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Food policy analyses and prioritisation of food systems to achieve safer food for South Africa

by

Tshilidzi Isaac Dama

Mini-dissertation

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Supervisors: Dr Olwethu Loki

Co-supervisor: Dr Wegayehu Fitawek

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Declaration

I, Tshilidzi Isaac Dama (10676148) hereby declared that this mini dissertation, which I hereby submit for the degree of Master of Agriculture in Rural Development at the University of Pretoria is my own work, and where someone's work was used it was acknowledged and cited properly. I have not previously submitted this mini-dissertation at this or any other tertiary institution for a degree purpose.

Signature … 

Date 26 March 2024…….

Supervisor: Dr O. Loki

Signature: …….

Date: …….

Dedication

I dedicate this work to all the people in the world who are working towards ending hunger, poverty and malnutrition in urban and rural communities. Giving up is not an option, your contributions mean a lot.

Acknowledgement

I recognise and acknowledge the following people and organisations for making this mini-dissertation possible. I will start by thanking the Almighty God for making all this possible. Dr. Olwethu Loki, my supervisor, for constantly giving me constructive criticism, which I highly valued. You were patient and provided me with immeasurable guidance and support throughout the whole process. Many thanks to my Co-supervisor, Dr.Wegayehu Fitawek who provided guidance, encouragement and emotional support throughout this study.

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Abstract

Food policy analyses and prioritisation of food systems to achieve safer food for South Africa

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Food safety has become an important international public health and economic issue since the first and only publication of the global estimates on burden of food borne diseases by the World Food Organisation in 2015 and by the World Bank in 2018. Food safety refers to all microbial and chemical hazards, whether chronic or acute, that may contaminate and make food injurious to the consumer. The consumption of unsafe food has had a detrimental effect on public health and economic development due to productivity loss, chronic diseases and death as a results of consumption of unsafe food.

Systematic review and stakeholder interviews methods were used to identify challenges hindering the provision of safe food and potential no-regret solutions. The challenges that constrain provision of safe food in South Africa's food systems and potential solutions were identified through systematic literature review and meta-analysis. Potential solutions were then ranked through stakeholder interviews. Best-Worst scaling and hierarchical clustering were used to rank and prioritise actions as no- regret actions to transform food systems.

There were 12 actions prioritised as no-regret solutions from various thematic focus. The prioritised no-regret actions included research and technology actions such as the collaboration of researchers in different sectors of the food system to develop strategies to deal with the complexity of food systems and identify priorities for interventions, adopt technological innovations throughout the value chain to improve food safety, strengthen laboratory diagnostic services, and conducting more research studies on the use of easy to understand food safety labels to improve awareness. The no-regret options prioritised are feasible, and provide basis for policy interventions to improve food safety and achieve developmental goals. This study recommended harmonising the legislative framework to improve stakeholder collaboration and accelerate the much needed transformation of the food systems.

Keywords: food safety, food systems, food-borne diseases, no-regret options, transformation.

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List of Acronyms

AfCFTA	Africa Continental Free Trade Agreement
BWS	Best worst scaling
CAADP	Comprehensive Africa Agriculture Development Programme
DALY	Disability Adjusted Life Year
DALRRD	Department of agriculture, land reform and rural development
DoH	Department of health
DTI	Department of Trade and Industry
FAO	Food and Agriculture Organisation
FBD	Food-Borne Diseases
GAP	Good Agricultural Practices
HLPE	High Level Panel of Experts
HACCP	Hazard Analysis Critical Control Point
NICD	National Institute of Communicable Diseases
INFOSAN	International Food Safety Authorities Network
PRISMA	Preferred Reporting Items on Systematic Reviews and Meta-Analysis
SDG	Sustainable Development Goals
SOFI	State of Food and Nutrition in the World
WHO	World Health Organisation
WHO	FERG-World Health Organisation Food-borne Disease Burden Epidemiological Reference Group
WTO-SPS	World Trade Organisation-Sanitary and Phytosanitary
UNFSS	United Nations Food Systems Summit
UNICEF	United Nations International Children's Emergency Fund

Chapter 1: Introduction

1.1 Background

Globally, food safety is a major challenge that affects not just public health but also social cohesion and economic stability. Ensuring the safety of South Africa's food systems is a complex issue that necessitates careful analysis and deliberate response. The purpose of this research is to examine the complexities of South Africa's food systems, with a particular emphasis on improving food safety to protect public health and strengthen the country's agricultural and economic underpinnings. This chapter looks at the background of the study, research questions, problem statement and the significance of the study. The chapter concludes by addressing the layout of the thesis.

Food safety is considered an important national and international public health, trade and developmental issue (Grace *et al*, 2019; WHO, 2022). Food safety is essential to achieve positive health and economic outcomes from the food systems. (WHO, 2022). Food safety is considered an outcome of the food systems. Food safety is a complex concept, involving several sectors such as water, energy, trade agriculture, education and health (Morse *et al*., 2018). Food safety systems involves ways, standards and controls to prevent food contamination with pathogens or chemicals, during production, processing, storage, transport and distribution of food, as well as in the household. (FAO *et al*., 2020).

Food safety refers to all microbial and chemical hazards, whether chronic or acute, that may contaminate and make food injurious to the consumer (FAO *et al*., 2020). Food-borne diseases are illnesses caused by consumption or exposure to contaminated food (Grace *et al*, 2019). The food-borne diseases causes illnesses and sometimes deaths creating health and economic burden hampering the development of a country (Havelaar *et al.*, 2015). Food safety and nutrition are inextricably linked, with unsafe food creating a vicious circle of diseases and malnutrition, affecting mostly children and the elderly (Havelaar *et al.*, 2015). The evidence of food safety in low and middle income countries is still limited, therefore the full health and economic impact of unsafe food are not known.

Food safety hazards reported to cause significant food-borne illnesses by World Health Organisation-Food-borne Disease Burden Epidemiology Reference Group (WHO-FERG, 2015), include pathogens such as Bacteria, Fungus, Viruses and Diarrhoeal pathogens. Parasitic organisms such as tapeworms, nematodes were also reported. Chemicals

and toxins such as aflatoxins, dioxins, lead, arsenic and Cassava cyanide were also reported to contribute significantly to food-borne illnesses (Havelaar *et al.*, 2015).

The 2015 WHO-FERG released the first and only estimates on the burden of Food-borne diseases and reported that food-borne diseases have a health burden equal to or greater than malaria, HIV/AIDS, or tuberculosis. Moreover, an estimate of 98% of food-borne disease cases fall on children under the age of five in low to middle-income countries and has caused 600 million illnesses and 420 000 deaths globally in 2010. According to FAO *et al*., (2020) the sudden increase in food systems globalisation means more people are exposed to food safety hazards as food produced in one country is handled and consumed by many people. The WHO-FERG in 2015 estimated that 33 million healthy lives in 2010 were lost annually worldwide due to food-borne diseases caused by 31 food hazards (Havelaar *et al.*, 2015). WHO-FERG 2021-2024 is currently updating the data of estimates (WHO, 2023). Food systems are integral to the health of the population.

In 2018, The World Bank reported an estimate of US$95.2 billion per year of total productivity losses associated with food-borne diseases in low and middle income countries and an annual cost of US$15 billion spent on treating food-borne diseases globally in 2016 (Jaffee *et al*., 2019). Productivity losses are directly linked to development of a nation.

In South Africa, the National Institute for Communicable Diseases (NICD) reported that 327 food-borne diseases outbreaks were notified between 2013 and 2017, causing illness in 11 155 individuals and 49 deaths (Shonhiwa, *et al.*, 2019). The NICD further reported 338 outbreaks between 2018 and 2020, of which 98 were fully investigated and found 2 932 illnesses and 20 deaths (Ramalwa, *et al*., 2020). There is no account of total health and economic burden caused by those food-borne diseases outbreaks between 2013 and 2020.

African countries need to prioritise food safety and adopt evidence-based food safety policies to transform food systems to achieve the development goals. Hawkes *et al.*, (2020) suggested that policy actions can transform food systems. Transforming food systems will entail identifying challenges to the food systems and possible solutions.

Policy innovations are required to reduce food safety risks and hazards in developing countries (Grace *et al.*, 2019). Many of the costs associated with the health and economic burden of food safety hazards could be avoided by adopting measures that improve food handling from farm to fork (FAO, 2019). Food safety in developing countries should be strengthened to ensure healthy and sustainable food systems. The Listeriosis outbreak of 2017 in South Africa

demonstrated the health and socio-economic impact of food-borne diseases (Boatemaa *et al*, 2019).

Understanding the links between food safety hazards and health will help policymakers to develop better evidence-based policies with clear pathways to transform food systems. Transformed food systems are likely to address the global burden of food-borne diseases and diet-related non-communicable diseases (FAO, 2019). This study reviewed and analysed food safety and health-related policies in South Africa to establish no-regret options to transform food systems towards safer foods. No-regret options are justifiable specific measures, with a clear pathway to impact transforming food systems under any future circumstance (Hawkes *et al.*, 2020).

1.2 Problem statement

The food supply chain's safety is jeopardized by several issues facing South Africa's food systems (Hove-Sibanda, 2021). Public health is seriously threatened by contaminated products, weak regulatory frameworks, and lack of monitoring and enforcement. Foodborne illness incidents and outbreaks pose a threat not only to consumer safety but also to the food systems. It is essential to address these issues in order to develop a reliable and resilient food system.

Considering the above, food safety challenges impose economic and health burdens and hampers the achievement of developmental goals such as ending hunger and eradicating poverty (Grace et al., 2020). Food-borne diseases are caused by consuming contaminated food, leading to ill- health and sometimes death (WHO, 2021). The impact of food-borne diseases on health has been overlooked for many years, until WHO-FERG published evidence in 2015 (Havelaar *et al.*, 2015).

Food-borne diseases are linked to malnutrition. Most of food-borne diseases are caused by the body physiological responses such as inflammation, diarrhoea, and loss of appetite (Tappenden *et al*, 2013). Diarrhoea is associated with stunting and wasting (Havelaar *et al.*, 2015). Poor nutrition leads to compromised immune system, which may cause other illness by non-food hazards (Havelaar *et al.*, 2015).

Food-borne diseases are also associated with economic costs. Economic costs may include loss of productivity due to illness, cost of treatment and food recalls (Grace *et al.*, 2019). The World Bank published a first report estimating the economic burden of food borne diseases in 2019 (Jaffee *et al.*, 2019). Food-borne diseases caused by the failure to adopt food safety measures

cost Africa about US$ 17 billion annually in terms of lost human capital due to illness and death, and approximately US$ 1 billion in rejection of exported foods due to no-compliance with trade regulations in 2016 alone (Jaffee *et al*., 2019). The World Bank further reported that South Africa, Nigeria and Angola collectively have annual costs exceeding US$ 1 billion.

Efforts to improve food safety in most sub-Saharan African countries are hampered by a lack of policy coherence, fragmented food control systems, weak surveillance and weak regulatory enforcement (Alarcon, 2021). The recent implementation of the Africa Continental Free Trade Area agreement, to advance inter-continental trade in Africa, further necessitates promoting effective food safety systems since agricultural trade is likely to increase, leading to a longer and more complex regional food systems (Kruger and Karim, 2022).

Several studies (Grace *et al.*, 2015; 2019; Riley and Crush, 2023; Von Braun *et al*., 2023) have been conducted to contribute to the transformation of food systems for food security and nutrition through policy interventions. Most studies (Morse *et al.*, 2018; Sparling *et al*., 2024; Alacorn *et al.*, 2021) focused on the development of frameworks to understand the linkages between food systems, food security and nutrition. Politically food security is often prioritised over food safety in low-middle income countries (Walls *et al*., 2019).

Policymakers often prioritise short-term of acute issues hence food availability is prioritised over food safety. The provision of unsafe food to end hunger causes synergies in the food systems which impact the population's health. For instance, “the triple burden of malnutrion”- whereby underweight, overweight and obesity, as well as nutrient deficiency co-exist at the same time in the same household, community or even an individual (Walls *et al*., 2016a).

Despite political wills such as commitments to the Comprehensive Africa Agriculture Development Programme (CAADP) in 2014 and the United Nations Sustainable Development Goals in 2015 to achieve sustainable food security and nutrition for all through policy interventions (AU Commission, 2014; Opoku, 2016; Canfield *et al*., 2021), the 2021 United Nations Food Systems Summit (Von Braun, 2023) very little work has been done to improve food safety policies and actions in developing countries (FAO *et al*., 2023).

To date, no study has synthesised literature using systematic review and conduct stakeholder consultation to identify challenges in South African’s food systems and develop no-regret options to transform food systems for a safer diet. This study will synthesise policy options through a review and further conduct stakeholder consultations. Systematic reviews conducted with standardised and structured methods can identify gaps and present potential solutions for

interventions to improve food safety (Ernawati *et al*., 2021). Stakeholder consultation is very crucial because of the variety of role players in the food systems.

1.3 Overall objective

The overall objective of this study is to identify and prioritise non-regrets actions to ensure the provision of safer food in South Africa's food system. Actions that are worth-while, justifiable with plausible impact to transform South Africa's food systems to provide safe food under current and future conditions.

Specific sub-objectives

- To identify the key challenges in the South Africa's food systems that constrain the provision of safe food.
- To identify no-regret solutions to constraints to the provision of safe food.
- To prioritise options available to stakeholders to ensure food systems provide safe food in South Africa through stakeholder interviews.

1.4 Research questions

- What are the key challenges in the South Africa's food systems that constrain the provision of food safety?
- Which no-regret solutions can contribute to the provision of safe food?
- To what extent do stakeholders ensure food systems provide safe food in South Africa through their stakeholder engagement?

1.5 Significance of the study

This study is significant for food systems in South Africa and worldwide in many ways: firstly, in South Africa and many other developing countries food systems research is a new phenomenon. Thus, the finding of this study will increase the body of knowledge and understanding of food systems. Secondly, the study will identify challenges in the food systems and potential solutions. This study will provide pathway to future studies on food policy analyses on the highlighted areas for food systems transformation in South Africa. Thirdly, the methodology used in this study involved various stakeholders within the food systems. Thus, demonstrating the potential of mixed methods studies on multi-sectoral policy development. The multi-disciplinary stakeholder interviews would enlighten stakeholders to understand the complexity of food systems and their respective roles.

Provision of safe food contributes to health and productivity of a population (Walls, *et al*., 2019). This study will further contribute to attaining developmental goals such as United Nations Sustainable Development Goals, National Development Plan and Malabo declaration by contributing to food systems transformation. Food systems transformation for safer foods will contribute to food security, health, economic development and at the same time achieving sustainable food systems.

This study will identify and prioritise no-regret policy options to transform South Africa's food system to provide safe food. A rigorous, explicit and impartial literature-wide assessment of previous work will be used together with stakeholder perceptions to develop interventions with clear pathway to impact.

The implications of this study will include contributing to the knowledge and literature gap in food safety knowledge. The most practical implication of this study is to increase food safety knowledge base of the multi-sectoral stakeholders in food systems who participated in this study. This study will also have implications on food policy framework for South Africa's food systems governance through identifying no-regret policy options to transform the food systems. No-regret policy actions will enable policy makers to address the linkages and synergies in food policies, health, nutrition and economic development.

1.6 Limitations to the study

These types of studies can have some limitations such a non-random selection when recruiting interview participants. Less socio-demographic diversity of the sample. The complexity of the food systems makes it challenging to get perspective from all the role players in the food system. The major limitation of this study was a smaller sample size of interview participants and the lack of demographic information from the participants. The online Google Form was used to validate the policy actions instead of a focus group discussion due to challenges related to the unavailability of participants, limited resources for physical direct sessions, and other unknown issues that led to participant's non-attendance of online discussion session. Focus group discussion would enable the participants to provide more insights and deliberations on the identified policy options to transform the food systems.

1.7 Organisation of dissertation

The study revolves around five chapters as presented in Figure 1.1.

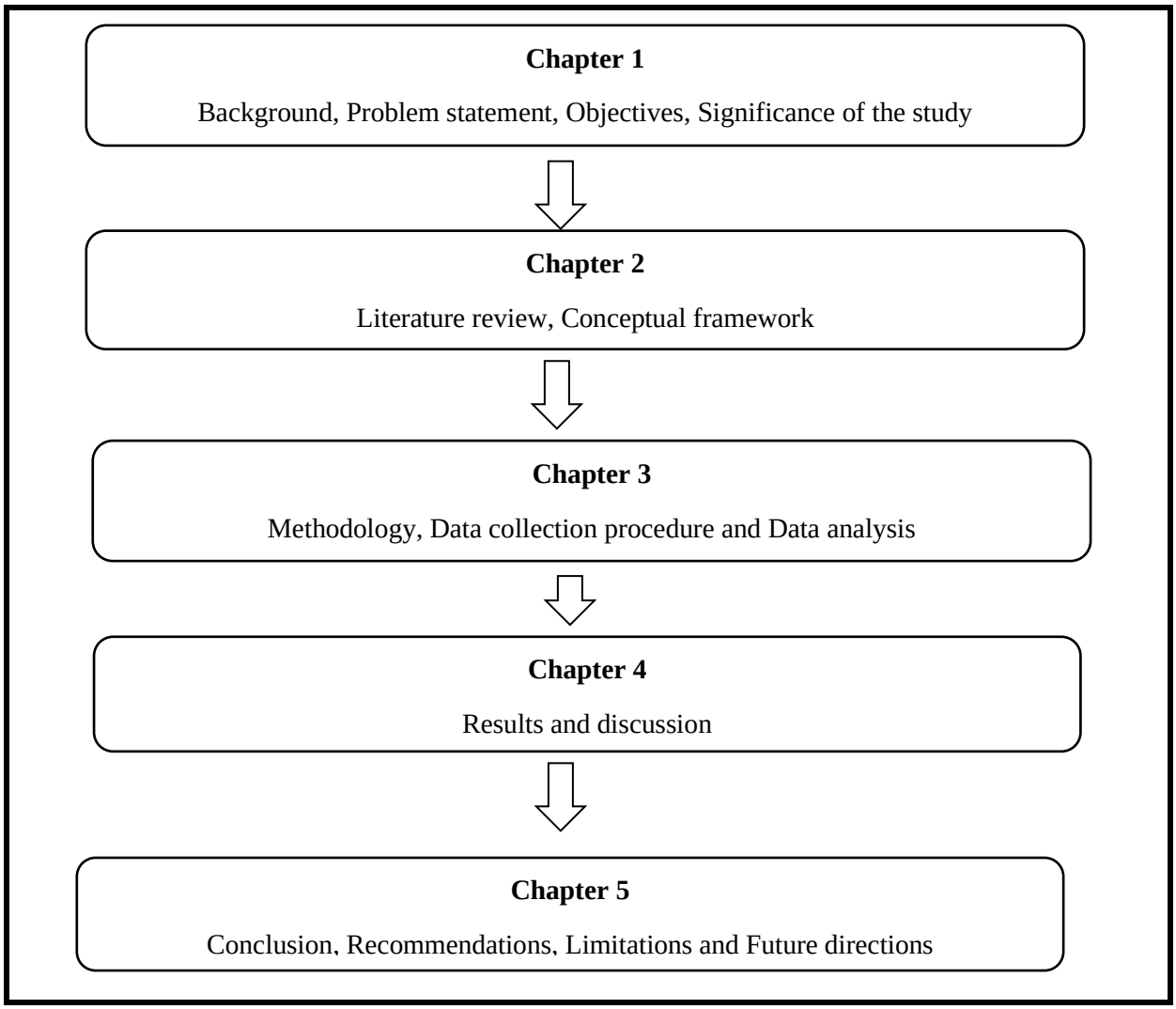

Figure 1.1: Organisation of the dissertation chapters, *Author (2023).*

Chapter 2: Literature Review

2.1 Introduction

This chapter present the literature review that was conducted to explore and understand the conceptual background on food systems and food-borne diseases, understanding the impact of food safety failures on health, nutrition outcome and economic development. This literature review provides the analysis of approaches used to develop policy options. This literature review produced a conceptual framework that was used as a precursor to the structured systematic review conducted to identify challenges and potential solutions to constraints of food safety.

