product level rather than on a system level. Collaboration and consensus among the stakeholders of a food system are crucial to achieving holistic sustainability – an approach that policies are currently endorsing.

Food systems existed long before sustainability was even introduced. Thus, in practice, some stakeholders voluntarily adopted certain sustainable principles and took concrete steps, while others maintained business as usual. Figure 3 illustrates the current scenarios of stakeholders in terms of sustainability and where policies want them to be; these layers can be described as the sustainability spectrum (Seager, 2008).

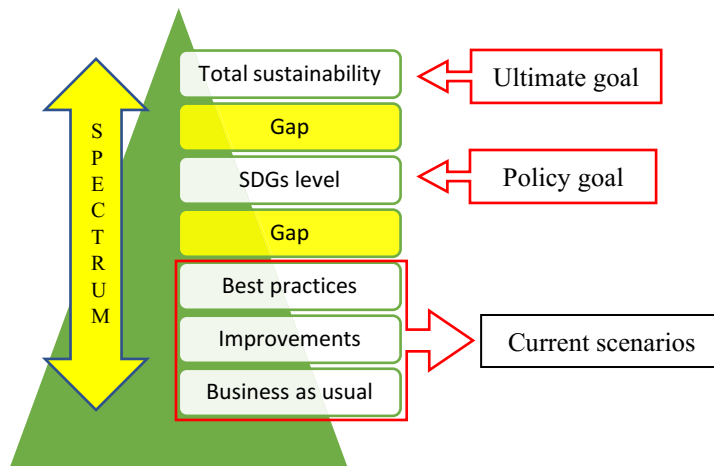


Figure 3 Food sustainability spectrum (created by the researcher)

Based on the above, the following scenarios must be considered when analysing a food system:

- **Business as usual:** where a system continues to operate without being influenced by sustainability. The introduction of sustainable development did not alter anything in the system. However, that system could be analysed in today's context of sustainability to identify any innate sustainable characteristics that could potentially be present, but not necessarily triggered by, sustainable development.
- **Sustainable initiatives:** where measures for adjustments have been taken, in comparison to business as usual. Measures can be associated with current sustainability attributes.
- **Best practices:** where stakeholders within a system takes leadership in setting exemplary practices in areas affecting the sustainability of the food product. Best practices could be attributed to mandatory or voluntary standards; however, in both cases, they can potentially raise benchmarks in a relevant sector and promote the sustainability of the entire system.

From a policy perspective (The Federal Government, 2021), there is one main scenario:

- **National policies:** this is the level that policy makers set for the entire country, including food systems and stakeholders. The policy level in Germany is reflected in the SDGs, which feature specific targets and indicators of the level the country wants to reach in the future (i.e. objectives for development). The GSDS act as guidelines to encourage the transformation of the public and private sector towards sustainability, but this is not mandatory.

From an idealistic perspective, there is one more scenario:

- Total sustainability: although it sounds very idealistic, it can exist when a food system perfectly balances between environmental, social, economic and nutritional aspects, and can easily adapt to current and future changes (Kuhlman & Farrington, 2010). This level goes beyond policy targets that were developed as realistic, political milestones towards sustainability.

3.5. Food Sustainability Initiatives

Several initiatives have been developed by the scientific community, public and private sectors in the form of tools and techniques to help monitor and assess food sustainability (de Olde et al., 2017; Grubb et al., 2019; Wulf, Werker, Ball, Zapp, & Kuckshinrichs, 2019).

In Germany, for instance, multiple assessment programmes have been created. Most use credible assessment methods and strict processes leading to a certification confirming the compliance with specific sustainability attributes (i.e. environmental, social, or economic). Some of the examples in this area include:

- The EU Organic label for agriculture and food products: this is a publicly managed ecolabel (Eurostat, 2016); its key principles are to stop using synthetic pesticides and fertilisers, antibiotics and genetically modified organisms (GMOs), and to encourage crop rotation. Organic farming is believed to promote biodiversity, animal health, ecological balance and water/soil quality; it is, therefore, a responsible management of natural resources. The certification process for food companies, such as bakeries, ensures they are compliant with these standards, especially if they process or incorporate additional ingredients to produce new products. The EU Organic label is specifically designed to communicate these standards across the value chain to the consumers in the form of a logo.
- Fairtrade label: this is a certification programme developed by the private sector, which ensures certain social ethics are compliant with sustainability and fairness standards. It mainly aims to ensure farmers are being paid a fair price for their products (Bissinger & Leufkens, 2020).

In 2014, the FAO also developed guidelines for SAFA systems; these presented a framework for assessment and monitoring tools (FAO, n.d.-c) and it aimed to align and coordinate current initiatives as presented in Table 4.

Table 4 Summary of SAFA framework (adopted from SAFA framework)

Level	Tools	Rationale	Examples
Policy	Planning	Planning is used by policy makers to address specific areas/sectors	National strategies
Organisation	Reporting	Reporting is done by organisations regarding their sustainability status	EMAS
Standards	Benchmarks	Benchmarking is done to identify best practices within sectors/organisations	Global Social Compliance Programme
Product	Standards	Standards can be adopted at product level as preferred scenarios	Organic, Fairtrade
Performance	Assessment	Assessment is developed to measure performance of specific stakeholders/elements in a specific area	Sustainability Monitoring and Assessment RouTine (SMART), Response-Inducing Sustainability Evaluation (RISE)

However, in their latest policy updates, the FAO, the European Union and Germany, all emphasised the importance of a holistic approach towards agriculture and food systems. This meant bringing policy and performance closer to one another (i.e. effective alignment) to achieve better and faster progress.

3.6. Assessment Techniques

As a technique, sustainability assessment can help monitor sustainable characteristics of a food system; therefore, it can be an integrated system of environmental, social and economic assessment (for general sustainability). An effective sustainability assessment method must comprise the scope and objectives of assessment, appropriate sustainability indicators,

assessment technique, and finally the interpretation and application of assessment (de Olde et al., 2017). The two main assessment techniques include:

- Assessment of exposure, vulnerability and resilience variables (Greggs et al., 2019); this is mostly to test the sensitivity of the food system and the impact of risk factors on the productivity and sustainability of the given system (i.e. strengths and weaknesses of the system, what affects them, and to what extent). This can help to proxy the metrics of a food system.
- Assessment based on indicators: this is the most common approach; it studies a selected set of variables that are believed to influence the sustainability of the system within the area being investigated (environment, economic, social or holistic) (Waas et al., 2014).

The assessment based on indicators appears to be the most convenient technique for a holistic approach such as the case in this study (i.e. bread system). However, any assessment method using indicators should be based on a conceptual framework with a defined study area, clear drivers of change, and clear indicators affecting the causal relationships within the system (Ericksen, 2008).

3.7. Chapter Summary

This chapter explored the theories of food sustainability with a focus on the empirical approaches to study food system sustainability and the relevant assessment approaches and techniques. It provided general understanding on how and why a holistic approach is necessary in today's context from a practical point of view, while comparing current scenarios. The next chapter will critically analyse the bread system in Germany, with the system theory in mind, to establish and justify the conceptual framework for this study.

4. The Bread System in Germany

4.1. Introduction

This chapter explores the national bread system and how its major elements interrelate and/or interconnect with artisan bakeries. It critically analyses the role of artisan bakeries by looking at the influence of bread sustainability on a macro level. The purpose of this chapter is to explore the causal relationships within the bread system in today's context. Moreover, it helps identify bread sustainability dimensions and relevant criteria from a holistic perspective.

4.2. The Uniqueness of German Bread

To enumerate the many ways in which the German bread system works, one must first understand the uniqueness of this food, which is favoured by 80 million people and beyond. German bread is different from its culinary brethren around the continent. Instead of the bright white and starchy bread found in Italy and France, the German style of bread is coarser and uses unrefined grains; it is usually composed of whole grains, most notably wheat, rye or spelt. Because it uses the entire grain, the bread has a certain density. It is ironic, as current health trends strive to create multi-grain dense loaves when the Germans have been producing it throughout time. It is the bread of their ancestors, with some recipes coming from the time of Gauls and Visigoths. In fact, for a brief period, an industrialised white roll was introduced in the early nineteenth century (Gerschenkron, 1989) – a product similar to other countries' bread, which that could be made cheaply from processed grain – but there was a backlash against the new bread and they quickly returned to the hearty dense bread they were known for. The exclusivity and uniqueness of German bread are captured by the writer Samuel Fromartz:

'I was drawn to German bread mainly because of their distinct whole grain composition and complex fermenting processes — specifically associated with sourdough (Sauerteig). Plus, you can't find this kind of bread in the U.S. Yes, we have Jewish Rye, which comes close, but the coarse, thick German bread is really non-existent. Instead, we have imported the starchier varieties—say from the Italians, who immigrated here along with the French baguette. The East European immigrants came the closest to recreating such loaves but soon succumbed to consumer demand for starchier white slices of bread. German bread is really the exception and very hard to find outside of Germany - the big reason why I came to Berlin. The bread is basically 90% rye or spelt, which is crazy given how much sugar, salts, and god knows what goes into them. You have a slice of this for breakfast and you are set for a long time' (Hannon, 2011).

One of the hallmarks of this bread is the multi-grain structure, especially in non-wheat varieties. The many different varieties were often dictated by the grain that was available at the time, so bread made solely from wheat is a distinctly modern concept. Many of the areas in Germany were not conducive to wheat production, so they were forced to use heartier grains such as rye. This is the reason why Northern Germany is known for certain dark loaves, such as *Roggenbrot*, or rye bread, or *Vollkornbrot*, a whole grain variety (Spiekermann, 2006).

4.3. The Conceptual Framework of the National Bread System

To understand the bread system in Germany from a holistic perspective, Thilmany's food model was applied to create the conceptual framework as illustrated in Figure 4.

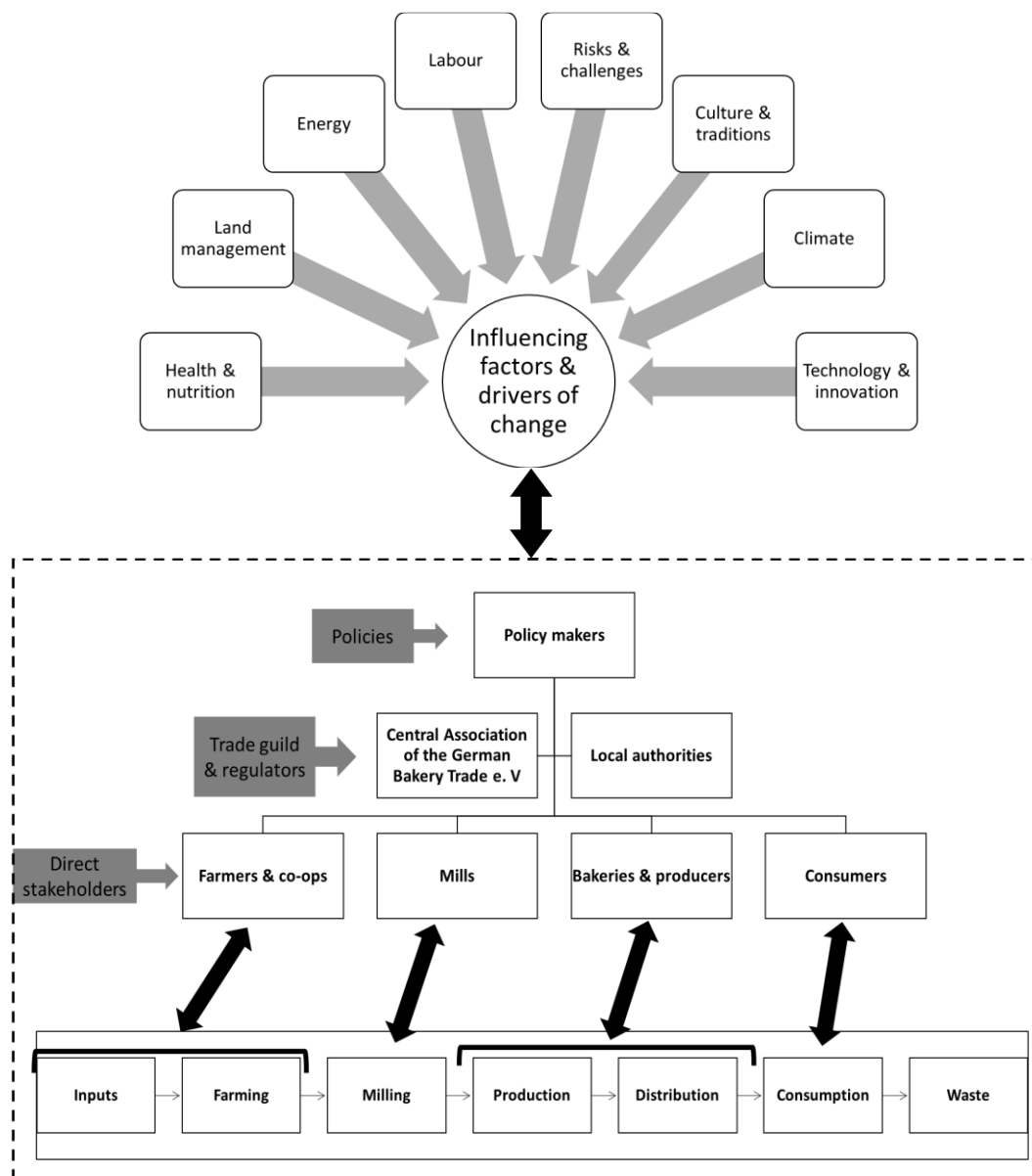


Figure 4 Bread system conceptual framework (created by the researcher)

4.4. The Value Chain and its Stakeholders

The bread value chain consists of input, farming, milling, breadmaking/production, distribution and consumption. Waste is an element that occurs across the entire chain and is discussed after the value chain. Influencing factors and drivers of change are discussed at each stage of the value chain to closely relate them to the context. The influence of bakeries is identified at each stage to highlight their impact on the bread system as well as on bread as a product.

4.5. Farming of Grains

The first phase of the bread supply chain is agriculture, which consists of inputs and the farming of grains. Germany is well-known for being one of the top agricultural producers in the world, and its grain sector is no exception with 45 million tonnes produced in 2020 (Lyddon, 2019). Common grain varieties harvested in Germany include wheat, barley, rye, spelt, emmer, einkorn, oats, millet, and buckwheat. Germany is the world's top producer of rye and one of the world's top ten producers of wheat. Wheat and rye are the most popular grains used in bread production; one of the most popular breads in Germany is Mischbrot, which is made from a combination of wheat and rye. Other flours regaining popularity include spelt, emmer and einkorn; these ancient varieties are being reintroduced to the market.

In Germany, the yield volume normally varies depending on climate, precipitation, heat and other factors. Table 5 shows the major grain production in 2020 (Lyddon, 2019), the allocated land area, and the average productivity per hectare of farmland.

Table 5 Major grain yields in Germany in 2020 (Lyddon, 2019)

Crop type	Land area <i>In million hectares</i>	Yield <i>In million tonnes</i>	Avg. productivity <i>Million tonnes per hectare</i>
Wheat	2.9 MH	21.1 Mt	7.2 Mt/ha
Barley	1.5 MH	10.4 Mt	6.9 Mt/ha
Rye	0.59 MH	3.1 Mt	5.2 Mt/ha
Triticale	0.34 MH	1.9 Mt	5.5 Mt/ha

The production of the above crops used around 30% of agricultural land in Germany or nearly 15% of the total land area, a share that might not be available to many other countries with high bread consumption. Grain farming for food production, however, significantly affects biodiversity and agrobiodiversity (Monetti, Pregernig, Speck, Langen, & Bienge, 2021).

Agriculture is a major contributor to GHG emissions, soil degradation and ground water pollution.

Currently, there are two grain farming scenarios in Germany: conventional and organic. Organically grown grains are those produced without the use of synthetic herbicides, pesticides, or fertilisers (Schaack & Willer, 2012). In the context of regulatory definitions, to be sold and distributed as ‘certified organic’, grains must pass a set of organic inspection criteria, specified by Germany and governed by regulation number 834/2007/EC under Germany’s Organic Farming Act (The Council of the European Union, 2007). Requirements under this regulation are numerous and relate to aspects such as the use of registered organic fertilisers, pesticides, and practices. Obtaining this certification allows German grains to be sold throughout Germany and the EU with appropriate organic ecolabelling – a publicly managed ecolabel (Umweltbundesamt, 2018).

Conventional grain farming refers to that which abides by non-organic federal regulatory inspection standards and which may use synthetic fertilisers, pesticides, or herbicides. However, while conventional production methods can yield an immediate abundance of resources, the repetitive, seasonal use of synthetic fertilisers contributes to soil fertility degradation, and the use of pesticides can present challenges to human health upon the consumption of non-organic products.

Thus, Germany has taken several measures to make agriculture more eco-friendly, by reducing fertilisers, pesticides and herbicides, and by promoting organic farming as a more responsible farming model. Furthermore, organic farming requires significantly less energy to produce crops than conventional farming practices, and it produces fewer GHG emissions (Eurostat, 2016); however, being organic, it has other negative aspects such as lower yield and higher production costs (Eurostat, 2016). If Germany transforms to fully organic farming, the grain yield could drop by up to 50% and grain prices will significantly increase. In addition, regarding the impact on the global market, Germany’s global wheat input represents around 4.3% of global wheat exports; any changes to this input would affect global wheat prices, and, therefore, would, automatically, affect importers.

Although Germany's grain production exceeds its needs, it imports grain products from the Czech Republic, Poland, France, Lithuania and Canada (Lyddon, 2019). Table 6 shows the grain import/export figures of 2020.

Table 6 Germany's main grain imports and exports (Lyddon, 2019)

Grain variety	Exports in million tonnes	Imports in million tonnes
Wheat	5.2 Mt	3.7 Mt
Barley	1.8- Mt	1.3 Mt
Rye	0.14 Mt	0.52 Mt

Grains are not only used for human food production, but also as animal feed, biofuel and as a raw material in industry (Szarka et al., 2021). German wheat is commonly used alongside sugar beet to produce ethanol, and Germany is the world's second largest producer of fuel ethanol after France (Cardoso, Özdemir, & Eltrop, 2012).

The main challenges affecting grain farming (Meyer & Früh-Müller, 2020) include climate change and extreme weather (especially droughts), the increasing prices of fertiliser and pesticides, and energy prices; diesel is the most common type of fuel used in agriculture.

Bakeries can influence farming via the demand linkage. Bakeries that aim to keep their bread more affordable tend to use conventional flours, while organic bakeries tend to increase their prices to cover additional costs. Bakeries can influence and shape consumer demand via innovation and trend setting, so the criteria for selecting suppliers is an important aspect to investigate.

The main stakeholders in grain farming include individual farmers, farmers holdings, the German Cooperative and Raiffeisen Federation, the German Farmers' Union (DBV), the German food and farming ministry (BMEL) and more.

4.6. Milling

Milling is the extraction of flour from grains; the percentage of extraction represents the volume of flour obtained from the original volume of grains being milled. Milling can be done in industrial mills, artisan mills or in domestic mills.

In 2021, there were around 550 mills in Germany, 185 of which had the capacity to mill more than 1,000 tonnes of grain, thus classified as large mills. German mills grind about 8.7 million

tonnes of grain every year (Zentralverband des Deutschen Bäckerhandwerks e. V., n.d.-a); breadmaking varieties such as wheat and rye make up as much as 8.3 million tonnes of that volume (approx. 7.5 million tonnes of wheats and 800,000 tonnes of rye). Large mills alone produce just under 6 million tonnes of wheat flour, 242,000 tonnes of spelt flour and around 588,000 tonnes of rye flour.

Due to technological advances, large industrial mills have the capacity to operate 24 hours a day. Flour production in an industrial mill has a lighter environmental impact than the same process in a domestic mill due to production optimisation (Reinhardt, Braschkat, Patyk, & Quirin, 2003). The coupling of growing organic crops with an industrial mill that is equipped with machines that are efficient and have a smaller impact on the environment often helps to deliver flour with less environmental impact (Reinhardt et al., 2003; Zarrouki, 2016).

Most mills in Germany adapt very strict food safety and quality standards, as well as trying to be competitive and reaching a larger client base. Partnerships between a bakery, a farm and a mill are very common in Germany, particularly with longstanding collaborations based on trust and professionalism. The links between bakeries and mills tend to have a strong mutual influence; the flour varieties and quality supplied by mills enables bakeries to produce a wide variety of breads. A stable and reliable supply is a key element in their relationship. Bakeries also influence mills via the demand linkage. In a very competitive bread market, bakeries constantly seek ‘best quality, low price’ to remain competitive and gain advantage. A pressure factor sometimes leads mills to produce standardised flours (a flour with a standard composition that does not change with yearly harvests and conditions). Bakeries with automated production systems tend to utilise standardised flour to maintain consistency. Bakeries sometimes buy ready-mix, which is a bread mix prepared by mills or by a third party, to ensure consistency and simplify the production process.

Major stakeholders include small mills, industrial mills, the German millers association, distributors, and more.

4.7. Bread Production and Distribution

Three categories of modern bread production currently characterise Germany’s bread market. These include industrial producers, supermarkets and discounters, and artisan bakeries (GTAI, 2017). Industrial producers include those leveraging mechanised, and often automated, processes to manufacture bread products at mass production and distribution scales (i.e.

factories). Industrial producers leverage less manual labour and greater mechanisation. Breads are often produced to withstand a long shelf life and distance transport desired by retailers. Supermarkets and discounters include end-of-supply-chain distributors, selling bread products from industrial bakeries to consumers, and some in-house production. Supermarkets and discounters may implement practices and methods of industrial producers and/or artisan bakeries; however, neither can use the term ‘bakery’ due to regulatory restrictions protecting the bakery trade (Gewerbeanmeldung.de, 2022). Industrial producers and supermarkets and discounters are introduced here as significant stakeholders of the bread system, but they will not be studied in this research.

To be allowed to use the term ‘bakery’ in its trade name, a bakery must have at least one certified baker, and be registered with the Central Association of the German Bakery Trade or what is normally referred to as ZDB (Zentralverband des Deutschen Bäckerhandwerks e. V., n.d.-b). The bakery trade is protected and regulated via a complex system explored in detail in Section 4.11. Artisan bakeries share around 55% of the national bread market; they produce around 2.75 million tonnes of bread every year. Artisan bakeries, generally, use fewer synthetic additives and implement historically traditional techniques of bread production (GTAI, 2017).

Artisan bakeries include companies of different sizes and shapes. Bread preparation components and methods in artisan bakeries include the following: outsourcing of flours or grains, dough preparation/mixing, first proofing, rolling and shaping, second proofing, baking, cooling, packaging and labelling and finally, selling (Reinhardt et al., 2003). While these methods vary by specific bread type, simply and generally, outsourcing includes supply decision making. Dough preparation includes combining ingredients according to recipes or using ready-mix prepared by suppliers as an alternative option. Dough mixing refers to how ingredients are added and mixed, sequentially, the level and vigour of mixing, the extent of mixing, and, in most cases, kneading. First proofing most generally refers to allowing the dough to ferment and rise, while second proofing refers to a second rise after the bread has been rolled and/or shaped into its appropriate size/weight and form. Baking and cooking logically describe the duration, temperature, and setting under which bread is heated and the combined ingredients synthesise. Most breads are oven-baked, whether in a technologically advanced oven, a basic small-scale oven, or, in some cases, a wood oven.

Bread baking is the most energy intensive phase of the entire bread life cycle, making bakeries the major contributor to the bread energy consumption footprint. Bakeries, however, can bake

using natural gas, diesel, electricity (conventional or renewable) or simply wood. The type of energy used has a significant impact on the type and volume of emissions associated with bread production, or what is mainly referred to as the bread carbon footprint. Bakeries sometimes invest in energy efficient ovens, to optimise their energy consumption and reduce costs. Energy saving is a double dimension in this case, reducing the energy footprint and reducing the costs related to production. Energy is considered to be a major driver of change for artisan bakeries; it can affect production costs, can, therefore, make them less competitive, especially against suppliers of cheaper bread options.

Another significant driver of change related to artisan bakeries is the low attractiveness of the bakery trade as a profession. The difficult working conditions and irregular hours make the baking profession a stressful and physically intensive job. The mechanisation of production processes is driving bakeries to employ fewer bakers; this further contributes to the job's low attractiveness and the ability of bakeries to offer competitive salaries, a topic that must be explored in this research.

The following subsections provide a general overview of differences and similarities between individual and chain bakeries.

4.7.1. Individual Bakeries

Individual bakeries employ a production system in which production and selling are carried out in a contained cycle, within a single, individual bakery. In other words, bread is produced in and sold from the same location. Depending on the bread type, this usually involves the following processes: 1) outsourcing (i.e. selection of supplier and flour types and quantities); 2) dough preparation; 3) first proofing; 4) dough rolling and shaping; 5) second proofing; 6) baking; 7) cooling; 8) packaging and labelling (if necessary); and 9) displaying and selling. After step 4, leftover dough from a first batch is often combined and reused during subsequent processing rounds. In some cases (including individual and chain bakeries) leftovers from step 9 can be reused (recycled) as an additional ingredient to prepare new dough (Dri, Antonopoulos, Canfora, & Gaudillat, 2018). Figure 5 illustrates the components most often and generally involved in the individual bakery production process.

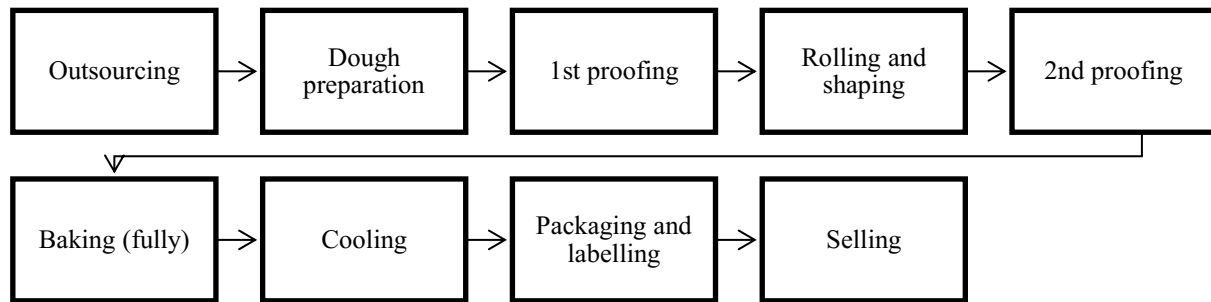


Figure 5 Production system in an individual bakery (created by the researcher)

4.7.2. Chain Bakeries

Chain bakeries, or bakeries involving more than one location/branch, generally implement a much more complex, involved, and multi-step process (Rosell, 2011). This process involves steps 1–9, as described by individual bakeries, in addition to the distribution steps of the process and, in some cases, the final baking phase of certain items (i.e. bread rolls, pretzels and other items). While some chain bakeries may bake bread at each location, more commonly, chain bakeries prepare at single locations and distribute products to hub locations, mostly within a geographic proximity. The structure and size of the chain is unique to each company; the shape of its inner-production/distribution-network is often very complex and difficult to draw (access to this type of data is considered a limitation and can only be investigated on a case-by-case scenario). Figure 6 describes the production system of a chain bakery in which bread is fully or partially produced in one or more places and distributed to points of sale in more than one location.

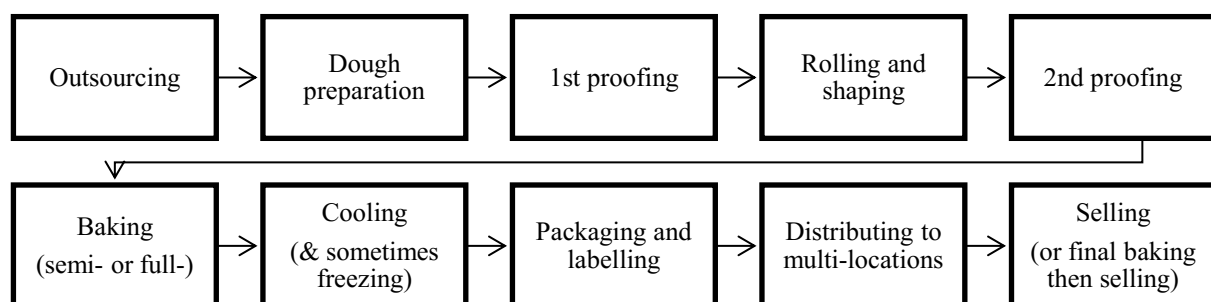


Figure 6 Production chain in a chain bakery (created by the researcher)

4.8. Other Stakeholders

Other stakeholders in the bread system include the Federal Government and local authorities. Their role is to ensure all stakeholders abide by the laws and rules (Geffert, von Philipsborn,

Stratil, & Rehfuess, 2020), meet the production and trade standards, maintain food safety and hygiene, and fulfil commercial responsibilities with regard to taxes and duties. They are also responsible for the dissemination of sustainability requirements applicable to the sector, with the collaboration of ZDB (this role will be explored further in Section 4.11).

The Federal Government and ZDB are working closely to promote bread sustainability through the incorporation of sustainability in the bakery trade via the Federal Institute for Vocational Training (Bundesinstitut für Berufsbildung – BIBB) (The Federal Institute for Vocational Training, n.d.).

4.9. Consumption

Bread consumption in Germany is relatively high, especially when compared to neighbouring countries. Germans get around one-fifth of their daily calories from bread and tend to prefer fresh bread from artisan bakeries to other sources (German Commission for UNESCO e. V., 2014), which is why artisan bakeries remain attractive and economically successful. Factors affecting consumer demand include preferences related to bread types, quality, taste, texture, availability and price. Major drivers of change for consumption include health and nutrition trends, the buying power of consumers in relation to artisan bread prices, and the availability of alternatives.

Consumer demand has a great impact on artisan bakeries; market segments with lower buying power tend to prefer cheap bread, while middle- and high-income segments seek high-end quality bread and can, therefore, encourage bakeries to innovate and elevate their quality standards.

In recent years, consumption has faced a growing trend in demand for ecolabels (Grunert, Hieke, & Wills, 2014), especially the organic label as it is the most common and popular ecolabel used in bread compared to the wide range of labels used in the food sector (Janßen & Langen, 2017). Consumer awareness of sustainable practices is growing and, nowadays, consumer decision making involves criteria other than just price, quality and quantity.

Consumption stakeholders include consumers, regulators of consumer rights and food safety, private and public sector organisations working toward promoting sustainable consumption, and more.

4.10. Waste

Waste is an important element of the bread system; it occurs at every stage of the bread value chain. Pre- and post-harvest waste is influenced by the level of care and attention paid to crop health, harvesting processes, handling methods, transportation and storage conditions. Harvest to retail waste is estimated at around 4.3% of wheat (D. Kumar & Kalita, 2017). Waste at mills occurs through the filtration of infested grains and cleaning processes, poor storage conditions and/or through milling and extraction. Lower extraction rates mean that a higher percentage of the grain is removed to obtain softer flours; leftover bran is sometimes sold as a by-product or used as animal feed. At the bakery stage, waste mainly occurs due to unsold bread, although sometimes it can be reused in production, donated or sent for use as animal feed. At the consumption stage, waste occurs when bread gets stale, mouldy and/or does not meet the taste preferences of the consumer. The majority of waste across the bread system occurs at bakeries and through consumption, with one-third and two-thirds, respectively (Upadhyaya, 2019).

4.11. German Bread Culture

The German bread culture is a significant element of the bread system; it is mainly associated with artisan bakeries within a strict protected trade framework. German bread culture was inscribed by UNESCO as an Intangible Cultural Heritage (ICH) in 2014. Bread craftsmanship is considered an expression of human development and a heritage of mankind as it derives from centuries-old traditions and practices embedded in German culture (German Commission for UNESCO e. V., 2014).

Bread is part of important cultural and religious events in Germany such as Christmas, New Year, Easter, carnivals and All Saints Day. It is also present in important life events such as birth and baptism, marriage and burials. Bread in literature is used as a synonym for food in a representation to its importance in human life. Bread has always been a political tool associated with power and ideology. Since the 1200s, the breadmaking craft in Germany has been dominated by guilds with periods of conflicts and harmony over the control of that important trade (German Bread Institute e. V., n.d.). However, in today's context, the bakery trade is managed by a set of stakeholders who protect, promote and develop it.

Artisan bakeries are associated in the form of a union called the Central Association of Bakery Trade, or ZDB (Zentralverband des Deutschen Bäckerhandwerks e. V.), which was founded in 1948 to regulate the bakery trade. ZDB works closely with the German Confederation of

Skilled Crafts or ZDH (Zentralverband des Deutschen Handwerks), which is the umbrella organisation that represents 53 German chambers of craft trades (public bodies), and 48 central craft trade associations, including ZDB (German Confederation of Skilled Crafts, 2017).

ZDH and ZDB both develop public regulations for vocational training and examinations of the bakery trade, which are carried out to transfer knowledge to new bakers. This mainly includes knowledge of raw materials and baking processes, and an awareness of tradition, customs and modernity. ZDH is, in fact, a member of the expert committee of the German Commission of UNESCO and works closely with ZDB to ensure bread heritage is protected. The conservation framework includes the following measures:

1. Identification, documentation, research (including inventory-making)
2. Preservation, protection
3. Promotion, enhancement
4. Transmission, (non-)formal education
5. Revitalisation
6. Political advocacy

Within identification, documentation and research, artisan bakers can contribute by documenting their recipes via the German Bread Register, which is a unique online archive/database for recipes (showing ingredients and special features, but not preparation techniques). So far, there are more than 3,000 recipes registered (German Bread Institute e. V., n.d.). Their preservation and protection, promotion and enhancement are mainly ensured by ZDB and ZDH through coordination, support and advocacy across the artisan bread sector and other stakeholders. Bakeries contribute to transmission through the training of young bakers, while revitalisation is promoted through innovation and creativity. Therefore, the two main areas in which bakeries directly contribute to the preservation of bread heritage through the UNESCO framework, are: a) adding their recipes via German Bread Register; and b) training bakers.

4.12. Influencing Factors and Drivers of Change

Influencing factors and drivers of change can affect the bread system and its ability to operate feasibly and sustainably – financially, economically, environmentally and socially – as well as its transformation for the future. They include:

- Climate change and weather conditions mainly affecting the farming and input resources. They can have a significant impact on the yield and quality of harvested grains. Price changes and quality are affected by what and how much is available. While climate and weather are uncontrollable, mitigation measures can be taken to ensure crops' productivity and yields are protected, and national reserves are built up for shortages and emergency cases.
- Energy prices: this is a main influencing factor as it can be one of the most expensive input elements within the bread system. Energy in Germany is mostly imported; this exposes the national bread system to global risks of energy price changes and shortages, such as in the scenario during Russia's invasion of Ukraine and the energy supply crisis. Increasing energy costs can significantly push prices higher as most stages of the value chain need energy to function (i.e. diesel for farming, electricity for mills, fuel for transportation, energy for baking, etc.). Although Germany has made significant progress towards developing renewable energy sources, affordable energy is needed to keep bread prices low and affordable.
- Skilled labour shortage: with the increasing trends towards healthy, balanced lifestyles, the baking profession is proving to be one of the least attractive in today's market. Common reasons include the low salary (in comparison to work requirements), and long, irregular hours. Bakeries could face a skilled baker shortage, which will definitely affect their ability to operate. This factor could be more influential if a bakery relies on handwork with less equipment, which is the case in most small, individual bakeries. Chain bakeries can be less vulnerable to this factor because they tend to implement more automated production processes.
- Technology and innovation: technology and innovation can have a significant impact on the bread system. In regard to productivity, they can increase productivity across all elements of the value chain. In terms of connectivity, they can simplify the exchange of information, data and facilitate the communication across the bread system. With

regard to efficiency, innovation in sustainable energy can help reduce Germany's exposure to imported energy as well as making bread eco-friendlier by minimising its footprint. Regarding waste, bakeries and consumers can benefit from new apps (such as the new 'Too Good To Go' and delivery apps) to calibrate their production in line with demand and/or to reduce waste by selling bread leftovers for a reduced price.

