Embracing the risks and the potentials for a sustainable dairy value chain in Georgia: Assessment of dairy value chain sustainability, constraints and opportunities in Kvemo Kartli region, Georgia

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by

Rami Al Sidawi

First Supervisor:

Prof. Dr. Angelika Ploeger

Second Supervisor:

Prof. Dr. Teo Urushadze

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Declaration

I herewith give assurance that I completed this dissertation independently without the prohibited assistance of third parties or aids other than those identified in this dissertation. All passages that are drawn from published or unpublished writings, either word-for-word or in paraphrase, have been clearly identified as such. Third parties were not involved in the drafting of the content of this dissertation; most specifically, I did not employ the assistance of a dissertation advisor. No part of this thesis has been used in another doctoral or tenure process.

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Rami Al Sidawi
Witzenhausen, Oktober 2021

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List of Abbreviations

ALCP	Alliances Caucasus Programme
ANOVA:	Analysis of Variance
As	Arsenic
CARD	Center for Agribusiness and Rural Development
Cd	Cadmium
Co	Cobalt
Cr	Chromium
CRRC	Caucasus Research Resource Center
Cu	Copper
DVC	Dairy Value Chain
EBRD	European Bank for Reconstruction and Development
EFSA	European Food Safety Authority
ENPARD	European Neighbourhood Programme for Agriculture and. Rural Development
EU	European Union
FAO	Food and Agriculture Organization
Fe	Iron
GeoStat	National Statistics Office of Georgia
GIs	Geographical Indications
g	Gram

Kg	Kilogram
HACCP	Hazard Analysis and Critical Control Point
HM	Heavy Metals
HS	High season
IDF	International Dairy Federation
IFAD	International Fund of Agriculture Development
LOD	Limit of detection
LS	Low season
mg	Milligram
mg/L	Milligram pro Litter
mg/kg	Milligram pro Kilogram
Mn	Manganese
Mo	Molybdenum
Ni	Nickel
Pb	Lead
SD	Standard Deviation
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable development goals
Se	Selenium
SPSS:	Statistical Package for the Social Sciences

UN	United Nations
UNDP	United Nations Development Program
USSR	Union of Soviet Socialist Republics
WHO	World Health Organization
Zn	Zinc
≤	Less than or equal to
<	Less than
>	Greater than
%	Per centage

Preface

Since I finished my bachelor's degree, I've always aspired to go deeper into organic food science and focus on sustainable food systems. Studying for a master's degree in organic food has given me an excellent opportunity to expand my knowledge and keep pace with the development in this field. In my last year of master's studies, I had an excellent opportunity to complete my master's thesis with Prof. Dr. Angelika Ploeger in Georgia in sustainable water resource management for a safe food system. The working group focused on river water pollution in Georgia with heavy metals and the factors affecting it. So far, the work has resulted in many publications explaining the reasons for the presence of these HMs and the extent of pollution in the rivers of the studied region, clarifying the political role in this region and its consequences for farmers and residents. My role in this work was to focus on understanding the current situation of smallholder farmers and their dependence on this polluted water.

After I finished my master's degree, and during my doctoral study, I focused more in-depth on the role played by smallholder farmers to develop Georgia's economy, and we focused on the dairy value chain in particular, as it is one of the most important pillars of the economy in Georgia. We did investigations that had not been done before.

This doctoral dissertation comprises of three published papers in two scientific journals: Sustainability, with IF (3.251), Foods, with IF (4.350)

Published articles

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- Al Sidawi, R., Ghambashidze, G., Urushadze, T., & Ploeger, A. (2021). Heavy Metal Levels in Milk and Cheese Produced in the Kvemo Kartli Region, Georgia. Foods, 10(9), 2234. https://doi.org/10.3390/foods10092234

Acknowledgments

My parents once told me, son, if you cannot find any path to success, then make your own path. The beginnings that precede the path to success are tough, but every difficult road has an end, and every end is a new beginning.

It has been a long journey, full of obstacles and difficulties but most importantly full of surprises, wonderful people, endless experiences, and multiple ways of learning, all of which have made this journey a wonderful path to success.

First of all, I would like to express my heartful thanks to one of the most influential people who were able, with her wisdom, great experience, and patience to always push me forward and pave the way for me to complete my PhD, my supervisor Professor Dr. Angelika Ploeger, the extraordinary professor who has always been by my side on my PhD journey. She was a great teacher, friend and family. I want to thank her for her continuous support and guidance that helped me reach the end of this path and complete this work. All the interactive sessions I had with her during these years were a source of great inspiration. I consider myself a lucky person who had the chance to learn from a person who teaches science with humility, show exceptional interest in the ideas presented, and always provide me with necessary support which could help me in any aspect. All of this made me learn a lot and encouraged me to develop professionally and personally. Professor Ploeger once again, thank you very much for everything, no matter how hard I try to write, I miss the words.

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I also want to say a very special and loving thanks to someone who has been by my side throughout my master and PhD journey Olga Olashyn, words here are completely incapable of describing or expressing how I feel. You were the person I would read about in novels and never thought I would meet. Olga, thank you for everything, for your continuous support, attention, and help over these years. You are one of the reasons for the success of my journey. But the lines fail me here to express all what I feel about you. I love you Olgi.

To my Mom and Dad, to the biggest supporters in my life. From the very beginning of my master's degree journey and reaching this stage, I can only thank God and thank you for everything. Without you, I wouldn't be here today, and I wouldn't be able to write these lines. I love you so much, the precious thing in my life, thank you from a heart full of love for you both, and no matter how many words are here, they will never suffice. I love you both.

To my brothers Wael and Hani, thanks God to have you both, you are my favourite people and I will never forget that you are one of the reasons for my success in this path. I love you both.

Special thanks to someone who has had a huge impact on my journey right from the start, Smail Bahri, a brother and a friend. The words cannot describe how grateful I am having you by my side during all this period. Thank you and your family for love, friendship and support that you gave me all this time. love you all.

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Last but not least, I want to thank Giorgi Ghambashidze from Georgia to his support, Irwa Issa, and all the people who played an important role in my journey, excuse me for not mentioning names, the list is very long, but I am very lucky to have you in my life and thank you all from the bottom of my heart. Your presence helped me complete this mission and gain huge experiences over these years. I love you all.

Abstract

The agricultural sector in Georgia and many countries of the world plays the leading role in these countries' economies and is considered one of the essential pillars for reducing poverty and reviving the local economy. Georgia is striving to achieve sustainability systems and implement them in all its new policies. But it is not possible to rely solely on agriculture to meet the current challenges. Therefore, agricultural policies in many countries focus on agricultural industries and develop these industries along the value chain, from farm to consumer. The dairy value chain in Georgia occupies a large part of the Georgian economy. Smallholder farmers are the cornerstone of the country, especially after the collapse of the Soviet Union. But there is a large gap between the political decision-makers, smallholder farmers, laws, and legislation along the chain, and many obstacles and problems affect the development of this chain. Therefore, this doctoral research aims at (1) an in-depth study of the dairy value chain in Georgia in general and in the Kvemo Kartli region in particular, and to analyze the expert opinion of the current situation of the chain. (2) Determining the role of smallholder farmers in developing the chain and shedding light on the problems they face. (3) Verifying that the raw milk produced in this region and the locally made cheese is not contaminated with heavy metals, which is one of the most critical problems facing the value chain development. To our knowledge, many aspects of these issues have not previously been studied or addressed. This study relies on two main methods: questionnaires based on open and closed questions systems and laboratory analyses to determine the level of heavy metals in milk and cheese. The first part of the study shows the stages of development of the dairy value chain and the factors affecting its development, the opinion of experts on the current status of the chain, and the role of existing policies and legislation in its development. The second part of the study focuses on smallholder farmers' problems and shows the gap between them and policymakers. As for the third part, the results show that most raw milk samples produced by these farmers were not contaminated with heavy metals, compared to cheese samples, which exceeded the permissible limits.

The importance of this study lies in identifying the weaknesses in the dairy value chain by understanding the problems faced by all the elements of the chain and emphasizing the important role that smallholder farmers play in the dairy value chain on the one hand, and the local economy on the other. Besides, this study will affect the food safety policies in Georgia, especially in the Kvemo Kartli region.

Zusammenfassung (DE)

Der Agrarsektor in Georgien und vielen Ländern der Welt spielt die führende Rolle in der Wirtschaft dieser Länder und gilt als eine der wesentlichen Säulen für die Verringerung der Armut und die Wiederbelebung der lokalen Wirtschaft. Georgien strebt danach, Nachhaltigkeitssysteme zu erreichen und diese in seiner neuen Politik umzusetzen. Doch allein auf die Landwirtschaft kann man sich nicht verlassen, um die aktuellen Herausforderungen zu meistern. Daher konzentriert sich die Agrarpolitik in vielen Ländern auf die Agrarindustrie und entwickelt diese Industrien entlang der Wertschöpfungskette vom Bauernhof bis zum Verbraucher. Die Milchwertschöpfungskette in Georgien ist von großer Bedeutung für die georgische Wirtschaft. Kleinbauern sind ökonomisch die Eckpfeiler des Landes, insbesondere nach dem Zusammenbruch der Sowjetunion. Aber zwischen den politischen Entscheidungsträgern, Kleinbauern und Gesetzen entlang der Wertschöpfungskette besteht eine große Kluft und viele Hindernisse und Probleme wirken sich auf die Entwicklung dieser Kette aus. Daher zielt diese Doktorarbeit darauf ab, (1) eine eingehende Untersuchung der Milchwertschöpfungskette in Georgien im Allgemeinen und in der Region Kvemo Kartli im Besonderen zu erstellen und die Expertenmeinung zur aktuellen Situation der Kette zu analysieren. (2) Ermittlung der Rolle der Kleinbauern bei der Entwicklung der Kette und Aufklärung der Probleme, mit denen sie konfrontiert sind. (3) Überprüfung, dass die in dieser Region erzeugte Rohmilch und der lokal hergestellte Käse nicht mit Schwermetallen belastet sind, was eines der kritischsten Probleme bei der Entwicklung der Wertschöpfungskette ist. Unseres Wissens wurden die angesprochenen Aspekte dieser Fragen bisher weder adressiert noch untersucht. Diese Studie stützt sich auf zwei Methoden: Fragebögen basierend auf offenen und geschlossenen Fragesystemen (sozialwissenschaftlicher Ansatz) sowie Laboranalysen zur Bestimmung des Schwermetallgehalts in Milch und Käse (naturwissenschaftlicher Ansatz). Der erste Teil der Studie zeigt die Entwicklungsstadien der Milchwertschöpfungskette und die Faktoren, die ihre Entwicklung beeinflussen, die Meinung von Experten zum aktuellen Status der Kette sowie die Rolle bestehender gesetzlicher Regelungen und Rechtsvorschriften bei ihrer Entwicklung. Der zweite Teil der Studie konzentriert sich auf die Probleme der Kleinbauern und zeigt die Kluft zwischen ihnen und den politischen Entscheidungsträgern auf. Im dritten Teil zeigen die Ergebnisse, dass die meisten Rohmilchproben dieser Landwirte nicht mit Schwermetallen belastet sind, im Vergleich zu Käseproben, die die zulässigen Grenzwerte überschreiten.

Die Bedeutung dieser Studie liegt darin, die Schwächen in der Wertschöpfungskette von Milchprodukten zu identifizieren, indem die Probleme aller Elemente der Kette verstanden werden und die wichtige Rolle hervorgehoben wird, die Kleinbauern in der Wertschöpfungskette von Milchprodukten einerseits und der lokalen Wirtschaft andererseits spielen. Diese Studie hat das Potenzial, die Lebensmittelsicherheitspolitik in Georgien, insbesondere in der Region Kvemo Kartli, zu beeinflussen.

Chapter 1:

1.1. Introduction

Georgia has suffered tremendously in the post-Soviet era; the socio-economic and political situation was challenging. The economic situation, in particular, was very bad, and the government had to take several measures to try to get out of this crisis. One of the most important steps taken by the state at that time was the agrarian reform. In 1992, thousands of small farms (on average, about 1 hectare of land) were established in all Georgian regions, and the ownership of these pieces of land were transferred to smallholder farmers [1–4]. These farmers depended mainly on diverse subsistence farming and owning small numbers of farm animals (cows, sheep, chickens, pigs, goats, and others), and they allotted part of the land for growing some crops to feed their livestock [5]

As a result, Georgia became highly dependent on smallholder farmers, who became a crucial player in the local Georgian economy [1–5]. Accordingly, the Georgian economy in total has been under transformation [6]. After trying to promote the local economy and efforts to solve social issues, Georgia has entered a new phase since 2004. New economic strategies appeared, aiming to integrate liberalization and economic modernization [7]. Foreign investments and international relations appeared in several fields, where the agricultural sector took the largest share, especially in dairy and cheese production. As 90% of small farmers in Georgia, who live in rural areas, depend mainly on dairy products. Which in turn contributes to securing the family's livelihood, supporting the sovereignty of food and nutrition, and maintaining food safety. Consequently, the country's milk production became dependent on these farmers [8–12]. In a step to support these farmers, the state allocated large areas of land for pastures and transferred the ownership of these lands to the municipalities, which determine how to use them [13].

All these steps have helped, since 2004, in reviving the local economy, but despite this, the agricultural sector has suffered from many problems. For example, the inability of government agencies to monitor unlisted companies, which do not follow the stipulated laws and thus prevent access to fair competition, leads to the destabilization of the agriculture sector [6,14–16]. On the other hand, despite opening the door to foreign investments and supporting them, these parties did not fully adhere to environmental protection laws and did not take into account international standards in several areas, which led to the emergence of significant adverse effects and had a negative impact on the health of the citizen on the one hand and the local economy on the other[6,14–16].

In addition, the conditions and challenges that Georgia is currently facing are closely related to the current global challenges, such as climate change, global warming, water scarcity and others. Thus, current and future sustainable plans and projects play an important role in the development of Georgia's economy [17,18].

On September 25, 2015, the United Nations announced 17 "sustainable development goals (SDGs)" and 169 targets [19]. And in 2016, as Georgia is a member of the United Nations, the Georgian government announced the inclusion of these goals in its annual work plans [20,21] and an attempt to implement them in all fields. In dairy production, the following five sustainable development goals (1,2,5, 12, 17) play a fundamental role in developing the value chain for the dairy sector, which in turn reflect positively on the development of the agricultural industry and the local economy. The inclusion of these goals in the existing projects has helped to eradicate hunger, eradicate poverty, and improve nutrition, as it has strengthened the role of rural women in society and provided them with appropriate opportunities to keep abreast of developments in various fields. In addition to all this, it has also helped to ensure patterns of sustainable consumption and production and to activate the role of the global partnership to reach a sustainable development, finally.

1.2. Background of the Study

1.2.1. Heavy metals contaminations

Heavy metal pollution is considered one of the most dangerous types of pollution to both humans and the environment. Human activities are considered one of the most crucial causes of this pollution, such as chemically intensive agricultural inputs, industries, and many others, which may pose a real risk of contamination with heavy metals and a silent threat to food safety for decades. Where humans can be exposed to contamination with these metals directly, for example, drinking polluted water, or indirectly, such as consuming polluted crops, which have been exposed to these metals either directly, such as their presence on public roads, or through contamination of soil or water with these metals. Thus, in both cases, human health is at risk due to the gradual accumulation of these different heavy metals in the food system [22–24].

In Georgia, in the stage of reviving the economy again after the collapse of the Soviet Union, the way was opened for many foreign investments, which in turn helped to support the country's economy, immensely. Still, on the other hand, some of them harmed human health and the safety of the environment. For example, the "Madneuli" mining plant started its activities near the village of Kazreti in 1975, which was a direct source of pollution with HM [24]. In 2014, the government approved the opening of the RMG Gold and Copper Mine, located on the right and left banks of the Mashavera River in the Dmanisi-Bolnisi district of Kvemo Kartli [23,24].

This river is considered the main source for irrigating crops, and even some people use it as a source of drinking water. Many previous research and studies have shown that this river is polluted with heavy metals (*Cu, Cd, Zn, Pb, Fe, Mn, Ni, Cr, Hg*), as a result of the activity of these [23,24,33,25–32]. Where these factories dispose of the waste resulting from the mining process directly in the river, or bury it in the surrounding lands, allowing these toxic metals to pollute the river directly, and move

to groundwater and soil, and then to crops and plants, which has a serious impact on human and animals health in the short and long term [24,30,34–36]. Also, farmers use the waters of this river and pastures whose soil, groundwater and plants have been polluted to graze cattle, goats and sheep [36,37].

1.2.2. Georgian dairy value chain

The agricultural and animal production sector occupies a vital part of the Georgian economy and is considered a cornerstone in all development and modernization plans that the government is working on. The production of milk and dairy products is one of the most critical sectors in the country. Kvemo Kartli, in particular, is one of the most critical regions in Georgia, which is concerned with the production of raw milk and cheese. Therefore, the government has directed its special attention to developing the dairy value chain. Each element of the chain is crucial in the development of the chain as a whole [7,14,38].

The value chain of food begins along the supply chain. The supply chain can be defined as a collaborative activity of many forms designed to create "value" through a combined effort within the chain. The supply chain includes several activities, such as processing, packaging, transportation, warehousing and retailing [39]. As Figure (1) shows, the value chain for dairy products, for example, is a set of businesses and their interactions that add "value" to agricultural commodities as the product passes through the chain. Strategic relationships and alliances with consumers and producers were founded, which helps to diversify products and improve financial returns[15,40]. For example, Figure (2) shows the cheese-making value chain in the Imereti region, Georgia, and all the elements that participate in this chain, which takes the product from farm to fork [41].

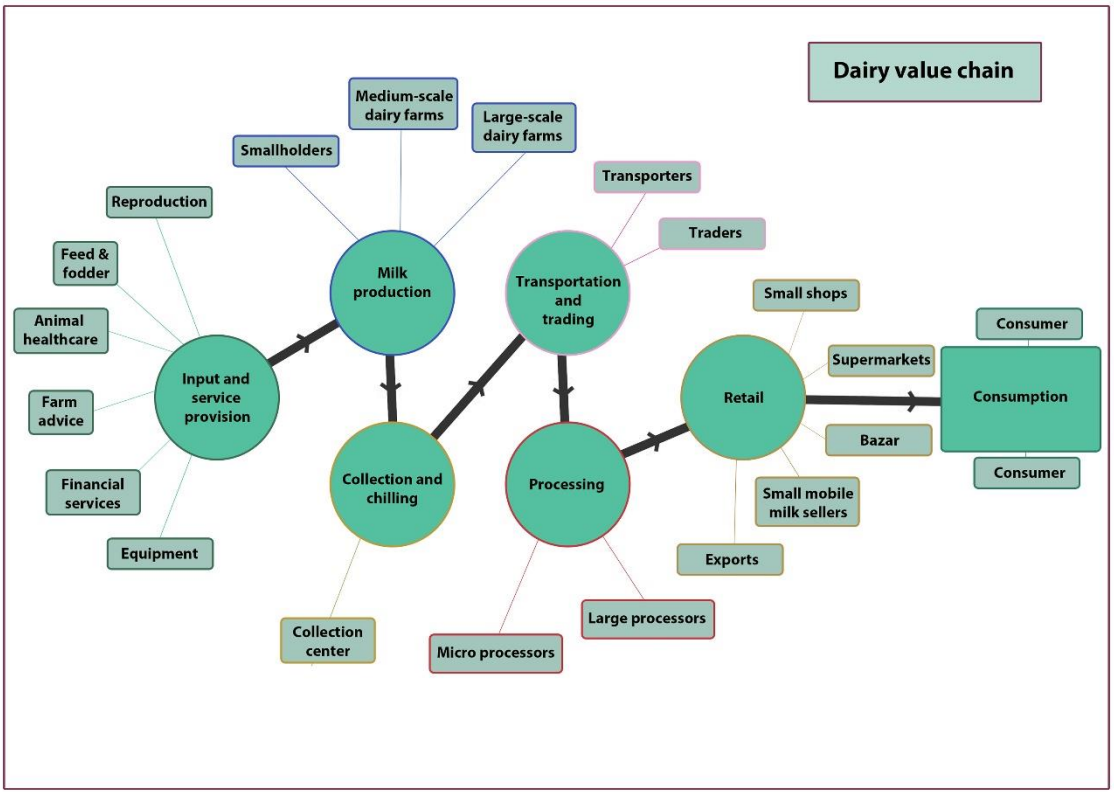

Figure 1. The components of the dairy value chain [15,40]

Thus, the dairy value chain in Georgia is characterized by complex interactions, which link several small and large parties together in the chain.

The way food chains are organized and managed will directly affect the effective control of food safety. It is one of the goals that Georgia seeks to implement the standards of the European Union and try to achieve the goals of sustainable development. Where Kaplinsky and Morris [42] described the concept of governance, which depends on the coordination systems between the actors within the chain and their interactions. Where they focused on developing livelihood strategies and dealing with the constantly occurring changes. And studying the relationship between companies and all concerned organizations, which helps in the integration of all the elements of the chain together. Which in turn leads to changing livelihoods, preserving traditions and creating new opportunities, which leads to the upgrading of the value chain. Several studies have shown that these interactions between actors are semi-structured, not wholly random [42–46].

Therefore, the country's plans for developing the value chain depend on a coherent system of value chain governance, which determines production standards, ways and reasons for the

interaction of relevant stakeholders, and enacts laws and legislations that are in the interest of all parties. Develop appropriate plans for local and international projects that are compatible with sustainability laws. Like all of this, in turn, ensures that food safety standards are reached and that they keep pace with international standards [42–46].

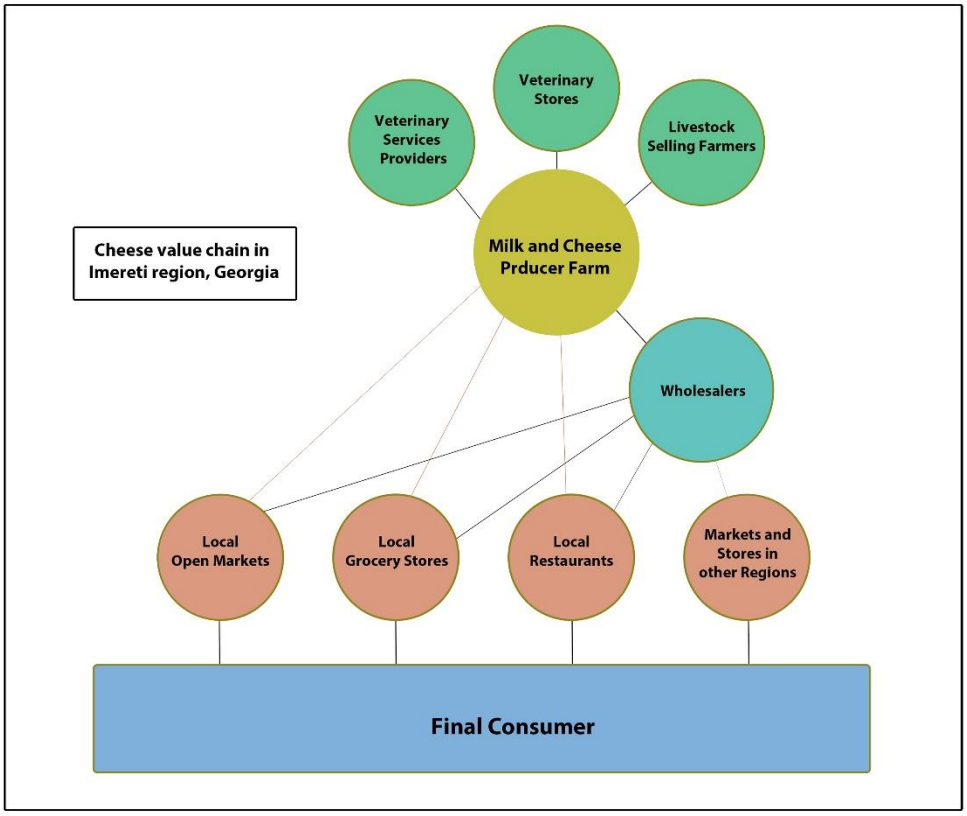

Figure 2. Cheese-making value chain in the Imereti region, Georgia [41]

1.2.3. Dairy smallholder farmers

Smallholder farmers are the backbone of the local economy in most countries, especially in developing countries. These family farms help farmers and people with limited income secure their daily livelihood [20,47]. The conditions in which these farmers live differ according to the circumstances of the countries. Georgia, for example, after undergoing fundamental changes from the collapse of the Soviet Union until now, smallholders play an essential role in supporting the local economy[48].

However, Georgian smallholders suffer from a wide range of needs and constraints. Whereas, despite farmers' efforts, these farms are not economically viable for them. Smallholders living in rural areas are the most vulnerable and poorest of the Georgian population [15,48]. According to the Oxfam report, the smallholder farming sector suffers from many problems and faces complex challenges.

These farmers suffer from low productivity, as they cannot access the local and national market or keep pace with knowledge, knowledge inputs and modern technology [49]. According to the FAO report, developing and supporting the role of smallholders effectively will help the local economy of Georgia, as they will play a significant role in achieving sustainable development in its various fields, such as economic, environmental and social [50]. This leads to an increase in productivity and raising the income of family farms. It also allows achieving optimal and sustainable use of resources and plays a fundamental and essential role in better integration into agri-food value chains [49–51].

1.2.4. Food safety and food security

According to the European Union, food safety is all control processes intended for the safe preparation, handling and storage of food. These processes must include comprehensive control from farm to factory and the consumer and even beyond (recycling). The risk of food contamination is present at each of these stages [52]. Thus, food safety guarantees a high level of protection for humans and their health, and it also ensures the protection of consumers' interests [52,53]. Also, looking forward to achieving food safety, all responsible parties must observe the general objectives of the Food and Feed Law, which stipulate taking into account animal health and welfare, plant health and the environment, and thus protecting human health [52,53]. Figure (3) shows the seven basic principles of safety that the European Union demands for the production and trade of food "from the field to the plate"[53]. This system defines specific responsibilities and tasks to ensure safe and harmless food and a harmonized legal framework for producing and trading foodstuffs in the European Union. This system also defines all necessary measures to ensure food safety consistently along the entire food chain. Therefore, all parties in the chain are responsible for ensuring the security of their products [49,50]. For example, in the dairy sector value chain, factories are responsible for selecting and inspecting raw material such as the delivered milk. Farmers are also responsible for selecting feed, hygiene standards in barns, and animal welfare in raising their livestock. In turn, government agencies are responsible for legislating laws with the duty to protect the rights of all parties, constant monitoring along the chain, and support for smallholders as an essential element of the chain [49,50].

Georgia strives in various ways to implement these principles in its economic and political legislation. According to a CRRC-Georgia report and a study conducted in Georgia, the results showed that consumers do not have sufficient understanding or knowledge about food safety or international hygiene standards [54]. The Mercy Corps report emphasized the importance of the political role as a bridge between suppliers, smallholders, and the owners of large companies, the importance of legislating laws that have to serve all parties, and the continuous monitoring of each element of the

chain [15,55,56]. Which in turn supports access to international food safety standards. In 2010, Georgia introduced in all its economic plans and laws stipulating the application of European Union standards in the food safety system to develop the local economy and try to reach the principle of sustainable food safety [57].

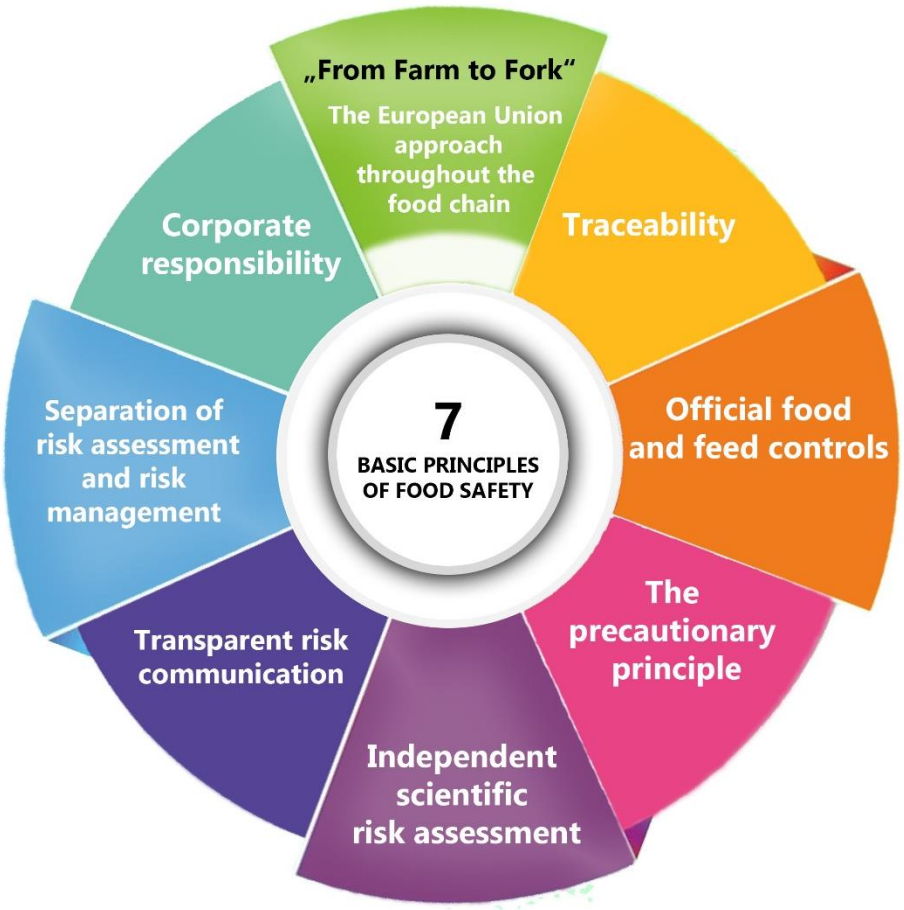

Figure 3. The seven basic principles of food safety according to the European Union [53].

1.3. Objectives and Structure of the Thesis

This doctoral research aims to:

- Examine the dynamics of the dairy food value chain by inquiring about the relationship between the stakeholders as the result of a literature review.

- Scrutinize the current dairy production policies and, e.g., safety regulations by interviewing experts of the dairy value chain.
- Analyse the difficulties of the local and national dairy market sectors in Georgia.
- Find out which kind of socio-economic impacts occur in smallholder dairy farmers marketing their products, focusing on the region of Kvemo Kartli in Georgia.
- Find out which mechanisms can be implemented to empower better management in the dairy value chain of smallholder dairy farmers in this region and Georgia in general.
- Help define an appropriate value chain for dairy products from the 'stakeholders' point of view, primarily driven by consumers' expectations.
- To determine whether smallholder farmers' ethical and cultural identity is critical in developing the Georgian local dairy value chain.
- Explore the various obstacles faced by dairy farmers, whether smallholder farmers follow the quality and food safety standards stipulated by the relevant governmental organizations on the one hand, and the extent of harmony between these governmental organizations and private entities and Smallholder farmers on the other hand.
- Investigate whether raw milk and cheese manufactured in the Kvemo Kartli region are contaminated with heavy metals (cadmium, lead, iron, zinc, copper, chromium, manganese, cobalt, nick-el, selenium and molybdenum) on the one hand and the other hand, whether heavy metals were transmitted to livestock by grazing in areas contaminated with these heavy metals or drinking from polluted rivers.

1.3.1. Problem statements

The contamination of plants, soil, and water with heavy metals has been a problem in Georgia for more than 40 years and still until now [24], especially in mining activities. First of all, numerous studies have shown that many regions in Georgia are contaminated with HM [25,30,33,58–61]. Most of these studies focused mainly on soil and water pollution, especially in areas used for agriculture or grazing by smallholder farmers. The results of this research significantly serve the studies concerned with the contaminations of plants and the exposure of animals to these metals. However, these studies are still the subject of much debate due to the many limitations and challenges they face. Therefore, there is a need for more studies and experimental research to know how these heavy metals are transferred from the soil, water, and plants to the Cows, particularly to their milk and later to the cheese.

Secondly, Georgia, as a developing country, which has suffered from many challenges over the past years, is facing many rapid changes in various fields, especially in the dairy production

sector, population growth, and the increase in the activities of the local economy, and openness to international trade, puts the dairy value chain in continuous changes[62–66]. Therefore, the government and the competent authorities must pay attention to each element of the chain and face the challenges and risks that stand in the way of developing the dairy value chain [62–66]. Nonetheless, no studies went through deepening the concept of the value chain of dairy production in Georgia in general and in the Kvemo Kartli region in particular. In addition, there are no studies focused on monitoring the development of this chain and the changes taking place in it and the challenges it faces, especially the problems faced by smallholder farmers, and delve into the factors that influence the evolution of the chain, such as traditions and ethical, social and environmental factors.

Thirdly, the decisions makers in the Georgian government and researchers have always discussed in many aspects the importance of smallholder farmers to the local Georgian economy. However, since the government decided to give farmers ownership of small lands so that they can invest it and support the local economy through it, in a step to advance the country's economy after the collapse of the Soviet Union., these farmers have become a cornerstone in supporting the national economy in various fields. The dairy smallholder farmers were of particular importance [12,67]. At the same time, Georgia's annual milk production is equivalent to approximately 500 million tons [67]. The Kvemo Kartli region is one of the most milk-producing regions in Georgia[15,67]. But smallholder farmers in this region suffer from many problems. Still, there are several studies and researches on the role of these farmers in the development of the Georgian economy, the extent of their influence on the development of the dairy value chain, and the importance of the role they play in various fields [9,15,48,67–73]. Therefore, more studies are needed to shed light on the challenges and difficulties faced by these farmers and the relationship between government agencies and institutions on the one hand and the dairy producers of small farmers on the other hand.

Last but not least, implementing the international food safety system in Georgia and trying to catch up with international safety laws to develop the dairy value chain is not an easy way, but it has many obstacles. In 2014, the Georgian government signed the Association Agreement between Georgia and the European Union "EU-Georgia Association Agreement" on the food safety system. In all Georgian systems, it later adopted legislative activities and comprehensive plans, bringing it closer to the standards of the European Union[6,56,57,74]. Nonetheless, there are no studies focused on the role of smallholder farmers, government organizations, and private companies in developing the dairy value chain and its reflection on food safety in Georgia.

1.3.2. The structure of the thesis

The structure of the thesis is as follows:

Chapter 1 presents a theoretical study, which is a short overview of what Georgia has gone through since the collapse of the Soviet Union, and the economic problems that the country suffers from. It also highlighted the issues of soil, water, and plant pollution with heavy metals and Georgia's attempt to implement the international food safety system to achieve sustainable development goals and catch up with European Union standards. Also, this section presents the problem statements, and the importance of this PhD work, clarifying the research objectives of the thesis.

Chapter 2 presents the first original publication that discusses the dairy value chain in the Kvemo Kartli region in Georgia, and all the factors affecting the chain, the problems and difficulties facing the development of this chain, and it also presents the opinion of experts in this matter (from government agencies, state institutions and private companies).

Chapter 3 presents the second publication on factors and components affecting smallholder dairy farmers and the local value chain in the Kvemo Kartli region in Georgia.

Chapter 4 presents the third publication on heavy metals levels in milk and cheese produced in the Kvemo Kartli region in Georgia and comparing them with internationally permissible limits.

***Chapter* 5** presents the general discussion of the results of this dissertation. It also addresses the scientific contribution of the work and its limitations and recommendation for future research.

Chapter 6 demonstrates the complete list of the bibliography of the thesis.

1.4. Materials and Methods

This thesis is part of a collaborative research work between the University of Kassel, Faculty for Organic Agricultural Sciences and the Agricultural University of Georgia since 2018. Several systematic research methods were adopted to complete this study. This study was conducted in the Kvemo Kartli region of Georgia. Eight villages were selected from this region (Chapala, Vanati, Bolnisi, Mtskneti, Sabereti, Ratevani, Khidiskuri, Kazreti, Kvemo Bolnisi), based on the results of previous studies, which indicate that the soil and water of these villages are contaminated with heavy metals.

The work was divided into two parts. In the first part, *Quantitative Research* was adopted to study the current situation of the dairy value chain in Georgia and to study the history of smallholder's farmers in Georgia and basic information about raw milk production and cheese industry in Georgia. A survey was conducted in the Kvemo Kartli region, Georgia, where 140 smallholder farmers participated in this survey. This questionnaire was based on open and closed questions. The questionnaire was printed on paper and filled out, and we got support from the Georgian University to translate the dialogue from Georgian into English. All these questionnaires were filled out during the interviews, and the data was analyzed later in Germany. SPSS version 27.0 (IBM, USA) software

was used for all the statistical analyses. We did a Spearman correlations (rs) test, t-test for independent samples, and Chi-Square Test for data analysis.

The second part of the work was divided into three experimental phases. The first phase was based on empirical data (*Qualitative Research*), which consisted of a semi-structured personal face-to-face interview, in which interviews were conducted with experts from government agencies, international organizations, the private sector, representatives from the dairy industry and people working in quality laboratories. Where the questionnaire was based on open questions. Structured content analysis was used to evaluate the data. The MAXQDA 18 software, which was used to analyze the data and transcribe all the audio files of the interviews. This software helped to encode the data and use the coding system to analyze the data completely.

In the third stage, samples of milk and cheese were collected from smallholders (195 milk samples, 25 cheese samples -16 from Imeruli cheese and nine from Sulguni cheese-, to see if they contain heavy metals (cadmium, lead, iron, zinc, copper, chromium, manganese, cobalt, nickel, selenium and molybden). The samples were analyzed in a special laboratory in Tbilisi, Georgia (Scientific-Research Center of Agriculture). The determination of heavy metals in all samples was carried out by inductively coupled plasma-mass spectrometry. SPSS version 27.0 (IBM, USA) was used to obtain the descriptive statistical analysis and to calculate the mean and standard deviation, to show the differences in the values of the samples. ArcGIS Pro was used to map the study area at all stages of the research.

References

1. Bernabè, S., & Stampini, M. (2009). Labour mobility during transition Evidence from Georgia 1. Economics of Transition, 17(2), 377-409.

2. Lerman, Z., Csaki, C. and Feder, G., Agriculture in Transition: Land Policies and Evolving Farm Structures in Post-Soviet Countries; Lexington Books: Lanham, MD, USA, 2004; ISBN 0739108077.

3. Terra Institute, Ltd., Georgia Land Market Development Project Final Report; Terra Institute, Ltd.: Blue Mounds, WI, USA, 2005; Available online: http://www.terrainstitute.org/pdf/Georgia_LMDP_Final_Report.pdf (accessed on 10 August 2021).

4. Pignatti, N. Demographic Structure, Labor Market Conditions and Stalled Agricultural Development in a Post-Transition Country; Tbilisi State University (TSU): Tbilisi, 2017.

5. SDC. Alliances Kk Synthesis Report of the First Phase: September 2011 to September 2013; Swiss Development Cooperation (SDC): Kvemo Kartli, Georgia, 2013. Available online: http://alcp.ge/pdfs/9b82125e5c11d2996b53c881302f1447.pdf (accessed on 12 October 2020).

6. Gelashvili, S.; Deisadze, S. Difficulties of Implementing the Technical Regulation on Milk and Dairy Products; ISET Policy Institute: Tbilisi, Georgia, 2019.

7. EI-LAT. The Economic Transformation of Georgia in Its 20 Years of Independence; Summary of the Discussion Paper; Liberal Academy—Tbilisi: Tbilisi, Georgia, 2012.

8. Olomola, A. Policy Options for Agricultural Investments and Governance of Markets: In Support of Small-Scale Agriculture in Nigeria; Oxfam Research Report; Oxfam International: Oxford, UK, 2013.

9. Hemme, T.; Otte, J. Status and Prospects for Smallholder Milk Production: A Global Perspective; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2010.

10. FAO. Gender, Agriculture and Rural Development in Georgia, Country Gender Assessment Series; FAO: Rome, Italy, 2018.

11. F.A.O. (2009). Agribusiness Handbook: Milk / Dairy Products. 2009, 65. Retrieved from: http://www.eastagri.org/publications/detail.php?id=36 (Accessed on 04 August 2021).

12. Morgan, N. Smallholder Dairy Development: Lessons Learned in Asia; Animal Production and Health Commotion for Asia and the Pacific and FAO: Bangkok, Thailand, 2009.

13. Raaflaub, M.; Dobry, L.M. Pasture Management in Georgia. Current Situation, Frame Conditions, Potentials of Development; Swiss Agency for Development and Cooperation SDC: Bern, Switzerland, 2015; Volume 42.

14. ALCP, Ensuring Sustainability in the Dairy Market Sector; Swiss Agency for Development and Cooperation SDC: Bern, Swiss, 2017.

15. CARD Baseline Assessment of the Dairy Sector in Georgia; Center for Agribusiness and Rural Development: Tbilisi Georgia, 2018.

16. ALCP, Better Cheese, Better Work, International Labour Office, Georgia, 2020. Available online: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_746235.pdf (accessed on 02 August 2021).

17. Terlau, W., & Hirsch, D. (2015). Sustainable consumption and the attitude-behaviour-gap phenomenon-causes and measurements towards a sustainable development. International Journal on Food System Dynamics, 6(3), 159-174.

18. Feulner, G. (2017). Global challenges: Climate change. Global Challenges, 1(1), 5.

19. UN Resolution der Generalversammlung, Resolution der Generalversammlung, verabschiedet am 25. September 2015,. 2015. Available online: https://www.un.org/Depts/german/gv-70/band1/ar70001.pdf (accessed on 5 August 2021).

20. FAO. Transforming Food and Agriculture to Achieve the SDGs; FAO: Rome, Italy, 2018; ISBN 9789251306260.

21. UN. First Voluntary National Review On Implementation Of The Sustainable Development Goals; UN: Tbilisi, Georgia, 2016. Available online: https://sustainabledevelopment.un.org/content/documents/10680SDG Voluntary National Review Georgia-.pdf (accessed on 5 August 2021).

22. Guerra, F., Trevizam, A. R., Muraoka, T., Marcante, N. C., & Canniatti-Brazaca, S. G. (2012). Heavy metals in vegetables and potential risk for human health. Scientia Agricola, 69, 54-60.

23. Felix-Henningsen, P.; Urushadze, T.F.; Narimanidze, E.I.; Wichmann, L.; Steffens, D.; Kalandadze, B. Heavy metal pollution of soils and food crops due to mining wastes in an irrigation district south of Tbilisi, Eastern Georgia. Ann. Agrar. Sci. 2007, 5, 11–27.

24. Avkopashvili, G., Avkopashvili, M., Gongadze, A., Tsulukidze, M., & Shengelia, E. (2017). Determination of Cu, Zn and Cd in soil, water and food products in the vicinity of RMG gold and copper mine, Kazreti, Georgia. Annals of Agrarian Science, 15(2), 269-272.

25. Lomsadze, Z., Makharadze, K., & Pirtskhalava, R. (2016). The ecological problems of rivers of Georgia (the Caspian Sea basin). Annals of agrarian science, 14(3), 237-242.

26. G. Avkopashvili, A. Gongadze, R. Gakhokidze, M. Avkopashvili, Phytoremediation of contaminated soils, contaminated with heavy metals from gold mine in Georgia, International Conference Applied Ecology: Problems, Innovations. Proceedings. Tbilisi, Georgia, 2015, pp 154-157, ISBN 978-9941-0-7644-2. (Accessed on 04 August 2021).

27. Avkopashvili, G., Avkopashvili, M., Gongadze, A., & Gakhokidze, R. (2017). Eco-Monitoring of Georgia's Contaminated Soil and Water with Heavy Metals. Carpathian Journal of Earth and Environmental Sciences, 12(2), 595-604.

28. Matchavariani, L., & Kalandadze, B. (2012, December). Pollution of soils by heavy metals from irrigation near mining region of Georgia. In Forum geografic (Vol. 11, No. 2, pp. 127-136).

29. Banerjee, D., Kuila, P., Ganguli, A., Das, D., Mukherjee, S., & Ray, L. (2011). Heavy metal contamination in vegetables collected from market sites of Kolkata, India. Electronic Journal of Environmental, Agricultural and Food Chemistry, 10(4), 2160-2165.

30. Withanachchi, S. S., Ghambashidze, G., Kunchulia, I., Urushadze, T., & Ploeger, A. (2018). A paradigm shift in water quality governance in a transitional context: A critical study about the empowerment of local governance in Georgia. Water, 10(2), 98.

31. Matchavariani, L., Kalandadze, B., Lagidze, L., Gokhelashvili, N., Sulkhanishvili, N., Paichadze, N., & Dvalashvili, G. (2015). Soil quality changes in response to their pollution by heavy metals, Georgia. Journal of environmental biology, 36(1), 85.

32. Agenda Mining Resumes at Controversial Sakdrisi Gold Mine. (2014). Retrieved from https://agenda.ge/en/news/2014/2863. (Accessed on 3 April 2021).

33. Withanachchi, S. S., Kunchulia, I., Ghambashidze, G., Al Sidawi, R., Urushadze, T., & Ploeger, A. (2018). Farmers' perception of water quality and risks in the Mashavera River Basin, Georgia: Analyzing the vulnerability of the social-ecological system through community perceptions. Sustainability, 10(9), 3062.

34. Asanidze, L., Avkopashvili, G., Tsikarishvili, K., Lezhava, Z., Chikhradze, N., Avkopashvili, M., ... & Chartolani, G. (2017). Geoecological monitoring of Karst water in the Racha Limestone Massif (Country of Georgia). Open J Geol, 7, 822-829.

35. Tsikaridze, N., Avkopashvili, G., Kazaishvili, K.H., Avkopashvili, M., Gognadze, A., Samkharadze, Z. (2017). Kvemo Kartli Manufacturing Mining Pollution Analysis in Green Politics Context; Green Policy Public Platform, Tbilisi, Georgia, (In Georgian)

36. Tsivtsivadze, N., Matchavariani, L., Lagidze, L., Paichadze, N., & Motsonelidze, N. (2014). Problem of Surface Water Ecology in Georgia. Environment and Ecology in the Mediterranean Region II, Cambridge Scholars Publishing, Cambridge, 283-294.

37. Melikadze, G. (2006). Monitoring and spatial-time modelling of groundwater on territories of Georgia for solving ecological and seismic problems (in Georgian). Ph.D. Dissertation, Tbilisi State University, Tbilisi, Georgia

38. Republic of Georgia, IFAD Dairy Modernisation and Market Access Programme (DiMMA): Final project design report; Republic of Georgia: Tbilisi, Georgia, 2018.

39. Neven, D., Developing Sustainable Food Value Chains; FAO Rome, Italy, 2014; 25; ISBN 9789251084816.

40. Gómez, M.I.; Barrett, C.B.; Buck, L.E.; De Groote, H.; Ferris, S.; Gao, H.O.; McCullough, E.; Miller, D.D.; Outhred, H.; Pell, A.N.; et al. Research principles for developing country food value chains. Science (80). 2011, 332, 1154–1155, doi:10.1126/science.1202543.

41. ENPARD. Milk and Dairy Production Agricultural: Agricultural Value Chain in Imereti and Racha Regions; Enhancing Small Farmers' Cooperation and Productivity in Imereti and Racha Regions (ENPARD): Tbilisi, Georgia, 2015; pp. 1–27.

42. Kaplinsky, R., & Morris, M. (2000). A handbook for value chain research (Vol. 113). Brighton: University of Sussex, Institute of Development Studies.

43. Gereffi, G., & Lee, J. (2009). A global value chain approach to food safety and quality standards. Global Health Diplomacy for Chronic Disease Prevention, Working Paper Series, Duke University, Durham.

44. Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. Review of international political economy, 12(1), 78-104.

45. Porter, M. E. (2008). Competitive advantage: Creating and sustaining superior performance. simon and schuster.

46. FAO. Milk Value Chain food loss analysis, causes and solutions, 2017; Food and Agriculture Organisation of the United Nations (FAO): Rome, Italy, 2017

47. Wolfenson, K. D. M. (2013). Coping with the food and agriculture challenge: smallholders' agenda. Food and Agriculture Organisation of the United Nations, Rome.

48. IFAD. Livestock insurance for smallholder farmers in rural Georgia, 2020; Livestock insurance for smallholder farmers in rural Georgia, Project fast facts, status as of march 2020, Georgia.

49. Dadiani, L. (2015). Building Farmer Cooperatives in Georgia: Supporting smallholder farming in the post-socialist context.

50. FAO. Smallholders and family farms in Georgia, 2020; Regional TCP on Empowering Smallholders and Family Farms (TCP/RER/3601). Food and Agriculture Organisation of the United Nations (FAO): Budapest, 2020.

51. Oxfam. Research on DCFTA impact on small-holder farmers in Georgia, 2017. Oxfam GB, Tbilisi. Available online: https://www.researchgate.net/publication/322662813_Research_on_DCFTA_impact_on_small-holder_farmers_in_Georgia_in_English

52. European Parliament and Council Regulation (EC) No 178/2002 of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Off. J. Eur. Communities 2002, L31, 1–24.

53. Bundesministerium für Ernährung und Landwirtschaft (BMELV). Strategien der Lebensmittelsicherheit, 2013. Available online:

54. CRRC, Food safety in Georgia, 2010. Food safety in Georgia-Final Report, Tbilisi, 2010. Available online: https://crrc.ge/uploads/tinymce/documents/Completed-projects/Food_Safety_Final_report.pdf

55. Swiss Agency for Development and Cooperation, Meat and Cheese are Kvemo Kartli' s Future; Swiss Agency for Development and Cooperation SDC, Commonwealth of Independent States: Bern, Swiss, 2013.

56. Europe Foundation, Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2016; Europe Foundation: Tbilisi, Georgia, 2016.

57. Europe Foundation, Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2015; Europe Foundation: Tbilisi, Georgia, 2015.