2.2 Definition of main concepts

Food systems - have been conceptualised as "the complex and multi-dimensional webs of activities, resources and actors involving the production, processing, handling, preparation, storage, distribution, marketing, access, purchase, consumption, and loss and waste of food, as well as the outputs of these activities, including social, economic and environmental outcomes" South Africa's food systems encompass a diverse range of agricultural practices, food supply chains, and cultural elements that contribute to the availability, accessibility, and utilization of food for the population (CFS, 2021).

Food safety ensures the safety and quality of food is a critical aspect of South Africa's food systems. Food safety protocols will make sure that food does not cause adverse health effects to the consumer when it is prepared and/or eaten according to its intended use" (FAO, 2019).

Food safety policy- refers to a set of rules and guidelines that are set by food business operators, authorities to implement food safety management systems throughout the value chain to protect the health of the consumers (ISO 22000, 2018).

Food safety systems- This involves all the actors and their interlinked activities throughout the food systems aiming at improving, ensuring, maintaining, verifying and otherwise creating the conditions for food safety. These actors include national competent authorities, inspectorates, the private food business operators, consumers, academia and any other stakeholders which implement their activities to prevent food contamination and protect public health (WHO, 2022).

No–regrets actions - are actions by households, communities, and local/national/international institutions that are plausible and justifiable from economic, social, and environmental perspectives whether natural hazard event or other hazards occur or not (Siedenburg, 2012).

2.3 Background on food systems and food borne diseases

2.3.1 Food Systems

Food systems involves a web of interconnected activities, from food production, processing, distribution, marketing, consumption and waste disposal. Food systems are constantly shaped by different forces, drivers and structural changes and decisions by many stakeholders that could affect their sustainability (CFS, 2021). Food systems are crucial to dietary patterns, nutritional status as well as health of the population (WHO, 2022). The food systems have been overlooked over the years, with the focus on food security.

The increasing attention to food security has also expanded the understanding of food systems, as food security is a complex issue with environmental, political, social and economic determinants. Food systems go beyond the value chain to environmental and socio-economic drivers and food security outcomes (Von Braun, 2023). The global commitment to the 2030 Agenda for Sustainable Development Goals by the United Nations has further emphasised the inter-linkages within the food environment and between activities and outcomes of eradicating hunger and poverty, sustainable use of natural resources, promoting healthy and prosperous lives and social justice (Caron *et al*. 2018).

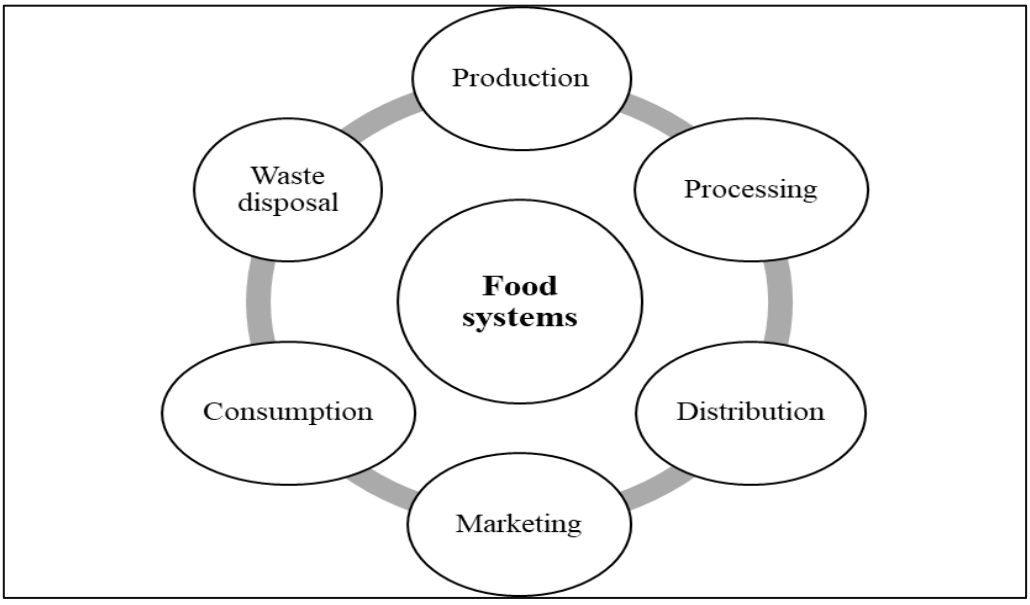

Figure 2.1: Food systems illustrations. *Adopted from, Fanzo et al., 2017).*

Food systems consists of the activities and actors that take place in food from production to consumption and disposal of its waste, as illustrated in Figure 2.1 (Hawkes and Ruel, 2012). Natural elements and Societal elements such as policies, laws and regulations, socio-cultural norms, education, organisations, infrastructure play a significant role on how the food is produced, processed, marketed, prepared and consumed (Fanzo *et al*., 2017).

2.3.1.1 Food production

Food production systems affect food availability and affordability, quality and diversity (Fanzo *et al*., 2017). Different types of food, and where and how they were produced can significantly affect their quality and safety (Von Braun, 2023). Large scale conventional farming is often associated with higher risks of chemical hazards compared to small scale subsistence production (Fanzo *et al*., 2017). Food production in higher income countries is dominated by conventional production because most rely on supermarkets for food, compared to production systems in low to medium income countries where there is domestic food production.

2.3.1.2 Food processing

Food processing is a vital part of each nation's food system. It entails turning unprocessed agricultural materials into consumer-friendly, wholesome, and safe food items. Food processing entails tasks including washing, arranging, grading, packing, and preserving food (Pereira and Drimie, 2016). Food processing and packaging contributes to food safety by destroying toxins and reducing food-borne pathogens (Augustine *et al*., 2016).

Food systems in high income countries consist of more processed food than in low to middle income countries (Reardon, 2015). However, contamination may also occur during food processing. In high income countries, the food processing techniques and systems are advanced to reduce the risks of contamination. In low to medium income countries there is low investments in food processing technologies, thus making food processing a high risk activity for food safety (Hawkes, *et al*., 2015).

2.3.1.3 Food distribution

Once food has been processed, it moves to the markets that may be near or distant from communities and households (FAO, 2019). Food that is distributed over long distance has greater chances of contamination and loss of quality, which affects nutrition and health of consumers (Fanzo *et al*., 2017). The food systems are complex and connected due to market

liberalisation and globalisation. Food that is produced in one country is distributed to many countries. Thus, making food safety regional policies more essential (Reardon, 2015).

2.3.1.4 Food marketing

These markets shape the food environment in which consumers make purchasing decisions. The rapid spread of supermarkets and fast food chains in low to medium income countries influences consumer behaviour and dietary patterns (Reardon *et al*., 2015). The evolution of supermarkets and fast foods offers a wide range of cheaper food products in a more convenient way than traditional markets. Morden fast foods use social media and online platforms to promote their products, thus shaping the consumer demand and dietary shift (Von Braun, 2023). This dietary shift leads to consumption of cheaper, available and globalised foods (Misselhorn and Hendriks, 2017). The fast food market evolution is linked to malnutrition in low to medium income countries.

2.3.1.5 Food consumption

The food consumption patterns are influenced by drivers of the food environments. The consumer food choices are made in the food environment, which affect the food systems (Fanzo *et al*., 2017). The food environment in high income countries seems to support unhealthy foods and sedentary lifestyle. In the low to medium income countries the dietary patterns have changed radically in recent years due to evolution of fast foods and supermarkets in peri-urban and semi-rural areas (Hawkes *et al*., 2015; Fanzo *et al*., 2017).

There are emerging forms of complex triple burden of malnutrition in the low to medium income countries (Ridoutt, 2019). Emerging triple burden of malnutrition in the low to medium income countries is linked to increasing per capita income that is shaping foods and consumer choices, leading to consumption of unhealthy and unsafe food (AGRA, 2020).

2.3.1.6 Food waste disposal

Globally, 13 % of the food produced for human consumption is wasted in the food systems (FAO, 2019). Food waste is a loss of quality or quantity of food resulting from decisions or actions by those handling food (FAO, 2019). A key target of SDG 12 is to reduce food waste and reduce food loss by 50 % by the year 2030. Improper food waste disposal may lead to contaminations and affect sustainability of the food systems. food systems transformation should aim at developing actions to reduce food waste. Food waste should be properly disposed as they have the potential to re-enter and contaminate the food systems.

2.3.2 Food Safety

Safe food is vital for food and nutrition security as well as growth and transformation of the food systems, which needs to feed the growing population. Food safety is a result of actions or inactions by role players who operate within the food environment. Role players includes farmers, food handlers, processors, distributors, regulators, consumers, scientists, educators and media (Jaffee *et al.*, 2019).

Food safety challenges arise from contamination with biological or chemical hazards (natural or processed contaminants, pesticides or veterinary residues) during production, processing, storage, distribution and at household (Fanzo *et al*., 2017). Food safety is often confused with food quality. Food quality includes all attributes that influence the value of a product to the consumer, such as origin, colour, flavour, texture, odour and food processing method (WHO, 2003). Food safety ensures that the food is safe for human consumption and not harmful to human health (Independent Evaluation Group, 2014, cited by Neufeld *et al*, 2021).

2.3.3 Food safety and Nutrition

Food safety and nutrition are closely connected, unsafe food creates a vicious cycle of diseases and malnutrition affecting infants, young children and the elderly (Havelaar *et al*., 2015). The main link between food safety and nutrition is through the body physiological response to intoxication due to the consumption of unsafe food. Nutrition and safety status of food are a major component of a healthy diet. A healthy diet is health-promoting and disease-preventing. It provides adequate, without excess, of nutrients and health-promoting substances from nutritious foods and avoids the consumption of health-harming substances (Von Braun, *et al*., 2023).

Physiological responses include reduced nutrients absorption and poor metabolism, leading to poor nutrition (Tzioumis *et al*., 2016). Good nutrition sets children on the path to survive and thrive, as well-nourished children grow, develop, learn, play and contribute to economic development, while malnutrition robs children of their future and potential, with national and global economic and social consequences (WHO, 2021). The forms of malnutrition are stunting, wasting and overweight, often called the triple burden of malnutrition (FAO, 2019). In child malnutrition stunting refers to children who are too short for his or her age, wasting refers to a child who is too thin for his or her age, overweight or obesity refers to a child who is too heavy for his or her age.

Many countries, including South Africa are now facing the triple burden of malnutrition. The triple burden of malnutrition is the co-existence of undernutrition, overweight and overnutrition within the same country, community or even within the same individual at the same time. The causes of undernutrition, underweight and obesity are similar and interrelated. They range from poverty, lack of access to adequate foods, poor infant and young child feeding practices and the marketing and sales of unhealthy foods and drinks (UNICEF, 2021).

2.4 Impact of trade policies on food safety and economic development

The African continent was reported to lose US$17 billion annually in 2016 on trade rejections due to non-compliance with trade regulations in major markets (Jaffee *et al.*, 2019). The African Continental Free Trade Area Agreement (AfCFTA) was signed in March 2018 in Rwanda, Kigali, to address Africa's challenges of poverty and inequality at the continental level by stimulating intra-continental trade and promoting macro-economic cooperation (Pasara and Dunga, 2023). AfCFTA requires members to remove tariffs from 90% of the goods, allowing free trade of goods and services across the continent (Signé *et al*., 2019). Removing tariffs without strengthening compliance with regulatory requirements on trade of safe food may not lead to economic development as envisaged in AfCFTA.

The inter-continental trade openness may affect food safety due to the increased movement of food across borders, meaning poor handling of food from one source may affect many people in the region. (Cuevas Garcia- Dorado *et al*., 2019) The capacity to manage food safety risks for exports in many countries appear to be considerably stronger than capacities to protect domestic consumers (Jaffee *et al.*, 2019). Regional trade openness may improve food systems if actions are taken to improve food safety. Failure to improve food safety may seriously impact regional and continental development.

Therefore, authorities must strengthen engagements with agencies that set food standards and guidelines (WHO, 2023). The AfCFTA should not divorce the WTO-SPS Agreements which obligates authorities to implement sanitary and phytosanitary measures on the standards, guidelines and recommendations of the Codex Alimentarius, the World Organisation of Animal Health (WOAH) and the International Plant Protection Convention (IPPC) when implementing their trade openness (WHO, 2011).

2.5 Impact of food-borne diseases on health and nutrition outcomes

Food-borne diseases have been part of human health from the early years of human life. Food-borne diseases causes substantial economic losses through healthcare costs and loss of productivity (Grace *et al*., 2020). Billions of people around the world remain at risk of consuming unsafe food (Fung *et al*., 2018). Food has become the major pathway of human exposure to microbial pathogens, which causes food-borne diseases and other food-related hazards due to the globalisation of the world food systems (Goodwin *et al*., 2022). Microbial organisms are part of the food system from the farm to the fork because food by nature is biological and is capable of supporting the growth of microorganisms that are capable of causing food-borne diseases (Fung *et al*., 2018), it is therefore important not to only focus on food but understanding the pathways and relationships between and within the food system in order to identify challenges and possible solutions to transform food systems.

The current evolution of food systems across the globe has changed the production, distribution and consumption of foods, contributing to food-borne diseases, hazards and diet-related non-communicable diseases, which affects health outcomes (Alarcon *et al*. 2021). Food systems also surround the institutions that define the social, economic, political and physical environment in which all the activities within the systems occur. Food safety can be considered an outcome of a food system, impacting the health system (Jaffee *et al*, 2019). The following table summarises the first ever and the only published estimates of global burden of food borne diseases on health and wellbeing published in 2015.

Table 2.1: Summary of estimated global food-borne illnesses, death and DALY's by food hazards in 2010.

Hazard	Food-borne illness	Food-borne death	Food-borne DALY
Diarrhoeal	548 595 679	230 111	17 659 226
Viruses	124 803 946	34 929	2 496 078
Bacteria	349 405 380	187 285	14 490 808
Protozoan	671 826 64	5 558	492 354
Helminths	129 289 44	45 226	5 810 589
Castodes	430 864	36 500	3 158 826
Aflatoxin	21 757	19 455	636 869
Cassava cyanide	1066	227	18 203

Source: Havelaar et al., (2015).

Note: - DALY= disability-adjusted life year.

-FERG 2021-2024 is currently updating this data.

Incidences of borne diseases are well documented in countries such as the United States, Japan and China and less documented in developing countries (Fung *et al*., 2018). Havelaar *et al*., (2015) estimated that less than 10% of food-borne illnesses cases were reported, and less than 1% were reported in developing countries. The global burden of food-borne disease to public welfare and the economy has been undermined due to underreporting and difficulty linking food contamination and diseases or mortality.

WHO-FERG in 2015 reported that one-third of the global death toll for food-borne diseases is in the African region. 91 million people fall ill and 137 000 die annually in Africa. Diarrhoeal diseases are responsible for 70% of the burden of food-borne diseases, with chemical hazards (cyanide and aflatoxin) causing more than 3000 deaths annually in African. Paralysis caused by cyanide in cassava, which is unique to the African region causes death to one in every five people affected (Havelaar *et al*., 2015).

The updated global estimates of the burden of food-borne diseases will be reported towards the year 2025, following the fourth meeting of WHO-FERG for 2021-2024 in November 2022 (WHO, 2022). The updated report will provide updates on the progress made to curb food-borne diseases as well as shaping the plans for country activities. The report will also assist in developing indicators and the impact measurement framework (WHO, 2022).

2.6 Food safety and Sustainable Development Goals

Food safety is important in achieving several sustainable development goals. Food safety is linked to poverty through the employment of the poor in agri-food value chains and as food consumers (Jaffee *et al*, 2019). A single food safety event can disrupt livelihoods of those employed in food value chains and push people to poverty. Poverty causes change in consumer purchasing and consumption patterns. Improving food safety will be crucial in achieving Sustainable Development Goals such as SDG 1 of ending poverty. Food-borne diseases are the primary cause of ill-health amongst the poor, leading to a loss of productivity and assets. Food-borne diseases can also impact the SDG 2 of ending hunger as they have multiple interactions with nutrition. The health burden of food-borne diseases is comparable to that of malaria, HIV/AIDS, and tuberculosis, meaning SDG 3 of good health and wealth may not be achieved if food-borne diseases compromise immunity (Jaffee *et al*, 2019). SDG 1,2 and 3 also contribute to the achievement of SDG 6 (clean water and sanitation), 8 (decent work and

economic growth), 12 (sustainable production and consumption of food) and 17 (partnership for the goals) (WHO, 2022).

2.7 No-regret policy options

In the context of food systems, a "no-regrets" solution is an intervention or strategy that has minimal negative effects and is useful in a variety of hypothetical future scenarios. Usually strong and resilient, these solutions produce favourable results in a variety of situations, including ambiguous or shifting ones (Hawkes *et al*., 2020)

No-regrets approach has been widely used in climate change adaptation, disaster risk management and social protection policy analysis (Siegel; Heltberg, 2009).
No–regrets actions are plausible and justified from economic, social, and environmental perspectives whether hazard occur or not (Siedenburg, 2012). No- regret actions increase resilience, which is the ability of a system to deal with different types of hazards and shocks in timely, efficient and equitable manner" (Siegel, 2011; Heltberg, 2009).

No-regret policy interventions seek to address varying health and nutrition issues with complimentary options that are justifiable with plausible impact on improving the compatibility of heathy nutrition and food safety. No- regret options generate social and economic gains, irrespective of hazard occurrence as well as across a range of possible future circumstances (Siedenburg, 2012).

Stakeholder engagement is critical to achieve no-regret policy actions to transform food systems. Actions prioritisation by stakeholders may reduce the negative impact of synergies across the interlinked themes in the food systems (Walton *et al*., 2023).

2.8 Analysis of approaches to selecting no-regret policy options

Several approaches are used in selecting and prioritising policy options, such as cost- benefit, multi-criteria analysis as well as systematic reviews. Hawkes *et al*., (2020) used systematic review to identify no-regret actions to transform food systems for a healthier diet, synthesised from evidence based expert reports.

Thaivalappil *et al*., (2020) used Preferred Reporting Items for Systematic Review (PRISMA) to identify, characterise and synthesise the published work on food safety knowledge and practices of older adults at home, and managed to identify knowledge gaps in domestic food safety practices.

Multi-criteria analysis techniques are also used to identify and prioritise policy options (Hasan, *et al*., 2020). These includes cost-benefits analysis and cost effective analysis of policy options. Hasan *et al.*, (2020) used multi-criteria analysis technique to identify and categorize transport emission reduction policies in New Zealand. Expert's opinions were evaluated and aggregated using Simple Additive Weighting (SAW) technique to identify the best policy options to reduce transport emissions.

There is a need for system approaches to develop coherent policies with a clear pathway to win- win solutions to our food system's challenges (Canfield *et al*., 2021). The food systems approach can create solutions for synergies and trade-offs of policies previously treated in isolation, such as polices on food, health and nutrition (Deconinck *et al*., 2021; FAO *et al*., 2022).

Approaches such as territorial and ecosystem approaches have been used to develop actions for developmental policies, to build territorial understanding at the national level (Forster, 2021). Territorial approaches enable the full participation of local role players in policy formation, prioritisation and data management within the national and private sector institutional environment.