Other factors and drivers of change include land management (discussed under 4.5); culture and traditions (discussed under 4.11); risks and challenges (discussed in the next subsection); health and nutrition (discussed under 4.9).

4.13. Risks and Challenges Affecting Individual Bakeries

In addition to facing challenges related to developing sustainable practices and production methods, individual bakeries are struggling with a decrease in their numbers (Zentralverband des Deutschen Bäckerhandwerks e. V., n.d.-a); this is likely a result of increasing industrialisation and the advantages chain bakeries have over single-location establishments (Eddy, 2014). The current global and industrial context is forcing individual bakeries to devise new means of mitigating these challenges, adapting to changing market contexts, and remaining competitive.

The primary risk faced by individual bakeries is that of becoming competitively obsolete amidst industrialism and mass corporations. Within this risk exist sub-risks related to changes in the local environment and clientele, as well as supply chain alterations (Eddy, 2014). Without multiple locations and cash flow leverage, a single obstruction to a necessary supply chain, or a dramatic shift in local consumer demand, may force an individual bakery out of business. It is, therefore, important in this study to investigate whether these factors are influencing the survival of individual bakeries, and to what extent. Means of mitigating these risks include remaining fluid and adaptable to changing consumer demands, such as the current and increasing demand for gluten-free products, and altering production to match demand. Another mitigation strategy may be to diversify production as much as possible and to offer loyalty benefits to repeat, local consumers.

Such challenges faced by individual bakeries are directly related to the topic of food sustainability in Germany because the disappearance of individual bakeries could compromise the sustainability of bread from a socio-cultural and economic standpoint. Culturally, individual bakeries tend to produce artisanal bread with less dependence on technology and

machines. Moreover, individual bakeries foster a locally focused economic system in which small businesses experience the opportunity to thrive, especially in towns and villages.

4.14. Risks and Challenges Affecting Chain Bakeries

In comparison to individual bakeries, chain bakeries appear to be developing in terms of their business reach and extensiveness. For instance, chain bakeries often produce bread in a mass, more mechanised fashion, and have the capital and technology to reach a broader, more diversified consumer market, as well as diversifying revenue sources between multiple locations. Because of the shelf-life requirements of distribution and transport, many chain bakeries rely on daily transportation and half-baking solutions to meet their customers' needs. The ability to withstand transport and reach a broader audience is a competitive advantage that chain bakeries have over individual bakeries, so are a threat to the viability of individual bakeries. The question of whether chain bakeries are to dominate the sector in the future, remains unknown. This research will investigate how the two models survive and develop in the current market structure from an economic standpoint.

However, chain bakeries face similar challenges as individual bakeries, but on a dramatically different scale. For instance, chain bakeries must also adapt to changing consumer demand. While chain bakeries often have more capital and infrastructure with which to work, adapting processes can often be cumbersome and time and cost intensive, considering that change management must be deployed within extensive, complex systems involving multiple stakeholders (multiple bakery locations, supply chain players, managers, and multiple local consumer demographics). Therefore, while large chain bakeries have certain cash flow and resource advantages over individual bakeries, change implementation can often be much more difficult to execute in terms of logistical feasibility and ease. Concerning their sustainability, this challenge faced by chain bakeries implies that sustainable changes regarding process and production management may take longer and be more complex to execute within chain bakeries; this study should reveal whether this is the case.

4.15. Chapter Summary

This chapter critically analysed the bread system in Germany. The elements of the bread value chain were first analysed to identify their role and influence on bread sustainability. The main focus was given to the role of artisan bakeries, how they affect the system element, and through which linkages (and to what level) enabled the researcher to identify bread sustainability

dimensions and relevant criteria. This chapter also differentiated between individual and chain bakeries, and explained how each system functions and the challenges they face. The chapter ended with an overview of the influencing factors, drivers of change and major risks and challenges facing artisan bakeries. The next chapter will introduce, explain and justify the methodology of this study.

5. Research Methodology

5.1. Introduction

This chapter will present the methodological approaches used to meet the research objectives. It will answer the three research questions and test the hypothesis.

To achieve the research objectives, three research questions had to be answered. To answer RQ1, the different perspectives to ‘What is sustainable bread?’ were explored and combined. These included the literature perspective conducted in Chapter 4, the political perspective conducted in Chapter 6 (i.e. the critical evaluation of the SDGs), and finally the bakeries’ perspective, through an investigation of their perceptions of sustainable bread using primary data collection. Criteria from the three perspectives were compared and synthesised into the five dimensions to characterise what sustainable bread is (including environmental, social, economic, nutritional and cultural dimensions). To answer RQ2, the linkages between the SDGs, the bread system, artisan bakeries and bread were mapped to understand the correlations and, therefore, the impact of bakeries (quantitative and qualitative). RQ3 was answered by assessing whether individual or chain bakeries had higher chances of survival under current challenges; as well as identifying the impact of individual bakeries’ disappearance on bread sustainability in the long term.

To test the hypothesis, results of the expanded framework can be compared to the results of the policy framework (i.e. SDGs) to validate and justify the inclusion of additional dimensions relevant to the holistic approach.

5.2. Literature Searches

The literature searches for this study were conducted using online resources with open access and online databases, to which the researcher acquired access, including BTU online library, Open Athens, Shibboleth, Scopus and Statista. Moreover, hard cover resources were consulted at the BTU library in Cottbus, the State Library in Berlin and the British Library in London.

Literature selection criteria included sources in the English language on food sustainability, holistic approaches to sustainability assessment, bread supply chain and related keywords, publications from the last 10 years, those of academic value, and/or published by a credible source. Selected sources were directly registered via Mendeley to develop the bibliography and maintain track of the references.

In terms of literature objectives, global sustainable development policies, most importantly the Agenda 2030, its progress reports, and the SAFA framework, provided an insight into the global sustainable development concepts, political and scientific backgrounds for food sustainability, and implementation frameworks. The UNESCO Convention for the Safeguarding of the ICH and the inscription of German bread culture provided information on the cultural dimension and conservation approach.

GSDS 2030, its progress reports, and publications by Federal Ministries and local authorities – often available in English – were used to understand the German context for sustainable development and food strategies. Several resources were only available in the German language, so support from a native speaker was obtained to translate and understand them. Secondary data and available statistics provided quantitative input on food systems.

Empirical studies, including books, journal articles and research papers, provided an understanding of methodological approaches to food sustainability and common assessment models. However, searches indicated a gap with regard to multidisciplinary assessment approaches and techniques, particularly in the area of food systems (i.e. holistic approaches) (Moscatelli et al., 2016). For the environmental dimension, footprint and LCAs were very common; for the economic dimension, predictions and cost-benefit analysis were commonly used; and for the socio-cultural dimension, social models and rating approaches were commonly used. However, integrated holistic models combining all dimensions, sometimes seen as one-size-fits-all solutions, were criticised for their feasibility and precision (D. Kumar & Kalita, 2017). Only a few empirical studies existed in that area, and none were on artisan bakeries in Germany. Table 7 presents the common assessment approaches, their purposes and scopes.

Table 7 Sustainability assessment approaches (created by the researcher)

Approach	Name	Primary purpose	Geographical scope	Thematic scope
LCA	Life Cycle Assessment	Research	Germany & UK	Environmental
GEMIS	Global Emissions Model for Integrated Systems	General	Various countries	Environmental
PROSA	Product Sustainability Assessment	Research	Germany	Env, Soc, Eco
SALCA	Swiss Agricultural Life Cycle Assessment	Research	Switzerland	Environmental
SEEBalance	SocioEcoEfficiency by BASF (strategies)	Assessment	Global	Env, Soc, Eco
SMART	Sustainability Monitoring and Assessment Routine (agriculture/crops)	Assessment, Monitoring	Germany & Global	Env, Soc, Eco
International Social and Environmental Accreditation and Labelling (ISEAL) Alliance	Global Membership Organisation for Credible Sustainability Standards	Assessment, Benchmarking	Global	Env, Soc, Eco
RobecoSAM	SAM Corporate Sustainability Assessment (CSA)	Assessment, Corporate	Global	Env, Soc, Eco

On the one hand, approaches such as LCA, GEMIS, SALCA or, similarly, Cradle to Grave (C2G), are powerful tools for studying the environmental impact of a product life cycle (Bilotta, Milner, & Boyd, 2014). However, they are applied on a case-by-case scenario, which is not feasible for this research given its sample size and scope. Additionally, the gaps regarding

other dimensions such as social, economic and cultural aspects, make their integration arguably complex. On the other hand, tools with a broader thematic scope, such as Product Sustainability Assessment (PROSA), have LCA and similar tools embedded within, and they are more suitable for a product assessment than a company assessment (i.e. bread versus bakery). SEEBalance and RobecoSAM are approaches to strategy improvement at a corporate level and could be beneficial for large bakery chains, but not small bakeries. Exceptionally, SMART provides a suitable model that can potentially be used (Sustainable Food Systems GmbH, n.d.); one of its advantages is that it is aligned with the FAO's SAFA framework and has the potential to be aligned with SDGs; however, access and use of their software is not available to researchers.

Other frameworks include the Global Membership Organisation for Credible Sustainability Standards (ISEAL Alliance), for research on general sustainability (ISEAL Alliance, n.d.); however, it follows a benchmarking approach suitable for best practices at sector level, which is not the case in this study (Topolansky Barbe, Gonzalez-Triay, & Hensel, 2013).

Food sustainability initiatives of public and private sectors, including food ecolabels and certification programmes, can be used to understand the operationalisation of sustainability attributes at operation level (e.g. product, company, etc.). However, labels normally focus on a specific dimension and can be based on different standards (Janßen & Langen, 2017).

The literature searches confirmed the suitability of the national SDG framework for a holistic approach to food sustainability, particularly, with regard to its indicators being valid, universal and significant. Alternative approaches would require the development of a sustainability context, the identification of impact areas and suitable indicators, something that the SDG framework has already established on a national level.

5.3. Research Philosophy and Methodology

According to the methodological literature (Balnaves & Caputi, 2018; J. Creswell & Plano Clark, 2011; W. Creswell, 2015; Hesse-Biber, 2012; Jackson, 2015; Leary, 2016; McBurney & White, 2017; McNabb, 2016; Yin, 2009; Zikmund, 2016), the three main types of research methodology are as follows: (a) quantitative methods; (b) qualitative methods; and (c) mixed methods (that is, a combination of both).

Table 8 exhibits McNabb's description of the characteristics of, and the differences between, quantitative and qualitative research.

According to McNabb (2016), quantitative methods tend to be deductive, based on the assumption of a single and measurable reality; they are value-neutral, formal, and not dependent on researcher interaction. However, qualitative methods are inductive, accepting of multiple possible realities, value-laden, informal, and informed by the manner of researcher observation. The mixed-method approach contains a combination of the characteristics of quantitative and qualitative research. This study used the mixed-method approach.

Table 8 Quantitative and qualitative research methods: characteristics and differences adopted from McNabb.

Philosophical Foundations	Qualitative Research Designs	Quantitative Research Designs
Ontology (perceptions of reality)	Researchers assume that multiple, subjectively derived realities can coexist.	Researchers assume that a single, objective world exists.
Epistemology (roles for the researcher)	Researchers commonly assume that they must interact with their studied phenomena.	Researchers assume that they are independent of the variables under study.
Axiology (researchers' values)	Researchers overtly act in a value-laden and biased fashion.	Researchers overtly act in a value-free and unbiased manner.
Rhetoric (language styles)	Researchers often use personalised, informal, and context-laden language.	Researchers most often use impersonal, formal, and rule-based text.
Procedures (as employed in research)	Researchers tend to apply induction, multivariate, and multi-process interactions, following context-laden methods.	Researchers tend to apply deduction, limited cause-and-effect relationships, with context-free methods.

The choice of an appropriate research methodology is governed by factors such as (a) the nature and context of an identified research problem; (b) tools available to the researcher; and (c) the phenomenon or phenomena under investigation. The phenomenon under investigation in this study is sustainability. This phenomenon is capable of being measured quantitatively (Epstein & Roy, 2001), but it is also characterised by the subjectivity of interpretation (Perrini & Tencati, 2006). Table 9 summarises the methodological approaches selected for this study.

Table 9 Methodological approaches for this study (created by the researcher)

Research Objective	RQ	Assumption	Approach	Design
Explore the various perspectives, including literature, policymakers and artisan bakeries to achieve a broader understanding of sustainable bread.	What is sustainable bread?	Sustainable bread is the product of a bread system that positively contributes to national sustainable development, while preserving its environmental, social, economic, cultural and nutritional aspects.	Investigate the criteria of a sustainable bread from a holistic perspective, including literature, policy and bakeries.	Qualitative
Examine Germany's bread system and evaluate the role of artisan bakeries with a focus on the sector-specific dimensions.	What is the role of artisan bakeries in promoting bread sustainability? And, how do they contribute towards achieving the SDGs?	Artisan bakeries promote the sustainability of bread system either directly or via linkages, their sustainable practices can also be associated with national SDGs.	Critically evaluate the contribution of artisan bakeries to bread sustainability, and to national SDGs.	Qualitative and quantitative
Conduct a primary research to investigate artisan bakeries perspective to sustainable bread and their current state of sustainability in regard to national SDGs.	What influence does a changing artisan bakery sector have on bread sustainability?	The ongoing consolidation in the sector, could potentially lead to individual bakeries disappearing; losing them might negatively affect the sustainability of the bread system.	Assess the sustainability and viability of individual versus chain bakeries and the impact of challenges on the sector transformation.	Qualitative and quantitative
Analyse data and relate to the wider context for the purpose of future research.	N/A	N/A		N/A

The use of the mixed-method approach requires researchers to specify how, or if, these two methodologies will be blended. The blending approach selected for this study is concurrent triangulation, which is described as follows:

- In this design, quantitative and qualitative data are collected concurrently in one phase. The data are analysed separately and then compared and/or combined. An example would be if a researcher collected survey data and interview data at the same time and compared the results. This method is used to confirm, cross-validate, or corroborate findings. It is often used to overcome a weakness in one method with the strengths of another (CIRT, n.d.).

Because the research questions contain emphases that are equally open to quantitative and qualitative exploration, a concurrent triangulation design was selected.

One important consideration in the use of any methodology is understanding and applying the underlying philosophical orientation. In quantitative methods, as noted by Creswell (2015), the underlying orientation is often that of positivism or post-positivism, which share a common commitment to measurement and precise definitions. According to the philosopher Gottlob Frege (1960), one of the founders of positivism, ‘A definition of a concept...must be complete; it must unambiguously determine, as regards any object, whether or not it falls under the concept.... Thus, there must not be any object as regards which the definition leaves in doubt whether it falls under the concept.... the concept must have a sharp boundary’ (Geach & Black, 1960). Therefore, in a positivistic or post-positivistic approach to the quantitative analysis of sustainability, the concept of sustainability should be precise rather than fuzzy, in a manner that the philosopher of science Robert Klee describes as ‘cutting nature at its seams’ (Klee, 1997).

However, in the social constructivist philosophy that is often associated with qualitative research methods, there is room for fuzzier concepts (W. Creswell, 2015). As Gillett (1998) writes, for social constructivists, one important point of departure is that ‘beliefs about reality are constructed by the mind and are relative to various frameworks: history, culture, and individual circumstances’. The qualitative component of the study is influenced by the philosophy of the social constructivist paradigm, particularly in terms of being open to different, clashing, and fuzzy definitions of the concept of sustainability as applied to different stakeholders.

Moreover, in terms of the quantitative portion of the study, the commitment is to post-positivism rather than positivism. The distinction between these philosophical commitments is that, for positivists, a phenomenon can be reduced to its measurement; thus, for example, sustainability can be accepted as a positivist concept solely insofar as it can be measured and observed. However, for post-positivists, measurement and mathematics are considered to be indispensable tools and useful approximations of reality, but not the substance of reality itself (Hasan, 2016). The adoption of both post-positivism and social constructivism, as underlying philosophies, indicates an openness to various definitions and measurements of the phenomenon of sustainability. Such openness is necessary when attempting to integrate the different perspectives of bread system stakeholders, who, as noted in the presentation of qualitative findings, often disagree with each other in their definitions and explorations of sustainability, but agree with each other in different contexts.

5.4. Design and Rationale

For the qualitative portion of the study, a descriptive phenomenological design was chosen. In such a design, according to Englander (2012), ‘The phenomenon is the object of investigation, not the person, although obviously, a person is required to describe the phenomenon’. Each of the three research questions of the study contained at least one sustainability-related phenomenon of interest that could be explored descriptively, as follows:

- The phenomenon implied in RQ1 is bread sustainability and how it is perceived.
- The phenomenon implied in RQ2 is that of bakeries’ sustainability and its links to the bread system and national SDGs.
- The phenomenon implied in RQ3 is that of the sector transformation and its impact on bread sustainability.

In terms of quantitative design, the selected approach was correlational. In correlational designs, according to Keppel et al. (1992), ‘The variables included...are isolated and measured by the investigator, but they are characteristics that occur naturally in the subjects...a correlation study consists of establishing a relationship between variations in the X variable to variations in the Y variable’. In RQ2, the outcome, or Y variable, was the sustainability of the bread system, and the X variables were bakery characteristics (or practices). In RQ3, the outcome variable was whether or not a bakery is successful, and the predictor variable was the

type of bakery (i.e. individual or chain). The presence of predictor (also known as independent) and outcome (also known as dependent) variables meant that a correlational design was the right design to apply to the study.

5.5. Population and Participants Selection Logic

Two populations were used for the study, given that the units of analysis were different for the quantitative and qualitative parts. For the quantitative portion, the population consisted of artisan bakeries. The population for the qualitative portion comprised managers or owners of artisan bakeries. In both cases, the setting for the study was Germany.

The quantitative samples consisted of 52 artisan bakeries, some of which were individual in one single location, and others were chains with two or more locations. The 52 bakeries together own 562 branches or points of sale. The sample consists of bakeries rather than branches because each bakery reported total values. For example, bakery #1 reported having eight branches (all in Hamburg), 58 employees, and producing a total of 2,500 kg of bread. The bakeries did not report varying employee numbers, bread production data, or other variables on a branch-by-branch basis. Therefore, the sample of the quantitative part consisted of artisan bakeries ($n = 52$) rather than branches ($n = 562$). The 52 bakeries, however, with their 562 branches, represent 1.6% of the total population of 35,000 branches in Germany (this is described as a population cluster). According to the Qualtrics sample size calculator, for a population of 35,000, an ideal sample size is 380. Collecting data for population clusters in this representative manner has been developed in health, community, and social science research using novel methods, as described by Treiman, Lu and Qi (2012).

The sample of the qualitative portion of the study consisted of 10 individuals who responded to the interview questions disclosed in the qualitative interview protocol (see Appendix 5). Demographic data on these participants were not collected. According to Creswell (2015), 10–16 individuals constitute an adequate sample for qualitative studies. Therefore, the small sample size of the qualitative part can be considered a limitation. This limitation was partially addressed by including qualitative data from an open-ended question appended to the quantitative questionnaire.

5.6. Recruitment and Participation

Recruitment began in July 2020 by the researcher, who first consulted the directory of the Central Association of the German Bakery Trade and the German Bread Institute, the

association through which all artisan bakeries are registered (Deutsches Brotinstitut, 2021). The German Bread Institute provides a software application through which bakeries can be identified and contact can be made. Next, the researcher conducted a search via Google Maps, to cross-validate and identify each bakery's geographical distribution and to obtain its contact details. Then, three bakeries were selected for a pilot study, which led to amendments in the initial questionnaire (e.g. simplification of terms, omission of repetitive/similar questions, addition of ethylene glycol as a proofing energy source, etc.). Across 38 cities, towns and villages in Germany, 586 bakeries were identified. The researcher emailed each bakery with a letter of intent and ethical considerations (Appendix 2), along with a link to the study questionnaire, which was developed on the Smart Survey website (Appendix 3). The response rate was 8.8%, or 52 responses out of 586 contacts.

Within the questionnaire, a question was included about willingness to participate in an interview. Those who expressed interest by answering affirmatively provided their email address so that the interview could be scheduled and conducted.

5.7. Holistic Assessment Framework: Operationalisation of SDGs

Due to the lack of holistic assessment approaches, and the need for an assessment framework with valid indicators, the SDG framework was deemed appropriate for this study (Zanten & Tulder, 2021). The advantage of selecting this particular framework is that it helps contextualise the sustainability of the national bread system; eventually, the bakeries operate within its scope. This approach has been used, in the same sense, by other scholars (Montiel, Cuervo-Cazurra, Park, Antolín-López, & Husted, 2021; Song et al., 2022; Zanten & Tulder, 2021). It has the potential for replication elsewhere using respective national frameworks and indicators (Kroll, Warchold, & Pradhan, 2019). Some of the disadvantages include the need for a critical evaluation of each indicator from a bread perspective to argue and prove their suitability and correlations. Also, measurements can be challenging because some indicators use date values as baselines, which are not always available in the case of bakeries. Moreover, it might be necessary to expand it to address potential gaps.

The operationalisation of SDGs to a bakery level requires a mapping of the linkages between the SDGs and the bakery via the bread system. Figure 7 illustrates the position of bakeries within the bread system from a holistic perspective in relation to SDGs.

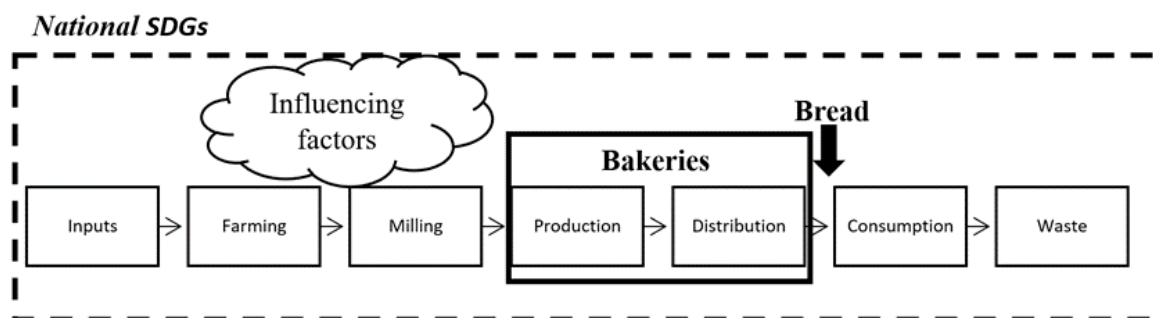


Figure 7: Bread system conceptual framework (created by the researcher)

The critical evaluation of the SDGs and their operationalisation was conducted according to the following steps:

- Introduction to each SDG and its scope
- Exploration of the current status of the SDG area using key facts and figures
- Critical evaluation of the SDG and its significance for the bread system
- Application of indicator to a bakery level
- Explanation of bakeries' potential impact
- Identification of relevant sustainability criteria associated with bread

Table 10 provides a summarised example of how SDG1 was critically evaluated and operationalised to a bakery level.

Table 10 Example of SDG critical evaluation and operationalisation (created by the researcher)

Process	Explanation	Link to bread system	Link to bakery
SDG 1	No Poverty	-	-
Global scope	7 targets & 13 indicators	-	-
National scope	1 target & 1 indicator (material deprivation)	Material deprivation affects the affordability of consumers	Consumer affordability

Rationale	<u>Poverty line</u> Global: \$1.9/day Germany's risk of poverty line €41.1/day	Poverty affects access to bread, therefore food security and nutrition	Low production costs (e.g. flour, labour, energy) help bakeries keep bread affordable
Key facts in Germany	National minimum wage: €74.2/day Bakeries sector: €112/day Artisan bread: €3.5/kg average	3 days of work on minimum wage, are sufficient to buy bread for the whole year (56kg/person/year)	Labour input & consumer buying power
Critical evaluation	Germany's current poverty outlook does not have significant impact on the bread system; however, if national poverty increases, affordability will decrease.	Poverty affects consumer affordability and can push bread prices down	Bakeries' labour is 33% higher than minimum wage Bread average bread price is €3.5/kg
Significance	Low	Current affordability is high	Current affordability is high
Sustainability criteria	Affordability	Consumer affordability	Affordable bread

A complete critical evaluation of the 17 SDGs is conducted in Chapter 6; it is an extensive, but integral, element of the methodology, following the same steps presented in Table 10, but in narrative form. In some cases, where the SDG/indicator is evaluated to be of low significance in relation to bread, it is made redundant. Moreover, some indicators are slightly moderated to improve their suitability for this study.

The critical evaluation identifies the following significant SDGs and their indicators suitable for this study: SDG 2 (2.1.a & 2.1.b); SDG 3 (3.1.f); SDG 7 (7.2.a & 7.2.b); SDG 8 (8.1 & 8.5.a); SDG 11 (11.2.a & 11.4); SDG 12 (12.1.a, b & 12.2); SDG 13 (13.1.a); and SDG 15 (15.1).

The SDG framework addresses environmental, social, economic and nutritional dimensions. However, there is a gap regarding the cultural dimension of bread. Therefore, the UNESCO framework discussed in 4.11 is used to evaluate what, and how, bakeries promote in that area. The two main indicators are the number of recipes registered on the heritage database and the number of baker trainees.

5.8. Data Collection and Instrumentation

5.8.1. RQ1 Data Collection and Instrumentation

To define sustainable bread, three perspectives were explored, including a) the literature – what sustainable bread is from a theoretical perspective; b) SDGs and UNESCO frameworks – what sustainable bread is from a policy perspective; and c) bakeries – what sustainable bread is from a bakery perspective. The three sets are presented in Table 11.

Table 11 Perspectives to bread sustainability (created by the researcher)

Perspective	Source of criteria set	Generation method
Literature	Chapter 4 ‘Bread System’	Critical analysis of bread system
Policy	Chapter 6 (and section 4.11)	Critical evaluation of SDGs, and heritage framework
Bakeries	Interviews with bakeries	Screening of interview records

The sustainability criteria in Chapter 4 were explored through a critical analysis of the bread system in Germany using food system theory, and the criteria existed across all dimensions. The critical evaluation of SDGs in Chapter 6 will help to identify environmental, social, economic and nutritional criteria from a policy perspective, as well as the cultural criteria identified in 4.11 (bread heritage). Bakeries’ criteria will be explored using interview records, after the following questions are asked:

1. How do you describe a sustainable bread? (Q3)
2. How do you think a bakery can become sustainable? (Q2)
3. What is a traditional German bread? (Q6)
4. What traditions should be protected, and how? (Q7)
5. Did you register any recipes on Bread Register? (Q15)
6. How do you transmit knowledge to baker trainees? (Q16)
7. Would you like to add anything else? (Q18)

5.8.2. RQ2 Data Collection and Instrumentation

RQ2 consists of two parts: first, the role of bakeries with regard to bread sustainability (i.e. the bread system); second, their contribution to national SDGs. Therefore, the causal relationships (correlations) among the indicators and targets of Germany's SDGs, the bread system, the artisan bakeries and bread as a food product, are mapped in Table 12- to identify the linkages and impact factors. In Table 13, questions for the data collection are allocated accordingly. Furthermore, a performance assessment scoring system is suggested to rate the performance of bakeries under each indicator (0 for no contribution and 1 for positive contribution). The rating system will help visualise the contribution of bakeries to national SDGs using the score to create graphs. The questionnaire aims to mainly gain quantitative insights, while the interview questions aim to gain an explanation on, and interpretation of, the figures. In some areas, additional questions are added to shed more light on topics pinned out during the literature.

Table 12 RQ2 Correlations between SDGs and bread bakeries (created by the researcher)

SDG	Indicator	2030 Target	Current state	Link to bread system	Link to bakery	Causal relationship	Impact on bread
SDG 2	2.1.a Nitrogen surplus in agriculture	70 kg/ha	87 kg/ha in 2018	Farming	Farmed grains used as flour input	Contribution to Nitrogen surplus via demand	Nitrogen footprint
	2.1.b Organically farmed agricultural land	20%	9.6% in 2020	Farming	Farmed grains used as flour input	Contribution to organic farming via demand	Ecological footprint
SDG 3	3.1.f Obesity rate among adults	Permanently halt increase	15.4% in 2021	Consumption	Bakeries supply bread to consumption	Healthy bread promotes healthy diets	Nutritional value
SDG 7	7.2.a Share of renewable energies in gross final energy consumption	30%	19.2% in 2021	Entire system	Bakeries consume energy to operate and bake bread	Shift to renewable energy promotes progress towards 2030 target	Energy footprint
	7.2.b Share of electricity from renewable energy sources	65%	41.1% in 2021	Entire system	Bakeries consume energy to operate and bake bread	Shift to renewable electricity promotes progress towards 2030 target	Energy footprint
SDG 8	8.1 Raw material input productivity	+60% Compared to 2000	+26% in 2016	Entire system	Bakeries use raw materials (input/output)	Alignment with national target	Waste ratio
	8.5.a Employment rate (20 to 64-year-old)	78%	79.6% in 2021	Entire system	Labour intensity at bakeries	Increase employment (skilled)	Labour intensity

SDG 11	11.2.a Final energy consumption in goods transport	85% compared to 2005 level	101.8% in 2020	Entire system	Bakeries procurement of flour	Reduction of transport (using energy)	Transport footprint
SDG 12	12.1.a Market share of products certified with publicly managed ecolabels	34%	7.9% in 2019	Product	Bakeries produce bread with organic ecolabel	Increase eco-labelled bread production	Ecological footprint
	12.1.b Global environmental impact of household consumption	Steady reduction compared to 2010	94.1% in 2017 (energy)	Consumption	Bakeries moderate impact of household consumption	Bakeries can decrease energy and packaging	Consumption footprint
	12.2 EMAS eco-management (Eco-Management and Audit Scheme)	5,000 locations	2,290 in 2021	Production	Bakeries can register in EMAS	Bakeries registration help achieve 2030 target	Production transparency
SDG 13	13.1.a Greenhouse gas emissions (also reflected in 12.1.b). Reflected in 12.1.b						
SDG 15	15.1 Biodiversity & landscape quality. Reflected in 2.1.b						

Table 13 Question mapping and scoring system (created by the researcher)

SDG	Indicator	Questionnaire	Potential answer	Score	Score justification	Interview
SDG 2	2.1.a Nitrogen surplus in agriculture	Which flours do you use? Conventional or organic? (Q9) Why don't you convert to fully organic? (Q10)	Conventional	0	Contribution to nitrogen surplus	What are your flour selection criteria? (Q11)
	2.1.b Organically farmed agricultural land		Organic	1	Promotion of organic farming	
SDG 3	3.1.f Obesity rate among adults	Do you use synthetic ingredients?	Use of synthetic ingredients	1	Synthetic ingredients do not promote healthy diet	How do you make bread healthy? (Q15)
			Use of natural ingredients	0	Healthy ingredients promote healthy diet	
SDG 7	7.2.a Share of renewable energies in gross final energy consumption	What type of energy do you use? (Q12)	Use of renewable energy	1	Promotion of renewable energy	Is sustainable energy available and affordable to your bakery? (Q13)
	7.2.b Share of electricity from renewable energy sources		No renewable energy	0	No promotion	
			Use of renewable electricity	1	Promotion of renewable electricity	
			No renewable electricity	0	No promotion	
SDG 8	8.1 Total raw material productivity	How much bread is wasted every day? (Q22) What happens to unsold bread? (Q21)	Above average productivity	1	High productivity indicates less waste	How can bakeries reduce bread waste? (Q14)
			On or below average productivity	0	Low productivity indicates more waste	

	8.5.a Employment rate	How many employees do you have? (Q4) How much bread do you produce per day? (Q5)	High labour intensity	1	High labour indicates more handwork and less automation	Is it difficult to find and recruit bakers? (Q9)
			Low labour intensity	0	Low labour indicates less handwork and more automation	
SDG 11	11.2.a Final energy consumption in goods transport	How far is your mill from the bakery? (Q8) how often do you receive flour from supplier? (Q20)	Below average transport footprint	1	Less energy for transport of flour	What are your flour selection criteria? (Q11)
			On or above average transport footprint	0	More energy for transport of flour	
SDG 12	12.1.a Market share of products certified with publicly managed ecolabels	What is the share of organic certified bread? (Q9) What are the challenges to ecolabelling? (Q24)	Producing organic labelled bread	1	Contribution to reaching 34%	What do you think about ecolabels? (Q4)
			Not producing organic labelled bread	0	No contribution	
	12.1.b Global environmental impact of household consumption	Have you taken measures to reduce energy consumption? (Q19) What energy do you use for proofing? (Q11) How do you package your bread for sale? (Q14)	Reducing energy or packaging footprint	1	Reduction of energy and packaging reduce consumption impact	How can you use energy more efficiently? (Q12)
			Not reducing energy or packaging footprint	0	Not reduction of energy and packaging maintain consumption impact	
12.2 EMAS eco-management (Eco-Management and Audit Scheme)	Do you have EMAS? (Q23) Do you report to any other body? (Q25)	EMAS	1	EMAS improves transparency	What do you think about reporting your sustainability? (Q5)	
		No EMAS	0	No contribution		

5.8.3. RQ3 Data Collection and Instrumentation

For this question, both qualitative and quantitative inputs were designed. The qualitative questions included prompts designed to elicit comments about the prospects of individual bakeries as well as the risks of losing that part of the sector in the process of consolidation. The disappearance risk of small bakeries was constructed as an index variable designed to assign a low score to items indicating a lower risk of disappearing and a high score to items indicating a higher risk of disappearing. While preparing questions for analysis in RQ3, advantage was taken of the difference between chains and individual bakeries. The following questionnaire items were then identified as being relevant to RQ3, with each item based on, or related to, at least one questionnaire item from the study:

- The distribution of challenges (Q17: implementing new technologies, new and increasing regulations, sustainability requirements, rising production costs, taxes, finding skilled labour, changing consumer behaviour, and competition) between chains and individual bakeries.
- The distribution of production trends (Q16: increasing or decreasing) between chains and individual bakeries
- The distribution of business expansion (Q15: expanding or not expanding) between chains and individual bakeries
- Production efficiency between chains and individual bakeries (Q5: daily production/Q4: number of employees)

5.9. Data Analysis

Details on the data analysis were provided for each research question. Particular attention was paid to the quantitative data analysis because of (a) the preponderance of quantitative data and (b) the greater intricacy of analytical details as applied to quantitative versus qualitative data analysis. All data analysis and graphs for the study were executed using Excel software.

Appendix 1 contains most of the raw data utilised in the study, as space forbids the inclusion of the entirety of the raw data.

5.9.1. RQ1 Data Analysis

To analyse the multiple criteria of sustainable bread, the qualitative Multi-Criteria Decision Analysis (MCDA) was selected. The MCDA is a transparent process that can be used either quantitatively or qualitatively (DiStefano & Krubiner, 2020) to show which criteria are prioritised by which stakeholders (or perspective) as explained in RQ1. MCDA can identify similarities and gaps with regard to different perspectives/stakeholders. The MCDA is a valid tool, and is suitable to improve decision making involving multiple criteria decisions such as those in RQ1.