58. Bakradze, E.; Vodyanitskii, Y.; Urushadze, T.; Chankseliani, Z.; Arabidze, M. About rationing of the heavy metals in soils of Georgia. Ann. Agrar. Sci. 2018, 16, 1–6, doi:10.1016/j.aasci.2017.09.002.

59. Avkopashvili, G.; Avkopashvili, M.; Gongadze, A.; Gakhokidze, R. Eco-Monitoring of Georgia's Contaminated Soil and Water with Heavy Metals. Carpathian J. Earth Environ. Sci. 2017, 12, 595–604.

60. Felix-Henningsen, P.; Urushadze, T.; Steffens, D.; Kalandadze, B.; Narimanidze, E. Uptake of heavy metals by food crops from highly-polluted Chernozem-like soils in an irrigation district south of Tbilisi, Eastern Georgia. Agron. Res. 2010, 8, 781–795.

61. Ziarati, P., Moslehishad, M., & Mohammad-Makki, F. M. (2016). Novel adsorption method for contaminated water by wild endemic almond: Amygdalus scoparia. Biosciences biotechnology research asia, 13(1), 147-153.

62. Bolkvadze, B. Investment Strategy of Georgia as a Country of Transition Economy: Trends, Problems, Prospects. Eur. J. Mark. Econ. 2018, 1, 19, doi:10.26417/ejme.v1i1.p19-25.

63. Mohan, S. Institutional Change in Value Chains: Evidence from Tea in Nepal. World Dev. 2016, 78, 52–65, doi:10.1016/j.worlddev.2015.10.004.

64. FAO, Georgian Milk Producers Learn from Italy and the United States. Available online: http://www.fao.org/europe/news/detail-news/en/c/1100229/ (accessed on: 05 August 2021).

65. Wood, A., Value chains: An economist's perspective. IDS Bull. 2001, 32, 41–45, doi:10.1111/j.1759 5436.2001.mp32003005.x.

66. Schmitt, E.; Barjolle, D.; Tanquerey-Cado, A.; Brunori, G. Sustainability comparison of a local and a global milk value chains in Switzerland. Bio-based Appl. Econ. 2016, 5, 175–198, doi:10.13128/BAE-17140.

67. CARD. Business Case Study Dairy Sector in Georgia; Center for Agribusiness and Rural Development: Tbilisi, Georgia, 2018.

68. Hemme, T.; Otte, J. Status and Prospects for Smallholder Milk Production: A Global Perspective; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2010.

69. Food and Agriculture Organization of the United Nations (FAO). The economic lives of smallholder farmers, 2015. The economic lives of smallholder farmers An analysis based on household data from nine countries, Food and Agriculture Organization of the United Nations Rome, 2015. Available online:

http://www.fao.org/3/i5251e/i5251e.pdf

70. A Guide to Georgian Dairy Products Available online: https://folkways.today/georgian-dairy-products/. (Accessed on 3 August 2021).

71. Kartvelishvili, T. Cattle sector and dairy chain developments in Georgia, Azerbaijan and Armenia. In The Cattle Sector in Central and Eastern Europe: Developments and Opportunities in a Time of Transition; Wageningen Academic Publishers: Wageningen, The Netherlands, 2009; p. 133.

72. Al Sidawi, R.; Urushadze, T.; Ploeger, A. Changes in Dairy Products Value Chain in Georgia. Sustainability 2020, 12, 5894.

73. Georgia Department of Agriculture, Georgia's Dairy Industry; Georgia Department of Agriculture: Tbilisi, Georgia, 2014.

74. Europe Foundation, Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2017; Europe Foundation: Tbilisi, Georgia, 2017.

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Chapter 2

Article

Changes in Dairy Products Value Chain in Georgia

Rami Al Sidawi [1,*], Teo Urushadze [2] and Angelika Ploeger [1]

[1] Specialized Partnerships in Sustainable Food Systems and Food Sovereignty, Faculty of Organic Agricultural Sciences, University of Kassel, 37213 Witzenhausen, Germany; a.ploeger@uni-kassel.de

[2] School of Agricultural and Natural Sciences, Agricultural University of Georgia, Tbilisi 0159, Georgia; t.urushadze@agruni.edu.ge

* Correspondence: rami.alsidawi@uni-kassel.de; Tel.: +49-055-42981621

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Abstract: The livestock sector, as a part of the traditional food system in Georgia, occupies a considerable portion of the national economy. Though smallholder farmers are the key suppliers at the primary stage in the food value chain, the empowerment of smallholder farmers in the dairy production system in Georgia is questionable. This research study reports the results of changes in the dairy sector in Georgia (Caucasus) after becoming independent from the Soviet Union (literature survey) and how these changes are seen by experts in the dairy value chain. In addition, this study aimed to look in-depth at the dynamics of the value chain of dairy in Georgia and examine the current dairy production policies. Qualitative research was applied as the methodology for expert interviews in 2019. The findings showed the difficulties experienced by the local and national dairy market sectors in Georgia nowadays. Where these difficulties were analyzed by the parameters of the value chain, it states the impact of the current regulations and policies on the safety and the quality of dairy production in the country and the depth of social, economic, and ethical impacts on the marketing of dairy products for smallholders. Furthermore, the Sustainable Development Goals on the dairy value chain are described.

Keywords: dairy products; value chain; Georgia; food safety; expert interviews; small farmers

1. Introduction

After the collapse of the Soviet Union, a di_cult political, socio-economic situation arose in Georgia, which was further aggravated by the civil war in the country. The government saw the formation of self-su_cient farms as one of the ways to get out of the challenging economic situation, and in 1992 the land reform began, which involved the transfer of land to the Georgian population.

As a result, thousands of small farms (on average, about 1 hectare of land) have been established in the Georgian regions [1–4]. Though the agricultural sector in Georgia has been decreasing since the collapse of the Soviet Union, it turned out to be much more reliant on smallholders' farmers, which now deliver about 90% of the entire agricultural products being produced in Georgia [5]. Nevertheless, Georgia is still dependent on imports in general, and the dairy products sector has high imports.

In the last few years, due to the fact of this reform, which mainly aimed to solve the social issues, the Georgian economy has been under transformation [6]. This changing period can be alienated in two

core stages: from 1990 to 2003 and 2004 up to present. After 2004, economic strategies started to integrate the concepts of economic liberalization and modernization [7]. However, 90% of the smallholder farmers who live in the rural areas are dependent mainly on grass-based dairy production, and they are using the available pasture in the summertime and reliant on hay in the winter period. After the collapse of the Soviet Union in 1991, the privatization of pasture lands was halted [8], and in 2008, the state-owned large areas of land designated for rangelands were passed to the municipalities to decide how and by whom to be used. Often the mountain pastures are used informally for free and without any restrictions by local herders or nomads [9].

Milking cows and producing a good quality of milk helped the country economically with the development of the dairy sector, as well as the other livestock like sheep or goats [10]. According to IFAD [11], there is nearly one million head of livestock in Georgia, around 50% of which are dairy cows. Nevertheless, between 2004 and 2014, there was a reduction of dairy cow number by 25%, and that was faced with a 40% increase in milk production per cow, which is due to the change in the cow's breeds and feeding system. However, between 2006 to 2015, the milk production increased by 11% which is still lower than the political scope [11].

The cheese industry was one of the most important industrial revolutions in Georgia. It is worth noting that, under the Soviet system between 1921 and 1991, the goal of economic decision-makers at that time relied on the quantity in the manufactured cheese. That helped to feed the people of the USSR [12]; the reason was to manufacture only four types of Georgian cheese that are easy and fast to produce: Imeruli, Sulguni, Karkhunli, and Guda [12–14]. After the collapse of the Soviet Union and the proclamation of independence, Georgia strongly witnessed the return of national identity which was, for example, the revival of culinary traditions. Many of which were lost due to the industrialization of agriculture in the Soviet era, although Georgia is home to dozens of other cheeses [15].

In the last few years, the cheese market has been formalized in Georgia, as smallholder farmers provided the means, projects, and necessity to grow, they developed the sector of small and medium dairy projects and secured an increasingly formal market [5,10,16]. According to CARD [17] in 2016 and because of the high demands on traditional cheese sorts, the consumption of cheese was 12.7 kg per capita, followed by milk consumption of 8.3 litres per capita. Today, cheese is the most daily food consumed among dairy products in Georgia, and this consumption is progressively increasing [17].

Despite the continuous development of the cheese sector, there are restrictions currently facing this development. There are farmers in rural areas who decide to make cheese at home and selling it informally. So, this product is completely free of food safety control and might be produced under low hygiene standards. Since the National Food Agency (NFA) is not able to monitor this production at smallholder farmers' homes, a law was implemented in 2020, prohibiting the sale of home-made cheese; therefore, it is only valid for family consumption [6,10,11,17].

Likewise, one of the current problems facing the development of this sector is the inability to monitor and control unregistered companies and which might be incompatible with the existing regulations, and prevents access to fair competition and thus destabilizes the sector completely [6,10,17,18]. One of the biggest problems is the use of powdered milk in the cheese industry, thus creating an imbalance in the local markets and increasing the exports of powdered milk, which undermines the potential

added value of Georgian dairy products. In 2017, NFA made changes to the regulation on milk and dairy products, which prohibits using the name "cheese" on the products containing milk powder [10,17–19].

Thus, and based on the foregoing, the purpose and importance of the study lies in the scrutiny and study of the current dairy production policies in Georgia and the current and future difficulties they face, especially in the post-Soviet period, and any attempt to define the relationship between stakeholders and small farmers.

2. Dairy Food Chain

The supply chain is a multiform collaborative activity designed to create "value" through a combined effort within the chain. This activity includes aspects such as processing, packaging, transport, storage, and retailing [20]. All these activities and actors will take the product from its conception to disposal.

A value food chain starts along a supply chain. A value food chain is a set of businesses and their interactions that bring farm products from its conception and design to its end use by the consumer and even further on to waste management. Producers and consumers of agricultural goods form form strategic alliances with other supply chain players such as aggregators, processors, distributors, and retailers, to improve financial returns through product variation that promote social or environmental values [17,21].

The activities allow adding "value: to it during the passage of the product through the chain. Even today, considering ecological or social factors in agriculture and food business, economic factors mostly describe this value. As a result, it is possible to describe the value chain with what and where the values are added in the supply chain for and by these activities and players [22,23]. Therefore, each factor in the chain (Figure 1) is utilized to ensure that the value of the product resulting from this chain is high and meets the satisfaction of the consumer [24].

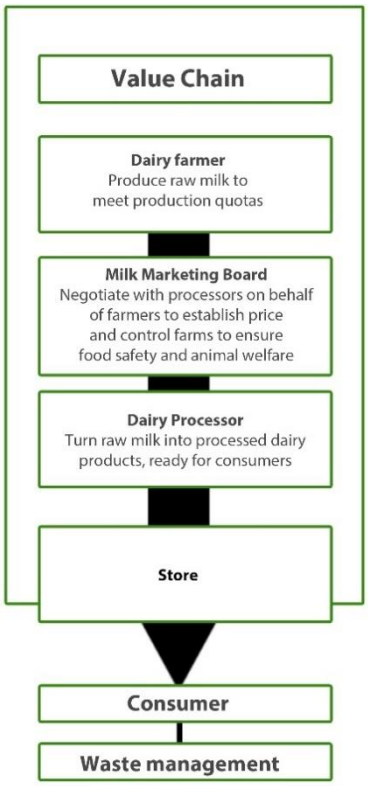

Figure 1. A shortened illustration of the dairy value chain [86].

The food value chain facing rapid changes in developing countries, many factors lead to this change, as population increases, income growth, and local and global expansion in the food trade change, distribution, and sale operations. For example, the consumer and the government are demanding not only a product with proper specifications and a low price but unique characteristics that exceed the price, such as food safety certification, nutritional content, low greenhouse gas emissions, and many others [21].

Georgia, as a developing country in a transitional economy [26] and the food value chains, are affected by these institutional changes, too [27]. International forces, regional and global quality standards, are influencing the Georgian dairy chain as well. Therefore, the economic aspect is essential in understanding the value chain, as it provides a solid ground. According to FAO [28], Georgia, a country with comprehensive free trade, is open for imports of dairy products from the European Union (EU). Still, it cannot export its dairy products to the EU due to food safety and milk quality issues [29]. Besides, Georgia possesses an essential heritage (traditional) of dairy products. Still, these products do not have great market visibility, as the economic factors of the chain did not give a particular concern to heritage at the moment [29]. However, if the local food chain performance will be provided with a critical analysis focusing and comparing with the global ones, it may help to accurately evaluate the real benefits and problems of local and global food chains [30].

Therefore, there are many indicators by which value chains can be developed, compared, and distinguished. For example, local milk could be easily compared to imported milk. This difference in performance can be explained partly by important factors in the chain. That affects the degree of the evaluation of many indicators. For example, the strategy of animal feeding and the choice of animal feed varies depending on the system followed or it may rely on old traditions (cultural heritage). Also, the rotation of crop possibilities and their productivity per hectare per cow, animal welfare, low

or high greenhouse gas emissions, as well as the quality of fats in the milk [17,30,31] can be possible indicators.

These lead to the existence of different products, which generates different marketing strategies, which in turn lead to the arrangement of a diverse supply chain. Besides, all of this affects the relationships between all actors in the supply chain, the difference in prices, and transparency for consumers.

On the contrary, some of the global strategies being used in standardizing products, reduce the transparency component for both consumers and farmers. Still, they may help, on the other hand, to reduce production costs and reduce waste [30,31]. However, all actors in the dairy food chain are linked by the product flow (supply chain) and the economics being involved. For consumers besides food safety and food quality, additional factors are essential for dairy consumption, such as social and environmental factors, as well as traditional or on-farm produced foods [17,21,30]. Therefore, constructive support for local products and considering the economic, ethical, and social aspects, cultural heritage, and traditions may help to develop a "consumer-driven" value chain and, which in turn, directly and indirectly, affect sustainability and access to food of high quality and safety standards [22,30].

This research paper is providing comprehensive literature that could help to define an appropriate value chain for dairy products from the "stakeholders" point of view, especially driven by consumers' expectations.

Moreover, the study aims to (i) investigate the dynamics of the dairy food value chain by examining the relationship between the stakeholders as the result of a literature review; (ii) scrutinize the current dairy production policies such as safety regulations to define the difficulties that are facing the local and national dairy market sectors in Georgia; (iii) explore the impact of the socio-economic on the smallholder dairy farmers when marketing their products focusing on the region of Kvemo Kartli in Georgia, and (iiii) investigating the best mechanisms to be implemented to empower better management in the dairy value chain of smallholder dairy farmers in this region and Georgia in general.

These documents provide a valuable tool for illustrating the complexity of the chain. It also helps to understand the experts' point of view and how to see a development in the dairy chain linked with political, economic and ecological as well as social situations of farmers in this region of Georgia Figure 2 demonstrates the hypothesis presented in this work. On the other hand, the expert interviews help in evaluating relationships between actors along the vertical and horizontal dimensions of the dairy value chain and understanding the contribution of the factors to this chain, such as ethnic and socio-economic dynamics, which were highlighted. It also helps to understand the relationships among the various interest groups, such as investors, processors, big companies, producers, etc.

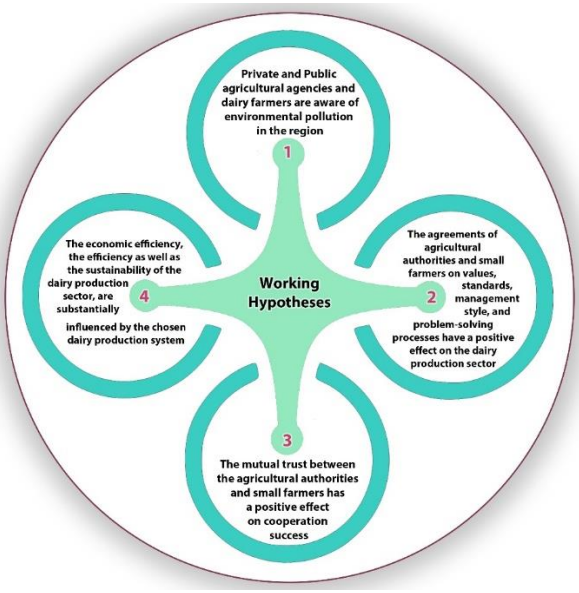

Figure 2. Working hypotheses.

3. Materials and Methods

This research study is part of a cooperative research work between the University of Kassel, Faculty for Organic Agricultural Sciences and the Agricultural University of Georgia since 2018.

The work was divided into two parts, first providing a review of the current state of the value chain analysis as a tool to evaluate the Georgian dairy sector, second, conducting expert interviews.

3.1. Region

The study area, Kvemo Kartli (Figure 3), is situated in the south part of Eastern Georgia. Kvemo Kartli fills 9.4% of the whole territory of Georgia which is 6.5 thousand square Kilometers [32].

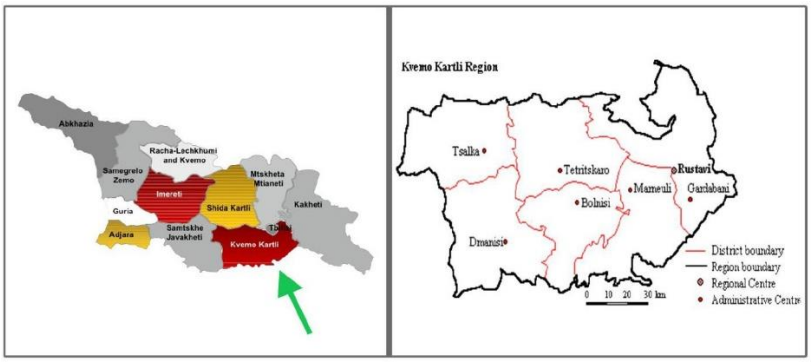

Figure 3. Kvemo Kartli region, source: [89].

The Kvemo Kartli region, which is close to the capital Tbilisi, Georgia, is considered the biggest beef producer, and families earn their living from livestock, cattle, and sheep. Usually, they own an average of five cattle, and up to 40 sheep. However, the production of good quality of locally produced meat and dairy products is a growing market in Georgia. Farmers in Kvemo Kartli face difficulties related to the lack of modern farming machinery, lack access to vets, and poor knowledge of and connection to the meat and dairy international markets [34].

3.2.A Review of the Current State of the Value Chain

This paper was designed to provide a review of the current state of the value chain analysis as a tool to evaluate the Georgian dairy sector. Besides, a literature review and gathering primary data through expert interviews were used to obtain insights into the Georgian dairy value chain.

To clarify the factors of the comprehensive literature research, we conducted an online search using keywords such as "value chain," "dairy Georgia," milk production Georgia", and "food safety Georgia." Authorized documents, together with regulation guidelines, government policy regulations, and reports published by the Georgian government agencies and their research institutes, as well as documents from international organizations, have been evaluated as reliable sources (see Appendix A. Literature Review Keywords).

A total of 35 interviewees were selected. Due to the sensitivity of the information investigated in this research, some of the experts refused to meet us and expressed their inability to disclose that information, besides their limited time. Twenty-two dairy chain experts took part in the survey.

The value chain of the dairy is usually a_ected by the di_erent variables such as the independent variable (such as age, gender, and education), the intervening variable (government policies), and the moderating variable (e.g., extension services) [34]. In this study, the expert interviewees were chosen based on the intervening variables and di_erent moderating variables such as the rearing system adopted by the farmers living in the Kvemo Kartli region. Figure 4 shows the main criteria of the the selection for the expert interviewees.

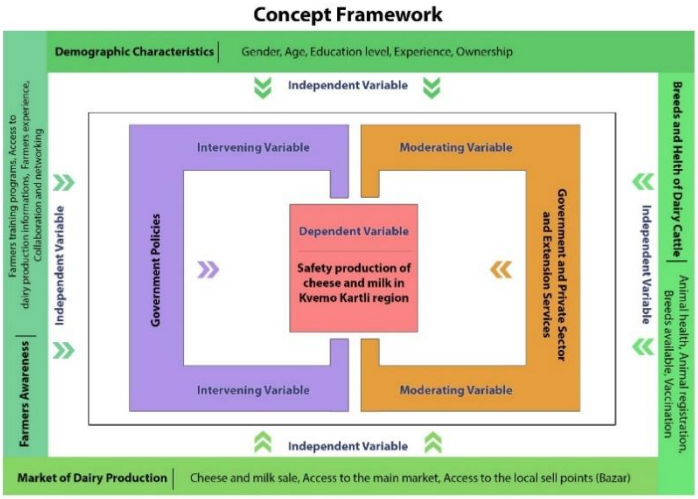

Figure 4. The main criteria of the selection for the expert interviewees.

Usually, the independent variable influences the value of the dependent variable, as there is a cause-effect relationship between these two variables. Thus, the variable that affects the cause and effect relationship between these two variables is the moderator variable [35]. The moderating variable will explain one of the research aspects, which will be for this research the cultural issues affecting the dairy products, for example, which rearing system is adopted by the farmers living in the Kvemo Kartli region. One of the main characteristics of choosing the interviewees is the intervening variable, as an intervening variable is a variable that may affect the cause and effect relationship of dependent and independent variables, but it may be difficult to measure it clearly or be ignored during research [35], which is in our study represented by the government policies. For this, we executed an analysis of interviews that were done in a different government facility.

3.3. Data Collection

Data collection for this work occurred in June 2019. The research was based on empirical data, which consisted of a semi-structured personal face-to-face interview (N = 22), which can help to illuminate several problems that may not appear with other qualitative research methods [36].

The guided interviews were taken with representatives of the dairy industry, governmental bodies', and people working in quality laboratories of private sectors and international organizations. According to Mayring [37], the structured content analysis was used for the evaluation with regards to the quality criteria (objectivity, reliability, validity). Because of the different interests among the participants being interviewed, we prepared an interview guide, which helped to ensure that the data collection was similar and systematic (in concentrating on the relevant topics).

In total (Table 1), six experts from the dairy industry (DI), 12 experts from the governmental body's and laboratory (G), three experts from the private sector (P), and one expert from FAO (IO) were interviewed (N = 22). These interviewees were chosen carefully to represent the target groups.

All interviews were conducted in both languages Georgian and/or English. A translator was required.

Table 1. Codes and Interview Details.

Code	Position	Interview Date
Government/G1	Chief Director	10.06.2019
Government/G2	Director	12.06.2019
Government/G3	Director	12.06.2019
Government/G4	Director	12.06.2019
Government/G5	Director	12.06.2019
Government/G6	Director	12.06.2019
Government/G7	Director	12.06.2019
Government/G8	Director	12.06.2019
Government/G9	Head of the department	13.06.2019
Government/G10	Chief Veterinarian	13.06.2019
Government/G11	Technical Veterinarian	13.06.2019
Government/G12	Technical Veterinarian	13.06.2019
Private sector/P1	Food Safety Manager	06.06.2019
Private sector/P2	Quality Manager	
Private sector/P3	Consultant	07.06.2019
Dairy industry/DI1	Main Office—Team—Coordinator	14.06.2019
Dairy industry/DI2	Senior Team Officer	14.06.2019
Dairy industry/DI3	"The Queen of Cheese"	09.06.2019
Dairy industry/DI4	Technical Director	11.06.2019
Dairy industry/DI5	Georgian Farmers Association	16.06.2019
Dairy industry/DI6	Certification Specialist	16.06.2019
International organization/IO1	National Team Leader	13.06.2019

All participants were chosen through the personal contacts of the researchers. Moreover, according

to Edwards et al. [38], the researcher must provide additional care in the validity of the interview material in the context of the qualitative research, and the interviewer can focus on the interview and build an understanding instead of being unfocused with extensive note-taking. For this reason, the interviews were recorded, after obtaining the permission of the interviewer first.

Yet, the sample size of this study seems to be small to conduct a decent research interview, it is enough to determine the required number of experts and choosing the right informants [39], but it does not allow the generalization of the results for the whole of Georgia. Thus, the results of this study may indicate tendencies for the dairy production situation and the current applied regulations in Georgia due to their qualitative nature. This investigation was made to gain primary expertise about the dairy value chain in Georgia because, in the next part of the empirical studies, dairy farmers of the region will be interviewed to catch their perspective.

The recorded audio files were transcribed using the MAXQDA 18 program. The interview guideline served as the basis for the main categories to be defined at the beginning. This approach is referred to as "deductive category formation" [37]. For the most accurate classification of the data, additional subcategories were added during the coding phase; this is called inductive category formation. Significantly, it is important to use coding, as text data are dense data, and its understanding and analysis take a long time. Therefore, through coding, this data can be indexed and formatted. Then we can get an overview of the data, understand it, and understand its relevance to research questions [40]. Table 2 shows all codes and sub-codes being used.

According to Eriksson et al. [41] and Cassell et al. [42], the ethical guidelines in this research have been taken into consideration, which states that every researcher should treat all study participants with respect. This was done, as mentioned previously, by informing all the interviewees about the research goal (development of the Georgian dairy value chain) and ensuring that their names were not mentioned if this was their desire.

All participants voluntarily joined in this research, and the permission to record the interviews have been asked each time before the meeting. Besides, all people interviewed for this research are undeniable.

Sufficient time has been given for interviews and in-depth engagement with participants. After completing the interviews and conducting data analysis, some participants were contacted and were given a complete transcript of their coded interviews to set whether the codes harmonized their standpoint.

According to Rädiker et al. [43], in this workflow, the data were first encoded by one person, and to demonstrate reliability, the coding was performed and checked by another person. To check the "interrater-reliability" to this work and to quantifies the quality of the qualitative analysis in a number and translates the work into a comprehensible with a familiar form, a coefficient like Kappa was calculated (Kappa = 0.89) [44]. Based on Rädiker et al. [43], if the Kappa-value was >0.81, this means that we are talking about a very good result ("almost perfect"). This shows that the coding list was reliable. Discord points were then discussed; then, all the new changes in the coding groups were applied to all transcripts.

Table 2. Codes and Sub-Codes.

	Codes							
	Marketing	**Animal Welfare**	**Import/Export**	**Investment**	**Dairy Food Regulation**	**Government Support**	**Food Quality and Safety**	**Production System**
Sub-codes	Local market	Animal health	Quality control over the imported dairy products	private sector	Organic dairy production	Farmer education	Heavy metals	Production development
	Bazar		Price difference	Farmers ownership	2020 new regulations	Farmer knowledge	Hygiene	Milk collection point
	Main market				integration of EU Regulation	Control on the dairy production value chain	Quality parameters	Cheese varieties
	Self-consumption					Veterinarian	Quality control	Milk powder
	Dairy products coast					International organizations		Challenges
	Dairy production in Georgia (percentage)					Government cooperation		Gender

4. Results

In this section, the results gathered from the literature study and expert interviews are presented and discussed. The literature study opens the view of how diverse and complex a dairy value chain is seen in different countries and from the different stakeholders in the dairy sector. Because the consumers decide which quality and expectation towards the dairy product they want to pay for, the different criteria of a dairy value chain are described in this part. Furthermore, the opinions of these experts will be discussed on how the various factors that will be mentioned affect the value chain in Georgia.

4.1. Stat of the Dairy Value Chain

4.1.1. Dairy Value Chain Based on Economics

Economically, the value chain is of great importance, but its importance has increased, as it has become a tool for analyzing the country's economic relations in recent years. Georgia has suffered from significant economic difficulties since the collapse of the Soviet Union. It has persevered in developing this economy day after day, as analysis of the value chain was considered an important contribution to the interpretation of unequal development and continuous underdevelopment [45,46].

The balance between growth on the one hand and collateral damage on the other hand and assistance in developing economic and political recommendations gave the economic value chain a leading role in developing the Georgian economy [45,46].

This helped in the consistency of information within the value chain which is linked to the relations between small- and medium-sized companies and their allocation of profits and helped to establish a strong relationship between the public and private sectors which in turn helped to support the dairy sector and open new horizons in their economic growth

According to the Geostat Report, in 2017, half of the cows in Georgia, which are approximately 900,000 head of cattle, are milking cows, and the report has cleared that the productivity of cows has increased, but in return, the number of these cows has decreased (Figure 5). With a cow's productivity of about 1400 litres per year, Georgian milk production is still much lower than the European Union and other developed countries [47].

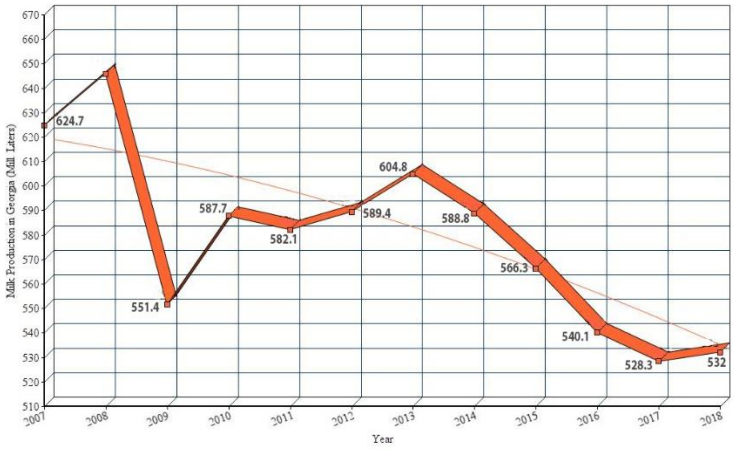

Figure 5. Annual milk production in Georgia (millions of litres) [102].

Based on Geostat Report in 2020 (Figure 6), in the first quarter of 2020, there was an increase in milk production by 5.0 per cent compared to the same period of the last year, and by 14 per cent compared to 2014, where production has become nearly 107.0 million litres [48].

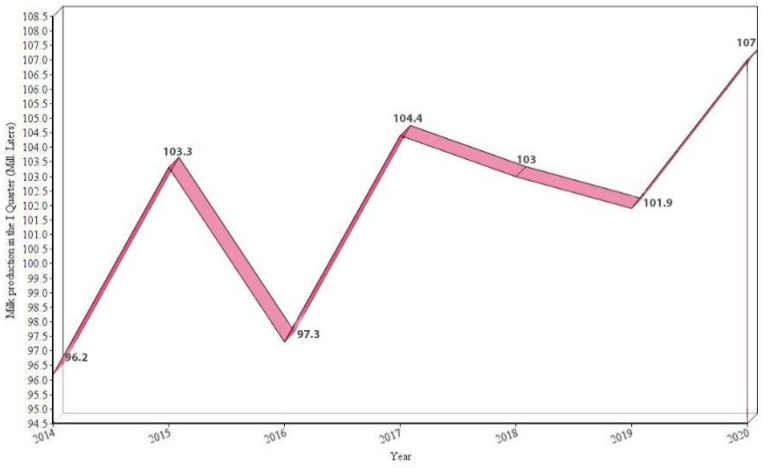

Figure 6. Milk production in the first quarter (January, February, and March) of 2014–2020 (millions of litres) [103].

4.1.2. Dairy Value Chain Based on Ethics

The dairy value chain also means consideration of animal welfare. These days the consumer's awareness about the quality and the safety of food is increasing; besides the concerns over food scares, such as salmonella or avian influenza, ethical factors are playing a major role in consumers' behaviour which cause farmers to consider the welfare of their animals [49].

Based on Mayfield et al. [49], almost all consumers in Great Britain, Italy, and Sweden are concerned about animal welfare. According to Napolitano et al. [50], animal welfare is becoming progressively significant in the hierarchy of societal matters. As stated by Pirsich et al. [51], numerous consumer studies in Germany have revealed that consumers are eager to pay 10–35% more for animal welfare-friendly products. According to Rodiger et al. [52], several studies have demonstrated consumer willingness to buy meat and milk and pay more for outdoor access of farm animals, besides, studies have also shown that currently in some European Union countries, consumers have only a limited choice, either organic or traditional products.

According to the Georgian Government report in 2017 [53], the use of antibiotics in animal foods may generate resistance that can be transmitted to humans eating milk or milk products. Georgia, with its nonstop work to achieve the EU food safety regulations standards, has focused sharply on improving animal husbandry and improving the feeding [54]. The lack of adequate feed and shelter during the winter months causes severe problems in milk production and quality, especially in the absence of hygiene, sanitation problems, and animal diseases. Therefore, farmers do not benefit from better prices; this results in a sharp decline in the supply market [11].

In the dairy sector, to produce an appropriate amount of milk, feed considered as the main input for livestock, and families that own many animals use their farms to provide enough grass in summer, maize, hay, and straw in winter. They are unable to guarantee the necessary feed proportions for their animals due to the shortage and high cost of concentrates [9,17].

Therefore, the productivity of their animals is low. Still, the owners of big farms and large enterprises, as in Kvemo Kartli (our research area) and eastern Georgia, depend on purchasing the necessary feed (such as wheat, corn, and straw) [11]. Moreover, according to CARD [17], the import of animal feed is increasing. In 2017, the index was two times higher than in 2009, providing farmers with the opportunity to secure their needs and take care of their animals. But feeding high amounts of concentrate, such as wheat and soybeans, is not ethical, because this is not according to their physiology and will cause illness such as mastitis [55]. Also, some farmers try to treat their cows with antibiotics in advance to prevent illness which will cause a problem for humans [56].

4.1.3. Dairy Value Chain Based on Cultural Identity

In addition to what has mentioned, dairy products are very important to Georgian cuisine. One can see how important the value chain is and specifically concerning traditional Georgian food products that reflect the rich natural

identity of the country, especially in the post-Soviet period [57,58]. Farmers and processors are the protectors of this food heritage and they have deep knowledge of this heritage. The value chain plays a vital role as an engine for rural development on the one hand, and on the other hand, paves the way to raise the awareness of stakeholders, practitioners, and investors about how to sustain production and develop it in a manner that preserves National Food Identity [43,44].

Based on FAO [59], Georgia is a country which has many precise regional and traditional products with durable territorial identities. Because of this, in 2014, the European Union developed a project to support many countries in this field—and Georgia is one of them.

Wine and cheese were among the most important belongings, which the European Union cared for in Georgia. As these two types of cheese (i.e., Megruli and Sulguni) were especially described as being a significant cultural and traditional heritage in the country. Institutional arrangements in Georgia have been formulated according to the system of geographical indications that operate in the European Union, with the protected designation of origin (PDO) and the Protected Geographical Indication (PGI) as classifications of listed products, in addition to the traditional speciality guaranteed (TSG). Georgia has to protect the names, quality, and exact nature of recorded products [59]. Besides, in 2019 EU funded a new project with a budget of 1.5 million euro, which aims to provide sustenance to the development of "Appellations of Origin (AOs)" and "Geographical Indications (GI–s)" structures in Georgia, and this project will last until January 2021 [60].

According to the FAO report [61], the traditions of Georgian cheese production are linked to the traditional knowledge and traditional cultural expressions and dates back over 80 centuries. It is listed among the top 10 cheese producing countries. It produces around 250 different cheeses. As each type is distinguished by a different texture and flavour, the figure below (Figure 7) shows how the historical–ethnic areas of Georgia developed their varieties of cheese and cheese cultures.

Also, Georgia owns a non-profit organization, "Slow Food Coastal Georgia", which is part of the global Slow Food International movement that is working in more than 160 countries, where volunteers (mostly consumers, farmers, processors) are working in this organization trying hard to inspire society to change towards good, clean, and fair food for everyone in Georgia [62].

Figure 7. Georgian types of cheese and cheese cultures [116].

4.1.4. Dairy Value Chain Based on Ecology

The value chain also means considering environmental standards in the use of resources and directing them to serve the chain. According to the TEEB report [63], the great challenge facing the chain is not only developing a framework that includes eco-agri-food systems based on natural systems but also social policies, economic, political, and interactions among them and within them.

The development of the agricultural sector is highly dependent on ecological services such as managing sustainable ecosystems and conserving water and fertile soil. Unsustainable and irresponsible agricultural practices in Georgia have led to deterioration and depletion of these resources, especially in rural areas, as 60% of agricultural land has medium

or low fertility. As a result, the rangelands deteriorated significantly [63,64]. Based on Withanachchi et al. [65], the use of mountainous areas for mining in Georgia leads to pollution of rangelands. The development of the agricultural sector depends on the process of environmental impact associated with it. According to FAO [61] Korakhashvili et al. [66] Karanja et al. [67] and the department of agriculture in Georgia [68], research in Georgia has proven that the soil is contaminated with heavy metals. Therefore, water contamination leads directly and indirectly to soil pollution, which is the same soil that is used for agricultural production. Animals, such as cows, graze in these contaminated areas and drink the water from creeks and rivers and, therefore, these cows are exposed to these heavy metals. Unfortunately, there are not yet studies which analyze milk from cows grazing on polluted meadows or analyses of the final product, such as cheese. Therefore, damage to it leads to damage to all dairy chain parts. As the agricultural sector in Georgia is closely related to the environmental effect associated with it [63,64].

4.1.5. Dairy Value Chain Based on Social Factors

As explained earlier, each component of the value chain has a strong impact on the whole chain which means that considering social issues is essential, and must be addressed, as smallholder farmers
in Georgia rely heavily on milk production [17].
But the lack of necessary training, skills, and technical knowledge for them to produce high-quality milk and their inability to control the marketplace put them in the face of many problems. The farmers depend mainly on dairy processors because they lack effective links to the market [17,64]. For example, the import of low-priced milk powder showed a significant increase in 2016 compared to 2012. In 2016, the milk powder import reached 8334 tons, this was 121% higher than in 2012 which increased the problems faced by small farmers. In 2017, the entire quantity of milk powder imports increased was almost 9862 tons which was mostly imported from Ukraine (24.7%), Germany (15.7%), Belgium (10.7%), and Belarus (8.6%) [16,17].

Therefore, as a social factor in the dairy value chain would be to link the smallholder farmers with the market or empower them to produce high-quality and safe dairy products on their farms.

4.1.6. Dairy Value Chain Based on SDG's

On top of that, the value chain also means taking into account the globally accepted Sustainable Development Goals (SDGs); these goals encompass 17 goals and 169 targets which were confirmed on 25 September 2015 [69]. Georgia, as a member of the United Nations, was ready to go into the implementation of the SDGs and targets which are set for 2030, as the Georgian government in 2016 incorporated those goals into its annual work plans [70,71].

According to the CARD Report [72], several of the SDGs were significant factors and had the highest impact on developing the Georgian dairy sector.

SDG2: end hunger, achieve food security, and improve nutrition and promote sustainable agriculture [69]. Increasing production and enhancing competition opportunities are among the goals that the Dairy Farmers Association aspire to.

Because they are directly related to the productivity and performance of smallholder farmers, as these associations provide the necessary services to them by obtaining advanced technology and improved breeds that help them cost-effectively increase their production. The rural population depends mainly on dairy products in their daily lives and, thus, will contribute to food security and the elimination of hunger. On the other hand, creating such opportunities will increase the income of dairy farmers. It will be economic support to those regions which serves the first goal of SDGs: end poverty in all its forms everywhere [69,72]. According to CRRC [16], in recent years, many internal and external investments and cooperatives have emerged that are trying to build a bridge between small-and medium-sized companies and small farmers, with the main goals to support farmers to obtain a stronger position in the market. For example, the Alliance Caucasus Program (ALCP), which started in 2008 and entered into force in 2017, was funded by the Swiss Cooperation Authority (SDC) and is being implemented by Mercy Corps. This program runs until 2021 and focuses on the development of the livestock sector in Georgia. The program supports dairy factories for small and medium enterprises (SME) and is establishing a close and sustainable relationship with local communities and smallholder farmers. On the other hand, the smallholder dairy production sector in Georgia is under the leadership of men, but, men and women work together. Besides, women are more responsible to produce milk and dairy products on family farms. Despite this, and concerning the old tradition's, men are always presented to play the main role which

made SDG 5 "Achieve gender equality and empower all women and girls" [69] of the sustainable development goals very important, as it also provides women with an opportunity for equality and fairness.

The implementation of the new regulations "which provides for the prevention of agencies that work in milk processing and production from receiving milk from unknown cattle that were not registered electronically in the official records" [6] in 2020, will support the responsible parties for the dairy sector in Georgia in controlling production amounts and raising awareness among dairy farmers.

This leads to achieving a low level of food loss, which is one of the most important sustainable goals, which is SDG 12 "Ensure sustainable consumption and production patterns" [69,72]. As well as the implementation of SDG 17, "Revitalize the global partnership for sustainable development" [16] which is considered one of the main axes of the value chain, as mentioned previously, the consolidation of the relationship between the public and private sectors on issues related to the industry, helps directly and indirectly to play a mediating role between farmers and the government, and thus opening new horizons for each of the smallholder farmers and producers, big companies and investors, which has a positive impact on the chain [11].

4.1.7. Dairy Value Chain Based on Food Quality and Food Safety

Despite the above facts, the development of the regulatory sector for Georgian dairy foods is one of the most important pillars of the value chain. It should give access to a high-quality product that satisfies both consumers and legislators need strict laws and standards [19]. For example, taking care of animal welfare, good hygiene standards, implementing risk analysis, and knowledge about critical control points in Georgian dairy supply chain and facing the risk of antibiotic resistance, all of which drive the value chain to new stages of development and progress [54].

According to the Europe Foundation report [54], since 2004, Georgia has been concentrated on developing a food safety system in the country, including the safety regulation for dairy products, which changed, especially after the collapse of the Soviet Union. One of the most important motives for developing these regulations was the signing of a partnership agreement "EU-Georgia Association Agreement" between Georgia and the European Union in the year 2014 regarding the food safety system. At the beginning of 2010, Georgia adopted its food safety system, a comprehensive plan, and legislative activities, closer to the standards of the European Union [54]. On 1 August 2015, the technical regulations for milk and dairy products were put into action which, in turn, stimulates a ban on the sale of foods that carry the name "dairy products" and which components do not contain animal milk but are manufactured from other raw materials. Besides, in the same year, the government monitored the milk and dairy production sector to ensure that the regulations entered into force and, thus, protect the consumer from misinformation [54]. The National Food Agency (NFA), a governmental body, which is the major player in the Georgian Agriculture sector, which is the responsible and trustworthy actor for regulating food safety, is in charge of checking the output of food products compared to the data provided on labels. It has spotted many cases where laws were violated [73]. The Georgian government is working unceasingly to develop and improve the food legislative framework which, in turn, is responsible for solving problems in the livestock sector. This should lead to obtaining a safe milk source based on the existence of healthy livestock. The responsible authorities, through the electronic animal registration database, develop the monitoring of all related dairy systems, including vaccination programs for the livestock sector [6].

Moreover, at the beginning of 2019, new laws were developed. The aim is the traceability of the value chain and transparent processes. This law came into force in 2020 to prevent the agencies that work in milk processing and production from receiving milk from unknown cattle that were not registered electronically in the official records. Whereas, in the year 2020, food producers will be obligated to be listed as business operators which, in turn, will solve the problem of non-registered enterprises and family farmers at the governmental level [6].

4.2. Results of Expert Interviews

4.2.1. Participants Statements of the Dairy Value Chain in Georgia

Supporting the value chain economically is not an easy process. Many experts emphasized that the government's role in supporting dairy production in Georgia is diverse and highly controversial. The government support for different sectors is widely discussed by the interviewees.

The provision for veterinary services is the only way that government support reaches dairy farmers. Other sectoral support includes the market or when the production is limited which, in turn, hinders the development of the chain to some extent.

The following interview mentioned this issue clearly:

"G1: The government provides the farmers just with veterinary services; also, we are doing the vaccination free."

Besides, according to other experts: "Imported milk is cheaper than Georgian milk and is used from the dairy producers to make cheese and other products, and that is a big problem for us and our economy. The farmers, in this case, are not supported."

The government is trying to support all aspects of the value chain. Regimes are seriously trying to control the health of animals because they are vulnerable to disease which, in turn, poses health risks to the entire population—especially considering that dairy products are of heritage importance and is considered one of the most popular national foods, as the government's views indicate this aspect.

> "G2: These associations have veterinarian doctors all the time, and these cows sit in stations, so they don't go out to the field, so they always kept there, but no idea how often the veterinarian is checking them, and the cows are completely healthy and the get a good treat with medicine and everything regularly, and there is no chance for them to get sick because they are always inside."

> "DI1: We have food safety control, and it will be done by NFA, and they are controlling everything, but about export, they cannot do anything now, but we hope in the next five years all will be better, at least now we can export wine, honey, and tea, etc. (Products without animals)."

However, the government technical staff denied such an argument. They revealed that the government is supportive of education and knowledge building in the dairy sector. They are getting support from the EU and other international donor agencies to advance their technical support to the farmers:

> "P1: Yes, we are trying to supporting them with most knowledge, training, we are not supporting them with funds for example 5000 Lari, and they will use it to buy a car for their son, they are just asking for money, and they thought they don't need any training on food safety issues, they said my father is always doing that, so it is hard time for us to persuade the donors as well as the government that our aim to do something to keep the food otherwise just spending this 15.5 million on particular persons who are not willing to have any training and just be handed makes no sense."

> "DI1: That is why education is very important, because they are lazy, and they want to live in good conditions but without having any control. They are crying that the government is not helping them. However, when they come to help, they are refusing that help."

Enabling relationships and cooperation with companies outside Georgia to support the value chain helps open several avenues for the advancement of the dairy production sector, and this international collaboration provides financial support to the existing government program. US Aid is one of the key supporters:

> "G3: There is no time frame for this training it depended on the farmers when he asked us to come to his farm and give him some help and also some different organization like from the US, and they are supporting for free the farmers (14 million projects)."

The import of milk and milk powder in Georgia is one of the most significant causes that damage the dairy value chain. It is increasing year by year and exceeds export, ensuing in undesirable trade stability of milk and milk products. In terms of amount, Georgia's export of milk and dairy products is very limited. However, according to experts, many cases have confirmed this concern:

"G4: For example, the imported powder milk from the neighbour's countries, it is cheaper than Georgian milk and is used from the dairy producers to make cheese and other products, and that is a big problem for us and our economy."

"P2: for example, let's say, the coast of milk in Georgia is two times higher than the imported one based on our survey, which we made almost in all country, and that is unfair competition."

"G5: Georgian dairy production coast is higher than the imported one also, as we told you before, most of the big producer is using imported powder milk, and it is much cheaper than Georgian milk."

This increase in milk and milk powder import demand remains in the opinion of experts, the key driving force for moving the Georgian local dairy market backwards. The experts view mentions this aspect:

"DI2: We are importing milk and milk powder to the country because our production is not enough, and we can cover just 30% from our need, and this 70% from all DP is imported especially milk powder."

"P3: In Georgia, the milk products which in the whole markets done by milk powder, so almost 75% from the whole production and this milk powder imported into Georgia."

On the other hand, the experts stressed the importance of traditions in developing the chain and the problems that it suffers from and how to benefit from it and implement it under the new regulations where one of the experts stated:

"IO: This grandmother made real cheese from milk, but she doesn't have any hygiene so she never follows any hygiene steps, for example, you must pasteurized milk and then making the cheese so from the milking to making the cheese (a lot now in Georgia are using milk powder) no hygiene at all. Sometimes, if they are boiling the milk, the milk will lose his substance and is hard then to make the cheese, so they are not boiling, so from the row milk you have a lot of problems, bacteria, etc.), so this cheese is for home consumption, but if they have some more, and especially in this period, they will sell it. So, they will go to the Bazar and unfortunately it is not controlled yet by the government because they will be allowed to control the grandmother's place from 2020 by NFA and they will check the place so it will be much easier."

Another expert also stated that other traditional methods are used to this day, and if they are taken advantage of and applied, it may provide special character to the value chain:

"DI1: Another art of cheese is made in a very strange way, they will prepare the cheese and its hard cheese, and then they will add butter and salt; later on, they will put this cheese in sheep stomach (empty one) and push it to animal tactical or stomach. Then roosting this cheese and make it like sausages. And they are storing it for 3-4 month under the ground until they sell it (cheese name: Karam Kaimagh – Mtskheta region)."

All experts agree that animal welfare is one of the most important facts of the dairy value chain.

In addition, farm animal welfare is reliant on human care. Farmers in the Georgian villages make decisions on housing systems and how they are managing it. On the other hand, the government is trying to apply dairy farming regulations all over the country, and they are facing many difficulties concerning smallholder farmers. One of the experts mentioned that:

"P2: The problems we are facing in dairy farming are a lot, first of all, we have very bad conditions in the barns and the cows' situation there is really bad, the government controls normally just the production sector, they are controlling where they are producing milk or cheese or another product, but they have no idea what is happening in the barns."

The farmers in all regions were not always aware of their animals' health problems. For example: "DI2: Another thing they are receiving the milk from the farmers and the farmers have no idea about their own animals' health condition." Supporting the value chain, the government formed several policies to support dairy farmers and drive the dairy sector forward, as one expert noted: G6: Every month they ask this forum from the farmers which proves that your animal has been checked and they are healthy."

Considering that farmers and veterinarians have a precise responsibility in affecting animal health, still, few farmers took sick animals to a veterinary centre for treatment; the remaining farmers depended on traditional treatments. One of the experts mentioned that: "G7: Also, the animals must get treatment, and in the best condition, which is not the good thing in Georgia if you visited the field, you will see the animal welfare situation."

The government sees that the marketing chain of milk and milk products from smallholder farmers is carried out in an unorganized way; one of the reasons is due to the traditions used in the villages.

In the Georgian milk market, we can recognize two different marketing structures:

1. Traditional village systems, where milk from farmers is sold on the opening market, restaurants, and/or groceries as within the region or by using middlemen. As one expert noted:

> "G6: Another case, there is a third party like a farmer that takes the milk and delivers the milk to a second person who is dealing with the companies and the producers who are making cheese. But still very few cases and normally it's like official agreement."

2. Milk collecting points; in this approach, the milk will be collected from the farmers for processing and marketing by private companies.