2.9 Conceptual framework on Food safety, health and development

The burden of unsafe food evolves in a systemic manner in a complex food system. When the food system produces unsafe food, Unsafe food contains microbiological, chemical or physical hazards (Hawkes *et al*, 2015). The consumption of contaminated food causes infections, followed by body physiological responses such as inflammation, poor metabolism and diarrhoea (Alarcon *et al*, 2021). Physiological response to infections give raise to a food-borne disease, as illustrated in Figure 2.2. Body responses often lead to illness, which may be acute or chronic, that in extreme cases cause death or permanent disability (Jaffee, *et al*, 2019).

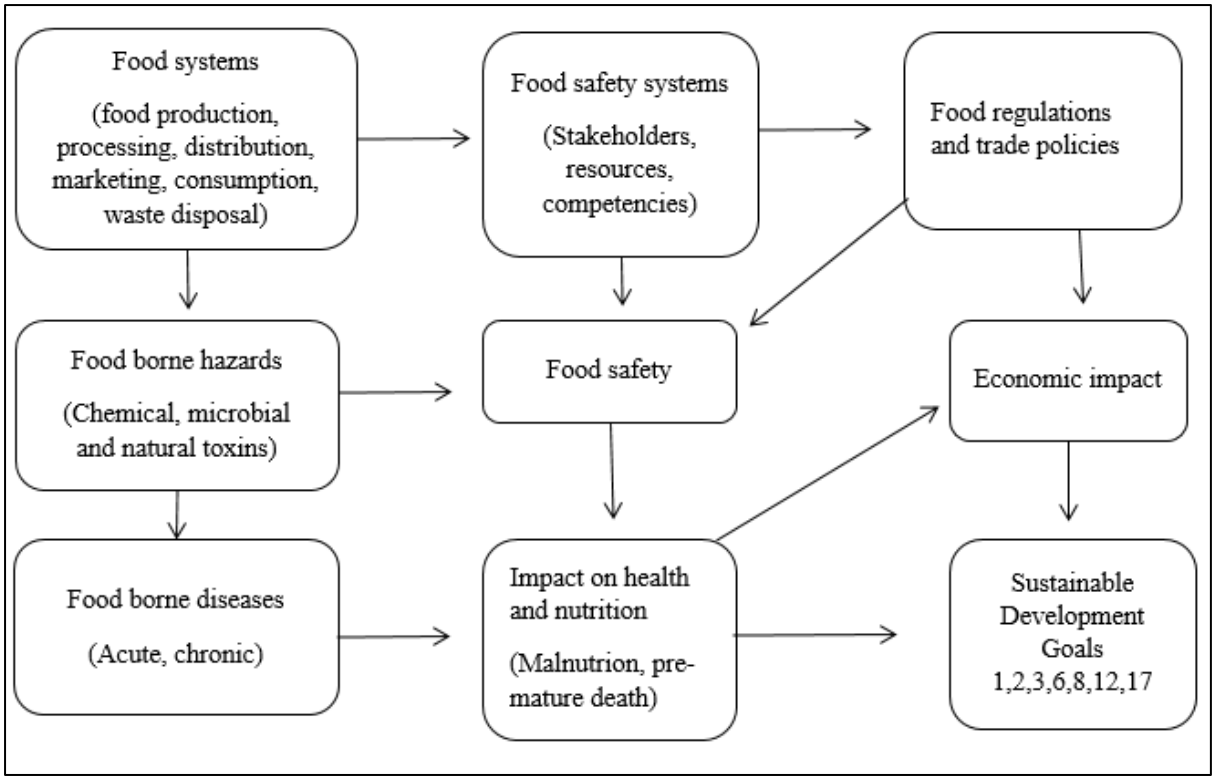

Figure 2.2: Conceptual framework of the pathway to impact between food systems, food safety, nutrition, health, health and development. *Author (2023).*

Food contamination reduce nutrients bioavailability, and this affect health as it leads to malnutrition (Alarcon *et al*, 2021). Malnutrition is a burden to the public health care system. The malnourished populations have compromised immune systems, making way for non-food infections, which may lead to pre-matured death. Nutritional deficiencies and sicknesses lead to low population productivity and loss of income (Hawkes *et al*, 2015).

The health burden of food-borne hazards also affect trade and economic development as unsafe product are removed from markets leading to revenue losses. Food trade policies also plays an important role of ensure trade of safe food and limiting the economic impact of food-borne hazards. The food safety cycle does not only evolve around the food systems but the whole food environment. Improving food safety can have a profound effect on achieving Sustainable Development Goals. Figure 2.2 shows the pathway to impact, synergies and connectedness of food safety, health, nutrition and sustainable development (FAO *et al*., 2020).

2.10 Action for food safety

The action for food safety framework indicates that food safety is an outcome of food systems (WHO, 2022). It is also a system on its own. The food safety system is a component of the food system. It consists of all stakeholder activities in the food and feed chain that safeguard the health and well-being of people, animals and the environment (WHO, 2022).

Resources and role players drive a food safety system. Figure 2.3 illustrates the principle of shared responsibility in transforming food systems towards safer foods. It diverges from the traditional model of official food safety control by the government. This framework emphasises the interdependent roles of consumers, business agencies and the state, with the food safety systems at the centre. This further demonstrates how shared responsibility and stakeholder cooperation can improve resource mobilisation and competencies to ensure adequate food safety systems.

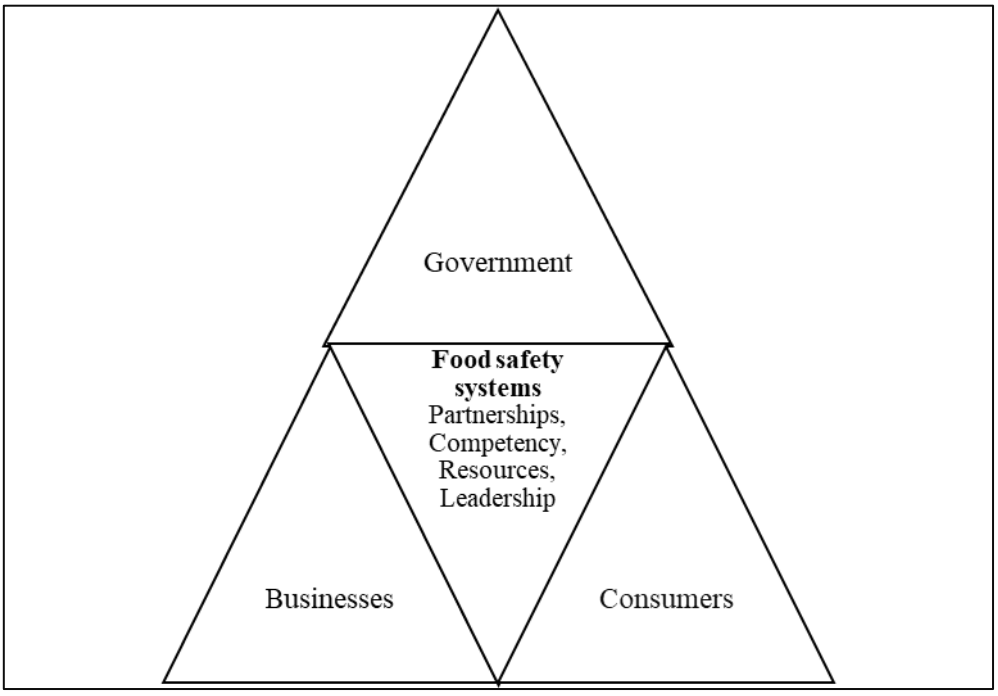

Figure 2.3: Framework for action on food safety, *Adopted from: World Health Organisation (2020).*

Food safety system is shaped continuously by various forces, drivers and structural changes and decisions by many stakeholders that could affect their sustainability. The food safety systems, type and availability of resources affect response to outbreaks. Stakeholder partnerships enable risk-based inspection and enforcement and promote efficient

communication and awareness. Multi-sectoral role players in the food safety system all have a fundamental role in transforming the food systems to ensure sustainable food safety system.

2.10.1 Role of government in food safety systems

Globally, there is a growing awareness of the need to strengthen national food safety systems to promote public health and economic benefits of the safe food supply (WHO, 2022). In South Africa, the government provides leadership on policy and legal frameworks that govern the food safety system, businesses and consumers. For example, the South African government spearheaded the successful regulation of sodium in some food products through the amendment of the Foodstuffs, Cosmetics and Disinfectants Act of 1976 (Hofman and Lee, 2013). The de-regulation of agricultural sector in early 1990's has limited the role of government in agri-food value chain to quality control measures and support on research and technology (Adeniyi *et al*, 2021).

Government should ensure enabling environment for stakeholder partnerships at all levels. Policies which promote the flow of financial, educational and technical resources at appropriate levels for improving systems to ensure food safety across the entire food systems.

2.10.2 Role of consumers in food safety systems

Consumers are also role players in the food safety systems. They protect themselves through their food choices and food preparation practices. However, consumers may not recognise many types of food safety hazards when making food choices or consuming the food (Fanzo *et al*., 2017). Several studies have demonstrated that most consumers have insufficient food safety knowledge (Bashir, 2020; Louw and Van der Merwe, 2020; Imathiu, 2020; Nagaraj, 2021; Thaivalappil, 2020). For the food safety system to work efficiently, consumers need to have sufficient knowledge on food safety in order to play their role.

2.10.3 Role of food business operators in the food safety systems

In low to medium income countries, food business operators are categorised as informal, emerging and commercial business operator. Food business operators bear the primary responsibility of producing safe food for all consumers. In South Africa, since the deregulation of the agri-food sector in early 1990's, the minimalist stance of government in food systems regulations gave the corporate *de facto* power of setting and enforcement of private standards (Adeniyi *et al*., 2021). Small and emerging businesses struggle to participate and benefit from

the food systems due to private regulations pushing them to the informal market (Nyarugwe, 2020).

2.11 Chapter summary

This chapter conducted a literature review on the main concepts in the food safety and food systems. the literature review find that food safety has impact on nutrition, health as well as economic development. the trade policies on food products were also reported to be essential due to the globalisation of the food systems and the recent implementation of the AfCFTA.

The review also finds that food borne diseases affect productivity and present a burden on the health system, thus impacting the attainment of the developmental goals such as the United Nations SDG's. A conceptual framework was developed illustrating the linkages and synergies between the food systems, food safety, food safety systems, health and economic development.

The literature review suggested the need for policy innovation for food systems transformation (WHO, 2022). Hawkes *et al* (2020) suggested that no-regret policy approach can produce resilient policy interventions for food systems transformation. The review reported on the significance of shared responsibility amongst the stakeholders in the food safety system. The actions by government authorities, consumers and food business operators are essential to attain food safety.

Chapter 3: Research Methodology

3.1 Introduction

This section describes the state-of-the-art procedure used to address the research questions of this study. The following sub-sections describe the study area used for the study, research design and approach, the types and methods of data collected and the choice of analysis methods.

3.2 Choice of research strategy

The qualitative exploratory strategy was adopted for this study. Firstly, a systematic review was conducted, followed by completion of an online questionnaire by stakeholders and lastly a validation questionnaire by stakeholders to prioritise identified policy actions.

3.2.1 Data collection for systematic literature review

A structured systematic review was conducted to identify key challenges in South Africa's food systems that constrain the provision of safe food. The transformation of South Africa's food system to enable the provision of safe food for all will entail identifying and prioritising key challenges hindering the provision of safe food, and justifiable no-regret solutions. No-regret solutions are plausible, justifiable options policy makers can consider. The process of identifying no-regret solutions to enable the provision of safe food started by identifying challenges hindering the provision of safe food.

A systematic literature review was conducted to identify (i) challenges hampering South Africa's food systems to provide safe food and (ii) possible solutions. A review was conducted using a standardised systematic review methodology developed by Page *et al*., (2020) referred to as the Preferred Reporting Items for Systemic reviews and Meta-analysis approach (PRISMA). The following sub-sections explains how the identification, screening for eligibility and inclusion of records was conducted for the review, as illustrated in Figure 3.1.

3.2.1.1 Search strategy to identify sources from databases

A search strategy was developed for a literature database using the following keywords: food safety, safe food, food-borne disease, food-borne illness, food systems, food hygiene, food value-chain and food value chain.

These keywords were considered because they were relevant to the food systems concept and the problem of food-borne diseases. A trial search was conducted on 10 August 2021 to

improve search terms and identify synonyms. A Boolean operator keywords and their synonyms were used to broaden the search and yield more results. The Boolean operator "OR" was used to connect synonyms to cover the concept adequately. Table 3.1 lists the keywords and syntax of phrases used to search for literature sources.

Table 3.1: Keywords and syntax used for search of the literature

No	*Keywords and syntax*
1	Food safety OR safe food* OR foodborne disease OR food-borne disease OR food-borne illness* OR safe foodstuff* OR food hygiene
2	Challenge* OR problem* OR obstacle* OR issue*
3	Food system* OR food value-chain OR food value chain
4	2011-2022

Source: Author (2023).

These terms were searched in September 2021 and update in October 2022 across several databases including Scopus (Elsevier Inc., Netherland), Web of Science (Clarivate Analytics., United States), PubMed (United States National Library of Medicine), Google Scholar, Semantic Scholar, Research gate and Science Direct, which are extensively used to produce systematic literature reviews in the field of life, health, and social sciences (Thaivalappil *et al*., 2020). All identified sources were listed to Mendeley (Elsevier Inc.) to remove duplicate and collate the references. A complementary search for grey literature was conducted in October 2022 through Google. The period for grey literature considered for review was also between 2011 and 2022. Grey literature refers to materials produced outside traditional or commercial publishing channels, such as reports, working papers, government documents, conference proceedings and regulatory data (Adams *et al*., 2016).

3.2.1.2 Screening and eligibility for sources to be considered for review

A structured screening form was used to assess the relevance of titles, abstracts and documents identified. The relevance assessment was based on the food safety context and documents issued or published between 2011 and 2022 were considered. Microbial studies that were not directly linked to food systems were excluded. All records identified were loaded to Mendeley software for screening using the above-mentioned inclusion criteria.

The eligibility criteria for reports to be included for review included the following:

- Focus on food safety or food-borne diseases/illnesses in broader context of food systems and food policies globally.
- Provide insight on existing food systems challenges
- Provide insight or recommendation on possible solutions to the challenges in food systems
- Recognition of the need to transform food systems to improve food safety and consumer welfare were considered for review.

Due to the multi-sectoral and inter-connectedness of food systems, reports from any part of the food systems from production to consumption were considered for review. The sources of evidence included journal articles, government papers, and research documents such as dissertations, theses and conference proceedings compiled in English between 2011 and 2022. The reason for selecting this period is that the food system concept is relatively new and still evolving, and Older literature (11 years older) might not give the required information about the concept. All primary research designs were considered including other systematic reviews on food safety.

All records that did not meet the above-mentioned inclusion criteria were considered ineligible and excluded from the review. The total number of records identified from Scopus, PubMed, Web of Science, Research gate, Google Scholar and Sematic Scholar was one thousand three hundred and twenty (1320), an additional one hundred and sixty-eight (168) records were identified from other sources (including grey literature), resulting in a total of 1488. Mendeley removed seven hundred and eighty-two (782) records as duplicates. Five hundred and thirty-eight (538) abstracts were screened and four hundred and fourteen (414) were excluded because they were irrelevant.

A further screening process involved reading abstracts, after exclusion and scrutinising the first few pages for grey literature to determine the content relevance using the above-mentioned criteria. A total of eighty-eight (87) records were retrieved and considered for review. Full texts for the included eighty-eight (87) records were exported to Mendeley and used for systematic review, (Figure 3.1).

3.2.2.1 Identify evidence based expert reports

The first step was to identify expert reports with clearly articulated actions on transforming food systems to improve food safety through a systematic review. A similar search strategy as employed for identifying challenges to the food systems was used to search for expert's reports. The databases searched included Scopus (Elsevier Inc., Netherland), Web of Science (Clarivate Analytics., United States), PubMed (United States National Library of Medicine), Google Scholar, Semantic Scholar, Research gate and Science Direct. Grey literature found from different reliable sources were also included. The inclusion criteria of expert reports with potential solutions included:

- Dealing explicitly with how food systems challenges can be addressed to transform food systems and improve food safety.
- Provides recommendations of policies and actions on transforming food systems to improve food safety.
- Provides an evidence-based review of food safety issues and
- Potential action must be practical and specific to address the problem.

3.2.2.2 Extract recommendations

The identified reports were reviewed in detail to identify relevant recommended actions. Measures that aimed at transforming food systems to improve food safety or reduce the availability of unsafe food and improve food safety culture from farm to fork were extracted. Recommendations with no clear pathway to the provision of safe food were not included. Recommended actions with similar potential effect were combined into comprehensive measures to produce a list of no-regret actions with potential to transform food systems for safer foods. Recommended actions were refined and classified according to their pathway to impact on the food system. A pathway to impact for each action was written indicating how the action will impact food systems, food environment and consumer safety. the recommended actions were used to develop semi-structured questionnaire for stakeholder interviews.

3.2.2 Data analysis from the systematic literature review

The content analysis was used for synthesis using Atlas.ti 9. Atlas.ti is a Computer Aided Qualitative Data Analysis Software used to manage analysis for qualitative data using codes and annotations (Smit, 2002).

The synthesis was conducted in the following manner, recording of details for all identified documents in a table format. The details include the author, title, year of publication (if

published), country or region, recommended action, number of articles for that action and possible impact on the food system. Selective coding was used to categorise recommendations identified during the review by creating segments.