5.9.2. RQ2 Data Analysis

For the quantitative portion of RQ2, the contribution of bakeries towards the SDGs, were scored with 0 or 1. The total score varied between 0 and 10 (parameters and scores are presented in Table 13). Lower scores indicated lower contribution and higher scores indicated higher contribution. Scoring systems are common in sustainability performance rating; a similar scoring example is used in SAFA framework (FAO, n.d.-c).

For the qualitative portion, the interview questions expanded the knowledge on the indicators by identifying the factors influencing their performance of bakeries in these areas. Both quantitative and qualitative data were used to answer RQ2, in the discussion section.

5.9.3. RQ3 Data Analysis

Analyses for RQ3 were based on differentiating between individual and chain bakeries. Each of the outcomes for RQ3 were treated as a Bernoulli trial (n.d.), which made it possible to apply logistic regression with odds ratio (*OR*) calculations. Logistic regression is a regression in which the outcome variable is dichotomous, that is, taking a value of either 0 or 1. Table 14 contains the independent and dependent variables for each of the questions examined as part of RQ3, combined with an interpretative framework.

In each of the logistic regressions for RQ3, the underlying question is whether there is an effect of bakery size (defined dichotomously, as being an individual bakery vs being a chain) on the outcome of interest. Because each of the outcomes of interest is also defined dichotomously, logistic regression is the right analytical approach to apply to these questions. The choice of an *OR* rather than a logistic regression coefficient is designed to make the findings more readily interpretable. As is clear from Table 14, the real-world interpretations of *ORs* are simple to communicate and do not lose any of the analytical power of logistic regression.

The data analysis strategy presented in Table 14 provides a means of comparing individual and chain bakeries on a wide variety of performance indicators. This comparison can, in turn, enable the identification of potential weak spots (for example, in the domain of perceived challenges) for individual bakeries that could contribute to the risk of business failure. These analyses can, in turn, complement analyses that arise from qualitative data to present a unified picture of the risk of individual small bakeries disappearing in the future.

Table 14 Analytical approach for RQ3 (created by the researcher)

Comparator Group	Independent Variable	Dependent Variable	<i>OR</i> Interpretation ($p = .10$)
Individual (= 1) vs Chain (= 0) bakeries	Implementing new technologies	(0 = not a challenge; 1 = a challenge)	<i>OR</i> > 1: Individual bakeries experience this challenge more than chains
Individual (= 1) vs Chain (= 0) bakeries	New and increasing regulations	(0 = not a challenge; 1 = a challenge)	<i>OR</i> > 1: Individual bakeries experience this challenge more than chains
Individual (= 1) vs Chain (= 0) bakeries	Sustainability requirements	(0 = not a challenge; 1 = a challenge)	<i>OR</i> > 1: Individual bakeries experience this challenge more than chains
Individual (= 1) vs Chain (= 0) bakeries	Rising production costs	(0 = not a challenge; 1 = a challenge)	<i>OR</i> > 1: Individual bakeries experience this challenge more than chains
Individual (= 1) vs Chain (= 0) bakeries	Taxes	(0 = not a challenge; 1 = a challenge)	<i>OR</i> > 1: Individual bakeries experience this challenge more than chains
Individual (= 1) vs Chain (= 0) bakeries	Finding skilled labour	(0 = not a challenge; 1 = a challenge)	<i>OR</i> > 1: Individual bakeries experience this challenge more than chains

Individual (= 1) vs Chain (= 0) bakeries	Changing consumer behaviour	(0 = not a challenge; 1 = a challenge)	<i>OR</i> > 1: Individual bakeries experience this challenge more than chains
Individual (= 1) vs Chain (= 0) bakeries	Competition	(0 = not a challenge; 1 = a challenge)	<i>OR</i> > 1: Individual bakeries experience this challenge more than chains
Individual (= 1) vs Chain (= 0) bakeries	Production trends	(0 = not increasing, 1 = increasing)	<i>OR</i> > 1: Individual bakeries are more likely than chains to increase production
Individual (= 1) vs Chain (= 0) bakeries	Expansion trends	(0 = not expanding, 1 = expanding)	<i>OR</i> > 1: Individual bakeries are more likely than chains to expand
Individual (= 1) vs Chain (= 0) bakeries	Food disposal	(0 = no food waste, 1 = food waste)	<i>OR</i> > 1: Individual bakeries are more likely than chains to dispose of food as waste

5.10. Ethical Procedures

All members were informed of their right to voluntary participation, informed consent, confidentiality, and anonymity. Before continuing with the questionnaire and/or agreeing to participate in an interview, all participants confirmed their understanding, agreement, and voluntary participation by affirmatively answering an initial question describing the study's procedures.

5.11. Chapter Summary

The purpose of this chapter was to describe and defend the research methodology and design of the study. It began by identifying the literature search, outcomes and knowledge gaps in regard to holistic approaches. It provided justification for the research design and approaches, particularly, the selection of the SDG framework and the methods of operationalising the SDGs to bakery level, by disclosing procedures and examples (the detailed process is provided in Chapter 6). It introduced the population and participants and explained the sampling strategy, data collection and data analyses.

6. Critical Evaluation and Operationalisation of the SDGs

6.1. Introduction

This chapter is an integral part of the methodology. It starts with an overview of the German sustainable development framework, to establish the context of sustainability assessment; the national framework is important as the bread system operates within it. It then critically evaluates the 17 SDGs to establish the assessment framework and identify the significant indicators suitable for this study. This chapter is important as it brings facts and figures about the areas identified within the SDGs, as well as secondary data regarding the food systems and bread in particular.

6.2. Germany's Sustainable Development Framework

Germany's sustainable development framework has been consistently refined for nearly two decades since the principle of sustainability was introduced to national policies, at which time The Federal Government adopted what is known as the National Sustainable Development Strategy (The Federal Government, 2002). The government's approach to offer its sustainability policy as guidance aimed to encourage nationwide initiatives and to persuade private sector companies to implement their own plans for sustainability.

In 2015, Germany and other world leaders adopted the 2030 Agenda for Sustainable Development, which included 17 SDGs. Germany adopted the same 17 SDGs as part of its own strategy, which are listed in their abbreviated titles as follows: 'No Poverty; Zero Hunger; Good Health and Well-Being; Quality Education; Gender Equality; Clean Water and Sanitation; Affordable and Clean Energy; Decent Work and Economic Growth; Industry, Innovation and Infrastructure; Reduced Inequalities; Sustainable Cities and Communities; Responsible Consumption and Production; Climate Action; Life below Water; Life on Land; Peace, Justice and Strong Institutions; Partnerships for the Goals'.

The Federal Government has set a series of targets and target values for the 17 SDGs to monitor progress in these areas. It has also developed an indicator system that depicts the indicator field type, the indicators of sustainability, the targets and their unique target values followed by the status of the country's progress.

A preliminary review of the 17 SDGs in 2015 led to the assumption that Goal 12, which relates to sustainable production and consumption, was the most significant one from which to contextualise bread sustainability in Germany. Research was being conducted to identify the

suitable framework and indicators; however, in 2021, the strategy update was released, and, for the first time, it introduced a new holistic approach to sustainable agriculture and food systems, associating them with SDGs 2, 3, 12 and 15. The strategy update linked agriculture to food systems and, eventually, the SDGs associated with them. Food sustainability involves both sustainable agriculture and a sustainable food system.

With that in mind, the 17 SDGs are critically evaluated to identify their significance for this study. The significant SDGs are operationalised to a bakery level.

6.2.1. SDG-1: ‘No Poverty’

The global SDG-1 aims to eradicate poverty through strong partnerships between developing and developed nations, and Germany is committed to this through its global partnerships. Globally, there are 689 million people (World Vision, n.d.) living on less than \$1.9 US per day; this is defined as extreme poverty. In Germany, however, extreme poverty does not exist; the official statistics show that 15% of the population is *at risk of poverty* with an average income of €14,109 (Destatis, n.d.). The only national indicator found in this goal is 1.1.a, b, in relation to material deprivation, which can potentially affect the affordability of consumers if they move towards the poverty line zone. Indicators within SDG1 have low significance in today’s context because poverty is not currently an issue in Germany. The main bread sustainability criteria associated with bread, with regard to poverty, is affordability.

6.2.2. SDG-2: ‘Zero Hunger’

The extended title of the second SDG is ‘End hunger, achieve food security and improved nutrition and promote sustainable agriculture’ (The Federal Government, 2016). The global SDG-2 aims to achieve both sustainable food production and food security at the same time; or in other words, a sustainable food security (Sonnino et al., 2014). Figure 8 presents the world hunger map in 2020 (World Food Programme, n.d.).

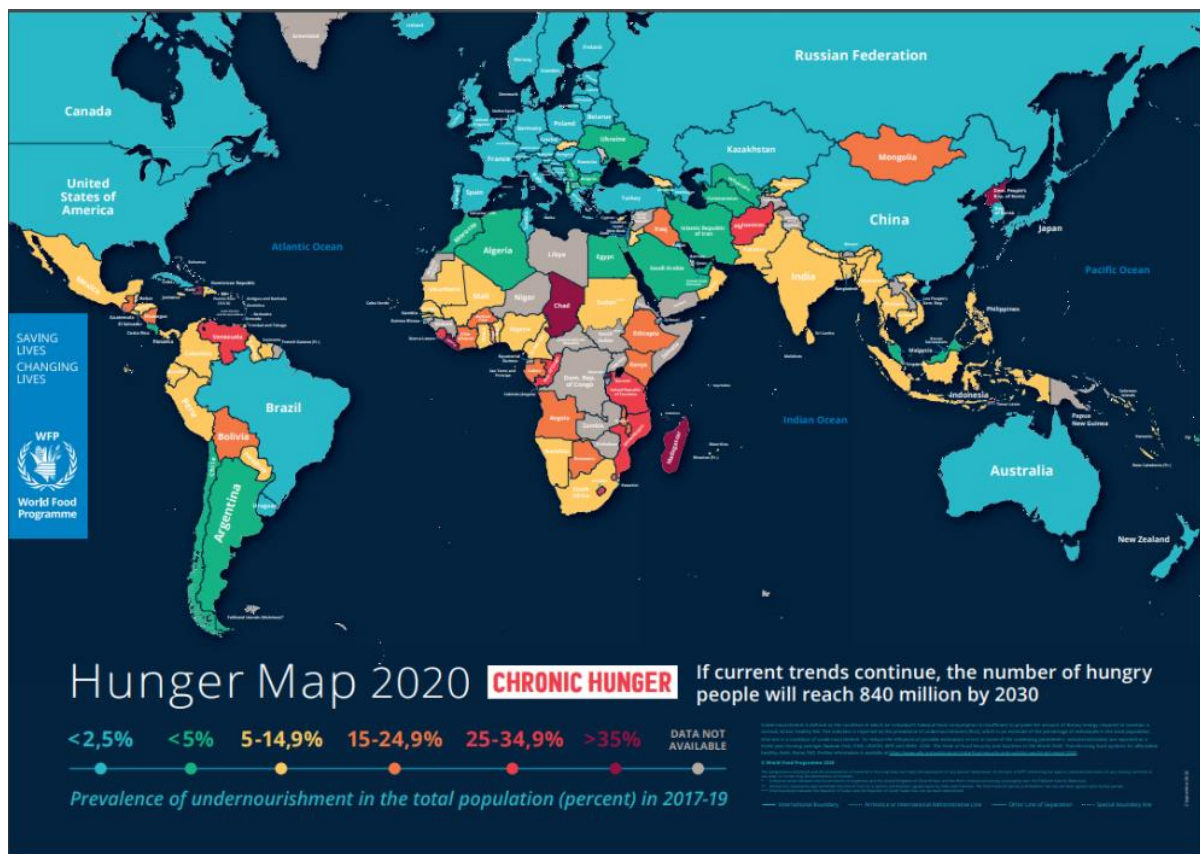


Figure 8 World Hunger Map in 2020 (World Food Programme, n.d.)

Germany is currently ranked 13th on the GFSI (The Economist Intelligence Unit, n.d.), and the national version of SDG-2 reflects this situation. It includes two target areas: ‘land management’ and ‘food security’. In land management, the target is to ‘produce in an environmentally friendly way in our cultivated landscapes’; the respective indicators are 2.1.a, ‘nitrogen surplus’ and 2.1.b, ‘organic farmed land share’. The targets values are a) to reduce nitrogen surplus to 70 kg per hectare of agricultural land; and b) to increase the organic farmed land share by 20%. The 2018 Indicator Report suggests that the five-year averages of nitrogen surplus from 2000 until 2016 fall between 110 and 97 kg per hectare, increasing to 102 kg in 2016 (Becker & Hoffmann, 2019). Similarly, the share of organic farmland was 6.8% in 2017, an increase of only 3.9% from 1999 and falling short of the 20% target for 2030 (Becker & Hoffmann, 2019). Regarding ‘food security’, the target is to ‘realise the right to food worldwide’, with one single indicator 2.2 ‘supporting good governance in achieving adequate nutrition worldwide’. The food security indicator does not cover Germany, although obesity rate is currently a national food security challenge.

With regard to sustainable land management, artisan bakeries’ main input from agriculture, is flour: it comes from grain crops farmed through either an organic or a conventional system as

discussed in Chapter 4. Bread, as a product, and considering its full lifecycle, has a nitrogen footprint. However, bakeries do not have a direct influence over the farming practices or use of nitrogen; they only influence the demand for grains/flours, and this influence is similarly driven by market demand and consumer preferences for organic versus conventional food consumption.

Therefore, to evaluate the potential contribution of bakeries to nitrogen surplus reduction and organic farmland expansion, this has to be seen as how bakeries promote either system as an intermediary. If holistic bread sustainability was assessed, then the bread's nitrogen footprint would be considered a significant factor. The significance of 'organic' is also addressed in indicator 12.1.a, in the context of sustainable consumption since the organic label is the only publicly managed label applicable to bread. The main criteria associated with bread sustainability in the context of land management is biodiversity.

In terms of facts and figures, 30% of Germany's land is covered by forests, 14% by settlement and infrastructure and 50% used for agriculture (Statistisches Bundesamt, 2019). Within agriculture, a large share of the land is used for grain crops (Figure 9).

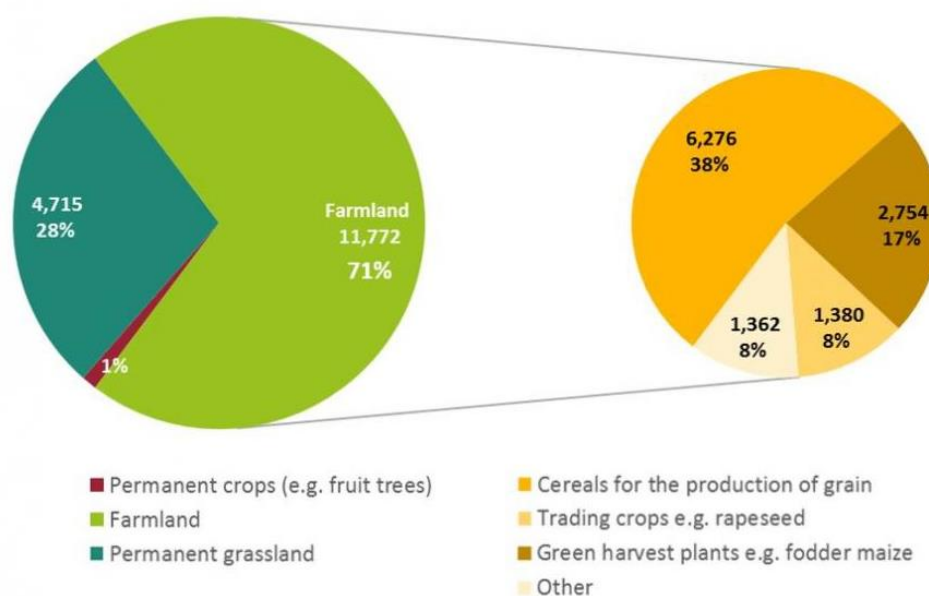


Figure 9 Land use in the agricultural sector (Statistisches Bundesamt, 2019)

Conventional farming provides a higher yield compared to organic farming; therefore, the shift from conventional to organic, which is targeted at 20% by the government, will have an impact on yields. Maintaining current grain output levels might then require additional farmland to compensate for the decrease. SDG-2 aims to maintain healthy biodiversity and is closely

related to SDG-3, which, in turn, aims to ensure a healthy population; both goals are intrinsically interconnected.

6.2.3. SDG-3: ‘Good Health and Well-being’

On a global level, this goal is one of the most detailed, with 28 indicators; it primarily measures health through indicators related to lifespan, smoking, and obesity (Federal Statistical Office - Destatis, n.d.). On a national level, SDG-3 includes seven indicators associated with food such as: 3.1.e and 3.1.f targeting obesity among children, adolescents and adults. The indicators related to obesity can be linked to food security, more specifically, the utilisation aspect, but this is not directly linked to bread. German bread is, generally, considered a healthy food, especially the multi-grain and full-grain varieties, which are rich in fibre, vitamins and minerals. Artisan bakeries contribute to people’s healthy diet by supplying a healthy, natural bread. Synthetic ingredients can negatively affect bread’s nutritional value (Chazelas et al., 2021). An additional indicator, 3.2.a ‘air pollutant emissions’, which is under the target ‘maintain healthy environment’, includes sulphur dioxide (SO₂), nitrogen oxides (NO_x), ammonia (NH₃), volatile organic compounds (NMVOC) and particulate matter (PM_{2.5}); however, these are not very significant to bread. SDG-3 is associated with SDG-2, as explained above; therefore, they are both significant to bread.

6.2.4. SDG-4: ‘Quality Education’

SDG-4, on both global and national levels, relates to quality education, and for this reason, is far from the context of bread production; therefore, it is considered of low significance to bread.

6.2.5. SDG-5: ‘Gender Equality’

Similarly, SDG-5, on both global and national levels, relates to gender equality, so its indicators are not significant to bread. If social and economic gender equality were significant national concerns, then the labour gender gap within the bread system would be an important factor. Indicators within SDG-5 have low significance to bread in the current context.

6.2.6. SDG-6: ‘Clean Water and Sanitation’

The global SDG-6 has 11 indicators targeting the availability and sustainable management of water (Federal Statistical Office - Destatis, n.d.). The national SDG-6 has two main indicator fields – ‘water quality’ and ‘drinking water and sanitation’ – both of which are not directly related to bread production. Water use in the context of resource efficiency is discussed in SDG-12. Indicators within SDG-6 have low significance to bread within the current context.

6.2.7. SDG-7: ‘Affordable and Clean Energy’

The global SDG-7 targets affordable and renewable energy with six indicators. On a national level, clean energy is a very important aspect of Germany’s National Sustainable Development Strategy (The Federal Government, 2002, 2018). The national SDG-7 has two targets: a) ‘use resources economically and efficiently’; and b) ‘expand sustainable energy supply’. The indicator of resource conservation has two indicators: 7.1.a ‘final energy productivity’ and 7.1.b ‘primary energy consumption’. The indicators for renewable energy are: 7.2.a ‘share of renewable energy’ and 7.2.b ‘share of renewable electricity’.

Regarding energy conservation target values, annual percentage rates of total energy productivity should increase by 2.1% for each year between 2008 and 2050, while total primary energy consumption decrease 20% by 2020 and 50% by 2050 in comparison to 2008 data. From 2008 to 2017, total energy productivity increased by 9.6% which equates to an average annual increase of only 1%, with productivity even falling by 0.9% in 2017 from the previous year (Becker & Hoffmann, 2019). Starting from an initial percentage of 100%, the target for productivity by 2050 is 239%, with the latest estimates being 109.6 in 2017 (Becker & Hoffmann, 2019). Starting from 100%, the 2020 target for energy consumption is 80% with 2017 data estimating 94.5%; experts believe the 2030 target will not be achieved if economic development continues at the same rate (Becker & Hoffmann, 2019). While bread might be linked to indicator 7.1.a,b, the impact of its contribution to the national target makes it insignificant.

Regarding the share of renewable energy sources – relative to total energy consumption – it should reach the target of an increase to 30% by 2030. Meanwhile, the share of renewable energies relative to total electricity consumption – that is, the percentage rate at which renewable energy sources generate electricity – is currently above target.

Affordable and clean energy relate to sustainable bread, and the energy factor is discussed within indicator 12.1.b, with the baking being the most energy intense phase in the entire bread system (and bread lifecycle). Indicators 7.2.a ‘share of renewable energies in gross final energy consumption’, and 7.2.b ‘share of electricity from renewable energy sources in electricity consumption’ both relate to bread. Bakeries’ potential contribution to indicators 7.2.a and 7.2.b can be seen as the share of their renewable energies, which include renewable electricity and wood (Sreevani, 2018) (based on the assumption that it comes from sustainably managed sources). However, given the national energy profile and low contribution of bakeries (less

than 1%) to national energy consumption, the significance of renewable energy does not appear to be highly influential in terms of achieving the targets; yet, they do contribute. Indicators within SDG-7 are significant to bread.

6.2.8. SDG-8: ‘Decent Work and Economic Growth’

The global SDG-8 has 16 indicators mainly targeting the economic growth as an essential prerequisite to achieve a global sustainable development (Federal Statistical Office - Destatis, n.d.). The national SDG-8 includes six targets related to: a) resource conservation; b) national debt; c) economic provision for the future; d) economic efficiency; e) employment; and f) global supply chain. Resource conservation, economic efficiency and employment can potentially relate to bread. Regarding the economic efficiency, the indicator is ‘gross domestic product per inhabitant’ (GDP/inhabitant). The contribution of overall bread production in Germany is estimated around €15 bn (Statista, n.d.-a), which is less than 0.04%; therefore, it is not very impactful. Alternatively, the economic contribution of bakeries must be assessed within the context of local economies, especially in rural areas and villages; however, this aspect is not covered by this indicator. Regarding employment, indicator 8.5.a,b is ‘employment rate’ with regard to age groups, which is another area only significant on a national level. The potential link to the bread system and bakeries can be associated with the employment of skilled labour, particularly bakers. The entire bread system is a major contributor to employment, especially artisan bakeries, which, alone, employ around 250,000 people. The increasing automation of production in artisan bakeries can potentially lead to less human labour and more machine output; a factor that can be explored through labour intensity with regard to output levels.

Regarding resource efficiency, the target is to ‘use resources economically and efficiently’, and the indicator is 8.1 ‘total raw material input productivity’. On a national level, this indicator relates to the value of goods (in Euros) in relation to the mass of raw materials used for their production (including biotic and abiotic materials). In the context of bread, this can be translated as the value of bread in relation to all raw material input used across the bread life cycle. The bakery’s contribution to this can be seen as its productivity in regard to input and output; in the context of resource efficiency, this can be translated as the ratio of wasted bread with regard to the input of raw materials. Although this can be interpreted through monetary and economic value, it is more significant to focus on the volume since bread waste also has an ethical dimension. A high waste ratio can, therefore, indicate poor resource efficiency

productivity, while a low waste ratio can indicate more efficient productivity. Although the waste factor is highly important with regard to food sustainability, the economic context of SDG-8 makes this factor less important as it is considered from an economic perspective. Resource efficiency is also reflected in indicator 12.1.b, but from a consumption impact perspective. Therefore, two indicators within Goal 8 are significant to bread.

6.2.9. SDG-9: ‘Industry, Innovation and Infrastructure’

The global SDG-9 aims to achieve a resilient infrastructure and sustainable industrialisation through innovation, it includes 12 indicators (Federal Statistical Office - Destatis, n.d.). The national SDG-9 has one target: ‘shaping the future sustainably with new solutions’, and two indicators: 9.1.a ‘public and private spending’ and 9.1.b ‘broadband expansion’. Neither of the indicators relate to bread; however, when discussing industry innovation in relation to sustainable future, it might be significant to investigate how innovation within the baking sector is helping bakeries progress towards sustainability. Indicators within Goal 9 have low significance to bread in the current context.

6.2.10. SDG-10: ‘Reduced Inequalities’

The global SDG-10 aims to reduce inequalities within and between countries, it includes 14 indicators. The national SDG-10 includes two targets: ‘improve educational success of foreigners in Germany’, and ‘prevent excessive inequality in Germany’, both not related to bread. Indicators within Goal 10 have low significance to bread in the current context.

6.2.11. SDG-11: ‘Sustainable Cities and Communities’

The global SDG-11 targets housing, transportation, urbanisation, cultural and natural heritage, and the quality of life in cities and communities, it includes 14 indicators (Federal Statistical Office - Destatis, n.d.). National SDG-11 targets land use, mobility (transport), housing and cultural heritage. Land use, mobility and cultural heritage appear to be related to bread.

Regarding land use, the target is to ‘use space sustainably’ and includes three indicators: 11.1.a ‘increase in settlement and transport area’, 11.1.b ‘loss of free space’, and 11.1.c ‘settlement density’. In the context of sustainable cities, none of these indicators seem to be significant to bread.

Regarding mobility, the target is to ‘secure mobility – protect the environment’, with three indicators: 11.2.a, ‘final energy consumption in goods transport’; 11.2.b, ‘final energy consumption in passenger transport’; and 11.2.c ‘central and regional centres that can be

reached by public transport'. Indicators 11.2.b and 11.2.c do not relate to bread production, while 11.2.a appears to be related. The target for 11.2.a is to reduce the final energy consumption in goods transport by between 15 and 20% compared to 2005 levels. Data shows that the only time the energy consumption decreased was in 2009; the latest record was 106.2% in 2018, while the target is to lower it to 85% in 2030. This target seems to be difficult to achieve given the current trend. Transportation within the bread system occurs at several stages: a) transport from farm to mill; b) mill to bakery; and c) transport within the bakery branches (in the case of chain bakeries). Bakeries have no influence on transportation between farm and mill, but they directly influence the transportation distance from mill to bakery by selecting distant versus closer mills/suppliers, and the frequency of their orders. Energy consumption for procurement represents a small portion of total energy consumed per every 1 kg of bread. The transportation within chains (between branches), is the third area in which energy is used for goods transportation, and it can also be seen in the same context. However, it is sometimes argued by bakeries that producing in one location and distributing to branches can be more energy efficient because bakeries save baking energy by optimising the baking process, saving a more significant amount of energy exceeding that of transport. Therefore, bakeries' potential contribution to indicator 11.2.a can be assessed through the transportation distance between mill and bakery, as the other aspects can be assessed on a case-by-case basis.

Regarding heritage, the target is to 'improve access to cultural heritage' and the indicator is 11.4 'number of objects in the German Digital Library'. The target of this indicator is 50 million objects, while the latest data show 33 million in 2020 (Federal Statistical Office - Destatis, n.d.). While the topic of heritage is, in principle, highly significant to bread, indicator 11.4 does not provide a meaningful framework. The significance of bread heritage in the context of sustainability is alternatively discussed using UNESCO's conservation framework. Indicator 11.2.a appears to be the only significant aspect in this goal. Therefore, one indicator within Goal 11 is significant to bread.

6.2.12. SDG-12: 'Responsible Consumption and Production'

SDG-12 will be discussed in detail because it is very important for the context of this study.

Overview of SDG-12

The global SDG-12 includes 11 targets, and 13 indicators focusing on reducing food waste and making production and consumption more sustainable; its German equivalent includes only three targets and four indicators, which are focused on: production and consumption, including

ecolabelling; global environmental impact from consumption; reporting; and responsible procurement. The patterns for SDG-12, global versus national, represent two disparate contexts with different priorities. The global target is concerned with ensuring a sustainable food supply to feed the world population by reducing waste and making production and consumption more sustainable, while the national counterpart focuses on aligning consumption and production with the national environmental plans; this evaluation will focus on the national context.

In principle, the national SDG-12 prioritises the satisfaction of ‘justified’ needs of current and future generations. At the same time, it aims to achieve the necessary changes to ways of life and business (Federal Statistical Office - Destatis, n.d.), with the hope of making the satisfaction of needs (i.e. consumption) more sustainable.

The next three sections will examine the national context of each indicator field, assess the available secondary data (i.e. facts and figures) and evaluate the potential links to bread and bakeries.

Sustainable Consumption: Indicators 12.1.a and 12.1.b

Indicator 12.1.a is ‘market share of products certified by publicly managed ecolabelling schemes’. The target for 2030 was set at 34%. There are more than 37 nationally endorsed ecolabels directly applied to food products in Germany, some of which apply to bread (GIZ GmbH, n.d.). However, not all of these labels are accepted under this indicator; publicly managed labels are the only ones considered for the measurement of this indicator by the government. The main reason for this is the lack of data regarding other labels (Federal Statistical Office - Destatis, n.d.). The four publicly managed ecolabels under this indicator include: ‘EU ecolabel’, ‘EU Organic label’, the ‘Blue Angel’ and the respective, highest class ‘EU energy label’. The energy label addresses energy consumption and GHG emissions, while the other ecolabels address environmental pollution. To summarise, indicator 12.1.a aims to monitor how eco-friendly products are replacing conventional ones. Among the selected labels counted under this indicator, the EU ecolabel is not applicable to food products, including bread (Sengstschmid et al., 2011). Although it covers thousands of other products, some of which might be used by bakeries, such as cleaning materials, they are not significant to bread in the context of this study. The Blue Angel label is also applicable to a range of products, but not directly to food nor bread (Umweltbundesamt, n.d.). The highest-class EU energy label mostly applies to domestic and household equipment (The European Commission, n.d.), but not to trade equipment commonly used in bakeries, such as commercial ovens through which

production energy is mostly consumed. The EU Organic label is applicable to grains/flours and other ingredients used by bakeries, as well as to breads and other baked goods produced by bakeries. To add the organic label to their breads, bakeries must undergo a strict certification process (The Council of the European Union, 2007); therefore, bakeries directly contribute to indicator 12.1.a through the production of breads bearing the EU Organic label. The potential contribution of the bakeries towards the 34% national target for 2030 can be considered as the share of organic eco-labelled breads within total national production; the latest secondary data show that this is 8.6% (Statista, n.d.-b). To successfully contribute to the national target for indicator 12.1.a, organic bread production should reach 34% by 2030. This is substantial progress given the latest data. Using the secondary data, the national bread production volume of 5 million tonnes per year means that the organic bread production volume can be estimated at around 430,000 tonnes per year. However, the share from artisan bakeries is unknown. It is important here to note that, although the type of flour (organic versus conventional) does not have a direct effect on the functions of the bread production system (i.e. preparation and baking), the certification itself implies strict measures to the management of the production system to ensure the regulation standards are being implemented. This process usually leads bakeries to fully convert to organic instead of developing two production lines. The reasons why bakeries decide to produce organic bread, and whether there are additional challenges associated with the certification process, are unknown and must be investigated in this study.

Indicator 12.1.b falls within the same target as 12.1.a, ‘making consumption environmentally and socially sustainable’; however, both indicators appear not to directly relate to social aspects as discussed in previous sections, they both have an environmental dimension in this case. Indicator 12.1.b, ‘global environmental impact from consumption by private households’, is influenced by three factors. For the purpose of clarity, these will be described as sub-indicators. Therefore, 12.1.b involves three sub-indicators: a) domestic and foreign energy consumption; b) CO₂ emissions; and c) use of raw materials in connection to production and consumption of goods destined for household consumption (Federal Statistical Office - Destatis, n.d.). Germany’s target within indicator 12.1.b is to ‘continuously reduce’ – without a quantitative target – the impacts of consumption by private households, with the levels of 2010 being a baseline for comparison.

First, the energy consumption (Figure 10) of the 41 million households in Germany is around 26% of the total energy consumption (Deutsche Energie Agentur, n.d.); the industry, trade and services consume around 42%. From this share, only 5.6% is used for food products

(Statistisches Bundesamt, 2020). Therefore, the share of energy consumption for food products from the total energy consumption in Germany is 2.3%, but the specific share of bakeries in this percentage is unknown. Moreover, secondary data revealed that 1 kg of bread consumes 16.1 MJ on average (Monforti-Ferrario et al., 2015). Using this data, the estimated energy consumption for the 2.75 MT of bread produced via bakeries (Appunn, Haas, & Wettengel, 2020), is around 44 TJ (equal to 1.8% of total household consumption, or 0.4% of total national consumption). Bakeries contribute to nearly two-thirds of the energy consumption of the bread life cycle, specifically during the baking phase in the process of heat generation. Therefore, bakeries' estimated contribution equal to 1.2% of household consumption, or 0.26% of total consumption. Reducing the energy footprint of bread will, eventually, lead to reducing the impact of consumption.

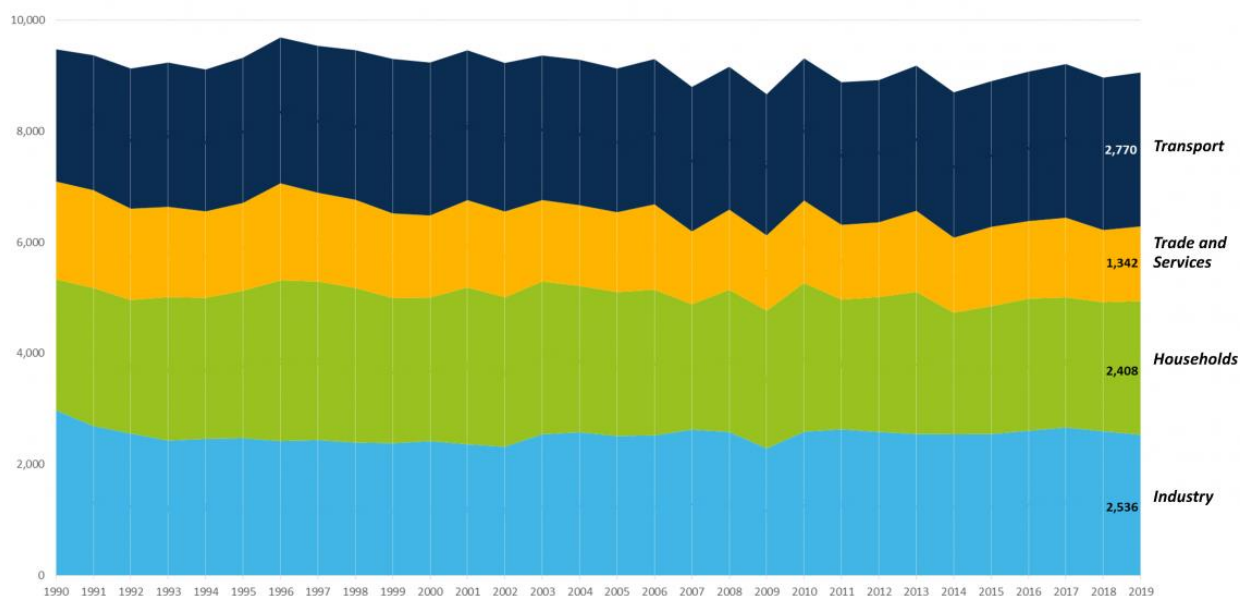


Figure 10 Final energy consumption (in petajoule) by consumer group (Deutsche Energie Agentur, n.d.)

Indicator 12.1.b does not specify a quantitative target, but rather a descriptive trend of 'continuously lower' energy consumption compared to 2010 levels; therefore, the potential contribution of bakeries towards the reduction of energy consumption can be considered as their reduction measures during the last 10 years. The efficiency of the measures can only be investigated on a case-by-case basis.