Therefore to mitigate challenges that limit productivity, the government and the private sector are working hard to support the smallholder dairy farmers along the dairy value chains and develop pertinent and suitable strategies to alleviate the difficulties which facing them and improve dairy production and marketing systems in Georgia, experts stated that: "DI3:...they are receiving and buying milk from farmers, our main beneficiaries are farmers, but we are working with farmers role services providers, we are the program which implements an approach we are creating the market for poor people, in this case, the farmers."

However, based on experts, the Georgian milk, which costs the customers and the producers more than the imported one appears to be unpopular with Georgian dairy sector: "DI4: Georgian dairy costs more than the imported."

Nevertheless, the Georgian government is trying so hard to control the dairy farmers by selling their milk without any food safety measures which leaves consumers questioning product quality, the food regulatory experts mentioned:

> "G8: The smallholder farmers they cannot be controlled completely, there is a market and supermarket (where you are sure everything safe) but the other one called the Bazar and there the cheese from the farmers have been sold, and you cannot be sure at all if this cheese is safe or if they are contaminated or with different diseases, and that's because normally these farmers are not allowed to sell their product in the supermarket so they are standing on the road or in the Bazar to sell their cheese and own product and here no one will tell them anything or make any control on them."

> "G7: Right now, you can see small supermarkets, there are people who opened their small business, and the farmers are going there to sell their products, so the main cheese."

Furthermore, they need to improve the safety of dairy farms in traditional societies. It plays an important role in the chain, including supervision of good practices in animal feeding, hygiene, and animal husbandry; the local indigenous farmers are the major actor, those are in most instances not aware enough of the value of their indigenous knowledge which has been transient from generation after generation.

Currently, in Georgia, there is a crucial need for this information through government support and development actions; some of the experts reveal this situation as:

"DI5: In the old times, we were always working in the cleaning process, like cleaning hands, and all safety processes by milking or other steps in dairy products, but now it is different. In Georgia, when we are preparing cheese, we remove hair from the hands completely, but now it is not anymore about removing the hair, they do not even wash the hands."

Based on the expert's views, the following key area could be noted:

"DI4: For example, there is a farmer, a woman, she has two cows, she has some implication on her fingers, and with these hands, she is not allowed to milk the cows. The first time she put some plastics cover to protect the cows, but later, she removes it and continues milking the cows. Therefore, it does not matter how many times we are telling her about that, and she never listened to us until we told her story on TV, and she was ashamed, then she removed that disease from her hands."

Also, the government's attempt to support the chain from an ecological perspective, the Georgian government looks forward to initiating organic farming in the dairy food sector. The new proposal wrote to get the money for such a project: "P3: Now the government wrote a new project which it will support the organic sector in Georgia, it's like they will pay 80% for certification, for example, if it costs 1000 Lari, the government will pay 800 Lari, and they will also buy organic fertilizer for farmers."

The current food quality and food safety situation of the Georgian dairy value chain was clarified from the perspective of the experts. It addressed the current dairy situation, constraints, and regulations. According to the experts, the dairy sector in Georgia has weak food safety systems in terms of required infrastructure, qualified human resources, food safety culture, and enforceable regulation which, in turn, reflects negatively on the chain.

One of the explanations for these conditions is limited farmer awareness about animal diseases and food safety standards on their farms and their significances in terms of health risks for farm households, consumers, and the whole society:

"P1: The problem is very low awareness; they don't know about hazards from hygiene condition, food safety hazard; you have to tell a lot starting from feed safety, cleaning, hand washing, storage, temperature of milk. they know almost nothing about these kinds of things; you have to start with very simple things to explain."

Internationally recognized safety systems are used to maintain food safety and quality in the dairy sector of Georgia. The level of seriousness of adaptability or applicability is not well-represented in the total dairy value chain. The expert views reflect two sides of argumentation in this regard. One argument is that the difficulties in the implementation of such an international safety system due to the lack of willingness of stakeholders or the lack of formalities in the dairy food value system. Another argument is that the fragmentation within the general food regulations in Georgia. One expert (N3) expressed this issue as:

"P2: If a producer is officially registered then, this food business operator must implement good hygiene requirement, and there is a piece of legislation, government regulations 1-7-3, also this kind of producers must implement HACCP principles and also there is a technical regulation for milk and dairy products, and there is also a different piece of legislation regarding microbiological requirement for food, on a legislative level, the situation is quite good, the problem is the implementation of this legislation and control."

Still, some experts have a positive view of the adaptation of the international food safety system. For example, the HACCP – (Hazard Analysis and Critical Control Point) is applied to minimizing the risk of safety hazards in dairy products. The view of a group of the expert is

" DI6: Almost all the dairy factory where they are working they have HACCP, is HACCP certified, and they have records, we started working with cheeses factory's to help them upgrade their equipment and be compliant according to the national and international requirement of HAACP and other food safety requirement."

However, the connectivity between sectors is a crucial factor in the line. If the HACCP is not practically implemented and not monitored, food safety cannot be expected, said the experts. The food regulatory experts mention:

"DI4: There is a lot of requirement which that the factory should meet; for instance, milk should be collected from the farmers and must be raw milk. The factory must have HACCP, not in a paper factory must fallow requirement which rotating to HACCP documents."

Therefore the safety and quality of dairy products should be ensured to protect the consumers, especially sensitive categories such as children and pregnant women, but according to the expert's farm hygiene, it is not the only underlying problem in the dairy sector, if environmental cleanliness is involved, its influence is probable to be small relative to the growing effect of these other issues. For instance, the contamination of heavy metals:

"G8: In Kvemo Kartli the most interesting thing is that they have the mining companies who are digging for gold and others precious stones so these companies are exploring the mountains and digging there so it can happen there is a lot of metals in the ground or soil or water, so that's one of the interesting things. And they checked the river Masha Vera, and because of washing the gold inside this river, they analyzed the milk from the cows and soil, and they found heavy metals there, and the main was in the downstream area."

On the other hand, it is remarkable that not all the government sectors are on the same page, what concerns the heavy metals contamination because they do not evaluate the situation as being problematic or affect the value chain directly, few experts explained that the dairy sector does *not* face a significant health risk from trace metals: "G9: I think we had not such a case with milk or dairy product where we found to exist of any HM, but it's difficult to say, and not just in milk also in meat." Other experts pointed: "G5: In Kvemo Kartli region, they did not find any trace of the heavy metals at all just in the west part of Georgia almost 15 cases when they found lead in the products."

However, according to the experts, particularly important cases have lately confirmed this concern:

> "G10: There was a case in Georgia about spices, and some persons made an analysis in Turkey and found that it was contaminated with a high amount of lead, and then the National Food Agency made a risk assessment, then they prohibited selling spices because there were no traceability for the product, that is why and afterwards the investigation of lead became popular also in other products."
>
> "DI1: Example When the bees were contaminated with heavy metals, we did first the analysis in Ukraine then we decided to do it in Germany, it is too much expensive for us, but you know they are professional, and we trust them, and normally we did all laboratory analyses in Germany, but when we tried Ukraine, it was a huge difference according to the prices."
>
> "P3: The next problem is water, sometimes the cows are drinking from the streets or the close rivers; for example, in Bolnisi the cow are drinking from the river there and it is common that it is contaminated, but the problem is that they have no other option. At night, the farmers are giving the cows just a small amount of water because the water resources are so far from the farm, and it is a big problem because the milk production is dependent also on the water."

To ensure a high quality of dairy products and improve the dairy value chain, it is necessary to precisely and quickly monitors the individual production steps so that they can be quickly corrected and optimized. In the Georgian case, the National Food Agency is responsible for dairy production quality control: "G9: About control, the production it must be done by the National Food Agency."

However, based on experts, currently, there is no quality control at all on-farm level: "P1: There is no control for primary production, farmers (small families) are not controlled at all."

In the villages, farmers still milking cows by hand without using any milking equipment or hand and udder protection. The production on farms is still primitive. Farmers are not aware of the feeding practices and the use of storage techniques or equipment for ensuring the safety and the quality of milk:

> "DI4: …but I am not sure, but animal food is not controlled at all, there is no legislation for this, it can be imported, or made in Georgia without any legislation or control since there is control everybody tries to have the feed which also contains antibiotics and Microbe's in order the animals to be in the safe side."

It is a big challenge to control the dairy production chain. This sector is facing different serious issues like low production, non-existence of modern equipment and technologies, and lack of management practices: "DI6: The main focus is about safety [rather] than the quality because quality is more difficult in the country to control and implement because of the lack of veterinarian services in the country, this very painful."

The experts also mentioned: "G11: In the food safety sector, Georgia wants to be a long time ago more closely to EU Regulations. Therefore, there is a basic hygiene requirement for dairy production and a new regulation for that."

Georgia is working hard to implement the sustainable development goals, including strengthening relationships and investments with other countries, to develop the value chain, for example, Georgia at the stage of a new partnership with the EU, the reaction for the new structures has been identified by the experts in the dairy products sector as follows: "P3: About EU regulations, first, we must fix some of the rules and regulations inside the country then, later on, we can think about the EU regulations, you know EU have their cheese and a lot of milk production compared with Georgia." Also, "P2: The European Union concluded Association Agreements (AAs) with Georgia, the Republic of Moldova."

> "P1: We signed an association agreement, and we have a DCFTA agreement (Deep and Comprehensive Free Trade Agreement) with the European Union, and the Government undertakes the obligation to implement EU legislation in Georgia when this process started in 2006, and it will be finally finished in 2030 I think, step by step on a legislative level we have implemented several EU documents and this process is quite supported by the government, but then the problem was to implement and control. On paper, we have quite a good situation, but it's very difficult because of a lack of knowledge, lack of education, lack of resources for control, lack of inspectors; there is always no control on the primary level, farmers level, only registered more or less small and middle producers controlled but there are a lot of areas that are not controlled."

Besides, one of the most important goals in the SDGs is to end poverty which in turn brings positive results to the chain. For instance, the Georgian government opened its agricultural and food markets and decreased its role within the dairy sector. Large dairy enterprises and other private sectors increased their investments in dairy facilities and equipment which caused, for smallholder farmers, mostly economic losses, as one expert noted: "DI2: Small hold farmers, the poor ones, which have 1, 2 or 3 cows, what about them? How do you think it is possible to give this farmer the awareness or the knowledge and solve their problems?"

Moreover, for the government, it is important to support the development of small-scale dairy production to serve the local markets. Using the milk powder and increasing investment of private companies in milk production threatens the local milk markets and the existence of smallholder farmers, one the experts mentioned that: "DI3: We started working with them and develop the other services for example support services (feeding veterinarian services, food safety, breeding, etc...)".

Besides, the government believes that next to everything it offers and all its efforts, there is an enormous gap among these three parties: government, smallholder farmers, and the private sectors. Farmers also felt there was unused functionality in their political system and that they could profit more from increased support from both the government and the investors. Dairy industry companies want to take the lead in constructing awareness of modern dairy production while facilitating admittance to free information about technology competence and investment. For instance, one of the experts mentioned that:

> "DI4: Also what I see is a gap of a common platform of private and the state, sitting and making decisions, this is a problem that the government makes a decision based on something, maybe on wrong ideas, and

this has not been discussed with the private sector, the private sector is going forward and getting smarter, so the government has to go also in this way with a better strategy."

Another stated: "G2: We have contact with the private sector but not a big deal."

Other experts noted:

"G1: The National Food Agency is the official body that belongs to the government and provides official control, and there is quality food control and food safety control cooperation with the private sector and also quality management because it is our tool control to check inside the companies because the marketing standard has the same conditions from food safety."

Nevertheless, the farmers and the private sector are still focusing on their interest in the production chain, despite all the problems they face; experts stated that: "*G8: So, usually the case is that the companies are dealing directly with the farmers, so the farmer will collect the milk for the cows and delivered immediately to the producers because with the third party it is not working at all.*"

4.2.2. Summary of the Empirical Study with Experts in the Dairy Supply Chain

This study aimed to examine the dynamics of the dairy food value chain in Georgia, scrutinize the current dairy production safety regulations and policies, and to find out which kind of socio-economic impacts occur for smallholder dairy farmers marketing their products.

Thus, this study successfully outlined the differences between the dairy value chain factors, and how each of these factors plays an important role in achieving the balance among all parties in the chain and developing its work. Farmers and processors in Georgia are using diverse strategies to compensate for the absence of proper arrangements. One example is that the government does not see the importance of some factors in the value chain, such as the Slow-Food "Value" (heritage value) for the farmers and its connection with food culture practised by consumers, combined with ethics in Georgia.

For the moment, the current dairy value chain provides these farmers with just a source of employment and a small share of the entire family income. Furthermore, the most important goal that must be focused on is to integrate smallholders in the dairy sector with the private and public ones. This coexistence provides a balanced mechanism of action within the chain. It makes it easy to integrate sustainable development goals with the other value chain factors which, in turn, leads to the advancement of the current situation to a new step of success. The development is creating a competition in milk supply which causes rapid growth in both supply and demand for milk. This growth encourages food production (such as cheese) that is more dependent on social, cultural, and ethical factors.

5. Conclusions and Discussion

5.1. Summary of the Literature Results

The value chain, as the results of our literature study, demonstrates the full range of factors and activities needed to create a particular "valuable" product. The dairy value chain includes the steps necessary to transform the product from just an idea to being distributed and reaching the final consumer. The primary goal of the value chain and its analysis is to provide the greatest possible value and create a competitive advantage.

The concept of "value" here is intended to include not only economically but also culturally, socially, environmentally, ethically as well as health-based aspects from production to consumption. It is an integrated concept that cannot be divided. It supports the concept of internalizing external effects. Every activity or passivity of one object creates external effects that affect another entity. These effects can be positive or negative. The goal of internalization here is to optimize the welfare level of all participants in the chain (e.g., society) and the entire economy and to include the social costs caused by the effect in a total cost calculation. Besides, internalizations are assessed according to (ecological) effectiveness and economic efficiency [74,75].

Thus, considering all aspects of the economy will help to support the value chain and create a balance between its components. It helps to build a bridge between the processors, smallholder farmers, and the big companies, and it also assists in strengthening the relationship between the private sector and the public one. All this creates job opportunities and will help farmers to be engaged positively in the process of economic development, thereby increasing the capabilities, assets, and activities available to families to generate income.

The value chain also depends directly on the ethical concept. For example, the value chain for milk relies on animal health and animal welfare. This includes their handling, feeding, and how clean the sheds are used and protecting these animals from diseases, risks, and support control. On the other hand, the social factor plays a fundamental role in developing the chain, like gender equality, supporting the young people, smallholder farmers, and community development. All of this helps to improve the ability of community members to join their efforts to take collective actions and find solutions to common problems which, in turn, are positively reflected in the chain's work mechanism. The cultural factor in which food value chains operate is an essential component. The consideration of language, religion, ethics and traditions, education, entrepreneurship, history, and attitudes are related to the methods commonly used in food production, processing, distribution, and preparation at home. Also, maintaining the health of ecosystems and making optimal use of the available natural resources, and not damaging them, significantly affects the value chain. Carbon- and water footprints, plant and animal health, pests and weeds, biodiversity, soil, and water health are all directly related to the stability and development of the chain. In addition to all of this, the sustainable development goals (SDGs) stipulated by the United Nations are an essential pillar in developing and supporting the value chain.

The food safety and quality regulations followed and stipulated directly affect the food value chain, the quality, and safety of food must be preserved, and the use of substances that may negatively affect production, such as powdered milk, must be limited. Therefore, the safety of all steps of the product from the farm to the consumer must be monitored, a clean work environment, milk collection, and storage operations and all necessary laboratories must be controlled which guarantees the safety and quality of the final product.

5.2. Graphical Results

Figure 8 illustrates all the factors covered in this study which were discussed through expert interviews and which presented some of the main challenges facing the dairy value chain in Georgia.

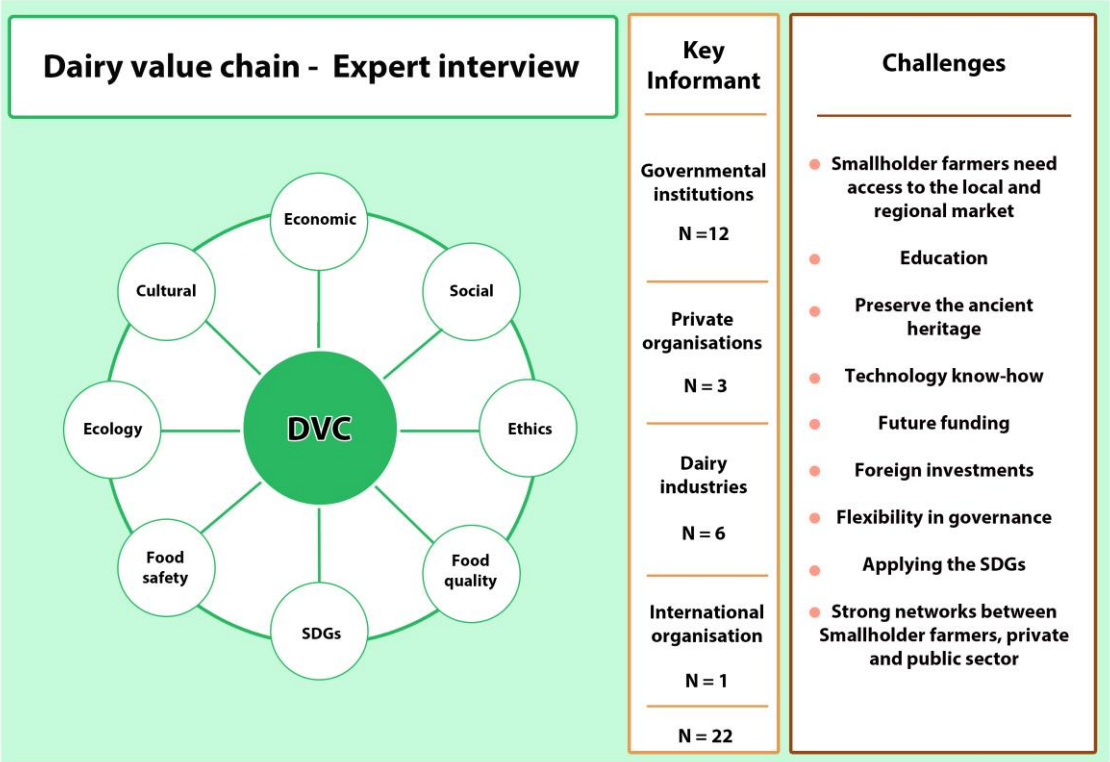

Figure 8. Graphical results of the expert Interview.

The results of this research have shown that the structure of the dairy value chain in Georgia is closely related to the efficiency and level of integration of all the factors that make up this chain.

The results also outlined the differences in expert opinions in assessing the status of each of the elements of the chain.

As the study outcomes show, the marketing issues, for instance, take a lot of attention from the private sector compared to the public sector, which did not pay much attention to it, as this aspect was mentioned during the interviews only a few times from the governmental side, while the majority of non-governmental parties talked about it at length. On the other hand, the government side focused more on how to provide support to farmers to try to include them in the current agricultural political process.

Where the literary studies have proven that economic and agricultural policies are the cornerstones of the value chain, also the government support to the farmers must consider all aspects, without limitation, which supports the chain and builds a solid bridge for cooperation. Especially after Georgia has experienced major economic difficulties since the collapse of the Soviet Union, it is necessary to see the fundamental transformations in the working systems to see the initiatives, that have been successfully developed and maintained to build or improve the value chains [45,46].

As Willett et al. [76] conclude, farmers subsidy programs, which support the rural economies and should help to create the balance between food prices and food safety and quality, play a major role to reach a sustainable value chain, as smallholder farmers are the main contributors to maintaining public health. This means that all stakeholders in Georgia, including the government, have to make an additional effort to build a sustainable business model with a long-term commitment which will lead to a stable value chain, aiming to compete more effectively.

The results obtained from this study partially support the results of previous studies that indicate an important role for the ethical factor in developing the value chain and its impact on all different elements within the chain. But experts did not have the same opinions about the importance of animal welfare and on the necessity of consumer awareness of food quality and safety. As stated by the Nuffield [77] report, the ethical framework for public health needs to include social values, through which we can meet standard health needs and elevate them to reach sustainability.

Also, this study identifies that one of the challenges facing the chain is the development of ecological services in the agricultural sector. Springmann et al. [78] and Tilman et al. [79,80] indicated that the increase in demand for animal products negatively affects land use, leads to increased greenhouse gas emissions, and irresponsible animal feeding programs using grains or pastures which negatively affect water wealth. However, responsible animal production is necessary to alleviate poverty, support livelihoods, and environmental services in the grassland [81]. Therefore, the optimal use of feed and animal welfare affects the value chain positively in environmental contexts [82].

The study also showed how important it is to implement SDGs to develop the value chain in Georgia, as it is a shared responsibility of government authorities, civil society, and the private sector [71]. As the ICSU report [83] emphasized, it is important to work on developing rural infrastructure and integrating small-scale enterprises into the value chain, supporting investment and sustainable agricultural programs. In addition to maximizing the overall social, environmental, and ethical impact, building communication between companies and direct suppliers is necessary. All these aims should be reached to achieve the SDGs in a way that ensures the sustainability of the dairy value chain and implementing the SDGs.

In conclusion, this study explored the factors that influence the efficiency of the dairy value chain and how to evaluate and develop its factors. It also presented the importance of the interaction among the components of the chain and all parties belonging to it, and how the efficiency of the value chain is closely related to food safety and quality. It also showed the extent of the involvement of the ethical, cultural, and social aspects in the success of the work and balance of this chain. It also outlined the positive aspects of applying SDGs to the value chain and how important they are in political, economic, and environmental decisions. These results may help develop the dairy value chain in Georgia and develop an appropriate plan for each of the elements of the chain, where all actors should take into account all factors and continuously coordinate and build among them to ensure the sustainability of the value chain.

6. Further Work to Do

Future studies in the Georgian dairy sector should provide more quantitative statistics on dairy smallholder situations. Such studies should focus more on the causes of low-quality milk production and its relationship to the value chain. More details should be provided on how smallholder farms could be associated to the current dairy regulations. It will also be of great importance to take the gender, ethical, and cultural identity viewpoints into consideration for future studies.

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Appendix A

Literature Review Keywords (Section 3.2)

Dairy value chain
Value chain
Supply chain
Dairy supply chain

Georgia
Dairy value chain in Georgia
Supply chain in Georgia
Dairy
Milk value chain
Milk value chain in Georgia
Milk supply chain
Milk supply chain in Georgia
Cheese value chain
Cheese supply chain
Georgian cheese
Dairy products
Food safety
Food quality
Georgian food regulation
Georgian dairy regulation

References:

1. Bernabé, S. and Stampini, M. Labour Mobility During Transition. Evidence from Georgia. *Econ. Transit.* **2009**, *17(2)*, 377–409.
2. Lerman, Z., Csaki, C. and Feder, G., *Agriculture in Transition: Land Policies and Evolving Farm Structures in Post-Soviet Countries*; Lexington Books: Lanham, MD, USA, 2004; ISBN 0739108077.
3. Terra Institute, Ltd., *Georgia Land Market Development Project Final Report*; Terra Institute, Ltd.: Blue Mounds, WI, USA, 2005; Available online: http://www.terrainstitute.org/pdf/Georgia_LMDP_Final_Report.pdf (accessed on 18 June 2020).
4. Pignatti, N. *Demographic Structure, Labor Market Conditions and Stalled Agricultural Development in a Post-Transition Country;* Tbilisi State University (TSU): Tbilisi, 2017.
5. GeoStat National Statistics Office of Georgia (GeoStat); Tbilisi, GA, USA, 2014. (https://www.geostat.ge/regions/#)
6. Gelashvili, S., Deisadze, S., *Difficulties of Implementing the Technical Regulation on Milk and Dairy Products;* ISET Policy Institute: Tbilisi, Georgia, 2019.
7. EI-LAT, *The economic transformation of Georgia in its 20 years of independence. Summary of the discussion paper*; Liberal Academy—Tbilisi: Tbilisi, Georgia, 2012.
8. Gvaramia, A. *Land ownership and the development of the land market in Georgia*; ALCP study: Tbilisi, Georgia, 2013.
9. Raaflaub, M.; Dobry, L.M. *Pasture Management in Georgia. Current Situation, Frame Conditions, Potentials of Development*; Swiss Agency for Development and Cooperation SDC: Bern, Swiss, 2015; *42*.
10. ALCP, *Ensuring Sustainability in the Dairy Market Sector*; Swiss Agency for Development and Cooperation SDC: Bern, Swiss, 2017.
11. Republic of Georgia, *IFAD Dairy Modernisation and Market Access Programme (DiMMA): Final project design report;* Republic of Georgia: Tbilisi, Georgia, 2018.

12. Weidman, T. The Woman Saving Georgia's Lost Cheeses. Available online: https://forbes.ge/news/7609/The-Woman-Saving-Georgia's-Lost-Cheeses (accessed on: 02 April 2020).
13. ALCP, *National Cheese Sector Research*; Swiss Agency for Development and Cooperation SDC: Bern, Swiss, 2016.
14. ALCP, *Analysing Systemic Change Trends in the Dairy Sector*, ALCP: Marneuli, Georgia, 2018.
15. Gonashvili B., Mosiashvili M. and Sisvadze, N., *Perspectives on Sheep Farming & The Sheep Market System in Georgia;* Swiss Agency for Development and Cooperation SDC: Bern, Swiss, 2013.
16. CRRC, *Dairy and Beef Consumer Preferences;* Caucasus Research Resource Center: Tbilisi Georgia, 2018.
17. *CARD Baseline Assessment of the Dairy Sector in Georgia*; Center for Agribusiness and Rural Development: Tbilisi Georgia, 2018.
18. ALCP, Better Cheese, Better Work, International Labour Office, Georgia, 2020. Available online: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_746235.pdf (accessed on 02 April 202).
19. Europe Foundation, *Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2015*; Europe Foundation: Tbilisi, Georgia, 2015.
20. Neven, D., *Developing Sustainable Food Value Chains*; FAO Rome, Italy, 2014; *25*; ISBN 9789251084816.
21. Gómez, M.I.; Barrett, C.B.; Buck, L.E.; De Groote, H.; Ferris, S.; Gao, H.O.; McCullough, E.; Miller, D.D.; Outhred, H.; Pell, A.N.; et al. Research principles for developing country food value chains. *Science (80).* **2011**, *332*, 1154–1155, doi:10.1126/science.1202543.
22. Hawkes, C.; Ruel, M. Value Chains for Nutrition. In Proceedings of the 2020 Conference: Leveraging Agriculture for Improving Nutrition and Health. 2020 Conference Paper #4, New Delhi, India, 15 Feburary 2011, *4*, pp. 1–4.
23. Cucagna, M.E.; Goldsmith, P.D. Value adding in the agri-food value chain: Research article. *Int. Food Agribus. Manag. Rev.* **2018**, *21*, 293–316, doi:10.22434/IFAMR2017.0051.
24. Fanzo J.C., Downs S., Marshall Q.E., de Pee S., Bloem M.W., Value Chain Focus on Food and Nutrition Security. In de Pee S., Taren D., Bloem M. (eds) Nutrition and Health in a Developing World, 3rd ed.; Humana Press, Cham: New Jersey, USA, 2017; pp. 753–770, ISBN 9783319437378.
25. IBR, Analysis Canadian Dairy Farmers: Not Crying Over Spilt Milk. Available online: https://iveybusinessreview.ca/5738/canadian-dairy-farmers-crying-spilt-milk/ (accessed on 24 May 2020).
26. Bolkvadze, B. Investment Strategy of Georgia as a Country of Transition Economy: Trends, Problems, Prospects. *Eur. J. Mark. Econ.* **2018**, *1*, 19, doi:10.26417/ejme.v1i1.p19-25.
27. Mohan, S. Institutional Change in Value Chains: Evidence from Tea in Nepal. *World Dev.* **2016**, *78*, 52–65, doi:10.1016/j.worlddev.2015.10.004.
28. FAO, Georgian Milk Producers Learn from Italy and the United States. Available online: http://www.fao.org/europe/news/detail-news/en/c/1100229/ (accessed on: 20 April 2020).
29. Wood, A., Value chains: An economist's perspective. *IDS Bull.* **2001**, *32*, 41–45, doi:10.1111/j.1759 5436.2001.mp32003005.x.
30. Schmitt, E.; Barjolle, D.; Tanquerey-Cado, A.; Brunori, G. Sustainability comparison of a local and a global milk value chains in Switzerland. *Bio-based Appl. Econ.* **2016**, *5*, 175–198, doi:10.13128/BAE-17140.
31. Binder, C.; Schmid, A.; Steinberger, J.K. Sustainability solution space of the Swiss milk value added chain. *Ecol. Econ.* **2012**, 210–220, doi:10.1016/j.ecolecon.2012.06.022.
32. Civil Development Agency, *Multi-Ethnic Society in Georgia*; Civil Development Agency: Rustavi, Georgia, 2011.
33. Kvemo Kartli Region. Available online: http://elibrary.bsu.az/yenii/ebookspdf/uhgkT5jc.pdf. (accessed on 15.04.2020).
34. Swiss Agency for Development and Cooperation, *Meat and Cheese are Kvemo Kartli' s Future*; Swiss Agency for Development and Cooperation SDC, Commonwealth of Independent States: Bern, Swiss, 2013.
35. Shukla, S., VARIABLES, Hypotheses and stages. 2018. Available online: https://www.researchgate.net/publication/325127119_VARIABLES_HYPOTHESES_AND_STAGES_OF_RESEARCH_1 (accessed on 20 April 2020).
36. Rubin, H.J.and Rubin, I.S. *Qualitative Interviewing: The Art of Hearing Data*; SAGE Publications, Inc: Newbury Park, California, USA, 2011; ISBN 1412978378.
37. Mayring, P., *Qualitative Inhaltsanalyse : Grundlagen und Techniken*; Beltz Verlag: Weinheim, Germany; Basel, Switzerland, 2015; ISBN 9783407293930.
38. Edwards, R.; Holland, J. *What is Qualitative Interviewing?* Bloomsbury Academic: London, UK, 2013; ISBN 9781780938523.
39. Libakova, N.M.; Sertakova, E.A. The method of expert interview as an effective research procedure of studying the indigenous peoples of the north. *J. Sib. Fed. Univ. Humanit. Soc. Sci.* **2015**, *1*, 114–129, doi:10.17516/1997-1370-2015-8-1-114-129.
40. Creswell, J.W., *30 Essential Skills for the Qualitative Researcher*; SAGE Publications, Inc: Newbury Park, California, 2015.

41. Eriksson, P.; Kovalainen, A. *Qualitative Methods in Business Research: A Practical Guide to Social Research*; SAGE Publications, Inc: Newbury Park, California, 2015; ISBN 1446273393.
42. Cassell, C., Cunliffe, A.L., and Grandy, G., *The SAGE Handbook of Qualitative Business and Management Research Methods*; SAGE Publications, Inc: Newbury Park, California, 2018; ISBN 9781526429261.
43. Rädiker, S.; Kuckartz, U. *Analyse qualitativer Daten mit MAXQDA*; Springer : Berlin, Germany, 2019; ISBN 9783658220945.
44. Brennan, R. L. and Prediger, D. J. Coefficient kappa: Some uses, misuses, and alternatives. *Educational and Psychological Measurement,* 1981 *41*(3), 687–699. https://doi.org/10.1177/001316448104100307.
45. Shaburishvili, S. Social changes and economic development in Georgia. 2017. Available online: https://www.researchgate.net/publication/318883168_Social_changes_and_economic_development_in_Georgia (accessed on 20 April 2020).
46. Zubiashvili, T., and Silagadze, L. Some aspects of the Georgian economy at the contemporary stage, *Ecoforum*, **2016**, *5*, 1–5.
47. ISET Policy Institute, *Safety and Quality Investment in Livestock : Georgian Dairy Market System Analysis and Mapping*; ISET Policy Institute: Tbilisi, Georgia, 2019.
48. National Statistics Office of Georgia, *Geostat Agriculture of Georgia 2020 1 Quarter, preliminary data on animal husbandry*; National Statistics Office of Georgia: Tbilisi, Georgia, 2020.
49. Mayfield, L.E.; Bennett, R.M.; Tranter, R.B.; Wooldridge, M.J. Consumption of welfare-friendly food products in Great Britain, Italy and Sweden, and how it may be influenced by consumer attitudes to, and behaviour towards, animal welfare attributes. *Int. J. Food Agric.* **2007**, *15*, 16.
50. Napolitano, F.; Girolami, A.; Braghieri, A. Consumer liking and willingness to pay for high welfare animal-based products. *Trends Food Sci. Technol.* **2010**, *21*, 537–543, doi:10.1016/j.tifs.2010.07.012.
51. Mounier, L. and Veissier, I., *Proceedings of the 6th international conference on the assessment of animal welfare at the farm and group level*; Wageningen Academic Publishers: Wageningen, The Netherlands, 2014; ISBN 978-90-8686-247-4.
52. Rödiger M., Janssen, M. and Hamm. U.,. *Multi-Level Animal Welfare Labels Reflect Consumer Preferences: Insights from a Systematic Review*; Wageningen Academic Publishers: Ede, The Netherlands, 2017; ISBN 9789086868629.
53. Resolution N 29, Antimicrobial Resistance for 2017-2020 On the approval of the national strategy, Government of Georgia, Georgia, 2017; p p. 7.; 2017; Available online: https://www.ncdc.ge/Handlers/GetFile.ashx?ID=cfaca9b4-17f5-417b-bdad-a37f20209920 (accessed on 20 April 2020).
54. Europe Foundation, Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2016; Europe Foundation: Tbilisi, Georgia, 2016.
55. Ingvartsen, K.L. Feeding- and management-related diseases in the transition cow: Physiological adaptations around calving and strategies to reduce feeding-related diseases. *Anim. Feed Sci. Technol.* **2006**, *126*, 175–213, doi:10.1016/j.anifeedsci.2005.08.003.
56. Oliver, S.P.; Murinda, S.E.; Jayarao, B.M. Impact of antibiotic use in adult dairy cows on antimicrobial resistance of veterinary and human pathogens: A comprehensive review. *Foodborne Pathog. Dis.* **2011**, *8*, 337–355, doi:10.1089/fpd.2010.0730.
57. FAO. *Atlas of Origin Linked Food Products in Georgia*; FAO: Rome, Italy, 2019.
58. Muehlfried, F. Sharing the same blood—culture and cuisine in the Republic of Georgia. *Anthropol. Food* **2008**, *S3*, doi:10.4000/aof.2342.
59. FAO. *An Overview of Legal and Institutional Frameworks and Opportunities, Challenges and Recommendations for Geographical Indication Products in*; FAO: Rome, Italy, 2018.
60. Ministry Of Environmental Protection And Agriculture Of Georgia, EU -Funded Project "Establishing Efficient Protection and Control System of Geographical Indications (GIs) in Georgia". Available online: https://mepa.gov.ge/En/News/Details/11737 (accessed on: 16 April 2020).
61. FAO-EBRD, *Support to Sustainable Value Chains through the Development of Geographical Indications in the Dairy Sector*; European Bank for Reconstruction and Devlopment: London, United Kingdom, 2016.
62. Slow food USA, Slow Food Costal Georgia. Available online: https://www.slowfoodcoastalga.org/ (accessed on 5 April 2020).
63. TEEB. *TEEB for Agriculture & Food: An Interim Report*; TEEB: Geneva, Switzerland., 2015.
64. Ministry of Environment and Natural Resources Protection of Georgia. *Fifth National Report to the Convention on Biological Diversity;* Ministry of Environment and Natural Resources Protection of Georgia: Tbilisi Georgia, 2014; pp. 1–221, doi:10.1044/leader.PPL.20012015.20.
65. Withanachchi, S.S.; Kunchulia, I.; Ghambashidze, G.; Al Sidawi, R.; Urushadze, T.; Ploeger, A. Farmers' perception of water quality and risks in the Mashavera River Basin, Georgia: Analyzing the vulnerability of the social-ecological system through community perceptions. *Sustainability* **2018**, *10*, doi:10.3390/su10093062.
66. Korakhashvili, A.; Jeiranashvili, G. Food safety hazards in Georgian Tushuri Guda cheese. *Ann. Agrar. Sci.* **2016**, *14*, 212–216, doi:10.1016/j.aasci.2016.08.005.

67. Karanja, G.M.; Kiruiro, E.M. Biogas production. *Statistics (Ber).* **2003**, 107–208. Available online: http://www.kalro.org/fileadmin/publications/tech_notes/tecNote10.pdf (accessed on: 16 April 2020).
68. Georgia Department of Agriculture, *Georgia' s Dairy Industry*; Georgia Department of Agriculture: Tbilisi, Georgia, 2014.
69. UN Resolution der Generalversammlung, Resolution der Generalversammlung, verabschiedet am 25. September 2015,. 2015. Available online: https://www.un.org/Depts/german/gv-70/band1/ar70001.pdf (accessed on 5 April 2020).
70. FAO. *Transforming Food and Agriculture to Achieve the SDGs*; FAO: Rome, Italy, 2018; ISBN 9789251306260.
71. UN. *First Voluntary National Review On Implementation Of The Sustainable Development Goals*; UN: Tbilisi, Georgia, 2016. Available online: https://sustainabledevelopment.un.org/content/documents/10680SDG Voluntary National Review Georgia-.pdf (accessed on 5 April 2020).
72. CARD. *Business Case Study Dairy Sector in Georgia*; Center for Agribusiness and Rural Development: Tbilisi, Georgia, 2018.
73. Europe Foundation, Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2017; *Europe Foundation*: Tbilisi, Georgia, 2017.
74. Schubert, R., Ohndort, M. and Rohling, M., *Umweltökonomie Kapitel III: Internalisierung externer Effekte,* Eidgenössische Technische Hochschule Zürich (ETH): Zürich, Switzerland, 2012.
75. Sauer, D. *Die Internalisierung externer Effekte Eine kritische Analyse des Kyoto-Protokolls;* GRIN Verlag: Munich, Germany, 2008; ISBN 9783640412167.
76. Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S. and Jonell, M., Food in the Anthropocene: The EAT–Lancet Commission on healthy diets from sustainable food systems. *Lancet* **2019**, *393*, 447–492.
77. Nuffield Council on Bioethics (Great Britain), *Public health: Ethical issues*; Nuffield Council on Bioethics: London, UK, 2007; ISBN 9781904384175.
78. Tilman, D.; Clark, M. Global diets link environmental sustainability and human health. *Nature* **2014**, doi:10.1038/nature13959.
79. Springmann, M.; Godfray, H.C.J.; Rayner, M.; Scarborough, P. Analysis and valuation of the health and climate change cobenefits of dietary change. *Proceedings of the National Academy of Sciences* **2016**, 1–6, doi:10.1073/pnas.1523119113.
80. Tilman, D.; Clark, M.; Williams, D.R.; Kimmel, K.; Polasky, S.; Packer, C. Future threats to biodiversity and pathways to their prevention. *Nature 546, 73–81,* **2017**, doi:10.1038/nature22900.
81. Smith, J.; Sones, K.; Grace, D.; Macmillan, S.; Tarawali, S. and Herrero, M. Beyond milk, meat, and eggs: Livestock' s role in food and nutrition security. *Animal Frontiers,* **2012**, *3*, 6–13, 10.2527/af.2013-0002.
82. Herrero, M.; Havlík, P.; Valin, H.; Notenbaert, A.; Ru, M.C. amd Thornton, P.K. Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. *Proceedings of the National Academy of Sciences of the United States of America,* **2013**, *110*, 1–6, doi:10.1073/pnas.1308149110.
83. Griggs, D.J.; Nilsson, M.; Stevance, A.; McCollum, D. A guide to SDG interactions: From science to implementation. *Int.Counc. Sci. Paris* **2017**, Available online: https://www.sei.org/publications/a-guide-to-sdg-interactions-from-science-to-implementation/ (accessed on: 16 April 2020).

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Chapter 3

Factors and Components Affecting Dairy Smallholder Farmers and the Local Value Chain— Kvemo Kartli as an Example

Rami Al Sidawi [1,*], Teo Urushadze [2] and Angelika Ploeger [1]

[1] Specialized Partnership in Sustainable Food Systems and Food Sovereignty, Faculty of Organic Agricultural Sciences, University of Kassel, 37213 Witzenhausen, Germany; a.ploeger@uni-kassel.de
[2] School of Agricultural and Natural Sciences, Agricultural University of Georgia, Tbilisi 0159, Georgia; t.urushadze@agruni.edu.ge
* Correspondence: rami.alsidawi@uni-kassel.de; Tel.: +49-055-42981621

Abstract: Smallholder farmers are the cornerstone of the livestock sector and an essential element in building and developing the local dairy value chain, critical for developing its local economy. In Georgia, and despite the efforts made since independence from the Soviet Union until now, farmers still face many problems that prevent them from participating effectively in developing the dairy value chain, especially heavy metal pollution that afflicts the study region. This research study refers to smallholder farmers' viewpoints in the Kvemo Kartli region on the dairy production sector and the problems these farmers face. This study also investigates the effect of several factors (ethical factors, traditions, animal welfare, cultural factors, etc.) on the dairy value chain. The convergence model was used in the mixed-method approach's triangular design as a methodology for this research study. As part of the social data, 140 farmers who produce and sell milk and cheese in the Kvemo Kartli region were interviewed. The results showed the influence of the ethical, cultural, and traditional factors in developing the value chain. The results also showed the problems and difficulties small farmers face in rural areas, on the one hand, and the gap between these farmers and governmental and private organisations on the other hand. These results are compared to those of a previous study, where interviews with experts in Georgia's dairy production sector were performed.

Keywords: dairy products; value chain; smallholder farmers; food safety; heavy metals; Georgia

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1. Introduction

Studies indicate that about 75% of the farms in the world are family farms, as most of them are small family farms. Despite the different development and modernisation policies that each country adopts to advance the agriculture field in all its sectors, smallholder farmers face many challenges at the local and international levels [1].

Smallholders are the backbone of the economy in countries that depend heavily on agriculture. The dairy sector is one of the most important agricultural sectors for smallholder farmers, as it plays a fundamental role in their daily income and self-sufficiency as well as food security [2–6]. If farmers are forced to change their behaviour due to international hygiene standards without suitable governmental solutions to support them, social problems will arise, and economic issues will appear for society. Thus, this may lead to the farmers' abandoning their farms. The resulting consequences may be drastic, which may occur in fundamental changes in the landscape due to the lack of pastoralism and the inadequate supplies and nutritional status of former smallholders

[2–7]. The change will also affect the range of goods; for example, instead of traditional Georgian cheese, it will be replaced by the international cheese ''type gouda."

In Georgia and most developing countries, milk production depends on smallholder farmers. It also contributes to securing family livelihoods, supporting food and nutrition sovereignty, and maintaining food safety [8–10]. Therefore, smallholder farmers in these countries are considered one of the most important actors in developing the agricultural

sector. Milk production is an integral part of the small farm economy in Asia and many other countries. It is what provides them with self-sufficiency in terms of food and some cash. For example, smallholder dairy producers in countries such as China and Thailand account for a large part of the economic policies adopted in developing the dairy sector. Many smallholder farmers in these countries have become able to compete and grow their produce [11–13].

On the other hand, there are several countries in which the dairy production sector at the local and international levels is still in the initial stages, and there are continuous attempts to develop and advance it to reach the level and efficiency of local and international standards. In countries such as Georgia, Pakistan, Bangladesh, Mongolia, and others, smallholder farmers mainly contribute to the provision of milk. However, the dairy value chain in these countries is still under development to meet the local requirements of dairy and cheese, and then to try to reach production efficiency with international standards that would help develop this chain [11–13].

However, dairy production growth in developing countries globally results from an increase in the number of animals kept rather than an increase in productivity per head [10,14]. The low quality of feed, animal care and disease prevention, the demand of access to markets, and the utilisation of all available services in turn lead to the non-development of the dairy value chain [10].

Dairy production is one of the oldest agricultural sectors in the Kvemo Kartli region in Georgia [15]. The dairy market in Georgia is one of the most important economic sectors in the country; Georgia annually produces approximately 500 million tons of milk [16]. The smallholder farmers are the main and the most important producers of milk. However, smallholder farmers sell milk through informal channels without any health or legal supervision, as most of them do not have the necessary experience to produce milk with safety specifications [15,16].

The collapse of the Soviet Union for Georgian farmers was a huge turning point in every aspect. In the Soviet era, there were collective farms that kept stock of breeds in the dairy sector, but in the post-Soviet period, these farms no longer existed. Small land areas were allocated to all smallholder farmers and provided access to common pastures [17–20].

Nevertheless, because of the civil war and all the economic and political problems and crises that the country suffered from, smallholder farmers mainly adopted diversified subsistence farming, with a few cows or small numbers of other farm animals (such as chickens, sheep, goats, pigs, etc.). They also cultivated some crops to feed livestock and others for personal consumption [19].

At that time, the economic conditions were deplorable, so small farmers relied on producing milk and selling it in the local market in their villages or sending it to Tbilisi with a third person, earning some money to barter this milk for other food products [19,21,22]. Non-cash exchange trading became very popular, for example, exchanging cheese for hay.

It also appeared that farmers sent their livestock daily with the village herds to the pastures; the shepherd supervised them. Thus, there was no supervision or control over the reproduction of this livestock or the bulls' quality. As local breeds of adapted and unimproved cows increased, there was limited potential to improve productivity in the dairy and meat sector [19,23].

At the time of the collapse of the Soviet Union, the available veterinary services collapsed, including all the other services that were provided for money despite their low

quality and poor value. The relationship between farmers and veterinarians was damaged, as there was a lack of trust in all parties' services [19]. The changes that occurred during the collapse of the Soviet Union and afterwards in Georgia affected women in particular, as the responsibility for livestock farming, cleaning and feeding the animals, and milking the livestock was the women's share, including processing dairy products and making cheese [19,24].

Women had enough experience at that time to know if disease had afflicted any of the livestock, and they were also able to diagnose these symptoms and order the necessary medicines. However, in the pre-and post-Soviet era, women were suffering from limited freedom in society due to social and cultural reasons. As men were doing all the work outside the home, women had limited access to any new information or development in agriculture and livestock [19,24,25].

In the past few years, and during the reforms being undertaken by the country, the Georgian economy was in an essential stage of transformation [26], and especially after 2004, intensive work was done on developing concepts and methods of working economic strategies and deepening the concept of economic liberalisation [21]. Despite this, small farmers who live in rural areas still depend on dairy products. They use the state's pastures for grazing and send their livestock to mountain grazing areas accompanied by the shepherd in the summer season, informally. They depend heavily on hay in the winter [22,27].

This study is considered part of several research pieces, some of which have been published [28,29], which delved into experts' opinion in developing the dairy value chain in Georgia and farmers' perception regarding water quality and risks in the Mashavera River Basin in the Kvemo Kartli area.

As several studies also dealt with water and soil analyses in the Kvemo Kartli region in Georgia, this region suffers significantly from heavy metal pollution. Therefore, this research aims to determine the problems that farmers suffer from on the ground and the extent to which food safety systems are applied and compare them with experts' opinion.

1.1. Socio-Cultural Factors

The citizens' concept of sustainability in the livestock sector illustrates the critical and fundamental role of values. For many, especially smallholder farmers, sustainability is a socio-cultural concept of livestock production systems [30]. In Ethiopia or the Netherlands, for example, the socio-cultural aspect plays a critical role. Production is not the only goal of the dairy sector, but several considerations must be taken into account, such as the connection of dairy and cheese production to the national or agricultural culture and the technology used for production, which may differ according to different cultures and traditions [30,31]. For Azerbaijan, Armenia, and Georgia, the socio-cultural concept was greatly important, especially in the transition period [32].

The dependence of smallholder farmers in Georgia on producing milk is substantial. The production and sale of milk and the manufacturing of many types of cheeses are still the cornerstones of Georgian society and Georgian culture [33]. However, producing high-quality milk requires technical skills and accurate knowledge for every dairy value chain step. Despite their extensive and ancient experience in milk production and its derivatives, farmers in Georgia face many problems represented in the lack of training and failure to keep pace with modern technology and the inability to control the market [33,34]. For example, the increase in the import of powdered milk, and the increase in the demand for it by large dairy producers, negatively affected small farmers. In 2016, the import of milk powder reached 8.34 tons, compared to 2017, when it increased to nearly 9862 tons [33,35].

Farmers, relying on their ancient culture and traditions, do not see that self-managed animal feed is necessary to feed their livestock. They depend entirely on pastures, as some practices still exist even after the Soviet Union's collapse, e.g., farmers grazing their

livestock together [23]. Farmers send their cows with a shepherd to feed on the pastures, or the peasants take turns doing that daily, but if the farmer is unable to do so, he hires a shepherd to do this task [23].

As farmers who do not have the time or ability to take care of their livestock, they sometimes rent their cows to other farmers or milk production companies that pay them in cash or give them in return products such as cheese or butter [23]. The old norms of dealing between farmers and milk collectors still exist, as all that is agreed upon is verbally between the two parties, and the payment process for farmers is either weekly or every two weeks. However, some farmers prefer advance payments for other needs. The milk collectors sometimes depend on giving the farmers some of what they need (such as fodder, for example) and thus deduct the feeding cost from the final amount to be paid to the farmer in exchange for milk [23]. These traditions, which depend on the ancient peasant culture, still dominate Georgian society in the countryside to a large extent and build a steady bridge of trust between farmers and milk collectors [36].

Religious culture also has a significant role in Georgia, and it also affects the demand for dairy products. As the majority of Georgians are Orthodox Christians, the rates of demand for dairy products decrease during fasting periods; thus, prices are significantly affected by this, as farmers are affected automatically during this period. In the post-fasting period, the demand for these products increases dramatically, and consequently, the pressure on prices increases, which directly affects farmers [23].