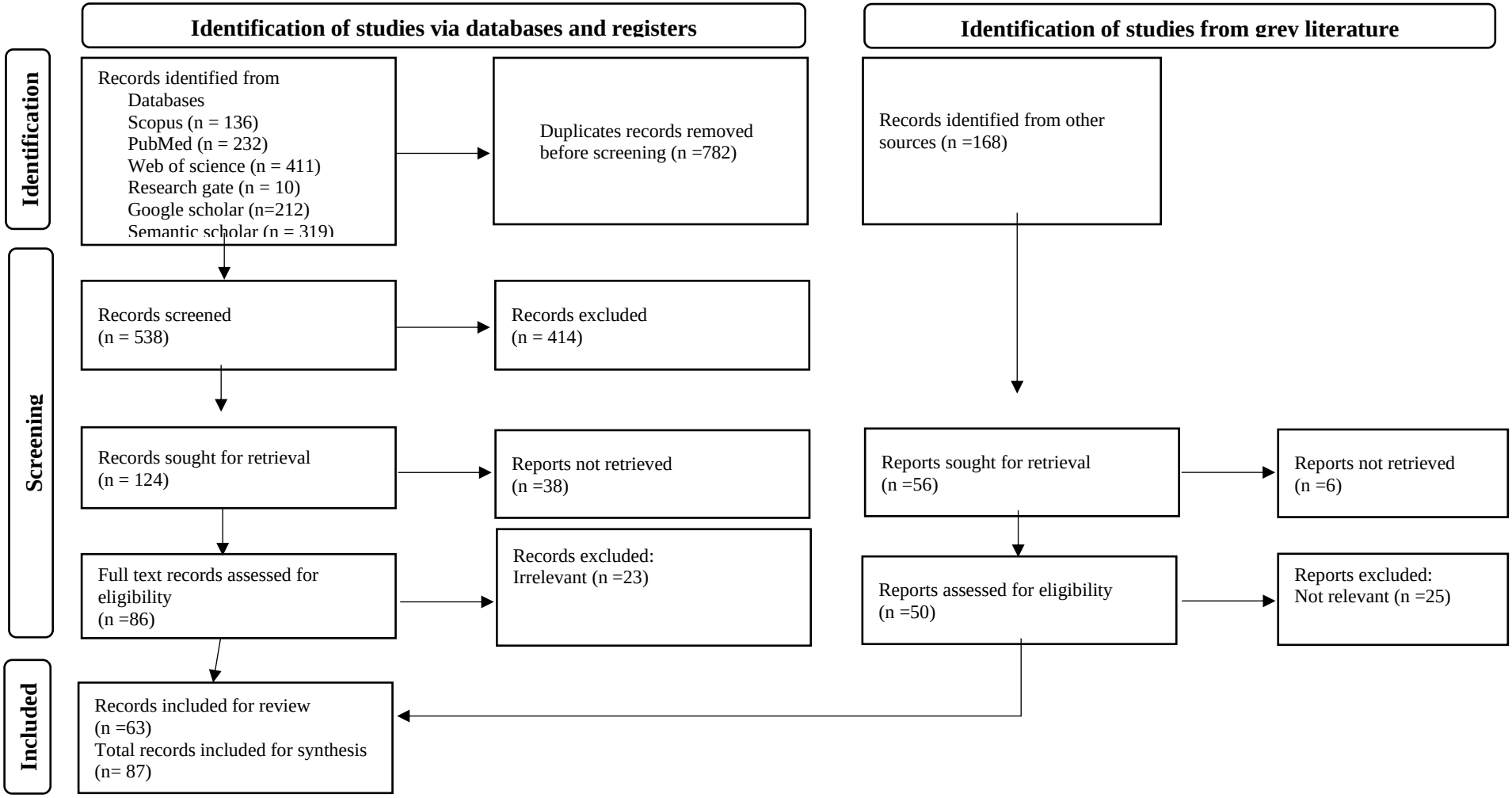

Figure 3.1: PRISMA 2020 Review flow chart for systematic reviews which includes databases, registers and grey literature, *adopted from: Page et al., (2020).*

3.3 Semi-structured online questionnaire

3.3.1 Sampling for online questionnaire

The purposive sampling method was used to identify participants for semi-structured interviews. Purposeful sampling is a widely used technique in qualitative studies for the identifying and selecting information rich participants (Patton, 2002). Individuals were selected based on the assumption that they possess knowledge and experience in food safety and food borne diseases and would be able to provide detailed information. The participants were selected from the larger population because they meet the same criteria. In this case, individuals who are playing a specific role in the food systems or implementation policies related to food systems were eligible and considered information rich. This type of purposive sampling is called Criterion-i sampling (Palinkas, *et al*., 2015).

Stakeholders in the food systems were used as population to identify and select participants for the interviews. Participants were role-players who are doing business or working in the food systems. permission was requested from various organisations and businesses, some participants were directly contacted after getting permission and others were referred by their principals as they were believed to have enough knowledge and experience for the interviews. The above-mentioned criteria was used to select suitable individuals for the interviews. Invitations to participate were sent to selected stakeholders a week before interviews through either email or Short Message Services (SMS). Individuals who were available and willing to participate and expressively share opinions were considered for the interviews. A total of 50 participants were invited for stakeholder questionnaire but only 22 responded and participated in the action ranking questionnaire.

3.3.2 Data collection with online stakeholder questionnaire

The questionnaire and consent form were forwarded to selected participants with instructions for the interviews through Google forms. Informal street food vendors without access to the internet were handed a hardcopy of the questionnaire and a consent form.

The participants were provided with a list of the identified possible solutions from the review in the form of a questionnaire. They were given instructions to select which actions they thought were more practical and likely to have an impact on transforming food systems for a safer food. Actions that the policy makers will not regret implementing them. There were two options for each action to provide top and bottom-ranked actions by ticking either most or least.

Actions that were considered as least were grouped aside and actions that were considered top were also grouped aside.

3.3.3 Analysis of qualitative data from online questionnaire

The qualitative data from the Best-Worst Scaling method was subjected to a hierarchical cluster analysis. Hierarchical clustering uses an aggregate measure of 'most' and 'least' for each attribute. An aggregate BWS score is calculated by subtracting the aggregate 'least' value from the aggregate 'most' value for each attribute (Umberger *et al.*, 2010). de-Magistris *et al*., (2011) reported that the importance of each attribute in a BWS could be easily interpreted by using a standardised interval scale, which is calculated by dividing the square root of the frequency of the best by the frequency of the worst for each attribute. In this way, a scale is created so that attributes with the highest rank (sqrt B/W) become 100 (most important) and all other attributes are measured relative to this attribute. Below is the formula for Best Worst score:

$$\sqrt{\text{Best-Worst scores}} = \frac{\text{No. of times action chosen as Best - Worst}}{\text{No. of times action appears}}$$

The Best-Worst Scaling (BWS) method was used to provide rankings for measures identified through the systematic review. BWS is also referred to as different maximum scaling (Cohen, 2003, cited by Van Schoubroeck *et al*., 2023). The approach was fist pioneered by Louviere and Woodworth (1990) as a choice modelling experimental procedure that requires a list of attributes expressed on a continuum. Van Schoubroeck *et al*., (2023) indicated that BWS could be used as a data collection tool and a theory for respondents to provide top and bottom-ranked items from a list of attributes.

In this study the BWS was used as a method to provide rankings of identified actions from systematic literature review. BWS method was chosen over rating scales methods for several reasons. First, because rating scales do not force participants to discriminate items, it allows participants to indicate that some items are of similar high importance. Secondly, reliability and frequency of rating scales are often unknown (Van Schoubroeck *et al*., 2023). Thirdly, BWS method has been found to achieve the most accurate and reliable data with high level of discrimination between variables (Cohen, 2003, cited by Van Schoubroeck *et al*., 2023). A short-list of top ranked potential solutions were used to develop a questionnaire for validation to be considered no-regret actions.

3.4. Validation for no- regret actions questionnaire

Online self-filling questionnaire was also used to validate the top-ranked potential solutions from the initial stakeholder questionnaire. The questionnaire for validation was developed using the top-ranked actions from the stakeholder questionnaire.

3.4.1 Sampling for validation questionnaire participants

Purposive sampling was used to select participants for validation interviews. The participants were from the same background or industry with similar or related knowledge, expertise and role in the food system. The same participants who were part of the first questionnaire were selected to validate the selections for prioritisation. Participants were categorised as follows based on their role in food systems:

- Farmers or food producers, Food processors, Distribution, Food handler, Street vendors (includes both formal and informal food vendors).
- Researcher and educators, Media and advertising agencies.
- Regulators, Government officials from Agriculture, Rural Development and Land Reform, Health, Trade and Industry and their Inspection or enforcement agencies.
- Food consumers

3.4.2 Online validation questionnaire

Top-ranked policy actions from the stakeholder questionnaire was presented to the participants in the form of a Google form. A set of top ranked and bottom ranked actions was presented to the participants. Participants were asked if they think the ranking reflect their selections, and they were further asked to indicate by making a final vote on the top ranked actions, selecting options they think should be prioritised as no-regret actions. Actions with 100 percent consensus were considered as priority or no-regret actions.

3.5 Reliability, believability and validity of instruments

The instruments used for this study are valid and reliable. A structured systematic review strategy adopted from Page *et al*., (2020) was used for data collection. *Atlas ti*. was used for analysis of data from the review. Records for systematic review was collected from trusted online sources and were attached as appendix for believability. Participants for the semi-structured online questionnaire were credible stakeholders in the food systems. Credible in a sense that they were active role players in their respective sectors of the food systems. some of

them were referred by their principals who know their knowledge and experience in the food systems.

3.6 Ethical considerations

The nature and purpose of the interviews were explained to the participants during the initial invitation. The first invitation included the consent form and the information leaflet. The online questionnaire was only sent to participants who completed the consent and willing to participate. Participants were made to understand their role in transforming the food system at the beginning of the interviews by explaining to them how the food systems work within the food environment. The role and significance of each role player were presented to participants. Ethics approval from the university with reference number NAS260/2021 was requested for this task to ensure confidentiality, anonymity and privacy. Participants were informed that their participation was voluntarily, and that their personal information will not be disclosed. Their role in the food system and demographic information will be recorded and used for analysis.

3.7 Chapter summary

The chapter described the procedures used to collect and analyses data from different sources to synthesise recommended policy actions and identify potential solutions to food safety challenges in the South African food systems. The chapter gave a description of the study area, and research approach used as well as the type of data collected and how it was analysed.

The data from various sources was collected in three stages. Data from online databases from all over the world as collected through a structured review. Semi- structured online questionnaire was used to collect data from stakeholders in the South Africa's food systems to identify potential actions and to validate no-regret actions to transform the food systems to enable provision of safe food.

The chapter also described the ethical considerations for the study. The reliability and validity of instruments and methods used was also explained in this chapter.

Chapter 4: Results and Discussions

4.1 Introduction

This chapter describes the findings of the study in four sub-sections. The first sub-section illustrates the chapter and then describes the findings of the systematic review conducted to identify challenges hindering the provision of safe food in the second sub-section. The third section demonstrates the potential solutions identified from the reviews and their connectedness. The final sub-sections describe the findings of the prioritised options from the stakeholder's discussion to ensure food systems provide safe food in South Africa through stakeholder engagement.

4.2 Key challenges hindering food systems from providing safe food

A total of 192 quotations on challenges hindering the provision of safe food in food systems were generated using a selective coding system, producing a total of 34 challenges after analysis (Figure 4.1). The identified challenges varied considerably in terms of area of focus in the food systems.

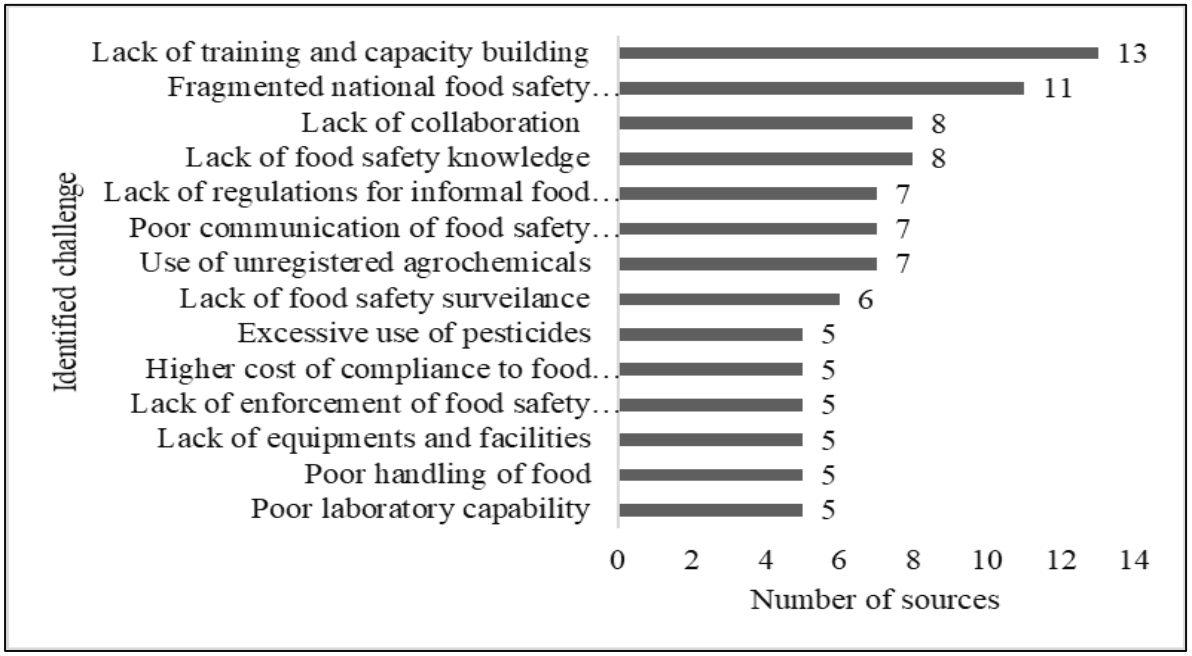

Figure 4.1: Key challenges cited in five or more records, *Author (2023).*

4.2.1 Training and capacity building

Thirteen records (37 %) cited the lack of training and capacity building as the leading constraint hindering food systems in providing safe food, as illustrated in Figure 4.1.

This finding concurs with Boatemaa *et al*. (2019), who cited the lack of training on food safety as one of the major challenges in South Africa's food retail sector. Most role-players (60 %) in the food systems do not have adequate knowledge of food safety risks. The lack of knowledge of food-borne diseases and their clinical signs can be attributed to the under-reporting of food-borne diseases.

4.2.2 Fragmented institutions

As shown in Figure 4.1 a total of nineteen records (21.8 %) from the review cited institutional challenges such as fragmentation and lack of stakeholder collaboration within the food systems. Poor stakeholder collaboration is attributed to failures of the food system to provide safe food. The fragmentation of structures, functions and legislations with overlaps and gaps makes it difficult for stakeholders to communicate and manage food safety risks (Pereira and Drimie, 2016). As a result, stakeholders often operate in silos making very little success. Eight records (9.1 %) cited lack of collaboration as one of the institutional challenges leading to poor communication between structures and role players. In addition, the lack of collaboration limits the ability to manage risks and outbreaks related to food safety.

4.2.3 Regulation of farm inputs

Two records (2.2 %) reported poor regulation of farm inputs as one of the challenges affecting food safety. Poor monitoring and enforcement of regulations on of farm inputs could lead to the use of unregistered pesticides, and irresponsible use of pesticides. One record (1%) cited outdated legislation as a challenge that makes it difficult to manage food safety risks. Most of our regulations related to food safety are outdated and need to be revised to address risks related to food safety. The South African Department of Agriculture, land reform and rural development (DALRRD), formerly the Department of agriculture forestry and Fisheries (DAFF) 2016, presented a National Policy on Food and Nutrition to create a central food safety control system. Still, there is no legislation to combine and centralise the functions of DALRRD, the Department of Health (DoH) and the Department of Trade and Industry (DTI) into one entity that will prioritise food safety systems.

4.2.4 Inspection

Five records (5.7 %) reported poor enforcement of existing regulations and lack of regulation for food handling and distribution as a hindrance to ensuring the provision of safe food. This report concurs with Grace (2015) that the domestic food safety enforcement capacity in developing countries is weak. Jaffee *et al*. (2019) also reported that developing countries often prioritise the enforcement of food produced for export markets. It is, therefore, imperative for developing countries to develop approaches and models that are implementable within our food systems and regulatory environments to promote the safety of food for domestic consumption.

4.2.5 Policy and governance

The regulatory environment and governance structures play a vital role in shaping food systems. Government policies, legislation, and institutions influence agricultural practices, trade, and food security. Effective governance is crucial for addressing challenges and fostering sustainable development in the food sector.

Seven records (8%) reported that poor regulation of informal street food vendors and traditional domestic foods present food safety risks. The traditional slaughtering of animals was reported as a significant risk for zoonotic transmission during the slaughtering and consumption of meat. Enforcement of the Meat Safety Act often focuses on the formal market. However, Grace *et al*., 2015 argued that food sold in the informal sector is not always unsafe. Few studies have compared the safety of food sold in formal and informal markets. They often find that food sold in formal markets is not always safer or sometimes worse than food sold in the informal markets (Roesel and Grace, 2014). Therefore, regulating the informal street food vendors is essential but will not necessarily improve food safety.

One record from the review reported that grains used for home–brewed traditional beverages are often contaminated with mycotoxins (Ezekiel *et al*., 2018). Still, there are no regulations in place targeting traditional beverages to reduce the risk of mycotoxins. A recent study in South Africa reported that mycotoxins found in maize used for brewing traditional beer is linked to the prevalence of Oesophageal Cancer in the Eastern Cape Province (Nji, *et al*. 2022). The existing fragmentation and gaps in food regulations make it challenging to regulate and ensure the safety of traditional grain-based beverages. For example, there is poor co-ordination on enforcement of the Liquor Products Act enforced by the Department of Agriculture, Land Reform and Rural Development and the Liquor Act enforced by the South African Police

Service. These legislation focuses more on access and distribution of alcoholic beverages, not safety.

4.2.6 Agricultural production

South Africa's food systems begin with agricultural production, which includes a mix of large-scale commercial farming and smallholder production. Production of various crops, livestock, and aquaculture contribute to the nation's food supply.

Twelve records (13.7%) reported agricultural challenges such as the use of unregistered agrochemicals and excessive use of pesticides at the farm level as a challenge to food safety. Using unregistered chemicals poses a serious risk to the product's user, environment and consumer, as the safety of the chemicals used is often unknown. In South Africa, the use of unregistered chemicals may be attributed to the cost of agrochemicals, as the unregistered chemicals cost less than the registered chemicals.

The excessive use of antibiotics in farm animals may lead to antimicrobial resistance. Besides resistance, they may remain in the product at higher levels, posing a health risk to the consumers (FAO, 2019). Pesticides and chemicals used for artificial fruit ripening also contribute to food safety risks due to high levels of residues in food products (Aworh, 2021).

4.2.7 Research and technology innovations

Five records (5.7%) cited challenges related to research and technology such as poor laboratory capabilities due to a lack of facilities and low technology adoption. The South African national microbial and residues monitoring program is run by the Department of Agriculture, Rural Development and land reform, with only two laboratories in Pretoria and Stellenbosch. This led to the testing of animal products at farms, abattoirs and packing stations. Three records (3.4%) reported low adoption of sophisticated technologies for effective fresh produce decontamination to reduce risks related to excess chemical residues (Aworh, 2021).

Another challenge related to research that was reported in one record from the review was the lack of food safety indicators. The lack of appropriate food safety indicators contributes to difficulties in managing food safety risks. Appropriate indicators could be developed through technological discussion at international level (WHO-Technical Advisory Group, 2021) The integration of technology and innovation is transforming South Africa's food systems. From precision agriculture to digital platforms connecting producers with consumers, technological advancements play a role in improving efficiency of food safety systems and reducing waste.

4.2.8 Distribution and supply chain

The distribution and supply chains in South Africa's food systems involve the transportation, storage, and retailing of food products. This includes the movement of goods from farms and processing facilities to markets, grocery stores, and ultimately to consumers.

Three records (3.4%) mentioned food supply challenges such as food fraud, with activities ranging from selling expired food to wrong and misleading labelling and ambiguous origin of food from labelling on imported foods. Food fraud is emerging as a serious problem in South Africa's food systems. Another supply chain challenge mention in three records (3.4%) included chemical residues in food as a problem. The excessive use of chemicals during the decontamination of fresh produce at pack houses may lead to unacceptable levels of chemical residues in food.

4.2.9 Financial investments

Three records (3.4%) from the review reported financial and investment challenges such as inadequate financial investments as a contributing issue to food safety risks. Lack of financial investments often leads to a lack of equipment and facilities required to manage food safety risks. Another issue cited as a contributor to the funding problem is the lack of food safety indicators, which makes it challenging to identify priority areas for funding interventions to reduce food safety risks (FAO, 2019).

4.2.10 Connectedness and linkages of identified challenges

The challenges identified from the review were mostly connected or interrelated. the challenges identified from the review were mostly connected or interrelated. These challenges have causal as well as association relationship, indicating that one problem is the result of the other, i.e. the lack of knowledge by farmers may result in the excessive and irresponsible use of pesticides which may lead to chemical residues in the food product. The lack of a regulation of farm inputs and enforcement may lead to the use of unregistered agrochemicals during food production, which may lead to unsafe food production (FAO, 2019; Aworh, 2021).