Another sub-indicator of 12.1.b are CO₂ emissions. In 2020, CO₂ emissions in Germany recorded around 739 million tonnes (Monforti-Ferrario et al., 2015). Food production, including its farming, transportation and processing stages, contributed to the total emissions. The food industry, which includes bakeries as a sector, produced around 23% of total emissions; however, the specific share of bakeries is unknown. CO₂ emissions occur in several areas within the bread system, including: a) emissions caused by baking (heat generation) using fossil fuels, natural gas, wood or via the consumption of conventional electricity; b) emissions caused by transportation (mainly within chain bakeries); and c) emissions caused by the general energy consumption within the bakery (i.e. equipment, lighting, etc.). Research about bread emissions in the EU shows that every 1 kg of bread is responsible for emissions of around 1.3 kg of CO₂-eq (Espinoza-Orias, Stichnothe, & Azapagic, 2011); almost half of that is generated during the farming stage (Espinoza-Orias et al., 2011; Goucher, Bruce, Cameron, Lenny Koh, & Horton, 2017), a quarter from consumption (Espinoza-Orias et al., 2011), and around a quarter from bread production (i.e. bakeries). Therefore, in this scenario, bakeries contribute by approximately 0.3 kg of CO₂-eq per every 1 kg of bread. However, another study was conducted in Germany (Baumgardt & Schmidt, n.d.) and revealed that 1 kg of bread produces 2.5 kg of CO₂-eq, which is nearly double of that in the previous study. According to the German study, around 7% of emissions come from the bakery (nearly 175g CO₂-eq per 1 kg of bread). Using the data of Baumgardt and Schmidt (n.d.), CO₂ emissions caused by the 2.75 MT bread produced in bakeries (full bread lifecycle) is estimated at around 6.8 million tonnes (0.8% of industry emissions), of which 0.48 million tonnes (0.06% of total emissions) is a direct contribution by bakeries. Using data from the EU study, these figures might increase up to 30%. Emissions caused by bakeries come mainly from their energy consumption; therefore, their energy reduction measures in the last 10 years can be investigated as CO₂ reduction measures.

The third sub-indicator of 12.1.b is the reduction in the use of raw materials in connection to production and consumption; this includes renewable resources and abiotic raw materials such as energy sources (which is addressed in the first two sub-indicators). Reduction in the use of raw materials in the context of bread production includes bread ingredients, energy sources and packaging. While the reduction in bread ingredients as raw materials (mainly flour, and sometimes other ingredients according to bread type) does not seem to be significant because it is based on recipes and cannot be altered, the reduction in energy sources and packaging can be considered significant. Energy reduction is covered by the first two sub-indicators (energy

consumption and CO₂ emissions); therefore, the main remaining raw material connected to production and consumption under this sub-indicator is the packaging material. In bakeries, bread is almost always sold using paper bags; other scenarios include plastic bags or no packaging at all. To understand the context of packaging and its environmental impact: Germany produced 18.7 million tonnes of packaging waste in 2017 (DW, 2019), around 43% is made of paper and cardboard (Umweltbundesamt, 2020). In 2019, the recycling of paper was above 70%, one of the highest recycling rates among other categories, compared to plastic at around 36% (Umweltbundesamt, 2020). Germany's new Packaging Ordinance and the Packaging Act aim to reach 90% in paper recycling, and 63% in plastic from 2022 (Umweltbundesamt, 2020). Environmentally speaking, paper's impact is lower than plastic, and its high recycling ratio makes it an eco-friendlier option in Germany; therefore, in terms of environmental impact, ranging from the best scenario to the worst, the order becomes: no packaging, then paper then plastic. The potential contribution of bakeries under this sub-indicator, within the environmental impact area, can, therefore, be considered as the reduction of the environmental impact through the use of eco-friendlier packaging, according to the scenarios identified herein.

As a reflection on the sustainable consumption target and its two indicators, sustainable consumption has been clearly prioritised in Goal 12, and two out of the four indicators in this goal were allocated to this target. The national sustainable consumption strategy focuses on reducing consumption and/or improving consumption decisions by informing consumers about the impact of products on the environment; this, according to the strategy, can be achieved through the use of so-called ecolabels. Ecolabels are expected to increase consumers' awareness and help them make better, environmentally aware buying decisions. The other area of the target is the reduction of the global environmental impact caused by household consumption, which includes three main factors: energy consumption, CO₂ emissions and the reduction in the use of raw materials. This indicator is also reflected in Goal 8 as per the indicator description (Federal Statistical Office - Destatis, n.d.). It can be noted here that food waste, as a consumption challenge, was not covered by any of the two sustainable consumption indicators, although the largest share of waste occurs at household level (Schmidt, Schneider, & Claupein, 2019). Another gap in the sustainable consumption indicators is the absence of nutritional factors. Although a healthier diet to tackle national obesity was identified repeatedly as a challenge within the indicator reports, it was only addressed within SDG2 (Becker & Theis, 2017; Becker & Hoffmann, 2019; Federal Statistical Office, 2014).

Sustainable Production: Indicator 12.2

Indicator 12.2, EMAS, refers to the area of responsible production, with the target of ‘increasing the proportion of sustainable production’. Within SDG-12, sustainable production is simply reduced to one single indicator, EMAS registration, which basically represents a voluntary environmental plan that can be initiated by the business and verified by an External Environmental Verifier (European Commission, 2021).

It is first important to understand the EMAS scheme and evaluate how it can help businesses achieve environmental sustainability. The EMAS (European Commission, 2021), is a voluntary environmental management tool created by the European Commission in 1993 to help organisations manage and develop their environmental performance.

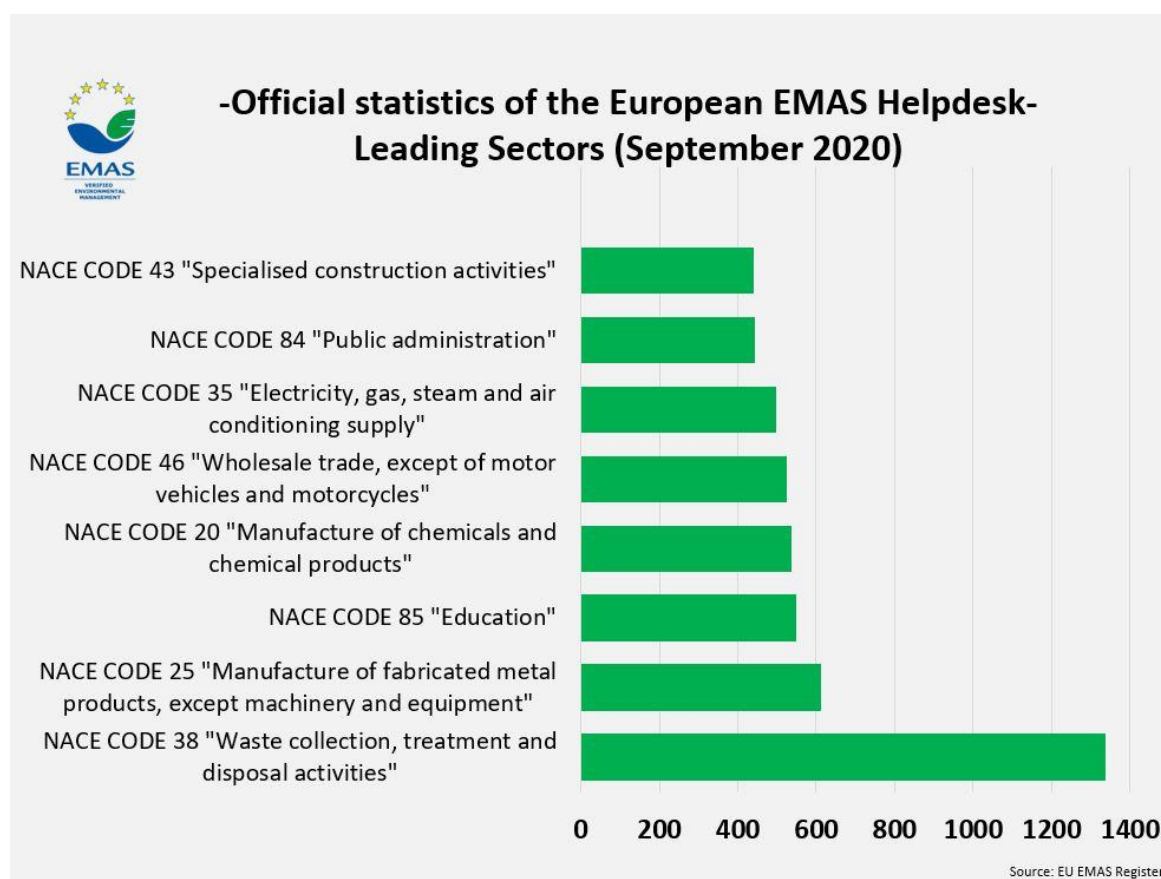


Figure 11 EMAS leading sectors (EU EMAS Register)

EMAS registrations are mainly dominated by leading industrial and manufacturing sectors (Figure 11). Germany was among the top countries within Europe to achieve a high number of EMAS registrations. The actual number of EMAS registrations from the food sector represents around 4.6% of the total number of registrations (Dri et al., 2018), including all types of food companies without specifying the number of bakeries within. The EMAS indicator is, in

principle, highly important because it is the only indicator on the agenda related to sustainable production, and it represents an important, transparent environmental management tool for any production system. The EMAS scheme is designed to systemise how companies align their environmental performance with national standards (Figure 12) (European Commission, 2021). However, this framework is mainly designed for large companies, and might not be suitable for small businesses such as artisan bakeries. It can be argued here that businesses might be promoting sustainability in practice, but not via the EMAS framework; this brings up the following questions: is environmental reporting, specifically, or sustainability reporting, in general, the best indicator of a sustainable production? How do bakeries obtain information on sustainability in the first place? How do they perceive reporting? What are the sustainability areas promoted by bakeries from outside of the EMAS framework?



Figure 12 EMAS registration process (European Commission, 2021)

To understand the reporting context, it is essential to explore the sustainability governance framework Germany, as presented in Figure 13 (The Federal Government, 2018).

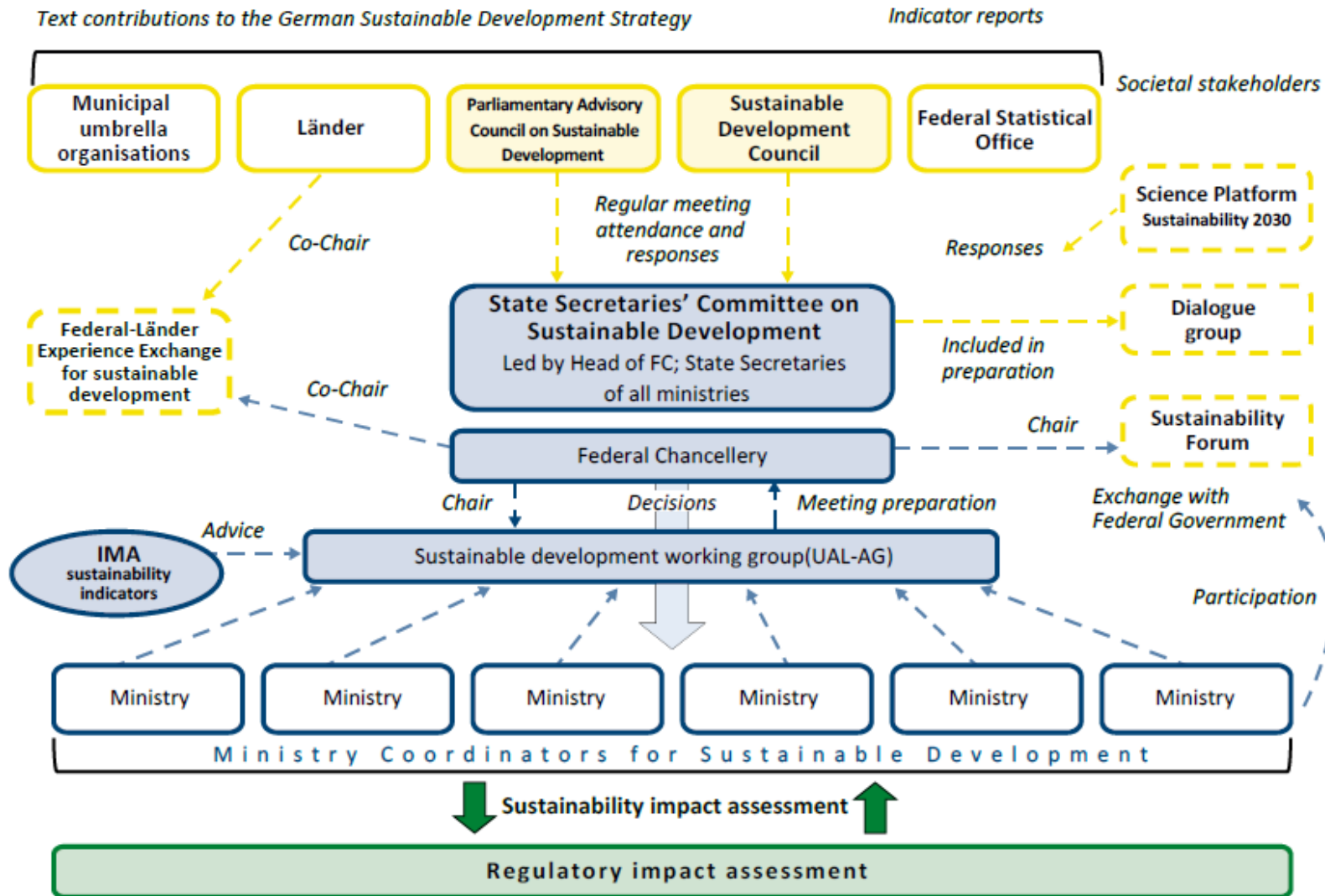


Figure 13 Sustainability Management System in Germany (The Federal Government, 2018)

As a policy, sustainability in Germany is the responsibility of the Chancellery (German Council for Sustainable Development, n.d.). The ministries are responsible for the implementation of the National Sustainable Development Strategy in coordination with the State (Länder) and local authorities as they possess legislative and administrative powers (The Federal Government, 2018). Private sector stakeholders also play certain roles in addition to other societal and political stakeholders. The Chambers of Crafts in Germany, as important stakeholders, actively participate in promoting sustainability within their areas and continuously provide information and support to their members. One of the 53 Chambers of Crafts in Germany (ZDH, n.d.) is the Central Association of the German Bakery Trade, which represents the artisan baking sector. Therefore, the sustainability policy, which starts at Chancellery level, is disseminated to artisan bakeries in the form of information and guidelines. However, the way artisan bakeries perceive sustainability, and the effectiveness of the governance system from the bakeries side, is unknown; this study will also shed light on this area.

Responsible Procurement: Indicator 12.3

Indicator 12.3 (the newly added one), ‘responsible procurement’, aims to monitor and achieve a sustainable procurement for the public sector; two indicators are used for the purpose of illustrating (as examples) how to measure progress within two areas (CO₂ emissions and papers with the Blue Angel label). The strategy acknowledges that it is difficult to limit sustainability aspects to one or few indicators, and that it is preferred here to focus on product-specific indicators (Becker & Hoffmann, 2019). While the topic of responsible procurement might relate to bread production, there is no potential contribution from artisan bakeries to achieving this (public sector) target and it seems insignificant to evaluate how this can be done.

Overall, SDG-12 is significant and three indicators are related to bread.

6.2.13. SDG-13: ‘Climate Action’

Goal 13 aims to combat climate change through immediate actions. The global SDG-13 targets resilience, education and institutionalisation funding, and the promotion of actions; it has eight indicators (Federal Statistical Office - Destatis, n.d.). The national SDG-13, however, has two targets: a) ‘reduce greenhouse gases’, with one indicator, 13.1.a ‘GHG emissions’; and b) ‘contribution to international climate finance’, with one indicator, 13.1.b ‘international climate finance’. While indicator 13.1.a appears to relate to bread production, indicator 13.1.b does not. The target for indicator 13.1.a is to reduce GHG emissions to 45% by 2030 and 0% by

2050 compared to 1990 (baseline). The latest data reveal that GHG emissions in Germany declined by more than 40% between 1990 and 2020 (Umweltbundesamt, 2021). Based on the indicator, GHG emissions include carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), sulphur hexafluoride (SF₆), nitrogen trifluoride (NF₃), partially halogenated fluorocarbons (HFC/HFC) and perfluorocarbons (HFC/PFC). Emissions related to bread occur at several stages of the value chain; however, they mainly consist of CO₂ emissions. This indicator is also reflected in indicator 12.1.b under SDG-12. Potential contribution of bakeries to this indicator can be considered the same way as in indicator 12.1.b: energy efficiency measures taken by bakeries, as energy is the main source of emissions. Therefore, one indicator within SDG-13 has significance to bread, but is reflected within 12.1.b.

6.2.14. SDG-14: ‘Life Below Water’

The global SDG-14 aims to conserve and sustainably use the oceans, seas and marine resources, it includes 10 indicators. The national SDG-14 has one target: ‘protect seas and marine resources and use them sustainably’, and two indicators: 14.1.a ‘measuring nitrogen input to the Baltic Sea and North through German inflows’, and 14.1.b ‘measuring the proportion of sustainable fish stocks in the Baltic Sea and North’. SDG-14 is not related to bread; therefore, indicators within SDG-14 have low significance.

6.2.15. SDG-15: ‘Life on Land’

The global SDG-15 aims to protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and end reverse land degradation and loss of biodiversity. It has 14 indicators (Federal Statistical Office - Destatis, n.d.). The national SDG-15 has three targets: a) ‘preserving species – protecting habitats’; b) ‘protect ecosystems, maintain ecosystem services and preserve habitats’; and c) ‘avoid deforestation worldwide and protect soils’. None of the three targets are directly related to bread, although biodiversity is impacted by agricultural activities of the bread system. Moreover, the policy perspective associates SDG15 with food systems with regard to biodiversity; the same dimension is reflected in 2.1.b under SDG2 or organic farming. Therefore, one indicator within SDG-15 has a significance for bread, but is also reflected in SDG2.

6.2.16. SDG-16: ‘Peace, Justice, and Strong Institutions’

The global SDG-16 aims to promote peaceful societies, justice, and inclusive institutions; it has 24 indicators (Federal Statistical Office - Destatis, n.d.). The national SDG-16 targets crime, peace and security and good governance. SDG-16 is more politically oriented and is not, therefore, directly related to bread production. Indicators within SDG-16 have low significance to bread.

6.2.17. SDG-17: ‘Partnerships for the Goals’

The global SDG-17 aims to strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development; it has 24 indicators (Federal Statistical Office - Destatis, n.d.). The national SDG-17 has three targets with three indicators related to international cooperation, which do not relate to bread production. Indicators within SDG-17 have no significance.

6.3. SDGs Dimensions Associated with Bakeries

6.3.1. The Environmental Dimension

The first dimension to synthesise is environmental, including the efficient use of energy and natural resources, and food waste. To understand the energy context (also discussed within indicator 12.1.b), it is important to examine Germany’s national energy profile (Figure 14) (Wettengel, 2020).

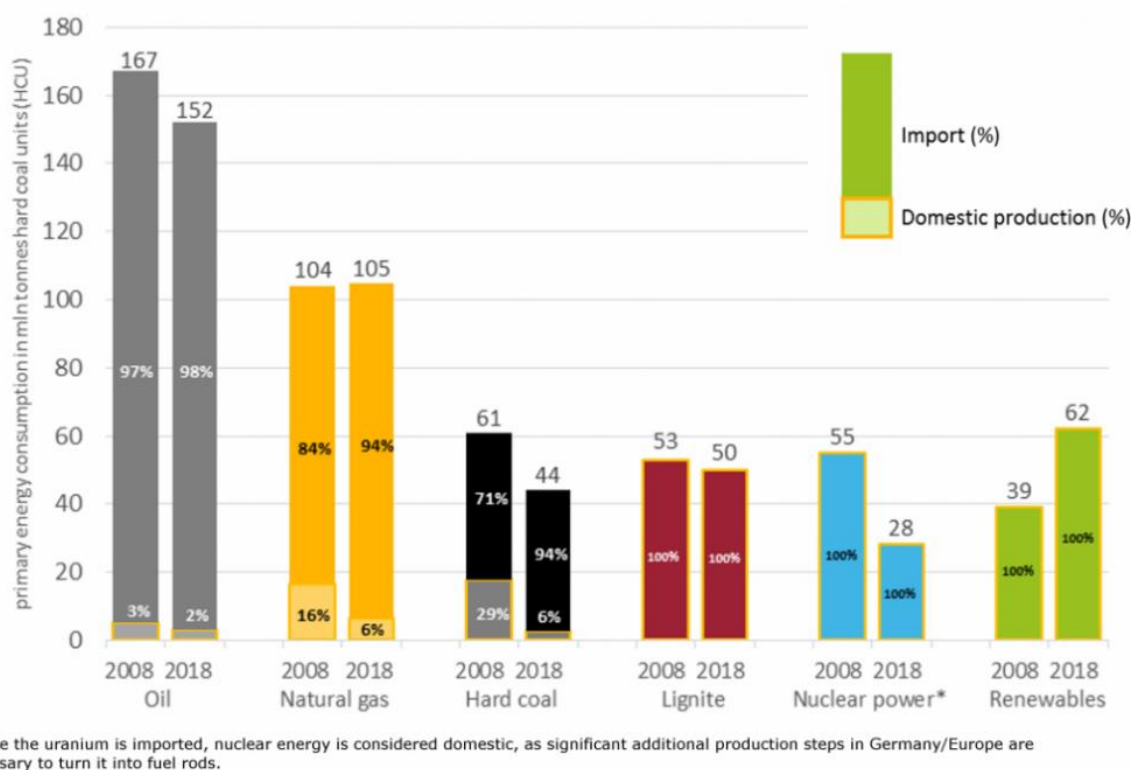


Figure 14 Germany's import dependency by primary energy source (Wettengel, 2020)

Germany is highly dependent on energy imports (around 60%), including oil, natural gas and hard coal, while lignite, nuclear and renewable energy are domestically produced. Increasing domestic production of renewable energies will help lower dependency on imports and decrease emissions, a main target of the National Sustainable Development Strategy (The Federal Government, 2002, 2018). Energy consumption in Germany is distributed among several sectors; the industry makes up to 35% of it and food production's share is around 5% (Bajan, Mrówczyńska-Kamińska, & Poczta, 2020). Artisan bakeries represent a fraction of the food sector, which makes them consumers of an estimated less than 1% of the total energy. The energy used in the food sector is generated from 72% fossil fuel, 15% renewable and 13% nuclear (Monforti-Ferrario et al., 2015); although these are EU averages, the German patterns are very similar. Nevertheless, bakeries consume oil products and natural gas in ovens operating on these energy types, and both are almost fully imported. Therefore, although bakeries' contribution to national energy consumption is very small, the decarbonisation strategy and plans to shift to renewable energy sources means their energy consumption patterns are not in line with the national sustainability strategy. To gain further insight into the energy consumption of bread compared to other food products, a comparison of the energy footprint is illustrated in Figure 15. It shows that bread remains one of the lowest energy

consuming foods, with coffee as an outlier and butter, cheese, beef and prepared meals in leading positions (Monforti-Ferrario et al., 2015).

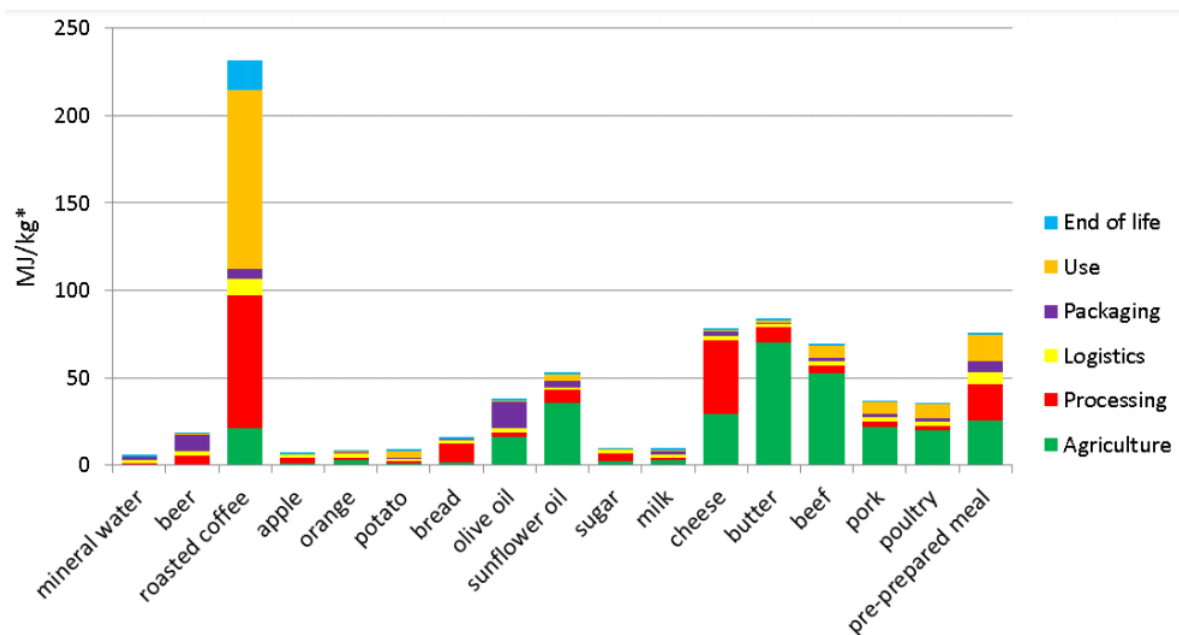


Figure 15 Energy consumption per food product (Monforti-Ferrario et al., 2015)

Energy consumption within the bread life cycle is illustrated in Figure 16. Baking bread requires the highest processing (baking) energy compared to other food types, with almost two-thirds of its total energy footprint linked to baking. Common energy sources used in baking include electricity (conventional or renewable), fossil fuel, natural gas and wood. Therefore, energy consumption is a highly significant aspect of bakeries' sustainability.

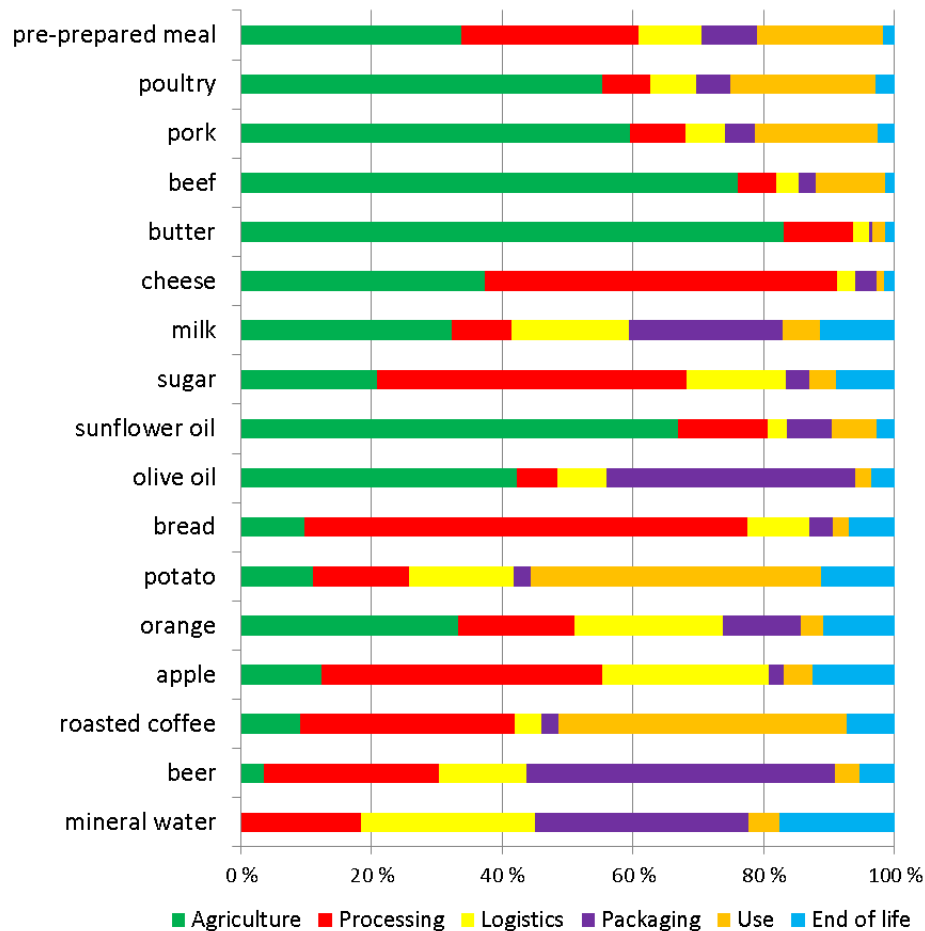


Figure 16 Shares of energy embedded along production steps of a kg of product (Monforti-Ferrario et al., 2015)

Therefore, current energy consumption patterns in artisan bakeries (specifically for baking), and their transition towards renewable energy sources, must be investigated to understand their performance in this regard; energy efficiency measures are reflected in indicator 12.1.b). The challenges bakeries face in shifting to renewable energy sources must be investigated.

In addition to energy, water is an important natural resource related to bread production. Water efficiency, in the context of bread sustainability, must be examined from global versus national perspectives to understand how its significance dramatically changes according to geographical contexts.

Water on our planet comprises 97% saltwater, 2% frozen and 1% freshwater, and most countries struggle to satisfy their freshwater needs (United Nations Association – UK, n.d.). Of the 1% freshwater available, 72% is used for agriculture (mainly to produce human food), 16% is used by households and 12% by industries. On a global level, the problem with water

is that it is, generally, a scarce resource, and drinking water, in particular, is not accessible to all people; drinking water is a main ingredient of bread. Therefore, if water scarcity is a concern, it then becomes highly significant for bread sustainability. Figure 17 illustrates the water footprint of a selection of food products (Statista, 2017).

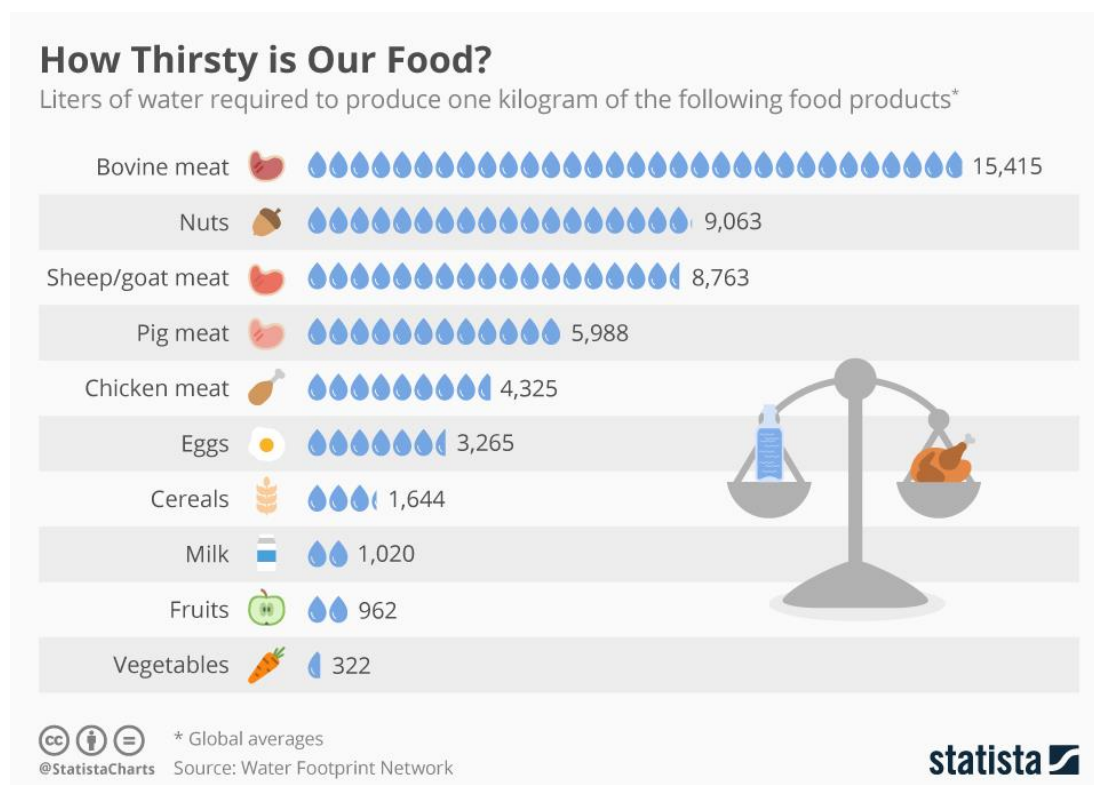


Figure 17 Water footprint of food (Statista, 2017)

The production of 1 kg of beef requires 15,415 litres of water compared to 1,644 litres for 1 kg of cereals (including wheat and other crops used for bread production). The water footprint of animal food products is much higher compared to plant-based ones, hence the recent trends to promote plant-based food products (i.e. vegetarianism and veganism) (The Vegetarian Resource Group, n.d.). In principle, the water footprint of bread is low compared to other foods, making bread a more sustainable food choice when water scarcity is a concern. Therefore, from a sustainability perspective, the significance of water efficiency strictly depends on the abundance of water as a natural resource. Moreover, the water factor is always interconnected to, and interrelated with, other factors such as land use, deforestation and other environmental aspects.

In Germany, the context is different and water supply is secure and expected to remain this way for the near future (The Federal Government, 2008); therefore, water efficiency does not

seem to be a significant factor of bread sustainability in Germany. Regarding other natural resources used in bread production, such as spices, seeds, nuts, dried fruits etc., these will not be investigated because they represent less than 1% of the bread production volume and do not have a great overall impact.

6.3.2. Waste

The topic of food waste is another significant factor that has not been sufficiently covered by the 17 national SDGs, although it is a main component of the global Agenda 2030 (Federal Statistical Office - Destatis, n.d.), and a national concern, as indicated in the national strategy (The Federal Government, 2002, 2018). To understand the significance of food waste for food sustainability, it is important to overview the food waste context.

One-third of global food is wasted or lost, 53% of which is cereals including wheat (Lipinski, 2013); waste and losses occur due to decisions made throughout the value chain, including those of farmers, retailers and suppliers, producers and consumers. Food waste is considered a severe problem because it has, in addition to its environmental dimension, an ethical/moral dimension, with 9% of the world's population suffering from hunger (The United Nations, n.d.-b).

Hunger, poverty and other challenges are all interrelated, and developed countries have an ethical and moral responsibility towards ending global hunger; thus, food waste is at the core of their initiatives (BMEL, 2015). Food waste is not limited to the volume of food being wasted; it actually represents a very complex problem. It involves the waste of agricultural land use (30% worldwide) (The United Nations, n.d.-a), time and resources used to produce the food, and the associated economic and environmental losses. This is all on top of the produced GHG emissions wasted through the whole life cycle of wasted foods; these are estimated at 6% of total emissions (Poore & Nemecek, 2018).

The direct economic consequences of total food waste are estimated by the UN to be around \$1 trillion per year (The World Counts, n.d.). Figure 18 illustrates the lifecycle stages at which food waste mostly occurs (EPRSB, 2013). The largest shares of food losses/waste mainly occur at the consumption stage (35%), followed by production and handling and storage (each at 24%).