1.2. Socio-Demographic and Socio-Economic Factors

Socio-demographic factors such as gender, family, and language, socio-economic statuses such as income, education, employment, and locality or living area are essential vital factors that directly affect farmers and the existing agricultural economic system [37–40].

According to the Eurostat report in 2019, the National Statistics Office of Georgia (Geostat) follows the international standards in labour market statistics. Still, there are some exceptions; in Georgia, farmers who produce goods for their consumption are classified as workers. The percentage of these people is considerable, which directly contradicts the International Labour Organization (ILO) concept, as the rate of employment in Georgia is overestimated. In return, there is a low rate of unemployment compared to other countries [41].

Figure 1 shows the difference in the population between urban and rural areas in Georgia. It shows that the proportion of the rural population has decreased since 1926, reaching 41.0 in 2020 compared to previous years [42,43].

Based on the Geostat report 2016, the number of populations in the Kvemo Kartli region has decreased significantly compared to the 2002 census, dropping to 14.6% compared to the capital Tbilisi people, which increased by 2.5% [44].

As Georgia has undergone massive changes since the collapse of the Soviet Union and its conflicts, many constructive initiatives and programs have emerged that help develop the countryside and support smallholder farmers [17,18,45,46].

The government promoted women in rural areas, provided the necessary support for them in agricultural businesses and cooperatives, and supported their participation in industry and their inclusion in local decision-making bodies [47,48]. Based on the IFAD report in 2018, rural women's access to information, available services, and decision-making are much lower compared with men in Georgian agrarian society. Therefore, according to the United Nations Global Gender Gap Index, Georgia is ranked 90 out of 144 countries [47]. The average male income in Georgia's agricultural sector is 25 per cent higher than that of women, as women own only about 31 per cent of the farms, which is almost a quarter of the farms owned by men [47].

The access of farmers in rural areas to and control of the market is complicated, especially with respect to climate change. Smallholder farmers face new risks, but they do

not have sufficient knowledge of adaptive measures and cannot afford them. This development represents a new threat that may threaten rural areas [47,49].

Based on the Geostat report in 2019 (Table 1), the farmers' share of the sale of agricultural products concerning the household's total income decreased in 2019 to 5.5% compared to 6.4% in 2016 [43].

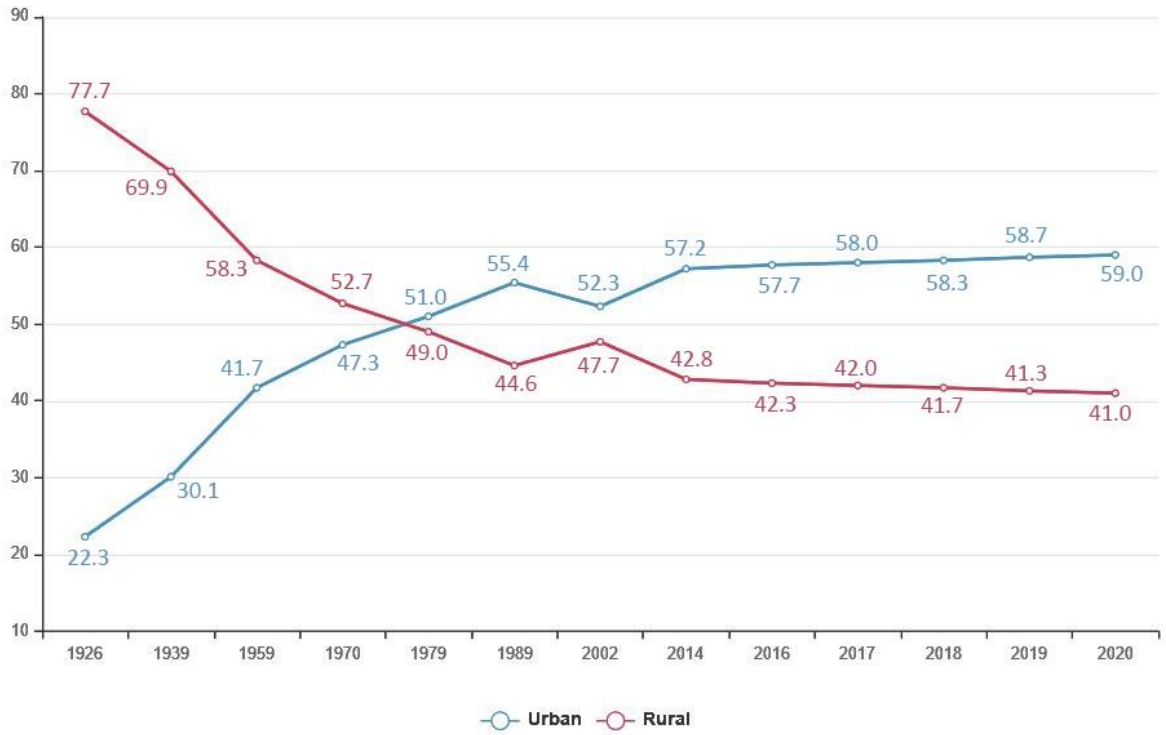

Figure 1. Distribution of the Georgian population (%) in urban and rural areas [29,30].

Table 1. Farmers share of agricultural products from the total income of the household (%) [30].

Year	2016	2017	2018	2019
Share of income (%)	6.4	4.7	5.5	5.5

All these factors subject Georgia dairy production to significant challenges: the decline in the population in rural areas, the increase in poverty, and the loss of dynamism and entrepreneurship in those areas with a rise in the emigration of young people and a small number of retirees, who depend for their livelihoods on remittances, as well as social transfers and subsistence farming [35,47].

1.3. Ethical Factors

The Georgian society relies heavily on animal products and, in particular, on dairy products [22]. The demand for these products increased in the past years, and this massive increase in production raised a wide range of ethical issues. One of the most important of these issues is the concern for animal welfare [50].

Consumer awareness of food quality and safety has increased dramatically, as animal products' ethical factor has played a significant role in consumer behaviour [51,52]. On the other hand, dairy producers, retailers, and the food industry are demanding higher standards for animal welfare to obtain superb quality, which supports the economy on the one hand and maintains food safety and food security standards on the other hand [50]. All this prompted small farmers and large landholders to think about the safety and welfare of the animals.

Animal welfare is a complex subject that differs from one culture to another. It is a subject that has scientific, cultural, social, ethical, religious, and political dimensions. Providing safe food for people depends on the health and productivity of these animals [50]. For example, the state legislation that aims to support animal welfare in farmers' opinions is not entirely fair from a political perspective. The increase of such laws creates a feeling of insecurity among farmers and undermines confidence in the political decision [26,33,50].

Regarding traditions, studies have shown that rural farmers have a common understanding of the cultural, political, economic, and social context of what it means to be a good farmer. Therefore, modern financial plans and legislation aimed at developing the dairy sector and increasing interest in animal welfare are considered by many farmers as a threat because this contradicts their culture and deep-rooted traditions [26,33,50,53].

Besides, these farmers' experience is also a significant factor, especially in the ethical matter. Political decisions, which aim to increase farmers' awareness and knowledge, play a major role in creating a communication bridge between them and the responsible parties [33,50]. As a result of all the circumstances that Georgia went through, from the collapse of the Soviet Union to the internal problems that the country suffered from, small farmers were and still face many issues in the dairy production sector [26]. The lack of fodder and the limited pastures available for grazing cows are among the most critical problems facing farmers. The lack of adequate shelter for animals or places prepared for them in terms of health in rural areas increases the dangers that animals suffer [53]. The farmer's use of antibiotics in animal foods is due to the lack of health care caused by the lack of veterinarians [54,55]. The human consumption of these dairy products and milk may generate diseases and resistance that may be transmitted to farmers and threaten their safety and health [54,55].

In an attempt by small farmers to take care of the animals and in an effort to increase the quality of the dairy products, families owning many cows are trying to secure enough food from the grass in the summer and wheat, corn, and straw in the winter, despite the high prices of these materials, and to keep pace with animal welfare regulations [33,53]. In the Kvemo Kartli region, most farmers own a small number of cows with low productivity. Thus, securing the necessary fodder may be a problem for them compared to those with extensive holdings [53].

2. Methodology

2.1. Study Area

The research study was conducted in southeastern Georgia in the Kvemo Kartli region (see Appendix A, Figure A1 and Figure A2). A survey on smallholder farmers' dairy production was completed in eight villages in Summer 2019 (Figure 2) in the Bolnisi and Dmanisi municipalities (Chapala, Vanati, Bolnisi, Mtskneti, Sabereti, Ratevani, Kazreti, and Kvemo Bolnisi).

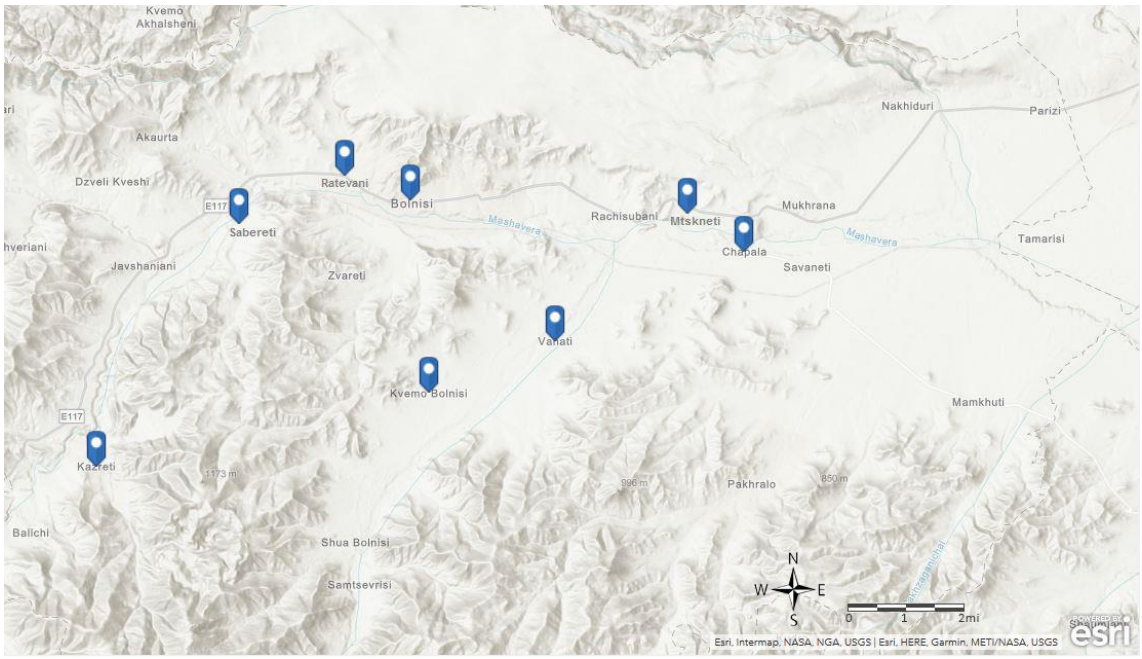

Figure 2. Map of the study area (Authors' illustration); ArcGIS Pro Data sources: Base map layer; ESRI satellite (ArcMap).

The Kvemo Kartli region of Georgia is considered the largest beef producer in the country and is close to the capital, Tbilisi. The primary source of income for families in this region depends on livestock, cattle, and sheep. According to Geostat statistics 2019 [56], the Kvemo Kartli region has holdings oriented mainly on livestock production (18.4 per cent), which is the highest percentage compared to the rest of Georgia's regions. The total population of Kvemo Kartli is 434.2 people. In comparison, 244.5 inhabitants live in rural areas [43].

The total number of smallholder farmers in the Kvemo Kartli region is unknown. Many families do not depend on agriculture or raising cows or other husbandry animals in their living. However, they own a small number of cows and do officially sell their milk as raw milk or as homemade cheese. For this reason, it is difficult to know the actual number of farmers working in this field until now.

Smallholder farmers suffer from several problems, for example, the absence of modern agricultural machinery, the difficulty of accessing the local and international markets, the lack of knowledge of the current developments in the dairy markets and their produc-tion methods, and the problem of accessing veterinarians. Despite all these difficulties and challenges, producing good quality meat and dairy products is a growing market in Georgia.

2.2. Mixed Method Approach

This study relied on the convergence model in the tripartite design of the mixed-method approach. The use of a mixed-method design allows questionnaires or surveys and interviews to be conducted together [57].

As shown in Figure 3, we used the experimental design of qualitative and quantitative surveys and interviews as primary data. Data and information for the dairy sector in Georgia were approved as supporting data. The results of the interviews with dairy experts have been published [57]. This publication aims to present a quantitative survey with Georgian farmers and discuss the factors given expert opinions.

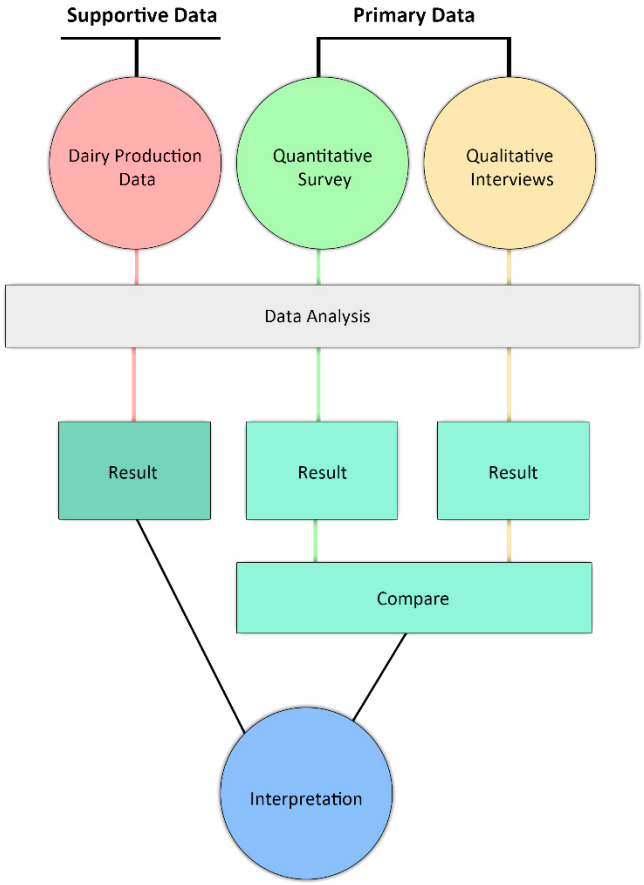

Figure 3. Study-method design (Adaption from Creswell and Clark (2006)).

2.3. Survey and Data Collection

All data used in this study were collected through a survey conducted in Georgia's Kvemo Kartli region. We collected these data from eight villages in June 2019. These villages were chosen based on our previous research, which showed heavy metal pollution in water, soil, and plants. We wanted to get in close contact with the smallholder farmers who live in this region and know the problems occurring in the area and their adherence to food safety standards in dairy production.

When we entered these villages, we did not establish any particular criteria to select the farmers whom we wanted to interview. Most farmers are not very welcoming to strangers, especially those who gather information, because they think they work for the government. Besides, these regions are known for having multiple nationalities. There are Georgians, Azerbaijan's, and a few Russians. Therefore, field trips were carried out to meet all the difficulties facing us.

The questionnaire was based on open and closed questions. All participants in this survey are smallholder farmers who depend for their livelihoods on raising livestock as a primary income or secondary income and on subsistence farming. The questions were arranged logically and interconnected with each other depending on the aim of this research. All interviews were face-to-face, and all these questionnaires were filled out during the interviews. Table 2 shows that the questionnaire was based on several factors (see Appendix A. Table A1), the most important of which are demographic and

geographic factors, Georgian traditions, social and economic factors, and the ethical factor.

The survey included 140 smallholder farmers, of whom 105 were males and 35 were females. These interviews were conducted on the farms in Georgian and Russian languages with the presence of a translator. All farmers were selected randomly. Later, all data were transferred and saved in English. Upon completing the survey, all data for the survey were transferred to an Excel datasheet.

The number of farmers interviewed was not high, but it is sufficient to know the opinions of small farmers in the Kvemo Kartli region of Georgia [58], so the size of these samples does not allow generalisation of the results to all small farmers in Georgia.

As for the following research study, an analysis of raw milk samples and homemade cheese will be performed. These samples were collected from those farmers being interviewed to see whether the milk is contaminated with heavy metals. Recent studies have proven their presence in soil, plants, and drinking water [29].

2.4. Data Analysis

As Table 2 shows, all the data were transferred to an excel sheet as coded data, to show the descriptive statistical results for each section of the variables. Age was not considered in this questionnaire because most farmers refused to mention their age, either because of their society's customs or because they did not know their exact birth date.

Because of the importance of animal welfare, animal husbandry places in the survey were divided into three sections (small barn with the other animals, separate barn without other animals, and outside the small open barn with other animals). The questionnaire also led to knowing the source of water used to feed the livestock. The majority of the results were distributed between the Khrami River and the Mashavera River. As previous studies indicated, these rivers are polluted with heavy metals [59–63], and farmers are dependent on these river waters as a significant resource (water and grass) for their animals. The factor "type of feed and livestock feeding areas" indicates the validity of the fodder provided to livestock and its sources and whether the farmer depends only on grass or other feed. SPSS version 27.0 (IBM, USA) software was used for all the statistical analyses, where the overall comparison between the survey factors was calculated using Spearman correlations (rs). A t-test for independent samples tested whether the means of two independent samples were different. ArcGIS Pro was used to map the study area.

Table 2. The coded data and descriptive statistical analysis (N = 140).

Domains and Variables	Category (Coded)	%
Upstream (Input supplies)		
Sociodemographic/socio-geographic		
Village	Chapala	20
	Vanati	7.1
	Bolnisi	15
	Mtskneti	13.6
	Sabereti	6.4
	Ratevani	13.6
	Kazreti	12.1
	Kvemo_Bolnisi	12.1
Gender	Male	75
	Female	25
Household socio-economic background		
Size of the household	Up to four members	46.4

	More than four members	53.6
Animal housing	Small barn with other animals	41.4
	Separate barn without other animals	17.1
	Outside small open barn with other animals	41.4
Dairy production or animal husbandry is the only financial income	Yes	12.9
	No	87.1
On-farm (production)		
General		
Started the dairy farm	More than 20 years ago	100
Basic knowledge of dairy farming	Yes	100
Reasons for starting dairy farming	Income	12.9
	Own consumption	32.1
	Both	55
Dairy farm structure, facilities, and management		
Other livestock on the farm	Hen	65
	Sheep	10
	Goat	5
	Calf	17.1
	Pigs	20
Number of cows	1–3 Cows	57.1
	4–7 Cows	22.1
	8–11 Cows	7.9
	12–15 Cows	7.9
	More than 15 Cows	5
Responsibility on the animals/farm	Wife, only	36.4
	Husband, only	2.9
	Wife and children	12.9
	Husband and wife	20
	More than two family members	27.9
Animal breed	Local breed	23.6
	Georgian mountain breed	2.1
	Both	7.1
	No idea	67.1
Cows for milk and meat purposes	Yes	100
Labour use in dairy farming		
Responsibility for feeding, cleaning, milking, and processing as well as marketing	One person	37.1
	Two people	33.6
	More than two people	29.3
Feeding		
Type of grazing for dairy animals	Free grazing (in the pasture) between March to August and no grazing between September to February	95
	Other	5
Feeding type	Grass	100
	Hay	70
	Corn	33.6
Sending the cows to the mountain in HS *	Yes	47.1
Enough fodder for dairy animals (for the entire year	Yes	3.6

Making conserved feed (e.g., hay)	Yes	3.6
Sources of water are available for animals	Khrami river	26.4
	Mashavera river	73.6
Satisfied with the water quality of the primary water sources	Yes	60
Water-amount enough for animals (yearly)	Yes	18.6
Output (Downstream)		
Milk selling point	Bazar	42.1
	Small Supermarket	30
	Collecting point (third person)	20
	On the road	17.1
Difficulties selling the milk	Yes	53.6
Cheese varieties	Sulguni	12.1
	Imeruli	39.3
	Sulguni + Imeruli	47.9
Cheese for marketing or self-consumption	Marketing	4.3
	Self-consumption	40.7
	Both	54.3
Milking techniques	With hand	100
Washing udder before and after the milking process	Yes	85.7

* HS: high season: from March to August.

3. Results and Discussion

3.1. The Factors and Components Affecting the Dairy Farmers and Value Chain Development

3.1.1. Socio-Demographic Factors

The results showed that the percentage of male farmers who participated in the survey was higher than the women's share (75% to 25%). The questionnaire's demographic characteristics show how Georgian society has been affected by ancient culture and traditions. Women in rural areas still do not have enough freedom or access to the market and follow up on all agriculture developments, especially the dairy production sector. As the questionnaire results show (see Figure 4), women are mainly responsible for the livestock on the farm or at home. They are the ones who milk the cows and prepare the milk for sale or for home use in making cheese or other products. Some of the women we interviewed reveal this situation as:

I: ''We are the ones who do all the work at home. The men send the cows in the morning to the pastures only, and we are the ones who in the evening collecting the milk and preparing it for sale or to make cheese. This is the hard work and not selling the milk and cheese.'' (09 June 2019, Chapala).

Other women stated that:

I:''My mom and grandmother did this work in the past; they milked cows and made cheese and prepared it for sale or home consumption. And here we are, doing the same work, nothing has changed.'' (10 June 2019, Bolnisi).

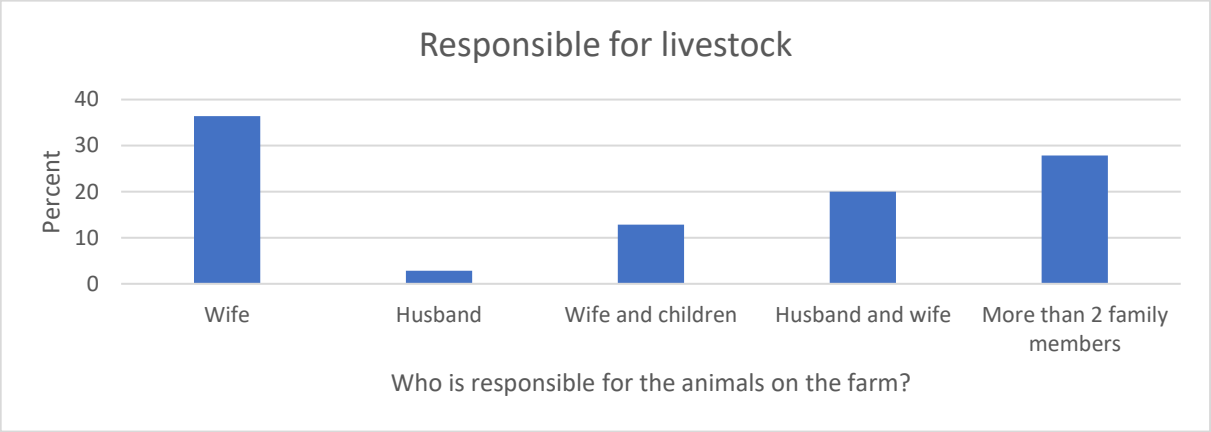

Figure 4. Persons responsible for livestock on smallholder farms in Georgia (N=140, Mean= 28, Std. Dev. = 18,207).

3.1.2. Social and Cultural Factors

Furthermore, Georgian culture and traditions play an important role in rural society and directly influence livestock raising and marketing.

Figure 5 shows that 47.9% of the smallholder farmers interviewed use a large portion of the milk to make two types of cheese, Sulguni + Imeruli, as these two are among the most consumed types of cheese in Georgia.

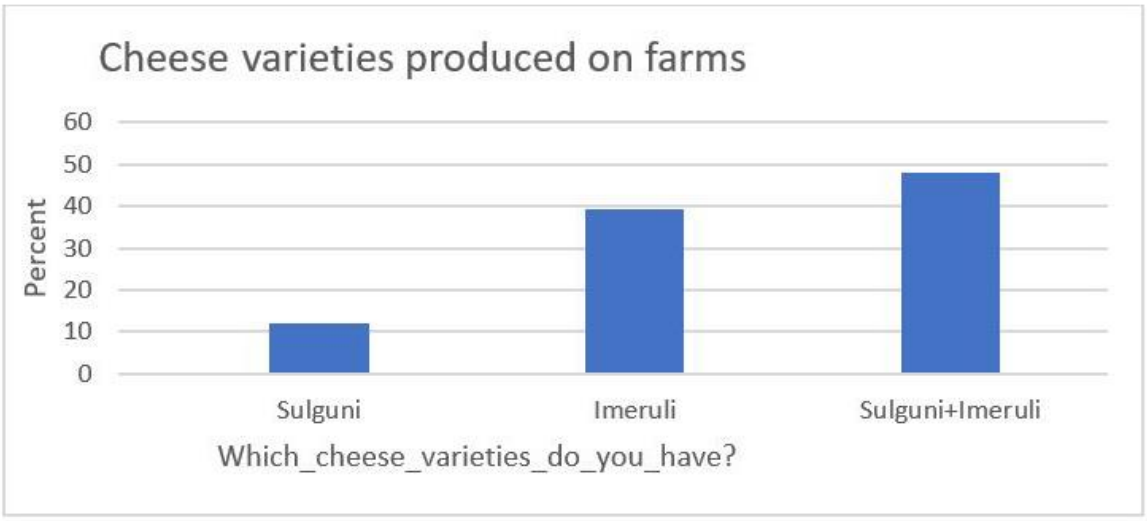

Figure 5. Cheese varieties made on interviewed farms (N = 140, Mean = 35, Std. Dev. = 31,112).

Smallholder farmers used to use pastures for grazing cows. It was not their previous habit to manufacture conserved fodder, as the questionnaire showed that 96.4% of them did not resort to making this fodder (see Table 2).

These results were compared with a previous study we conducted (interview with experts in dairy production in Georgia) [28]. The experts focused on Georgia's culture and traditions in developing the value chain of dairy products, especially in rural areas. It is crucial to take into account the cultural and social background of small farmers. With several reservations, women in rural areas are still the ones who make cheese at home and milk cows. Hygiene standards and food safety measures are rarely applied [28]. They sell the cheese or milk they produce on the streets, in small supermarkets, or the Bazar, and thus it is difficult to monitor them.

Based on all of this, smallholder farmers' social and cultural identity is an important and essential factor in developing the value chain for dairy production and supporting the rural community, which helps raise the local economy.

According to the United Nations' Women Oxfam report, the roles of men and women in agriculture and livestock are justified based on various factors, the most important of which are the differences in physical strength between them and gender stereotypes [64,65].

Women and men's roles are determined according to the available activities, as men believe that all work and activities that require physical strength are their responsibility. On the other hand, raising livestock and milking cows also requires a massive effort, especially in transporting milk and water intended for washing cows' udders, which is what women do in rural areas [64,65]. However, this patriarchal system is still prevalent in Georgia, especially in rural areas, as this society's traditions place women as responsible people [65–67]. According to the FAO report, many smallholder farmers consider gender equality in Georgia to jeopardise Georgian traditions, identity, and culture, pushing them to adhere to these traditions more strongly [68]. The Georgian government is striving to integrate women into the decision-making process and trying to help them reach the latest developments in the field of livestock breeding [64,68,69].

Thus, a proper understanding of women's role in the dairy chain helps develop and strengthen the dairy value chain. Rural women are the cornerstone for that, starting from the milking stage to preparing raw milk or making cheese for sale. Therefore, these laws and legislation should give more attention to rural women's roles and provide them with all the necessary support to include them in the stage of developing the local economy.

3.1.3. Ethical Factors

Furthermore, animal welfare and the microbiological quality of dairy products are essential factors in livestock breeding. They are closely related to the development of the dairy value chain on the one hand and the maintenance of food safety standards on the other hand.

In addition, microbiological quality is a significant component of the marketing and quality of dairy products, and therefore it is imperative to take this factor into account.

The results of the questionnaire (Figure 6) show that 41.4% of small farmers put cows in a small closed barn with other animals. This means the animal does not have freedom of movement at all. The area allocated to each animal is minimal, as cleaning, milking, and animal hygiene care is done in an unhealthy manner, and sanitation is almost non-existent. Sometimes the barn is not equipped with windows. The results also show that 41.4% of farmers keep their animals in a small open barn with other animals, as these animals suffer from the same conditions that the rest of the animals suffer in closed barns, but these barns have access to fresh air. As for 17.1%, they house cows separate from the other farm animals (Table 3), but it also does not fulfil the necessary animal welfare or food safety conditions.

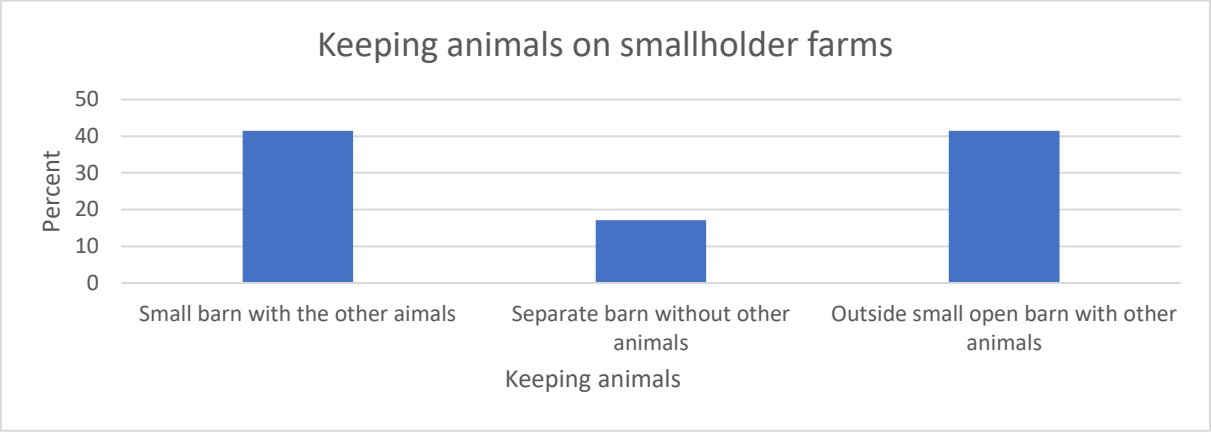

Figure 6. Percentage of farmers keeping cows together with other farm animals or in separate barns in Georgia (N = 140, Mean = 47, Std. Dev. = 19,629).

Table 3. The percentage of farmers interviewed who own other animals on the farm (%).

Other farm animals owned by farmers	Hens	Sheep	Goat	Calf	Pigs
N* = 100%	65	10	5	7,1	20

* N = 140 interviewees.

By comparing these results with other studies, Gieseke et al. [70] emphasised in a study conducted in Germany the importance of animal welfare in the development of the dairy sector as the cubicle's characteristics play a fundamental role in animal health.

Compared to another study conducted in Sweden, which focused on the importance of animal welfare and its positive effect on production quality, securing the necessary fodder for the cows, treating them well, and ensuring sufficient spaces in the barns help in developing the dairy value chain [71].

Another study in Canada showed that a lack of concern for animal welfare could lead to enormous consequences that harm cows' health and negatively affect the chain [72].

The results of the questionnaire also showed that all farmers interviewed depend only on the hand-milking process. As shown in Table 3, more than half of the farmers, 57.1%, have from one to three cows. Only 5 per cent of them have more than 15 cows. Therefore, a milking machine cannot be considered, as it costs money that the farmer cannot afford. It needs training to use it; also, the farmer does not receive any support from any party.

However, hand-milking in rural areas is also a big problem, as the questionnaire showed that 85.7% of farmers (Table 3) wash the cow's udder before milking. During the farmers' interview, we asked them to do the cows' milking in front of us if possible, and the results were shocking. Most farmers did not wash their hands before starting the milking process, and some of them had some wounds on their hands that were not covered during the milking process.

On the other hand, most of the places where cows were milked had deplorable sanitary conditions.

Each farmer had specific standards for cleaning the cow's udder. Therefore, fresh milk has not yet been analysed to ensure it is free from any type of bacteria or heavy metals. It is also susceptible to contamination from external factors that are not related to the cow's feed, the type of water supplied, or its health condition. As mentioned earlier, in a subsequent study, the milk taken from the cows of the farmers we interviewed will

be analysed to support or reject our hypothesis regarding food safety and smallholder's dairy production.

One of the smallholder farmers stated:

I: ''We milk the cows as our parents and grandparents used to do, and their health was durable, and here we are also healthy too, and this is evidence that these methods are feasible.'' (10 June 2019, Vanati).

Another farmer said:

''I: When we were children, my grandmother would allow us to drink milk directly from the cow's udder without even washing it. That is why our generation is healthier than today's generation. My granddaughter sometimes does not drink milk if it is not boiled.'' (11 June 2019, Ratevani).

The results show that depending on the Pearson factor in the correlation analysis, there is a strong relationship between the number of cows the farmer owns and between his/her consumption and the milk intended for sale.

A previous study with experts in dairy products [28] showed that it is challenging to monitor farmers fully, as the farmer who sells milk to a third party or dairy and cheese production companies is well observed. Still, the farmers who sell milk on the roads and in the Bazar or small supermarkets find it challenging to monitor them.

According to the FAO reports, small farmers who live in rural areas in Georgia do not have the knowledge and technical expertise to produce safe and high-quality milk. For them, there is no relationship between food safety and human health on the one hand and caring for animal health on the other hand [73,74].

The National Food Agency and the Ministry of Environmental Protection and Agriculture in Georgia are working hard in providing awareness campaigns and training courses in aspects related to livestock breeding. Still, the difficulty of trusting farmers in these departments and organisations is one of the most critical obstacles they face [33]. A small-holder farmer in rural areas trusts other experienced farmers more than they trust these organisations [33]. Likewise, most farmers in rural regions of Georgia are still milking cows by hand. They do not use any equipment for milking, as production on these farms is still rudimentary. Safety requirements and hygiene standards are still not met [33,73].

Despite all the National Food Agency (NFA) efforts and other organisations, farmers in rural areas still make cheese at home without supervision and sell it informally. Hence, food safety and hygiene standards are deficient [3,26,33,75].

At the beginning of 2020, a law was implemented that does not allow homemade cheese to be sold and can be consumed only at home. However, monitoring farmers, informal sales centres, storage, and transportation operations is challenging, negatively affecting dairy's value chain in Georgia and its development [3,33,75,76].

Thus, this research may clarify the importance of balancing the laws stipulated for livestock breeding and animal welfare and farmers' interests (applied or under implementation). For example, these new laws prohibit milk products' direct sale from farmers who did not follow the basic food safety measures. In that case, this may help the local economy increase the production of high-efficiency milk from large stables or enterprises. Still, it will negatively affect small farmers because they depend on their daily income by selling raw milk. Therefore, the development plan must provide alternatives to help these farmers with their income or develop their methods used in producing milk.

3.1.4. Economic Factor

The questionnaire results also showed that most farmers, at a rate of 53.6% (Table 2), have significant problems selling the milk they produce, as farmers do not control the dairy market. Therefore, they always resort to selling their products through illegal channels. Previously, farmers relied on an intermediary person who collected milk from

farmers and distributed it to dairy and cheese companies. Due to farmers' problems in rural areas and the lack of necessary resources and equipment, the produced milk became incompatible with milk producers' standards. Therefore, as Figure 7 shows, most of the farmers, 42.1%, sell their milk products in the bazaar, 30% of them depend on small supermarkets, and 17.1% try to sell what they produce on the roads. As for 20%, they still depend on a third party (collection point).

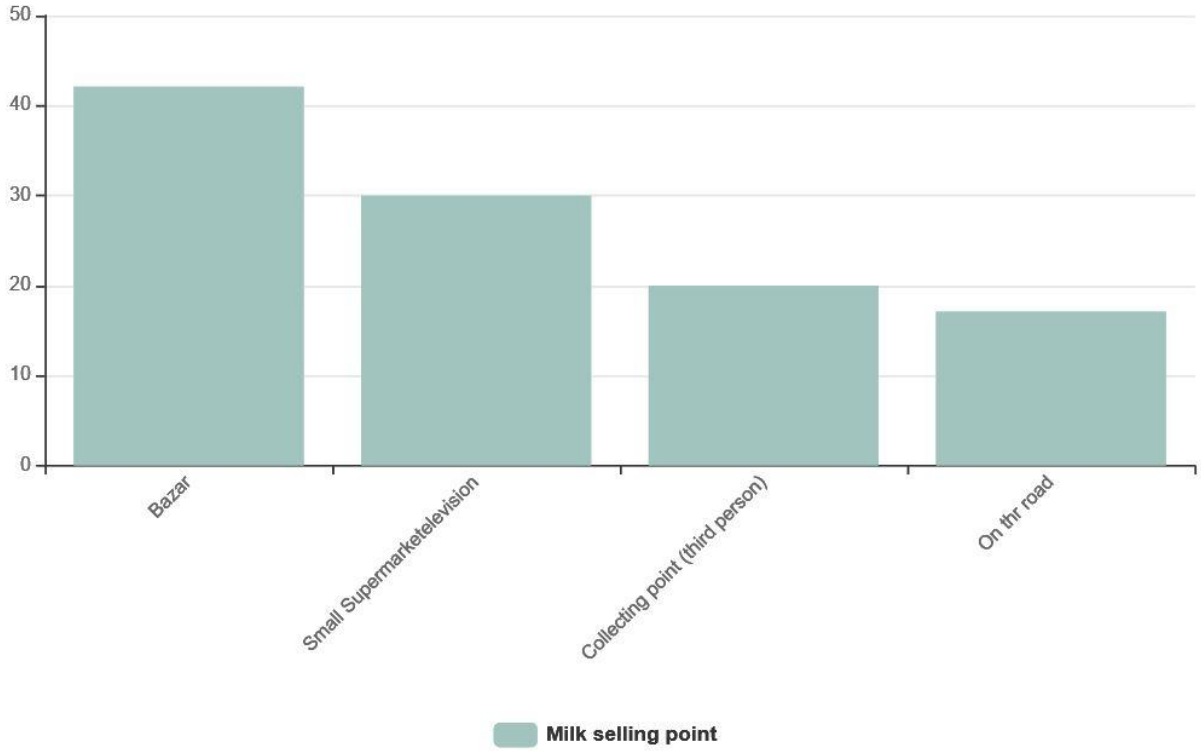

Figure 7. Milk selling points of smallholder farmers in the Kvemo Kartli region (N=140, Mean= 38, Std. Dev. = 15,840).

Farmers cannot produce high-quality milk as they do not have adequate and appropriate resources to reach these standards. Dairy SME and large cheese factories refuse to buy raw milk as it does not follow food safety laws.

To verify the significant issues in terms of selling milk, a T-test was used to compare farmers who suffer from difficulties in selling their milk products and others who do not face this problem (see Table 4). The T-test showed that there is a difference between farmers who suffer from selling the milk compared to others who do not face this problem concerning the amount of fodder in the high season (HS), (Mean with difficulties = 1.243, Mean without difficulties = 1.415, $t = -2.051$, $p < .05$). The lack of necessary fodder and pastures negatively affects the quality and quantity of milk, making it difficult to sell, whereas Cohen's $d = -0.349$ suggests a medium effect size of the relevant test.

This difference also appears regarding the animals' water sources (Mean with difficulties = 1.667, Mean without difficulties=1.815, $t = -2{,}004$, $p < .05$). As in the scarce seasons, it is challenging to sell milk, but also, with the lack of water, selling becomes more difficult for these farmers. Cohen's $d = -0.340$ suggests a medium effect size of the relevant test. Therefore, farmers are still suffering from a large problem in selling their milk products, and the gap between them and the small and large milk producers have become very complicated.

Spearman correlation analysis was applied to analyse the data. Table 5 shows that the correlation between the purchase in the low season and the average of the milk in the low season is $rs = 0.304$ ($p < 0.001$); thus, the correlation is statistically significant. The positive sign of the correlation coefficient shows that this is a relationship between the

two variables in the same way; this means that higher purchase values in the low season are associated with higher milk values in the low season. Likewise, Table 4 shows that the correlation between the purchase in the high season and the average of the milk in the high season is $rs = 0.395$ ($p < 0.001$); thus, the correlation is statistically significant. The positive sign of the correlation coefficient shows that this is a relationship between the two variables, which means that higher purchase values in the high season are associated with higher milk values in the high season.

Table 4. Independent Samples t-Test of the difficulties in selling milk.

Note. Student's *t*-test, * HS: high season: from March to August, ** LS: low season: from September to February.

Independent Samples t-test.							
				95% CI for Mean Difference			
	t	**df**	***p***	**Mean Difference**	**Lower**	**Upper**	**Cohen's d**
Keeping animals	1.114	138	0.267	0.172	−0.134	0.478	0.189
reason for starting dairy farming	3.576	138	< 0.001	0.413	0.185	0.642	0.606
Feeding in HS*	−2.051	137	0.042	−0.172	−0.338	−0.006	−0.349
Feeding in LS**	−0.831	138	0.408	−0.037	−0.125	0.051	−0.141
Purchase HS*	−1.729	138	0.086	−0.242	−0.519	0.035	−0.293
Purchase LS**	−1.797	138	0.075	−0.155	−0.325	0.016	−0.304
Sources of water are available for animals	−2.004	138	0.047	−0.149	−0.295	−0.002	−0.340
Average of the milk in HS * L/day	0.105	138	0.917	0.013	−0.238	0.265	0.018
Average of the milk in LS ** L/day	0.542	138	0.589	0.042	−0.111	0.195	0.092
Cheese varieties	0.067	138	0.946	0.008	−0.233	0.249	0.011

Table 5. Correlation matrix of milk production and animal feeding (Spearman correlations-rs).

Spearman's Correlations											
Variable		**Feeding in HS.**		**Purchase HS.**		**Purchase LS.**		**Feeding grass in the mountain in HS.**		**Average of the milk in H.S. L/day**	**Average of the milk in L.S. L/day**
Feeding in HS.	Spearman's rho	—									
Purchase HS.	Spearman's rho	0.257	**	—							
Purchase LS.	Spearman's rho	0.208	*	0.794	***	—					
Feeding Grass in the mountain in HS.	Spearman's rho	0.149		−0.135		0.006		—			
Average of the milk in H.S. L/day	Spearman's rho	0.386	***	0.395	***	0.333	***	−0.127	—		
Average of the milk in L.S. L/day	Spearman's rho	0.301	***	0.372	***	0.304	***	−0.048	0.589	***	—

* $p < .05$, ** $p < .01$, *** $p < .001$, H.S.: high season, LS: low season.

Comparing these results with the previous ones of expert interviews [28] showed that government agencies specialising in the field of dairy and cheese production and small and large factories require farmers to obtain milk of high standards, which includes all the conditions and specifications of food safety. Smallholder farmers, in turn, do not have sufficient and necessary resources to fulfil these conditions, so a large gap has arisen between these parties.

Experts have confirmed that smallholder farmers play an essential role in the new laws and legislation in dairy production. Compared to this questionnaire's results, farmers suffer from many problems, and government support for them is insufficient, as the relationship is poor between them. One of the farmers interviewed stated when we asked him if he suffers from a lack of feed or water:

"I: Veterinarians are the only ones who communicate with us, but also not always. In specific periods of the season, we may suffer from a shortage of feed or even water, and we do not always have the price of preserved fodder. At that time, the cows may suffer from some diseases, and their production will be deficient, so then we find only these veterinarians to help us." (09 June 2019, Bolnisi).

Another farmer stated:
"I: When we see one of the government agencies in our village, we know immediately that problems are coming, so it is better to avoid talking to them." (12 June 2019, Mtskneti).

Moreover, this study shows that smallholder farmers face different problems in the Georgian dairy value chain than those faced by experts and government agencies. The experts focused on food safety and international food safety standards and their importance in developing the value chain for dairy production. In contrast, the farmer sees this problem differently; for example, water availability and quality are some of the most critical factors for small farmers. As Table 2 shows, 81.4% of farmers do not have enough water for their livestock, and all of them depend on the existing rivers.

As indicated by the survey, in the Kvemo Kartli region, farmers depend mainly on the Khrami River and the Mashavera river. Table 6 shows the value of the Chi-Square test

($X^2 = 3.961$, df = 1, $p < 0.05$), as it explains that the farmers who are dependent on these two rivers have problems selling their milk. These results suggest that the respondents in the Khrami River area face more problems by selling their milk than in the area of the Mashavera River.

A farmer declared the following when asked whether the current water source suffices his needs for the whole year:

''I: The river is not close to my house, and therefore we have to walk a long distance every day to bring water for the livestock, as drinking water is limited, and we cannot always give our livestock from it. Unfortunately, no one offers us an alternative or solution to this problem.'' (09 June 2019, Chapala).

And another stated:

''I: How can the milk production of my cows be high when we do not have enough water or sufficient amount of feed?'' (13 June 2019, Kvemo Bolnisi).

Table 6. Chi-Square Test of the difficulties selling milk.

Contingency Tables				
	Difficulties Selling Milk			
Sources of water are available for animals	**Yes**	**No**	**Total**	
Khrami River	25	12	37	
Mashavera River	50	53	103	
Total	75	65	140	
Chi-Squared Tests				
	Value	**df**	**p**	
X^2	3.961	1	0.047	
Likelihood ratio	4.039	1	0.044	
N	140			
Log Odds Ratio				
		95% Confidence Intervals		
	Log Odds Ratio	**Lower**	**Upper**	**p**
Odds ratio	0.792	0.003	1.582	
Fisher's exact test	0.787	0.063	∞	0.035

Note. For all tests, the alternative hypothesis specifies that group *Khrami River* is more significant than *Mashavera River*.

A T-test was used to compare farmers' difficulties, depending on the two rivers that pass through these villages (see Table 7), because the hypothesis states that people in this region of Khrami River have different answers from farmers in the region of Mashavera river.

The test showed a fundamental difference in milk production between farmers who use the Khrami River compared with farmers from other villages who depend on the Mashavera River in LS.

The milk production of farmers in the Khrami River region is, on average, higher than the milk production of the farmers in the Mashavera River region (Mean Khrami = 1.351, Mean Mashavera= 1.155, t = 2.273, p <.05). Simultaneously, the farmers in the Mashavera River region suffer from many problems, including the difficulty of accessing river water or permanent water pollution. Cohen's d value (Cohen's d = −0.340) suggests a medium effect size of the relevant test.

Nevertheless, as shown in Table 2, 96.4% of the farmers do not have sufficient fodder for cows for the whole year, and they cannot make preserved fodder (such as hay; see Figure 4). Therefore, the cows suffer from a significant shortage of feed, which is negatively reflected in the amount of milk production.

Table 7. Independent Samples t-Testof the available water sources.

Independent Samples T-Test							
					95% CI for Mean Difference		
	t	df	*p*	Mean Difference	Lower	Upper	Cohen's d
Keeping animals	−1.262	138	0.209	−0.220	−0.566	0.125	-0.242
reason for starting dairy farming	2.590	138	0.011	0.346	0.082	0.609	0.496
Feeding in H.S *	0.520	137	0.604	0.050	−0.141	0.242	0.101
Feeding in L.S **	−0.083	138	0.934	−0.004	−0.104	0.095	-0.016
Purchase H.S *	1.300	138	0.196	0.207	−0.108	0.521	0.249
Purchase L.S **	1.652	138	0.101	0.161	−0.032	0.354	0.317
Average of the milk in H.S * L/day	0.546	138	0.586	0.078	−0.206	0.363	0.105
Average of the milk in L.S ** L/day	2.273	138	0.025	0.196	0.025	0.367	0.436
Difficulties selling milk	−2.004	138	0.047	−0.190	−0.378	-0.003	-0.384
Cheese varieties	−0.716	138	0.475	−0.099	−0.371	0.174	-0.137

* HS: high season, ** LS: low season.

A T-test was used to compare farmers who have enough fodder for their animals (for the entire year) and others who do not (see Table 8). It is essential to know if the farmers depend only on local pastures or different types of local or imported feed. The T-test showed that there is a difference between farmers who have enough fodder compared to others who do not have the required amount of fodder in the low season (LS), (Mean have enough fodder =1.400, Mean don't have enough fodder = 1.044, $t = -3.069$, $p < 0.05$).

Table 8. Independent Samples T-Test of Enough Fodder for dairy animals (for the entire year).

Independent Samples T-Test			
	t	df	p
Size of the household	0.706	138	0.481
Number of cows	−0.160	138	0.873
Milking the cows (per day)	2.304	138	0.023
Milk for cheese production	0.562	138	0.575
Feeding in L.S **	3.069	138	0.003
Purchase H.S *	0.312	138	0.756
Purchase LS **	NaN		
Feeding in H.S *	2.201	137	0.029
Starting dairy farm	NaN		
Processing cheese	−0.896	138	0.372
Responsibility for feeding, cleaning, milking, and processing as well as marketing	0.219	138	0.827
Average of the milk in HS* L/day	1.198	138	0.233
Average of the milk in LS** L/day	−0.035	138	0.972
Milk consumption at home	−0.669	138	0.505
Milk sold	−0.335	138	0.738

Note. Student's t-test, * HS: high season, ** LS: low season

Studies have shown that the Georgian agencies in the development of the dairy sector in Georgia are working to legislate and apply strict laws and regulations, which raise the efficiency and quality of the final product [27].

However, after the Georgian government adopted a unique system concerned with food safety in the country in 2010 [77], several new laws and legislation entered into force in 2020. These laws prevented all dairy companies from purchasing and collecting milk

from farmers whose cows were not registered in the official government system [26]. Moreover, in 2014, after the signing of the joint agreement ''EU-Georgia Association Agreement" between Georgia and the European Union, Georgia is working hard to implement all food safety standards applied in the European countries [78,79].

However, all of these laws serve the consumer, and for the producer's interest so as to produce sufficient quantities of high-quality milk, adequate amounts of good quality feed must be available. Therefore, farmers try to save some money to buy preserved or concentrated fodder, especially for winter (wheat, corn, and straw). Thus, it becomes difficult for them to secure cleaning and sanitation services for their barns [53].