Many countries, including South Africa, are now facing a triple burden of malnutrition. The triple burden of malnutrition is the co-existence of undernutrition, overweight and overnutrition within the same country, community or even within the same individual at the same time (UNICEF, 2021). The triple burden of malnutrition is a good example of the inter-relatedness and connectedness of challenges which cannot be solved in isolation. The same applies to the

food safety challenges. Food safety challenges not only exist or affect the food product but involve the agricultural inputs, consumer practices and behaviour, food value chain practices, preparation and consumption of food and disposal of food waste. The effectiveness of the systems around each stage is significant in managing the food safety challenges throughout the food systems. Food-borne diseases result from many connected challenges hindering the food system from providing safe food.

4.2.11 Geographic locations of identified challenges

The sources used for this systematic review had a broad geographic focus. When South Africa was included as a keyword during the literature search few records were yielded, but when South Africa was removed, it produced many results to review. Although South Africa was removed as a keyword in the search string, most of the records included for review (43%) were from South Africa. 21% of the records were focused on the global level, followed by the African continent, with 9% of the included records. Figure 4.2 summarises the geographical focus of studies included in the review.

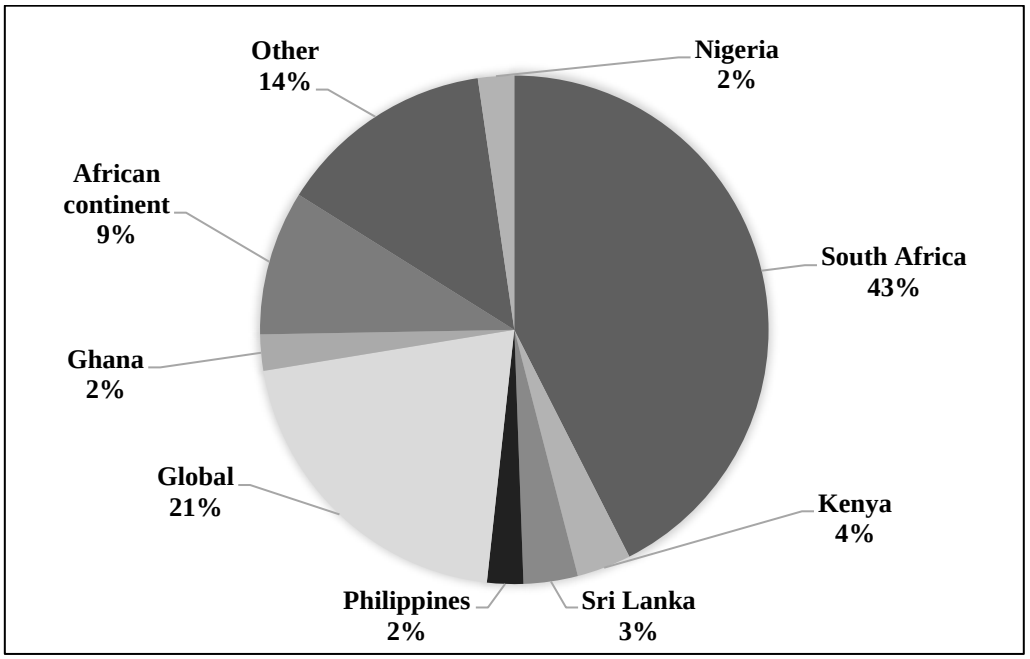

Figure 4.2: Illustration of geographic focus of the reviewed records, *Author (2023).*

Most of the literature in the review focused on the African continent and South Africa. This was unsurprising as the Havelaar *et al*., (2015) report suggested that one-third of the global death toll for food-borne diseases was in Africa. Havelaar *et al*., (2015) further reported that 91 million people fall ill and 137 000 die annually in Africa. Therefore, the availability of literature on food safety in South Africa can be a sign of positive work towards policy development to improve food safety.

4.3 Solutions to constraints of safe food provision in South Africa.

There is a consensus that most developing countries cannot ensure safe food for both domestic and international consumers. However, food-borne diseases are preventable and can be managed with sound policies and approaches (WHO, 2022). Most developing countries have adopted standards and approaches to improve food safety from the developed countries. Approaches such as farm-to-fork, risk analysis, Global GAP and HACCP were adopted but only implemented primarily in the formal sector for exported foods. Therefore, there is a need for developing countries to develop policy options and implementation approaches that are suitable for our food environments. The following section discusses the identified possible solutions from the review analysis.

Following the identification of food safety challenges through the PRISMA systematic review, the methodology adopted by Hawkes *et al*. (2020) was used to identify possible solutions to the identified food safety challenges hindering the provision of safe food. A total of Eighty-seven 87 records were analysed using *Atlas.ti*. A total of thirty-four (34) potential actions were identified through the systematic review as possible solutions. The consolidated solutions with more than one solution to food systems problems are illustrated in Figure 4.3.

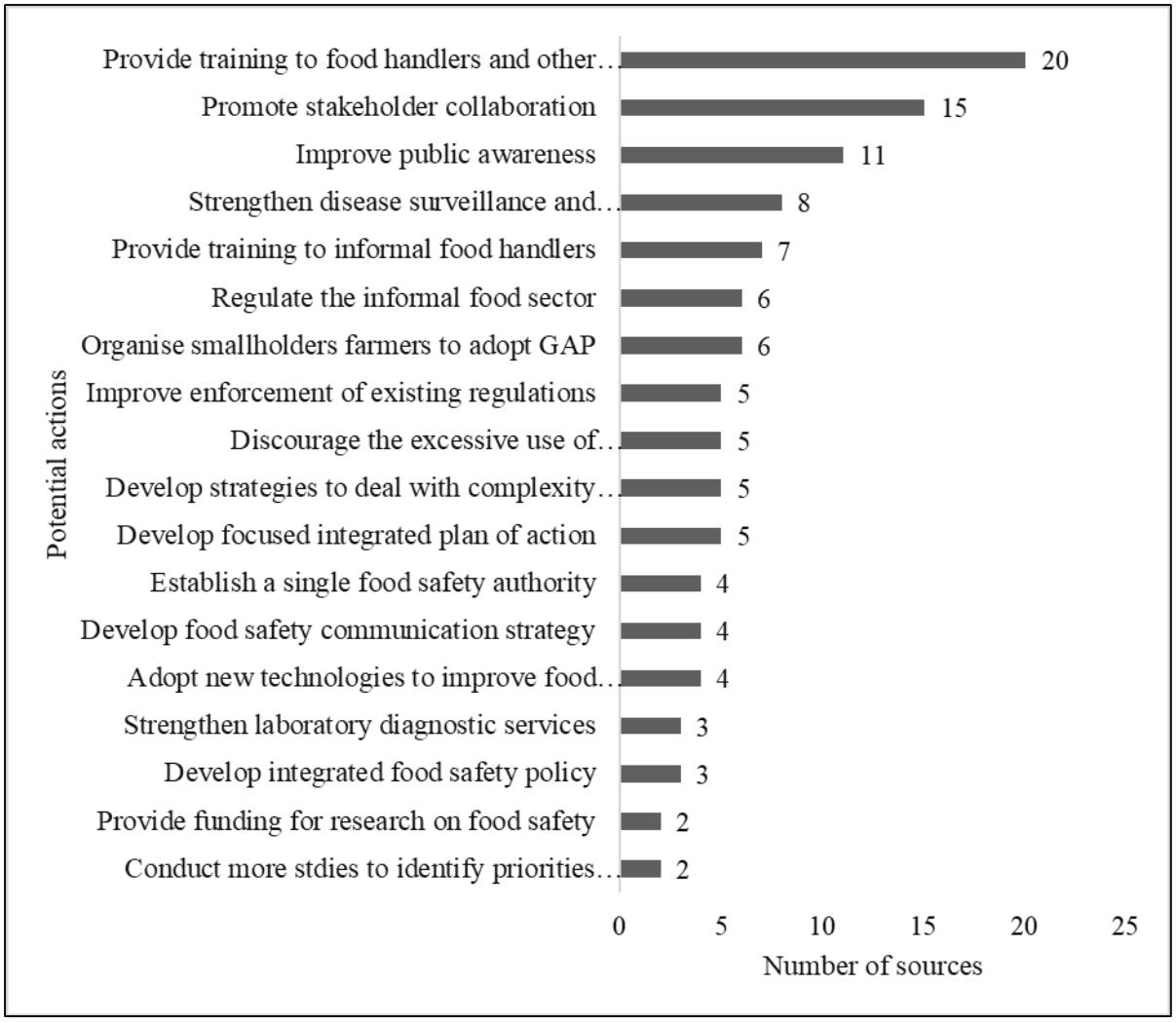

Figure 4.3: List of identified potential solutions to constraints to safe food provision, *Author (2023).*

The following sub-sections discuss key thematic areas from the *Atlas.ti* analysis reflecting the recommendations of potential solutions.

4.3.1 Agricultural actions

Several agricultural actions were identified as potential solutions to ensure safe food production. Out of Eighty-seven records (87), Six (6) records from the review recommended that organising smallholder farmers in associations and promoting the adoption of global best agricultural practices (GAP) can ensure the production of safe food. Several developed countries have managed to reduce food-borne diseases quickly by reducing contaminations at the farm level (Grace, 2015). Therefore, promoting the adoption of GAP is likely to reduce contaminations and contribute to improved food safety. However, some reports suggest a low

impact of GAP on domestic food safety compared to food produced for export (Grace, 2017; Sun *et al*., 2021). The low impact of GAP on local food safety can be attributed to the lack of incentives for domestic producers.

Five (5) records from the review reported that discouraging the excessive use of agrochemicals can produce safe food. This involves changing the mind-set of farmers on the use of chemical fertilisers and pesticides and implementing strict measures to curb the irresponsible use of antibiotics at the farm level.

4.3.2 Education, training and public awareness actions

Most of the reports from the review focused on education, training and public awareness. Twenty (20) records out of 87 records suggested that providing food safety training to food handlers and other role players in the food systems is likely to improve food safety.

New food safety training and communication strategies are needed to improve the management of food safety hazards (Boatemaa *et al*., 2019, Mabaso *et al*., 2021). Providing effective continuing education to all role players in the food system, including consumers, can help to improve food safety knowledge and develop a food safety culture. Abdelradi *et al*. (2021) suggested that integrating food systems concepts in school curricula may improve understanding of the drivers and complexity of the ever-changing food systems.

Training initiatives have been shown to be effective in improving food safety in some countries. For example, a training initiative in Ibadan improved meat quality and reduced the cost of human illness by US$780 per butcher per year (Grace *et al*., 2015). However, they mainly focus on training farmers and food processors on chemical quality and safe use (Grace *et al*., 2015. Training initiatives pay very little attention to consumers, which may have contributed to the under-reporting of food-borne diseases in developing countries, particularly the African continent.

The is a need to develop a food safety communication strategy to promote reporting, diagnosis and handling of food-borne diseases. The underreporting of food-borne diseases in developing countries (Havelaar *et al*., 2015) often complicates linking food contamination with diseases or mortality.

Only two (2) records from the review recommended financial actions. A report by DAFF, DoH and DTI (2013) recommended that the provision of funds for research on food systems transformation could enable the development of better food safety strategies.

Creating a research funding base for policy development will improve food safety policy innovations (Abdelradi *et al*. 2021). The provision of funding for research would also allow feasibility studies on different models of institutional arrangements with a centralised food control system.

Investments in street food vending facilities may enable the provision of safe food for most consumers. Better infrastructure is needed to improve how food is handled, stored, sold and consumed in the informal sector. However, Grace *et al*. (2015) cautioned that infrastructure provision should not be seen as a solution to food-borne diseases. The provision of infrastructure to improve food safety in the informal food sector is expensive and has been reported to have a low impact on food safety. WHO and FAO have developed several programmes to improve food safety in the informal sector concerning infrastructure provision, but they were difficult to implement and had a low impact (WHO, 2011; 2022; Henson *et al*, 2023). Funding research on policy development may produce food safety strategies that are implementable to transform the food systems effectively.

4.3.3 Public institutions actions

Fifteen (15) records from the review were of the view that the promotion of multi-stakeholder engagement and consultations at all levels might improve efforts to identify food safety problems and possible solutions with mutual accountability. Several studies have reported that policies and programmes within the food systems in South Africa are fragmented and lack integration. The fragmentation of policies and programmes often leads to role players operating in silos, thus impacting outcomes.

The report by DoH, DAFF and DTI (2013) further supported the idea that developing strategies to deal with the complexity of food systems, such as developing formal agreements on food safety standards between authorities and unregulated industries, might contribute to food safety in the absence of regulations.

Four (4) records from the review have supported the establishment of a single food safety authority with a focused integrated plan of action. A single central food safety authority will improve collaboration and shorten the response time for tracing and recalling food products during outbreaks. For example, in South Africa, there are three government departments with pieces of legislation to manage food safety but operating in silos with little success (Boatemaa *et al*., 2019).

4.3.4 Supply chain actions

Four (4) actions were suggested for challenges related to the food supply chain. Actions such as the development of food product tracing systems, food product tracing systems will reduce the availability or marketing of fake and unsafe food.

One (1) record was proposed for increasing access to clean water to improve hygiene in the post-harvest food handling, processing and manufacturing (Thompson, *et al*. 2021). Access to clean water has always been attributed to hygiene. Food processing, manufacturing industries, and domestic food preparation need clean water to provide safe food.

One (1) record mentioned that mild preservation and disinfection of food to reduce the chemical residues in food, thus reducing chemical hazards. The record further indicated that adopting new sophisticated sorting and cleaning technologies could be employed to reduce grain contamination with toxins. The adoption of new techniques could lead to a reduction in the use of chemicals for disinfection.

4.3.5 Regulatory and enforcement

The review analysis produced several potential regulatory and enforcement actions that can be implemented to transform food systems to provide safe food. Six (6) records suggested the regulation of the informal food sector to improve food safety. This attributes the under-regulation of the informal sector in South Africa to the consumption of unsafe food.

There is a common belief that many challenges in the food systems, including food-borne diseases, can be alleviated by regulating and formalising the informal food sector. Although, few studies have reported that food sold in the formal sector is not always safer than food sold in the informal sector (Aduah *et al*., 2021). A South African study reported that informal street food vendors could produce safe food with low bacterial counts (Von Holy and Makhoane, 2006). The regulation of the informal sector could reduce the dumping of unsafe food rejected in formal markets into the informal markets. Therefore, regulating the informal food sector can protect many poor consumers who rely on the informal markets for daily consumption.

On the other hand, one (1) record suggested that regulating and screening food raw materials to reduce food hazards in the food value-chain. The mandatory screening of food raw materials could prevent the spread and distribution of food-borne pathogens to other parts of the food systems. For example, if mycotoxins are detected at the farm level, measures could be put in

place to prevent them from entering the food value-chain. However, this approach mainly applies to formal or commercial industries where enforcement is easy.

Three (3) records from the review cited that enforcing existing regulations could improve food safety. However, they did not clearly indicate how enforcement of existing regulations can be improved.

Reviewing the legislative framework could assist in establishing a single food safety authority to develop an integrated food safety policy and robust inspection system. Hence, one (1) record suggested the review of the agricultural and food legislative framework. The current food safety legislative framework has overlapping and sometimes conflicting roles for government departments responsible for food control.

One (1) record from the review suggested the introduction of mandatory medical examinations for all food handlers with clinical signs of contagious diseases (Government of Republic of South Africa, 2012). The mandatory testing of people with clinical signs has proven to help reduce communicable diseases during the Covid-19 pandemic. Although, during the Covid-19 pandemic, the transmission of the pathogen with food was not given enough attention.

One (1) record from the review cited the statement made by the Sri Lankan government (Canfield *et al*., 2021) indicating that they would develop legislations to restrict the importation of pesticides and chemical fertilisers to reduce the hazard of chemical residues in food products. In South Africa, it would be challenging to discourage the use of pesticides and chemical fertilisers as most of the population is based in urban areas and rely on foods produced on commercial farms. The producers in South Africa are under pressure to produce enough food to meet the higher demand. Therefore, using agrochemicals to control pests and diseases improves yield or productivity to meet the higher demand for food.

One (1) record suggested the review of the legal definition of food and its explanation. The review and explanation of the definition of food could promote the regulation of all food substances. For example, it is unclear whether a plant is considered food after harvest. For this reason, some traditional beverages remain unregulated and continue to pose food safety hazards to consumers. The clear and well-explained definition of food would also help include all food handlers in risk communication and develop food safety strategies and training initiatives for food handlers.

4.3.6 Research and technology actions

A total of fifteen (15) research and technology actions were generated after *Atlas.ti* analysis. Four (4) records from the analysis recommended the adoption of new technologies to reduce food contamination at the farm level. The adoption of new technologies has the potential to reduce food-borne diseases. In addition, rapid, competent and reliable methods of detecting and identifying pathogens at the farm level could reduce the spread of food-borne pathogens beyond the farm level, thus keeping many food handlers and consumers safe.

Five (5) records suggested more research on developing strategies that could deal with the complexity of food systems. The complexity of food systems in South Africa has made it challenging to develop effective food governance policies. Dealing with complexity will enable the development of integrated strategies to manage risks associated with food safety.

One (1) record cited promoting pro-active participatory research as a tool to develop food safety policies instead of reactive research. Promoting proactive and participatory research would lead to developing policies that respond to the needs of the people and systematic challenges, not only solving the identified problems. In addition, participatory research would provide data to enable policymakers to develop evidence-based policy interventions.

One (1) record recommended research to improve the detection and identification of food-borne disease pathogens in food products. Quickly identifying pathogens during outbreaks could enable proper communication and implementation of appropriate risk management strategies.

One (1) record cited the need for research to develop protocols to detect Covid-19 in food. However, during the Covid-19 outbreak in 2020, very little attention was given to studying the transmission of the virus through food. Research on developing antigens to detect SARS Covid-19 in food could have prevented the distribution and marketing of contaminated foods.
One (1) record reported that conducting more research on the impact of labelling and marketing fake foods on food safety could help develop risk management strategies. The impact of poor labelling and food fraud on public health in South Africa remains unknown. Therefore, studies on quantifying the impact and extent of food fraud could assist in allocating resources for proper interventions.
Two (2) records recommended more studies on identifying priority areas for interventions. Currently, there are no indicators for food safety. Research on developing indicators for food safety would help set priority areas for food safety risk management.

From the thirty-three (33) potential actions identified from the review, only eleven (11) were recommended more than five (5) times. The provision of training on food safety to food handlers and other role players was recommended in twenty (20) records. Fifteen (15) records recommended the promotion of multi-stakeholder collaboration and consultations to improve food safety. Eleven (11) records reported that improving public awareness of food safety issues is essential. Eight (8) studies suggested strengthening food-borne disease surveillance and monitoring to detect unreported cases and quantify the national burden of food-borne disease. Six (6) studies recommended the regulation of the informal sector and encouraging smallholder farmers to adopt GAP.

4.3.7 Thematic focus of the systematic review records

The food systems concept is comprehensive and inter-disciplinary. The included records were categorised into seven (7) overarching themes as illustrated in Figure 4.4. These are agricultural, finance, supply chain, legal and regulatory, public institutions, research and technology and education, training and public awareness.