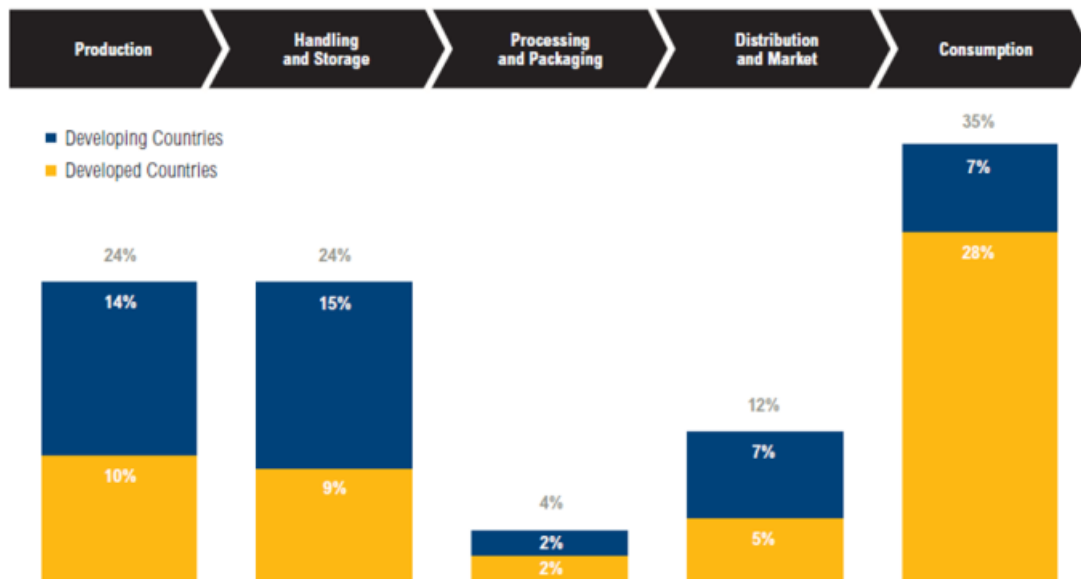


Figure 18 Share of total food loss and waste by stage (EPRSB, 2013)

Food waste in Germany is illustrated in Figure 19 (Upadhyaya, 2019).

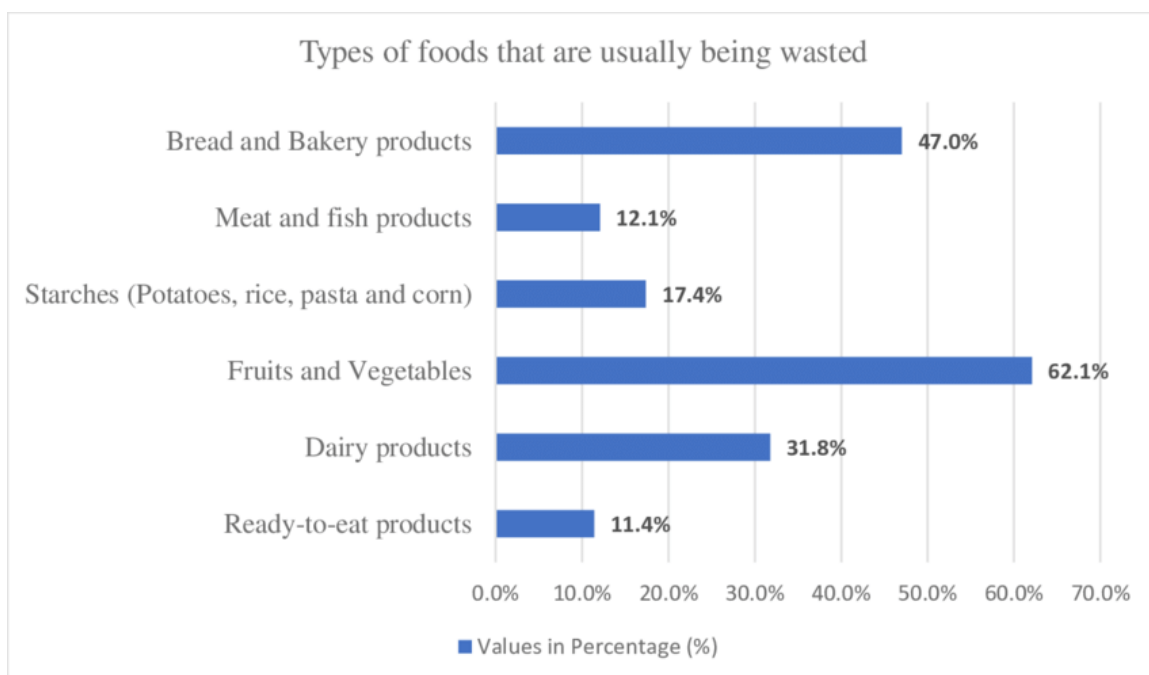


Figure 19 Types of foods being wasted in Germany (Upadhyaya, 2019)

Bread and baked goods represent nearly half of all food waste in Germany. National bread waste was recorded at 1.7 million tonnes in 2015; the majority of this loss occurred in households, followed by bakeries and other retailers. Therefore, the potential contribution of

artisan bakeries to national food waste and losses is through the quantity of bread they waste on a daily basis; this is a significant factor for bread sustainability.

6.4. Synthesis and Chapter Summary

To summarise the critical evaluation of the 17 national SDGs and their operationalisation to a bakery level, criteria have been categorised according to their action from the perspective of bakeries:

- **Responsible procurement:** the way bakeries procure their flour has an influence on bread sustainability. Bakeries' potential contribution in this field can be through local procurement of flour (indicator 11.2.a), and their use of sustainable packaging (indicator 12.1.b – 3rd factor).
- **Ecolabelling:** ecolabels are used to certify sustainable characteristics of a product. In the case of German bread, the EU Organic label means that the bread ingredients come from organic farming, have a lower environmental and energy footprint, and promote human health. Bakeries' contributions include producing organic, eco-labelled breads (indicator 12.1.a), and the promotion of organic farming (indicator 2.1.b). Knowledge gaps in this category include how bakeries perceive ecolabels, and the challenges associated with the certification process from a logistical perspective.
- **Resource conservation:** bread has a low water footprint compared to other food products; moreover, water is not a significant factor for bread sustainability in Germany due to its availability. Bakeries contribute to energy conservation through energy efficiency measures (indicators 7.2.a,b; 11.2.a; 12.1.b), especially during baking, when two-thirds of the bread lifecycle energy is consumed. Regarding food resource conservation, bakeries contribute through the reduction of bread waste (indicator 8.1) by improving their productivity and minimising losses. They also contribute to increasing employment levels (indicator 8.5.a), especially with regard to skilled labour of a protected trade. Knowledge gaps in this area include how bakeries promote resource conservation from an operational perspective and how they manage their food waste.
- **Emissions:** this aspect is highly related to energy consumption in the case of bread production; it relates to GHG/CO₂ emissions, a highly important factor of bread sustainability in Germany. Bakeries contribute through energy reduction measures

(indicators 7.2.a,b; 11.2.a; 12.1.b), and through transition to renewable energy sources (indicators 7.2.a,b; 13.1.a). Knowledge gaps in this area include how bakeries reduce emissions from an operational perspective, and what challenges they face with the transition to renewable energy sources.

- **Reporting:** reporting is an important factor of bread sustainability given the current framework in Germany, where EMAS (indicator 12.2) is employed as the only indicator to measure potential contributions in relation to environmental performance. Knowledge gaps in this area include how bakeries perceive sustainability and reporting.
- **Heritage:** German bread heritage is a very significant factor for bread sustainability because it is inscribed as an intangible cultural heritage. The bakeries contribute toward its conservation through the documentation of their unique recipes, and the transmission of knowledge to young baker trainees.

These indicators and criteria can also be classified according to their sustainability dimension, as follows:

- **Environmental dimension:** 2.1.a,b; 3.1.f; 7.2.a,b; 11.2.a; 13.1.a; 12.1.a,b; 12.2
- **Economic dimension:** 8.1
- **Cultural dimension:** heritage conservation (recipes and knowledge transmission)

The national sustainability strategies clearly prioritise the environment and resource conservation as their main dimensions. While the potential contribution of bakeries within the SDGs can be mostly environmental, the heritage aspect and the bakeries' perspective will help achieve a broader understanding of sustainable bread. The following chapter will describe the results and subsequent discussion.

7. Results and Discussion

The quantitative results include results of the questionnaire from 52 respondents, including 15 individual bakeries and 37 chain bakeries; the total number of branches in both categories is 562. The qualitative results include interview results from 10 bakery owners/managers. Results are presented in the order of the research questions and types of data collected.

7.1. RQ1 Findings

The first research question of the study was ‘What is sustainable bread?’ The accompanying assumption was ‘sustainable bread is the product of a bread system that positively contributes to national sustainable development, and at the same time, preserves its associated environmental, social, economic, cultural and nutritional aspects’. The three perspectives used to identify the criteria for sustainable bread included the bread system perspective (conducted in Chapter 4), the policy perspective (conducted in Chapter 6) and the bakeries’ perspective (conducted via the interviews); the criteria from all three perspectives are combined and categorised according to their dimensions (i.e. environmental, social, economic, nutritional and cultural). Table 15 illustrates the identified criteria, the gaps and the similarities in how bread sustainability is perceived from the three perspectives (green means the criterion is significant from the relevant perspective; red means it is not significant, or not emphasised).

Table 15 Criteria for sustainable bread (created by the researcher)

Dimension	Criteria	Bread system	Policy	Bakeries
Social	Eco-friendly flour	Green	Green	Red
	Local supplier	Green	Red	Green
	Meets consumer preferences	Green	Red	Green
	Accessible	Green	Red	Green
	Meets consumer quality expectations	Green	Red	Green
	EMAS reporting	Red	Green	Red
	Trust	Red	Red	Green
Economic	Productive employment	Green	Green	Green
	Affordable	Green	Green	Green
	Profitable	Green	Red	Green
	Uses efficient machinery	Green	Red	Green
Environmental	Protects biodiversity/organic	Green	Green	Green
	Uses less fertilisers	Green	Green	Red
	Produces less waste	Green	Green	Green
	Promotes sustainable land management	Green	Green	Red
	Produces less GHG emissions	Green	Green	Red
	Uses energy efficiently	Green	Green	Green

	Has longer shelf-life			
	Uses renewable energy			
	Low water footprint			
	Low transport footprint			
Nutritional	Promotes food security			
	Promotes human health			
	Meets food safety standards			
Cultural	Preserves traditional recipes			
	Promotes traditional knowledge Sourdough & slow fermentation			
	Protects bakery trade			
Holistic	TOTAL: 27 criteria	24 criteria	14 criteria	18 criteria

Sustainable bread from a holistic perspective combines the criteria of a sustainable bread system, the policy criteria and the criteria of artisan bakeries (as two main stakeholders or decisionmakers). The gaps and similarities can be summarised as follows:

7.1.1. Sustainable Bread Criteria from a Bread System Perspective

From a bread system perspective, 24 criteria were identified. Some of the gaps with regard to policy perspective include EMAS reporting, renewable energy and water footprint. These findings correlate with the direction in Germany's strategy to emphasise environmental reporting as a voluntary measure initiated by the private sector; moreover, renewable energy reflects the importance of this factor for Germany, but it is not necessarily a universal criterion. The opposite can be seen with regard to water footprint; this is a universal issue compared to renewable energy. Interestingly, bakeries had the same position regarding EMAS and renewable energy, due, in some cases, to the arguable suitability of EMAS for bakeries, and the economic standpoint on the topic of energy.

7.1.2. Sustainable Bread Criteria from a Policy Perspective

From a policy perspective, 14 criteria were identified. The criteria reflect the policy priorities with regard to food sustainability as a balance between food needs and the environment. However, there are several gaps in the social, economic and cultural dimensions as important elements from a holistic perspective. The findings are in line with the policy approach towards prioritising the environment across the SDGs while ensuring economic and social transformation. Moreover, the cultural dimension remains a gap as the SDGs focused on the digitisation of cultural heritage and were not associated with food from that perspective.

7.1.3. Sustainable Bread Criteria from the Bakeries' Perspective

From the bakeries' perspective, 18 criteria were identified. Their perspective was somehow similar to that of the food system, except for the environmental dimension and its interpretation. Bakeries see that energy efficiency, waste reduction and longer bread shelf-life are essential economic measures that help bakeries minimise costs and optimise productivity; these can be seen as intrinsic characteristics of any food business. The double dimension of these criteria can encourage policymakers to promote investments in energy efficiency, waste reduction and the calibration of production forecasts as these will bring mutual benefits for both environmental and economic sustainability.

7.2. RQ2 Findings

The RQ2 findings include qualitative and quantitative findings. First, the quantitative findings are presented, included findings related to SDGs. Second, the qualitative findings are presented through a thematic analysis, which analyses the entire interview data, including data associated with RQ1, RQ2 and RQ3. Further discussions around RQ2 will be provided at the end of this chapter.

7.2.1. Findings on SDG-2

Summary of findings:

Table 16 Summary of findings on SDG-2 (created by the researcher)

Type of bakery	Using organic grains/flours	Using conventional grains/flours
Individual	11 out of 15 or 73%	4 out of 15 or 27%
Chain	10 out of 37 or 27%	27 out of 37 or 73%

2.1.a & 2.1.b – Organic versus conventional: 21 of 52 bakeries, or 40% utilised organic grains/flours (shares between individual and chain bakeries are explained in Table 16). However, in terms of total production, the organic share was only 17% (Figure 20) because most organic bakeries were either individual or small in size. The percentage of bakeries using organic flour was much higher than that of bakery chains; this is in line with literature stating that bakery chains are less flexible compared to individual bakeries, especially in adapting to strict certification programmes requiring logistical and operational adaptations. SDG-2 is important, from a policy perspective, because it is associated with food security and the environment. Moreover, the targets within indicators 2.1.a 'nitrogen surplus' and 2.1.b 'share of organic farmland' are both associated with emissions, energy use, land and water pollution,

sustainable land management, etc. These factors also come under other SDGs. Therefore, performance under this indicator has a potential impact on other SDGs and the impact of this indicator goes beyond the hunger goal.

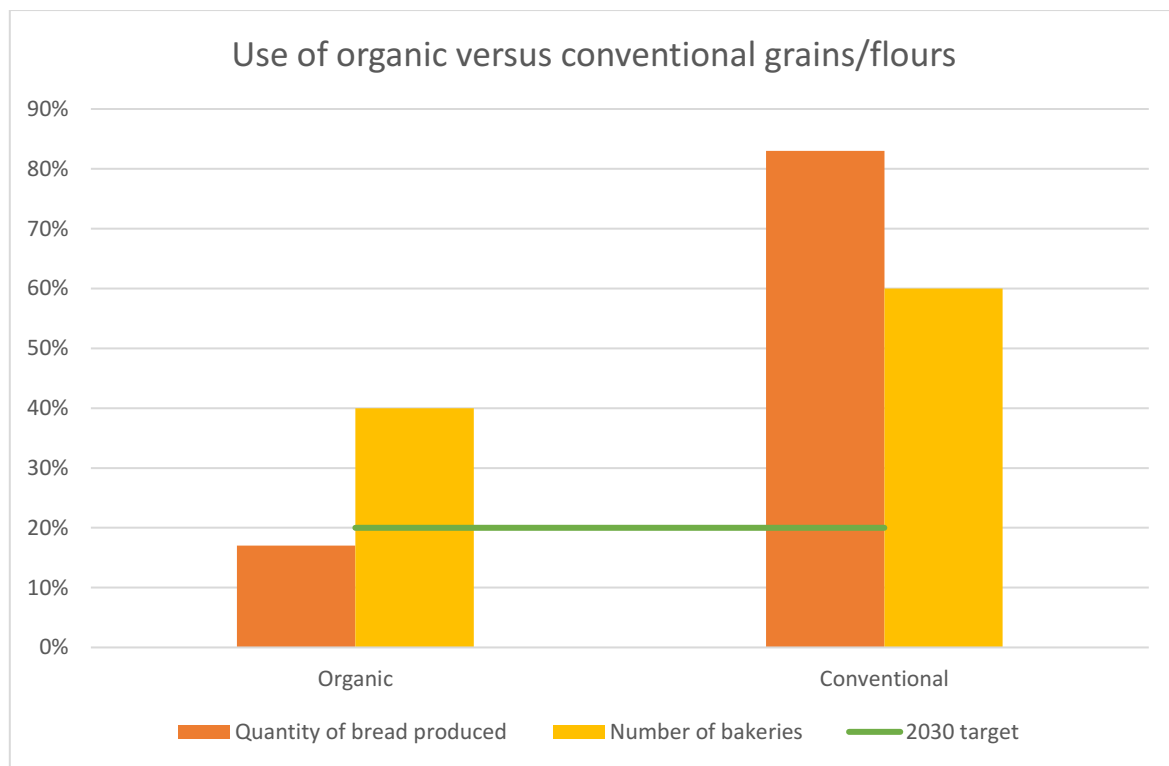


Figure 20 Use of organic versus conventional grains/flours (created by the researcher)

Because the use of organic flour has a broader significance, an additional investigation on the transition to organic was carried out. It revealed that the primary reasons that bakeries do not fully convert to organic are mainly the high pricing of organic flour and lack of demand (Figure 21); this means that, if progress was to be achieved in this area, the government might need to ensure organic flour becomes more affordable to bakeries and that consumers are more aware of the importance of organic food (promotion of an organic ecolabel). Of the nine individual bakeries using conventional flour, two cited price as a main factor, while seven out of nine considered the quality of their bread is far more important than it being organic. Of the 22 chain bakeries using conventional flour, 18 cited one of the two main reasons illustrated in Figure 21.

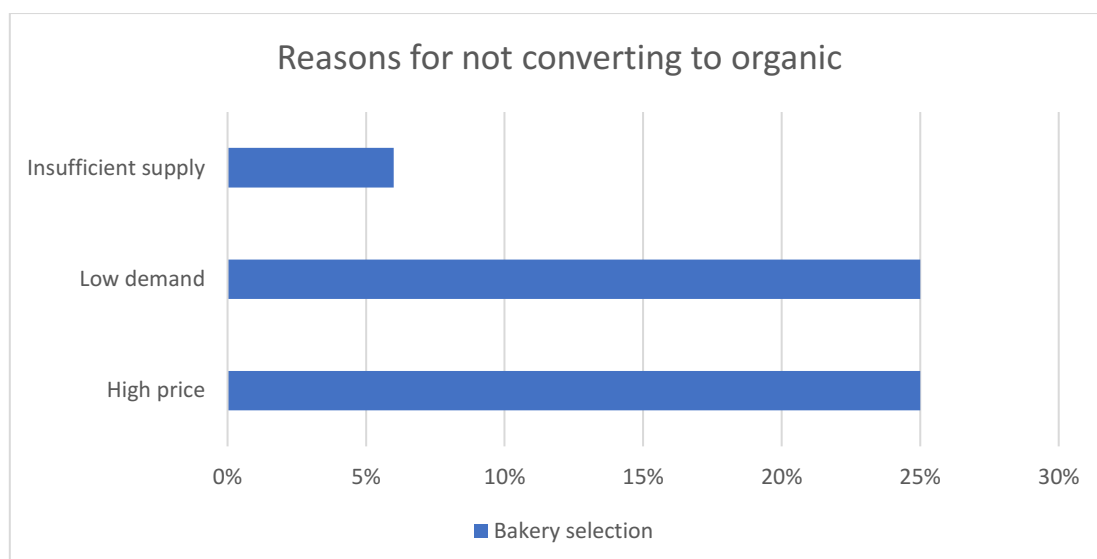


Figure 21 Reasons for not using 100% organic grains/flours (created by the researcher)

7.2.2. Findings on SDG-3

Summary of findings:

3.1.f – Obesity rate among adults: Of the 52 bakeries, 52 or 100% reported that they only use natural ingredients (flour, water, nuts, seeds, dried fruits, grains, etc.); depending on the type of bread, they might also use other ingredients such as fats to retain bread moisture and make it fluffier; sugar beet syrup to give a darker colour for bread and as an enhancement for yeast/sourdough; and, sometimes, ground leftover breads as an additional ingredient to enhance flavours and aroma. However, none of the respondents reported using synthetic ingredients. Data about such ingredients can be falsely disclosed as artisan bakeries try to promote the ‘natural’ characteristics to remain competitive against industrial bread. Nevertheless, the target under this indicator is to halt obesity, and, according to the literature, bread in Germany is, arguably, a healthy food. Using natural ingredients is another confirmation that bakeries try to keep it healthy.

7.2.3. Findings on SDG-7

Summary of findings:

7.2.a – Use of renewable energy: Of 52 bakeries, 17 or 32.6% utilised renewable energy for baking (i.e. wood and electricity from renewable sources) (Figure 22). Eight bakeries used wood, of which four were individual bakeries and four were chain bakeries; nine bakeries used renewable electricity, two of which were individual bakeries and seven were chain bakeries.

The target in this indicator is to increase the share of renewable energy to 30% in 2030 on a national level, and for 32.6% of bakeries to utilise renewable energy, although the precise share in total energy cannot be traced. Therefore, potential progress can be made by bakeries.

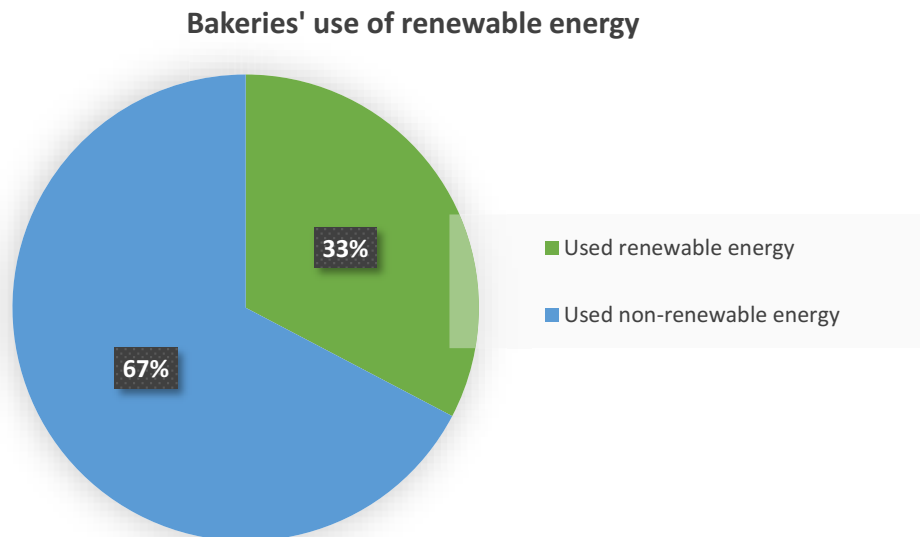


Figure 22 Use of renewable energy (created by the researcher)

7.2.b – Use of renewable electricity: Of the 52 bakeries, nine or 17.31%, utilised renewable electricity (i.e. electricity from renewable sources) (Figure 23). Of those nine, two were individual bakeries and seven were chain bakeries. The target in this indicator is to achieve 50% share of renewable electricity on a national level. However, the share within bakeries appears to be on the lower scale, which indicates that renewable electricity is, either not available or not affordable to bakeries, or both.

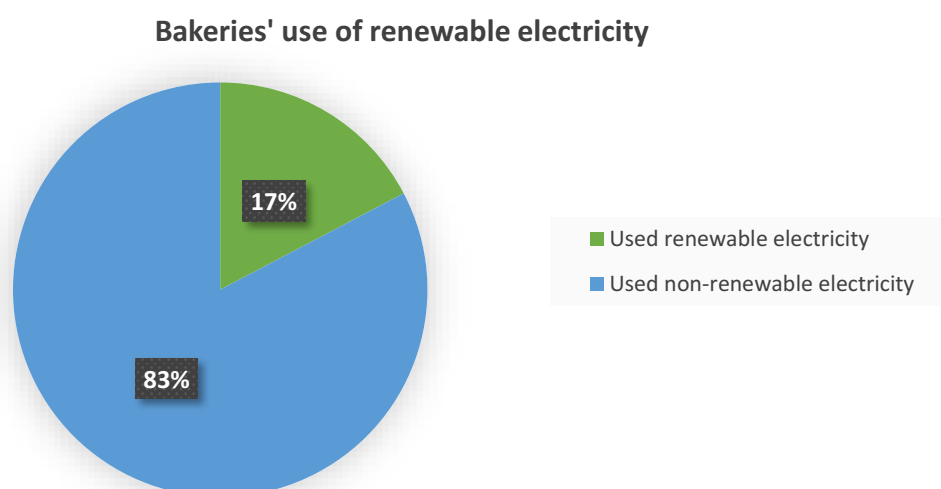


Figure 23 Use of renewable electricity (created by the researcher)

To understand the energy consumption patterns within bakeries, more data were collected on their energy sources (Figure 24). The data suggest that bakeries still rely on fossil fuel and natural gas as the two primary sources, both of which are imported; however, Germany's strategy for emissions reduction and renewable energy implies that bakeries need to shift towards renewable energy sources in the future.

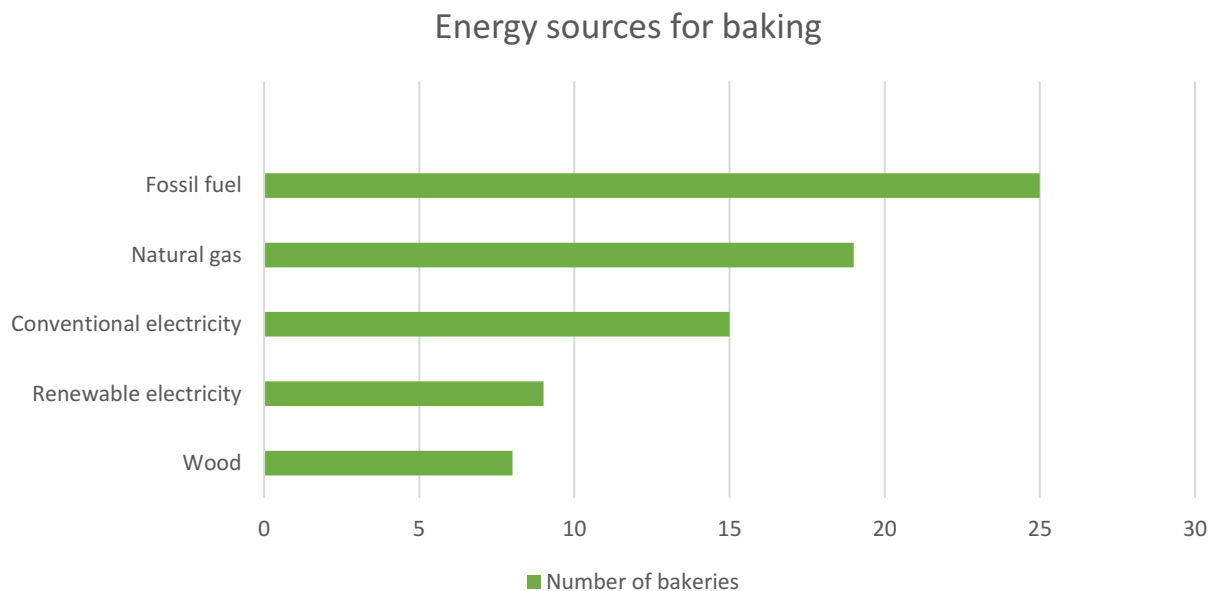


Figure 24 Energy sources for baking (created by the researcher)

7.2.4. Findings on SDG-8

Summary of findings:

8.1 – Raw material input productivity: Of the 52 bakeries, 27 or 51.92% were above the productivity mean (including five that reported zero waste, which appear as outliers in Figure 25). Interestingly, four of the five bakeries who reported 0 waste were chain bakeries. The productivity mean was 46.33 ($SD = 30.53$). This number indicated that the average bakery in the sample produced 46.33 kilograms of bread for every 1 kg of bread that had to be disposed of. The target in indicator 8.1 is to ‘continue to increase’ raw material input productivity by 2030; therefore, based on the average productivity in the sample, it was found that more than half of the bakeries optimised their production in this area, although some had room for improvement.

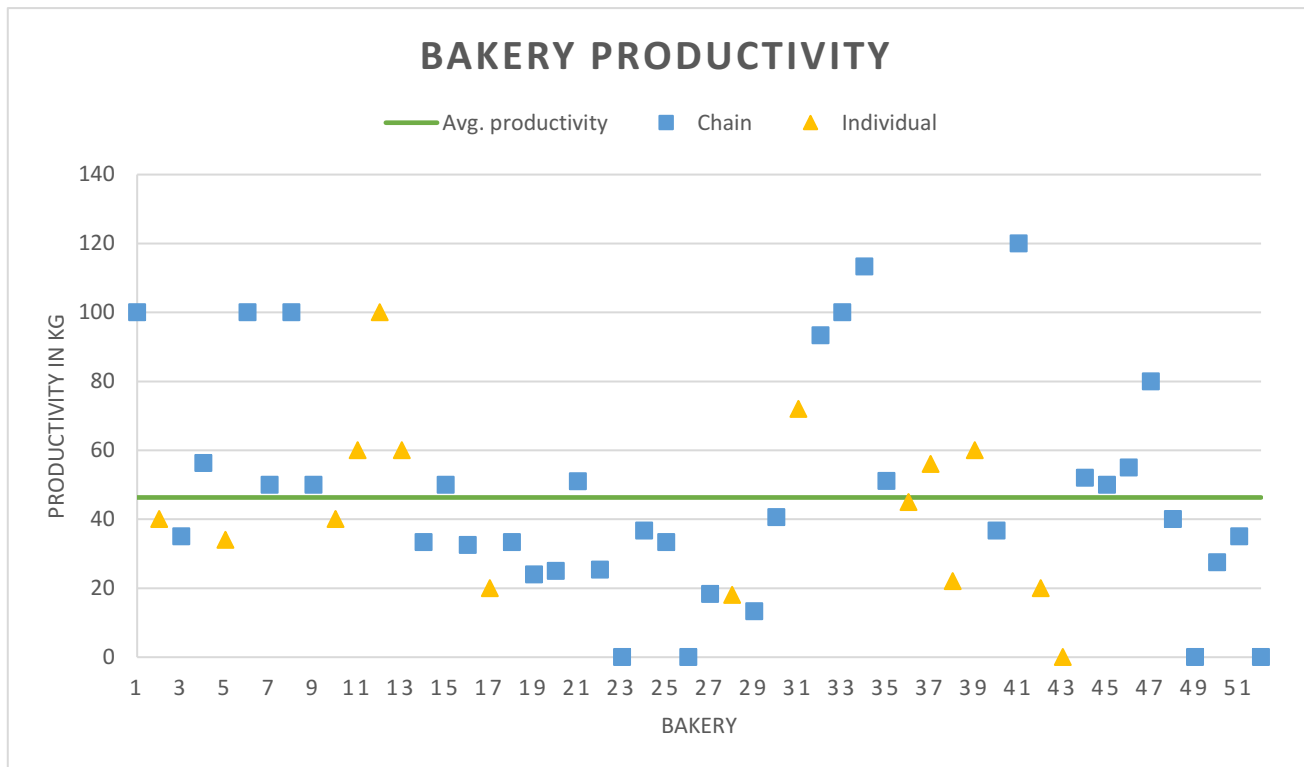


Figure 25 Raw material productivity: total kilograms of bread produced per one kilogram of bread waste (created by the researcher)

Additional investigations on waste showed that bakeries are continuously trying to improve their waste management scenarios (Figure 26). The two primary scenarios for bread waste management included providing unsold bread to third parties, mainly food charities, and reusing/recycling; more details on this process will appear within the qualitative data (i.e. interviews). Disposing of bread as food waste was considered as the least favourable scenario, which indicates that bakeries are well aware of the importance of reducing food waste. A biogas scenario was reported within the text box provided in the questionnaire for additional remarks by bakeries.



Figure 26 Bread waste management scenarios (created by the researcher)

8.5.a – Employment: the overall average employee per bakery branch was around 11. However, individual bakeries had almost 18 employees per bakery versus nine employees at chain branches. In terms of labour productivity, the overall average was around 27 kg of bread per employee across all samples. Interestingly, this figure was slightly lower at individual bakeries with around 23 kg per employee, while at chain bakeries it was 28 kg per employee.

The data indicate that individual bakeries use nearly double the labour compared to chain bakeries and produce 18% less bread. This is in line with the literature that individual bakeries tend to utilise more handwork processes compared to chain bakeries that have more advanced and automated production systems relying on more machines and less human labour. Of the 52 bakeries, 21 or 40% were on, or above, a labour intensity level (Figure 27), indicating a more positive contribution to handwork and, therefore, employment of skilled labour (i.e. bakers).

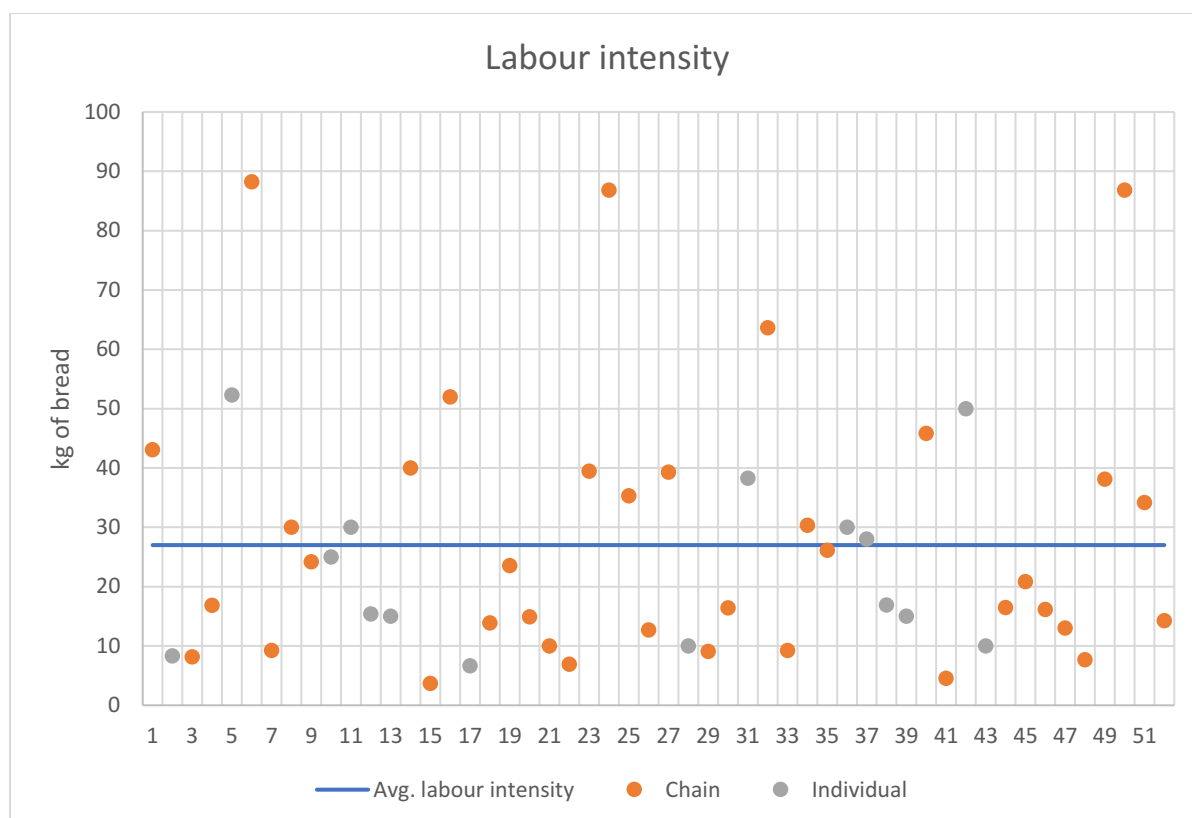


Figure 27 Labour intensity (created by the researcher)

7.2.5. Findings on SDG-11

Summary of findings:

11.2.a – Energy consumption in goods transport: 34 of 52 bakeries, or 65.38% were below the mean (i.e. lower transport footprint from monthly flour procurement) (Figure 28). A lower footprint means lower energy consumption for the transport of flour; moreover, local procurement encourages local economy, an aspect not covered by this indicator. The target in this indicator is to reduce energy consumption for goods transportation by 15 to 20% by 2030 compared to 2005 levels. Most bakeries appeared to be procuring from mills within their areas (38 km is a relatively small distance when discussing food supply chains), and some bakeries preferred to procure from distant mills (these reported that the quality of flour they require only exist at their selected suppliers). Further progress in indicator 11.2.a means bakeries and mills might develop eco-friendlier procurement practices (e.g. electric vehicles) and reduce the frequency of deliveries by ensuring more supplies are delivered less frequently; this aspect will require investment in efficient storage and larger inventory budgets.