The Georgian government provides veterinary services for free. However, farmers sometimes need to pay specific amounts to obtain certain medicines for their cows because these services do not always include giving medicines free of charge. Therefore, they treat their cows with antibiotics, which pose a significant danger to human health and the quality and safety of the milk produced [79].

Compared to other studies, Belay et al. [80] showed the importance and influence of the socio-economic characteristics of dairy farmers on the management and development of the dairy sector, which demonstrated the strong correlation between the education level and years of experience with dairy management practices. Tina et al. [2] also confirmed that taking into account the social and economic factors in the dairy sector significantly affects its sustainability and the development of the dairy value chain, especially if the other factors that affect the chain are taken into consideration. In addition, as Mlelwa emphasised in his research, the dairy sector is significantly influenced by several socio-economic factors, such as the number of cows, the farmer's experience, knowledge, and workforce in each household, which all play an essential role in the development of this chain [81].

The Georgian government has come a long way in developing a sustainable food safety system in the country. The National Food Agency (NFA) built significant relationships with smallholder farmers, especially in rural areas. Where the NFA is the leading player in the Georgian agricultural sector, it is directly responsible for consumer protection, applying food safety standards in the country, examining all dairy products' components, and comparing them to the final product [76,82]. Besides, Georgia now has a database to register animals electronically to monitor all dairy and cheese production activities and directly intervene if necessary [26].

Thus, based on all of the information mentioned in this section, the results of this research may help identify points of difference between decision-makers in governmental institutions and dairy experts on the one hand and smallholder farmers on the other hand. The comparison that was made between these parties and clarifying the problems these people face may offer future solutions based on the main factors mentioned in this research, which may be in the interest of all parties.

4. Conclusions

Smallholder farmers were and still are the cornerstone of the agricultural and dairy sector in Georgia. This study presents interviews with smallholder farmers in the leading region for milk and cheese production in Georgia. The results show their point of view, fear, wishes, and challenges and may help reach a common solution on how the dairy value chain should be developed. It may help government agencies to implement their plans for developing the dairy sector in Georgia and, at the same time, reach high food safety standards. The analyses of milk and cheese samples being purchased from the interviewed farmers will be analysed and may show critical points in the dairy value chain.

This study showed the impact of smallholder farmers' ethical and cultural identity on the Georgian dairy value chain. Farmers still adhere to the ancient traditions they inherited from their parents and grandparents, and rural women are still under the

influence of those traditions. Although in this pastoral society, women are considered the primary and active element in the process of dairy production and cheese making, women do not have access to modern technology and studies related to dairy production. As a previous study with some experts in dairy production in Georgia showed, women are not concerned with much interest in development and modernisation programs for the dairy production sector in Georgia. This proves that smallholder farmers' ethical and cultural identity is a fundamental factor in developing the value chain of Georgian domestic dairy products.

The questionnaire results indicated that farmers are afraid of increasing the number of large dairy producers in Georgia, as smallholder farmers' production capacity is limited. Smallholder farmers cannot meet the substantial market requirements, and it is difficult to adhere to the stipulated food safety conditions. Thus, this confirms that farmers fear that their presence in the dairy market will be threatened by specialised farms that produce large quantities of raw milk.

However, smallholder farmers' microbiological quality of their dairy products is no longer acceptable in the market. As a result, farmers suffer from the constant fear of not selling their raw milk and homemade cheese products.

The study also showed that the problems that farmers suffer from are entirely different from those problems that the experts stressed in a previous study that farmers suffer from.

As the questionnaire results showed, the lack of fodder and water scarcity and its low quality are fundamental problems that farmers face. The government is working to secure enough pastures for farmers in the summer, but that is not enough, as farmers do not have enough fodder or money to buy what is necessary for the winter season. The problems of river cleanliness in villages and river pollution with heavy metals do not receive much attention from the government agencies concerned. Therefore, directly and indirectly, all of this affects the quality of milk and cheese made in rural areas.

From the point of view of dairy experts, the problems of hygiene and animal welfare on the one hand, and the marketing of raw milk and dairy products, on the other hand, are the significant challenges facing these farmers. Thus, this proves a gap between dairy farmers and governmental and private organisations prioritising smallholder farmers' problems. On the other hand, these farmers do not give the quality of milk and animal welfare great importance due to the economic conditions and the problems they suffer from.

Hence, this study's results may help develop the dairy value chain in Georgia, where all the factors and components of this chain must be taken into account. The work of all actors and the continuous coordination between them will ensure the sustainability of this value chain.

On the other hand, the question remains open. Assuming that this stipulated legislation and laws have worked in smallholder farmers' interest and considered the factors critical to them, will this only have a positive impact? For years, these traditions used by smallholder farmers have been an essential part of the dairy sector's development stage in Georgia. Besides, will these farmers have the ability to control the local market or even develop production to suit food safety requirements if they can export their products to other countries?

The inability of smallholder farmers to cope with the changes taking place in the dairy sector may lead to the abandonment of farms, which in turn leads to a change in the range of products, a change in the cultural landscape (although there are under industrial animal husbandry, but more cows are kept in the barn), and food security changes. Therefore, the government should support the preservation of smallholder farmers through training and subsidies to create healthy and social living conditions.

Food safety laws have not curbed the pollution of rivers, soils, and plants with heavy metals from another perspective. The safety of farmers and the preservation of local production of high-quality milk and cheese should take priority.

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Appendix A

Table A1. Questionnaire Data.

Domains and Variables	Questions
Upstream (Input supplies)	
Socio-demographic/socio-geographic	
Village	
Gender	
Household socio-economic background	
Size of the household	
Keeping animals	
Dairy production or animal husbandry is the only financial income	Is dairy production or animal husbandry the only financial income?
On-farm (production)	
General	
Starting dairy farm	When did you start dairy farming?
Basic knowledge of dairy farming	Did you have basic knowledge of dairy farming?
Reasons for starting dairy farming	For which reason did you start dairy farming?
Dairy farm structure, facilities and management	
Other livestock on the farm	Do you have any other livestock on your farm?
Number of cows	How many dairy cattle do you have on your farm?
Responsibility on the animals/farm	Who is responsible for the animals on the farm?
Animal breed	Which animal breed you have?
Cows for milk and meat purposes	Are your cows for milk or meat purposes?
Labour use in dairy farming	
Responsibility for feeding, cleaning, milking, and processing as well as marketing	How many persons are responsible for feeding cleaning milking and processing as well as marketing?
Feeding	
Type of grazing for dairy animals	Can you tell me which type of grazing do you practise for your dairy animals and how many months a year?
Feeding type	
Type of fertiliser on your grazing land	Are you using any type of fertiliser on your grazing land?
Sending the cows to the mountain in HS.	
Feeding in the high season (HS.)	
Feeding in the low season (LS.)	
Purchase in the high season (HS.)	
Purchase in the low season (LS.)	
Enough fodder for dairy animals (for the entire year)	Do you have enough fodder for your dairy animals for the entire year?
Making conserved feed (e.g., hay)	Are you used to making conserved feed, e.g., hay?
Sources of water are available for animals	Which sources of water are available for your animals?

Satisfied with the water quality of the primary water sources	Are you satisfied with the water quality of the primary water sources?
Water-amount enough for animals (yearly)	Do you have enough water to feed animals yearly?
Output (Downstream)	
How many times do you milk your cows (per day)?	
What is the average of the milk in HS (L/day)?	
What is the average of the milk in LS (L/day)?	
Would you like to increase your milk production?	
Please can you tell me your milk consumption at home (%)	
Milk selling point	Are there any specific selling points where you are marketing your milk?
Difficulties selling milk	Do you ever face any difficulties selling your milk?
Cheese varieties	Which cheese varieties do you have?
Cheese for marketing or self-consumption	Is your cheese for marketing or self-consumption?
Milking techniques	How do you milk your cows?
Washing udder before and after the milking process	Do you wash udders before and after the milking process?

Appendix B

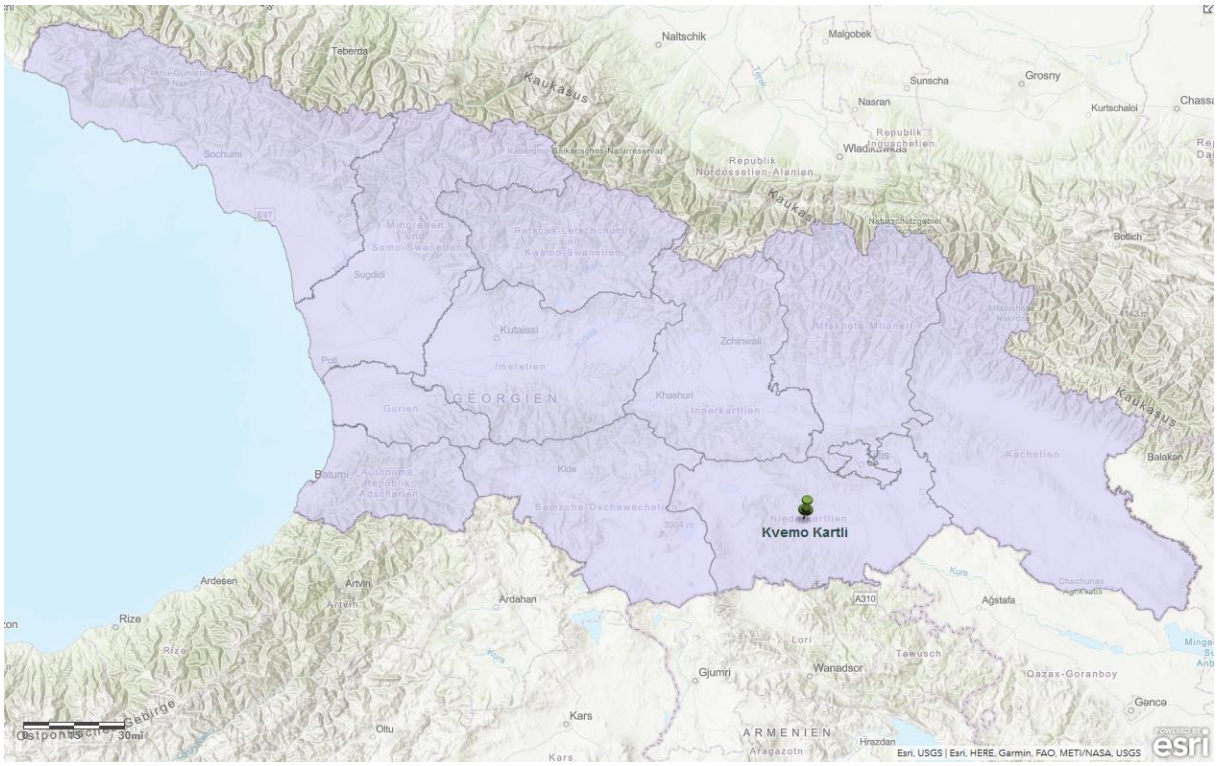

Figure A1. Georgia Map; ArcGIS Pro Data sources: Base map layer; ESRI satellite (ArcMap).

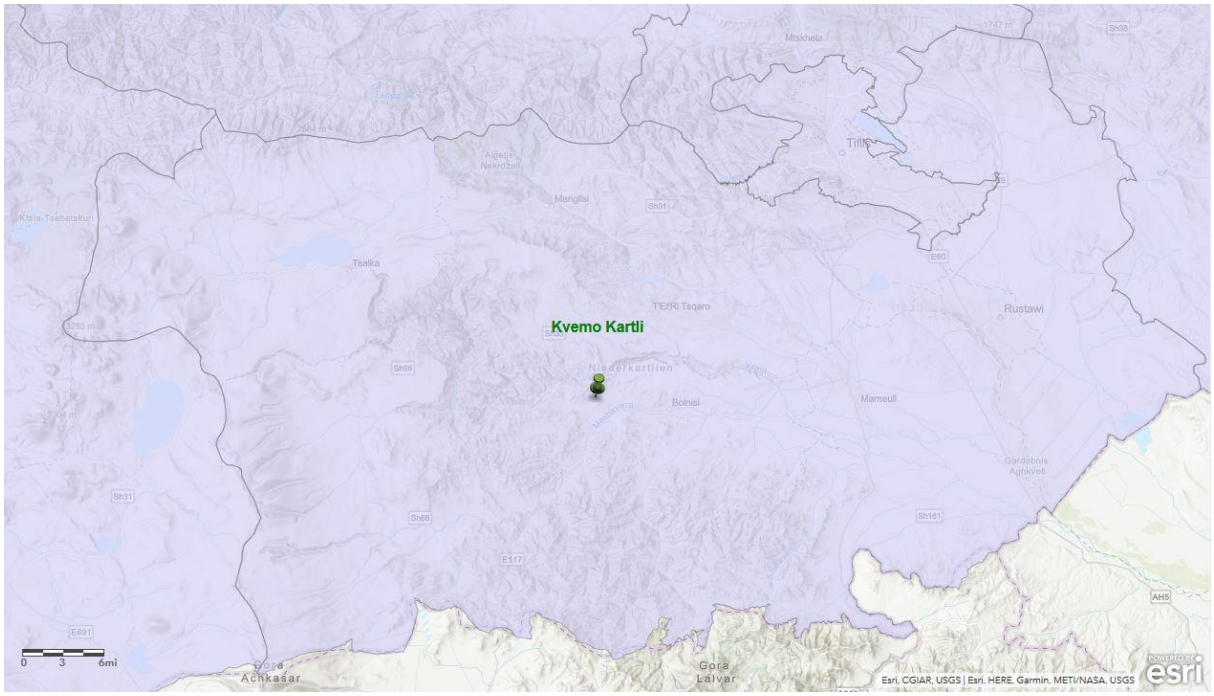

Figure A2. Kvemo Kartli region (Authors' illustration); ArcGIS Pro, Data sources: Base map layer; ESRI satellite (ArcMap).

References

1. FAO. *Transforming Food and Agriculture to Achieve the SDGs*; FAO: Rome, Italy, 2018; ISBN 9789251306260.
2. Jaklič, T.; Juvančič, L.; Kavčič, S.; Debeljak, M. Complementarity of socio-economic and emergy evaluation of agricultural production systems: The case of Slovenian dairy sector. *Ecol. Econ.* **2014**, *107*, 469–481, doi:10.1016/j.ecolecon.2014.09.024.
3. ALCP. *Ensuring Sustainability in the Dairy Market Sector*; Swiss Agency for Development and Cooperation (SDC): Bern, Swiss, 2017.
4. Wolfenson, K.D.M. *Coping with the Food and Agriculture Challenges: Smallholder Farmers' Agenda*; Food and Agriculture Organisation of the United Nations (FAO): Rome, Italy, 2013.
5. Markelova, H.; Meinzen-Dick, R.; Hellin, J.; Dohrn, S. Collective action for smallholder market Access. *Food Policy*, **2009**, *34*, 1–7, doi.10.1111/j.1541-1338.2010.00462.
6. Hong, D. *On world Food Day, Farmers should Come First*; One AcreFund Global: Kakamega, Kenya, 2015.
7. Olomola, A. *Policy Options for Agricultural Investments and Governance of Markets: In Support of Small-Scale Agriculture in Nigeria*; Oxfam Research Report; Oxfam International: Oxford, UK, 2013.
8. FAO. *Pro-Poor Livestock Policy Initiative: Status and Prospects for Smallholder Milk Production: A Global Perspective*; Food and Agriculture Organisation of the United Nations and International Dairy Federation.
9. FAO. 2011. Guide to good dairy farming practice. Animal production and Health - Guidelines. No. 8. Rome: Food and Agriculture Organization of the United Nations and International Dairy Federation. http://www.fao.org/3/ba0027e/ba0027e00.pdf. Accessed 13 Mai 2021.Wouters, A.P.; van der Lee, J. *Smallholder Dairy Development-Drivers, Trends and Opportunities*; WUR: Wageningen, The Netherlands, 2009.
10. FAO. *Milk/Dairy Products: Agribusiness Handbook*; Food and Agriculture Organisation of the United Nations (FAO): Rome, Italy, 2009.
11. Morgan, N. *Smallholder Dairy Development: Lessons Learned in Asia*; Animal Production and Health Commotion for Asia and the Pacific and FAO: Bangkok, Thailand, 2009.
12. Hemme, T.; Otte, J. *Status and Prospects for Smallholder Milk Production: A Global Perspective*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2010.
13. Rangnekar, D.; Thorpe, W.R. *Smallholder Dairy Production and Marketing—Opportunities and Constraints*; International Livestock Research Institute (ILRI): Nairobi, Kenya, 2001.
14. Thornton, P.K. Livestock production: Recent trends, future prospects. *Philos. Trans. R. Soc. B Biol. Sci.* **2010**, *365*, 2853–2867, doi:10.1098/rstb.2010.0134.
15. ENPARD. *Milk and Dairy Production Agricultural: Agricultural Value Chain in Imereti and Racha Regions*; Enhancing Small Farmers' Cooperation and Productivity in Imereti and Racha Regions (ENPARD): Tbilisi, Georgia, 2015; pp. 1–27.
16. CARD. *Business Case Study Dairy Sector in Georgia*; Center for Agribusiness and Rural Development: Tbilisi, Georgia, 2018.

17. Lerman, Z.; Csaki, C.; Feder, G. *Agriculture in Transition: Land Policies and Evolving Farm Structures in Post-Soviet Countries*; Lexington Books: Lanham, MD, USA, 2004; ISBN 0739108077.
18. Terra Institute, Ltd. *Georgia Land Market Development Project Final Report*; Terra Institute, Ltd.: Blue Mounds, WI, USA, 2005. Available online: http://www.terrainstitute.org/pdf/Georgia_LMDP_Final_Report.pdf (accessed on 15 October 2020).
19. SDC. *Alliances Kk Synthesis Report of the First Phase: September 2011 to September 2013*; Swiss Development Cooperation (SDC): Kvemo Kartli, Georgia, 2013. Available online: http://alcp.ge/pdfs/9b82125e5c11d2996b53c881302f1447.pdf (accessed on 12 October 2020).
20. ISET Policy Institute. *Policy Clarification*; Agricultural Registration Reform in Georgia: Tbilisi, Georgia, 2018; pp. 1–17. Available online: https://iset-pi.ge/images/Projects_of_APRC/Policy_Paper__Agricultural_Land_Registration_Reform_in_Georgia_GEO.pdf (accessed on 20 September 2020).
21. EI-LAT. *The Economic Transformation of Georgia in Its 20 Years of Independence*; Summary of the Discussion Paper; Liberal Academy—Tbilisi: Tbilisi, Georgia, 2012.
22. Gvaramia, A. *Land Ownership and the Development of the Land Market in Georgia*; ALCP Study: Tbilisi, Georgia, 2013.
23. ISET Policy Institute. *Safety and Quality Investment in Livestock: Georgian Dairy Market System Analysis and Mapping*; ISET Policy Institute: Tbilisi, Georgia, 2019.
24. Damenia, N.; Kharaishvili, E.; Sagareishvili, N.; Saghareishvili, M. Women's Employment Issues in Georgia and Solutions Based on European Experience. *Intern. J. Econ. Manag. Eng.* **2019**, *14*, 530–536.
25. UN-Resolution der Generalversammlung, Resolution der Generalversammlung, Verabschiedet am 25. September 2015. 2015. Available online: https://www.un.org/Depts/german/gv-70/band1/ar70001.pdf (accessed on 5 October 2020).
26. Gelashvili, S.; Deisadze, S. *Difficulties of Implementing the Technical Regulation on Milk and Dairy Products*; ISET Policy Institute: Tbilisi, Georgia, 2019.
27. Raaflaub, M.; Dobry, L.M. *Pasture Management in Georgia. Current Situation, Frame Conditions, Potentials of Development*; Swiss Agency for Development and Cooperation SDC: Bern, Switzerland, 2015; Volume 42.
28. Al Sidawi, R.; Urushadze, T.; Ploeger, A. Changes in Dairy Products Value Chain in Georgia. *Sustainability* **2020**, *12*, 5894.
29. Withanachchi, S.S.; Kunchulia, I.; Ghambashidze, G.; Al Sidawi, R.; Urushadze, T.; Ploeger, A. Farmers' perception of water quality and risks in the Mashavera River Basin, Georgia: Analysing the vulnerability of the social-ecological system through community perceptions. *Sustainability* **2018**, *10*, 3062.
30. Boogaard, B.; Oosting, S.; Bock, B. Defining sustainability as a socio-cultural concept: Citizen panels visiting dairy farms in the Netherlands. *Livest. Sci.* **2008**, *117*, 24–33, doi:10.1016/j.livsci.2007.11.004.
31. Galmessa, U.; Dessalegn, J.; Tola, A.; Prasad, S.; Kebede, L.M. Dairy production potential and challenges in western Oromia milk value chain, Oromia, Ethiopia. *J. Agric. Sustain.* **2013**, *2*, 1–21.
32. Kartvelishvili, T. Cattle sector and dairy chain developments in Georgia, Azerbaijan and Armenia. In *The Cattle Sector in Central and Eastern Europe: Developments and Opportunities in a Time of Transition*; Wageningen Academic Publishers: Wageningen, The Netherlands, 2009; p. 133.
33. CARD. *Baseline Assessment of the Dairy Sector in Georgia*; Center for Agribusiness and Rural Development: Tbilisi, Georgia, 2018.
34. FAO-EBRD. *Support to Sustainable Value Chains through the Development of Geographical Indications in the Dairy Sector*; European Bank for Reconstruction and Development: London, UK, 2016.
35. CRRC. *Dairy and Beef Consumer Preferences*; Caucasus Research Resource Center: Tbilisi, Georgia, 2018.
36. ISET-PI. *Livestock Farm-Enterprise Models in the Kakheti Region: Current Arrangements and Options for (Re-)Gaining Size and Competitiveness*; ISET-PI: Tbilisi, Georgia, 2016.
37. Bickerstaff, K. Risk perception research: Socio-cultural perspectives on the public experience of air pollution. *Environ. Int.* **2004**, *30*, 827–840, doi:10.1016/j.envint.2003.12.001.
38. Dogaru, D.; Zobrist, J.; Balteanu, D.; Popescu, C.; Sima, M.; Amini, M.; Yang, H. Community Perception of Water Quality in a Mining-Affected Area: A Case Study for the Certej Catchment in the Apuseni Mountains in Romania. *Environ. Manag.* **2009**, *43*, 1131–1145, doi:10.1007/s00267-008-9245-9.
39. Slovic, P. Trust, Emotion, Sex, Politics, and Science: Surveying the Risk-Assessment Battlefield. *Risk Anal.* **1999**, *19*, 689–701, doi:10.1111/j.1539-6924.1999.tb00439.x.
40. Leiserowitz, A. Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values. *Clim. Chang.* **2006**, *77*, 45–72, doi:10.1007/s10584-006-9059-9.
41. Eurostat. *Global Assessment of the National Statistical System of the Republic of Georgia*; Eurostat (The Statistical Office of the European Union): Tbilisi, Georgia, 2019. Available online: https://www.unece.org/fileadmin/DAM/stats/documents/technical_coop/GA_Georgia_2019_EN.pdf (accessed on 05 October 2020).
42. National Statistics Office of Georgia. *Geostat Agriculture of Georgia, Retro-Projection of Main Demographic Indicators for the Period 1994–2014*; National Statistics Office of Georgia: Tbilisi, Georgia, 2018.
43. National Statistics Office of Georgia. *Geostat Agriculture of Georgia, Statistical Publication*; National Statistics Office of Georgia: Tbilisi, Georgia, 2020.
44. GeoStat National Statistics Office of Georgia (GeoStat), Tbilisi, Georgia. 2014. Available online: https: //www.geostat.ge/regions/# (accessed on 02 October 2020).
45. Bernabé, S.; Stampini, M. Labour Mobility during Transition: Evidence from Georgia. *SSRN Electron. J.* **2008**, *17*, 377–409, doi:10.2139/ssrn.1141149.

46. Pignatti, N. *Demographic Structure, Labor Market Conditions and Stalled Agricultural Development in a Post-Transition Country*; Tbilisi State University (TSU): Tbilisi, Georgia, 2017.
47. Republic of Georgia. *IFAD Results-Based Country Strategic Opportunities Programme 2019–2024*; Republic of Georgia: Rome, Italy, 2018.
48. Muehlfried, F. Sharing the same blood—Culture and cuisine in the Republic of Georgia. *Anthr. Food* **2008**, *Food2008*, 3, doi:10.4000/aof.2342.
49. Springmann, M.; Godfray, H.C.J.; Rayner, M.; Scarborough, P. Analysis and valuation of the health and climate change cobenefits of dietary change. *Proc. Natl. Acad. Sci. USA* **2016**, *113*, 4146–4151, doi:10.1073/pnas.1523119113.
50. FAO. *Representation in Georgia*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2015. Available online: http://www.fao.org/3/bc305/bc305.pdf (accessed on 22 September 2020).
51. Zubiashvili, T.; Silagadze, L. Some aspects of the Georgian economy at the contemporary stage. *Ecoforum* **2016**, *5*, 1–5.
52. Mayfield, L.E.; Bennett, R.M.; Tranter, R.B.; Wooldridge, M.J. Consumption of welfare-friendly food products in Great Britain, Italy and Sweden, and how it may be influenced by consumer attitudes to, and behaviour towards, animal welfare attributes. *Int. J. Food Agric*. **2007**, *15*, 16.
53. Republic of Georgia. *IFAD Dairy Modernisation and Market Access Programme (DiMMA): Final Project Design Report*; Republic of Georgia: Tbilisi, Georgia, 2018.
54. Napolitano, F.; Girolami, A.; Braghieri, A. Consumer liking and willingness to pay for high welfare animal-based products. *Trends Food Sci. Technol.* **2010**, *21*, 537–543, doi:10.1016/j.tifs.2010.07.012.
55. Mounier, L.; Veissier, I. *Proceedings of the 6th International Conference on the Assessment of Animal Welfare at the Farm and Group Level*; Wageningen Academic Publishers: Wageningen, The Netherlands, 2014; ISBN 978-90-8686-247-4.
56. GeoStat National Statistics Office of Georgia (GeoStat), Tbilisi, Georgia. 2019. Available online: https://www.geostat.ge/en/modules/categories/196/agriculture (accessed on 10 March 2021).
57. Creswell, J.W.; Plano Clark, V.L. (Eds.) Choosing a Mixed Methods Design. In *Designing and Conducting Mixed Methods Research*; SAGE Publications: Thousand Oaks, CA, USA, 2006; pp. 58–88.
58. Libakova, N.M.; Siberian Federal University; Sertakova, E.A. The Method of Expert Interview as an Effective Research Procedure of Studying the Indigenous Peoples of the North. *J. Sib. Fed. Univ. Humanit. Soc. Sci.* **2015**, *1*, 114–129, doi:10.17516/1997-1370-2015-8-1-114-129.
59. Avkopashvili, G.; Avkopashvili, M.; Gongadze, A.; Gakhokidze, R. Eco-Monitoring of Georgia's Contaminated Soil and Water with Heavy Metals. *Carpathian J. Earth Environ. Sci.* **2017**, *12*, 595–604.
60. Bakradze, E.; Vodyanitskii, Y.; Urushadze, T.; Chankseliani, Z.; Arabidze, M. About rationing of the heavy metals in soils of Georgia. *Ann. Agrar. Sci.* **2018**, *16*, 1–6, doi:10.1016/j.aasci.2017.09.002.
61. Felix-Henningsen, P.; Sayed, M.A.H.A.; Narimanidze-King, E.; Steffens, D.; Urushadze, T. Bound Forms and Plant Availability of Heavy Metals in Irrigated, Highly Polluted Kastanozems in the Mashavera Valley, SE Georgia. *Ann. Agrar. Sci.* **2011**, *9*, 110–120.
62. Felix-Henningsen, P.; Urushadze, T.; Steffens, D.; Kalandadze, B.; Narimanidze, E. Uptake of heavy metals by food crops from highly-polluted Chernozem-like soils in an irrigation district south of Tbilisi, Eastern Georgia. *Agron. Res.* **2010**, *8*, 781–795.
63. Felix-Henningsen, P.; Urushadze, T.F.; Narimanidze, E.I.; Wichmann, L.; Steffens, D.; Kalandadze, B. Heavy metal pollution of soils and food crops due to mining wastes in an irrigation district south of Tbilisi, Eastern Georgia. *Ann. Agrar. Sci*. **2007**, *5*, 11–27.
64. UN Women. *Gender Assessment of Agriculture and Local Development Systems*; S.C.O.: Beijing, China; A.D.C.: Tbilisi, Georgia, 2018.
65. Oxfam. *Barriers for Women in Agriculture Focus Group Research*; Oxfam: Nairobi, Kenya, 2015.
66. UNDP. *Public Perceptions on Gender Equality in Politics and Businesses*; UNDP: New York, NY, USA, 2013.
67. UNFPA. *Men, Women, and Gender Relations in Georgia: Public Perceptions and Attitude*; UNDP: New York, NY, USA, 2020.
68. FAO. *Gender, Agriculture and Rural Development in Georgia, Country Gender Assessment Series*; FAO: Rome, Italy, 2018.
69. FAO. *Gender Equality, Social Protection and Rural Development in Eastern Europe and Central Asia*; Insights from the region: Budapest, Hungary, 2016.
70. Gieseke, D.; Lambertz, C.; Gauly, M. Effects of cubicle characteristics on animal welfare indicators in dairy cattle. *Animal* **2020**, *14*, 1934–1942, doi:10.1017/s1751731120000609.
71. Hansson, H.; Lagerkvist, C.J. Identifying use and non-use values of animal welfare: Evidence from Swedish dairy agriculture. *Food Policy* **2015**, *50*, 35–42, doi:10.1016/j.foodpol.2014.10.012.
72. Vasseur, E.; Borderas, F.; Cue, R.I.; Lefebvre, D.; Pellerin, D.; Rushen, J.; Wade, K.M.; De Passillé, A.M. A survey of dairy calf management practices in Canada that affect animal welfare. *J. Dairy Sci.* **2010**, *93*, 1307–1316, doi:10.3168/jds.2009-2429.
73. FAO. Survey Sheds Light on Georgian Farmer Attitudes toward Livestock Traceability. Available online: http://www.fao.org/georgia/news/detail- events/en/c/1073576/ (accessed on 20 September 2020).
74. FAO. Georgia Gets Ready for Possible Reemergence of Cattle Disease. Available online: http://www.fao.org/georgia/news/detail-events/en/c/853929/ (accessed on 24 September 2020).
75. ALCP. Better Cheese, Better Work. International Labour Office: Georgia, 2020. Available online: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---mp_ent/documents/publication/wcms_746235.pdf (accessed on 24 September 2020).
76. Europe Foundation. *Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2016*; Europe Foundation: Tbilisi, Georgia, 2016.

77. Europe Foundation. *Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2015*; Europe Foundation: Tbilisi, Georgia, 2015.
78. Europe Foundation. *Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2012*; Europe Foundation: Tbilisi, Georgia, 2012.
79. Resolution N 29. *Antimicrobial Resistance for 2017–2020 on the Approval of the National Strategy*; Government of Georgia: Tbilisi, Georgia, 2017; p. 7. Available online: https://www.ncdc.ge/Handlers/GetFile.ashx?ID=cfaca9b4-17f5-417b-bdad-a37f20209920 (accessed on 20 September 2020).
80. Belay, D.; Yisehak, K.; Janssens, G.P.J. Socio-Economic factors influencing urban small-scale dairy management practices in Jimma town, Ethiopia. *Libyan Agric. Res. Center J. Intern.* **2012**, *3*, 7–12.
81. Mlelwa, J. Dairy Cattle Milk Productivity in Namtumbo District Council. Ph.D. Thesis, Mzumbe University, Morogoro, Tanzania, 2018.
82. Europe Foundation. *Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2017*; Europe Foundation: Tbilisi, Georgia, 2017.

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Chapter 4

Heavy metal levels in milk and cheese produced in the Kvemo Kartli region, Georgia

Rami Al Sidawi [1,] *, Ghambashidze, G[2,3]., Teo Urushadze [2] and Angelika Ploeger [1]

[1] Specialized Partnership in Sustainable Food Systems and Food Sovereignty, Faculty of Organic Agricultural Sciences, University of Kassel, 37213 Witzenhausen, Germany; a.ploeger@uni-kassel.de
[2] School of Agricultural and Natural Sciences, Agricultural University of Georgia, Tbilisi 0159, Georgia; t.urushadze@agruni.edu.ge
[3] Scientific-Research Centre of Agriculture, Ministry of Environmental Protection and Agriculture of Georgia, , Tbilisi 0159, Georgia; g.ghambashidze@agruni.edu.ge
* Correspondence: rami.alsidawi@uni-kassel.de; Tel.: +49-05542 981621

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Abstract: Milk and dairy products are among the most important food sectors in Georgia, and milk is considered one of the most essential foods in the human diet according to Georgian food culture. Kvemo Kartli is one of the major regions in Georgia for milk production. This region suffers from heavy metal contamination in soil and water because of the mining industry. This study was conducted to determine the concentrations of cadmium, lead, iron, zinc, copper, chromium, manganese, cobalt, nickel, selenium and molybdenum in milk and cheese and to evaluate whether the concentrations of these elements correspond to the permissible levels of toxic elements in milk and cheese for Georgia and the EU. In total, 195 milk samples and 25 cheese samples (16 from Imeruli cheese and nine from Sulguni cheese) were collected from nine different villages in the Kvemo Kartli region in Georgia: Chapala, Vanati, Bolnisi, Mtskneti, Sabereti, Ratevani, Khidiskuri, Kazreti, Kvemo Bolnisi. The determination of heavy metal in all samples was carried out by inductively coupled plasma-mass spectrometry. The research results show that the concentration of these elements in most milk samples is fairly constant for all villages and is less than the permissible levels, except for seven samples from the following villages: Kvemo Bolnisi, Bolnisi, Mitskineti and Ratawani, where the concentration of lead in the milk samples was higher than the permissible limits mentioned in the literature, ranging from 0.027 to 1003 mg L^{-1}. As for copper, its concentration in milk in Sabereti and Vanati villages was above the permissible limits according to the EU limit, ranging from 0.42 to 1.28 mg L^{-1}. For cheese samples, the concentration of cadmium, lead, copper, Co and Ni in the two types of cheese was less than the permissible limit according to the laws of Georgia. Finally, the heavy metal concentrations in Imeruli and Sulguni cheese for manganese (Mn), chromium (Cr), selenium (Se), molybdenum (Mo) zinc (Zn) and iron (Fe) were above the permissible limit. Thus, the study results showed that the consumption of milk does not pose a direct and serious threat to the health of consumers. As for the two types of cheese, future studies and continuous monitoring are necessary to assess the cheese content of trace elements and the risk of its consumption to the consumer.

Keywords: heavy metal; milk; cheese; Georgia

1. Introduction

Milk and dairy products contain vital nutrients [1,2]. In addition to proteins, dairy products contain vitamins, lactose, unsaturated fatty acids and many minerals. On the other hand, they may contain amounts of various toxic pollutants. Many plants such as Oonopsis, Xylorrhiza and others accumulate selenium, and through grazing, these plants may lead to livestock intoxication [3]. Other toxic components come from contaminated soil (from industrial activity) or are geogenic, which pose a significant risk to human health, too [4,5].

The mineral contents of milk and dairy products can be classified into basic elements (iron, copper and zinc), present in low doses. These trace metals in milk are more dangerous than in other foods since milk consumption is higher in the most vulnerable age groups (the elderly and infants), approximately 30–150 kg/person/year in general [6] As for unnecessary or toxic elements (such as lead, cadmium and others), the latter's presence, even in low concentrations, may lead to serious health problems in humans [1,2,7–9] Some of the side effects of heavy metal on the human body are kidney failure, genetic mutations and nervous system disorders. It can also cause cardiovascular problems, many types of cancers, respiratory disorders, a weak immune system and it can also cause infertility [7,10,11].

The human body may be exposed to heavy metal in several ways: consuming contaminated drinking water, inhaling dust or transferring these minerals from polluted soil or groundwater to plants. Furthermore, the mobility of heavy metals depends on a considerable number of factors, and the level of absorption and accumulation of these trace elements in plants may vary according to soil type, micronutrient content, moisture and pH [12,13]. By directly consuming contaminated food plants, heavy metals may easily be transmitted to animals, as livestock feed on the grass in pastures or on concentrated feeds, which are contaminated, transfer these minerals to the animals. However, the transfer of these minerals can vary highly, especially in cattle [14–21].

For example, one study on traditional farms in central Greece analyzed the level of heavy metal in the bodies of cows and sheep who were exposed to fodder contaminated with heavy metal by industrial areas and crowded roads close to agricultural lands. The results showed that through foraging, copper transfers to the cows' bodies to the liver was in a much higher concentration than the level of this element in each of the cows' kidneys and muscle tissues; whereas the ratio of copper carryover to milk was very low or absent. The results also showed the presence of Cu in cow manure was the same as that found in cow kidneys and muscle tissues [22].

In another study conducted in Ibadan, Nigeria, on sites contaminated with lead slag, four heavy metal, Pb, Cd, Cu and Zn, were analyzed in the grass samples of the area where livestock grazed. The results showed that plants and feed contained all four heavy metal, and a lead concentration above the permissible limits was discovered. The concentrations of zinc, cadmium and copper were within the recommended limits. In that study, milk, faeces and blood of cows grazing in the area were analyzed, and the presence of lead in milk, blood and faeces was higher than the detectable limit of the measuring devices [23].

Another study examining the extent of heavy metal transfer to cow's milk proved that milk protein is affected by heavy metal contamination more than other milk components [24]. Cadmium in milk was associated with casein fractions, as 14% of cadmium was transferred to whey and 60% to curd [25]. Another study on copper, cadmium and lead in cheese and milk proved that the concentration of elements in cheese is much higher than in milk, as most of these elements are bound to casein, whereas just a small amount was released in whey [25]. A study on cheese showed that adding coagulant and salt may increase lead, cadmium and copper concentration in the curd [25].

The production of milk and dairy products in Georgia is considered one of the most important sectors in the country's food industry, and Kvemo Kartli is one of the most important areas that produce dairy and cheese in Georgia [26–28]. A popular type of

cheese, Sulguni and Imeruli (Appendix B), is mainly made in this region, where its sale and consumption are still local and national, and it cannot be exported because it does not meet international standards [29–32]. However, this region suffers from many problems, namely environmental pollution [33]. Part of the cause for pollution began in 1975, near the Kazreti village, when the "Madneuli" mining plant started its operations [34]. In 2014, in the Dmanisi-Bolnisi area of Kvemo Kartli, on the right and left banks of the Mashavera River, the RMG gold and copper mine was opened with government approval [34–39]. As a result of factory activities, severe environmental pollution with toxic metals has appeared. From this point of view, previous studies and research in this region have shown trace metal contamination of rivers, particularly the Mashavera River Basin, which was counted as one of several rivers contaminated with heavy metal in Georgia [33,34,40–43].

Farmers in this region depend heavily on the Mashavera River's water, which they use to irrigate their crops and lands, and some farmers may also use it as drinking water [44]. The Kvemo Kartli region is of great importance for its prominent participation in agriculture production. The river region supports all sectors producing for the local diet, such as beans, corn and wheat crops, dairy and meat products, and many types of vegetables and many kinds of local wine. Farmers also use the water and grass for grazing cattle, goats and sheep [44,45]. Numerous studies and research in recent years have proven that the amount of water and soil pollution from heavy metal is vast in this area and has exceeded the permissible and highly accepted standards [34,36,46,47]. Therefore, the pollution of rivers, soil and air with heavy metal will affect the health of the population on the one hand and the local diet in Georgia on the other hand [34,45].

After studies were previously conducted to determine the extent of contamination of rivers, soil and plants with heavy metal, the main objective of this research paper is to determine the level of heavy metal in raw milk and cheese manufactured in the Kvemo Kartli area.

2. Methodology

2.1. Sampling sites

A total of **195** samples of cow's milk and 25 samples of Imeruli and Sulguni cheese were collected during summer 2019 in nine different villages in the Kvemo Kartli region in Georgia: Chapala, Vanati, Bolnisi, Mtskneti, Sabereti, Ratevani, Khidiskuri, Kazreti and Kvemo Bolnisi (Figure 1).

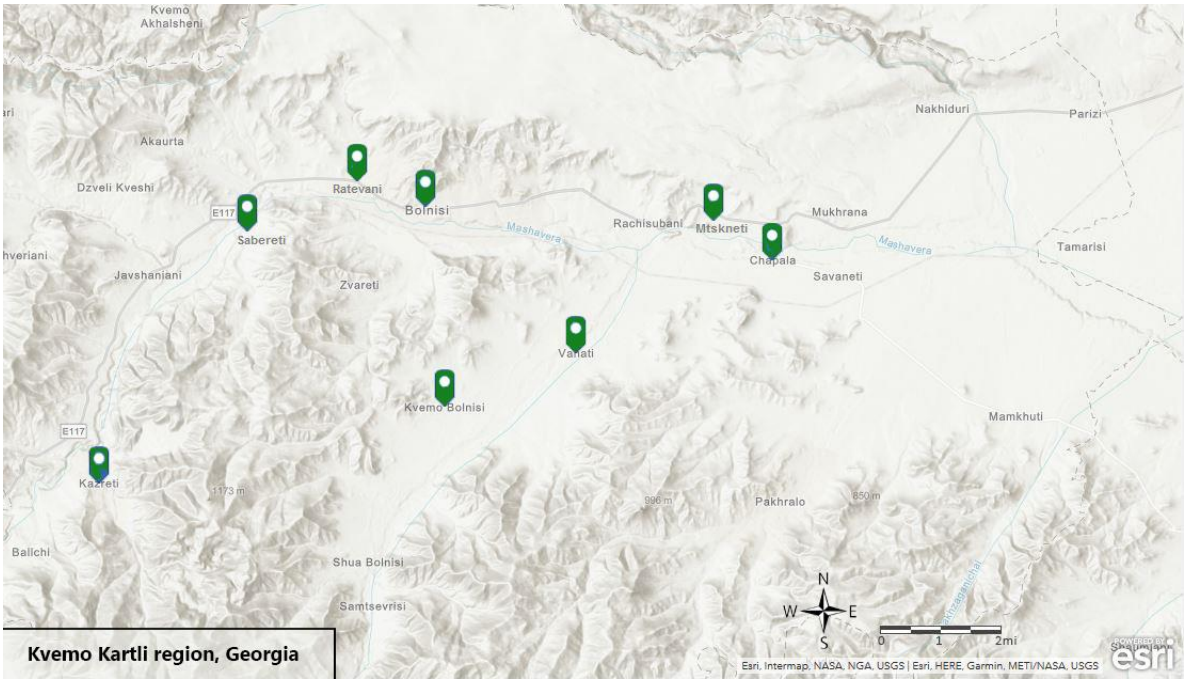

Figure 1. Map of the study area (Authors' illustration).

The sampling sites are located in villages adjacent to the Mashavera river or one of its sub-channels proven to be contaminated with heavy metal. The sampling protocols of milk, Imeruli cheese and Sulguni cheese were analyzed to reveal these elements: Cd, Pb, Cr, Cu, Fe, Mn, Se, Zn, Co, Ni, Mo.

2.2. Collection of Samples:

All milk samples were collected in the evening when the cows returned from grazing, as most farmers milked their cows in the evening. Polyethylene containers washed with nitric acid (concentration: 65%) were used to collect all milk samples. They were placed in a cooler with ice packs and then transferred directly to the accredited state laboratory, where they were stored at a temperature of −20 °C until analysis. Several procedures were followed to mitigate potential external contamination during milk sample collection:

- no mechanical milking machines were used,
- the person collecting the samples wore nitrile or latex gloves,
- the udder was well 'sanitized' before milking,
- all samples were numbered according to the villages in which they were taken from farmers.

The cheese samples were subsequently taken from the same farms that allowed us to take the milk samples. All were processed-made homemade cheese, which is typically sold in local markets.

2.3. Preparation and Analysis of Samples

2.3.1. Certified Reference Material (CRM)

Accuracy of obtained results was ensured by regular participation in Inter-Laboratory Proficiency Testing programs. Precision testing was carried out by performing duplicate analysis on one sample for every 20 samples. Calibration standards were prepared from CRM produced according to ISO 17034 and are traceable to NIST (National Institute of Standards and Technology).

The 10-point calibration curves (nine standards and one blank) were constructed for each element, and the correlation coefficients obtained were ≥0.9999 before starting the analysis.

Daily analyses of internal control materials were used for controlling the repeatability and accuracy. Uncertainties of the performed measurements were calculated following the EURACHEM guideline [48].

2.3.2. Milk and Cheese Samples

At first, 50.0 ml per sample in two replicates were placed in an open porcelain crucible treated with 1 mL of concentrated nitric acid (65%) and heated slowly on a hot plate (IKA, Germany) until fuming stop. As for cheese samples, 10.0 g per sample in two replicates were placed in an open porcelain crucible treated with 1 mL of concentrated nitric acid (65%) diluted (1:1) with deionized water, kept 15 min. Then both samples were ashed in a muffle furnace (Nabertherm, L15/11, Germany) preheated at 250°C with a gradual increase of temperature (50 °C every 30 min) to reach 450 °C. Ashing continued until obtaining grey ash, the residues were dissolved with dilute nitric acid, and the mixture was slowly dried on a hot plate (IKA, Germany) at 140 °C. After cooling, samples were placed back to the muffle furnace at 300 °C for 30 min. The last step was repeated until white ash was obtained. Finally, the ashed samples were dissolved with 5 mL of concentrated nitric acid and diluted to 25 mL (for cheese samples, diluted to 50 mL). With deionized water and filtered, two blank samples were carried out, in the same way using the reagents alone. The determination of metal contents in the obtained filtrate was carried out by inductively coupled plasma-mass spectrometry (ICP-MS, Agilent 7800, Agilent Technologies: Santa Clara, CA, USA) [49]. The LOD (limit of detection) for the studied metals are the following: for milk: Cr (0,00013), Mn (0,00010), Fe (0,00041), Co (0,00001), Ni (0,00007), Cu (0,00010), Zn (0,00033), Mo (0,00005), Cd (0,00001), Pb (0,00006) mg L^{-1}. As for cheese, there are: Cr (0,0013), Mn (0,00033), Fe (0,00349), Co (0,00003), Ni (0,00034), Cu (0,00106), Zn (0,00092), Mo (0,00023), Cd (0,00024), Pb (0,00018) mg/kg [wet weight (ww)].

All chemicals used were analytical grade with high purity. All plastic and glassware were cleaned using diluted (1:1) nitric acid in a hot acid bath and rinsed with deionized water before use.

This analytical methodology was used according to: GOST 26929-94. Raw material and foodstuffs. Preparation of samples. Decomposition of organic matters for analysis of toxic elements, 1994; GOST 26929-94 is a Georgia national standard method for analysis of food, including milk and milk products. The laboratory is a state research institute, it participates in proficiency testing programs every year to perform external quality control. As a state institute, it is not accredited.

2.4. Data Analysis

The heavy metal values shown in this study are expressed as mean ± SD of the repeated measurement. SPSS software version 27.0 (IBM, Armonk, NY, USA), was used to obtain the descriptive statistical analysis, to calculate the mean and standard deviation; in addition, an independent samples *t*-test was used to determine whether the means of two independent samples were different.

3. Results and Discussion

3.1. Toxic Metals

Table 1 shows the average concentrations of heavy metal in fresh cow's milk from nine villages in the Kvemo Kartli region in Georgia.

The contents of lead and cadmium in the milk samples are presented in Table 1. The concentrations of lead detected ranged from 0,004 to 0,048 mg L^{-1}. As for cadmium (Cd)

LOD: 0,00001 mg L^{-1}, the results showed that its concentration in fresh raw milk was <0,001 mg L^{-1}.

Comparing the lead and cadmium contents in milk samples with the maximum permissible limits (MPL) established by the International Dairy Federation (IDF) [50] and with the Maximum Permissible Concentrations (MPC) according to the Georgian regulation [51], the mean concentration of both cadmium and lead in raw cow's milk samples were lower than MPL and MPC, respectively (Cd: 0.0026 mg L^{-1}, Pb: 0.02 mg L^{-1} and Cd: 0,03 mg L^{-1}, Pb: 0, mg L^{-1}). Furthermore, according to the European Commission and Codex Alimentarius Commission, the limit for Pb in milk is 0.02 mg L^{-1} [52,53]. Thus, the analyzed milk samples did not exceed this permissible limit.

As for the cheese samples, Table 2 shows that the mean concentration of cadmium content of both types of cheese (Imeruli and Sulguni) was higher than in the milk samples (as expected), 0.002 and 0.007 mg/kg, respectively (Figure 2). However, it remains under the permissible limit. In the case of Pb, Sulguni cheese contained the highest concentration, 0.25 mg/kg ww, compared to Imeruli cheese, 0.12 mg/kg ww.

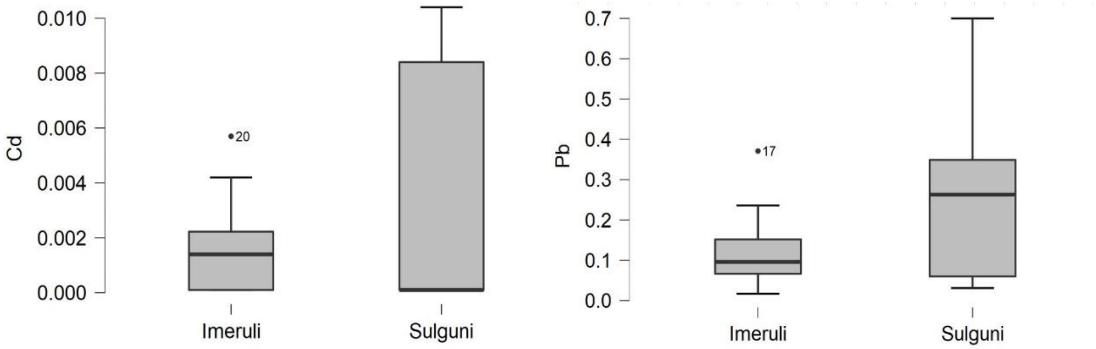

Figure 2. The cadmium (Cd) and lead (Pb) content of Imeruli and Sulguni cheese samples (mg/kg ww).