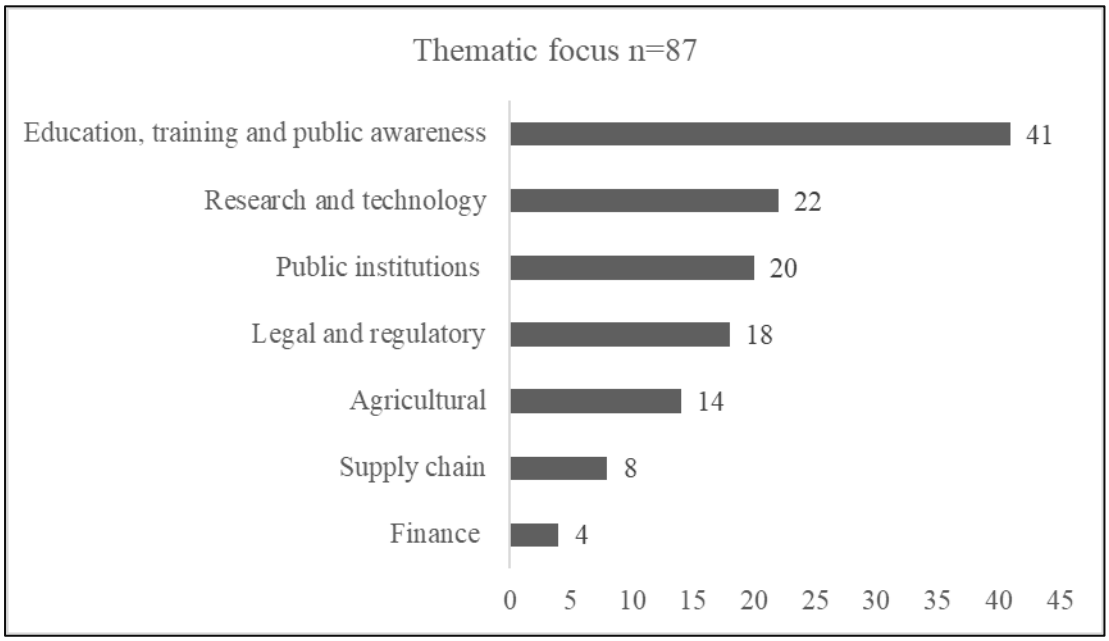

Figure 4.4: Illustration of thematic focus of the systematic review records, *Author (2023*).

. Out of the eighty-seven (87) included for systematic review, Forty-seven percent (n=41) focused on education, training and public awareness issues. Twenty-five per cent (n=22) focused on research and technology issues. Twenty-two per cent (n=20) focused on public institutions. Twenty per cent (n=18) focused on legal and regulatory actions. Sixteen per cent

(n=14) focused on agricultural actions. Nine per cent (n=8) focused on the supply chain. Four and a half percent (n=4) of the reviewed records focused on financial actions.

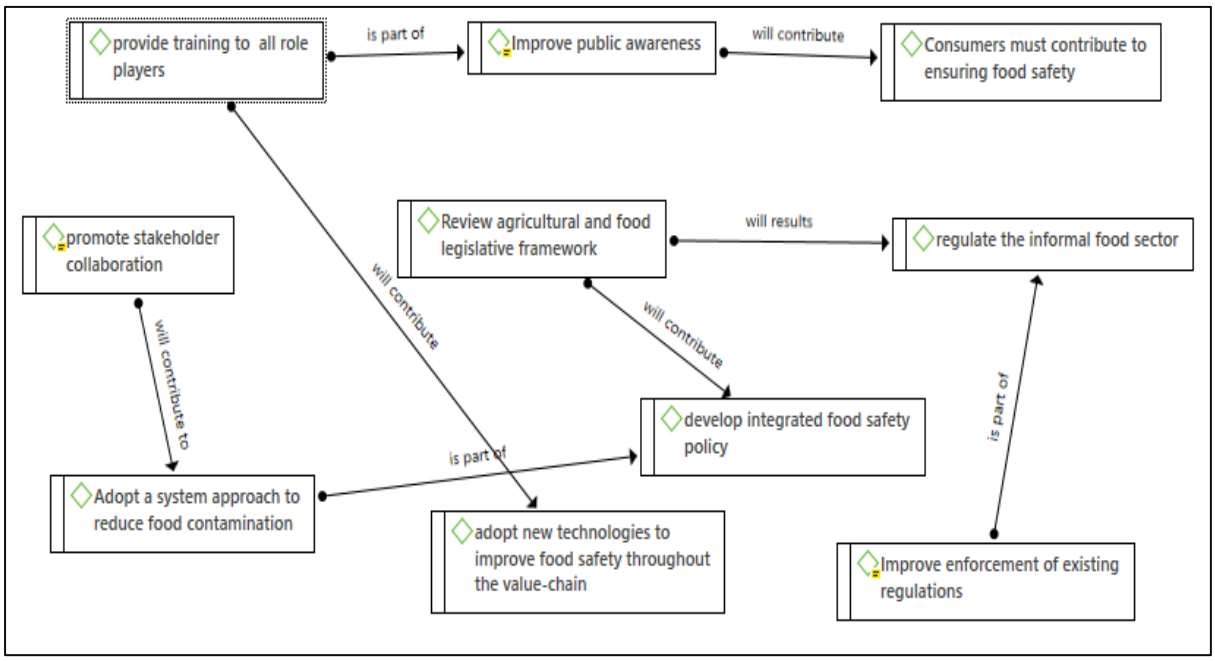

Figure 4.5: Network illustrating linkages and pathway of recommended actions, *Author (2023).*

Most of the recommended solutions are linked to each other and have similar pathways to impact, as illustrated in Figure 4.5. For example, funding for research in food safety policy development will enable the development of food safety indicators, identification of priority areas for interventions and development of focused integrated food safety policy.

Promoting stakeholder engagement and consultations may lead to adopting a systems approach with a focused integrated plan of action involving all stakeholders. An integrated plan involving all role players may improve awareness of the significance of food safety, adoption of food safety culture, and improve enforcement of regulations due to improved co-operations between the authorities and role players.

Consultation of stakeholders at all levels improves the awareness, which may result in consumers contributing to ensuring food safety. Informed consumers are likely to contribute to promoting safety of food (Boatemaa *et al*. 2019).

4.4 Potential solutions identified from semi-structured stakeholder interviews

4.4.1 Proportional representation of participants according to their sector

Semi-structured stakeholder interviews were conducted using online forms to provide a ranking of the recommended actions from the systematic review. This sub-section reports on the outcomes of the stakeholder interviews. The interviews participants consisted of stakeholders from various sectors of the food systems as illustrated in Table 4.1.

Table 4.1: Proportional representation of participants according to their sector

Name of industry or sector	***n=22***	***Percentage***
Regulators, Government officials, Inspection and enforcement agencies	8	36.4
Researchers, Academics, Educators, Media and advertising	6	27.3
Farmers or Food producers, Food processors, Food handlers, Distributors, Wholesalers and Street vendors	5	22.7
Food consumers	3	13.6

Source: Author (2023).

4.4.2 Rankings of actions by votes percentage, and BW score

Thirty-four potential solutions identified from the systematic review analysis were presented to the participants in the google form format to select actions that could transform the food systems for a safer food system. The outcome of the actions rankings is illustrated in Table 4.2 below as top and bottom ranked actions. The average percentage for Most votes was 82.4 percent. Actions with above average votes were considered top ranked, and those with below average were bottom-ranked, as shown in Table 4.2. Only seventeen potential actions (50 %) were considered top ranked actions using the Best-Worst scores.

Seventeen actions (50 %) were voted as actions with least potential to transform the food systems for safer food systems. Below is the discussion on thematic representation of the ranked actions.

Table 4.2: Ranking of actions by votes percentage and BW score

Actions	**Most votes %**	**Least votes%**	**BWS score**
Researchers should collaborate on developing pro-active food safety strategies	95.5	4.5	0.90
Mandatory and regular health screening of food handlers	90.9	9.1	0.81
Improve enforcement of existing policies and regulations.	90.9	9.1	0.81
Develop strategies and programmes to control sale of fake foods.	90.9	9.1	0.81

Actions	Most votes %	Least votes%	BWS score
Strengthen food-borne diseases surveillance and early warning systems	90.9	9.1	0.81
Develop food safety communication strategy	90.9	9.1	0.81
Use of visible, easy to understand food labels and media tools to improve public awareness on food safety	90.9	9.1	0.81
Develop strategies to deal with complexity of food systems	90.9	9.1	0.81
Conduct more studies to identify priorities for interventions	90.9	9.1	0.81
Organise smallholder farmers into associations to adopt global best agricultural practices	90.9	9.1	0.81
Adopts new technologies for testing, monitoring and tracing in food system	86.4	13.6	0.72
Strengthen laboratory diagnostic services	86.4	13.6	0.72
Train food handlers and all other role players in the food systems	86.4	13.6	0.72
Provide food safety training to informal food handlers	86.4	13.6	0.72
Increase access to clean water to promote Good Agricultural Practices (GAP)	86.4	13.6	0.72
Conduct more research studies on the use of food safety information labels and observational studies	86.4	13.6	0.72
Establish central food safety authority to deal with all import, export and local food control to protect consumer	86.4	13.6	0.72
Establish specialised laboratories for analysis of food safety hazards.	86.4	13.6	0.72
Revise agricultural and food legislative framework and develop a National policy on food safety	81.8	18.2	0.63
Improve hygiene in post-harvest handling, processing and manufacturing practices	81.8	18.2	0.63
Adopt new technologies to reduce contamination at farm level.	81.8	18.2	0.63
Provide funding for research on food systems transformation	81.8	18.2	0.63
Create funding base to support research on food safety policy development	81.8	18.2	0.63
Develop industry-led food safety culture	81.8	18.2	0.63
Adopt whole systems approach to reduce food contaminations	81.8	18.2	0.63
Develop legislation to recognise and regulate informal food sector	81.8	18.2	0.63
Develop food product tracing systems	77.3	22.7	0.54
Conduct in-depth food systems assessment to complement food safety risk analysis and strengthen institutions	77.3	22.7	0.54
Mild preservation and disinfection to reduce chemical residues in food products	72.7	27.3	0.45
Promote multi- stakeholder engagement and dialogues at all levels	72.7	27.3	0.45
Regulate raw materials and food ingredients	72.7	27.3	0.45
Restrict importation of pesticides and chemical fertilizers	57.1	42.9	0.13
Develop sensory protocol devices to detect the SARS-Covid-19 in food products.	57.1	42.9	0.13
Discourage excessive use of agrochemicals	57.1	42.9	0.13

Source: Author (2023).

4.4.2.1 Agricultural actions

Four agricultural actions were included in the interviews for ranking, two of them (50 %) were top ranked. The top ranked actions are the organisation of smallholder farmers into associations to adopt GAP and increasing access to clean water to promote GAP with 90.9 % and 86.4 % for "Most votes", respectively.

4.4.2.2 Research and Technology actions

The research and technology theme was the most successful in the rankings with six out of seven (85 %) actions ranked as the most potential actions to transform food systems. The collaboration of researchers to develop pro-active food safety strategies was the most voted action with 95.5 % for most votes and BW score of 0.90 %. The other top-ranked actions under this theme were conducting more studies to develop priority areas for interventions, observational studies on information labels and complexity of the food systems, adopt new technologies for testing, tracing and monitoring in the food systems, and strengthening laboratory diagnostic services to improve food safety.

4.4.2.3 Education, training and public awareness

The actions under the education, training and public awareness theme had three actions out of four (75 %) ranked as potential no-regret actions. Potential actions under this theme include providing food safety training to all food handlers and role players in the food systems and promoting public awareness by developing food safety communication strategy. The use of visible, easy to understand food labels and media tools were also ranked as a potential action to promote food safety awareness.

4.4.2.4 Supply chain actions

There were four potential supply chain actions recommended from the review. None of the four supply chain actions received above average votes in the interview, they were all bottom-ranked. This is surprising because most of the activities in the food systems take place within the value-chain. Thus, making supply chain actions crucial for transforming the food systems. However, this can be attributed to the smaller number of participants from the supply chain sector (22.7 %) in the interviews. The supply chain actions that were recommended from the systematic review were improving hygiene during post-harvest handling of food during processing and distribution, as well as developing industry-led food safety culture. They both received 81.8 % for "Most votes ". Development of food product tracing systems received 71.3

% for “Most votes “, mild preservation and disinfection of food during processing to reduce chemical residues in the food products received 72.7 % for “Most votes “during the interviews.

4.4.2.5 Financial actions

Only two of the financial actions were recommended as potential no-regret actions from the systematic review. Both the actions were bottom-ranked during the interviews. The provision of funding for research on food systems to transform food systems and create funding base on food safety policy development both received 81.8 % for “Most votes “during the interviews. This supports the argument reported by Grace *et al*, (2015), that providing financial support does not always result in improved food safety. However, Hendriks *et al*., (2021) suggested that the provision of funds for research may speed up food systems transformation, through identifying priorities for interventions and policy development.

4.4.2.6 Public institutions actions

Seven actions under the public institutions theme were considered for the interviews. Two out of seven actions (57.1 %) were ranked top. Public institutions are crucial for any policy development. Strengthening food-borne diseases surveillance and early warning systems and developing strategies to combat the sale of fake foods received 90.9 % “Most votes “respectively. The establishment of a central food authority and the establishment of food safety laboratories both received 86.4 % votes.

Public institution's promotion of multi-stakeholder engagements was bottom-ranked with 72.2 % votes. This finding opposes Adeniyi *et al*., (2021) who emphasised that stakeholder engagement plays a key role in managing governance and administration of formal and informal rules in the food systems. The other two public institutions actions that were bottom-ranked are the adoption of the whole systems approach to reduce food contaminations and conducting the in-depth food systems assessment to complement food safety risk analysis and strengthen institutional capacity. Food systems is interconnected. Therefore, the adoption of a whole system approach would enable a smooth transformation of the food systems.

4.4.2.7 Legal and regulatory actions

Six potential actions were considered for interviews under the legal and regulatory theme. Two out of six actions (33 %) were top-ranked as potential no regret actions. The two top-ranked actions under this theme were improving enforcement of existing policies and regulations, and mandatory and regular health screening for all those involved in food handling. Both actions received 90.9 % votes. The legal and regulatory systems play a crucial role in formulating

policies and regulations to transform the food systems. The WHO food safety strategy (2022) suggested strengthening national food controls to improve food safety, through a modern and harmonised legislative framework for food systems control. Developing a modern legislative framework is important for transforming the food systems to improve food safety.

No action received consensus at this stage although research and technology actions received higher votes from the participants. The BW Score as illustrated in Table 4.2 shows a significant difference between the top and bottom ranked actions. The top ranked actions ranged from 0.72 to 0.90 BW Score, and the bottom ranked actions ranged from 0.13 to 0.63 BW Score to 2.12 intervals. Table 4.3 shows the statistical description with minimum and maximum votes, mean and standard deviations of actions from the interview.

4.4.3 Descriptive statistics for the action votes

Table 4.3: Descriptive statistics for the actions votes, n=34

	Minimum	***Maximum***	***Mean***	***Standard deviation***
Most (%)	57.1	95.5	82.4	9.85
Least (%)	4.5	42.9	17.5	9.85

Source: Author (2023).

The mean for the most voted actions was 82.4 and 17.5 for the least votes, with a standard deviation of 9.85. The standard deviation illustrates a greater variation in action voter for most and least actions. The actions vote for “Most” were higher on average and the “Least” score was low on average. This standard deviation means the participants were less consistence when voting for both the “Most” and “Least” actions.

4.5 No-regret solutions prioritised from validation interviews.

4.5.1 Prioritisation of actions by sector

Table 4.4 illustrate the proportion of participants of the interviews and their respective sectors in the food systems.

Table 4.4: Proportion of participants who validated the prioritised actions by sector (n=14)

Name of industry or sector	***Percentage***
Regulators, Government officials, Inspection and enforcement agencies	38.5
Researchers, Academics, Educators, Media and advertising	15.4
Farmers or Food producers, Food processors, Food handlers, Distributors, Wholesalers and Street vendors	15.4
Food consumers	30.8

Source: Author (2023).

The validation interviews were conducted online using Google Forms to enable participants to validate the rankings of the actions and establish a consensus on actions to be considered as no-regret actions. Invitations to participate in the validation interviews were distributed to 22 participants who were part of the initial interviews. Only fourteen participants from various food systems sectors participated on the validation and prioritisation interviews (63% completion rate).

4.5.2 Thematic focus of 12 prioritised actions

Figure 4.7 illustrate the proportion of the thematic of focus of the 12 prioritised actions. Most of the actions (six) prioritised fall under the research and technology theme, followed by legal and regulatory, and education, training and awareness both with two actions.

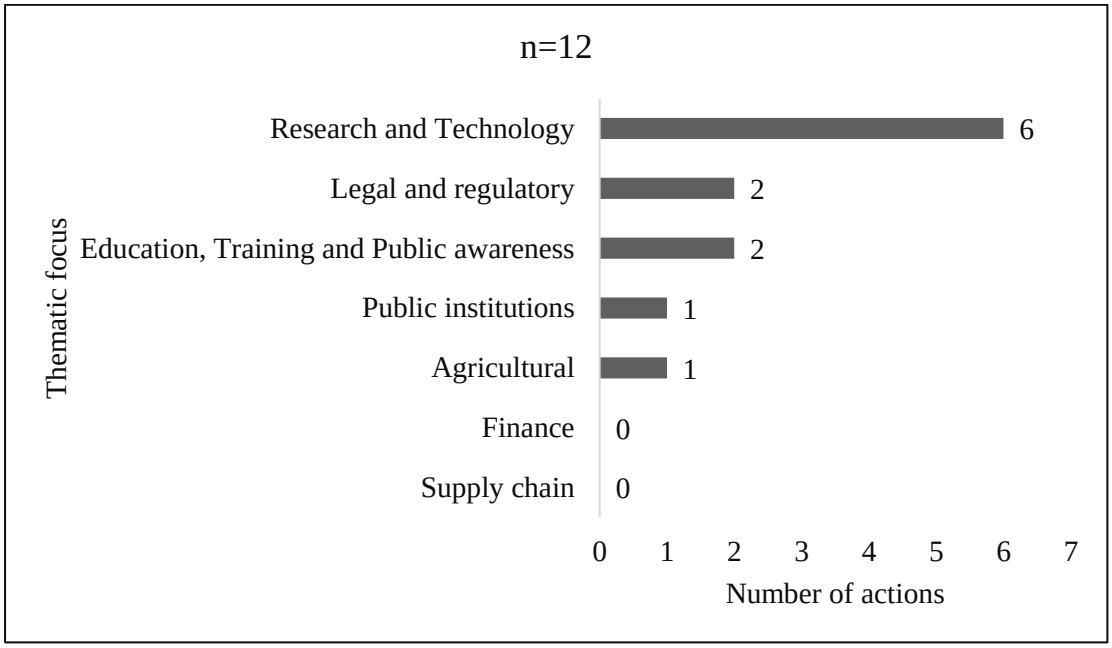

Figure 4.7: Proportion of thematic focus of the prioritised actions, *Source: Author (2023).*

The 12 prioritised actions were from seven areas of thematic focus. The proportional distribution of prioritised actions reflect how each theme was considered significant by the participants. The dominance of research and technology actions in the prioritised actions was somewhat surprising because majority of the records from the review focused on the education, training and public awareness. This was an indication that prioritisation of actions was purely based on the participant's perception of the potential impact of the actions, not the frequency of records in the systematic review.

4.5.3 List of actions prioritised with consensus and their thematic focus

Table 4.5 shows the actions with a hundred percent consensus from the validation interviews. Only twelve (12) actions out of seventeen (17) actions reached the hundred percent (100%) consensus for validation. Those are the actions which were prioritised to be considered as no-re-regret actions to transform the food systems. The following paragraphs discuss the prioritised actions according to the thematic focus.