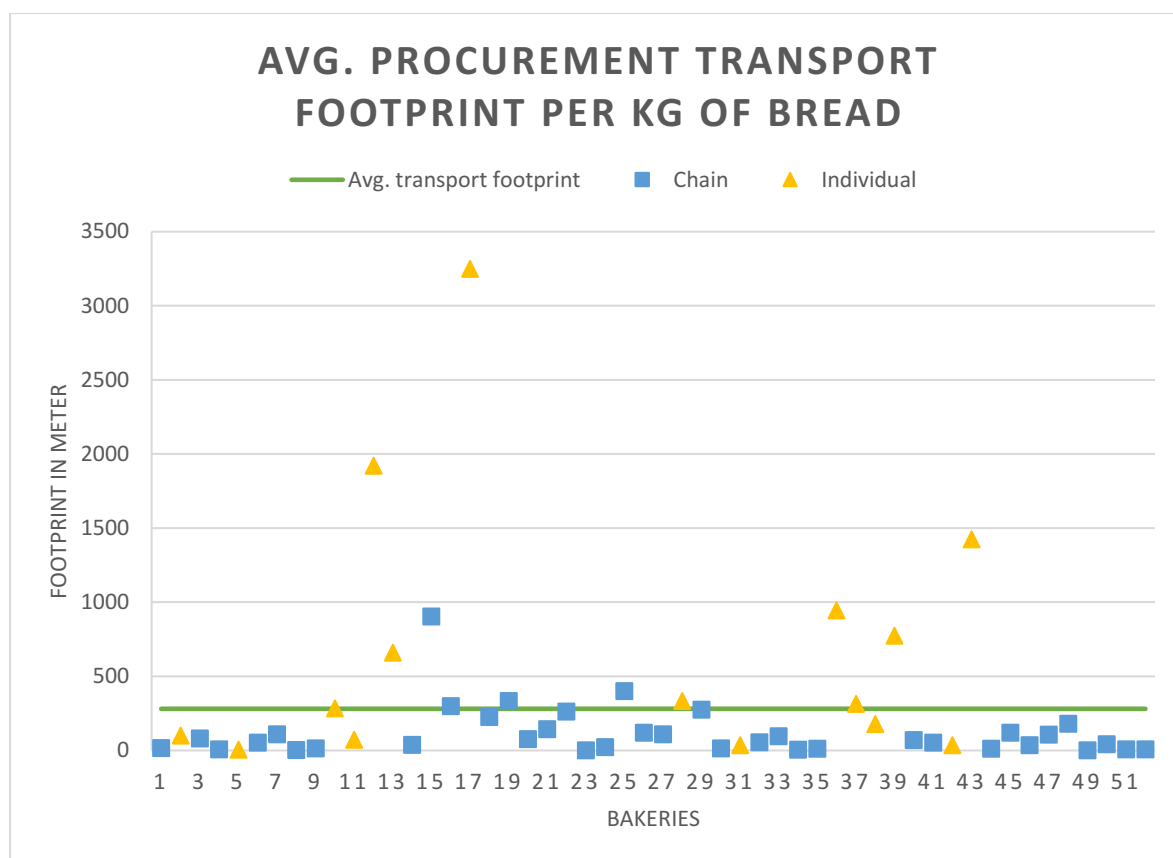


Figure 28 Daily transport requirement per 1kg of bread (created by the researcher)

7.2.6. Findings on SDG-12

Summary of findings (**Error! Reference source not found.** provides a visual summary of the bakeries' contributions within SDG-12).

12.1. a – Use of ecolabels: Of the 52 bakeries, 21 or 40% used publicly managed ecolabels (i.e. EU Organic such as Bio, Bioland, EU Biosiegel, Biokreis, and FairBio). Of the 21 bakeries, 11 were individual and 10 were chains (the chain samples were more than double the number of individual bakeries). The national target within this indicator is a 34% market share of products with ecolabels. While 40% of bakeries contributed to this indicator, the share of bread with EU Organic labels was 17% of total production – all samples combined. This was due to the difference in production volume between individual and chain bakeries. Therefore, there is room for progress to be in line with the 34% target, especially from the chain bakeries' side.

12.1.b (1st factor) – Measures to reduce energy consumption: All 52 bakeries, or 100% had taken steps to become more energy efficient in the past 10 years (i.e. energy-saving ovens, automatic lighting, heat insulation and heat recovery ventilation). Energy saving also has an

economic dimension as it helps bakeries reduce production costs and maintain profitability.

12.1.b (2nd factor) – Sustainable packaging: All 52 bakeries, or 100% used either no packaging or recyclable paper bags. The national target for this indicator is to ‘continuously lower’ environmental impact from household consumption; both factors helped reduce the consumption footprint associated with emissions and packaging and bakeries’ contributions are in line with the target; however, more investigations on specific practices will help evaluate their efficiencies and impacts.

12.2 – EMAS: 0 of 52 bakeries, or 0% had EMAS. The target within this indicator is to reach 5,000 locations with EMAS registrations; however, data from bakeries reveal that there was no contribution from the bakeries’ side in this indicator. This area has been discussed within the critical evaluation of the SDGs, and it was predicted that the EMAS scheme might not be a convenient approach for the artisan baking sector. An alternative scheme for bakeries and similar businesses could be considered by the government to incorporate this sector in the progress towards sustainable production.

Goal 12 results indicate that bakeries made significant progress in initiating energy efficiency practices to lower energy consumption and eventually emissions, and in using sustainable packaging (indicator 12.1.b. factors 1 and 2), slightly below average in ecolabelling (indicator 12.1.a), when considering bakeries rather than bread and poor reporting (as defined in indicator 12.2). The use of ecolabels is an area for improvement while EMAS represents the main challenge.

Additional investigations on challenges to ecolabelling (12.1.a) revealed that the main challenge for bakeries in this area was the complicated ecolabelling process; the results are summarised in. This means, significant progress in indicator 12.1.a requires a simplification of the certification process so it does not obstruct bakeries’ operations or cause logistic complications, particularly in chain bakeries. Another factor is high cost, which means the certification process and associated costs need to be lower so that bakeries can feasibly implement it.

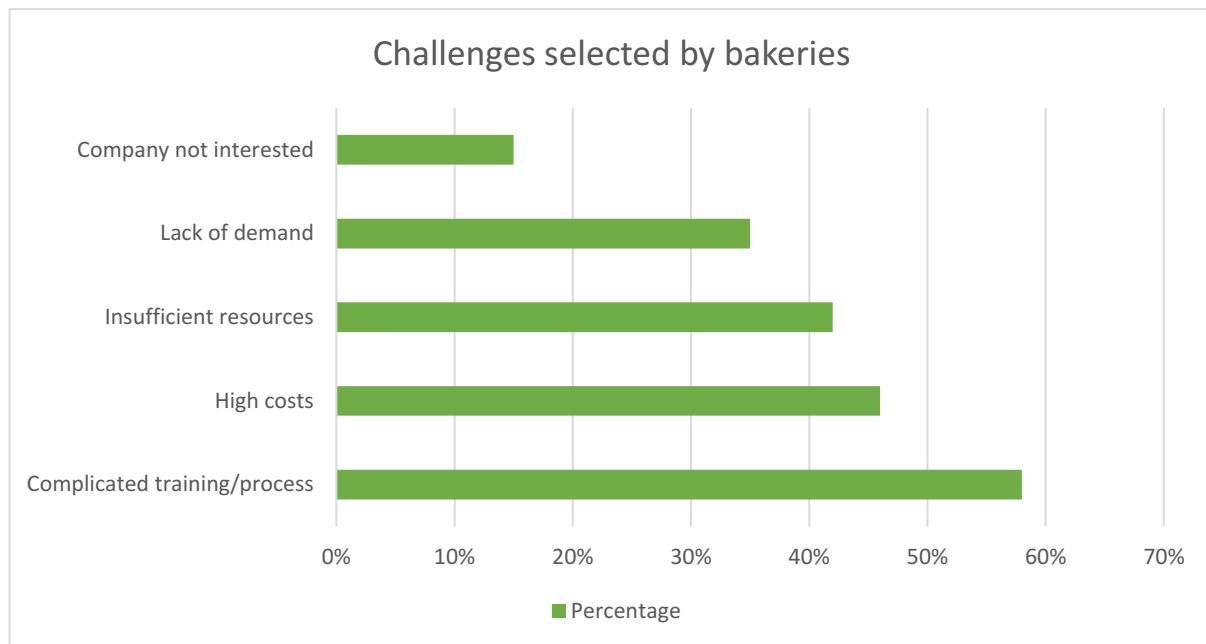


Figure 29: Challenges to ecolabelling as selected by bakeries (created by the researcher)

Additional investigations on potential energy-saving measures (12.1.b), other than in baking, showed that the majority of bakeries use room temperature (enhanced by oven heat) for the proofing of bread, which requires a generally warm environment (Figure 30). A small portion of bakeries use either electricity or ethylene glycol (mostly those who do not have effective heat insulation installed). Heat insulation appears to be an important factor for energy efficiency and heat recovery, an investment that can help bakeries recuperate and reuse the produced heat. Improved insulation would help lower the use of electricity and ethylene glycol which, in turn, would, reduce the consumption of energy and emissions associated with these two energy sources.

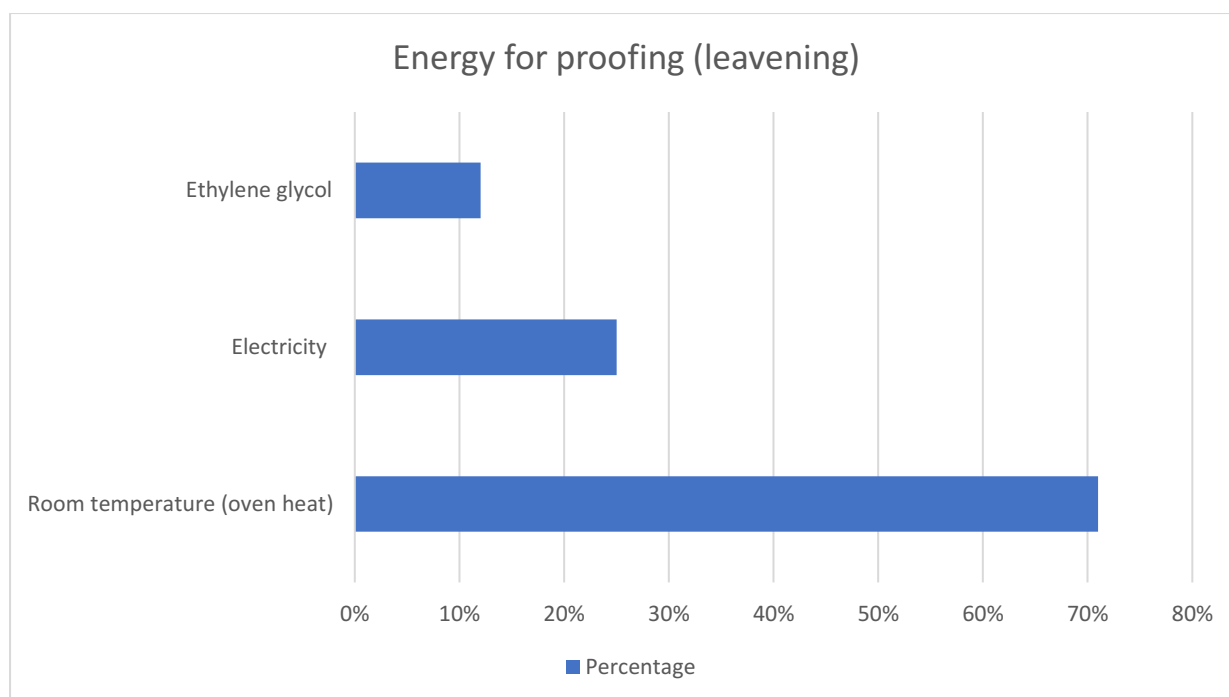


Figure 30 Energy sources for proofing (created by the researcher)

7.2.7. Summary of SDG Findings

Regarding SDG-2, bakeries have made good progress in promoting organically farmed grains and the shift from conventional lead to lowering the fertiliser footprint of bread. Regarding SDG-3, bakeries are contributing to a healthy diet, which can halt and reduce obesity among adults. Regarding SDG-7, bakeries' use of renewable energy and renewable electricity is still relatively low compared to the ambitious national targets; more progress can be done here, but the two main concerns for bakeries are the availability and affordability of renewable energy, and renewable electricity. Regarding SDG-8, bakeries are trying to improve their productivity, in terms of resource conservation, by reducing waste. However, the main challenge remains the difficulty in projecting accurate market demand so it can be aligned with production to minimise losses. Moreover, bakeries seem to maintain an effective level of skilled labour and makes a potential contribution to employment, especially on the individual bakeries' side. Regarding SDG-11, bakeries generally procure their flour from local mills and this contributes to reducing energy consumption associated with goods transportation; progress in this area includes the availability of special supplies (not available in proximity), and sustainable transport solution for the future between mills and bakeries. Regarding SDG-12, bakeries have made progress in improving their energy efficiency and reducing the global impact of production and consumption associated with their activities; however, the EMAS (reporting) represented a weakness that implies either significant progress from bakeries in this regard, or

an alternative scheme to help them progress. Regarding SDG-13, also reflected in indicator 12.1.b, bakeries have contributed to lowering GHG emissions by improving their energy consumption efficiency; more progress can be done in other areas by shifting to sustainably farmed raw materials. SDG-15 is also reflected in SDG-2 and SDG-12 through organic farming and ecolabelling as two measures for promoting biodiversity. Figure 31 illustrates the distribution of sample scores per number of bakeries.

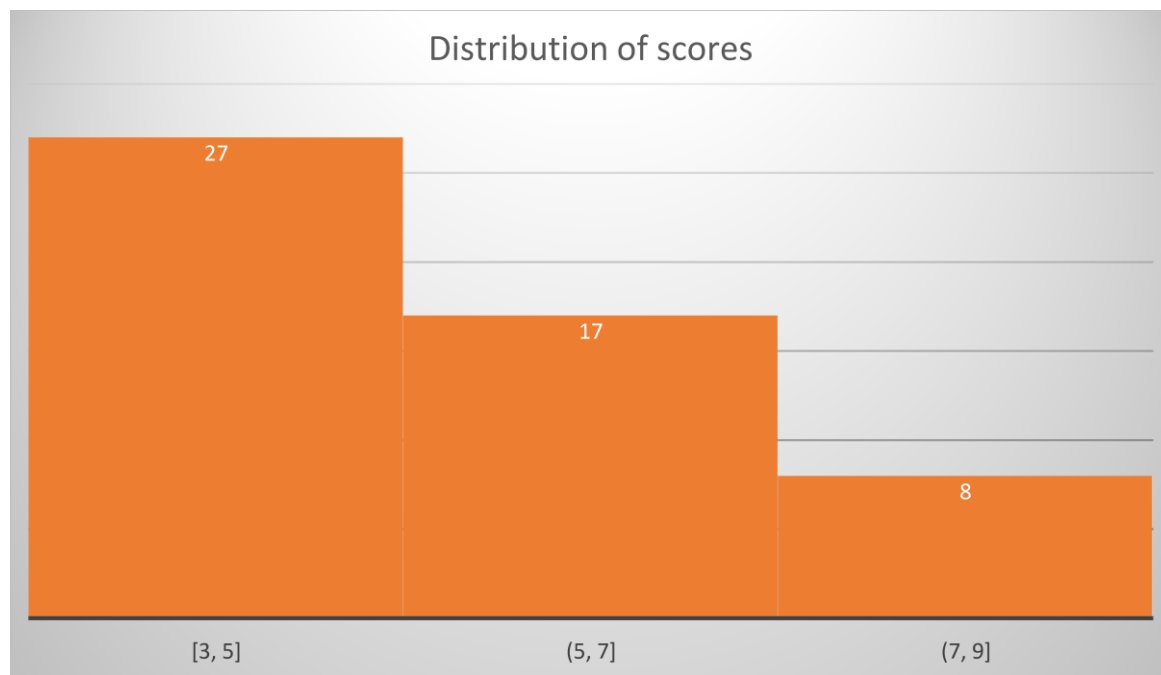


Figure 31 Sustainability index score (Y axis) and the number of bakeries (X axis) (created by the researcher)

The sustainability scores for the sample ranged from a low of 3 to a high of 9, with a mean of 5.5 (average) (SD 1.67), suggesting that bakeries' contribution to SDGs is positive and above average. However, very few bakeries are on either a very low or a very high sustainability level, suggesting that the general trend is still somewhere in the middle.

Next, an opportunity was taken to generate two histograms (Figure 32; Figure 33) for the sustainability index as distributed by bakery type (individual versus chain). The average score at individual bakeries was 6.1, while the average at chain bakeries was 5.2, suggesting that individual bakeries are slightly more sustainable from an SDG perspective.

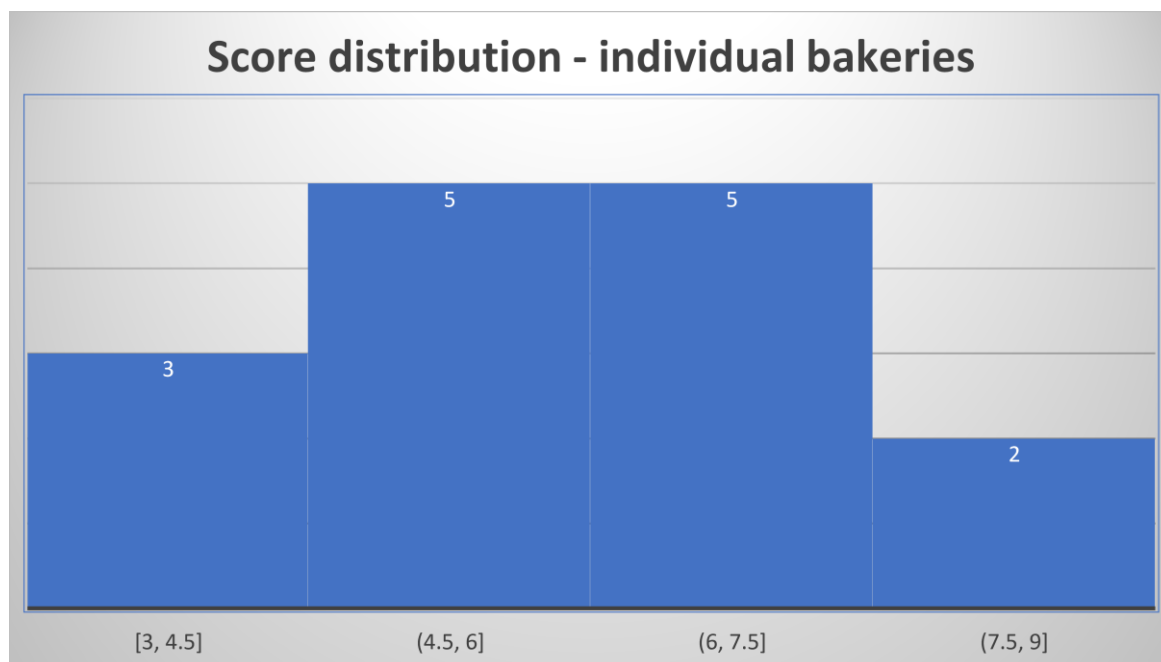


Figure 32 Score distribution in individual bakeries (created by the researcher)

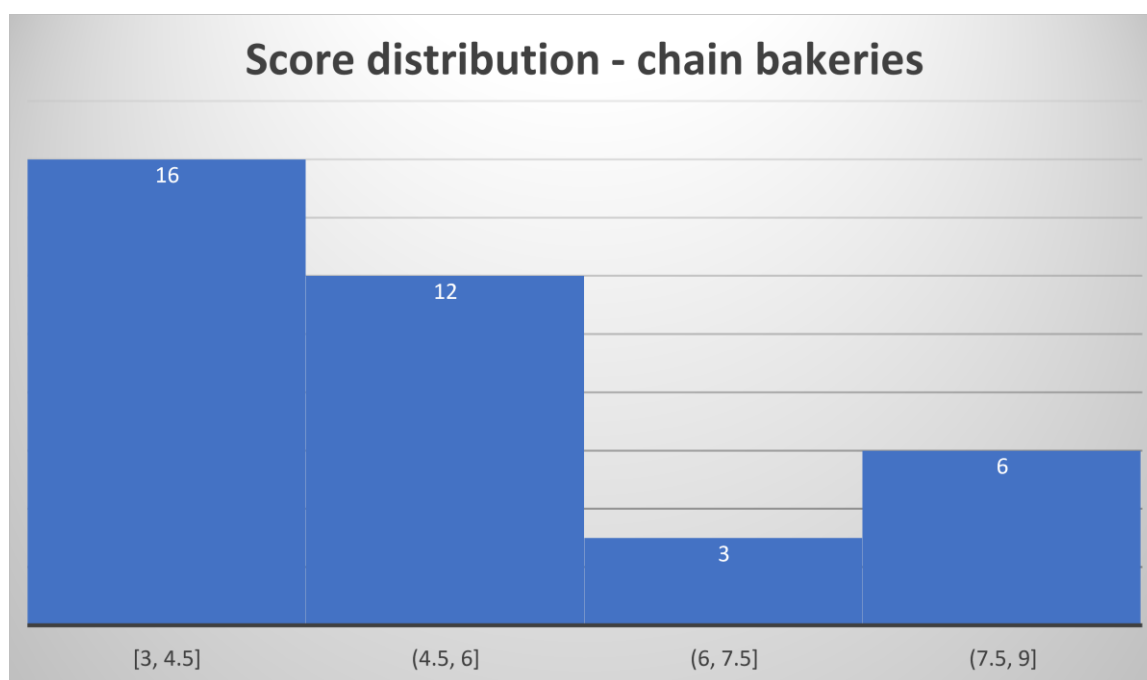


Figure 33 Score distribution in chain bakeries

7.3. RQ3 Quantitative Findings

RQ3 was also analysed quantitatively and took the form of *OR* calculations, as noted in the Methodology chapter. Each *OR* calculation below has been interpreted from the perspective of company size (individual vs branch) and is also illustrated using a confidence interval (*CI*) plot. These calculations are interpreted based on business continuity risk. Figure 34 and Figure 35 present a visualisation of the expansion and production.

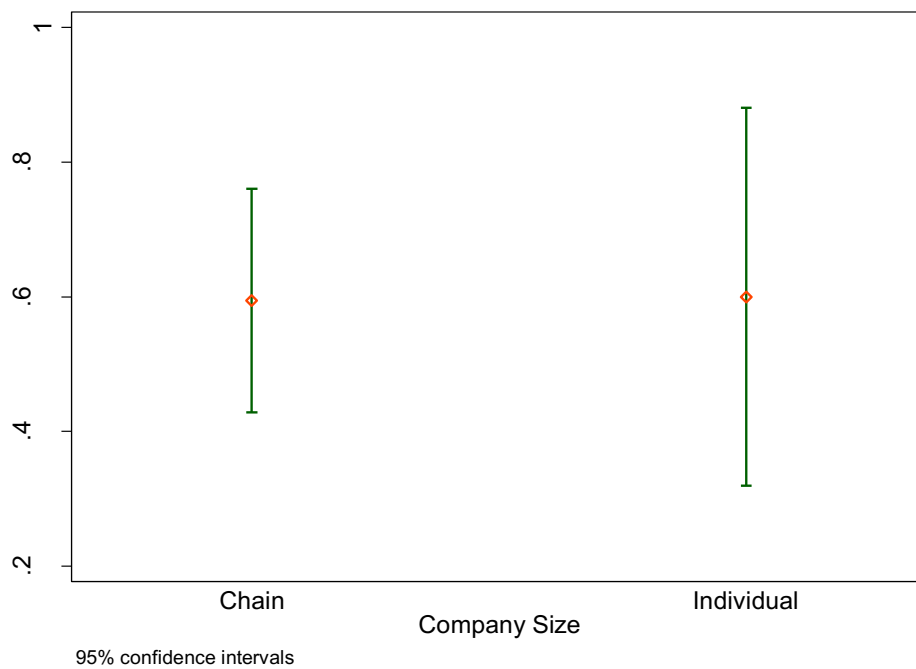


Figure 34 CI plot, business expansion by company size (created by the researcher)

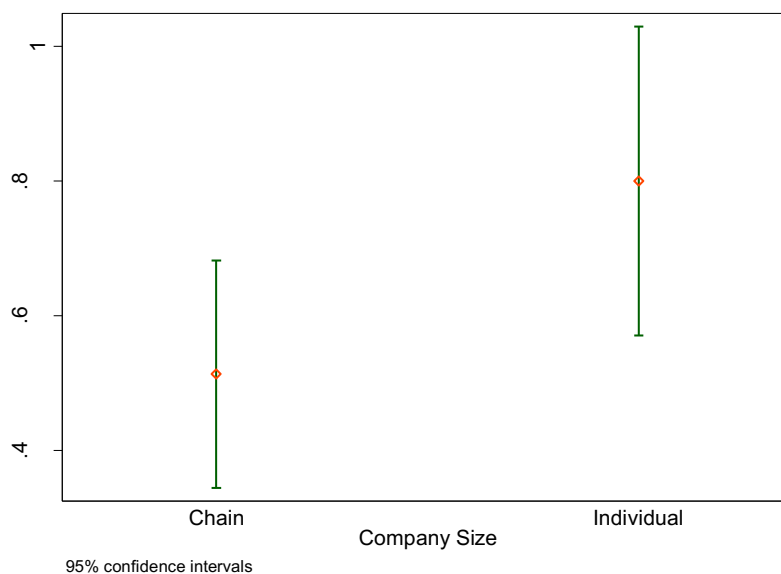


Figure 35 CI plot, production expansion by company size (created by the researcher)

It was found that 60% of individual bakeries expanded, compared to 59.46% of bakery branches. Therefore, there was no statistically significant effect of being an individual small bakery on the greater, or lesser, likelihood of expanding in comparison to a branch bakery, $OR = 1.02$ (95% $CI = 0.30, 3.48$), $p = .97$. If expanding a business is a sign of continuity and future prospects, then individual small bakeries in Germany do not appear to be at a disadvantage.

Next, it was found that 75% of individual bakeries increased production, compared to 51.35% of bakery branches (Figure 35). Therefore, there was a statistically significant effect of being an individual bakery on a greater or lesser likelihood of increasing production in comparison to a chain bakery, $OR = 3.79$ (95% $CI = 0.92, 15.68$), $p = .07$. If increasing production is a sign of continuity and future prospects, then individual bakeries appear to be at a marked advantage relative to branch bakeries. Individual bakeries are nearly four times more likely than branch bakeries to have increased production in the past 10 years, testifying to increased demand and excellent survival prospects.

Next, it was found (Figure 36) that 33% of individual bakeries do not throw bread away, compared to 29.73% of branch bakeries. Therefore, there was no statistically significant effect of being an individual bakery on a greater or lesser likelihood of throwing bread away in comparison to a branch bakery, $OR = 1.18$ (95% $CI = 0.33, 4.27$), $p = .80$. If disposing of bread as waste indicates that a company is, more or less, likely to be meeting regulatory requirements for sustainability, then individual bakeries do not appear to be at a disadvantage vis-à-vis branch bakeries in Germany.

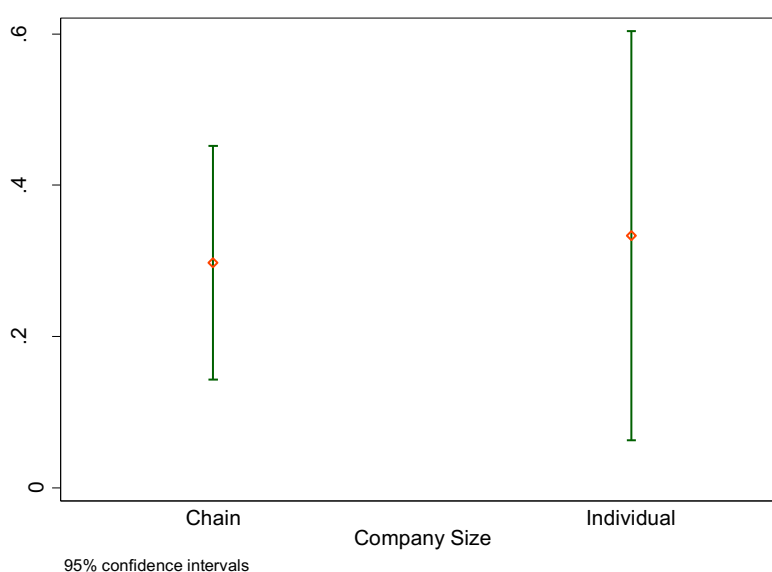


Figure 36 CI plot, food disposal by company size (created by the researcher)

Next, it was found that 20% of individual bakeries experience technology challenges compared to 10.81% of chain bakeries. Therefore, there was no statistically significant effect of being an individual small bakery on a greater or lesser likelihood of experiencing technology challenges, $OR = 2.06$ (95% $CI = 0.40, 10.59$), $p = .39$. If experiencing technology challenges indicates that a company might be struggling in a manner that threatens its continuity, then, based on the distribution of technology challenges as experienced by individual bakeries and chain bakeries, individual ones do not appear to be at a disadvantage vis-à-vis branch bakeries.

Next, it was found that 86.67% of individual bakeries experience regulatory challenges compared to 78.38% of branch bakeries. Therefore, there was no statistically significant effect of being an individual bakery on a greater or lesser likelihood of experiencing regulatory challenges, $OR = 1.79$ (95% $CI = 0.33, 9.64$), $p = .50$. If experiencing regulatory challenges indicates that a company might be struggling in a manner that threatens its continuity, then, based on the distribution of regulatory challenges, as experienced by small bakeries and chain bakeries, individual ones do not appear to be at a meaningful disadvantage vis-à-vis chain bakeries.

Next, it was found that 20% of individual bakeries experience sustainability challenges, compared to 24.32% of chain bakeries. Therefore, there was no statistically significant effect of being an individual bakery on a greater or lesser likelihood of experiencing sustainability challenges, $OR = 0.77$ (95% $CI = 0.18, 3.39$), $p = .74$. If experiencing sustainability challenges indicates that a company might be struggling in a manner that threatens its continuity, then, based on the distribution of sustainability challenges as experienced by individual bakeries and chain bakeries, individual ones do not appear to be at a disadvantage vis-à-vis branch bakeries.

Table 17 summarises the logistic regression results comparing individual bakeries and chain bakeries. In these comparisons, both the OR for the comparison (of individual bakeries to chain bakeries) and the accompanying p -value for the OR are provided. Of these comparisons, only production increase was statistically significant at $p < .10$. In essence, individual bakeries appear to be highly comparable to branch bakeries in terms of (a) the challenges they are experiencing at the current time; and (b) how their businesses and production capacities are running. On this basis, it appears not to be valid to conclude that individual bakeries are subject to any extra risk of not surviving.

Table 17 Summary of Individual/Branch Comparisons (created by the researcher)

Comparator	OR	Interpretation
Implementing new technologies	2.06 ($p = .39$)	No significant difference between small and branch bakeries.
New and increasing regulations	1.79 ($p = .50$)	No significant difference between small and branch bakeries.
Sustainability requirements	0.78 ($p = .74$)	No significant difference between small and branch bakeries.
Rising production costs	1.89 ($p = .32$)	No significant difference between small and branch bakeries.
Taxes	0.22 ($p = .17$)	No significant difference between small and branch bakeries.
Finding skilled labour	1.14 ($p = .83$)	No significant difference between small and branch bakeries.
Changing consumer behaviour	1.29 ($p = .74$)	No significant difference between small and branch bakeries.
Competition	1.56 ($p = .54$)	No significant difference between small and branch bakeries.
Production trends	3.79 ($p = .07$)	Individual small bakeries have been nearly 4 times more likely than branch bakeries to have expanded production in the past 10 years.
Expansion trends	1.02 ($p = .97$)	No significant difference between small and branch bakeries.
Food disposal	1.18 ($p = .80$)	No significant difference between small and branch bakeries.

Although RQ3 was answered in terms of data collected from the survey portion of the study, secondary data are also relevant to the context of this research question. Annual statistics (Henrich, 2020) from 2006 to 2018 indicate a fairly linear decline in the number of total bakeries in Germany, although the total number of points of sale has remained almost constant. One of the possible implications of this statistic is that bakeries are consolidating, an implication that can be confirmed by calculating the yearly ratio of employees per company in

Germany bakeries from 2011 to 2018 (Zentralverband des Deutschen Bäckerhandwerks e. V., n.d.-a). Figure 37 charts the decline in the total number of bakeries in Germany and is followed by the application of an ordinary least squares (OLS) regression to the data.