This difference between the cheese types may be due to the different methods used for cheese production; Imeruli cheese is usually taken as the base for making Sulguni cheese. To produce a kilogram of Imeruli cheese, one needs to have about seven liters of raw milk and only three ingredients: milk, salt and rennet. First, a solution of saltwater is prepared, and unheated curd is soaked in it for a period ranging from two to three days. The purpose of the brine is to stop the effect of bacteria, which enables the cheesemaker to adjust the time to control the acidity level of the Imeruli cheese, thus obtaining a highly melted cheese. Well-prepared Imeruli cheese should also have many small holes, as their presence is an indication that the bacteria have used up the lactic acid in the cheese, releasing carbon dioxide [54–57].

As for the manufacture of Sulguni cheese, either Imeruli cheese is used directly as the base or the following ingredients: milk, salt, rennet, whey and cream. About 10 L of raw milk are needed to produce a kilogram of Sulguni cheese. To prepare the Sulguni cheese, all these ingredients are combined and gently heated; the cheesemaker shapes it into a ball, then dried and pressed. Sulguni cheese, compared to other types of cheese, contains magnesium, phosphorus, potassium, sodium and iron [54–57].

According to the European Commission and Codex standards [53,58], it was observed that the Pb content in both cheese samples was above the maximum level (0.020 mg/kg ww). However, according to the Georgian regulation [51], the Maximum Permissible Concentrations (MPC) of lead in both types of cheese is less than the permissible limit (0.50 mg/kg ww).

This study showed that the cadmium concentration is very low and below the permissible levels, although several studies have confirmed that the water and pastures

used by farmers in these regions are contaminated with heavy metal, including cadmium [39,47]. Cadmium and lead are considered highly toxic and have harmful effects on human health [59,60]. Milk usually contains a very low concentration of cadmium, so when there is a high cadmium content in the milk, the reason is that these animals may have fed on cadmium-contaminated feed or drank from contaminated water as well [61]. The acute toxicity of cadmium in the human body leads to the defection of the skeletal and cardiovascular systems [61,62].

Table 1. Essential trace elements and heavy metal in milk *N* = 195 (mean ± standard deviation; mg L^{-1}) obtained in an area with water and pastures contaminated with heavy metal through mining industry in the Kvemo Kartli region, Georgia.

Milk Samples	Mean Concentration (mg L^{-1}) ± Standard Deviation (SD)										
	Trace Elements									Toxic Metals	
	Chromium (Cr)	Manganese (Mn)	Iron (Fe)	Cobalt (Co)	Nickel (Ni)	Copper (Cu)	Zinc (Zn)	Selenium (Se)	Molybdenum Mo	Cadmium Cd	Lead Pb
Bolnisi (*n* = 22)	0.002 ± 0.0016	0.036 ± 0.026	0.987 ± 0.841	<0.001	0.001 ± 0.0007	0.274 ± 0.370	2.975 ± 1.423	0.007 ± 0.0106	0.014 ± 0.0022	<0.001	0.006 ± 0.0079
Chapala (*n* = 22)	0.004 ± 0.002	0.075 ± 0.010	1.541 ± 1.284	0.0056 ± 0.003	0.017 ± 0.004	0.173 ± 0.079	3.458 ± 2.054	0.042 ± 0.023	0.022 ± 0.009	<0.001	0.008 ± 0.006
Daba Kazreti (*n* = 24)	0.002 ± 0.0036	0.044 ± 0.0617	1.391 ± 2.0387	0.004 ± 0.0107	0.002 ± 0.0016	0.133 ± 0.1404	2.411 ± 1.7129	0.005 ± 0.0038	0.009 ± 0.0068	<0.001	0.005 ± 0.0039
Kvemo Bolnisi (*n* = 24)	0.003 ± 0.002	0.036 ± 0.011	0.717 ± 0.525	0.003 ± 0.003	0.007 ± 0.005	0.133 ± 0.055	3.116 ± 0.959	0.020 ± 0.020	0.034 ± 0.025	<0.001	0.048 ± 0.204
Khidiskuri (*n* = 22)	0.001 ± 0.0013	0.023 ± 0.0229	0.502 ± 0.3815	0.007 ± 0.0172	0.006 ± 0.0075	0.120 ± 0.0811	2.223 ± 1.9752	0.020 ± 0.0142	0.011 ± 0.0092	<0.001	0.009 ± 0.0067
Mitskineti (*n* = 22)	0.003 ± 0.0014	0.049 ± 0.0185	1.089 ± 1.5586	0.005 ± 0.0030	0.002 ± 0.0026	0.142 ± 0.0544	3.916 ± 0.5227	0.006 ± 0.0022	0.022 ± 0.0138	<0.001	0.008 ± 0.0114
Ratawani (*n* = 23)	0.003 ± 0.002	0.058 ± 0.023	2.650 ± 2.137	0.002 ± 0.001	0.003 ± 0.003	0.404 ± 0.189	4.209 ± 1.671	0.011 ± 0.006	0.035 ± 0.025	<0.001	0.013 ± 0.015
Sabereti (*n* = 12)	0.002 ± 0.0006	0.032 ± 0.0059	5.537 ± 0.5251	<0.001	0.002 ± 0.0009	0.568 ± 0.1445	2.862 ± 0.3414	0.011 ± 0.0063	0.004 ± 0.0017	<0.001	0.004 ± 0.0029
Vanati (*n* = 24)	0.004 ± 0.0025	0.079 ± 0.0361	6.150 ± 2.5317	0.002 ± 0.0017	0.004 ± 0.0029	0.592 ± 0.2698	4.294 ± 1.0783	0.007 ± 0.0034	0.047 ± 0.0108	<0.001	0.012 ± 0.0115
Permissible limit *	0.02 [63] [1]	0.02–0.05 [64] [2]	0.7 [65,66] [3,4]	0.006 [63,66,67] [1,4,5]	0.027 [63,67] [1,5]	0.4 [68] [6,7]	3–5 [69] [8]/2–6 [70] [9]	0.5 [71] [10]	0.05 [63] [1]	0.2 [51] [6]	0.020 [53,58] [11,12] 0.500 [51] [6]
LOD, mg L^{-1}	0.00013	0.00010	0.00041	0.00001	0.00007	0.00010	0.00033	0.00533	0.00005	0.00001	0.00006

***** [1]. Flynn, A. (1992). [2]. Knowles et al. (2006). [3]. Storelli et al. (2007) [4]. Safonov, V. (2020). [5]. L. Hurleyw (1997). [6]. Ministry of Labour and Health, and Social Affairs of Georgia. (2001) [7]. European Commission (EC). (2001). [8]. World Health Organization (1996). [9]. Pechovà A, et al. (2008). [10]. EFSA—European Food Safety Authority (2011). [11]. European Commission. (2006). [12]. Codex Alimentarius. (1995).

Table 2. Trace elements and toxic metals in Imeruli and Sulguni cheese n = 25 (mean ± standard deviation; mg/kg ww) were obtained in an area with water and pastures contaminated with heavy metal (caused by mining industry) in the Kvemo Kartli region, Georgia.

Mean Concentration (mg/kg *) ± Standard Deviation (SD)			
	Cheese Samples *n* = 25		
Trace Elements	Imeruli (*n* = 16)	Sulguni (*n* = 9)	LOD
Cr	0.035 ± 0.017	0.079 ± 0.057	0.0013
Mn	0.886 ± 0.595	2.348 ± 2.267	0.00033
Fe	69.09 ± 64.918	101.1 ± 91.166	0.00349
Co	0.013 ± 0.011	0.03 ± 0.026	0.00003
Ni	0.011 ± 0.007	0.026 ± 0.029	0.00034
Cu	1.261 ± 0.739	2.463 ± 2.314	0.00106
Zn	75.86 ± 52.528	124.8 ± 97.775	0.00092
Se	1.003 ± 0.901	3.06 ± 3.144	0.01107
Mo	0.289 ± 0.111	0.401 ± 0.254	0.00023
Toxic metals			
Cd	0.002 ± 0.0015	0.007 ± 0.003	0.00024
Pb	0.121 ± 0.093	0.258 ± 0.215	0.00018

* Results are presented on a wet weight (ww) basis.

As for Pb, the results show that the content in milk was low compared to cheese, as it was higher in the two types of cheese than the maximum level according to European standards. The results may be cause for concern since Pb is very dangerous to human health. Exceeding the permissible levels may have carcinogenic effects, and it may cause direct genotoxicity or an increase in oxidative stress, expression of growth factors and altered DNA repair [72]. However, the Pb values in this study are considered below the established Georgian standards.

The Sulguni cheese contained the highest amount of Pb compared to the Imeruli cheese. One reason may be the difference in the methods and making of these two types of cheese. It is known that during cheesemaking, the hydrolysis of κ-casein causes milk to be divided into two compounds: (1) the curd, which is mainly composed of casein and fat; (2) the whey, containing all soluble compounds, the most abundant of which are lactose and whey proteins. It is worth highlighting that, among heavy metals, lead tends to associate to casein more than to whey proteins, which contributes to an increase of its concentration in cheese. On the other hand, the moisture content in cheese is very important, as, with higher water content, the proportion of Pb in cheese (wet weight) is diluted [73].

3.2. *Trace Elements*

Furthermore, Table 1 and Figure 2 show the zinc, copper and iron concentrations in the raw milk and cheese samples. The concentrations of these trace elements (Zn, Fe and

Cu) were detected in milk samples in amounts ranging from 2.22 to 4.29 mg L^{-1} (Zn), 0.5 to 6.15 mg L^{-1} (Fe) and 0.12 to 0.59 mg L^{-1} (Cu), respectively (Figure 3), and in both cheese samples Imeruli, 75.86 mg/kg ww Zn), 69.09 mg/kg ww (Fe) and 1.261 mg/kg ww (Cu), and Sulguni 124.8 mg/kg ww (Zn), 101.1 mg/kg ww (Fe) and 2.463 mg/kg ww (Cu), respectively (Figure 4).

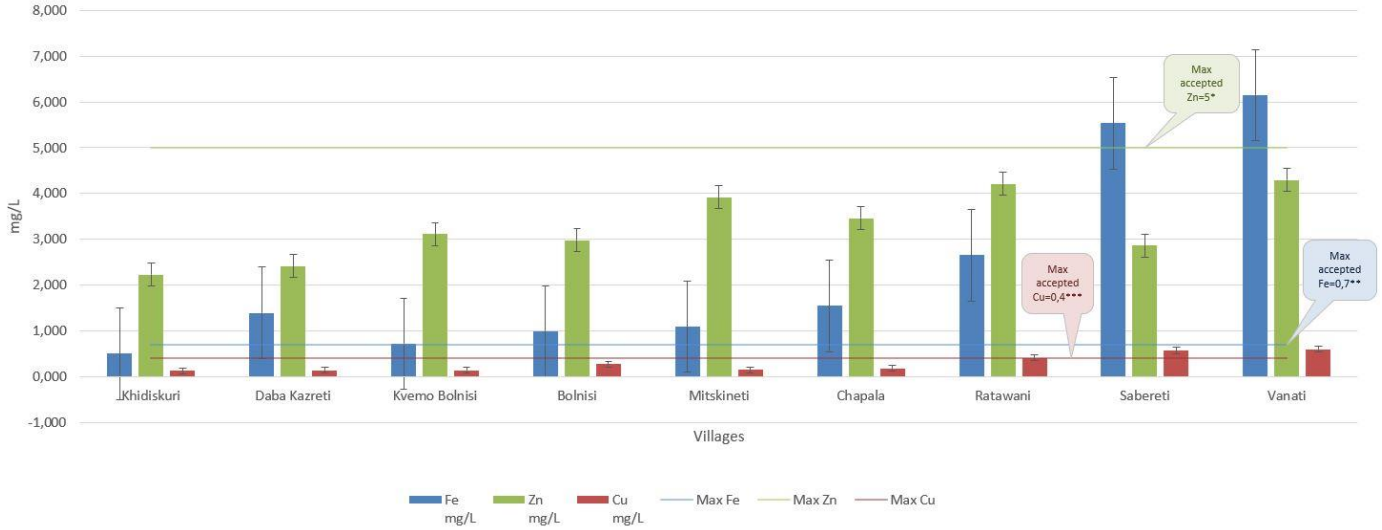

Figure 3. Concentration ranges (mg L^{-1}) of Iron, zinc, and copper in milk samples ($N_{Bolnisi}$= 22, $N_{Chapala}$= 22, $N_{Daba\ Kazreti}$= 24, $N_{Kvemo\ Bolnisi}$= 24, $N_{Khidiskuri}$= 22, $N_{Mitskineti}$= 22, $N_{Ratawani}$= 23, $N_{Sabereti}$= 12, N_{Vanati}= 24).

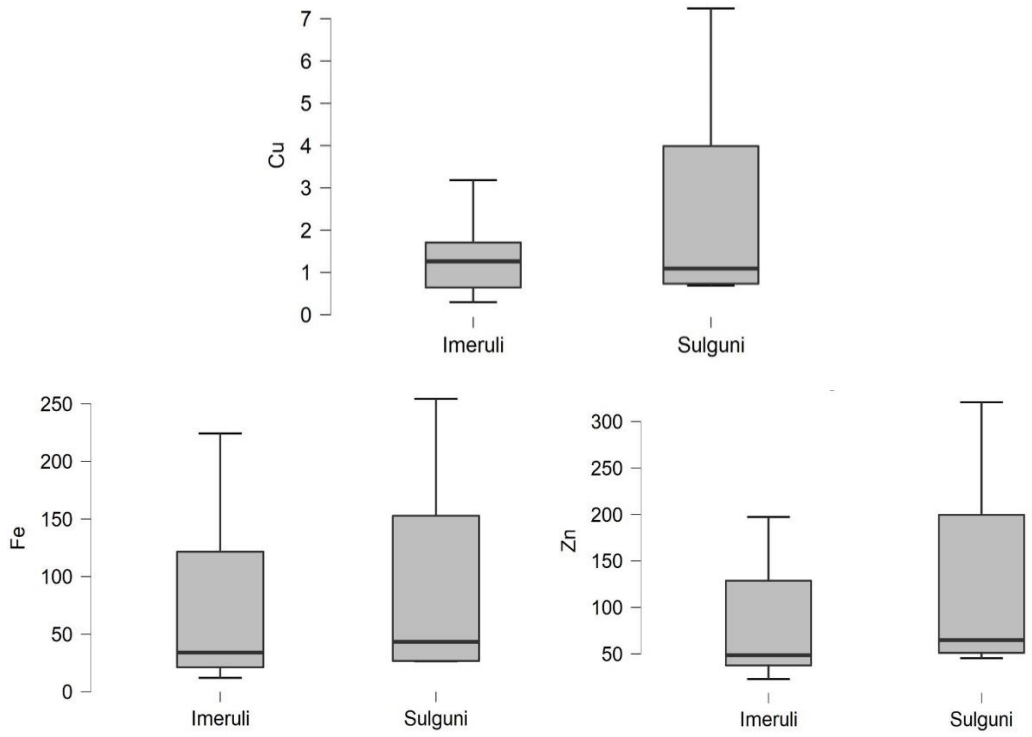

Figure 4. The iron, zinc, and copper content of Imeruli (n=16) and Sulguni (n=9) cheese samples (mg/kg wet weight).

According to WHO, the permissible limit for zinc in raw milk should be between 3–5 mg L^{-1} [69]. Compared to Pechová et al., the permissible zinc content in milk could be within 2–6 mg L^{-1} [70]. Thus, the zinc content in raw milk in this study is considered within the acceptable limit. Comparing the amount of zinc in the milk samples with the cheese samples shows that the Imeruli and Sulguni cheese (mg/kg WW) zinc content is much higher than the concentration in the milk (75.86, 124.8), respectively, where the processing of cheese affects that.

Zinc is considered a heavy metal due to its high density (7.133 g/cm^3); once it exceeds 5 g/cm^3, it is considered a heavy metal [74]. Still, zinc has an important role in the immune system's physiological processes and functional performance in the human body. It is also involved in the structure and activity of approximately 300 enzymes in the body. These enzymes are responsible for replication and insulin secretion and cellular differentiation, protein synthesis and nucleic acid, and sexual maturation [75,76]. On the other hand, an increase in zinc content in the body and chronic exposure to it has negative effects on the human body, leading to anaemia and leucopenia and causes gastrointestinal diseases and diarrhea [75,76].

As for copper, the European Union has set the highest permissible amount of copper in milk and its products, which should not exceed 0.4 mg L^{-1} [68]. The results show that the concentration of copper in milk was less than the permissible limit, except for the Sabereti and Vanati regions, where the concentration of copper in milk was higher than the permissible value (0.56 and 0.59 mg L^{-1}), respectively.

As for the cheese samples, the copper content in both types of cheese, Imeruli and Sulguni, and according to the Georgian regulation MPC [51] was less than the permissible limit (1.26 and 2.46 mg/kg wet weight), respectively. Copper is also considered one of the essential elements for humans but exceeding the normal permissible consumption levels may lead to toxic effects on the human body. It may cause gastrointestinal disorders, liver cirrhosis, reduced immunity, neurological disorders and dermatitis [65,77,78].

As for iron, the results in Tables 1 and 2 show that iron concentrations in both milk and cheese were higher than the permissible limit [66,79] (0.138–0.700 mg/kg WW) in all the villages except for Khidiskuri village. The amount of iron in milk in this village was less than the permissible limit (0.502 mg L^{-1}). In addition, the analysis of milk samples shows that the concentration of iron was relatively high in raw milk in the villages of Sabereti and Vanati compared with the rest of the villages (5.53 and 6.15 mg L^{-1}), respectively.

The iron content of both Imeruli and Sulguni cheese samples was very high compared to the raw milk samples (69.09 and 101.1 mg/kg wet weight), respectively. Table 2 shows that Sulguni cheese had a higher iron content than Imeruli cheese, as the concentration of each of them exceeded the permissible limit.

Iron is an essential and important element for the human body, as it participates in many redox reactions[80]. Iron also has critical metabolic functions, and one of its most essential functions is oxygen transport. Iron deficiency in the body leads to decreased immune function, anaemia, impairment of cognitive performance and psychomotor development [80]. An increase in iron in the body may lead to dysfunction of the liver, spleen and brain [81]. In addition, iron can influence the concentration of other minerals in the body, as it can help increase cobalt and decrease calcium, copper and chromium (through excretion or binding) [81].

Furthermore, and based on the results in Tables 1 and 2, the highest concentrations of the essential trace elements in the raw cow's milk samples in the order of Cr, Mn, Co, Ni, Se and Mo (mg L^{-1}) were detected in raw milk in amounts ranging from 0.001 to 0.004, 0.023 to 0.079, 0.001 to 0.007, 0.001 to 0.017, 0.004 to 0.042 and 0.004 to 0.047, respectively; and in Imeruli cheese 0.035, 0.886, 0.013, 0.011, 1.003 and 0.289 mg/kg ww, and Sulguni cheese 0.079, 2.348, 0.03, 0.026, 3.06,and 0.401 mg/kg ww, respectively (Figure 5).

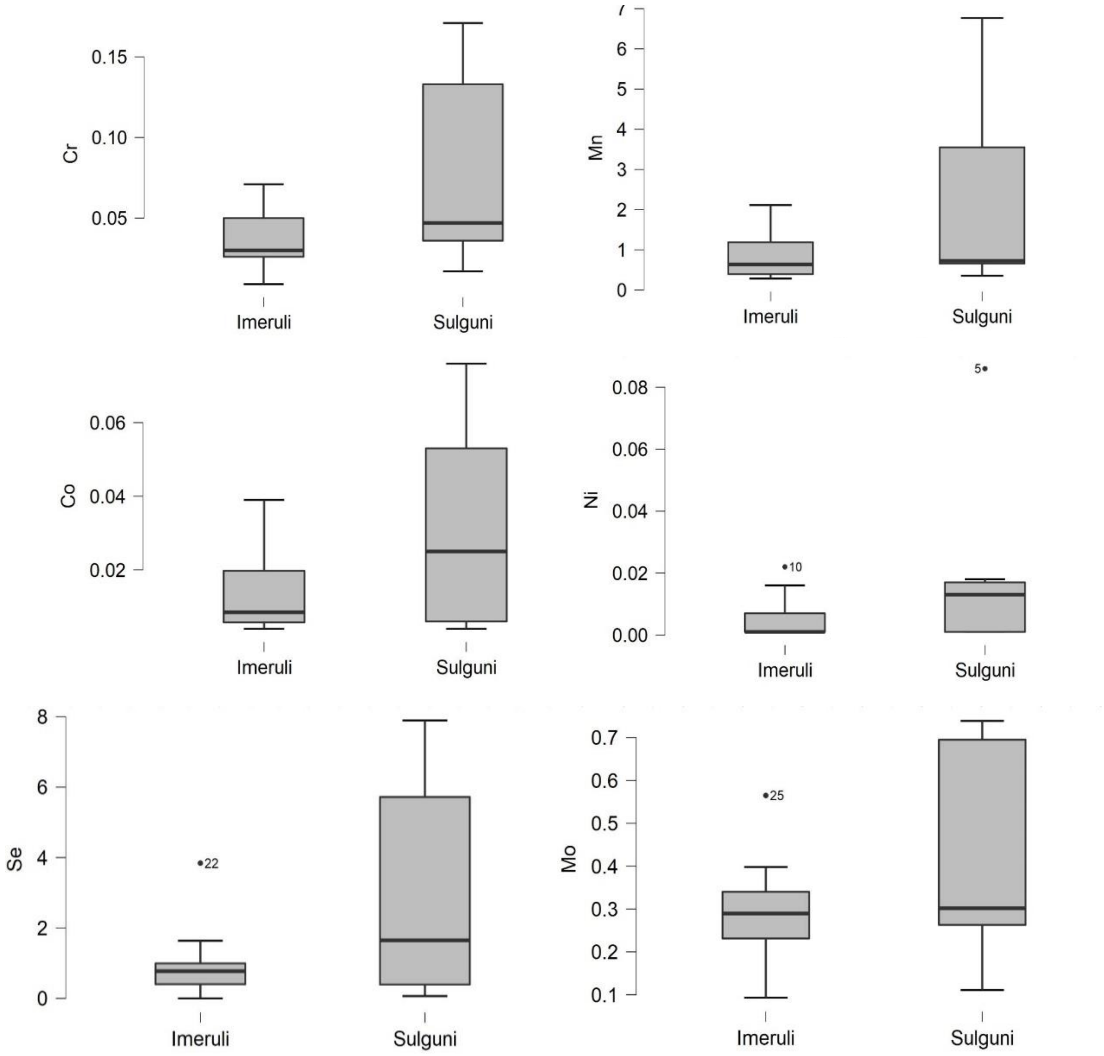

Figure 5. The Cr, Mn, Co, Ni, Se and Mo content of Imeruli and Sulguni cheese samples (mg/kg wet weight).

Environmental pollution, especially human-induced pollution, is one of the most significant factors in the occurrence of many trace and toxic elements, along with the phenomena of interelement interactions. For this reason, the data available differs from the permissible limit for these elements to be present in milk and milk products [82].

The selenium concentration in milk varies according to the natural soil content of Se or by geographical location. Selenium is present in soil inorganic salts, where plants absorb these salts, convert them into organic forms of the element (mostly as selenomethionine), and then incorporate them into proteins. In this way, selenium enters the food chain, as dependent mainly on the properties of the soil. There are several reasons for increases of this element in milk, for example, cattle feed supplementation with organic forms of Se (such as selenomethionine [64,83–87], or from the application of inorganic forms of selenium parenterally [88,89]).

The concentration of selenium in all milk samples in this study (Table 1) did not exceed the permissible limit compared with the European Food Safety Authority (0.5 mg/kg) [71]. Compared with other literature sources, the content of Se in the raw milk samples was lower than the values reported by Hermansen et al. (0.0223 mg L^{-1}) [90] and Hurle (0.04 mg L^{-1}) [67].

As for the Se in the cheese samples, Table 2 shows that both types of cheese, Imeruli and Sulguni, exceeded the limit of Se in the literature 1.003 and 3.06 mg/kg wet weight, respectively. The proportion found in Sulguni cheese was higher than in Imeruli cheese because more milk is needed for this type of cheese.

In addition, the results in Tables 1 and 2 show manganese levels in milk and cheese. Due to the lack of studies on manganese in milk and cheese, these results are compared with several pieces of literature. According to Knowles et al. [64], the manganese concentration in the milk must be between 0.02 and 0.05 mg L^{-1}. Milk samples in 7 villages were within this limit, except for Chapala and Vanati, where they exceeded the permissible limit of 0,075, 0,079 mg $L^{-1,}$ respectively.

In comparison to the permissible limit according to Flynn and Hurley [63,67] (0.03, 0.02 mg L^{-1}), the milk samples in this study have exceeded these limits. As for the cheese samples of Imeruli and Sulguni, we find that Mn in all samples exceeded the permissible limit compared to Knowles, Flynn and Hurley [63,64,67]. Additionally, compared to other countries such as Poland, the permitted limit for manganese was 0.102 mg L^{-1} [89], as the samples in this study did not exceed this limit except for Sulguni cheese 2,348 mg/kg wet weight.

The amount of manganese in high doses seriously affects human health. It leads to emotional and mental disturbances (lack of coordination and muscle stiffness) and causes impairment of neuromuscular and neurological control [90]. The consumption of milk that contains high doses of manganese that have exceeded permissible limits leads to congenital disabilities, impaired bone development and causes impairment in male fertility. The brain is also very sensitive to an overabundance of manganese, and it is particularly vulnerable to this excess [90].

As the results showed in Table 1, the amount of Chromium and Molybdenum in raw milk was, according to Flynn [63], less than the permissible limit (0.02, 0.05 mg L^{-1}), respectively. Likewise, according to Hurley [67], the ratio of these two components in this study did not exceed the permissible limit (0.015, 0.07 mg L^{-1}).

As for the Cr and Mo analysis results in cheese samples, Table 2 shows that Chromium and Molybdenum exceeded the permissible limit in Imeruli and Sulguni cheeses (0.035, 0,079 mg/kg), (0.289, 0.401 mg/kg), respectively. However, according to Qin et al., [91], the permissible amount of chromium should not exceed 0.3 mg/kg.

Molybdenum and Chromium are essential trace elements, where molybdenum enters in a cofactor (molybdopterin) for some enzymes, which stimulates oxidation and reduction reactions. There are no sufficient studies or information that show toxicity or

problems caused by an excess of Chromium beyond the permissible limit, as most of the experiments are based on animals [92,93]. Chromium is considered non-toxic if taken orally in a normal proportion, as it becomes 100% reduced in the gut. However, high doses of chromium, especially when exposed through the respiratory system, may cause sinonasal cancer [94].

As for nickel, its concentration was lower than the permissible limit in milk and cheese (0.027 mg L^{-1}) [63,67]. An excess of Ni over the permissible limit may lead to neurotoxicity, impairment of the male reproductive system [95,96] and oxidative stress [97].

Increased content of cobalt was found in Imeruli and Sulguni cheese samples (0.013, 0.03 mg/kg/ wet weight), While its concentration in milk was less than the permissible limit (0.006 mg L^{-1}) [63,66,67]. The increase of cobalt in milk and cheese is directly related to the characteristics of the metabolic processes in a cows' body, where some metals (such as cobalt) can be transferred directly from the blood into the milk. Cobalt is considered to have a toxic effect if it is consumed at higher than the permissible limit. It may cause central nervous system dysfunction, thyroid disorder and polycythemia [66,98,99].

3.3. The Differences in the Presence of Minerals and Trace Elements in Cheese and Milk

A *t*-test was used to compare the trace element content of Imeruli and Sulguni cheese (see Table 3, Tabel A1). The *t*-test showed a strong significant difference in the content of Imeruli cheese and Sulguni cheese for chromium and selenium. The presence of each of these two elements was higher in Sulguni cheese than in Imeruli cheese, (**Cr**: Mean $_{Imeruli}$= 0.035, Mean $_{Sulguni}$= 0.079, t= 2.902, $p < 0.01$), (**Se**: Mean $_{Imeruli}$ = 0.878, Mean $_{Sulguni}$ = 3.06, t= 2.627, $p < 0.01$).

According to Cohen's d [100], this effect appears significantly (Cohen's d $_{Cr}$ = 1.209, Cohen's d $_{Se}$ = 1.095) and suggests a large effect size of the relevant test.

Table 3. Independent Samples *t*-Test of the trace elements in Sulguni and Imeruli cheese.

	t	df	p	VS-MPR *	Mean Difference	SE (Mean Difference)	Effect Size (Cohen's d)
Cr	2.902	23	0.004	16.591	0.044	0.015	1.209
Mn	2.468	23	0.011	7.566	1.461	0.592	1.028
Fe	1.024	23	0.158	1.261	32.030	31.290	-
Co	2.210	23	0.019	4.949	0.016	0.007	0.921
Ni	1.832	23	0.040	2.859	0.013	0.007	0.763
Cu	1.936	23	0.033	3.296	1.202	0.621	0.807
Zn	1.642	23	0.057	2.250	48.973	29.828	-
Se	2.627	23	0.008	9.990	2.182	0.830	1.095
Mo	1.574	23	0.065	2.080	0.112	0.071	-
Cd	1.489	23	0.075	1.893	0.002	0.001	-
Pb	2.229	23	0.018	5.103	0.137	0.062	0.929

For all tests, the alternative hypothesis specifies that group Imeruli is less than group Sulguni. Student's *t*-test. * Vovk-Sellke Maximum p -Ratio: Based on a two-sided p-value, the maximum possible odds in favour of H_1 over H_0. equals $1/(-e\ p \log(p))$ for $p \leq 0.37$ [101].

In addition, these differences appear in both cheese types for each of the following elements: (**Mn**: Mean $_{Imeruli}$ = 0.887, Mean $_{Sulguni}$ = 2.35, t = 2.468, p < 0.05), (**Pb**: Mean $_{Imeruli}$ = 0.122, Mean $_{Sulguni}$ = 0.259, t = 2.229, p < 0.05), (**Co**: Mean $_{Imeruli}$ = 0.014, Mean $_{Sulguni}$ = 0.030, t = 2.210, p < 0.05), (**Cu**: Mean $_{Imeruli}$ = 1.26, Mean $_{Sulguni}$ = 2.46, t = 1.936, p < 0.05), (**Ni**: Mean $_{Imeruli}$= 0.005, Mean $_{Sulguni}$ = 0.018, t= 1.832, p < 0.05). whereas Cohen's d suggests a large effect size of the relevant test [100]. (Cohen's d $_{Mn}$ = 1.028, Cohen's d $_{Pb}$ = 0.092, Cohen's d $_{Co}$ = 0.921, Cohen's d $_{Cu}$ = 0.807, Cohen's d $_{Ni}$ = 0.763).

Thus, these results show that the content of Sulguni cheese from Cr, Se, Mn, Pb, Co, Cu and Ni is higher than Imeruli cheese, which could be due to the use of Imeruli cheese as a basis for making Sulguni cheese or the different production methods [54–57].

On the other hand, Tables 4 and A2 shows the difference in the presence of trace elements in milk samples according to their presence in the areas of Mashavera and Khrami rivers. The t-test showed a strong significant difference for the presence of manganese and iron in the two rivers. The presence of these two elements in milk samples taken from the Mashavera River region was higher than in the samples taken from the Khrami River region. (**Fe**: Mean $_{Mashavera}$ = 2.493, Mean $_{Khrami}$ = 0.855, t = 4.118, p < 0.01), (**Mn**: Mean $_{Mashavera}$ = 0.053, Mean $_{Khrami}$ = 0.037, t = 2.876, p < 0.01).

Table 4. Independent Samples t-Test of the trace elements in milk according to the rivers.

	t	df	p	VS-MPR *	Mean Difference	SE Difference	Cohen's d
Cr	1.707	189	**0.045**	2.646	0.0006	0.0004	0.291
Mn	2.876	189	**0.002**	26.838	0.017	0.006	0.490
Fe	4.118	189	**<0.001**	1232.574	1.638	0.398	0.702
Co	1.383	189	0.084	1.767	0.002	0.001	-
Ni	0.770	189	0.221	1.103	0.0007	0.0009	-
Cu	2.007	189	**0.023**	4.225	0.085	0.042	0.342
Zn	1.226	189	0.111	1.509	0.336	0.274	-
Se	0.083	189	0.467	1.000	0.0002	0.003	-
Mo	-0.016	189	0.506	1.000	-0.0005	0.003	-
Cd	-0.206	189	0.582	1.000	-0.0003	0.0001	-
Pb	1.749	189	**0.041**	2.812	0.003	0.002	0.298

Note. For all tests, the alternative hypothesis specifies that group Khrami is less than group Mashavera. Student's t-test. * Vovk-Sellke Maximum p -Ratio: Based on a two-sided p -value, the maximum possible odds in favor of H_1 over H_0 equals $1/(-e\ p \log(p))$ for $p \leq 0.37$) [101].

Cohen's d value (Cohen's d $_{Fe}$ = 0.702, Cohen's d $_{Mn}$ = 0.490) suggests a large effect size of the relevant test [100].

The t-test (Table 4) also shows a significant difference between copper, lead and chromium in milk samples according to the rivers: (**Cu**: Mean $_{Mashavera}$ = 0.287, Mean $_{Khrami}$ = 0.202, t = 2.007, p < 0.05), (**Pb**: Mean $_{Mashavera}$ = 0.009, Mean $_{Khrami}$ = 0.006, t = 1.749, p < 0.05), (**Cr**: Mean $_{Mashavera}$ = 0.003, Mean $_{Khrami}$ = 0.003, t = 1.707, p < 0.05). Whereas Cohen's d suggests a large effect size of the relevant test [100]. (Cohen's d $_{Cu}$ = 0.342, Cohen's d $_{Pb}$ = 0.298, Cohen's d $_{Cr}$ = 0.291)

Therefore, these results show more trace elements in milk samples taken from the villages where the Mashavera River is located than the milk samples taken from the villages whose agriculture and irrigation depend on the Khrami River.

One explanation could be that mining companies are more present in the areas of the Mashavera River, as discussed in previous studies [34,36,39,41,42].

4. Conclusions

In conclusion, we hypothesized that milk and cheese samples would be contaminated above permissible limits because of soil and water pollution in areas contaminated with heavy metal from the mining industry in Georgia. The results showed that most of milk samples contained heavy metal below the permissible limit compared to the European Union and other literature. However, these results exclude lead from seven samples in each of the following villages: Kvemo Bolnisi, Bolnisi, Mitskineti and Ratawani, where the concentration of lead in some samples was higher than the permissible limits mentioned in the literature and compared to the concentrations stipulated by Georgian laws. The lead concentration in samples taken from these villages was below the permissible limit. As for copper, the amount in the villages of Sabereti and Vanati was above the permissible limits according to the European Union permissible limit.

The results remain the same until the milk is processed to make cheese. Most of these heavy metals exceeded the permissible limits (Cu: 1000 mg/kg ww, Zn: 5000 mg/kg ww, Cd: 0.2 mg/kg ww, Pb: 0.500 mg/kg ww. According to Georgian law, the presence of cadmium and lead was below the permissible limit but compared to the European Union and the other literature, their concentrations were above the permissible limits. As for lead, the results showed that both types of cheese exceeded the permissible limit (according to the European Union). Furthermore, the concentration of Pb in Sulguni cheese was higher than Imeruli cheese due to how this type of cheese is manufactured. As mentioned earlier, Imeruli cheese is used as the basis for making Sulguni cheese.

Copper concentration in cheese was below the permissible limit according to the Georgia laws. The presence of Co and Ni in cheese samples was also below the permissible limit compared to Cr, Co, Mn and Se, which exceeded these limits. The concentration of all these elements was higher in Sulguni cheese than in Imeruli cheese. Therefore, it is important to note that the presence of heavy metals in Sulguni cheese was high in all samples compared to Imeruli cheese, which could be the subject of future research to determine whether the cheese production causes this.

It is also worth noting that the permissible limits for lead, cadmium, zinc and copper, according to the laws stipulated in Georgia, are considered high when compared with the internationally permissible limits. As Georgia is currently seeking to enter the European Union, therefore following the standards EU regulation is a matter that must be changed, to reach European food safety standards.

This region is considered one of the most important regions in Georgia for smallholder dairy production. However, our results show that milk does not pose any serious health risks to consumers compared to cheese. Despite all this, periodic and regular monitoring of this region is vital and necessary to monitor the presence of heavy metals which might lead to adverse health effects such as immune deficiency.

Author Contributions: R.A.S., G.G., T.U. and A.P. conceived and designed the experiments; R.A.S. wrote the manuscript of the publication, A.P. supervised the working process, G.G. analyzed the

milk and cheese samples. All authors have read and agreed to the published version of the manuscript.

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Appendix A

Table A1. Descriptive statistic of the trace elements in Sulguni and Imeruli cheese.

Group Descriptives	Group	N	Mean	SD	SE
Cr	Imeruli	16.00	0.035	0.017	0.004
	Sulguni	9.00	0.079	0.057	0.019
Mn	Imeruli	16.00	0.887	0.595	0.149
	Sulguni	9.00	2.35	2.27	0.756
Fe	Imeruli	16.00	69.10	64.92	16.23
	Sulguni	9.00	101.13	91.17	30.39
Co	Imeruli	16.00	0.014	0.011	0.003
	Sulguni	9.00	0.030	0.026	0.009
Ni	Imeruli	16.00	0.005	0.007	0.002
	Sulguni	9.00	0.018	0.027	0.009
Cu	Imeruli	16.00	1.26	0.739	0.185
	Sulguni	9.00	2.46	2.32	0.772
Zn	Imeruli	16.00	75.86	52.53	13.13
	Sulguni	9.00	124.84	97.78	32.59
Se	Imeruli	16.00	0.878	0.906	0.227
	Sulguni	9.00	3.06	3.14	1048.00
Mo	Imeruli	16.00	0.290	0.111	0.028
	Sulguni	9.00	0.401	0.245	0.082
Cd	Imeruli	16.00	0.002	0.002	0.0004
	Sulguni	9.00	0.004	0.005	0.002
Pb	Imeruli	16.00	0.122	0.093	0.023
	Sulguni	9.00	0.259	0.215	0.072

Table A2. Descriptive statistic of the trace elements in milk according to the rivers.

	Group Descriptives				
	Group	**N**	**Mean**	**SD**	**SE**
Cr	Khrami	45	0.003	0.002	0.0003
	Mashavera	146	0.003	0.002	0.0002
Mn	Khrami	45	0.037	0.020	0.003
	Mashavera	146	0.053	0.037	0.003

	Group Descriptives				
	Group	**N**	**Mean**	**SD**	**SE**
Fe	Khrami	45	0.855	0.706	0.105
	Mashavera	146	2.493	2.634	0.218
Co	Khrami	45	0.002	0.003	0.0004
	Mashavera	146	0.004	0.008	0.0006
Ni	Khrami	45	0.005	0.004	0.0006
	Mashavera	146	0.006	0.006	0.0004
Cu	Khrami	45	0.202	0.269	0.040
	Mashavera	146	0.287	0.242	0.020
Zn	Khrami	45	3.024	1.194	0.178
	Mashavera	146	3.361	1.714	0.142
Se	Khrami	45	0.014	0.016	0.002
	Mashavera	146	0.015	0.017	0.001
Mo	Khrami	45	0.023	0.019	0.003
	Mashavera	146	0.023	0.019	0.002
Cd	Khrami	45	0.0003	0.001	0.0001
	Mashavera	146	0.0003	0.0007	0.0006
Pb	Khrami	45	0.006	0.007	0.001
	Mashavera	146	0.009	0.010	0.0008

Appendix B

Figure A1. Imeruli and Sulguni cheese, respectively (Source: https://georgianjournal.ge/georgian-cuisine/32138-georgia-among-top-10-countries-on-the-world-cheese-map.html, accessed date: 11 September 2021).

References

1. Licata, P.; Trombetta, D.; Cristani, M.; Giofre, F.; Martino, D.; Calo, M.; Naccari, F. Levels of "toxic" and "essential" metals in samples of bovine milk from various dairy farms in Calabria, Italy. *Environ. Int.* **2004**, *30*, 1–6.
2. Haryanto, B.; Suksmasari, T.; Wintergerst, E.; Maggini, S. Multivitamin supplementation supports immune function and ameliorates conditions triggered by reduced air quality. *Vitam. Min.* **2015**, *4*, 1–15.
3. Panter, K.E.; James, L.F. Natural plant toxicants in milk: A review. *J. Anim. Sci.* **1990**, *68*, 892–904.
4. FAO and UNEP. *Global Assessment of Soil Pollution—Summary for Policy Makers*; FAO: Rome, Italy, 2021; https://doi.org/10.4060/cb4827en.

5. Modabberi, S.; Tashakor, M.; Soltani, N.S.; Hursthouse, A.S. Potentially toxic elements in urban soils: Source apportionment and contamination assessment. *Environ. Monit. Assess.* **2018**, *190*, 1–18.
6. Ismail, A.; Riaz, M.; Akhtar, S.; Goodwill, J.E.; Sun, J. Heavy metals in milk: Global prevalence and health risk assessment. *Toxin Rev.* **2019**, *38*, 1–12.
7. Tavakoli-Hosseinabady, B.; Ziarati, P.; Ballali, E.; Umachandran, K. Detoxification of heavy metals from leafy edible vegetables by agricultural waste: Apricot pit shell. *J. Environ. Anal. Toxicol.* **2018**, *8*, 548.
8. Llobet, J.M.; Falco, G.; Casas, C.; Teixido, A.; Domingo, J.L. Concentrations of arsenic, cadmium, mercury, and lead in common foods and estimated daily intake by children, adolescents, adults, and seniors of Catalonia, Spain. *J. Agric. Food Chem.* **2003**, *51*, 838–842.
9. Hague, T.; Petroczi, A.; Andrews, P.L.; Barker, J.; Naughton, D.P. Determination of metal ion content of beverages and estimation of target hazard quotients: A comparative study. *Chem. Cent. J.* **2008**, *2*, 1–9.
10. Alimardan, M.; Ziarati, P.; Jafari Moghadam, R. Adsorption of heavy metal ions from contaminated soil by B. integerrima barberry. *Biomed. Pharmacol. J.* **2016**, *9*, 169–175.
11. Ziarati, P.; Moslehishad, M.; Mohammad-Makki, F.M. Novel adsorption method for contaminated water by wild endemic almond: Amygdalus scoparia. *Biosci. Biotechnol. Res. Asia* **2016**, *13*, 147–153.
12. Zwolak, A.; Sarzyńska, M.; Szpyrka, E.; Stawarczyk, K. Sources of soil pollution by heavy metals and their accumulation in vegetables: A review. *Water Air Soil Pollut.* **2019**, *230*, 1–9.
13. Faccia, M.; Gambacorta, G.; Quinto, M.; Di Luccia, A. Lead and cadmium in some milk and milk-based mozzarella cheeses from Apulia, Italy. *Ital. J. Food Sci.* **2010**, *22*, 150.
14. Chary, N.S.; Kamala, C.T.; Raj, D.S. Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. *Ecotoxicol. Environ. Saf.* **2008**, *69*, 513–524, https://doi.org/10.1016/j.ecoenv.2007.04.013.
15. Maas, S.; Lucot, E.; Gimbert, F.; Crini, N.; Badot, P.M. Trace metals in raw cows' milk and assessment of transfer to Comté cheese. *Food Chem.* **2011**, *129*, 7–12.
16. Joint, W.H.O.; World Health Organization. *Health Risks of Heavy Metals from Long-Range Transboundary Air Pollution (No. EUR/06/5067592)*; WHO Regional Office for Europe: Copenhagen, Denmark, 2007.
17. Lahiji, F.A.S.; Ziarati, P.; Jafarpour, A. Potential of Rice Husk Biosorption in Reduction of Heavy Metals from Oryza sativa Rice. *Biosci. Biotechnol. Res. Asia* **2016**, *13*, 2231–2237.
18. Razafsha, A.; Ziarati, P. Removal of heavy metals from Oryza sativa rice by sour lemon peel as bio-sorbent. *Biomed. Pharmacol. J.* **2016**, *9*, 543–553.
19. Motaghi, M.; Ziarati, P. Adsorptive removal of cadmium and lead from oryza sativa rice by banana peel as bio-sorbent. *Biomed. Pharmacol. J.* **2016**, *9*, 739–749.
20. Ziarati, P.; Alaedini, S. The phytoremediation technique for cleaning up contaminated soil by Amaranthus sp. *J. Environ. Anal. Toxicol.* **2014**, *4*, 2161–0525.
21. Gholizadeh, E.; Ziarati, P. Remediation of contaminated rice farmlands soil and Oryza sativa rice product by apple pomace as adsorbent. *Biosci. Biotechnol. Res. Asia* **2016**, *13*, 2245.
22. Leontopoulos, S.; Svarnas, C. Transfer of heavy metal contaminants from animal feed to animal products. *J. Agric. Sci. Technol. A* **2012**, *2*, 149–154.
23. Ogundiran, M.B.; Ogundele, D.T.; Afolayan, P.G.; Osibanjo, O. Heavy metals levels in forage grasses, leachate and lactating cows reared around lead slag dumpsites in Nigeria. *Int. J. Environ. Res.* **2012**, *6*, 695–702.
24. Zhou, X. Heavy Metals in Chinese Raw Cow Milk: Spatial Distribution and Relationships with Silage and Environmental Factors. Ph.D. Thesis, Université de Liège, Liège, Belgique.
25. Amer, A. Effect of processing of some dairy products on levels of some. In Proceedings of the The second international congress of food Hygiene and Human Health, Assiut, Egypt, 21–23 October 2003; pp. 15–31. Available online: https://www.researchgate.net/publication/312332697_EFFECT_OF_PROCESSING_OF_SOME_DAIRY_PRODUCTS_ON_LEVELS_OF_SOME_HEAVY_METALS (accessed on 3 April 2021).
26. Wouters, A.P.; van der Lee, J. Smallholder Dairy Development-drivers, trends and opportunities. In Proceedings of theAgriProFocus-Heifer Learning Event "Dairy and development: Dilemmas of scaling-up", Veessen, Netherlands, July 2009: 1-10.
27. FAO. *Agribusiness Handbook: Milk/Dairy Products*; Publisher: FAO, Rome, Italy 2009; p. 65. Available online: http://www.eastagri.org/publications/detail.php?id=36 (accessed on 14 June 2021).
28. Hemme, T.; Otte, J. *Status and Prospects for Smallholder Milk Production: A global Perspective*; Food and Agriculture Organization of the United Nations (FAO), Rome, Italy, 2010.
29. Korakhashvili, A.; Jeiranashvili, G. Food safety hazards in Georgian Tushuri Guda cheese. *Ann. Agrar. Sci.* **2016**, *14*, 212–216.