Table 4.5: List of actions prioritised with consensus and their thematic focus

No-regret actions	Thematic area of focus
Researchers should collaborate on developing pro-active food safety strategies	Research and technology
Develop strategies to deal with complexity of food systems	Research and technology
Conduct more studies to identify priorities for interventions	Research and technology
Adopts new technologies for testing, monitoring and tracing in food system	Research and technology
Strengthen laboratory diagnostic services	Research and technology
Conduct more research studies on the use of food safety information labels and observational studies	Research and technology
Mandatory and regular health screening of food handlers	Legal and regulatory
Improve enforcement of existing policies and regulations.	Legal and regulatory
Strengthen food-borne diseases surveillance and early warning systems	Public institutions
Use of visible, easy to understand food labels and media tools to improve public awareness on food safety	Education, training and awareness
Train food handlers and all other role players in the food systems including informal food handlers	Education, training and awareness
Increase access to clean water to promote Good Agricultural Practices (GAP)	Agricultural

Source: Author (2023).

4.5.3.1 Research and technology actions

Hendriks *et al*., (2021) reported that research and technology innovations have the potential to accelerate the transformation of food systems. Table 4.5 shows six actions that were considered for prioritisation under the theme research and technology. This finding concur with the report by Hendriks *et al*., (2021), who suggested the importance of knowing how different actions by different actors in the food systems affect the food systems. Collaborative research will contribute to coherent and evidence-based actions on food system transformation.

The second priority action under the research and technology theme was developing strategies to deal with the complexity of the food systems. To ensure the successful transformation of the food systems, it is essential to develop strategies to deal with the complexity of the food systems. Adeniyi *et al*., (2021) argued that the complexity of the food systems has limited the progress towards food and nutrition security, and effective food governance in South Africa. The food safety system is a component within the multi-layered food system, therefore research on the complexity of the food systems will contribute to achieving safer food systems. The one health concept is an example of the strategies developed to deal with the complexity of the food systems. The one health approach was developed by scientists to manage the risk of zoonosis (pathogens infecting animals and humans) in a whole system approach (Unnevehr, 2022).

The third priority research action identified from this study was identifying intervention priorities. Research plays an important role in gathering evidence for priorities. Resources for managing food safety risks can be allocated appropriately when the priority areas are known. Many challenges were found to be hindering the provision of safe food in South Africa. Therefore, only through research can challenges be prioritised and receive proper intervention. Policies for interventions are sometimes political but evidence is significant to ensure proper intervention decision making.

Adopting technologies was the fourth priority action considered as no-regret from this study. Technological innovations were considered significant for the food systems transformation. Adoption of technological innovations throughout the food value chain can contribute to ensuring safer food systems. This finding support Unneverhr (2022), who reported that new technologies such as whole genome sequencing and block-chain can potentially improve food safety information management. Whole-genome sequencing is used for the identification and tracking of specific food-borne pathogens, tracing of food to reduce food fraud and tracing the sources of anti-microbial resistance within the food value-chain.

The fifth priority action under this theme was strengthening the laboratory diagnostic services. Laboratory diagnostic services is significant to food safety management systems. Managing the food safety risks entails accurate and timely diagnosis of food-borne pathogens. Adopting food testing technologies and capacity building is likely to reduce the time taken to properly detect and identify food- borne pathogens to improve epidemiological investigations.

The last priority action under this theme was conducting research studies on the use of information labels and observational studies to improve food safety. Researchers use specific tools and methods to establish and validate the robustness of their studies. The issues they choose to study are based on the objectives of the organisations or institutions they work for, funding and personal values. There is polarity within the research communities between research-driven and demand-driven approaches to gathering evidence. However, scientific research is not the only way to gather evidence to drive policy intervention. Scientific research is among many knowledge producers. For example, the HLPE centres now recognise the importance of local and lay knowledge to support policy innovations (Von Brown, 2023). Therefore, the use of simple observations studies and information labels can be useful to gather evidence and enable proper policy interventions.

4.5.3.2 Legal and regulatory actions

Two actions out of two actions (100 percent) under legal and regulatory theme received consensus to be prioritised as no-regret actions. The first priority action under this theme was to introduce a regulation that will enable a mandatory and regular health screening for all food handlers in both formal and informal sector. Food handlers throughout the value chain are capable of transmitting the food-borne pathogens. This is backed by the findings from Siluma *et al*., (2023) who reported unhygienic meat handling practices such as 67 percent irregular washing of hands and 83 percent less usage of hand gloves in both commercial and informal meat traders in the Vhembe district of South Africa. This suggested the need for more interventions to reduce the risk of transmission of pathogens in the meat value-chain. Interventions to reduce food-borne diseases have been focusing on the bio-control (at the farm), transportation (cold-chain), processing facilities, market infrastructure, education and training of role players.

Very few interventions have targeted the pathogen transmission between the food-handler and food products. Mandatory health screening played a crucial role in controlling the spread of Covid-19 virus in many parts of the world during 2020 outbreak. However, this intervention

will require a specific value-chain for food-borne pathogens. Each value-chain may require screening for a specific food-borne pathogen at different intervals. For example, food handlers in the meat value chain will require screening for zoonotic pathogens, while handlers in the fruit sector will require screening for different Phytosanitary pathogens.

The second priority action under the legal and regulatory theme was to improve the enforcement of existing policies and regulations. This finding does not support overhauling the legislative framework to improve food safety but strengthening of the enforcement of the existing pieces of legislations related to food safety governance systems. This finding concurs with the WHO (2022) global strategy for food safety which prioritised strengthening national food control systems through strengthening compliance, verification and enforcement of legislations. However, the WHO (2022) strategy recommended establishment of a modern, harmonised and evidence-based framework for food legislations. The current food legislation policies in South Africa are outdated and fragmented thus negatively impacting on the food systems governance (Boatemaa *et al*., 2019). Different government departments (national, provincial and local) are involved in food systems governance with fragmented, overlapping initiatives, and duplication of roles.

4.5.3.3 Public institutions actions

One action out of two actions (50 percent) under the public institutions theme received consensus. Strengthening food-borne disease surveillance and early warning systems was prioritised in this study. Food-borne diseases surveillance programmes are key any food safety system (WHO, 2022). The public sector is dominant in the South African food control system (Adeniyi *et al*., 2021). Due to the limited capacity of the public sector, one of the best approaches to managing food safety risks is to develop continuous surveillance programmes, which involves all the role players in the food systems to ensure evidence and risk based approach. The evidence and risk based approach is a modern approach which use scientific information gathered through surveillance to direct more resources to the critical part of the food value-chain. The evidence-based surveillance system provides information on the presence and level of different food hazards in the food value-chain.

4.5.3.4 Educations, training and awareness actions

Two actions out of three actions under the education, training and awareness theme received consensus. The first priority action under this theme was using visible, easy to understand tools to improve awareness of food safety. Several studies have reported the lack of knowledge on

food safety among school children and older consumers as serious challenge (Thaivalappil *et al*., 2020; Wanniarachchi and Abeysundara, 2023; Mabaso *et al*., 2021; Unnevehr, 2022). The lack of knowledge of food safety hazards by children and elderly consumers often lead to improper handling and storage of food products. The use of visible, easy to understand tools is likely to improve food safety knowledge of the vulnerable groups. Visible and easy to understand tools includes posters, charts, infographics and videos.

The second priority action under this theme was provision of food safety training to food handlers and all other role players in the food systems. All role players in the food systems need to have adequate knowledge of food safety issues. This finding concur with several other studies conducted on the knowledge and practices of food handlers (Abdelradi *et al*., 2021; Madilo *et al*., 2023; Boatemaa *et al*., 2019; Siluma *et al*., 2023). Most studies demonstrated poor knowledge on food safety and hygienic practices. Training interventions have been widely offered to food handlers in the formal sector to implement food safety management systems. However, those interventions did not demonstrate the synergies between food safety, nutrition and economic development. This study finds that training interventions should be offered to all role players in the food systems including informal street food vendors to raise awareness of synergies and trade-off between food safety, nutrition and sustainable development.

4.5.3.5 Agricultural actions

One agricultural action out of two (50 percent) received consensus for prioritisation. The promotion of Good Agricultural Practices (GAP) through the provision of clean water was prioritised in this study. Water is an important input for food production. Water can be a carrier of many microbial pathogens, such as *E. coli, Salmonella* and *Cryptosporidium*. GAP were introduced to minimize microbial food safety hazards in the fresh fruits and vegetables industry. The provision of clean water is significant to enable sustainable food production systems with proper Sanitary and Phytosanitary practices at the farm level. However, Grace *et al*., (2015) argued that promoting GAP without introducing proper incentives will have less impact on food safety. Many actions on food systems transformation were discussed during the 2021 food systems summit but very little attention was paid to this important ingredient of the food systems (Canfield, 2021). In South Africa, the provision of clean water has always been attributed to human health without paying attention to the food system part where the provision of clean water throughout the value chain is vital.

The results of the study addressed the objective of the study, by identifying key constraints hindering the provision of safe food and potential solutions, as well as priority no-regret actions. Potential solutions that were considered no-regret options included various thematic areas of focus. The data from the stakeholder interviews differs from the data from the systematic review in terms thematic focus of the potential solutions. The data from the systematic review produced more actions from the education, training and public awareness but the data from stakeholder interviews produced more actions from the research and technology theme.

4.6 Chapter summary

This chapter presented the data from the systematic review of 87 records from various online databases, illustrating the key constraints hindering the provision of safe food and their thematic focus. This chapter also presented 34 potential solutions to constraints hindering the provision of safe food and their thematic focus. 18 out 34 potential solutions were top-ranked using the Best-Worst ranking scale through food systems stakeholder interviews. Lastly the chapter presented 12 prioritised potential solutions as no-regret actions to transform the food systems to enable provision of safe food.

Chapter 5: Summary, Conclusions and Recommendations

5.1 Introduction

This chapter summarises the core findings of the study, present the summary of the results, conclusions and recommendations. This study identified policy options to transform food systems for a safer food system. Food systems transformation for a safer food system will enable the achievement of several developmental goals.

5.2 Recap of study objectives and summary of the results

This study started with a systematic review to identify challenges hindering the provision of safe food. The systematic review identified several key challenges hindering the provision of safe food. The identified key challenges include the lack of training and capacity building of role players in the food systems, fragmented national food safety strategy to control the food safety system, lack of collaboration by role players in the food systems, lack of food safety communication strategy to improve public awareness on food safety hazards, and lack of food safety surveillance to prioritise areas for interventions and risk management.

The second phase of the study was to identify potential solutions through a systematic review. The potential actions were identified through a systematic review and further prioritised by stakeholders during the interviews. The core finding in this study was the prioritisation of no-regret actions. The following potential actions were prioritised as no-regret actions to transform the food systems:

- Researchers should collaborate and develop pro-active food safety strategies
- Conduct more research studies on the use of food safety information labels and observational studies to identify priorities for interventions
- Develop strategies to deal with complexity of food systems
- Adopting new technologies for testing, monitoring and tracing in food system
- Strengthen laboratory diagnostic services
- Mandatory and regular health screening of food handlers
- Improve the enforcement of existing policies and regulations.
- Strengthen food-borne diseases surveillance and early warning systems
- Use of visible, easy to understand food labels and media tools to improve public awareness on food safety

- Provide training to food handlers and all other role players in the food systems including informal food handlers
- Increase access to clean water to promote Good Agricultural Practices (GAP)

The prioritised potential actions are mainly in the research theme. Six (6) research and technology actions were prioritised, followed by two (2) legal and regulatory actions, one (1) public institution action, two (2) education, training and awareness actions, and one (1) agricultural action was prioritised.

5.3 Conclusions of the study

The challenges identified from the review were across different focus areas, but most key challenges were related to education, training and public awareness, public institutions, and legal and regulatory focus areas. The identified challenges were mostly interconnected.

This study demonstrated that research and technology actions are perceived as critical to solve challenges and offer opportunities to improve food safety through food system transformation. More collaborative research is required to identify key drivers in the food safety systems. Researchers must also collaborate to develop strategies to deal with complexity of the food systems and improve food safety risk management. Technological adoptions such as block-chain technologies, whole-genome sequencing, artificial intelligence and digital agriculture can accelerate the transformation of food systems for improved food safety. However, technological innovations need strategies to manage the unintended consequences, ethical issues and ensure benefits to both food producers and the consumers. It is worth noting that, technological innovations in the food systems are challenging especially with the small-holder farmers and rural communities. Therefore, investments in science-based and participatory research is needed to identify realistic options for interventions.

This study prioritised two (2) legal and regulatory actions for food systems transformation. The regulatory framework is significant for successful implementation of policies and programmes for transformation. This study did not prioritise the need to change the regulatory framework for the food systems transformation, despite several reports on the fragmentation and overlapping food policies in South Africa. This study prioritised improving enforcement of the existing policies but vague on what exactly can be done to strengthen enforcement. To strengthen enforcement of food policies, a competent authority should conduct regular verifications, inspection and audit activities with proficient and competent staff. The informal food traders should be included in the verification and inspection activities. However, to

achieve improved enforcement the national food control system must have a harmonised and strong policy and regulatory framework (WHO, 2022).

This study also prioritised strengthening the surveillance of food-borne diseases. In most developing countries surveillance is mostly the responsibility of public institutions. Strengthening surveillance will entail developing a strategy, adopt technologies to trace food-borne pathogens, develop laboratory capability to identify and link food pathogens with the disease, and strengthen multi-sectoral stakeholder co-ordination.

Two (2) education, training and awareness actions were also prioritised. The use pictorial and other easy to understand food safety warnings in all public spaces was prioritised as well as provision of training to all role players in the food systems. However, this action must be accompanied by mechanisms to monitor public perceptions to ensure effectiveness.

The provision of clean water was also prioritised in this study. However, this study relates clean water with Good Agricultural Practices for the production of safe food. The provision of clean water is critical to ensure both sustainable production and consumption of safe food (Hendriks, *et al*., 2021). In South Africa, the provision of water is mainly a government responsibility. Therefore, this action can also be considered a public institution action to ensure access to clean water throughout the value-chain.

5.4 Policy implications based on the findings

The findings from this study provide basis for policy makers to review the food policy framework and develop interventions to transform the food systems for improved food safety. The findings are vague on strategies to deal with complexity of the food systems but revealed that collaborative research is key to deal with the inter-connectedness of the food systems. There is a need to develop a research policy framework to compel multi-sectoral collaboration and funding of food systems research.

The study reported the need to develop easy to understand food safety information materials. The marketing and advertising regulations can be amended to include mandatory food safety information on marketed products. The lack of food safety information and knowledge can also be addressed through basic education and training policy framework.

5.5 Recommendations

FAO (2023) in the preparation for the UN Food Systems summit +2 in 2023 reiterate that the world is not on track to achieve the SDGs by 2030. Food systems transformation presents an

extraordinary opportunity to achieve the 2030 agenda for sustainable development (United Nations sustainable development goals, SDGs). SDGs are connected and inter-related in a manner that one cannot be achieved without the other one.

Due to complexity and interconnectedness of the food systems, new forms of food system governance must be established to facilitate multi-sector collaboration to foster synergies and coherence in transforming the food systems. United Nations Food systems summit of 2021 projected that food systems transformation through policy innovations will have multiplier effects (FAO, 2022). Therefore, the implementation of no-regret policy approach is recommended to accelerate food systems transformation.

This study prioritised actions that are inter-connected and therefore a whole system approach is recommended to transform our food systems. The development of more integrated approach is necessary to accelerate food systems transformation to achieve multiple goals at the same time. This study further recommend harmonising the food governance legislative framework. A harmonised legislative framework will compel all role players in the food systems to play their respective roles in promoting food safety. The inability of one sector or actor to play its role in ensuring food safety will negatively affect the food system transformation. Therefore, policy makers in South Africa should review the food legislation and regulatory framework to ensure smooth transformation of the food systems.

5.6 Areas of further research

The food system is complex and evolutionary in nature. Therefore, continuous research is key to identifying equitable options for the sustainable transformation of the food systems. The collaboration of researchers in various sectors of the food environment was prioritised as one of the key actions to transform the food system to ensure food safety.

Further studies should be conducted at a larger scale to gather deep evidence from various stakeholders on their perceptions on the food policy framework. Studies involving stakeholder engagement through focus groups will contribute to developing strategies to deal with complexity and inter-connectedness of the food systems.

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Appendices

Appendix 1: Synthesis for recommended actions from systematic literature review

Agricultural actions				
Author/s	**Country/ Region**	**No of articles for this action**	**Action**	**Impact on food system**
Thomson, *et al*. 2013.	Global	1	Introduce commodity based animal diseases risk management approach	Including food safety to value chain will enable marketing and availability of safe products from controlled zones
Thompson, *et al*. 2021.	Cambodia	1	Increase access to clean water to promote Good Agricultural Practices	Reduce contamination at farm level
FAO, 2018	Asia-Pacific region	1	Organise smallholder farmers into associations to adopt global best agricultural practices	Production of safe food through good agricultural practices will improve availability of safe food
Mario van stade, 2019.	South Africa	1	Extension and advisory services should communicate food safety standards and legislations to emerging farmers	To promote production of safe food
FAO, 2018; Stentiford, *et al*. 2012.	Asia and Pacific, Global	2	Conduct farmers outreach to promote best disease management practices	Good agricultural practices for safe food production.
Grace, *et al*. 2015; Mutegi, *et al*. 2012	Kenya	2	Practise crop rotation and planting improved cultivars to reduce aflatoxin contamination from the field.	Reduce food contamination with Aflatoxin.
Fadi Abdelradi, *et al*. 2021.	African continent	1	Adopt new technologies to reduce contamination at farm level.	Production of safe food
Abdalla, *et al*. 2021.	South Africa	1	Establish antibiotic stewardship and develop guidelines for proper antibiotic use in animals.	Reduce antibiotic residue in meat products
Founou *et al*. 2018.	Cameroon, South Africa	1	Implement stringent and effective measures to curb irresponsible antibiotic use from the farm to fork continuum	Reducing antibiotic resistance and residues

Government of South Africa, Food Systems Summit 2021	South Africa	1	Promote sustainable local production of indigenous foods.	Availability and consumption of safe food
Government of Sri Lanka, Food Systems Summit 2021	Sri Lanka	1	Change mind- set of farmers to reduce use of chemical fertilizers and pesticides	To reduce chemical residues in foods.
Thomas, *et al*. 2020.	Africa	1	Improve human sanitary and hygiene measures	To reduce exposure of food animals to human faeces.
Research and technology actions				
Hall and Osses, 2013	Global	1	Conduct more research studies on the use of food safety information labels and observational studies	Improve consumer's understanding of food safety issues and hazards
FAO, 2018; Abdelradi, *et al*. 2021.	Asia-Pacific region, African continent	2	Adopts new technologies for testing, monitoring and tracing in food systems.	To ensure effective early warning and quick response to diseases outbreaks
Morse, *et al.* 2018; Thompson, *et al*. 2021; Farnkish, *et al*. 2021.	Sub-Saharan Africa, Australia.	3	Research on current gaps and understanding the role of food safety in food systems.	To identify weaknesses and develop proper risk management strategies
Report by DoH, DAFF and DTI, 2013; Stentiford, *et al*. 2012.	South Africa	2	Researchers should collaborate on developing food safety strategies and share best practices on prevention and control of food borne diseases.	Proper risk management and reduce impact of outbreaks
Dos-muchnagos, 2012.	South Africa	1	Develop rapid , competent and reliable methods of detecting and identifying food-borne pathogens directly, i.e. 3M Petri film.	Quick identification of food hazard can reduce infection rate
Stentiford, *et al*. 2012; Gutiérrez, *et al*. 2019; Dwivedi and Singh, 2011.	Global	3	Support research on the use of natural biological control agents	To reduce chemical residues and contamination throughout the food systems.
Govender *et al*. 2013.	South Africa	1	Research on integration of the HMS and HACCP in abattoirs.	To improve food safety and meet both regulatory and certification requirements
Mbonane and Rathebe, 2019.	South Africa	1	Address research gaps that exist in identifying the impact of fake food on public health	To ensure proper resource allocation to curb sale of fake foods.