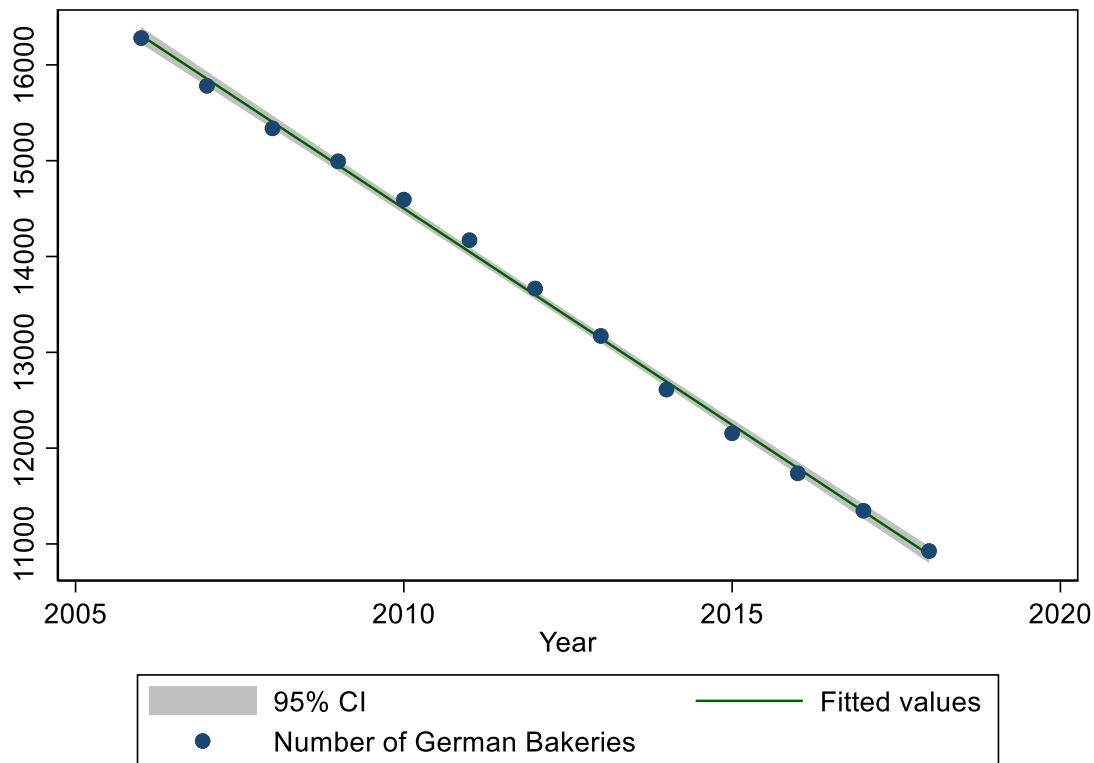


Figure 37 Scatter plot, change in the total number of German bakeries by year, 2016–2018. Note: OLS line of best fit and 95% confidence interval superimposed (Zentralverband des Deutschen Bäckerhandwerks e. V., n.d.-a)

As Figure 37 indicates, the decline in the total number of artisan bakeries by year is almost perfectly linear. The OLS regression of the total number of bakeries by year was statistically significant, $F(1, 11) = 6,787.87$, $p < .0001$. The coefficient of determination of this model was .9984, indicating that 99.84% of the variation in the number of bakeries can be explained by variation in the year. The coefficient for the predictor of year is -451.50 ($SE = 5.48$, $p < .001$), indicating that the number of bakeries in Germany is declining by 451.50 per year, with a 95% confidence interval of -461.56 , -439.44 .

Calculating changes in the number of German bakeries is also a means of measuring threats to individual bakeries. Theoretically, as the number of bakeries shrinks, there is a potential for the remaining bakeries to be larger. This supposition can be confirmed by examining data on the annual change in the ratio of employees per bakery, 2011–2018. These data confirm that artisan bakeries are growing bigger every year.

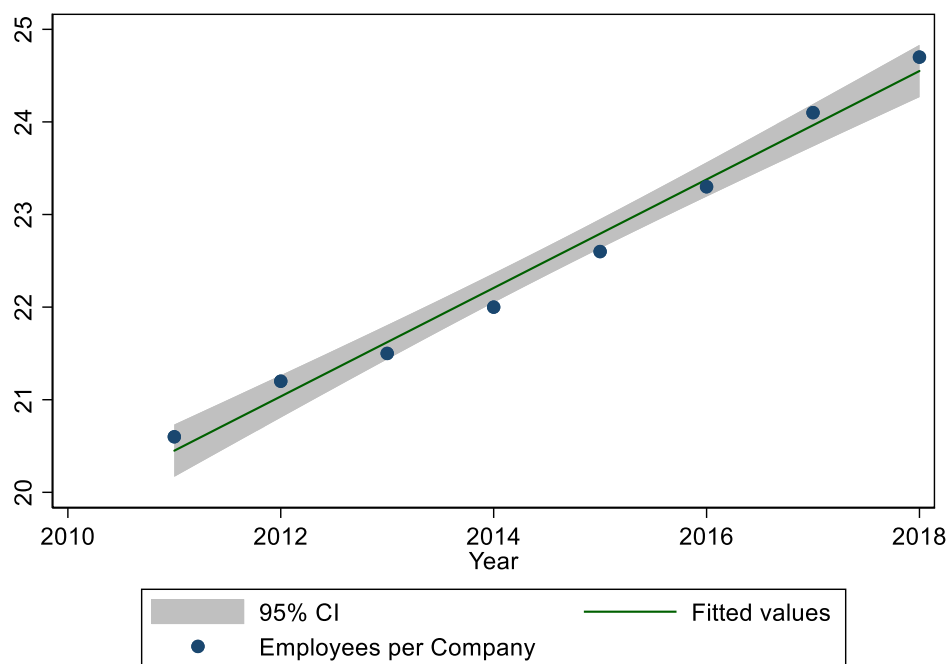


Figure 38: Scatter plot; change in the total number of employees per German bakery by year, 2011–2018. Note: OLS line of best fit and 95% confidence interval superimposed (Zentralverband des Deutschen Bäckerhandwerks e. V., n.d.-a)

As Figure 38 indicates, the increase in the total number of employees per bakery by year is almost perfectly linear. The OLS regression of the total number of employees per bakery by year was statistically significant, $F(1, 6) = 451.61, p < .0001$. The coefficient of determination of this model was .9869, indicating that 98.69% of the variation in the number of employees per bakery can be explained by variation in the year. The coefficient for the predictor of year is 0.59 ($SE = 0.03, p < .001$), indicating that the total number of employees per bakery is increasing by 0.59 per year (95% confidence interval: 0.52, 0.65). The trends assessed in the secondary analysis counter the findings generated in the primary analysis. Whereas the primary research indicates that individual bakeries are essentially indistinguishable from branch or chain bakeries and, therefore, are no less likely to survive, the two German market trends evaluated above suggest some possible points of danger for small individual bakeries. Should the trend of bakery consolidation in Germany continue, it is possible that many individual

bakeries will be folded into larger companies or forced to go out of business as they become unable to benefit from the economies of scale available to larger companies.

7.4. RQ1, RQ2 and RQ3 Qualitative Findings

The following summary of the qualitative findings, using a thematic analysis approach, indicates the emergent themes according to the questions asked. They are presented in consecutive order, according to their appearance in the interview form, as well as relevant subthemes. Of the 10 participants, six were owners/managers of chain bakeries, while four were owners/managers of individual bakeries. Participants are identified from one to 10 by the order of interview completion. The individual questions asked will be identified along with the main emergent theme; additional emergent themes and subthemes will be analysed accordingly.

7.4.1. Topic: Germany's Sustainable Development Strategy

Theme 1: In general, bakeries' owners/managers were not very knowledgeable concerning the country's sustainable development strategy.

When the participants were asked to respond with what they knew about SDGs 2030, they responded, nearly unanimously, that they did not know what they were. The majority responded with simple dissent; however, some offered a more in-depth opinion on the topic. The general consensus is that SDGs are not relevant to the bakery sector. Participant 8 indicated that they were aware of them; however, it appeared to be surface-level knowledge. Some were aware of global UN SDGs but could not pinpoint what Germany's targets were with specificity. However, there was more awareness of the United Nations Sustainable Development Goals (UN SDGs), which suggests that many bakers were, at least, vaguely aware of sustainable development goals. However, they were relatively unaware of how this could affect them and their businesses.

Several subthemes emerged from these responses. First, there were two opposing responses to this question, with the majority of responses falling in the middle with some form of noncommittal response or dissent. One of the interviewees was adamantly opposed to the idea of sustainability goals, believing that they fall into the realm of politics, which they do not consider sustainable. This interviewee was quoted as saying that the 'government has nothing to do with sustainability or they would do other laws', essentially meaning that the government is incapable of promoting sustainability in its current state; we can infer that the interviewee feels this way based on their opinion of the political factor, which means that perhaps they

believe that sustainability goals are a political tool. Only one interviewee was knowledgeable on the subject, but only because they had conducted outside research; therefore, this individual was an anomaly.

7.4.2. Topic: Criteria of a Sustainable Bakery

Theme 2: Sustainable bakeries share certain characteristics and practices, such as avoidance of overproduction, baking organic bread, consuming less energy, and locally sourcing their grain/flour.

There were numerous commonalities in the bakers' statements regarding the question of what makes a sustainable bakery. Nearly all agreed that overproduction is a pitfall that can prevent a bakery from becoming sustainable. This means that bakeries must produce to meet consumer demand to avoid bread waste; waste of product was a secondary concern, although few interviewees distinctly mentioned a lack of waste as a marker for sustainability. The majority of the bakers agreed that a sustainable bakery would only produce what could be sold. Additionally, these goods must be organic or made with natural ingredients and free of chemicals and pesticides; in Germany, organic products are referred to as biological (BIO) goods, so the bread must be BIO for some bakers to consider it 'traditional'. However, it is a common thought that the natural quality of the bread is understood and that labels – as promoted by the government – have little to do with this assurance. Producing bread that is 'organic' (BIO) or natural is simply part of the sustainability process and is not what defines an 'artisan' bakery, as some bakers do not use organic raw materials; the indication of organic (BIO) in this context is in the ingredients, but a bakery can still be artisanal, regardless.

Certain types of breads tend to only last a few days, which can make them harder to sell, but producing only for demand and using what is leftover in other bakes can reduce waste. A secondary concern for being sustainable and for selling organic (BIO) sustainable goods was that bakers should reduce the amount of 'bad' material used, such as plastic for packaging. Some bakers had implemented measures to reduce plastic and non-recyclable use across their operations. Half of the bakers were also convinced that sustainable bakeries should reduce their energy consumption from an economic standpoint, as well as try to find affordable renewable energy sources. Environmental impact was a concern, but from an economic standpoint, with central baking, productivity improvement to reduce energy use, and the avoidance of long shipping distances for products by sourcing goods locally all recommended as steps to reduce consumption. Nearly all of the bakers shared the opinion that local sourcing to reduce

environmental impact, and, more importantly, to support local economies, is a step towards sustainability; however, only participant eight mentioned shipping distances as an issue.

7.4.3. Topic: Criteria of a Sustainable Bread

Theme 3: Sustainable bread is marked by simplicity: simple, natural ingredients and simple processes that let the dough rest well enough to avoid causing digestive issues and to prolong product life to prevent waste.

Two key points were made that were shared by all of the interviewees in some capacity. The first point was that what goes into the baked goods process – or in this case, bread specifically, including ingredients, where they came from, and how the product is made – are all components of sustainability. Keeping the processes simple is preferred over long, complicated methods that involve the use of heavy machinery. As several interviewees noted, bread should only contain simple ingredients or components: water, salt and flour. One mentioned that yeast could also be included in this list, and a few interviewees provided an example of sourdough as a form of sustainable bread. Others noted that ingredients should be locally sourced and that trends such as using seeds and ingredients from other countries – such as Shia seeds and flour and seeds from China – are not beneficial for sustainability (although statistics did not show any flour imports from China); however, as noted, Germans bakers often use full grains in their bakes, which increases the shelf-life of the bread and eventually reduces waste. The implication from all of the responses was that bread that is not made from traditional or locally-sourced ingredients common to Germany – or any bread that uses a baking mix and enzymes – is not considered sustainable; the goal is to produce bread with natural ingredients to avoid waste.

The second point or subtheme that was indicated by the responses is that the process of making the bread is equally as important to producing sustainable bread as its ingredient list. Many of the bakers noted that using traditional knowledge such as letting the dough rest for a long time and using whole grains can not only help promote digestion but also reduces waste because the bread has a longer shelf-life, which allows it to be sold and consumed for a longer period of time and avoids the need to either toss it away or to use it as animal feed (which is a common method of using leftover waste as opposed to ‘binning’ it, as one baker noted). The specific processes that help naturally-produced bread dough have a better shelf-life – and, thus, be sustainable – includes primarily letting the dough rest without the aid of machines that cannot handle allowing dough to rest for as long as it needs to (at which time producers might add softener to the dough). Secondary considerations are to use re-growing components in the ingredients and chemical makeup of the bread, and to produce bread that allows proteins and

gluten to be processed naturally, which is also a by-product of better resting time. As the bakers noted, this part of the process is essential, but tends to be specific to the smaller, individual bakeries.

7.4.4. Topic: Ecolabels

Theme 4: Ecolabels on products are not an indication of sustainability and, as such, the majority of customers do not take this into consideration or prioritise this when choosing to buy bread at a bakery. This can also be considered a political or marketing ploy, but the complicated process, effectively, makes the product more expensive to produce and sell.

The response to the question concerning perspectives of ecolabels garnered significantly (and universally) negative feedback. The consensus among respondents was that while the government may consider ecolabels to be important, and they may feel like the government wants to enforce it, they see the ecolabels as: 1) redundant, as baked goods in artisan bakeries are in their perspective ‘clearly’ natural or organic (BIO) products; 2) they are very costly to acquire; 3) they and the customers alike believe that they are pointless as these bakeries establish trust and a reputation with their customers (inclusion of ecolabels does not affect this relationship); and 4) they resent that the government requires them to label their products if they intend to use the term ‘BIO’ in their marketing, despite the obvious signs of BIO characteristics that their products have (essentially, there is no need for the label because the product speaks for itself). The ecolabels themselves do not appear to add value to the product for neither the customer nor the bakery, and the methods of obtaining certification are time-consuming, complex, and tend to be costly. Overall, it is not typically considered worth the effort.

An underlying trend in these opinions is that the bakers feel the government is emphasising the importance of organic (BIO) over locally sourced. This is a trend that can be identified throughout many of the responses across the board (for all 15 items) as the bakers continue to reference that organic is not the only indicator of sustainability; many believe that products that are made from ingredients that have been locally sourced are superior to products that simply bear the BIO label. Other comments regarding the specific complexities of certain labels over others were described; one interviewee indicated that they do follow standards by EU-Bio Siegel but that Demeter’s standards are too complicated. Only two of the 10 subjects considered ecolabels and sustainability certification to be important for both their bakery (to make them appear legitimate as a producer of organic baked goods) and for their customers (who were noted to have specifically asked for products with organic labels).

7.4.5. Topic: Sustainability Reporting

Theme 5: Respondents either: 1) have limited knowledge on what authorities or agencies exist to which they may report their sustainability activities; or 2) are not aware that they may report data regarding their sustainability, and they are generally unaware of why this could be important. As a result, none of the respondents reported the status of their sustainability.

Of the bakers interviewed, only eight indicated that they report to an authority (Trade Chamber IHK, Handwerkskammer or the Bakers Union, and Bäckerinnung or the Bakers Guild), and only two bakers expressed that they receive advice on how to improve sustainability, with a focus on curbing energy consumption. Some of the subjects were of the opinion that if their bakery was not a certified BIO bakery (speaking to the issue of ecolabels and organic certification, which most of the respondents do not comply with) then this eliminated their need to report sustainability progress. Reporting taxes and market changes to the Statistics Office or to the necessary authorities (such as KfW bank) regarding finances seem to be the primary source of reporting. However, although they did not indicate that they reported sustainability progress, a few respondents also reported to the Bäckerinnung Bakers Guild or to the IHK, providing data related to other areas of their business.

The consensus on the need to report to such an agency or authority regarding sustainability was similar to the responses provided for the item concerning ecolabels. As some respondents noted, their priority is not to report to an authority on sustainability or to comply with certifications to label their products as organic (BIO). Instead, satisfying the customer is essential for artisan bakeries, and keeping production and sourcing local, as well as meeting employee needs and expectations, are just some of the ways that a bakery can be sustainable without needing to report their progress. The implication is that the government cannot impact the sustainability of artisan bakeries on more than a surface level such as requiring certification and data reporting. As such, government involvement in the sustainability practices of artisan bakeries is generally considered useless.

7.4.6. Topic: Traditional German Bread

Theme 6: German breads that are considered ‘artisan’ are breads that: 1) require very few ingredients; 2) are made with specific processes or recipes such as using full grain; 3) are specific types of bread including sourdough and Langzeitführung; and 4) have been passed down through generations of bakers.

The respondents identified that not only are there numerous bread types that are considered traditional to Germany but also that the processes with which they are made (or the

craftsmanship) are also important. This often indicates that traditions are methods that have been used by bakers for centuries or recipes that have been passed down through the generations until they have become traditional. The bread type most commonly identified as a traditionally German was sourdough bread, which is made using a simple three-step process of water, salt, flour and a sourdough starter called leaven, which allows the bread to rise; it is a fermented dough that is filled with natural yeast and lactobacilli. The second-most commonly identified bread was Langzeitfuehrung, which indicates a long fermentation time (also made with basic ingredients of water, salt, and flour). Additional traditional German breads identified included Mischbrot (equal parts of rye and wheat flour), bread made with spelt grain, Pumpernickel, Komissbrot, Socialbrot (which is a local bread one bakery owner uses), Vollkornbrot (full grain), and Bremer Klaben (another example of a local specialty). Other traditional breads include grains such as einkorn, which is an older type of bread.

The respondents emphasised the relationship between traditional knowledge that is associated with traditional techniques. As participant 8 noted, handwerk is a specific process traditional to German bakeries because ‘bread making is a craft [and] it must be produced by hand’. There were countless local specialties that the bakers considered important as they reflected on the specific cultures, traditions, and heritage of the towns and regions they came from. Other subthemes that can be identified in these responses are that it is important to retain and preserve traditions such as handwerk and use of whole grains (like einkorn), some of which have gone out of fashion in recent years. As noted by some, full-grain bread recipes are considered more traditional than non-full grain because this was the style of bread produced before baking became more ‘conventional’. Not only is this type of bread better from a nutrition standpoint but it also preserves the German baking heritage, which, according to the bakers, involves producing natural, organic breads.

7.4.7. Topic: German Bread Heritage

Theme 7: Identity is important for artisan bakeries, and certain protection needs to be in place to prevent factories and supermarkets/discounters from using the names or infringing upon the identities of the bakeries and traditional German bread. Specific processes such as handwerk and recipes for local specialties should be protected, and producers who use machines should not be able to capitalise on the label or the title of ‘bakery’.

Responses to this topic were a bit divided as the interviewees could not provide a consensus on whether or not traditions specific to artisan bakeries could be protected, or if the government could facilitate this protection. For instance, many agreed that traditions can be protected by

remaining relevant to the customers who demand these goods, and bakeries can accomplish this by continuing to use practices such as *handwerk*, producing organic breads with natural ingredients, and by supplying to demand. Baking regional or local speciality breads was also identified as an important component, along with the continuing production of *Sauerteig* and *Langzeitfuehrung*, which are two important characteristics of bread heritage. However, most respondents were unsure of how these practices could be protected. Most agreed that three key traditions could and should be protected: the names and identities of the bakeries, the recipes of local specialties, and the processes they use. When asked about their contributions to the German Bread Register (bread culture database), all of the bakeries confirmed they had registered at least one recipe, and some had registered up to five. Similarly, regarding knowledge transmission, bakeries ensured that baker trainees obtained sufficient support and guidance to learn about breadmaking traditions in the process of becoming a professional certified baker.

Furthermore, the protection of local specialties was considered important by many of the interviewees because these reflect the unique traditions of their specific region; thus, other producers should not be able to use the recipes to sell the bread in their stores. This is because many believe mass producers or retailers who sell pre-packaged, non-organic breads or who do not bake in-house should not be called a bakery or be allowed to use any label or naming scheme associated with artisan bakeries. Shops who also bake ‘ready-made’ goods or pre-mixed goods, should also not consider themselves a bakery or refer to themselves in such a way; this would seemingly protect the status of artisan bakeries and legitimise them in the customers’ eyes, as only labelled bakeries would produce bread from scratch and in-house. Participant 10 even suggested that grocery retailers such as Lidl and Aldi should not be allowed to bake at all – from scratch or pre-mixed products – because they are not, technically, bakeries. Only one interviewee was able to identify specific protections or seals that are already in place (such as PDO [Protected Designation of Origin]; PGI [Protected Geographic Indication]; and TSG [Traditional Specialty Guarantee]), which protect local bread varieties and their recipes. Most respondents believed that the best way to continue protecting bread heritage was to continue to use artisan breadmaking skills and attract customers to promote demand and interest.

7.4.8. Topic: Disappearance of Individual Bakeries

Theme 8: Individual bakeries began to suffer a decline in decades such as the ‘70s and the ‘80s, with the rise of supermarkets and discounters; however, interest in artisan bakeries and organic

products has been revived in the last decade. A niche for artisan small bakeries still exists, but many artisan bakeries have turned to new trends to stay relevant.

Perspectives on the challenges that small bakeries endure are common in the sense that many believe competition with supermarket or grocery retail stores and discount stores has made competition too fierce, as small bakeries cannot produce in the quantities that larger artisan bakeries or commercial, industrial, grocery retailer can (if they did, this would not be sustainable as they would not be supplying for demand). The consensus is that the disappearance of bakeries is not universal, but rather, some areas are seeing growth in individual bakeries and others are seeing a decline. A possible reason for this is that, in towns and local municipalities, where the niche interest of artisan baked goods can be capitalised upon, individuals who were once in another profession have decided to open bakeries (many noted that such new bakeries are often established by former bankers). These new bakeries adapt to modern methods to form new traditions, and this results in a loss of old heritage. So while these are still individual bakeries, they may be less 'artisan' than they appear to be at first glance; this has an interest implication of the label 'artisan' being another factor of sustainability that not all individual bakeries have, because some use traditional processes with traditional recipes, thereby baking 'artisan breads', while others do not. Of course, more than one bakery owner noted that it is also important to develop new traditions, as bread culture is an evolving element.

A subtheme that emerged from these responses was that individual bakeries suffer from high costs, which leads many respondents to open branches to make a profit. As Participant 3 notes, small bakeries face three key issues when they first open or when they are struggling to maintain a profit. First, it is more difficult to control bakeries regarding their production and sustainability activities (this sentiment was also reflected in previous responses concerning sustainability reporting and ecolabel use), which, in Participant 3's view, makes the government less amenable to individual bakeries (or more willing to require less of them legally). Second, because the legal regulations for German businesses are so stringent, individual bakeries struggle at times to cope with these requirements. Third, to be a bakery owner means to be self-employed, and, with this, comes the responsibility of having to keep trainees, employees, and bakers on payroll, comply with legal regulations, and maintain accounting paperwork, tax information, and additional data. As several interviewees noted, the lifestyle of a self-employed worker in Germany has lost its appeal to the general public over the last several decades, meaning that the culture of being self-employed, with all its legal and financial strings attached, is not desirable.

7.4.9. Topic: Finding and Recruiting Bakers

Theme 9: The reputation of a baker is hindered somewhat by the status of being self-employed, which is less desirable in Germany. However, respondents do not often have a hard time recruiting trainees for their bakery; neither is it their perception that this is an industry-wide problem. One of the primary reasons for the reduced retention of trainees is the working hours. There were several shared points made across the responses, which can be summarised as the following: 1) many people from different backgrounds (often banking) are expressing an interest in becoming trainees at bakeries with the view to, one day, opening their own bakeries; 2) retention of trainees can be difficult because: a) many become worn down by the long working hours (bakers must come in very early in the morning to prepare for the day, they often leave late at night, and many work on weekends); b) they find better employment before they start or they drop out of training; or c) they do not want to be self-employed; 3) well-established bakeries have few problems receiving applications for trainee positions, but bakeries in smaller states or cities can experience challenges; 4) bakeries mostly train in-house; 5) payment can be an issue because it is: a) generally low; and b) inconsistent across regions (Participant 2 and Participant 4 disagreed on whether the pay in South Germany was higher or lower than the Trade Union average); and 6) bakers tend to have a low reputation with the general public because the profession is associated with Hauptschule, or having the lowest form of education (high school). The overall implication is that the traditional aspect of becoming a baker in Germany is not quite appealing enough to make up for insufficient salaries or wages; however, if one has a passion for baking, or a strong interest in artisan baking, than these are individuals who fulfil their training, become bakers and develop experience, and subsequently, open their own bakeries.

7.4.10. Topic: Modern Apps and Delivery

Theme 10: Smaller artisan bakeries do not often use food delivery applications or services, mainly because the owners see that this defeats the purpose of their local bakery. Some artisan bakers choose to use these tools as a strategic method of reducing waste, with the implication that allowing more purchase options and sale channels increases profit and reduces waste at the same time by selling product more quickly (and to more customers). However, this is still not common practice.

The general consensus among the respondents was that they are consistently opposed to the use of food delivery services or applications, and many believe that the appeal of having a local, artisan bakery is the experience of shopping in-person to purchase goods that are fresh.

The concept of delivery services to sell more products is not a good reason to use such applications or services; although it could be of benefit, it would not be enough to offset the cost of using the services. Many respondents reflected on the fact that they would have to lose money to take part in the service, which, to them, seemed unnecessary given there is little demand for this type of purchase option among their customers (many of whom enjoy the experience of travelling to the local shops). Bakeries can sustain a profit by satisfying the customers, building trust with them, and producing for demand; therefore, there is little need to use modern applications and services.

However, several bakeries see the purpose in delivery services, with Participants 5 and 6 noting that they either used applications and services, or that they did not use third-party services because they preferred to make deliveries using their own employees. A few of the bakers suggested that applications and services can be a method of reducing waste, but this is only a useful method if waste is a top consideration for the bakery. For example, Participant 1 stated that their waste was less than 1% and that applications were not used for this purpose ‘because [they] don’t have problem with waste’, rather, they ‘sell good[s] from the day before for a cheaper price’ and that perhaps ‘one box per week will become chicken food’. Participant 6 was the only bakery owner who admitted to using applications or services (Too Good to Go, specifically); they used it for waste reduction rather than to gain a profit, considering that the maximum amount that could be sold was five small bags worth – essentially, what could not be sold on any particular day.

7.4.11. Topic: Selection of Flour and Bread Ingredients

Theme 11: Quality and location are the two most important factors for sustainability concerning ingredient selection – more so than an organic label (BIO). Purchasing locally-sourced ingredients at affordable prices is key to being sustainable because this reduces transportation costs and can cultivate trusting relationships with co-ops and farmers. This allows customers to feel more positive about buying baked goods.

Respondents need to be cognisant of several factors of sustainability when they purchase ingredients such as flour or grains. First, the ingredients and materials need to be locally sourced. Some consider this to mean organic, but as many perceive ‘organic’ to be not necessarily equivalent to natural, in this context, it is used to mean ingredients that are sourced from local farmers who the bakers know and have developed a partnership with; because of this, they are more aware of the sustainability of the farm itself and feel more secure in knowing that their raw materials and ingredients are natural or are of high quality. Second, sourcing

from farms that are BIO-certified and that do not mill mixed-flour, is a better option over farms that use mixed-flour and who use conventional methods. Third, partnering with farmers and obtaining low costs for ingredients is key to lowering production costs and overall sale prices; this is another key to being sustainable as this attracts customers to their bakery so that they can purchase quality baked goods at affordable prices; however, without these close partnerships, buying from local farmers is not always the most affordable option, although it is still the most sustainable as this supports local farmers and bakeries still receive quality ingredients.

The respondents were split with regard to the importance of cost when selecting flour and bread ingredients, with half perceiving cost to not be the most important factor and the other half of the respondents indicating that affordability was crucial. This implies that regional differences can be significant enough that prices for locally sourced organic or natural ingredients may differ from one region of the country to the other, and that this may affect perceptions. The respondents universally agreed that local sourcing was critical and that this indicates the true nature of artisan bakeries, which do not source their ingredients globally or acquire ingredients from foreign countries to satisfy popular trends or customer demand. These are not the most sustainable activities in bread production, which often includes the most simple processes and ingredients. Some bakeries in certain regions of Germany are better with regard to finding affordable, organic farms from which to source their ingredients, such as farms located in and around Berlin. A potential implication of this is that the population size and a healthier economy is what allows bakeries in urban cities to use the opportunity to find better options because they have more choices available to them.

7.4.12. Topic: Using Energy Sources Efficiently

Theme 12: Equipment and machinery that are designed to conserve energy are essential to being sustainable with bakeries' use of energy; however, maximising the use of a heat source is critical. Heat requires energy; therefore, planning must go into using this energy source efficiently as well as reducing the freezing process and using renewable energy.

The interviewees were extremely knowledgeable of practices to reduce energy consumption as well as the importance of this step in being a sustainable bakery. In fact, the recovery and reuse of heat sources were touched upon by several of the respondents as a key component of efficient energy use. Specifically, breads can be leavened at room temperature to reduce the use of a heat source initially, but when breads require, heat the baker should plan so that the heat source can be used to bake all of the bread at once, or, at least, to maximise the quantity of bread that

is baked at one time. Methods such as heat recovery ventilation can reuse and repurpose heat and recover up to 95% of the heat that is produced; insulating the production area also conserves energy by reducing heat loss (that way, bakers avoid needing to use even more heat to replace what has been lost due to natural cooling effects of inefficient insulation). The heat produced by the oven can also be used in the fermentation or leavening process once the ovens have already been put to use. As many of the bakers noted, there are ovens that can conserve up to one-third of the energy used by non-energy-saving ovens because they isolate well; however, these options are less affordable.

Several other methods of conserving energy or using energy efficiently were noted, including the use of electric cars to deliver baked goods (Participant 3 noted that this is how they have delivered bread to customers since 2012). Key strategies include not using more energy than what is required by cutting equipment off when not in use, or by turning lights off. The lighting can also be made more efficient by replacing traditional, conventional bulbs and replacing them with LED lights. Several bakers noted that avoiding the use of a freezing method and preparing everything fresh keeps energy use down (freezing requires the use of fridges and commercial freezers that use a large quantity of energy). Working with one's hands by using handwerk is also essential, and allowing the dough to rest at room temperature, or in a proving drawer, will also help if the bakers are not using machinery but allowing the dough time to ferment. Participant 4 noted that renewable or sustainable energy resources such as Biostrom are also important to seek out if the bakery owner desires to become more sustainable with their energy use.

7.4.13. Topic: Available and Affordable Sustainable Energy

Theme 13: Challenges to obtaining renewable energy or sustainable energy resources involve higher associated costs, despite the relative availability of these energy sources and the benefits that the bakers know they bring. Therefore, affordability is a barrier to renewable energies, and many bakeries would invest in this if it was more affordable.

The consensus among the 10 respondents was that, while it is important for bakeries to use renewable and sustainable energy sources, it is not an affordable process. While bakers attempt to save energy in any way that they can, conventional energy is more affordable than renewable, and as such, most bakeries focus on reducing energy consumption rather than choosing to find new sources of energy. Electricity is expensive, but there are cheaper forms of energy such as gas, specifically natural gas. This form of energy has been cited as not only an affordable option, but also one that accounts for less pollution, which bakeries understand

is an important environmental consideration concerning the sustainability of businesses and industries. Despite the costs, a consideration of many bakers is that although renewable and sustainable energies are more expensive, investing in these energy sources is not a foolish move because it will ultimately save the bakery money later on when their electricity and energy consumption is reduced.

A subtheme that emerged from the responses to this question is that choosing local energy providers is a strategic move towards sustainability. Several interviewees suggested that avoiding main energy suppliers such as Vattenfall (in Berlin) and using green energy suppliers such as Lichtblick, or partnering with small, local providers, is key to the responsible use of energy sources. Overall, respondents are cognisant of the need to use more 'green' energy or renewable sources, and that this will allow them to cut back on the overall amount of energy they consume. Of course, this must take place in combination with other practices to reduce energy consumption, such as more effective use of heat, proper insulation, installation of energy-saving equipment, and avoidance of freezing processes. The respondents understand that, to become truly sustainable, they must invest in processes that are less affordable at the outset so that they may benefit from the processes at a later date.

7.4.14. Topic: Reducing Waste

Theme 14: Artisan bakeries can be sustainable if they manage to reduce waste, and this requires the bakeries to avoid overproduction, to produce only what is needed to supply demand or what can reasonably be sold, and to either incorporate unused products in other bakes (as per adherence to regulations regarding percentage of old bread use) or dispose of them naturally by way of animal feed.

Reducing waste is considered to be a top priority for artisan bakeries, not only from a nationwide sustainability standpoint, but from the standpoint of reducing the burden that overproduction places on bakeries. A running theme throughout many of the respondents' comments, regarding this question and prior questions, has been the issue of waste, with some choosing to use leftover production for animal feed and the majority declaring that they limit waste by not overproducing or by simply producing for demand (in some cases, even producing less than demand to ensure that all products are sold by the end of the day). The respondents also referenced a specific technique called *Altbrot*, which is the use of old bread incorporated into new bakes. Participant 7 noted that, in their state, they are allowed by regulatory authorities to have their new products be comprised of 30% re-baked bread. This *Altbrot* method effectively recycles bread and cuts waste out almost completely. The bakers dry their waste

and then grind it for use in sourdough and other breads, and it counts as an official additive. As Participant 1 noted, 'It ties water and makes the bread moister, and it improves the taste. It is not waste; it is a raw ingredient. And you don't have to disclose it, because it is made of the same ingredients as the new bread itself. The old bread goes back into the production cycle'. Several other methods can be used by bakers to reduce their waste, including the following: commonly, waste is used in animal feed and this repurposes the waste, although it still results in a loss for the bakery; bakers can partner with organisations to pick up products in the shop that has become waste and use it for charity or other purposes; bakeries can donate waste to charities themselves, ensuring that the bread does not, essentially, become waste but rather that it is still consumed; or, in a particularly innovative method, bakeries can ensure that they only produce to meet demand by encouraging their customers to pre-order bread from the shop. By using the pre-order method, bakers can stay on top of demand and their overproduction by fulfilling orders and only producing enough to be sold in the shop that will either meet demand or fall slightly short. Other methods, such as reducing the cost of bread, can attract customers to purchase products before they become waste. Forecasting for demand and projecting daily sales are essential marketing and economic tools that bakers need to understand how to use to estimate customer demand.

7.4.15. Topic: General Comments and Thoughts

Theme 15: The primary responsibilities and obligations that respondents must have for them to be sustainable are to use 'traditional' baking methods, including handwerk and non-machinery processes, to create 'artisan' organic (BIO) bread.

The majority of the participants opted to not provide any additional comments or details; however, three interviewees had additional comments. Some of the shared perceptions and points made were that bakeries must be expected to take more responsibility for producing fully BIO products and avoid non-traditional methods by not using enzymes or pre-mixed flour. In fact, as suggested by Participant 2, there is little requirement for bakers to declare their ingredients, meaning that bakers can use unnatural ingredients such as enzymes and they can use pre-mixed flour formulas without needing to declare them; this implies that the nature and legitimacy of 'artisan' bakeries can be called in to question, as being 'artisan' is a factor of sustainability that includes producing baked goods that were made with natural, locally-sourced ingredients and simple processes. Many noted that an effect of the push for industrial producers and supermarkets/discounters to mass produce with machines has resulted in these bakeries feeling pressured to keep up, but they cannot, because of their limitations. However,

attempts to keep up would only hinder the bakery's sustainability because the dough cannot rest for long periods with the use of modern machines; therefore, it is the hope of artisan bakers that advancements in technology and machinery can mitigate this issue.

7.5. Summary of the Interview Findings

The qualitative findings for RQ1, RQ2 and RQ3 resulted in the identification of five themes. The themes are summarised as follows:

7.5.1. Local is Sustainable

Of the 10 participants, 6 emphasised local concepts in their definition of sustainable bread. The concept of local was discussed in terms of: (a) obtaining raw materials and labour from the immediate community; (b) serving local customers; and (c) continuing to participate in the local ecosystem of supply and demand. This concept of local indicated that, even when a bakery is a branch of a larger company headquartered in another city, the sustainability of that bakery still rests on the quantity and quality of its participation in local supply, demand, and ecosystem dynamics. One participant explicitly critiqued the practice of sourcing ingredients from other countries or from long distances away within Germany.