30. Swiss Agency for Development and Cooperation (SDC). Meat and Cheese are Kvemo Kartli's Future, Project Factsheet, Georgia September 2013. Available online: https://www.eda.admin.ch/dam/countries/countries-content/georgia/en/archive/resource_en_225775.pdf (accessed on 10 September 2021).
31. ALCP. *National Cheese Sector Research*; Swiss Agency for Development and Cooperation SDC: Bern, Switzerland, 2016.
32. Shields, D.A. Dairy pricing issues. *Congr. Res. Serv. November 6* **2009**, 40903. Available online: https://28xeuf2otxva18q7lx1uemec-wpengine.netdna-ssl.com/wp-content/uploads/assets/crs/R40903.pdf (accessed on 10 September 2021).
33. Lomsadze, Z.; Makharadze, K.; Pirtskhalava, R. The ecological problems of rivers of Georgia (the Caspian Sea basin). *Ann. Agrar. Sci.* **2016**, *14*, 237–242.
34. Avkopashvili, G.; Avkopashvili, M.; Gongadze, A.; Tsulukidze, M.; Shengelia, E. Determination of Cu, Zn and Cd in soil, water and food products in the vicinity of RMG gold and copper mine, Kazreti, Georgia. *Ann. Agrar. Sci.* **2017**, *15*, 269–272.
35. Banerjee, D.; Kuila, P.; Ganguli, A.; Das, D.; Mukherjee, S.; Ray, L. Heavy metal contamination in vegetables collected from market sites of Kolkata, India. *Electron. J. Environ. Agric. Food Chem.* **2011**, *10*, 2160–2165.
36. Withanachchi, S.S.; Ghambashidze, G.; Kunchulia, I.; Urushadze, T.; Ploeger, A. A paradigm shift in water quality governance in a transitional context: A critical study about the empowerment of local governance in Georgia. *Water* **2018**, *10*, 98.
37. Matchavariani, L.; Kalandadze, B.; Lagidze, L.; Gokhelashvili, N.; Sulkhanishvili, N.; Paichadze, N.; Dvalashvili, G. Soil quality changes in response to their pollution by heavy metals, Georgia. *J. Environ. Biol.* **2015**, *36*, 85.
38. Agenda Mining Resumes at Controversial Sakdrisi Gold Mine. 2014. Available online: https://agenda.ge/en/news/2014/2863. (accessed on 3 April 2021).
39. Withanachchi, S.S.; Kunchulia, I.; Ghambashidze, G.; Al Sidawi, R.; Urushadze, T.; Ploeger, A. Farmers' perception of water quality and risks in the Mashavera River Basin, Georgia: Analyzing the vulnerability of the social-ecological system through community perceptions. *Sustainability* **2018**, *10*, 3062.
40. Avkopashvili, G.; Gongadze, A.; Gakhokidze, R.; Avkopashvili, M. (2015, May). Phytoremediation of contaminated soils, contaminated with heavy metals from gold mine in Georgia. In International Conference Applied Ecology: Problems, Innovations. Proceedings. Tbilisi, Georgia (pp. 154-157).
41. Avkopashvili, G.; Avkopashvili, M.; Gongadze, A.; Gakhokidze, R. Eco-Monitoring of Georgia's Contaminated Soil and Water with Heavy Metals. *Carpathian J. Earth Environ. Sci.* **2017**, *12*, 595–604.
42. Matchavariani, L.; Kalandadze, B. Pollution of soils by heavy metals from irrigation near mining region of Georgia. *Forum Geografic* **2012**, *XI*, 127–136.
43. Felix-Henningsen, P.; Urushadze, T.F.; Narimanidze, E.I.; Wichmann, L.C.; Steffens, D.; Kalandadze, B.B. Heavy metal pollution of soils and food crops due to mining wastes in the Mashavera River Valley. *Bull. Georg. Natl. Acad. Sci*. **2007**, *175*, 35–49.
44. Tsivtsivadze, N.; Matchavariani, L.; Lagidze, L.; Paichadze, N.; Motsonelidze, N. Problem of surface water ecology in georgia. In *Environment and Ecology in the Mediterranean Region II*; Cambridge Scholars Publishing: Cambridge, UK, 2014; pp. 283–294.
45. Melikadze, G. Monitoring and Spatial-Time Modelling of Groundwater on Territories of Georgia for Solving Ecological and Seismic Problems. Ph.D. Thesis, Tbilisi State University, Tbilisi, Georgia, 2006. (In Georgian)
46. Asanidze, L.; Avkopashvili, G.; Tsikarishvili, K.; Lezhava, Z.; Chikhradze, N.; Avkopashvili, M.; Chartolani, G. Geoecological monitoring of Karst water in the Racha Limestone Massif (Country of Georgia). *Open J. Geol.* **2017**, *7*, 822–829.
47. Tsikaridze, N.; Avkopashvili, G.; Kazaishvili, K.H.; Avkopashvili, M.; Gognadze, A.; Samkharadze, Z. *Kvemo Kartli Manufacturing Mining Pollution Analysis in Green Politics Context*; Green Policy Public Platform: Tbilisi, Georgia, 2017. (In Georgian)
48. Ellison, S.L.R.; Williams, A. Eurachem/CITAC Guide: Quantifying Uncertainty in Analytical Measurement. Available online: www.eurachem.org (accessed on: 10 September 2021).
49. Górecka, H.; Górecki, J.; Dobrzański, Z. An application of plasma spectrometry ICP-OES and ICP-MS for metal content analysis in biological and environmental samples. *Chem. Agric.* **2001**, *2*, 359.
50. IDF Standard. Metal contamination in milk and milk products. In *International Dairy Federation Bulletin*; The International Dairy Federation: Schaerbeek, Belgium, 1979.
51. Ministry of Labour and Health; Social Affairs of Georgia. *Order of Minister of Labour, Health, and Social Affairs of Georgia—On Approval of the Norms of the Quality of Environment 297/N*.; Ministry of Labour and Health, Tbilisi, Georgia, 2001.
52. Codex Alimentarius Commission. Joint FAO/WHO food standards programme. In Proceedings of the Codex Committee on Methods of Analysis And Sampling, Twenty-Eighth Session, Budapest, Hungary, 5–9 March 2007.
53. European Commission. *Commission Regulation 2006/1881/EC of 19 December 2006 Replacing Regulation (EC)466/2001 Setting Maximum Levels for Certain Contaminants in Foodstuffs*; European Commission: 2006.

54. Cheese Story. Alliances Caucasus Programme (Alcp). 2018. Available online: http://alcp.ge/index.php?cat=3&news=18 (accessed on 3 July 2021).
55. Field Mission Report 10–15 December 2017, Georgia. Available online: http://eastagri.org/docs/group/476/Field%20mission%20report%2010-15%20December%202017.pdf (accessed on 3 July 2021).
56. The lost cheese of Georgia, David Farley 2019–03–19. Available online: http://dfarley.com/uploads/3/5/8/1/35811128/savvsp19_georgia_fordavid.pdf (accessed on 3 July 2021).
57. A Guide to Georgian Dairy Products Available online: https://folkways.today/georgian-dairy-products/ (accessed on 3 July 2021).
58. Codex Alimentarius. *Codex General Standard for Contaminants and Toxins in Food and Feed*; codex Standard 193–1995, Adopted 1995. Revised 1997, *2006*, 2008, 2009. Amended 2010, 2012; Codex Secretariat: Rome, Italy, 1995.
59. Zhuang, P.; McBride, M.B.; Xia, H.; Li, N.; Li, Z. Health risk from heavy metals via consumption of food crops in the vicinity of Dabaoshan mine, south China. *Sci. Total. Environ*. **2009**, *407*, 1551–1561.
60. Zhu, F; Fan, W.; Wang, X.; Qu, L.; Yao, S. Health risk assessment of eight heavy metals in nine varieties of edible vegetable oils consumed in China. *Food Chem. Toxicol.* **2011**, *49*, 3081–3085.
61. Eleboudy, A.A.; Amer, A.A.; Abo El-Makarem, H.S.; Hadour, H.; Abo, H. Heavy Metals Residues in Some Dairy Products. *Alex. J. Vet. Sci.* **2016**, *51*, 334–346.
62. Özcan, M.M.; Juhaimi, F.Y.A. Determination of heavy metals in bee honey with connected and not connected metal wires using inductively coupled plasma atomic emission spectrometry (ICP–AES). *Environ. Monit. Assess.* **2012**, *184*, 2373–2375.
63. Flynn, A. Minerals and trace elements in milk. *Adv. Food Nutr. Res.* **1992**, *36*, 209–252.
64. Knowles, S.O.; Grace, N.D.; Knight, T.W.; McNabb, W.C.; Lee, J. Reasons and means for manipulating the micronutrient composition of milk from grazing dairy cattle. *Anim. Feed. Sci. Technol.* **2006**, *131*, 154–167.
65. Storelli, M.M.; Barone, G.; Garofalo, R.; Marcotrigiano, G.O. Metals and organochlorine compounds in eel (Anguilla anguilla) from the Lesina lagoon, Adriatic Sea (Italy). *Food Chem.* **2007**, *100*, 1337–1341.
66. Safonov, V. Assessment of Heavy Metals in Milk Produced by Black-and-White Holstein Cows from Moscow. *Curr. Res. Nutr. Food Sci. J.* **2020**, *8*, 410–415.
67. Hurleyw, L. Lactation biology. In *Minerals and Vitamins*; Univ, U., Ed.; Univ. Urbana: Champaign, IL USA, 1997.
68. European Commission (EC). Setting maximum levels for certain contaminants in food stuffs. *Off. J. Eur. Communities* **2001**, *77*, 1–75.
69. World Health Organization; *Trace Elements in Human Nutrition and Health*; Geneva, Switzerland, 1996; p. 78.
70. Pechovà, A.; Pavlata, L.; Dvořàk, R.; Lokajovà, E. Contents of Zn, Cu, Mn and Se in Milk in Relation to their Concentrations in Blood, Milk Yield and Stage of Lactation in Dairy Cattle. *Acta Vet. Brno. Czech Repub.* **2008**, *77*, 523–53.
71. EFSA—European Food Safety Authority. Scientific opinion on the safety and efficacy of Sel Plex (organic form of selenium produced by Saccharomyces cerevisiae CNCM I-3060) for all species. *EFSA J.* **2011**, *9*, 2110.
72. Ghosh, J.; Sil, P.C. Mechanism for arsenic induced toxic effects. *Handb. Arsen. Toxicol*. **2015**, 203–231, doi:10.1016/B978-0-12-418688-0.00008-3.
73. Moreno-Rojas, R.; Sánchez-Segarra, P.J.; Cámara-Martos, F.; Amaro-López, M.A. Heavy metal levels in Spanish cheeses: Influence of manufacturing conditions. *Food Addit. Contam.* **2010**, *3*, 90–100.
74. Duffus, J.H. "Heavy metals" a meaningless term?(IUPAC Technical Report*). Pure Appl. Chem.* **2002**, *74*, 793–807.
75. Meshref, A.M.S.; Moselhy, W.A.; El-Houda, N.; Hassan, Y. Heavy metals and trace elements levels in milk and milk products. *J. Food MeasCharact* **2014**, *8*, 381–388, doi:10.1007/s11694-014-9203-6.
76. Vahcic, N.; Hruskar, M.; Markovic, K.; Banovic, M.; Baric, I.C. Essential minerals in milk and their daily intake through milk consumption .*Mljekarstvo* **2010**, *60*, 77–85.
77. Turnlund, J.R.; Jacob, R.A.; Keen, C.L.; Strain, J.J.; Kelley, D.S.; Domek, J.M.; Coulter, J. Long-term high copper intake: Effects on indexes of copper status, antioxidant status, and immune function in young men. *Am. J. Clin. Nutr.* **2004**, *79*, 1037–1044.
78. Barn, P.; Nicol, A.M.; Struck, S.; Dosanjh, S.; Li, R.; Kosatsky, T. Investigating elevated copper and lead levels in school drinking water. *Environ. Health Rev.* **2014**, *56*, 96–102.
79. EFSA (European Food Safety Authority). Scientific Opinion on nutrient requirements and dietary intakes of infants and young children in the European Union. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). *Eur. Food Saf. Auth. (EFSA) Parma Italy EFSA J.* **2013**, *11*, 3408.
80. EFSA (European Food Safety Authority). Opinion of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission related to the Tolerable Upper Intake Level of iron. *EFSA J.* **2004**, *125*, 1–34, doi:10.2903/j.efsa.2004.125.

81. Gemechu, T.; Beyene, F.; Eshetu, M. Physical and chemical quality of raw cow's milk produced and marketed in Shashemene Town, Southern Ethiopia. *J. Food Agric. Sci*. **2012**, *5*, 7–13.
82. Dobrzanski, Z.; Kolacz, R.; Górecka, H.; Chojnacka, K.; Bartkowiak, A. The content of microelements and trace elements in raw milk from cows in the Silesian region. *Pol. J. Environ. Stud.* **2005**, *14*, 685.
83. Muñiz-Naveiro, Ó.; Domínguez-González, R.; Bermejo-Barrera, A.; Bermejo-Barrera, P.; Cocho, J.A.; Fraga, J.M. Study of the bioavailability of selenium in cows' milk after a supplementation of cow feed with different forms of selenium. *Anal. Bioanal. Chem.* **2006**, *385*, 189–196.
84. Givens, D.I.; Allison, R.; Cottrill, B.; Blake, J.S. Enhancing the selenium content of bovine milk through alteration of the form and concentration of selenium in the diet of the dairy cow. *J. Sci. Food Agric.* **2004**, *84*, 811–817.
85. Heard, J.W.; Walker, G.P.; Royle, P.J.; McIntosh, G.H.; Doyle, P.T. Effects of short-term supplementation with selenised yeast on milk production and composition of lactating cows. *Aust. J. Dairy Technol.* **2004**, *59*, 199.
86. Juniper, D.T.; Phipps, R.H.; Jones, A.K.; Bertin, G. Selenium supplementation of lactating dairy cows: Effect on selenium concentration in blood, milk, urine, and feces. *J. Dairy Sci.* **2006**, *89*, 3544–3551.
87. Schöne, F.; Steinhöfel, O.; Weigel, K.; Bergmann, H.; Dunkel, S.; Kirmse, R.; Leiterer, M. Selenium in feedstuffs and rations for dairy cows including a view of the food chain up to the consumer. *J. Für Verbrauch. Und Lebensm.* **2013**, *8*, 271–280.
88. Grace, N.D.; Lee, J.; Mills, R.A.; Death, A.F. Influence of Se status on milk Se concentrations in dairy cows. *N. Z. J. Agric. Res.* **1997**, *40*, 75–78.
89. Malbe, M., Otstavel, T., Kodis, I., & Viitak, A. (2010). Content of selected micro and macro elements in dairy cows' milk in Estonia. Agronomy Research, 8(11), 323-326.Santamaria, A.B. Manganese exposure, essentiality and toxicity. *Indian J. Med. Res.* **2008**, *128*, 484–500.
90. Qin, L.Q.; Wang, X.P.; Li, W.; Tong, X.; Tong, W.J. The minerals and heavy metals on cow's milk from China and Japan. *J. Health Sci.* **2009**, *55*, 300–305.
91. European Food Safety Authority. Scientific opinion on dietary reference values for molybdenum. *EFSA J.* **2013**, *11*, 3333, https //doi.org/10.2903/j.efsa.2013.3333.
92. Gimou, M.M.; Pouillot, R.; Charrondiere, U.R.; Noël, L.; Guérin, T.; Leblanc, J.C. Dietary exposure and health risk assessment for 14 toxic and essential trace elements in Yaoundé: The Cameroonian total diet study. *Food Addit. Contam. Part A* **2014**, *31*, 1064–1080.
93. Shekhawat, K.; Chatterjee, S.; Joshi, B. Chromium toxicity and its health hazards. *Int. J. Adv. Res.* **2015**, *3*, 167–172.
94. Beckett, W.S.; Nordberg, G.F.; Clarkson, T.W. *Routes of Exposure, Dose and Metabolism of Metals: Handbook on the Toxicology of Metals*, 3rd ed.; Elsevier B.V.: Amsterdam, The Netherland, 2007.
95. Das, K.K.; Das, S.N.; Dhundasi, S.A. Nickel, its adverse health effects oxidative stress. *Indian J. Med. Res.* **2008**, *128*, 412.
96. Doreswamy, K.; Shrilatha, B.; Rajeshkumar, T. Nickel-induced oxidative stress in testis of mice: Evidence of DNA damage and genotoxic effects. *J. Androl.* **2004**, *25*, 996–1003.
97. Pšenková, M.; Toman, R.; Tančin, V. Concentrations of toxic metals and essential elements in raw cow milk from areas with potentially undisturbed and highly disturbed environment in Slovakia. *Environ. Sci. Pollut. Res.* **2020**, *27*, 26763–26772.
98. Filippini, T.; Tancredi, S.; Malagoli, C.; Malavolti, M.; Bargellini, A.; Vescovi, L.; Nicolini, F.; Vinceti, M. Dietary estimated intake of trace elements: Risk assessment in an Italian Population. *Expo. Health* **2019**, *12*, 1–15.
99. Cohen, J. Quantitative methods in psychology: A power primer. *Psychol. Bull.* **1992**, *112*, 155–159.
100. Sellke, T.; Bayarri, M.J.; Berger, J.O. Calibration of ϱ values for testing precise null hypotheses. *Am. Stat.* **2001**, 55, 62–71.

Chapter 5 General Discussion

The dairy value chain in Georgia is one of the essential pillars of the country's economy and one of the biggest challenges facing Georgia. The presence of other factors impeding the development of this chain, such as heavy metal pollution, and the existence of a gap between the elements that make up this chain, will negatively affect the local economy of Georgia and diminish efforts to achieve a sustainable dairy value chain. Therefore, it is necessary to understand the needs of each element of the chain, starting with smallholders, owners of large factories, private companies, and international organizations, all the way to government agencies and state institutions in all their sectors. All of this helps identify the problems and challenges facing the dairy value chain development and identify the chain's weaknesses.

5.1. Georgian dairy value chain

Our study aims to delve into the dairy value chain in Georgia and know what factors have affected it since the collapse of the Soviet Union. A few studies have been done with dairy and cheese production in Georgia in particular, without addressing the importance of the other elements in the chain. Therefore, this work is the first research to investigate into the matter and harmony of the aspects of the chain as a single block and to look at the problems and obstacles that prevent the development and sustainability of the chain.

This work investigated the factors and obstacles surrounding the dairy value chain in two directions. First, an in-depth study of the literature has been done to address each of these factors. The study sheds light on the economic status of the dairy value chain before and after the collapse of the Soviet Union, through the civil war, and up to the present day. The importance of this research lies in analysing the sequence of these stages and the evolution of the obstacles facing the chain.

Many studies focused on the privatization of pasture lands in the Soviet Union and how this system was no longer applied later [1–8]. However, it was revealed in this study that the Georgian economy, especially the agricultural economy, has undergone radical changes, which have been able to change the concepts of the pre-Soviet Union period, and to contemporary all the developments that occurred in it [4,9,10]. Also, the economic plans have become more sustainable and continuously attempt to keep pace and apply international standards [4,9–12].

On the other hand, the in-depth study of the literature showed the impact of cultural identity on the value chain of dairy production. Several studies show the importance of Georgian cuisine, its diversity, and how it is linked to the cultural identity of Georgia [13–15]. Still, the relationship between the Georgian cultural identity and the dairy value chain was monitored in this research through our visits to smallholder farmers on the ground, and the questionnaire that was

conducted with them It is a significant and essential part of the development of this chain, especially that the smallholder farmers are the guardians of this food heritage in the chain. And in particular, some types of Georgian cheese, which cultural history goes back more than 80 centuries [16–20]. This study also showed, in particular, the extent to which the social factor is interconnected with the other elements of the chain, especially concerning smallholders' farmers, and the problems they face are extensively examined. This research also demonstrates how the dairy value chain is interconnected with environmental standards and structuring and directing resources. Several studies have stated the importance of observing ecological standards in the agricultural sector and the policies to avoid environmental pollution in all its forms, especially heavy metals [21–26]. Our research links the importance of the environmental factor to the dairy value chain development intending to achieve sustainability. It links all the elements we mentioned earlier to the 17 United Nations Sustainable Development Goals. Clearly, it shows the extent to which these goals are interconnected with the chain elements.

The second part of this study was done by Face-to-Face interviews with experts from all chain sectors (governmental institutions, ministries, the private sector, international organizations, agricultural organizations). It was intended to have a clear understanding of the relationship between all elements of the dairy value chain on the one hand and the legislation stipulated in this regard on the other hand. Several studies have already been conducted interviewing experts in some fields. Still, these interviews could not include all the elements of the chain and analyze the opinion of the decision-makers in the Georgian dairy sector [27,28].. This allows us to compare the opinion of these experts with what is happening on the ground. So, this study was the first of its kind, which identified important factors of the value chain, and was intended to be a significant cornerstone for evaluating our other research on the dairy value chain in Georgia.

5.2. The role of dairy smallholder farmers

It is imperative to understand the role of smallholder farmers in Georgia and emphasize that they are the cornerstone of the Georgian economy. They are an integral part of all sustainability plans that Georgia seeks to implement in all fields. These farmer's roles now are not different from the essential role they played in the economic recovery stage, which began after the collapse of the Soviet Union. Thus, it is necessary to shed light on the current situation of farmers and implicitly to search for the problems and obstacles they face in their daily lives on the one hand and their positions within the framework of new economic plans and legislation on the other hand. Therefore, the current study aims to explore these problems and obstacles facing these farmers, know the depth of the gap between

them and the decision-makers in the state. Furthermore, to find their role in private sector investments and the national and local market.

Therefore, a questionnaire was conducted in 8 villages in the Kvemo Kartli region. This questionnaire was based on closed and open questions, which shed light on this research's critical and sensitive points.

Several studies have shown some of the problems that farmers suffer from in these areas, especially water pollution with heavy metals and the lack of water resources needed for farm animals and crops [21,26,27,29]. Many studies have also shown the role of small farmers in protecting agricultural culture, especially concerning the manufacture of traditional cheese, which dates back to dozens of years [17–20]. However, this study aimed to study all the elements that affect the positive advancement of the role of smallholder farmers. Besides their impact on the work and development of the dairy value chain on the one hand, and comparing the farmers' opinion and their current situation on the ground with the opinions of experts and their assessment of the current reality. Whereas, through this study, the living conditions of farmers and how the work of the dairy sector is carried out is verified.

This research also showed that farmers are not aware of the animal welfare issues and the international safety standards and regulations in milk production. The farmer does not have sufficient resources to develop their methods or keep pace with the development in the dairy sector. Also, they don't have enough money to purchase new equipment and modern technology, and there is no available means to receive advanced science and adequate education. This reflects negatively on the milk production process, which prevents the farmer from selling his products by legitimate means, as it does not comply with international and local standards. Therefore, it poses a threat to the local market, as it does not allow farmers to cover their sufficiency to secure the necessities of daily life.

Farmers use the pastures that the state provides free of charge to them and are located in areas contaminated with heavy metals, but the state sees that it gives the farmers great support. Still, the farmers do not have any other choice, as they do not have enough money to buy or grow fodder on their small lands. Therefore, even if the farmers know that these pastures are polluted, they are forced to use them. On the other hand, the experts stressed the need to adhere to international standards necessary for raw milk production compared to experts' opinions. Still, without taking into account, these are the fundamental problems that the farmer suffers from.

For example, experts believe that farmers must comply with the hygiene regulations in their barns and maintain animal's welfare, but some farmers do not have enough money to build barns that abide by the legitimate laws and cannot afford the cost of the appropriate space that the farm animals need. Therefore, this study showed the existence of a large gap between farmers ability and the demand from decision-makers. The situation is almost the same in the

private dairy sector. They are forced to implement the laws and legislation stipulated by the state (e.g. hygiene conditions) which causes investment but buying raw milk from smallholder farmers where the hygiene standards might be questionable. Hence, they resort to the big producers or import powdered milk from abroad and use it for their products such as yoghurt, cheese instead of raw milk. All of this affects the development of the dairy value chain in Georgia, which also negatively affects the local economy of Georgia. In addition, this gap between all parties of the chain may threaten food safety and food security in Georgia, impeding development and sustainability plans that the country is working on intensively.

5.3. Heavy metals contamination

Heavy metal pollution is considered one of the most dangerous types of environmental pollution that threatens food safety and the health of citizens [30–33]. The consumption of these elements leads to severe diseases, whether directly, such as drinking from a river contaminated with HM or inhaling these elements' fumes. Or indirectly, such as consuming plants and crops planted on soil contaminated with HM and irrigated from polluted rivers or consuming animal products raised in contaminated areas [34–39].

Heavy metals are very complex research. For example, numerous studies have delved into the dangers of heavy metals in food, whether in plants or animal products such as milk and cheese. Other studies have shown HM's complications and human health risks to which the consumer is exposed, whether he/she is a child or an adult [40–44].

Since heavy metal pollution is a subject of debate in Georgia, we focused on dairy products. As this doctoral research, to the knowledge of the authors, was the first to decide to go deeper into the examination of raw milk and homemade cheese from small farms in the Kvemo Kartli region. We wanted to find out the transfer of these toxic elements from water and plants, to raw milk, and finally to cheese made locally. This study relied on taking samples of milk from villages in which we conducted questionnaires with smallholder farmers to link all the factors affecting the value chain of dairy production. Still, to our knowledge, no study showed the contamination of raw milk and dairy products with these HMs for this region. The study showed that most milk samples were not contaminated, as only some showed a trim level of contamination that exceeded the international permissible limits.

Nevertheless, the cheese samples taken from the same villages were utterly different, as they indicated a high contamination rate for many of the studied elements. One would expect that depending on the cheesemaking process and the amount of milk used to produce one kg of cheese. Our research could show that Sulguni cheese is more contaminated with heavy metals than Imeruli cheese. Since seven liters of raw milk is enough to make Imeruli cheese, Sulguni cheese needs about 10 liters. Also, Imeruli cheese contains only a few ingredients, namely milk, salt, and rennet,

compared to Sulguni cheese, which needs milk, salt, rennet, whey, and cream. Farmers usually use Imeruli as the basis for making Sulguni cheese. Thus, we see that the consumption of Imeruli cheese is better than the other type, knowing that both contain heavy metals. Also, we found that the safety standards are not applied correctly in the farms. Which in turn prevents the chain from developing and endangering human health.

5.4 Scientific contribution

Our research aimed to a better understanding of the whole picture of the dairy value chain in Georgia. Through several questionnaires, theoretical studies, and laboratory analyses, we intended to identify each chain element and classify the existing obstacles and problems that have not been discussed before in the dairy sector.

Initially, this study showed the importance of the dairy value chain in Georgia and its essential role in the agricultural sector and the local economy. This study showed that the Georgian heritage and the inherited traditions that are still followed in most of the countryside in Georgia have a significant impact on the chain. Despite many new laws and regulations, which aim to develop the chain, they ignore many of the fundamental factors related to smallholder farmers. These traditions and social customs cannot be overlooked to find the necessary approaches for advancing the dairy sector. This study also showed that achieving balance in this chain, developing it and making it sustainable cannot be applied unless all elements are taken into consideration simultaneously.

This research had an important role in knowing the gap between smallholder farmers, political decision-makers, the private sector, and foreign companies. Farmers and political decision-makers have different opinions. Government agencies are interested in applying international standards and international food safety systems to enter the European Union by keeping pace with the laws, legislation, and standards regulation. Besides, the government has also stipulated new decisions and laws, that would include the 17 sustainable development goals (SDGs) in all current and future plans for all sectors of the state, but despite these positive moves to further advance the Georgian economy, all of this cannot be applied by ignoring the culture of these farmers, and trying to force them to implement laws and regulations that they cannot even understand the reason behind, due to their isolation from the political ground and their inability to access modern technology and advanced methods on the one hand, and the local market on the other.

Therefore, this research showed that achieving a sustainable dairy value chain can only be done by narrowing this gap between all the players of the chain, following several strategies to encourage the role of smallholder farmers in the

local economy, and applying legislation and laws designed to protect their heritage and traditions. All this will also positively affect the value chain's environmental factor, which is considered one of the most critical factors.

Protecting the environment and achieving animal welfare help reach the international food safety standards, which are effectively reflected in the chain. This study showed that the pollution of soil, plants, and water with heavy metals, which was mentioned in many studies, does not stop only at this point, as it poses an imminent danger to animals, directly threatening human health.

As far as we know, this was the first study that analysed milk and cheese samples from these contamination areas. The results showed that milk was contaminated only in very few places, especially in villages near the Mashvera River. But by comparing it with cheese samples, it was found that the two types of cheese showed contamination with these trace metals, which exceeded the allowed permissible limit. Farmers illegally sell their raw milk and homemade cheese without any control or safety standards because of their low financial returns and their attempt to get enough money to reach self-sufficiency. This is because the local market is not available to them because of the legislation on food safety standards, which they cannot afford. Therefore, it is necessary to note that all the elements of this chain are closely related to each other and must consider the factors affecting it. That allowed us to address all the problems and obstacles that have formed a considerable gap between these parties, achieve sustainability, and advance the Georgian economy to another stage.

5.5 Limitation

Although this study is the first of its kind in the field of the dairy value chain and analyzes samples of milk and cheese to detect any traces of heavy metals, this work lacks many aspects.

First of all, regarding the interviews with the experts, many of them refused to be interviewed. Some of them asked us to send them interview questions in advance and later apologized for the interview.

This made us suffer from many difficulties in covering the representatives of the economic system in the country, whether they are government agencies, the private sector, or international organizations. Therefore, it is essential in future research to expand the circle of interviews in Georgia and cover all specializations and establishments linked in one way or another with the dairy value chain.

On the other hand, we faced many other difficulties regarding the survey we conducted with smallholder farmers. At first, the researchers decided to survey nine villages instead of eight, but all farmers in the last village refused to take the interview. Despite that, we encountered many difficulties in conducting the survey. Some villages had farmers, not only Georgians but also Azerbaijanis. We faced many problems to convince them to take this survey, especially that we should only talk to men, even if they are not responsible for the milking process or the care of the cows. On the other hand, researchers believe it is important to expand the number of villages to include other regions of Georgia, facilitating comparisons and more accurately identifying and analysing problems and obstacles.

In the future, it is also necessary to carry out laboratory analyzes on a larger number and more types of cheese in particular and milk in general.

The presence of a larger number of samples increases the accuracy of the results. It also helps determine the level of heavy metals and know the causes of pollution through extensive analyses that may start from agricultural land and its water sources and end with the final product.

5.6. Implications

Based on the conclusions of our research, this sub-chapter has several implications for policy makers, smallholder farmers, private companies, and retailers.

Preserving the traditions of smallholder farmers and the cultural heritage of Georgia is a crucial point that clearly affects the local market. The results of this study indicated that the laws and legislations in the dairy sector do not take this point seriously.

Besides, the inability of smallholder farmers to keep pace with developments in the dairy sector locally and internationally is one of the main problems plaguing the chain. The presence of modern technology, and the ability of the farmer to access all the science and information related to raising livestock, will help the farmer to increase production, secure his income, and comply with all local and international safety standards. Thus, this helps both parties to play an active role in the development of the series.

Moreover, rural and village retailers are a major component affecting the development of the chain. Where these traders are the link between farmers, other traders and the consumer, however, the lack of strict laws clearly defining the role of these traders, and specifying requirements related to the dairy sector, may affect the development of the chain. The

import of powdered milk as an alternative to raw milk is also a major problem; Private companies use it because it is cheaper, constant availability, and compliance with international safety standards.

In addition to all this, the mining problem that started many years ago is considered one of the most important factors threatening the dairy value chain and the local economy. The presence and operation of these companies far from international safety standards posed a serious threat to the plants, soil and water of the entire region, resulting in heavy metal contamination. This adversely affects the dairy value chain.

Based on all of the above, taking serious steps in the following various factors may lead to positive developments on the dairy value chain and on the local economy:

- **The educational factor:** The government must immediately support educational plans and projects that help farms access modern science and raise the education rate among farmers. Such as conducting the necessary training courses to deal with modern devices and helping them understand the problems that the local market suffers from and the resulting damages that affect the Georgian economy.
- **The political factor:** government decisions and legislation must be in the interest of smallholder's farmers, by providing and securing the necessary financial support and loans for them. But there must be continuous supervision and periodic monitoring to ensure the validity of these action plans, and their development periodically.
- **The cultural and social factor:** The government should reconsider integrating the cultural identity and traditions of smallholder farmers with new laws and regulations. By taking their views and traditions seriously, to reach a common solution that preserves the cultural and historical identity of Georgia with regard to the dairy sector
- **Food safety factor**: The discrepancy between milk quality (hygienic standards and health standards) and small farmers is the cornerstone of maintaining food safety and implementing food safety standards. Which in turn protects the health of the consumer. Where farmers have to do more to keep barns and cows healthy and clean. Farmers must also observe the necessary health conditions when milking cows and storing milk, and they must follow the safety standards necessary for making cheese at home, which helps increase dependence on the production of these farmers. On the other hand, the government should ensure the necessary awareness through local media or local administrations in the countryside and villages. On the other hand, the government should set strict laws, limit the activities of mining companies, and force them to apply all international safety standards necessary to protect the local population on the one hand and stop the environmental pollution that occurs on the other.

References

1. Gvaramia, A. Land ownership and the development of the land market in Georgia; ALCP study: Tbilisi, Georgia, 2013.
2. Gelashvili, S., Deisadze, S., Difficulties of Implementing the Technical Regulation on Milk and Dairy Products; ISET Policy Institute: Tbilisi, Georgia, 2019.
3. Pignatti, N. Demographic Structure, Labor Market Conditions and Stalled Agricultural Development in a Post-Transition Country; Tbilisi State University (TSU): Tbilisi, 2017.
4. Lerman, Z., Csaki, C. and Feder, G., Agriculture in Transition: Land Policies and Evolving Farm Structures in Post-Soviet Countries; Lexington Books: Lanham, MD, USA, 2004; ISBN 0739108077.
5. EI-LAT, The economic transformation of Georgia in its 20 years of independence. Summary of the discussion paper; Liberal Academy—Tbilisi: Tbilisi, Georgia, 2012.
6. Bernabé, S. and Stampini, M. Labour Mobility During Transition. Evidence from Georgia. Econ. Transit. 2009, 17(2), 377–409.
7. GeoStat National Statistics Office of Georgia (GeoStat); Tbilisi, GA, USA, 2014. (https://www.geostat.ge/regions/#)
8. Terra Institute, Ltd., Georgia Land Market Development Project Final Report; Terra Institute, Ltd.: Blue Mounds, WI, USA, 2005; Available online: http://www.terrainstitute.org/pdf/Georgia_LMDP_Final_Report.pdf (accessed on 05 September 2021).
9. Zubiashvili, T., and Silagadze, L. Some aspects of the Georgian economy at the contemporary stage, Ecoforum, 2016, 5, 1–5.
10. Muehlfried, F. Sharing the same blood—culture and cuisine in the Republic of Georgia. Anthropol. Food 2008, S3, doi:10.4000/aof.2342.
11. FAO, Georgian Milk Producers Learn from Italy and the United States. Available online: http://www.fao.org/europe/news/detail-news/en/c/1100229/ (accessed on: 10 September 2021).
12. Neven, D., Developing Sustainable Food Value Chains; FAO Rome, Italy, 2014; 25; ISBN 9789251084816.
13. Muehlfried, F. Sharing the same blood—culture and cuisine in the Republic of Georgia. Anthropol. Food 2008, S3, doi:10.4000/aof.2342.
14. A Guide to Georgian Dairy Products Available online: https://folkways.today/georgian-dairy-products/. (Accessed on 3 September 2021).
15. FAO. Atlas of Origin Linked Food Products in Georgia; FAO: Rome, Italy, 2019.
16. Korakhashvili, A.; Jeiranashvili, G. Food safety hazards in Georgian Tushuri Guda cheese. Ann. Agrar. Sci. 2016, 14, 212–216, doi:10.1016/j.aasci.2016.08.005.
17. Swiss Agency for Development and Cooperation, Meat and Cheese are Kvemo Kartli' s Future; Swiss Agency for Development and Cooperation SDC, Commonwealth of Independent States: Bern, Swiss, 2013.
18. ALCP, National Cheese Sector Research; Swiss Agency for Development and Cooperation SDC: Bern, Swiss, 2016.
19. The lost cheese of Georgia, David Farley 2019-03-19, Available online: http://dfarley.com/uploads/3/5/8/1/35811128/savvsp19_georgia_fordavid.pdf (Accessed on 3 September 2021).
20. Cheese Story, Alliances Caucasus Programme (Alcp) 2018, Available online: http://alcp.ge/index.php?cat=3&news=18

(Accessed on 3 September 2021).

21. Avkopashvili, G.; Avkopashvili, M.; Gongadze, A.; Gakhokidze, R. Eco-Monitoring of Georgia's Contaminated Soil and Water with Heavy Metals. Carpathian J. Earth Environ. Sci. 2017, 12, 595–604.
22. Avkopashvili, G., Avkopashvili, M., Gongadze, A., Tsulukidze, M., & Shengelia, E. (2017). Determination of Cu, Zn and Cd in soil, water and food products in the vicinity of RMG gold and copper mine, Kazreti, Georgia. Annals of Agrarian Science, 15(2), 269-272.
23. Matchavariani, L., & Kalandadze, B. (2012, December). Pollution of soils by heavy metals from irrigation near mining region of Georgia. In Forum geografic (Vol. 11, No. 2, pp. 127-136).
24. Chartolani, G. (2017). Geoecological monitoring of Karst water in the Racha Limestone Massif (Country of Georgia). Open J Geol, 7, 822-829.

25. G. Avkopashvili, A. Gongadze, R. Gakhokidze, M. Avkopashvili, Phytoremediation of contaminated soils, contaminated with heavy metals from gold mine in Georgia, International Conference Applied Ecology: Problems, Innovations. Proceedings. Tbilisi, Georgia, 2015, pp 154-157, ISBN 978-9941-0-7644-2. (Accessed on 04 April 2021).

26. Lomsadze, Z., Makharadze, K., & Pirtskhalava, R. (2016). The ecological problems of rivers of Georgia (the Caspian Sea basin). Annals of agrarian science, 14(3), 237-242.

27. Withanachchi, S. S., Kunchulia, I., Ghambashidze, G., Al Sidawi, R., Urushadze, T., & Ploeger, A. (2018). Farmers' perception of water quality and risks in the Mashavera River Basin, Georgia: Analyzing the vulnerability of the social-ecological system through community perceptions. Sustainability, 10(9), 3062.

28. FAO. Survey Sheds Light on Georgian Farmer Attitudes toward Livestock Traceability. Available online: http://www.fao.org/georgia/news/detail- events/en/c/1073576/ (accessed on 02 September 2021).

29. Withanachchi, S. S., Ghambashidze, G., Kunchulia, I., Urushadze, T., & Ploeger, A. (2018). A paradigm shift in water quality governance in a transitional context: A critical study about the empowerment of local governance in Georgia. Water, 10(2), 98.

30. Felix-Henningsen, P.; Urushadze, T.F.; Narimanidze, E.I.; Wichmann, L.; Steffens, D.; Kalandadze, B. Heavy metal pollution of soils and food crops due to mining wastes in an irrigation district south of Tbilisi, Eastern Georgia. Ann. Agrar. Sci. 2007, 5, 11–27.

31. Hague, T., Petroczi, A., Andrews, P. L., Barker, J., & Naughton, D. P. (2008). Determination of metal ion content of beverages and estimation of target hazard quotients: a comparative study. Chemistry Central Journal, 2(1), 1-9.

32. Harmanescu, M., Alda, L. M., Bordean, D. M., Gogoasa, I., & Gergen, I. (2011). Heavy metals health risk assessment for population via consumption of vegetables grown in old mining area; a case study: Banat County, Romania. Chemistry Central Journal, 5(1), 1-10.

33. Guerra, F., Trevizam, A. R., Muraoka, T., Marcante, N. C., & Canniatti-Brazaca, S. G. (2012). Heavy metals in vegetables and potential risk for human health. Scientia Agricola, 69, 54-60.

34. Yadav, M., Gupta, R., & Sharma, R. K. (2019). Green and sustainable pathways for wastewater purification. In Advances in Water Purification Techniques (pp. 355-383). Elsevier.

35. Kulshrestha, A., Jarouliya, U., Prasad, G. B. K. S., Flora, S. J. S., & Bisen, P. S. (2014). Arsenic-induced abnormalities in glucose metabolism: Biochemical basis and potential therapeutic and nutritional interventions. World Journal of Translational Medicine, 3(2), 96-111.

36. Yayeh, Z., Kassa, A., & Dagnew, E. (2017). Milk Production, Marketing and Processing Practices of Dairy Cattle in Debremarkos Woreda of East Gojjam Zone, Amhara Regional State. J Nutr Food Sci, 7(607), 2.

37. Naujokas, M. F., Anderson, B., Ahsan, H., Aposhian, H. V., Graziano, J. H., Thompson, C., & Suk, W. A. (2013). The broad scope of health effects from chronic arsenic exposure: update on a worldwide public health problem. Environmental health perspectives, 121(3), 295-302.

38. Ismail, A., Riaz, M., Akhtar, S., Goodwill, J. E., & Sun, J. (2019). Heavy metals in milk: global prevalence and health risk assessment. Toxin Reviews, 38(1), 1-12.

39. Ivemeyer, S., Smolders, G., Brinkmann, J., Gratzer, E., Hansen, B., Henriksen, B. I., ... & Walkenhorst, M. (2012). Impact of animal health and welfare planning on medicine use, herd health and production in European organic dairy farms. Livestock Science, 145(1-3), 63-72.

40. Eleboudy, A. A., Amer, A. A., Abo El-Makarem, H. S., Hadour, H., & Abo, H. (2016). Heavy Metals Residues in Some Dairy Products. Alexandria journal for veterinary sciences, 51(2).

41. IDF Standard (1979) Metal contamination in milk and milk products. International Dairy Federation Bulletin. Document no. A. Doe37

42. Makovec, J. A., & Ruegg, P. L. (2003). Results of milk samples submitted for microbiological examination in Wisconsin from 1994 to 2001. Journal of dairy science, 86(11), 3466-3472.

43. Faccia, M., Gambacorta, G., Quinto, M., & Di Luccia, A. (2010). Lead and cadmium in some milk and milk-based mozzarella cheeses from Apulia, Italy. Italian Journal of Food Science, 22(2), 150.

44. Pal, M., Devrani, M., & Pinto, S. (2018). Significance of hygienic processing of milk and dairy products. Madridge J Food Tech, 3(2), 133-137.

Chapter 6 Bibliography of the Thesis (complete list)

A

A Guide to Georgian Dairy Products Available online: https://folkways.today/georgian-dairy-products/. (Accessed on 3 September 2021).

Agenda Mining Resumes at Controversial Sakdrisi Gold Mine. (2014). Retrieved from https://agenda.ge/en/news/2014/2863. (Accessed on 3 April 2021).

Al Sidawi, R.; Urushadze, T.; Ploeger, A. Changes in Dairy Products Value Chain in Georgia. Sustainability 2020, 12, 5894.

ALCP, Analysing Systemic Change Trends in the Dairy Sector, ALCP: Marneuli, Georgia, 2018.

(accessed on 02 April 202).

ALCP, Ensuring Sustainability in the Dairy Market Sector; Swiss Agency for Development and Cooperation SDC: Bern, Swiss, 2017.

ALCP, National Cheese Sector Research; Swiss Agency for Development and Cooperation SDC: Bern, Swiss, 2016.

ALCP. Better Cheese, Better Work. International Labour Office: Georgia, 2020. Available online: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---mp_ent/documents/publication/wcms_746235.pdf (accessed on 24 September 2020).

Alimardan, M., Ziarati, P., & Jafari Moghadam, R. (2016). Adsorption of heavy metal ions from contaminated soil by B. integerrima barberry. Biomedical & Pharmacology Journal, 9(1), 169-75.

Amer, A (2017). Effect of processing of some dairy products on levels of some., The second international congress of food Hygiene and Human Health, Assiut, Egypt. 21-23, October 2003, 15–31. Available on: https://www.researchgate.net/publication/312332697_EFFECT_OF_PROCESSING_OF_SOME_DAIRY_PRODUCTS_ON_LEVELS_OF_SOME_HEAVY_METALS

Asanidze, L., Avkopashvili, G., Tsikarishvili, K., Lezhava, Z., Chikhradze, N., Avkopashvili, M., ... & Chartolani, G. (2017). Geoecological monitoring of Karst water in the Racha Limestone Massif (Country of Georgia). Open J Geol, 7, 822-829.

Avkopashvili, G., Avkopashvili, M., Gongadze, A., & Gakhokidze, R. (2017). Eco-Monitoring of Georgia's Contaminated Soil and Water with Heavy Metals. Carpathian Journal of Earth and Environmental Sciences, 12(2), 595-604.

Avkopashvili, G., Avkopashvili, M., Gongadze, A., Tsulukidze, M., & Shengelia, E. (2017). Determination of Cu, Zn and Cd in soil, water and food products in the vicinity of RMG gold and copper mine, Kazreti, Georgia. Annals of Agrarian Science, 15(2), 269-272.

Avkopashvili, G.; Avkopashvili, M.; Gongadze, A.; Gakhokidze, R. Eco-Monitoring of Georgia's Contaminated Soil and Water with Heavy Metals. Carpathian J. Earth Environ. Sci. 2017, 12, 595–604.

B

Bakradze, E.; Vodyanitskii, Y.; Urushadze, T.; Chankseliani, Z.; Arabidze, M. About rationing of the heavy metals in soils of Georgia. Ann. Agrar. Sci. 2018, 16, 1–6, doi:10.1016/j.aasci.2017.09.002.

Banerjee, D., Kuila, P., Ganguli, A., Das, D., Mukherjee, S., & Ray, L. (2011). Heavy metal contamination in vegetables collected from market sites of Kolkata, India. Electronic Journal of Environmental, Agricultural and Food Chemistry, 10(4), 2160-2165.

Barn, P., Nicol, A. M., Struck, S., Dosanjh, S., Li, R., & Kosatsky, T. (2014). Investigating elevated copper and lead levels in school drinking water. Environmental health review, 56(04), 96-102

Beckett, W. S., Nordberg, G. F., & Clarkson, T. W. (2007). Routes of exposure, dose and metabolism of metals: Handbook on the Toxicology of Metals.(3rdedn).

Belay, D.; Yisehak, K.; Janssens, G.P.J. Socio-Economic factors influencing urban small-scale dairy management practices in Jimma town, Ethiopia. Libyan Agric. Res. Center J. Intern. 2012, 3, 7–12.

Bernabé, S. and Stampini, M. Labour Mobility During Transition. Evidence from Georgia. Econ. Transit. 2009, 17(2), 377–409.

Bernabé, S.; Stampini, M. Labour Mobility during Transition: Evidence from Georgia. SSRN Electron. J. 2008, 17, 377–409, doi:10.2139/ssrn.1141149.

Bickerstaff, K. Risk perception research: Socio-cultural perspectives on the public experience of air pollution. Environ. Int. 2004, 30, 827–840, doi:10.1016/j.envint.2003.12.001.

Binder, C.; Schmid, A.; Steinberger, J.K. Sustainability solution space of the Swiss milk value added chain. Ecol. Econ. 2012, 210–220, doi:10.1016/j.ecolecon.2012.06.022.

Bolkvadze, B. Investment Strategy of Georgia as a Country of Transition Economy: Trends, Problems, Prospects. Eur. J. Mark. Econ. 2018, 1, 19, doi:10.26417/ejme.v1i1.p19-25.

Boogaard, B.; Oosting, S.; Bock, B. Defining sustainability as a socio-cultural concept: Citizen panels visiting dairy farms in the Netherlands. Livest. Sci. 2008, 117, 24–33, doi:10.1016/j.livsci.2007.11.004.

Brennan, R. L. and Prediger, D. J. Coefficient kappa: Some uses, misuses, and alternatives. Educational and Psychological Measurement, 1981 41(3), 687–699.

Bundesministerium für Ernährung und Landwirtschaft (BMELV). Strategien der Lebensmittelsicherheit, 2013. Available online: https://umwelt.hessen.de/sites/default/files/HMUELV/strategienlebensmittelsicherheit.pdf

C

CARD Baseline Assessment of the Dairy Sector in Georgia; Center for Agribusiness and Rural Development: Tbilisi Georgia, 2018.

CARD. Business Case Study Dairy Sector in Georgia; Center for Agribusiness and Rural Development: Tbilisi, Georgia, 2018.

Cassell, C., Cunliffe, A.L., and Grandy, G., The SAGE Handbook of Qualitative Business and Management Research Methods; SAGE Publications, Inc: Newbury Park, California, 2018; ISBN 9781526429261.

Chartolani, G. (2017). Geoecological monitoring of Karst water in the Racha Limestone Massif (Country of Georgia). Open J Geol, 7, 822-829.

Chary, N. S., Kamala, C. T., & Raj, D. S. (2008). Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. Ecotoxicology and environmental safety, 69(3), 513–524. https://doi.org/10.1016/j.ecoenv.2007.04.013

Cheese Story, Alliances Caucasus Programme (Alcp) 2018, Available online: http://alcp.ge/index.php?cat=3&news=18 (Accessed on 3 july 2021).

Civil Development Agency, Multi-Ethnic Society in Georgia; Civil Development Agency: Rustavi, Georgia, 2011.

Codex Alimentarius Commission (2007) Joint FAO/WHO food standards programme. Codex committee on methods of analysis and sampling, twenty-eighth session, Budapest, Hungary, 5–9March 2007

Codex Alimentarius. 1995. Codex General Standard for contaminants and toxins in food and feed, codex Standard 193-1995, Adopted 1995. Revised 1997, 2006, 2008, 2009. Amended 2010, 2012. Rome Italy): Codex Secretariat.

Cohen, J. (1992). Quantitative methods in psychology: A power primer. Psychological Bulletin, 112(1), 155-159.

Creswell, J.W., 30 Essential Skills for the Qualitative Researcher; SAGE Publications, Inc: Newbury Park, California, 2015.

Creswell, J.W.; Plano Clark, V.L. (Eds.) Choosing a Mixed Methods Design. In Designing and Conducting Mixed Methods Research; SAGE Publications: Thousand Oaks, CA, USA, 2006; pp. 58–88.

CRRC, Dairy and Beef Consumer Preferences; Caucasus Research Resource Center: Tbilisi Georgia, 2018.

CRRC, Food safety in Georgia, 2010. Food safety in Georgia-Final Report, Tbilisi, 2010. Available online:

Cucagna, M.E.; Goldsmith, P.D. Value adding in the agri-food value chain: Research article. Int. Food Agribus. Manag. Rev. 2018, 21, 293–316, doi:10.22434/IFAMR2017.0051.

D

Dadiani, L. (2015). Building Farmer Cooperatives in Georgia: Supporting smallholder farming in the post-socialist context.

Damenia, N.; Kharaishvili, E.; Sagareishvili, N.; Saghareishvili, M. Women's Employment Issues in Georgia and Solutions Based on European Experience. Intern. J. Econ. Manag. Eng. 2019, 14, 530–536.

Das, K. K., Das, S. N., & Dhundasi, S. A. (2008). Nickel, its adverse health effects & oxidative stress. Indian journal of medical research, 128(4), 412.

Doberzanski, Z., Kolacz, R., Gorecka, H., Chojnacka, K., Bartkowiak A., 2005, The content of microelements and trace elements in raw milk from cows in Silesian region., Pol J Environ Stud., 14 (5), 685-689.

Dogaru, D.; Zobrist, J.; Balteanu, D.; Popescu, C.; Sima, M.; Amini, M.; Yang, H. Community Perception of Water Quality in a Mining-Affected Area: A Case Study for the Certej Catchment in the Apuseni Mountains in Romania. Environ. Manag. 2009, 43, 1131–1145, doi:10.1007/s00267-008-9245-9.

Doreswamy, K., Shrilatha, B., & Rajeshkumar, T. (2004). Nickel-induced oxidative stress in testis of mice: evidence of DNA damage and genotoxic effects. Journal of andrology, 25(6), 996-1003.