Narsaiah, *et al*. 2012; Arora, *et al*. 2011.	India	2	Conduct more research on the use of optical biosensors for the detection of pathogens, pesticide residues and other toxic substances in the food.	To improve surveillance and provision of food safe from all possible hazards.
Queenan, *et al*. 2021	South Africa	1	Promote policy focused research that is participatory and inclusive of stakeholders across the food systems	To generate political will to improve food safety.
Morse, *et al.* 2018.	Sub-Saharan Africa	1	Further research on evidence-based decisions and policy development.	To enable development of no-regret policy options
Tenorio and Flores, 2021.	Philippines	1	Conduct veterinary public health studies on the safety of meats available in the markets.	For early detection and control of food borne pathogens of animal origin.
Government of South Africa, National Food and Nutrition Security plan for South Africa 2018-2023.	South Africa	1	Revitalize national laboratory infrastructure and accreditation .	Provision of quality and safe food through high quality food testing standards.
Thomas, *et al*. 2020.	Africa	1	Conduct more studies on outbreak source attribution	To identify priorities for interventions to improve food safety.
Shenashen, *et al.* 2021.	Global	1	Develop sensory protocol devices for monitoring the SARS-Covid-19 antigen associated with food products.	To prevent Covid-19 contamination in food.
National Food and Nutrition Security plan for South Africa 2018-2023.	South Africa	1	Conduct feasibility studies for the establishment of modern institutional arrangements with centralised leadership	To improve allocation of resources and clear lines of responsibility on managing food safety risks.
Education, training and public awareness actions				
Serrem, *et al*. 2021; Dhama, *et al*. 2013; Mario van stade, 2019; Dang-Xuan, *et al*. 2016; Nyawo, *et al*. 2021; Teffo and Tabit, 2020. Mgqibandaba *et al*.	South Africa, Vietnam, Ghana, Thailand, Nigeria	13	Introduce mandatory food safety training to all food handlers on Food Safety Management System (FSMS) and Hazard Analysis Critical Control Point (HACCP)	To improve their knowledge of food safety and hygiene practices at all levels.

2020; Malavi, *et al.* 2021; Azanaw, *et al.* 2019; Tuglo, *et al*. 2021; Sirichokchatchawan, *et al.* 2021; Sunlier, *et al.* 2020; Grace, *et al*. 2019.			practices and procedures irrespective of their academic and employment status.	
Zikankuba, *et al*. 2019.	Tanzania	1	Inform all role players in the food system on the health risks associated with pesticides	To improve awareness on pesticides risks on food systems.
Tenorio and Flores, 2021.	Philippines	1	Develop community health education on food safety risk factors and proper food preparation practices.	To improve safe food handling in domestic setup.
Bolek, 2020; Munasinghe *et al*. 2014.	Sri- Lanka	2	Implement effective and continuous food safety education to consumers.	Improve food safety knowledge and develop food safety culture.
Bolek, 2020; Dhama, *et al*. 2013; Mario van stade, 2019; Dos-muchnagos, 2012;	South Africa	4	Use of media tools to improve communication on food safety standards, sanitation and regulation to public.	Increase awareness on food safety to consumers can change consumer behaviour can reduce the risk of foodborne illness.
Ezekiel, *et al*, 2018; Chibundu, *et al*. 2021.	Africa		Training intervention to promote the use of high quality grains for brewing traditional beverages.	The use of safe raw material will ensure consumption of safe beverages.
Boatemaa, *et al*. 2019; Chammem, *et al*. 2018.	South Africa	2	Find new ways of educating food handlers and consumers, such as social media.	To make learning food safety standards easier for all.
Dos-muchnagos, 2012; Mjoka and Selepe, 2017; Akabanda, *et al*. 2017.	South Africa Ghana	3	Routine review and updating of food safety training programmes for food handlers	Improve provision of safe food
Griffith, *et al.*2017; Chammem, *et al*. 2018.	South Africa	2	Develop food safety communication strategy	To improve communication between the different actors in the food systems to manage risks and control hazards in time.
Qekwana, 2012.	South Africa	1	Introduce training programmes for those involved in traditional slaughtering.	To ensure domestic consumption of safe food.

Mabaso, *et al*. 2021.	South Africa	1	Implement visible and easy to understand front of package labelling.	To improve consumer's awareness
Ramashia, *et al*. 2020; Mjoka and Selepe, 2017; Murwira, *et al*. 2017; Rani, *et al*. 2017; Asiegbu *et al*. 2020; Oladipo-Adekeye *et al*. 2021; Moloi, *et al*. 2021	South Africa	7	Municipalities should introduce basic training for informal street food vendors	To improve hygiene and provision of safe food to consumers.
Abdelradi *et al*, 2021.	Africa	1	Intergrade food systems concept in academic curricula	To improve understanding of drivers and complexity of this ever-changing food systems
Nyawo, *et al*. 2021;	South Africa	1	National School Nutrition Programme should strengthen, monitoring and evaluation for food handlers.	To reduce spread of food-borne diseases pathogens during food preparations in schools
Murwira, *et al*. 2017.	South Africa	1	Fast food outlets should employ trained food handlers and conduct regular refresher sessions on food safety	To ensure proper handling and preparation of food.
Supply chain actions				
Aworth, 2021; Castro-Ibanez, 2017; Lazar-baker, *et al*.2011; Munasinghe *et al*. 2014.	Sub-Saharan Africa, Pacific Islands, Sri Lanka	4	Improve hygiene in post-harvest handling, processing and manufacturing practices.	To reduce post-harvest contamination of food.
Chibundu *et al*, 2021.	African continent	1	Adopt new sophisticated grain sorting and cleaning techniques.	To reduce food contamination with toxins.
Qekwana, 2012.	South Africa	1	Veterinary services should pay more attention to traditional or ritual slaughter of animals for consumption.	To promote domestic consumption of safe meat.
Hoffman, *et al*. 2019.	South Africa	1	Develop industry-led food fraud vulnerability assessment.	To reduce availability and distribution of fake or unsafe food
Elgueta, *et al*. 2020			Assess and quantify pesticides residues	Assist in decision making to improve food safety enforcement
Financial actions				

Report by DoH, DAFF and DTI, 2013.	South Africa	1	Provide funding for research on food systems transformation	To enable development of food safety strategies.
Abdelradi, *et al.* 2021.	African continent		Create funding base to support research on policy development.	To promote food safety policy innovations
Mjoka and Selepe, 2017	South Africa		Invest in establishing street food vending centres with proper facilities and utility services	To enable provision of safe food for majority of consumers and improve compliance with regulations.
Zikankuba, *et al*. 2019.	Tanzania		Invest in non-persistence pesticides research.	To reduce pesticides residues in food
Public institutions actions				
FAO, 2017; FAO, 2015; Report by DoH, DAFF and DTI, 2013; Morse, *et al.* 2018; Chammem, *et al*. 2018; Anyogu, *et al.* 202; Rahimi, 2013; Zani du ploy, 2015; Pereira and Drimie, 2016; Fadi Abdelradi, *et al*. 2021; Rodovanovic, 2011; Morse, *et al.* 2018; Alabania FSS, 2021; Government of South Africa, Food Systems Summit 2021.	South Africa, Sub-Saharan Africa; USA, Global; Alabania	14	Promote multi-stakeholder engagement and dialogues at all levels.	To improve participation and efforts to identify problems and solutions with mutual accountability at all levels. To form strong foundations of science, share policy options and practices to improve food safety.
FAO, 2018.	Asia-Pacific region	1	Harmonise food safety standards at regional level	
FAO, 2015; FAO, 2017; Tambe, *et al*. 2018.	Global South Africa	3	Develop effective food safety early warning systems	For rapid alert and effective communication with key stakeholders at all levels to ensure quick outbreak response.
Queenan *et al*, 2021; Mario van stade, 2019.	South Africa	2	Adopt whole systems approach to address food systems challenges with participatory and inclusive policy development	To ensure provision of safe food with greater participation from all role players.
Report by DoH, DAFF and DTI, 2013.	South Africa	1	Develop formal agreement on food safety standards between authorities and unregulated industries.	To promote provision of safe food in absence of regulations.

Dhama, *et al*, 2013; Dos-muchnagos, 2012; Tshangela, 2014; Tambe , *et al*. 2018.	South Africa	4	Establish food-borne diseases surveillance network	To quantify national burden of food-borne diseases and monitor all laboratory confirmed cases.
Alacorn, *et al*. 2021	Global	1	Develop atlas of food systems maps for major commodities based on agreed methodology.	To strengthen regulation and inspections on high risk commodities.
Alacorn, *et al*. 2021	Global	1	Conduct in-depth food systems assessment to complement food safety risk analysis and strengthen institutional capacity.	To improve industry food safety and hygiene practices with better understanding of institutional settings.
Grace, *et al*. 2019.	Nigeria	1	Ensure enabling environment for stakeholder collaboration in the informal sector.	To improve food safety in the informal sector.
Collado, 2014; Bailey and Korsten, 2018.	Philippines South Africa	2	Establish central food safety authority to deal with all import, export and local food control to protect consumers	To improve collaboration and shorten time frame between outbreak, tracing and recall of food products.
Mbonane and Rathebe, 2019.	South Africa	1	Develop strategies and programmes to control sale of fake foods.	To ensure provision of safe and legit food in communities.
Rodovanovic, 2011.	Global	1	Establish specialised laboratories for analysis of food safety hazards.	To ensure quick and correct identification of food-borne diseases outbreak sources.
Rodovanovic, 2011.	Global	1	Upgrade or establish new regional centres for monitoring and registering food-borne diseases incidences.	Improve database and record management of food-borne infections for future planning.
Griffith, *et al*. 2017; Tshangela, 2014.	South Africa	2	Establish efficient food safety information and communication system for the entire population	For quick reporting and response to incidents caused by unsafe food
Legal and regulatory actions				
Boatemaa, *et al*. 2019; Murwira, *et al*. 2017; Tuglo, *et al*. 2021.	South Africa; Ghana	3	Strengthen enforcement of existing policies and regulations.	To improve compliance of existing food safety regulations.
Bailey and Korsten, 2018; Rodovanovic, 2011.	South Africa, Global	2	Revise food legislative framework and develop a National policy on food safety and a single	To develop comprehensive action plan that will ensure

			authority with improved governance.	provision of safe food for all.
Shukla, *et al*, 2018; Mabaso, *et al*. 2021.	India South Africa	2	Develop a robust food safety inspection system that is pro-poor and work for consumers.	Curb availability of unsafe food at all levels.
Mabaso, *et al*. 2021.	South Africa	1	Regulate the whole food environment	To reduce availability of unsafe food
Qekwana, *et al.* 2014; Rani, *et al*. 2017.	South Africa	2	Review and enforce Meat Safety Act 40 of 2000 to reduce risks associated with traditional slaughter of animals and regulate informal meat industry.	To reduce domestic consumption of unsafe food
Mjoka and Selepe, 2017	South Africa	1	Develop legislation to recognise street food vending and develop code of practice	To ensure provision of safe food following proper hygiene and sanitation
Mjoka and Selepe, 2017; Nkosi and Tabit, 2021.	South Africa	2	Build food stalls for street vendors with facilities and use licensing system.	To promote compliance with food safety regulation.
Dastile, *et al*. 2017	South Africa	1	Strict monitoring of abattoirs for hygiene during meat processing.	To ensure provision of safe processed meat.
Government of Republic of South Africa, 2012	South Africa	1	Mandatory medical examination of food handlers with clinical signs of contagious diseases.	To reduce food contamination with contagious diseases
Government of Sri Lanka, Food Systems Summit 2021	Sri Lanka	1	Restrict importation of pesticides and chemical fertilizers	To reduce chemical residues in foods
Ezirigwe, 2018.	Nigeria	1	Expand and clarify the definition of food.	To promote regulation of all food substances.
Mabaso, *et al*. 2021.	South Africa	1	Introduce strong advertising regulation to counteract industry influence to protect consumers	To reduce marketing of unsafe food products

Appendix 2: Link to consent form and information leaflet

https://forms.gle/dipoSqxYSsx26xyTA

Appendix 3: Link to questionnaire for stakeholders and responses

https://forms.gle/jdWH2DDYv2NQoPRU6

Appendix 4: Link to validation questionnaire and responses

https://forms.gle/MHiEnUVjrd8zpYh9A

Appendix 5: Interview instructions and questionnaire

Research project title: Food policy analyses and prioritisation of food systems to achieve safer food for South Africa

Thank you for agreeing to participate in this project. Ethical procedures for the University of Pretoria (Ethics approval number: NAS260/2021) will be followed during this interview process. The interview will take about 30 minutes. We don't anticipate any risks associated with your participation as mentioned in the consent form.

Name of industry/ sector_____

Role/responsibility _____

Date of interview _____

The following instructions must be followed:

- Below is a list of recommended actions with the potential to transform the food systems to enable provision of safe food. The listed candidate actions were identified through a systematic review.
- Read all the actions and select the actions that are most relevant such that no policy maker will regret taking them. The actions to be considered must be plausible, with clear pathway to impact, feasible (no hard trade-off's) and sustainable. The selection of options must consider the health, economic and environmental impact.
- Selection is made by ticking "most" or "least" box.
- The selected options will be analysed and used to develop no- regret policy actions to transform food systems to ensure provision of safe food for all. For each action there are two options to provide top and bottom-ranked actions by ticking either most or least.

	List of candidate actions identified from systematic review		
Agricultural actions		**Most**	**Least**
1.	Increase access to clean water to promote Good Agricultural Practices (GAP)		
2.	Organise smallholder farmers into associations to adopt global best agricultural practices		
3.	Adopt new technologies to reduce contamination at farm level.		
4.	Discourage excessive use of agrochemicals		
Research and technology actions			
5.	Conduct more research studies on the use of food safety information labels and observational studies		
6.	Adopts new technologies for testing, monitoring and tracing in food system		
7.	Conduct more studies to identify priorities for interventions		

8.	Researchers should collaborate on developing pro-active food safety strategies instead of reactive strategies.		
9.	Develop strategies to deal with complexity of food systems		
10	Strengthen laboratory diagnostic services		
11	Develop sensory protocol devices to detect the SARS-Covid-19 in food products.		
Education, training and public awareness actions			
12	Use of visible, easy to understand food labels and media tools to improve public awareness on food safety		
13	Train food handlers and all other role players in the food systems		
14	Provide food safety training to informal food handlers		
15	Develop food safety communication strategy		
Supply chain actions			
16	Improve hygiene in post-harvest handling, processing and manufacturing practices.		
17	Develop food product tracing systems		
18	Develop industry-led food safety culture		
19	Mild preservation and disinfection to reduce chemical residues in food products.		
Financial actions			
20	Provide funding for research on food systems transformation		
21	Create funding base to support research on food safety policy development.		
Public institutions actions			
22	Promote multi- stakeholder engagement and dialogues at all levels.		
23	Adopt whole systems approach to reduce food contaminations		
24	Strengthen food-borne diseases surveillance and early warning systems		
25	Conduct in-depth food systems assessment to complement food safety risk analysis and strengthen institutional capacity.		
26	Establish central food safety authority to deal with all import, export and local food control to protect consumers		
27	Develop strategies and programmes to control sale of fake foods.		
28	Establish specialised laboratories for analysis of food safety hazards.		
Legal and regulatory actions			
29	Improve enforcement of existing policies and regulations.		
30	Revise agricultural and food legislative framework and develop a National policy on food safety.		
31	Regulate raw materials and food ingredients		
32	Develop legislation to recognise and regulate informal food sector		
33	Mandatory and regular health screening of food handlers.		
34	Restrict importation of pesticides and chemical fertilizers		

Any comments and actions you think should be considered:

_____

_____

_____

_____

Thank you for participating in this project!

Appendix 6: Votes on actions

List of actions	Most	Least
Increase access to clean water to promote Good Agricultural Practices (GAP)	19	3
Organise smallholder farmers into associations to adopt global best agricultural practices	20	2
Adopt new technologies to reduce contamination at farm level.	18	4
Discourage excessive use of agrochemicals	12	10
Conduct more research studies on the use of food safety information labels and observatic	19	3
Adopts new technologies for testing, monitoring and tracing in food system	19	3
Conduct more studies to identify priorities for interventions	20	2
Researchers should collaborate on developing pro-active food safety strategies	21	1
Develop strategies to deal with complexity of food systems	20	2
Strengthen laboratory diagnostic services	19	3
Develop sensory protocol devices to detect the SARS-Covid-19 in food products.	12	10
Use of visible, easy to understand food labels and media tools to improve public awarenes	20	2
Train food handlers and all other role players in the food systems	19	3
Provide food safety training to informal food handlers	19	3
Develop food safety communication strategy	20	2
Improve hygiene in post-harvest handling, processing and manufacturing practices	18	2
Develop food product tracing systems	17	5
Develop industry-led food safety culture	18	4
Mild preservation and disinfection to reduce chemical residues in food products	16	6
Provide funding for research on food systems transformation	18	4
Create funding base to support research on food safety policy development	18	4
Promote multi- stakeholder engagement and dialogues at all levels	16	6
Adopt whole systems approach to reduce food contaminations	18	4
Strengthen food-borne diseases surveillance and early warning systems	20	2
Conduct in-depth food systems assessment to complement food safety risk analysis and	17	5
Establish central food safety authority to deal with all import, export and local food control	19	3
Develop strategies and programmes to control sale of fake foods.	20	2
Establish specialised laboratories for analysis of food safety hazards.	19	3
Improve enforcement of existing policies and regulations.	20	2
Revise agricultural and food legislative framework and develop a National policy on food sa	18	4
Regulate raw materials and food ingredients	16	6
Develop legislation to recognise and regulate informal food sector	18	4
Mandatory and regular health screening of food handlers	20	2
Restrict importation of pesticides and chemical fertilizers	13	9

Appendix 7: Ethics approval

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences
Ethics Committee
E-mail: ethics.nas@up.ac.za

9 February 2023

ETHICS SUBMISSION: LETTER OF APPROVAL

Mr TI Dama
Department of Agricultural Economics Extension and Rural Development
Faculty of Natural and Agricultural Science
University of Pretoria

Reference number: NAS260/2021
Project title: The prioritisation of policy options to transform food systems for safer food systems in South Africa

Dear Mr TI Dama,

We are pleased to inform you that your submission conforms to the requirements of the Faculty of Natural and Agricultural Sciences Research Ethics Committee.

Please note the following about your ethics approval:

- Please use your reference number (NAS260/2021) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.
- Please note that ethical approval is granted for the duration of the research (e.g. Honours studies: 1 year, Masters studies: two years, and PhD studies: three years) and should be extended when the approval period lapses.
- The digital archiving of data is a requirement of the University of Pretoria. The data should be accessible in the event of an enquiry or further analysis of the data.

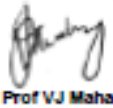
Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.
- **If Applications using GM permits:** If the GM permit expires before the end of the study, please make an amendment to the application with the new GM permit before the old one expires
- **If Applications using Animals:** NAS ethics recommendation does not imply that Animal Ethics Committee (AEC) approval is granted. The application has been pre-screened and recommended for review by the AEC. Research may not proceed until AEC approval is granted.

Post approval submissions including application for ethics extension and amendments to the approved application should be submitted online via the Ethics work centre.

We wish you the best with your research.

Yours sincerely,



Prof VJ Maharaj
Chairperson: NAS Ethics Committee

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