7.5.2. Waste Minimisation

Another theme, one that was attested by seven participants, was that of waste minimisation, primarily through supply-demand balancing. In the context of sustainable bakery management, waste minimisation can take several forms. For instance, participants discussed how waste can be minimised by: (a) refusing to overproduce bread (that is, by aligning supply and demand); (b) reducing or eliminating packaging; and (c) using full grains. Of these subthemes, (a) was of more interest, because it raised important points about how supply and demand can be aligned, given the short shelf life of certain kinds of bread.

7.5.3. Supply–Demand Balancing

Five participants indicated that sustainable bread should emerge from the context of supply–demand balance in production. Supply–demand balancing can be considered complementary to the theme of waste minimisation. In theory, no waste means that supply and demand are perfectly balanced.

7.5.4. Bread Culture is a Key Element of Bread Sustainability

Sourdough bread was noted as being an artisan German bread. Sourdough was discussed in terms of long-term fermentation as well as its basic ingredients of water, flour, and salt. The bread was associated with sustainability because of its longer shelf life, superior nutritional qualities, and connections to local traditions. Artisan bakeries, thus, emphasised the production of sourdough as one of their core values, relating the nature of production to sustainability. The main recurring themes in this area related to bread heritage conservation by bakeries included identification and documentation through the Bread Register, promotion through the protection of regional specialities and the name ‘bakery’, and transmission of traditional knowledge through the apprenticeship programmes for baker trainees.

Some participants made the distinction between artisan and industrial bread. Artisan bakeries not only associated themselves with traditional knowledge (such as those utilised to make sourdough), but also suggested that their status as artisan producers should be protected by regulations forbidding industrial bread producers to define themselves as bakeries.

Finally, some participants argued that borders should be protected to prevent the imports of foreign breads. In this sense, artisan bread was defined not only in terms of certain production techniques, but also in terms of its physical association with different regions of Germany. Border protection is clearly related to the subtheme of name/trademark protection that artisan bakeries demand.

7.5.5. The Risks of Losing Individual Bakeries

In terms of the risks, the qualitative findings indicated that the loss of small bakeries would represent an important cultural loss. One of the themes that emerged from the qualitative analysis was that, in recent years, Germans have begun to increase their demand for artisan bread. Many consumers now see artisan bread as a superior alternative to industrial bread. In addition, consumers who are influenced by environmentalism and other green motivations prefer the idea of purchasing artisan bread. This spike in demand in the German marketplace suggests that individual bakeries, which are more likely to specialise in artisan bread, have good prospects of surviving and thriving in the future, given their support by many consumers.

Several participants suggested that there is space for smaller bakeries as part of the niche of artisan bread production. The diversification and sheer size of the German economy makes it possible for individual bakeries to continue to survive by serving their niches in different

locations. From this perspective, individual bakeries have the opportunity to both survive and thrive in the years to come.

7.6. Discussions and Summary of Findings

7.6.1. RQ1

The first research question was: What is sustainable bread? Sustainable bread can be described from different perspectives, most importantly the policy perspective and artisan bakeries' perspective as key stakeholders in the artisan bread sector in Germany.

From a policy perspective, the concept of bread sustainability mainly focused on the environmental dimension. Therefore, a sustainable bread was characterised by:

- The use of organic ingredients to protect biodiversity
- The use of a credible ecolabel (publicly managed) to promote standards
- The use of renewable energy to lower energy dependency and emissions
- Reporting to EMAS to promote transparency
- Being efficiently produced to conserve resources
- Having a low environmental impact

Prioritising the environmental dimension might drive the bread system transformation to trade off socio-cultural characteristics for the benefit of environmental improvements. Modern technology, efficient production systems, and renewable energy are significantly costly measures for small businesses such as the artisan bakeries. Their competitive advantage remains focused around their socio-cultural aspects and the protection measures surrounding the bakery trade. A holistic approach towards food sustainability implies the preservation of the social, environmental, economic, cultural and nutritional aspects of a food system (Meybeck & Redfern, 2013). Therefore, the expansion of the policy perspective to include further dimensions and criteria associated with food such as culture and resilience of small, local food systems, are crucial to increase the resilience of the German food system in light of global challenges and risks.

From the bakeries' perspective, although there were some conflicting values, sustainable bread generally relates to the dynamics of the local economy (farm-bakery-customers), the protection of trade, as well as aspects related to traditional practices and energy and waste minimisation techniques. Therefore, a sustainable bread is characterised by:

- Locally farmed grains (natural or organic)
- Produced within an authentic artisan bakery
- Handmade
- Meets customer's expectations in terms of quality and freshness
- Prepared with full-grain flours and sourdough
- Allowed plenty of time to rest (*Lanzeitfuehrung*)
- Baked using energy efficient ovens
- Uses eco-friendly packaging (paper bag or no packaging at all)
- Recycled and reused when possible

Given that Germany's sustainable development strategy was only introduced in 2002, looking at how the artisan bakeries are adopting sustainable practices and making progress in that area, seems very optimistic. Two decades is a relatively short time for such a transformation, having in mind that the bread system could have in the first place some intrinsic sustainable values which could now be interpreted and associated with our current understanding of sustainability. Hence, the reason bread survived and remained one of the most well-established food systems ever known to humans.

In relation to literature, the dynamics of what sustainable bread is can change according to the context (mainly area and population). The farming of grains in a sustainable way depends on the capacity to sustainably supply grains; a parameter reflecting the balance between needs and capacity in the German context. Productivity levels and local needs affect the farming intensity and, therefore, the pressure on biodiversity through the extensive exploitation of the biological system (Monetti, Pregernig, Speck, Langen, & Bienge, 2021). Germany in this sense, tries to balance the need of Germans for bread and the health of the environment; however, the environmental capacity and population need are, somehow, currently, at a balanced, healthy level. Moreover, the transparency of the linkages among the food system stakeholders can help to achieve better management to address issues and challenges; in this regard, ecolabelling and reporting both relate to that area but appears to be unique to the European and German context. Bread's cultural dimension, nevertheless, is being protected, not via the SDGs but through a regulated framework involving ZDB and ZDH, who, in turn, try to implement sustainability in the sector, by advocating for the importance of the artisanal bread sector. The two movements can complement each other so that they promote bread sustainability.

7.6.2. RQ2

The second research question was ‘What is the role of artisan bakeries in promoting bread sustainability, how do they contribute towards achieving the national SDGs?’ The quantitative analysis of RQ2, with regard to national SDGs, provided evidence of positive contributions across a range of SDGs, including SDG 2, 3, 7, 8, 11, 12, 13 and 15, with individual bakeries performing slightly better than chains. The qualitative analysis for RQ2 revealed evidence of the general themes associated with bread sustainability including: (a) environment; (b) socio-cultural; (c) economic; and (d) nutritional, and the specific themes of: (a) the importance of traditions (sourdough and slow fermentation); (b) artisan vs industrial bread; and (c) the necessity of trade protection. General and specific themes interacted in RQ2 to provide a more complete picture of how bakeries contribute to bread sustainability, by adhering to traditional knowledge and local ingredients, while remaining competitive as a means of survival.

Artisan bakeries are engaged in efforts to protect biodiversity through their transition to organic (40%); they contribute to promoting the health of the population by producing simple healthy breads, and, as businesses, they contribute towards the transition to cleaner renewable energy sources (although, at a slower pace due to the cost of transition); they promote local economies (farmer–bakery–consumer) and positively contribute to the resilience of the bread system, especially at the local level. Further progress is necessary to connect bakeries with the national monitoring framework, perhaps, through an alternative route to EMAS.

7.6.3. RQ3

The third research question was ‘What influence does a changing artisan bakery sector have on bread sustainability?’ The risk of individual small bakeries disappearing was assessed to be low insofar as individual and chain bakeries were similar to each other in terms of their assessment of threats, their business expansion, and their bread waste. The main detected difference between individual and chain bakeries was found to be in the domain of production expansion; individual bakeries were found to be almost four times as likely as chain bakeries to have increased their production over the past 10 years. Although secondary analysis led to the conclusion that: (a) the number of bakeries is shrinking; and (b) the average employee count of bakeries is increasing, these findings do not necessarily suggest a threat to individual bakeries, given how well they occupy the niche of demand for artisan, sustainable bread. However, in terms of their contribution towards SDGs and to bread heritage, individual bakeries scored slightly higher than chain bakeries, especially in the area of organic production

and artisanal handwork processes. Losing individual bakeries could reduce the overall sustainability of the bread system in the long term, particularly in the areas of biodiversity (slow adaptation of chains) and heritage (mechanisation of production).

8. Conclusion

8.1. Synthesis

The sustainability index score indicated that artisan bakeries had a sustainability score of 5.5 on a 10-point scale. In general, the literature on sustainability suggests that many companies are moderately sustainable, with relatively fewer companies having either very low or very high levels of sustainability (Butler, Henderson, & Raiborn, 2011; Jones, Hillier, & Comfort, 2014; Rosano & Schianetz, 2014). The quantitative analyses indicated that this pattern of moderate sustainability also appears in the context of artisan bakeries. Most bakeries are close to being moderately sustainable, and relatively fewer bakeries have either high or low sustainability. The literature on sustainability also indicates that it can be achieved by a large cross-section of companies, regardless of size, and without reference to other industry and sectoral characteristics (Epstein & Roy, 2001; Eyhorn, Ramakrishnan, & Mäder, 2007; Perrini & Tencati, 2006). These previous findings are also in alignment with the finding that sustainability was both moderately and, potentially, normally distributed in the sample.

The qualitative, as well as quantitative findings, gave rise to the idea that sustainable bread is also traditionally and locally sourced, produced, and disseminated, confirming the importance of local capacity in the context of sustainability. In Chapter 3, the literature review, a substantial discussion was held on the evolution of food, both as an expression of culture and as part of industrialisation processes. In Germany, the concept of sustainable bread is closely related to cultural – that is, traditional – concepts about how bread should be sourced, produced, and disseminated. Sustainability has been discussed in the context of economic sustainability, which is closely connected to economies of scale and other large-scale business processes. It is important to note that the concept of sustainability that emerged from this study was only partially reliant on the concept of economic sustainability. The SDGs for Germany also define sustainability in terms of social justice, environmentalism, and other values.

Industrial bread production is, undoubtedly, efficient because of economies of scale, insofar as it can result in the production of more units of bread for fewer inputs (including labour and factory inputs). However, one of the points made by the participants in the qualitative portion of the study was that bread cannot be conceptualised solely in this fashion. The participants suggested that it is worth paying more for bread that, because of its rootedness in artisan production techniques, is healthier, has a longer shelf life, and is better tasting. In this sense,

there might be a trade-off between economic sustainability and socio-cultural sustainability. While people can certainly live on bread that is less nutritive and not as tasty, but that is cheaper to manufacture in large quantities, such a state of affairs would also represent an important social and cultural loss. As the durable demand for artisan bread in Germany attests, consumers are not approaching bread solely as a commodity; the taste, characteristics, and other qualitative aspects of bread are all part of its social sustainability, that is, the importance that it possesses for different communities within Germany.

Environmental sustainability is the main factor to consider, as it was prioritised within the national strategy and reflected through the 17 SDGs. Participants noted that artisan bread has a reduced carbon footprint, as ingredients are sourced locally and made with procedures that do not result in excess emissions.

8.2. Limitations

The suitability of the SDG framework for the sustainability assessment might be criticised as being too broad, as attested in the literature with regard to holistic approaches facing weaknesses related to their precision and feasibility. This has been justified and addressed, but the measurements within the indicators remain a limitation since baselines did not exist for the samples; therefore, the rating was slightly subjective in terms of categorising the performance as positive or negative without in-between categories reflecting real-life scenarios.

The qualitative findings had some limitations. One limitation was that there were only 10 participants. Creswell (2015) recommended between 10 and 16 qualitative participants to reach data saturation, that is, the point at which participants begin to repeat themselves. In addition to there being only 10 participants in the qualitative portion of the study, the participants did not necessarily provide what Creswell describes as rich descriptions. Rich descriptions are answers to questions that are characterised by length, depth, and insights. Answers that are brief, that recast open-ended queries into yes/no answers, and that otherwise do not engage meaningfully with either the form or the substance of what is being asked, do not result in the accumulation of rich data. Although some of the participants in the qualitative portion of the study offered rich descriptions, several did not. Therefore, the qualitative findings were limited by both the quantity and the quality of the responses given to the answers posed by the researcher.

The attained statistical power of the logistic regression procedures applied in the study was similarly low. On the assumption that logistic regression had a detectable *OR* of 1.5 and an α of .05, and based on one tail, the attained statistical power of the *OR* calculations in the study was approximately 0.39. Therefore, there was a mere, approximate 39% chance that the logistic regression results presented earlier were accurate. Simulation in *a priori* modelling suggested that a sample size of roughly 400 bakeries would have been necessary to achieve a higher level of statistical power, something that could not be achieved with the type of samples in this study (i.e. clusters). However, cluster analysis was not feasible due to the small number of participants, which can potentially hinder the interpretation of clustered characteristics.

8.3. Summary of Contributions

This study contributed to the literature on bread sustainability by applying and expanding knowledge on the holistic sustainability of the bread system, particularly the artisan bread sector. The study demonstrated how the national SDG framework for sustainability can be operationalised to assess the sustainability of artisan bakeries. The study utilised appropriate, explanatorily valid statistical methods to calculate the mean sustainability of German bakeries and contributed to an understanding of the similarities and differences between individual and chain bakeries. The study explored and explained numerous elements of artisan bread, assembled one of the largest samples of German bakeries attested in the existing empirical or scholarly research literature, and provided a rich discussion of sustainable bread and bread production in a German context. The study provided an example that can be followed by future quantitative and qualitative researchers interested in the topic of sustainable bread.

8.4. Directions for Future Research

There are several possible directions for future research. One possible direction is to focus on the SDG framework (or an equivalent national sustainability framework) as an explicit source for holistic sustainability measurement. In this study, some SDGs were mapped onto survey questions, and an alignment between the SDGs and bakeries was achieved in this way; causal relationships were defended with strong analysis. However, the SDGs included specific target scores that future researchers could develop into a larger, more comprehensive instrument to measure sustainability. To do so, future researchers can work backwards by: (a) taking each of the SDGs in turn; and (b) designing a question that can be plausibly posed to food businesses. However, it might be possible to survey more expansive industries (such as automotive manufacturing or financial services) in a manner that captures more of the SDGs and their sub-

components; baselines measurements are essential requirements for stronger, precise quantitative output.

Culture can also be an important theme in future research. Sustainability should be explored in a manner that is sensitive to the maintenance of cultural values – for example, as reflected in the preservation of German bread heritage, with its reliance on sourdough and artisan production methods. Future instruments for measuring sustainability could take elements of culture into account, on top of the classic environmental, social, economic and nutritional dimensions.

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Appendices

Appendix 1 Raw data

#	Location	Q1	Q2	Q3	Q4	Q5				Q6			Q7	Q8	Q9	Q10				Q11		
		Year es	Brar	Empl	Daily p	Supply	Rear	Flou	Grai	Own	Use of st	Farn	App	Con	Orga	Why	Price	Low	Insu	Com	Roof	Ethy
1	Hamburg	1889	8	58	2500	No	Yes	No	No	No	13	No	Yes	Yes	No	No	No	No	Yes	No	No	No
2	Leipzig	1912	1	24	200	No	Yes	No	No	Yes	10	Yes	No	No	No	No	No	our c	No	No	Yes	Yes
3	Bamberg	1938	4	43	350	No	Yes	No	No	Yes	14	Yes	No	No	No	Yes	No	No	Yes	No	No	No
4	Ravensburg	1883	52	400	6750	No	Yes	No	No	Yes	12	Yes	No	No	Yes	No	Yes	Impc	Yes	No	No	No
5	Münster	1990	1	65	3400	No	No	No	Yes	No	10	No	Yes	Yes	No	No	No	No	Yes	No	No	No
6	Hamburg	1985	5	17	1500	No	No	Yes	No	-	13	No	Yes	No	No	No	No	No	No	No	No	No
7	Hannover	1847	6	54	500	No	No	Yes	No	-	27	Yes	No	No	No	No	No	Do n	No	No	No	No
8	Heidenheim	1924	25	300	9000	No	Yes	No	No	Yes	5	Yes	No	No	No	No	No	Regi	No	No	Yes	Yes
9	Schwanewede	1868	30	372	9000	No	Yes	No	No	Yes	33	Yes	No	No	Yes	No	No	No	No	Yes	No	No
10	Berlin	1999	1	8	200	No	Yes	No	No	Yes	57	Yes	No	No	Yes	No	No	Certi	No	No	Yes	Yes
11	Arnstadt	2017	1	10	300	No	Yes	No	No	Yes	11	No	Yes	Yes	No	No	No	No	Yes	No	No	No
12	Berlin	2016	1	13	200	No	Yes	No	No	Yes	96	No	Yes	Yes	No	No	No	No	Yes	No	No	No
13	Aachen	1900	1	20	300	No	Yes	No	No	-	66	No	Yes	Yes	No	No	No	No	No	Yes	No	No
14	Regensburg	2010	2	15	600	No	No	Yes	No	No	11	No	Yes	Yes	No	No	No	No	Yes	No	No	No
15	Leipzig	1993	25	270	1000	No	Yes	No	No	Yes	113	Yes	No	No	No	Yes	No	No	Yes	No	No	No
16	Berlin	2012	3	25	1300	No	Yes	No	No	No	97	No	Yes	Yes	No	No	No	No	Yes	No	No	No
17	Freiburg	2014	1	3	20	No	Yes	No	No	No	65	No	Yes	No	No	No	No	We a	Yes	No	No	No
18	Annaberger-Buch	1957	31	180	2500	No	Yes	No	No	Yes	94	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
19	Baden-Wuertten	1936	4	51	1200	No	Yes	Yes	No	No	100	Yes	No	Yes	No	No	No	No	Yes	No	No	No
20	Hanover	1920	32	335	5000	Yes	Yes	No	No	Yes	77	Yes	No	No	Yes	Yes	No	No	No	No	Yes	Yes
21	Leipzig	1993	25	250	2500	No	Yes	No	No	Yes	90	Yes	No	No	No	No	No	curre	Yes	No	No	No
22	Hanover	1847	6	55	380	No	Yes	No	No	Yes	25	Yes	No	No	Yes	Yes	No	No	Yes	No	Yes	Yes
23	Hamburg	1985	5	38	1500	No	No	Yes	No	No	0	No	Yes	Yes	No	No	No	No	Yes	No	No	No
24	Beuster	1863	10	38	3300	No	Yes	No	No	Yes	19	Yes	No	No	No	No	No	we h	Yes	No	No	No
25	Lehrte	1965	9	85	3000	No	Yes	No	No	Yes	150	Yes	No	No	No	No	Yes	No	No	No	Yes	Yes
26	Münster	1860	19	236	3000	No	Yes	No	No	Yes	60	Yes	No	No	No	Yes	No	We a	Yes	No	Yes	Yes
27	Ulm	1890	2	14	550	No	Yes	No	No	Yes	15	Yes	No	No	Yes	Yes	No	No	Yes	No	No	No
28	Aalen	1912	1	18	180	No	Yes	Yes	No	No	20	No	Yes	Yes	No	No	No	No	Yes	No	No	No
29	Waren	1935	2	22	200	No	Yes	No	No	Yes	11	No	Yes	Yes	No	No	No	No	No	Yes	No	No
30	Schwerin	1890	26	198	3250	No	Yes	No	No	Yes	22	Yes	No	No	Yes	Yes	No	Orga	Yes	Yes	No	No
31	Göttingen	1985	1	47	1800	No	No	Yes	No	No	16	Yes	No	Yes	No	No	No	No	Yes	No	No	No
32	Kempten	1976	5	22	1400	Yes	Yes	No	No	-	13	No	Yes	No	No	No	No	No	No	No	No	No
33	Munich	1847	12	108	1000	No	Yes	Yes	No	No	32	No	Yes	Yes	No	No	No	No	Yes	No	No	No
34	Freiburg	1925	25	280	8500	No	Yes	No	No	Yes	12	Yes	No	No	No	No	No	Loca	No	No	Yes	Yes
35	Freiburg	1868	15	176	4600	No	Yes	No	No	Yes	10	Yes	No	No	Yes	No	No	No	No	Yes	No	No
36	Berlin	2001	1	6	180	No	Yes	No	No	Yes	85	Yes	No	No	Yes	No	No	Com	No	No	Yes	Yes
37	Erfurt	2016	1	10	280	No	Yes	No	No	Yes	22	No	Yes	Yes	No	No	No	No	Yes	No	No	No
38	Erfurt	2015	1	13	220	No	Yes	No	No	Yes	13	No	Yes	Yes	No	No	No	No	Yes	No	No	No
39	Munich	1901	1	20	300	No	Yes	No	No	No	58	No	Yes	Yes	No	No	No	No	Yes	No	No	No
40	Marburg	2005	2	12	550	No	No	Yes	No	No	13	No	Yes	Yes	No	No	No	No	Yes	No	No	No
41	Augsburg	1910	26	264	1200	No	Yes	No	No	Yes	32	Yes	No	No	No	Yes	No	No	Yes	No	No	No
42	Luckau	1982	1	8	400	No	Yes	No	No	No	7	No	Yes	Yes	No	No	No	No	Yes	No	No	No
43	Berlin	2014	1	4	40	No	Yes	No	No	No	57	No	Yes	No	No	No	No	We c	Yes	No	No	No
44	Magdeburg	1953	30	158	2600	No	Yes	No	No	Yes	14	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
45	Wolfsburg	1961	4	48	1000	No	Yes	Yes	No	No	40	Yes	No	Yes	No	No	No	No	No	Yes	No	No
46	Cologne	1919	34	340	5500	Yes	Yes	No	No	Yes	65	Yes	No	No	Yes	Yes	No	No	No	No	Yes	Yes
47	Bonn	1983	20	215	2800	No	Yes	No	No	Yes	60	Yes	No	No	No	No	No	No	Yes	No	No	No
48	Cologne	1846	6	52	400	No	Yes	No	No	Yes	36	Yes	No	No	Yes	Yes	No	No	Yes	No	Yes	Yes
49	Koblenz	1980	6	42	1600	No	No	Yes	No	No	0	No	Yes	Yes	No	No	No	No	Yes	No	No	No
50	Stendal	1863	5	19	1650	No	Yes	No	No	Yes	23	Yes	No	No	No	No	No	No	Yes	No	No	No
51	Brandenburg	1964	8	82	2800	No	Yes	No	No	Yes	10	Yes	No	No	No	No	Yes	No	No	No	Yes	Yes
52	Bremen	1860	18	224	3200	No	Yes	No	No	Yes	24	Yes	No	No	No	Yes	No	No	Yes	No	Yes	Yes

Q12			Q13			Q14			Q15			Q16			Q17									
Energy for baki			Bake Packaging			Expa			How do you de			Bigg												
Woo	Elect	Elect	Fossi	Natu	Other	Unp:	Pape	Oth:	Non-recy	Incre	Stab	Decr	Impl	New	Sust	Risr	Taxe	Find	Char	Com	Oth:			
No	No	No	Yes	No	No	Yes	No	Yes	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No	Build		
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Appendix 2 Letter to participants

Sehr geehrte Damen und Herren,

Mein Name ist Sarkis Nehme, ich bin Doktorand an der Brandenburgischen Technischen Universität Cottbus -Senftenberg (BTU). Im Zuge meiner Doktorarbeit mit dem Thema "Nachhaltigkeit in der Brotproduktion in Deutschland" am Institut für Umweltplanung unter der Leitung von Prof. Michael Schmidt führe ich zurzeit eine Datenerhebung in brotproduzierenden Betrieben in Deutschland durch.

Ihre Email-Adresse habe ich aus der Übersicht des Zentralverbands des Deutschen Bäckerhandwerks oder Ihrer Website entnommen, um Sie kontaktieren zu können.

Ich würde mich freuen, wenn Sie sich an der Umfrage beteiligen und damit die wissenschaftliche Datenerhebung unterstützen. Die Informationen, die Sie bei der Beantwortung des Fragebogens zur Verfügung stellen, werden ausschließlich für Forschungszwecke verwendet. Ein Rückschluss auf Ihr Unternehmen oder Ihre Person ist dabei zu keiner Zeit möglich. Für die Umfrage wird das Web-basierte und geprüfte System "Smart Survey" genutzt.

Zur Umfrage: [\[SURVEYLINK\]](#) (Bitte kopieren Sie diesen Link in Ihren Online Browser, um die Umfrage zu starten.)

Die anonymisierten Antworten werden im Archiv der Universität hinterlegt, um sie anderen Forschenden zugänglich zu machen. Dabei werden die rechtlichen Datenschutzregeln und -verordnungen eingehalten.

Die Beantwortung der Fragen wird maximal 5 Minuten in Anspruch nehmen. Die Namen von Personen oder Marken werden nicht benötigt, so dass die Antworten komplett anonym bleiben.

Nach Auswertung der Fragebogen werde ich in einem weiteren Schritt telefonische oder persönliche Interviews durchführen, um die Ergebnisse zu vertiefen. Ich würde mich freuen, wenn Sie sich auch hierzu bereit erklären. Bitte geben Sie dann am Ende des Fragebogens Ihre Email-Adresse an, damit ich Sie zwecks Terminabsprache kontaktieren kann.

Vielen Dank für Ihre Mühe

Mit freundlichen Grüßen

Sarkis Nehme (Herr)
Lehrstuhl Umweltplanung
Brandenburgische Technische Universität Cottbus-Senftenberg
Email: Sarkis.Nehme@b-tu.de

Appendix 3 Survey questionnaire



Datenerhebung zur Doktorarbeit - 2020

1. Allgemeine Informationen

1. An welchem Ort befindet sich Ihr Unternehmen (Standort der Unternehmenszentrale)? *

2. Wann wurde Ihr Unternehmen gegründet? *

3. Wieviele Filialen inkl. Hauptsitz hat Ihr Unternehmen? (bitte Anzahl angeben)

Anmerkungen:

4. Wieviele Mitarbeiter hat Ihr Unternehmen (Vollzeit und Teilzeit)?

Anmerkungen:

5. Wieviele Kilogramm Brot produzieren Sie im durchschnitt pro Tag (inkl. Brot, Brötchen, Bretzel, usw.)?(bitte Schätzwert angeben) *

kg

Total:

kg

Anmerkungen:

Anmerkungen:

2. Brotproduktion und Teigherstellung

6. Für die Brotproduktion kaufen wir von Zulieferern ein: (bitte alle angeben) *

- Fertigmischungen
- Mehl
- Getreide, das wir selbst mahlen
- Sonstiges (bitte angeben):

7. Nutzen Sie standardisiertes Mehl? *

- Ja
- Nein
- keine Angabe

Anmerkungen:

8. Wie groß ist die Entfernung zwischen der Mühle und Ihrer Bäckerei? (ungefähr in Kilometern) *

Anmerkungen:

9. Welches Mehl nutzen Sie?

- Konventionelles Mehl
- Bio-Mehl

Konventionelles Mehl und Bio-Mehl

Anmerkungen:

10. Warum nutzen Sie nicht ausschließlich (zu 100%) bio-zertifiziertes Mehl?(Mehrfachantworten Möglich) *

- Wir nutzen bereits zu 100% Bio-Mehl.
- Preis zu hoch
- mangelnde Nachfrage nach bio-Produkten
- Verfügbarkeit nicht ausreichend
- Sonstiges (bitte angeben):

11. Der Teiggahrung findet statt:(Mehrfachantworten Moglich) *

- bei Zimmertemperatur
- durch Ethylenglycol
- mit Hilfe von Elektrizitat
- Sonstiges (bitte angeben):

3. Backen

12. Welche Energieart nutzen Sie fur den Backvorgang?(Falls mehrere zutreffen bitte alle Relevanten markieren) *

- Holz
- Elektrizitat (konventionell)
- Elektrizitat (erneuerbar)
- Fossile Brennstoffe (Kohle, Erdol)
- Fossile Brennstoffe (Erdgas)
- Sonstiges (bitte angeben):

. Backen Sie bedarfsorientiert? (bitte auswählen)

Ja

Nein

Anmerkungen:

4. Verpackung

14. Die Mehrzahl Ihres Brots wird verkauft:(bitte nur eine Angabe) *

unverpackt

in Papiertüten

verpackt in recyclebarem Material (außer Papier)

verpackt in nicht-recyclebarem Material

Sonstiges (bitte angeben):

5. Trends und Herausforderungen

15. Haben Sie Ihr Unternehmen in den letzten 10 Jahren vergrößert und neue Standorte/Filialen eröffnet? *

Nein

Ja

Wir planen zur Zeit eine Vergrößerung

Anmerkungen:

16. Wie beschreiben Sie Ihre Brotherstellung über die letzten 10 Jahre am ehesten?(Bitte nur eine Angabe) *

- zunehmend
- gleichbleibend
- rückgängig
- Sonstige (bitte angeben):

17. Was waren die größten Herausforderungen für Ihren Betrieb in den letzten 10 Jahren?(Bitte alle relevanten Antworten ankreuzen) *

- Einführung neuer Technologien
- neue und zunehmende Regeln und Gesetze
- Nachhaltigkeitsanforderungen
- steigenden Produktionskosten
- Steuern
- Verfügbarkeit ausgebildeter Arbeitskräfte
- wechselndes Konsumverhalten
- Wettbewerb
- Sonstiges (bitte angeben):

18. Wie informieren Sie sich zu den Themen Nachhaltigkeit, Energiesparen, etc.?(Bitte alle zutreffenden Antworten ankreuzen) *

- Offizielle Informationen (von staatlichen Behörden oder Stellen)
- Nichtregierungsorganisationen (NGO)
- Mitgliedsorganisationen (z.B. Bäckerinnung, IHK, etc.)
- eigene Recherche
- Sonstiges (bitte angeben):

- Ja
- Nein
- Sonstiges (bitte angeben):

6. Lieferkette des Getriedes

20. Wie oft kaufen Sie Mehl bzw. Fertigmischung ein? *

Pro Monat

21. Was geschieht mit dem Brot nach Ablauf des Mindesthaltbarkeitsdatum?(Bitte alle relevanten Antworten ankreuzen) *

- wird als Lebensmittelabfall entsorgt
- wird Dritten gegeben (z.B. Hilfsorganisationen)
- wird als Tierfutter verwendet
- wird wiederverwendet oder recycled (Altbrot, Semmelbrösel, etc.)
- Sonstiges (Bitte angeben):

22. Wie hoch ist Ihr Brotabfall pro Tag? (Ungefähr in Kilogramm)

Anmerkungen:

23. Hat Ihr Unternehmen selbst ein oder mehrere offizielle Nachhaltigkeitszertifikate oder -label, z.B. EMAS Gütesiegel der EU, ISO 14001, CSE-Siegel? *

- Nein
- Ja (Bitte genaue Namen angeben):

Anmerkungen:

24. Welche Herausforderungen bestehen bei der Nutzung von Produktlabels oder der Zertifizierung Ihres Betriebs? (Mehrfachantworten Möglich) *

- komplizierter Bewerbungs- oder Zertifizierungsprozess
- ungenügende Ressourcen im Unternehmen für Bewerbung
- hohe Kosten
- Kunden haben kein Interesse
- Unternehmen hat kein Interesse
- Sonstiges (bitte angeben):

25. Berichten Sie die Nachhaltigkeit Ihres Unternehmens an irgendeine Stelle/Behörde/Agentur oder Organisation (z.B. EU EMAS, ISO 14001, CSE)? *

- Nein
- Ja (bitte angeben)

Anmerkungen:

7. Anmerkungen

26. Haben Sie weitere Anmerkungen oder Kommentare zum Thema oder wollen Sie eine oder mehrere Ihrer Antworten vertiefen, dann nutzen Sie bitte dieses Textfeld.

. Vielen Dank

27. Nach Auswertung der Fragebögen werden in einem weiteren Schritt Interviews telefonisch oder persönlich durchgeführt, um die Ergebnisse zu vertiefen. Ich würde mich freuen, wenn Sie sich auch hierzu bereit erklären. Bitte geben Sie in diesem Fall hier Ihre E-mail-Adresse an: *

Nein, danke

Ja. E-mail-Adresse:

Appendix 4 Interview letter to participants

Interviews zur Doktorarbeit "Nachhaltigkeit in der Brotproduktion"

Sehr geehrte Damen und Herren,

Zunächst möchte ich Ihnen noch einmal dafür danken, dass Sie an meiner Befragung zur Datenerhebung für meine Doktorarbeit zum Thema "Nachhaltigkeit in der Brotproduktion in Deutschland" teilgenommen haben. Nachdem ich in den letzten Monaten die erhobenen Daten ausgewertet habe, möchte ich nun die Datenanalyse vertiefen und persönliche Telefon-Interviews durchführen, um ein besseres Bild vom Produktionsprozess zu erhalten.

Freundlicherweise haben Sie bei der Online-Befragung zugestimmt, gegebenenfalls für ein Interview zur Verfügung zu stehen. Deshalb würde ich mich freuen, wenn wir einen Termin für ein Telefon-Interview innerhalb der nächsten sechs Tage vereinbaren können.

Noch einmal möchte ich Ihnen versichern, dass alle Daten vertraulich behandelt und nur zu wissenschaftlichen Zwecken erhoben werden. Der Name Ihres Betriebes wird bei der Beschreibung des Produktionsprozesses in meiner Arbeit nicht genannt, so dass alle an der Umfrage Teilnehmenden anonym bleiben. Die Telefoninterviews werden jedoch digital aufgezeichnet, um Ihre Antworten in Schriftform zu übertragen. Zusätzlich wird bei den Interviews ein Assistent aushelfen, der als Übersetzer dient, da mein Studium in Englisch durchgeführt wird, und Deutsch nicht meine Muttersprache ist.

Ich freue mich darauf, von Ihnen zu hören, ob Sie an einem Interview teilnehmen können, und an welchen Tagen und zu welcher Zeit dies möglich ist. Bitte teilen Sie mir freundlicherweise auch die Telefonnummer mit, unter der Sie am besten zu erreichen sind.

Mit freundlichen Grüßen

Sarkis Nehme

Appendix 5 Interview protocol

Doctoral Thesis Sustainability Assessment of Bread Production The Case of Artisan Bakeries in Germany

Interview with the owner of a bakery

Topics to cover:

The idea of sustainable bread

1. Q: Do you know anything about Germany's sustainable development goals?
2. Q: How do you think a bakery can become sustainable?
3. Q: How do you describe a sustainable bread?
4. Q: What do you think about eco-labels?
5. Q: Do you report to, or get any advice from local authority/government?

The values of a traditional German bakery

6. Q: What is a traditional German bread?
7. Q: What traditions should be protected? And how?

The changing market

8. Q: Do you think individual small bakeries are disappearing? Why?
9. Q: Is it difficult to find and recruit bakers?
10. Q: Do you use any of the modern apps/services (e.g. Deliveroo, Uber-Eat, Too Good To Go)?

The decision making and its influences

11. Q: What are the selection criteria when buying flours and other bread ingredients?
12. Q: How can a bakery use energy sources more efficiently?
13. Q: Is sustainable energy available and affordable for your bakery?
14. Q: How can we bakeries reduce bread wastes?
15. Did you register any recipes on Bread Register?
16. How do you transmit knowledge to baker trainees?
17. How do you make bread healthy?

Additional contribution

18. Q: Is there anything you would like to add?