Duffus, J. H. (2002). " Heavy metals" a meaningless term?(IUPAC Technical Report). Pure and applied chemistry, 74(5), 793-807.

E

Edwards, R.; Holland, J. What is Qualitative Interviewing? Bloomsbury Academic: London, UK, 2013; ISBN 9781780938523.

EFSA — European Food Safety Authority (2011a) Scientific opinion on the safety and efficacy of Sel Plex (organic form of selenium produced by Saccharomyces cerevisiae CNCM I-3060) for all species. EFSA J 9(4):2110

EFSA (European Food Safety Authority), 2004a. Opinion of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission related to the Tolerable Upper Intake Level of iron. The EFSA Journal 2004, 125, 1-34. doi:10.2903/j.efsa.2004.125.

EFSA (European Food Safety Authority), 2013. Scientific Opinion on nutrient requirements and dietary intakes of infants and young children in the European Union. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). European Food Safety Authority (EFSA), Parma, Italy, EFSA Journal 2013;11(10):3408

EI-LAT, The economic transformation of Georgia in its 20 years of independence. Summary of the discussion paper; Liberal Academy—Tbilisi: Tbilisi, Georgia, 2012.

Eleboudy, A. A., Amer, A. A., Abo El-Makarem, H. S., Hadour, H., & Abo, H. (2016). Heavy Metals Residues in Some Dairy Products. Alexandria journal for veterinary sciences, 51(2).

ENPARD. Milk and Dairy Production Agricultural: Agricultural Value Chain in Imereti and Racha Regions; Enhancing Small Farmers' Cooperation and Productivity in Imereti and Racha Regions (ENPARD): Tbilisi, Georgia, 2015; pp. 1–27.

Eriksson, P.; Kovalainen, A. Qualitative Methods in Business Research: A Practical Guide to Social Research; SAGE Publications, Inc: Newbury Park, California, 2015; ISBN 1446273393.

Europe Foundation, Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2016; Europe Foundation: Tbilisi, Georgia, 2016.

Europe Foundation, Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2015; Europe Foundation: Tbilisi, Georgia, 2015.

Europe Foundation, Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2017; Europe Foundation: Tbilisi, Georgia, 2017.

Europe Foundation. Food Safety Regulation in Georgia: Assessment of Government's Reform Efforts in 2012; Europe Foundation: Tbilisi, Georgia, 2012.

European Commission (EC). (2001). Setting maximum levels for certain contaminants in food stuffs. Off. J. Eur. Communities, 77, 1-75.

European Commission. 2006. Commission Regulation 2006/1881/EC of 19 December 2006 replacing Regulation (EC)466/2001 setting maximum levels for certain contaminants in foodstuffs. OJ L 364/5-24. [accessed 2006 Dec 20]. consolidated version.

European Food Safety Authority (2013) Scientific opinion on dietary reference values for molybdenum. EFSA J 11:3333. https ://doi.org/10.2903/j.efsa.2013.3333

European Parliament and Council Regulation (EC) No 178/2002 of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Off. J. Eur. Communities 2002, L31, 1–24.

Eurostat. Global Assessment of the National Statistical System of the Republic of Georgia; Eurostat (The Statistical Office of the European Union): Tbilisi, Georgia, 2019. Available online: https://www.unece.org/fileadmin/DAM/stats/documents/technical_coop/GA_Georgia_2019_EN.pdf (accessed on 05 October 2020).

F

F.A.O. (2009). Agribusiness Handbook: Milk / Dairy Products. 2009, 65. Retrieved from: http://www.eastagri.org/publications/detail.php?id=36 (Accessed on 04 August 2021).

Faccia, M., Gambacorta, G., Quinto, M., & Di Luccia, A. (2010). Lead and cadmium in some milk and milk-based mozzarella cheeses from Apulia, Italy. Italian Journal of Food Science, 22(2), 150.

Fanzo J.C., Downs S., Marshall Q.E., de Pee S., Bloem M.W., Value Chain Focus on Food and Nutrition Security. In de Pee S., Taren D., Bloem M. (eds) Nutrition and Health in a Developing World, 3rd ed.; Humana Press, Cham: New Jersey, USA, 2017; pp. 753–770, ISBN 9783319437378.

FAO and UNEP. 2021. Global assessment of soil pollution - Summary for policy makers. Rome, FAO.

FAO, Georgian Milk Producers Learn from Italy and the United States. Available online: http://www.fao.org/europe/news/detail-news/en/c/1100229/ (accessed on: 05 August 2021).

FAO. 2011. Guide to good dairy farming practice. Animal production and Health - Guidelines. No. 8. Rome: Food and Agriculture Organization of the United Nations and International Dairy Federation. http://www.fao.org/3/ba0027e/ba0027e00.pdf. Accessed 13 Mai 2021.Wouters, A.P.; van der Lee, J. Smallholder Dairy Development-Drivers, Trends and Opportunities; WUR: Wageningen, The Netherlands, 2009.

FAO. An Overview of Legal and Institutional Frameworks and Opportunities, Challenges and Recommendations for Geographical Indication Products in; FAO: Rome, Italy, 2018.

FAO. Atlas of Origin Linked Food Products in Georgia; FAO: Rome, Italy, 2019.

FAO. Gender Equality, Social Protection and Rural Development in Eastern Europe and Central Asia; Insights from the region: Budapest, Hungary, 2016.

FAO. Georgia Gets Ready for Possible Reemergence of Cattle Disease. Available online: http://www.fao.org/georgia/news/detail-events/en/c/853929/ (accessed on 24 September 2020).

FAO. Milk Value Chain food loss analysis, causes and solutions, 2017; Food and Agriculture Organisation of the United Nations (FAO): Rome, Italy, 2017

FAO. Pro-Poor Livestock Policy Initiative: Status and Prospects for Smallholder Milk Production: A Global Perspective; Food and Agriculture Organisation of the United Nations and International Dairy Federation.

FAO. Representation in Georgia; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2015. Available online: http://www.fao.org/3/bc305/bc305.pdf (accessed on 22 September 2020).

FAO. Smallholders and family farms in Georgia, 2020; Regional TCP on Empowering Smallholders and Family Farms (TCP/RER/3601). Food and Agriculture Organisation of the United Nations (FAO): Budapest, 2020.

FAO. Survey Sheds Light on Georgian Farmer Attitudes toward Livestock Traceability. Available online: http://www.fao.org/georgia/news/detail- events/en/c/1073576/ (accessed on 02 September 2021).

FAO. Transforming Food and Agriculture to Achieve the SDGs; FAO: Rome, Italy, 2018; ISBN 9789251306260.

FAO-EBRD, Support to Sustainable Value Chains through the Development of Geographical Indications in the Dairy Sector; European Bank for Reconstruction and Devlopment: London, United Kingdom, 2016.

Felix-Henningsen, P., Urushadze, T. F., Narimanidze, E. I., Wichmann, L. C., Steffens, D., & Kalandadze, B. B. (2007). Heavy metal pollution of soils and food crops due to mining wastes in the Mashavera River Valley. Bull. Georg. Natl. Acad. Sci. vol, 175(3).

Felix-Henningsen, P.; Sayed, M.A.H.A.; Narimanidze-King, E.; Steffens, D.; Urushadze, T. Bound Forms and Plant Availability of Heavy Metals in Irrigated, Highly Polluted Kastanozems in the Mashavera Valley, SE Georgia. Ann. Agrar. Sci. 2011, 9, 110–120.

Felix-Henningsen, P.; Urushadze, T.; Steffens, D.; Kalandadze, B.; Narimanidze, E. Uptake of heavy metals by food crops from highly-polluted Chernozem-like soils in an irrigation district south of Tbilisi, Eastern Georgia. Agron. Res. 2010, 8, 781–795.

Felix-Henningsen, P.; Urushadze, T.F.; Narimanidze, E.I.; Wichmann, L.; Steffens, D.; Kalandadze, B. Heavy metal pollution of soils and food crops due to mining wastes in an irrigation district south of Tbilisi, Eastern Georgia. Ann. Agrar. Sci. 2007, 5, 11–27.

Feulner, G. (2017). Global challenges: Climate change. Global Challenges, 1(1), 5.

Field Mission Report 10-15 December 2017, Georgia . Available online: http://eastagri.org/docs/group/476/Field%20mission%20report%2010-15%20December%202017.pdf (Accessed on 3 july 2021).

Filippini, T.; Tancredi, S.; Malagoli, C.; Malavolti, M.; Bargellini, A.; Vescovi, L.; Nicolini, F.; Vinceti, M. (2019). Dietary estimated intake of trace elements: risk assessment in an Italian Population. Exposure and Health, 1-15.

Flynn, A. (1992). Minerals and trace elements in milk. Advances in food and nutrition research, 36, 209-252.

Food and Agriculture Organization of the United Nations (FAO). The economic lives of smallholder farmers, 2015. The economic lives of smallholder farmers An analysis based on household data from nine countries, Food and Agriculture Organization of the United Nations Rome, 2015. Available online:

G

G. Avkopashvili, A. Gongadze, R. Gakhokidze, M. Avkopashvili, Phytoremediation of contaminated soils, contaminated with heavy metals from gold mine in Georgia, International Conference Applied Ecology: Problems, Innovations. Proceedings. Tbilisi, Georgia, 2015, pp 154-157, ISBN 978-9941-0-7644-2. (Accessed on 04 April 2021).

Galmessa, U.; Dessalegn, J.; Tola, A.; Prasad, S.; Kebede, L.M. Dairy production potential and challenges in western Oromia milk value chain, Oromia, Ethiopia. J. Agric. Sustain. 2013, 2, 1–21.

Gelashvili, S., Deisadze, S., Difficulties of Implementing the Technical Regulation on Milk and Dairy Products; ISET Policy Institute: Tbilisi, Georgia, 2019.

Gemechu T., Beyene F., Eshetu M. Physical and chemical quality of raw cow's milk produced and marketed in Shashemene Town, Southern Ethiopia. J Food Agric Sci.2012; 5(2):

Georgia Department of Agriculture, Georgia' s Dairy Industry; Georgia Department of Agriculture: Tbilisi, Georgia, 2014.

GeoStat National Statistics Office of Georgia (GeoStat), Tbilisi, Georgia. 2014. Available online: https: //www.geostat.ge/regions/# (accessed on 02 October 2020).

GeoStat National Statistics Office of Georgia (GeoStat), Tbilisi, Georgia. 2019. Available online: https://www.geostat.ge/en/modules/categories/196/agriculture (accessed on 10 March 2021).

Gereffi, G., & Lee, J. (2009). A global value chain approach to food safety and quality standards. Global Health Diplomacy for Chronic Disease Prevention, Working Paper Series, Duke University, Durham.

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. Review of international political economy, 12(1), 78-104.

Gholizadeh, E., & Ziarati, P. (2016). Remediation of contaminated rice farmlands soil and Oryza sativa rice product by apple pomace as adsorbent. Biosciences Biotechnology Research Asia, 13(4), 2245.

Ghosh J, Sil PC. 2015. Mechanism for arsenic induced toxic effects. Handbook Arsenic Toxicol. 203–231. doi:10.1016/B978-0-12-418688-0.00008-3

Gieseke, D.; Lambertz, C.; Gauly, M. Effects of cubicle characteristics on animal welfare indicators in dairy cattle. Animal 2020, 14, 1934–1942, doi:10.1017/s1751731120000609.

Gimou, M. M., Pouillot, R., Charrondiere, U. R., Noël, L., Guérin, T., & Leblanc, J. C. (2014). Dietary exposure and health risk assessment for 14 toxic and essential trace elements in Yaoundé: the Cameroonian total diet study. Food Additives & Contaminants: Part A, 31(6), 1064-1080.

Givens, D. I., Allison, R., Cottrill, B., & Blake, J. S. (2004). Enhancing the selenium content of bovine milk through alteration of the form and concentration of selenium in the diet of the dairy cow. Journal of the Science of Food and Agriculture, 84(8), 811-817.

Gómez, M.I.; Barrett, C.B.; Buck, L.E.; De Groote, H.; Ferris, S.; Gao, H.O.; McCullough, E.; Miller, D.D.; Outhred, H.; Pell, A.N.; et al. Research principles for developing country food value chains. Science (80). 2011, 332, 1154–1155, doi:10.1126/science.1202543.

Gonashvili B., Mosiashvili M. and Sisvadze, N., Perspectives on Sheep Farming & The Sheep Market System in Georgia; Swiss Agency for Development and Cooperation SDC: Bern, Swiss, 2013.

Górecka, H., Górecki, J., & Dobrzański, Z. (2001). An application of plasma spectrometry ICP-OES and ICP-MS for metal content analysis in biological and environmental samples. Chemistry for Agriculture, 2, 359.

Grace, N. D., Lee, J., Mills, R. A., & Death, A. F. (1997). Influence of Se status on milk Se concentrations in dairy cows. New Zealand Journal of Agricultural Research, 40(1), 75-78.

Griggs, D.J.; Nilsson, M.; Stevance, A.; McCollum, D. A guide to SDG interactions: From science to implementation. Int.Counc. Sci. Paris 2017, Available online: https://www.sei.org/publications/a-guide-to-sdg-interactions-from-science-to-implementation/ (accessed on: 16 April 2020).

Guerra, F., Trevizam, A. R., Muraoka, T., Marcante, N. C., & Canniatti-Brazaca, S. G. (2012). Heavy metals in vegetables and potential risk for human health. Scientia Agricola, 69, 54-60.

Gvaramia, A. Land ownership and the development of the land market in Georgia; ALCP study: Tbilisi, Georgia, 2013.

H

Hague, T., Petroczi, A., Andrews, P. L., Barker, J., & Naughton, D. P. (2008). Determination of metal ion content of beverages and estimation of target hazard quotients: a comparative study. Chemistry Central Journal, 2(1), 1-9.

Hansson, H.; Lagerkvist, C.J. Identifying use and non-use values of animal welfare: Evidence from Swedish dairy agriculture. Food Policy 2015, 50, 35–42, doi:10.1016/j.foodpol.2014.10.012.

Harmanescu, M., Alda, L. M., Bordean, D. M., Gogoasa, I., & Gergen, I. (2011). Heavy metals health risk assessment for population via consumption of vegetables grown in old mining area; a case study: Banat County, Romania. Chemistry Central Journal, 5(1), 1-10.

Haryanto, B., Suksmasari, T., Wintergerst, E., & Maggini, S. (2015). Multivitamin supplementation supports immune function and ameliorates conditions triggered by reduced air quality. Vitam. Miner, 4, 1-15.

Hawkes, C.; Ruel, M. Value Chains for Nutrition. In Proceedings of the 2020 Conference: Leveraging Agriculture for Improving Nutrition and Health. 2020 Conference Paper #4, New Delhi, India, 15 Feburary 2011, 4, pp. 1–4.

Heard, J. W., Walker, G. P., Royle, P. J., McIntosh, G. H., & Doyle, P. T. (2004). Effects of short-term supplementation with selenised yeast on milk production and composition of lactating cows. Australian Journal of Dairy Technology, 59(3), 199.

Hemme, T., & Otte, J. (2010). Status and prospects for smallholder milk production: A global perspective. Food and Agriculture Organization of the United Nations (FAO).

Herrero, M.; Havlík, P.; Valin, H.; Notenbaert, A.; Ru, M.C. amd Thornton, P.K. Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. Proceedings of the National Academy of Sciences of the United States of America, 2013, 110, 1–6, doi:10.1073/pnas.1308149110.

Hong, D. On world Food Day, Farmers should Come First; One AcreFund Global: Kakamega, Kenya, 2015.

Available online: http://www.fao.org/3/i5251e/i5251e.pdf

I

IBR, Analysis Canadian Dairy Farmers: Not Crying Over Spilt Milk. Available online: https://iveybusinessreview.ca/5738/canadian-dairy-farmers-crying-spilt-milk/ (accessed on 24 May 2020).

IDF Standard (1979) Metal contamination in milk and milk products. International Dairy Federation Bulletin. Document no. A. Doe37

IFAD. Livestock insurance for smallholder farmers in rural Georgia, 2020; Livestock insurance for smallholder farmers in rural Georgia, Project fast facts, status as of march 2020, Georgia.

Ingvartsen, K.L. Feeding- and management-related diseases in the transition cow: Physiological adaptations around calving and strategies to reduce feeding-related diseases. Anim. Feed Sci. Technol. 2006, 126, 175–213, doi:10.1016/j.anifeedsci.2005.08.003.

ISET Policy Institute, Safety and Quality Investment in Livestock : Georgian Dairy Market System Analysis and Mapping; ISET Policy Institute: Tbilisi, Georgia, 2019.

ISET Policy Institute. Policy Clarification; Agricultural Registration Reform in Georgia: Tbilisi, Georgia, 2018; pp. 1–17. Available online: https://iset-pi.ge/images/Projects_of_APRC/Policy_Paper__Agricultural_Land_Registration_Reform_in_Georgia_GEO.pdf (accessed on 20 September 2020).

ISET-PI. Livestock Farm-Enterprise Models in the Kakheti Region: Current Arrangements and Options for (Re-)Gaining Size and Competitiveness; ISET-PI: Tbilisi, Georgia, 2016.

Ismail, A., Riaz, M., Akhtar, S., Goodwill, J. E., & Sun, J. (2019). Heavy metals in milk: global prevalence and health risk assessment. Toxin Reviews, 38(1), 1-12.

Ivemeyer, S., Smolders, G., Brinkmann, J., Gratzer, E., Hansen, B., Henriksen, B. I., ... & Walkenhorst, M. (2012). Impact of animal health and welfare planning on medicine use, herd health and production in European organic dairy farms. Livestock Science, 145(1-3), 63-72.

Jaklič, T.; Juvančič, L.; Kavčič, S.; Debeljak, M. Complementarity of socio-economic and emergy evaluation of agricultural production systems: The case of Slovenian dairy sector. Ecol. Econ. 2014, 107, 469–481, doi:10.1016/j.ecolecon.2014.09.024.

Joint, W. H. O., & World Health Organization. (2007). Health risks of heavy metals from long-range transboundary air pollution (No. EUR/06/5067592). Copenhagen: WHO Regional Office for Europe.

Juniper, D. T., Phipps, R. H., Jones, A. K., & Bertin, G. (2006). Selenium supplementation of lactating dairy cows: effect on selenium concentration in blood, milk, urine, and feces. Journal of Dairy Science, 89(9), 3544-3551.

K

Kaplinsky, R., & Morris, M. (2000). A handbook for value chain research (Vol. 113). Brighton: University of Sussex, Institute of Development Studies.

Karanja, G.M.; Kiruiro, E.M. Biogas production. Statistics (Ber). 2003, 107–208. Available online: http://www.kalro.org/fileadmin/publications/tech_notes/tecNote10.pdf (accessed on: 16 April 2020).

Kartvelishvili, T. Cattle sector and dairy chain developments in Georgia, Azerbaijan and Armenia. In The Cattle Sector in Central and Eastern Europe: Developments and Opportunities in a Time of Transition; Wageningen Academic Publishers: Wageningen, The Netherlands, 2009; p. 133.

Knowles, S. O., Grace, N. D., Knight, T. W., McNabb, W. C., & Lee, J. (2006). Reasons and means for manipulating the micronutrient composition of milk from grazing dairy cattle. Animal feed science and technology, 131(3-4), 154-167.

Korakhashvili, A., & Jeiranashvili, G. (2016). Food safety hazards in Georgian Tushuri Guda cheese. Annals of Agrarian Science, 14(3), 212-216

Kulshrestha, A., Jarouliya, U., Prasad, G. B. K. S., Flora, S. J. S., & Bisen, P. S. (2014). Arsenic-induced abnormalities in glucose metabolism: Biochemical basis and potential therapeutic and nutritional interventions. World Journal of Translational Medicine, 3(2), 96-111.

Kvemo Kartli Region. Available online: http://elibrary.bsu.az/yenii/ebookspdf/uhgkT5jc.pdf. (accessed on 15.04.2020).

L

L. Hurleyw, Lactation Biology. Minerals and Vitamins, Ed. by Univ., Urbana, Illinois USA, (1997).

Lahiji, F. A. S., Ziarati, P., & Jafarpour, A. (2016). Potential of Rice Husk Biosorption in Reduction of Heavy Metals from Oryza sativa Rice. Biosciences Biotechnology Research Asia, 13(4), 2231-2237.

Leiserowitz, A. Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values. Clim. Chang. 2006, 77, 45–72, doi:10.1007/s10584-006-9059-9.

Leontopoulos, S., & Svarnas, C. (2012). Transfer of heavy metal contaminants from animal feed to animal products. Journal of Agricultural Science and Technology A, 2, 149-154.

Lerman, Z., Csaki, C. and Feder, G., Agriculture in Transition: Land Policies and Evolving Farm Structures in Post-Soviet Countries; Lexington Books: Lanham, MD, USA, 2004; ISBN 0739108077.

Libakova, N.M.; Siberian Federal University; Sertakova, E.A. The Method of Expert Interview as an Effective Research Procedure of Studying the Indigenous Peoples of the North. J. Sib. Fed. Univ. Humanit. Soc. Sci. 2015, 1, 114–129, doi:10.17516/1997-1370-2015-8-1-114-129.

Licata, P., Trombetta, D., Cristani, M., Giofre, F., Martino, D., Calo, M., & Naccari, F. (2004). Levels of "toxic" and "essential" metals in samples of bovine milk from various dairy farms in Calabria, Italy. Environment International, 30(1), 1-6.

Llobet, J. M., Falco, G., Casas, C., Teixido, A., & Domingo, J. L. (2003). Concentrations of arsenic, cadmium, mercury, and lead in common foods and estimated daily intake by children, adolescents, adults, and seniors of Catalonia, Spain. Journal of agricultural and food chemistry, 51(3), 838-842.

Lomsadze, Z., Makharadze, K., & Pirtskhalava, R. (2016). The ecological problems of rivers of Georgia (the Caspian Sea basin). Annals of agrarian science, 14(3), 237-242.

M

Maas, S., Lucot, E., Gimbert, F., Crini, N., & Badot, P. M. (2011). Trace metals in raw cows' milk and assessment of transfer to Comté cheese. Food chemistry, 129(1), 7-12.

Makovec, J. A., & Ruegg, P. L. (2003). Results of milk samples submitted for microbiological examination in Wisconsin from 1994 to 2001. Journal of dairy science, 86(11), 3466-3472.

Markelova, H.; Meinzen-Dick, R.; Hellin, J.; Dohrn, S. Collective action for smallholder market Access. Food Policy, 2009, 34, 1–7, doi.10.1111/j.1541-1338.2010.00462.

Matchavariani, L., & Kalandadze, B. (2012, December). Pollution of soils by heavy metals from irrigation near mining region of Georgia. In Forum geografic (Vol. 11, No. 2, pp. 127-136).

Matchavariani, L., Kalandadze, B., Lagidze, L., Gokhelashvili, N., Sulkhanishvili, N., Paichadze, N., & Dvalashvili, G. (2015). Soil quality changes in response to their pollution by heavy metals, Georgia. Journal of environmental biology, 36(1), 85.

Mayfield, L.E.; Bennett, R.M.; Tranter, R.B.; Wooldridge, M.J. Consumption of welfare-friendly food products in Great Britain, Italy and Sweden, and how it may be influenced by consumer attitudes to, and behaviour towards, animal welfare attributes. Int. J. Food Agric. 2007, 15, 16.

Mayring, P., Qualitative Inhaltsanalyse : Grundlagen und Techniken; Beltz Verlag: Weinheim, Germany; Basel, Switzerland, 2015; ISBN 9783407293930.

Melikadze, G. (2006). Monitoring and spatial-time modelling of groundwater on territories of Georgia for solving ecological and seismic problems (in Georgian). Ph.D. Dissertation, Tbilisi State University, Tbilisi, Georgia

Meshref AMS, Moselhy WA, El-Houda N,Hassan Y. Heavy metals and trace elements levels in milk and milk products. J Food MeasCharact 2014; 8(4):381-8. doi: 10.1007/s11694-014-9203-6

Ministry of Environment and Natural Resources Protection of Georgia. Fifth National Report to the Convention on Biological Diversity; Ministry of Environment and Natural Resources Protection of Georgia: Tbilisi Georgia, 2014; pp. 1–221, doi:10.1044/leader.PPL.20012015.20.

Ministry Of Environmental Protection And Agriculture Of Georgia, EU -Funded Project "Establishing Efficient Protection and Control System of Geographical Indications (GIs) in Georgia". Available online: https://mepa.gov.ge/En/News/Details/11737 (accessed on: 16 April 2020).

Ministry of Labour and Health, and Social Affairs of Georgia. (2001). Order of Minister of Labour, Health, and Social Affairs of Georgia—On Approval of the Norms of the Quality of Environment 297/N; Update 2012.

Mlelwa, J. Dairy Cattle Milk Productivity in Namtumbo District Council. Ph.D. Thesis, Mzumbe University, Morogoro, Tanzania, 2018.

Modabberi, S., Tashakor, M., Soltani, N. S., & Hursthouse, A. S. (2018). Potentially toxic elements in urban soils: Source apportionment and contamination assessment. Environmental monitoring and assessment, 190(12), 1-18.

Mohan, S. Institutional Change in Value Chains: Evidence from Tea in Nepal. World Dev. 2016, 78, 52–65, doi:10.1016/j.worlddev.2015.10.004.

Moreno-Rojas, R., Sánchez-Segarra, P. J., Cámara-Martos, F., & Amaro-López, M. A. (2010). Heavy metal levels in Spanish cheeses: influence of manufacturing conditions. Food Additives and Contaminants, 3(2), 90-100

Morgan, N. Smallholder Dairy Development: Lessons Learned in Asia; Animal Production and Health Commotion for Asia and the Pacific and FAO: Bangkok, Thailand, 2009.

Motaghi, M., & Ziarati, P. (2016). Adsorptive removal of cadmium and lead from oryza sativa rice by banana peel as bio-sorbent. Biomedical and Pharmacology Journal, 9(2), 739-749.

Mounier, L. and Veissier, I., Proceedings of the 6th international conference on the assessment of animal welfare at the farm and group level; Wageningen Academic Publishers: Wageningen, The Netherlands, 2014; ISBN 978-90-8686-247-4.

Muehlfried, F. Sharing the same blood—culture and cuisine in the Republic of Georgia. Anthropol. Food 2008, S3, doi:10.4000/aof.2342.

Muñiz-Naveiro, Ó., Domínguez-González, R., Bermejo-Barrera, A., Bermejo-Barrera, P., Cocho, J. A., & Fraga, J. M. (2006). Study of the bioavailability of selenium in cows' milk after a supplementation of cow feed with different forms of selenium. Analytical and Bioanalytical Chemistry, 385(1), 189-196.

N

Napolitano, F.; Girolami, A.; Braghieri, A. Consumer liking and willingness to pay for high welfare animal-based products. Trends Food Sci. Technol. 2010, 21, 537–543, doi:10.1016/j.tifs.2010.07.012.

National Statistics Office of Georgia, Geostat Agriculture of Georgia 2020 1 Quarter, preliminary data on animal husbandry; National Statistics Office of Georgia: Tbilisi, Georgia, 2020.

National Statistics Office of Georgia. Geostat Agriculture of Georgia, Retro-Projection of Main Demographic Indicators for the Period 1994–2014; National Statistics Office of Georgia: Tbilisi, Georgia, 2018.

National Statistics Office of Georgia. Geostat Agriculture of Georgia, Statistical Publication; National Statistics Office of Georgia: Tbilisi, Georgia, 2020.

Naujokas, M. F., Anderson, B., Ahsan, H., Aposhian, H. V., Graziano, J. H., Thompson, C., & Suk, W. A. (2013). The broad scope of health effects from chronic arsenic exposure: update on a worldwide public health problem. Environmental health perspectives, 121(3), 295-302.

Neven, D., Developing Sustainable Food Value Chains; FAO Rome, Italy, 2014; 25; ISBN 9789251084816.

Nuffield Council on Bioethics (Great Britain), Public health: Ethical issues; Nuffield Council on Bioethics: London, UK, 2007; ISBN 9781904384175.

O

Ogundiran, M. B., Ogundele, D. T., Afolayan, P. G., & Osibanjo, O. (2012). Heavy metals levels in forage grasses, leachate and lactating cows reared around lead slag dumpsites in Nigeria. International Journal of Environmental Research, 6(3), 695-702.

Oliver, S.P.; Murinda, S.E.; Jayarao, B.M. Impact of antibiotic use in adult dairy cows on antimicrobial resistance of veterinary and human pathogens: A comprehensive review. Foodborne Pathog. Dis. 2011, 8, 337–355, doi:10.1089/fpd.2010.0730.

Olomola, A. Policy Options for Agricultural Investments and Governance of Markets: In Support of Small-Scale Agriculture in Nigeria; Oxfam Research Report; Oxfam International: Oxford, UK, 2013.

Oxfam. Barriers for Women in Agriculture Focus Group Research; Oxfam: Nairobi, Kenya, 2015.

Oxfam. Research on DCFTA impact on small-holder farmers in Georgia, 2017. Oxfam GB, Tbilisi. Available online: https://www.researchgate.net/publication/322662813_Research_on_DCFTA_impact_on_small-

Özcan, M. M., & Juhaimi, F. Y. A. (2012). Determination of heavy metals in bee honey with connected and not connected metal wires using inductively coupled plasma atomic emission spectrometry (ICP–AES). Environmental monitoring and assessment, 184(4), 2373-2375.

P

Pal, M., Devrani, M., & Pinto, S. (2018). Significance of hygienic processing of milk and dairy products. Madridge J Food Tech, 3(2), 133-137.

Panter, K. E., & James, L. F. (1990). Natural plant toxicants in milk: a review. Journal of animal science, 68(3), 892-904.

Pechovà A, Pavlata L, Dvořàk R, Lokajovà E; Contents of Zn, Cu, Mn and Se in Milk in Relation to their Concentrations in Blood, Milk Yield and Stage of Lactation in Dairy Cattle; ACTA VET. BRNO; Czech Republic 2008, 77: 523-53

Pignatti, N. Demographic Structure, Labor Market Conditions and Stalled Agricultural Development in a Post-Transition Country; Tbilisi State University (TSU): Tbilisi, 2017.

Porter, M. E. (2008). Competitive advantage: Creating and sustaining superior performance. simon and schuster.

Pšenková, M., Toman, R., & Tančin, V. (2020). Concentrations of toxic metals and essential elements in raw cow milk from areas with potentially undisturbed and highly disturbed environment in Slovakia. Environmental Science and Pollution Research, 27, 26763-26772.

Q

Qin, L. Q., Wang, X. P., Li, W., Tong, X., Tong, W. J., 2009, The minerals and heavy metals on cow's milk from China and Japan., J Health Sci., 55(2), 300-305.

R

Raaflaub, M.; Dobry, L.M. Pasture Management in Georgia. Current Situation, Frame Conditions, Potentials of Development; Swiss Agency for Development and Cooperation SDC: Bern, Switzerland, 2015; Volume 42.

Rädiker, S.; Kuckartz, U. Analyse qualitativer Daten mit MAXQDA; Springer : Berlin, Germany, 2019; ISBN 9783658220945.

Rangnekar, D.; Thorpe, W.R. Smallholder Dairy Production and Marketing—Opportunities and Constraints; International Livestock Research Institute (ILRI): Nairobi, Kenya, 2001.

Razafsha, A., & Ziarati, P. (2016). Removal of heavy metals from Oryza sativa rice by sour lemon peel as bio-sorbent. Biomedical and Pharmacology Journal, 9(2), 543-553.

Republic of Georgia, IFAD Dairy Modernisation and Market Access Programme (DiMMA): Final project design report; Republic of Georgia: Tbilisi, Georgia, 2018.

Resolution N 29, Antimicrobial Resistance for 2017-2020 On the approval of the national strategy, Government of Georgia, Georgia, 2017; p p. 7.; 2017; Available online: https://www.ncdc.ge/Handlers/GetFile.ashx?ID=cfaca9b4-17f5-417b-bdad-a37f20209920 (accessed on 20 April 2020).

Rödiger M., Janssen, M. and Hamm. U.,. Multi-Level Animal Welfare Labels Reflect Consumer Preferences: Insights from a Systematic Review; Wageningen Academic Publishers: Ede, The Netherlands, 2017; ISBN 9789086868629.

Rubin, H.J.and Rubin, I.S. Qualitative Interviewing: The Art of Hearing Data; SAGE Publications, Inc: Newbury Park, California, USA, 2011; ISBN 1412978378.

S

S L R Ellison and A Williams (Eds). Eurachem/CITAC guide: Quantifying Uncertainty in Analytical Measurement, Third edition, (2012) ISBN 978-0-948926-30-3. Available from www.eurachem.org.

Safonov, V. (2020). Assessment of Heavy Metals in Milk Produced by Black-and-White Holstein Cows from Moscow. Current Research in Nutrition and Food Science Journal, 8(2), 410-415.

Santamaria, A. B., 2008, Manganese exposure, essentiality and toxicity., Indian J Med Res., 128, 484-500.

Sauer, D. Die Internalisierung externer Effekte Eine kritische Analyse des Kyoto-Protokolls; GRIN Verlag: Munich, Germany, 2008; ISBN 9783640412167.

Schmitt, E.; Barjolle, D.; Tanquerey-Cado, A.; Brunori, G. Sustainability comparison of a local and a global milk value chains in Switzerland. Bio-based Appl. Econ. 2016, 5, 175–198, doi:10.13128/BAE-17140.

Schöne, F.; Steinhöfel, O.; Weigel, K.; Bergmann, H.; Dunkel, S.; Kirmse, R. & Leiterer, M. (2013). Selenium in feedstuffs and rations for dairy cows including a view of the food chain up to the consumer. Journal für Verbraucherschutz und Lebensmittelsicherheit, 8(4), 271-280

Schubert, R., Ohndort, M. and Rohling, M., Umweltökonomie Kapitel III: Internalisierung externer Effekte, Eidgenössische Technische Hochschule Zürich (ETH): Zürich, Switzerland, 2012.

SDC. Alliances Kk Synthesis Report of the First Phase: September 2011 to September 2013; Swiss Development Cooperation (SDC): Kvemo Kartli, Georgia, 2013. Available online: http://alcp.ge/pdfs/9b82125e5c11d2996b53c881302f1447.pdf (accessed on 12 October 2020).

Sellke, T., Bayarri, M. J., & Berger, J. O. (2001). Calibration of ϱ values for testing precise null hypotheses. The American Statistician, 55(1), 62-71.

Shaburishvili, S. Social changes and economic development in Georgia. 2017. Available online: https://www.researchgate.net/publication/318883168_Social_changes_and_economic_development_in_Georgia (accessed on 20 April 2020).

Shekhawat, K., Chatterjee, S., & Joshi, B. (2015). Chromium toxicity and its health hazards. International Journal of Advanced Research, 3(7), 167-172.

Shields, D. A. (2009). Dairy pricing issues. Congressional Research Service, 40903.

Shukla, S., VARIABLES, Hypotheses and stages. 2018. Available online: https://www.researchgate.net/publication/325127119_VARIABLES_HYPOTHESES_AND_STAGES_OF_RESEARCH_1 (accessed on 20 April 2020).

Slovic, P. Trust, Emotion, Sex, Politics, and Science: Surveying the Risk-Assessment Battlefield. Risk Anal. 1999, 19, 689–701, doi:10.1111/j.1539-6924.1999.tb00439.x.

Slow food USA, Slow Food Costal Georgia. Available online: https://www.slowfoodcoastalga.org/ (accessed on 5 April 2020).

Smith, J.; Sones, K.; Grace, D.; Macmillan, S.; Tarawali, S. and Herrero, M. Beyond milk, meat, and eggs: Livestock' s role in food and nutrition security. Animal Frontiers, 2012, 3, 6–13, 10.2527/af.2013-0002.

Springmann, M.; Godfray, H.C.J.; Rayner, M.; Scarborough, P. Analysis and valuation of the health and climate change cobenefits of dietary change. Proceedings of the National Academy of Sciences 2016, 1–6, doi:10.1073/pnas.1523119113.

Storelli, M. M., Barone, G., Garofalo, R., & Marcotrigiano, G. O. (2007). Metals and organochlorine compounds in eel (Anguilla anguilla) from the Lesina lagoon, Adriatic Sea (Italy). Food Chemistry, 100(4), 1337-1341.

Swiss Agency for Development and Cooperation, Meat and Cheese are Kvemo Kartli' s Future; Swiss Agency for Development and Cooperation SDC, Commonwealth of Independent States: Bern, Swiss, 2013.

T

Tavakoli-Hosseinabady, B., Ziarati, P., Ballali, E., & Umachandran, K. (2018). Detoxification of heavy metals from leafy edible vegetables by agricultural waste: apricot pit shell. J Environ Anal Toxicol, 8(1), 548.

TEEB. TEEB for Agriculture & Food: An Interim Report; TEEB: Geneva, Switzerland., 2015.

Terlau, W., & Hirsch, D. (2015). Sustainable consumption and the attitude-behaviour-gap phenomenon-causes and measurements towards a sustainable development. International Journal on Food System Dynamics, 6(3), 159-174.

Terra Institute, Ltd. Georgia Land Market Development Project Final Report; Terra Institute, Ltd.: Blue Mounds, WI, USA, 2005. Available online: http://www.terrainstitute.org/pdf/Georgia_LMDP_Final_Report.pdf (accessed on 15 October 2020).

The lost cheese of Georgia, David Farley 2019-03-19, Available online: http://dfarley.com/uploads/3/5/8/1/35811128/savvsp19_georgia_fordavid.pdf (Accessed on 3 july 2021).

Thornton, P.K. Livestock production: Recent trends, future prospects. Philos. Trans. R. Soc. B Biol. Sci. 2010, 365, 2853–2867, doi:10.1098/rstb.2010.0134.

Tilman, D.; Clark, M. Global diets link environmental sustainability and human health. Nature 2014, doi:10.1038/nature13959.

Tilman, D.; Clark, M.; Williams, D.R.; Kimmel, K.; Polasky, S.; Packer, C. Future threats to biodiversity and pathways to their prevention. Nature 546, 73–81, 2017, doi:10.1038/nature22900.

Tsikaridze, N., Avkopashvili, G., Kazaishvili, K.H., Avkopashvili, M., Gognadze, A., Samkharadze, Z. (2017). Kvemo Kartli Manufacturing Mining Pollution Analysis in Green Politics Context; Green Policy Public Platform, Tbilisi, Georgia, (In Georgian)

Tsivtsivadze, N., Matchavariani, L., Lagidze, L., Paichadze, N., & Motsonelidze, N. (2014). Problem of Surface Water Ecology in Georgia. Environment and Ecology in the Mediterranean Region II, Cambridge Scholars Publishing, Cambridge, 283-294.

Turnlund, J. R., Jacob, R. A., Keen, C. L., Strain, J. J., Kelley, D. S., Domek, J. M., ... & Coulter, J. (2004). Long-term high copper intake: effects on indexes of copper status, antioxidant status, and immune function in young men. The American journal of clinical nutrition, 79(6), 1037-1044.

U

UN Resolution der Generalversammlung, Resolution der Generalversammlung, verabschiedet am 25. September 2015,. 2015. Available online: https://www.un.org/Depts/german/gv-70/band1/ar70001.pdf (accessed on 5 August 2021).

UN Women. Gender Assessment of Agriculture and Local Development Systems; S.C.O.: Beijing, China; A.D.C.: Tbilisi, Georgia, 2018.

UN. First Voluntary National Review On Implementation Of The Sustainable Development Goals; UN: Tbilisi, Georgia, 2016. Available online: https://sustainabledevelopment.un.org/content/documents/10680SDG Voluntary National Review Georgia-.pdf (accessed on 5 August 2021).

UNDP. Public Perceptions on Gender Equality in Politics and Businesses; UNDP: New York, NY, USA, 2013.

UNFPA. Men, Women, and Gender Relations in Georgia: Public Perceptions and Attitude; UNDP: New York, NY, USA, 2020.

V

Vahcic N, Hruskar M, Markovic K, Banovic M, Baric IC. Essential minerals in milk and their daily intake through milk consumption .Mljekarstvo 2010; 60(2):77-85.

Vasseur, E.; Borderas, F.; Cue, R.I.; Lefebvre, D.; Pellerin, D.; Rushen, J.; Wade, K.M.; De Passillé, A.M. A survey of dairy calf management practices in Canada that affect animal welfare. J. Dairy Sci. 2010, 93, 1307–1316, doi:10.3168/jds.2009-2429.

W

Weidman, T. The Woman Saving Georgia's Lost Cheeses. Available online: https://forbes.ge/news/7609/The-Woman-Saving-Georgia's-Lost-Cheeses (accessed on: 02 April 2020).

Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S. and Jonell, M., Food in the Anthropocene: The EAT–Lancet Commission on healthy diets from sustainable food systems. Lancet 2019, 393, 447–492.

Withanachchi, S. S., Ghambashidze, G., Kunchulia, I., Urushadze, T., & Ploeger, A. (2018). A paradigm shift in water quality governance in a transitional context: A critical study about the empowerment of local governance in Georgia. Water, 10(2), 98.

Withanachchi, S. S., Kunchulia, I., Ghambashidze, G., Al Sidawi, R., Urushadze, T., & Ploeger, A. (2018). Farmers' perception of water quality and risks in the Mashavera River Basin, Georgia: Analyzing the vulnerability of the social-ecological system through community perceptions. Sustainability, 10(9), 3062.

Wolfenson, K. D. M. (2013). Coping with the food and agriculture challenge: smallholders' agenda. Food and Agriculture Organisation of the United Nations, Rome.

Wood, A., Value chains: An economist's perspective. IDS Bull. 2001, 32, 41–45, doi:10.1111/j.1759 5436.2001.mp32003005.x.

World Health Organization; Trace elements in human nutrition and health; Geneva 1996, 78

Wouters, A. P., & van der Lee, J. (2009). Smallholder Dairy Development-drivers, trends and opportunities.

Y

Yadav, M., Gupta, R., & Sharma, R. K. (2019). Green and sustainable pathways for wastewater purification. In Advances in Water Purification Techniques (pp. 355-383). Elsevier.

Yayeh, Z., Kassa, A., & Dagnew, E. (2017). Milk Production, Marketing and Processing Practices of Dairy Cattle in Debremarkos Woreda of East Gojjam Zone, Amhara Regional State. J Nutr Food Sci, 7(607), 2.

Z

Zhou, X. (2019). Heavy metals in Chinese raw cow milk: spatial distribution and relationships with silage and environmental factors (Doctoral dissertation, Université de Liège, Liège, Belgique).

Zhu F, Fan W, Wang X et al (2011). Health risk assessment of eight heavy metals in nine varieties of edible vegetable oils consumed in China. Food Chem Toxicol, 49(12): 3081-3085.

Zhuang, M.B.McBride, H. Xia, N.Li,Z.Li, Health risk from heavy metals via consumption of food crops in the vicinity of Dabaoshan mine, south China. Sci. Total Environ. 407, 1551–1561 (2009)

Ziarati, P., & Alaedini, S. (2014). The phytoremediation technique for cleaning up contaminated soil by Amaranthus sp. J Environ Anal Toxicol, 4(208), 2161-0525.

Zubiashvili, T., and Silagadze, L. Some aspects of the Georgian economy at the contemporary stage, Ecoforum, 2016, 5, 1–5.

Zwolak, A., Sarzyńska, M., Szpyrka, E., & Stawarczyk, K. (2019). Sources of soil pollution by heavy metals and their accumulation in vegetables: A review. Water, Air, & Soil Pollution, 230(7), 1-9.

Appendix

Expert interview: open and closed questions

1. What are the main priorities in the dairy production sector in Georgia?

2. Do you identify any type of challenges (such as economic, south-south competition or quality or climate)?

3. How many dairy production is recorded per year?

4. Do you observe any reduction of the production?

5. How do you categorize the dairy producers? are they smallholder or mainly big owner or cooperate?

6. What type of financial assistant given by government to them?

7. How do you see the environmental quality impact on dairy products in General?

8. Where / which region produce more dairy products?

9. What is the customer feedback on food quality in dairy production?

10. Why there are lot of imported dairy products available in local markets?

11. How is you facilitate to enhance the food quality in the dairy industry?

12, Do you invest money to empower local smallholder farmers?

13. Do you facilitate the processing companies to check the dairy product quality?

14. Where is the weak points in food quality control in general?

15. Do you have a legal policies to establish food quality?

16. What are agencies that are doing food quality control?

17. An private sector involve in the process?

18. How is the organic dairy production in Georgia?

19. Does government promote organic food in Georgia? how?

20 How do you see the integration of EU Regulation on food quality into Georgia?

21. What kind of quality parameters that your institute used to control the Dairy products?

22. Do you have quality control over the imported dairy products?

Smallholder farmers questionnaire

Questionnaire for the Dairy Baseline Survey in Kvemo Kartli Georgia

UNIVERSITY OF KASSEL AND AUG UNIVERSITY is conducting THE SURVEY

Investigator Introduction:

Hello, my name is Rami Al Sidawi. I am conducting a study concerning dairy production issues in your region on behalf of Aug- and Kassel University as a part of my Ph.D. study. This study aims to understand dairy production systems, marketing and identify problems you encounter in your Farm. All the specific information about you, your family and undertakings will be treated confidentially. We hope that you will be willing to help us with this study.

Interviewer's Name: _____

Time Started: _____ Time Ended: _____

Date Checked ___/___/ 2019

MODULES:

Module 1: Upstream (Input supplies)
Module 2: On-farm (production)
Module 3: Output (Downstream)

Module 1: Upstream (Input supplies)

Section 1-1: Basic Household Information

Section 1-1-1: Background information

1) Gender of the respondent: ☐ Male ☐ Female

2) Farm address: Village_____

Milk-shed area_____

3) : _____

Section 1-1-2: Household socio-economic background

4) Size of the household : _____people

5) Where do you keep your animals?

6) Is dairy production or animal husbandry the only financial income? ☐ Yes ☐ NO

Module 2: On-farm (production)

Section 2-1: Dairy Farming

Section 2-1-1: General

7) When did you start dairy farming? _____

8) Did you have basic knowledge of dairy farming? ☐ Yes ☐ NO

9) If your answer is Yes, from where? _____

10) For which reasons did you start dairy farming?

☐ Income ☐ Other: _____

Section 2-1-2: Dairy farm structure, facilities and management

11) How many dairy cattle do you have at your farm? _____

12) Do you have any other livestock on your farm? ☐ Yes ☐ NO

13) If yes, which type of animals?

Type of animals	Number of animals

14) Who is responsible for the animals resp. the farm? _____

15) Can you tell me please, which animal breed you have, and for which purposes (milk or meat)

you are using your animals?

Animal Breed	For Milk purpose	For Meat purpose	For Milk and Meat purposes
	Number of animals	Number of animals	Number of animals

Section 2-1-3: Labor use in dairy farming

16) Is just 1 person responsible for feeding, cleaning, milking and processing as well marketing? YES or NO
If No than you may use the table (but not marketing but processing)

Activity	Responsible person
Feeding	
Fetching water (for cleaning, drinking, etc.)	
Cleaning	
Milking	
Processing	
Marketing	

Section 2-1-4: Feeding

17) Can you tell me which type of grazing do you practicing for your dairy animals and for how many months a year?

Grazing type	Month
☐ Free grazing (in the pasture)	
☐ Free grazing (in communal land)	
☐ Semi-zero grazing	
☐ Zero grazing	
☐ Other	

18) Are you using any type of fertilizer on your grazing land? Yes ☐ No ☐

19) If yes, please specify which type you are using and how often?

_____

20) Please provide us with more information about Feed/Fodder:

Feeding type	Source			Feeding practice			How much you feed your cow per day?	If purchase, please indicate the amount purchased per month	
	Plant by yourself	Natural pasture	purchase	Grazing	Stallfeed	both		HS	LS

- HS: High season
- LS: Low Season

Other notes:

_____

_____

_____

_____

_____

_____

21) Do you have enough fodder for your dairy animals (for the entire year)? Yes ☐ No ☐

22) Are you used to make a conserved feed (e.g., hay)? Yes ☐ No ☐

23) Can you tell if you found a difference in feed availability (e.g. last 5 years)? Yes ☐ No ☐

Notes: _____

24) Which sources of water are available for your animals?

_____

_____

25) Are you satisfied with the water quality of the main water sources? Ye☐ N☐

26) Do you have enough water to feed animals yearly? Yes ☐ No ☐

27) If NO:

When do you have the relatively low water supply to the feed animal?

_____

Section 2-1-5: Milk production

28) How many times do you milk your cows (per day)? _____

29) What is the average of the milk in HS and LS (L/day)?

HS: _____

LS: _____

30) Are you mixing evening milk with morning milk together? Yes☐ No ☐

31) If yes, are you doing that for your own consumption/ processing or for selling to the market?

_____

32) Would you like to increase your milk production? Yes ☐ No ☐

33) If yes, how you are going to manage that?

_____

_____

_____

34) In your experience, do you think there are any significant constraints to the dairy production of the farm?

Yes ☐ No ☐

35) If yes, can you please tell me, which are the most important constraints that you are facing in your dairy farm?

_____

_____

_____

Module 3: Output (Downstream)

Section 3-1: Dairy Marketing Chain

36) Can you provide me with this information´s?

Category	Average (L/day)	
	HS	LS
Your total production		
Your own consumption (at home)		
Milk sold (locally)		
Milk sold (another purpose)		
Processing cheese		
Other Information´s		

37) Are there any specific selling point, where you are marketing your milk?

_____

38) Do you ever face any difficulties by selling your milk? Yes ☐ No ☐

39) If yes, can you explain please, what are the difficulties?

_____

_____

_____

_____

Cheese:

40)What percentage of milk was used for cheese production?

41)Which cheese varieties do you have?

42)Is your cheese for marketing or self-consuming?

44)do you process your milk into cheese or another product?