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# Exploring Sustainable Food Consumption Research Agenda in South Africa: Possibilities for Circular Economy Based Approaches

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# EXPLORING SUSTAINABLE FOOD CONSUMPTION RESEARCH AGENDA IN SOUTH AFRICA: POSSIBILITIES FOR CIRCULAR ECONOMY BASED APPROACHES

**Abstract**: The growing income levels and population worldwide have increased the demand for food, leading to unsustainable production and consumption practices. Food waste has significant ecological impacts, such as contributing to greenhouse gas emissions through decomposition in landfills. This study aims to explore the barriers and motivators for sustainable food consumption (SFC) in South Africa. One aspect of this issue is examining the potential for the circular economy (CE) approaches to address post-harvest losses in the food supply chain. Further along the supply chain, food losses become more evident at the retail level, where the removal of unsold food from the chain—at the consumer level, generated waste by the disposal of unconsumed food. CE strategies can help reduce waste by directing edible food towards donations and finding alternative uses for food unsuitable for consumption, such as converting it into energy or animal feed. Implementing CE strategies can benefit society, the economy, and the environment in South Africa. However, policy support is needed to transition fully to a CE model.

**Keywords**: Circular economy, sustainable food consumption, food loss and waste, Sustainable Development Goals, South Africa

## Introduction

The South African economy relies mainly on the service sector, with agriculture's contribution to Gross Domestic Product (GDP) being lower than other Sub-Saharan African countries. As per Potgieter *et al*. (2020), approximately 27% of food is lost or wasted in South Africa, making it imperative to reduce this loss and waste. Under the Food Waste Voluntary Agreement (CGCSA, 2020), the Food Loss and Waste Protocol encourage stakeholders to disclose their food waste. Additionally, identifying circular economy (CE) programs for the food sector in South Africa is crucial. These food waste management strategies aim to prevent food waste and reduce food loss by avoiding landfills (Potgieter *et al*., 2020; Salomone *et al*., 2017).

Transitioning to a CE requires leveraging existing green economy policies and initiatives to reduce food loss and waste (FLW). Preventive interventions focus on production, distribution, and consumption and examine supply chains to determine how CE strategies can reduce FLW. On the other hand, recovery options focus on recycling surplus food and promoting organic products.

Access to sufficient food and water is a constitutional right in South Africa, and the government has implemented several policies and regulations to protect this right. These interventions address food security challenges by increasing access to food and water (Schönfeldt *et al*., 2018). International commitments, such as the Sustainable Development Goals established by the United Nations (UN), often influence the development of domestic policies and programs (Hendriks *et al*., 2016). However, despite government commitments to greater economic equality, the most vulnerable populations in South Africa continue to suffer (Hundenborn *et al*., 2019).

Food waste has unique characteristics compared to other waste types, making conventional recycling processes challenging (Zhao and Li, 2022; Thapa Karki *et al*., 2021). In addition, unlike different waste fractions, food waste cannot be stockpiled until proper reuse. To minimise losses and food wastage along the entire supply chain (or supply loops), promising ideas and potential options need to be transformed into clear and achievable goals and tasks (Lemaire and Limbourg, 2019; Amicarelli *et al*., 2021; Nahman and de Lange, 2013; Parfitt *et al*., 2010; Provin *et al*., 2021; Xue *et al*., 2017).

This perspective study aims to explore sustainable food consumption (SFC) in South Africa and identify gaps in barriers and motivators of SFC. It also examines CE-based approaches to assess their potential for addressing SFC issues. The study is crucial as food waste significantly contributes to climate change

through its ecological impact and is a significant source of greenhouse gas emissions. Practising CE strategies is critical to the transition towards a decarbonised society, and more than 70 countries have committed to achieving net carbon emissions by 2050 following the Paris agreement. However, South Africa has only intended to commit to net zero carbon emissions by 2050. Further research is needed to inform policy on implementing CE-based approaches in the food sector for sustainable production and consumption.

## *2. Understanding food consumption*

Food consumption encompasses food security, loss, and waste. With the recent population growth and expansion of the middle class, food consumption has increased, increasing food production, often through unsustainable methods. This surge in production has led to overproduction and inefficient food production, causing food losses and waste. It is crucial to address unsustainability across the various stages of the food lifecycle to address unsustainable food production and consumption. Circular approaches are potential solutions to these sustainability challenges. The following paragraphs provide further information on these issues.

### *2.1 Food loss and waste*

Food loss and waste are two distinct but related concepts in the food supply chain. Food loss refers to the decrease in quantity or quality of food, often occurring in the early stages of production, which makes it unsuitable for human consumption. On the other hand, food waste occurs when the removal of food from the supply chain that is still fit for human consumption occurs due to reasons such as expiration, spoilage, poor stock management, or economic factors (Joardder and Masud, 2019). The distribution of FLW varies between developed and developing countries, with FLW primarily occurring at the consumption stage in developed countries and more at the production stage in developing countries (Chen *et al*., 2020). The scope of the problem of FLW is significant, with over 1.3 billion tons of food waste produced globally, equivalent to 13.8% of food production (Parfitt *et al*., 2010). This food waste could feed around 1 billion people and contributes to global greenhouse gas emissions and resource depletion (Kummu *et al*., 2012; Porter *et al*., 2016). The causes of FLW are varied, including lifestyle changes as populations move above the poverty line, infrastructure limitations, environmental and climate factors, and grading for quality or safety (Dora *et a*l., 2021). Addressing the challenges of FLW requires increased attention and action from all actors along the food supply chain.

#### 2.1.1 Defining food loss and waste

Food loss and food waste are often interchangeable, but they refer to different stages of the food supply chain. Food loss refers to a decrease in the quantity or quality of food, often in the early stages of production, which makes it unsuitable for human consumption (Gustafsson *et al*., 2013; Chen *et al*., 2020). This food loss can be due to a lack of proper systems or infrastructure in post-harvest activities. On the other hand, food waste occurs when the removal of food from the supply chain that is still fit for human consumption occurs due to expiration, spoilage, poor stock management, or economic reasons (Joardder and Masud, 2019). Food redirected to agricultural compost, animal feed, or bio-energy also falls under this category (Joardder and Masud, 2019).

However, the distribution of FLW along the food value chain differs between developed and developing countries. In developed countries, FLW mainly occurs at the consumption stage, while in developing countries, the losses happen more at the production stage (Parfitt *et al*., 2010; Amicarelli *et al*., 2021). According to Chen *et al*. (2020), approximately one-third of the food produced globally is lost or wasted at the post-harvest and pre-consumption stages or the post-consumption stage along the food supply chain. Thus, addressing the challenges of FLW requires a comprehensive understanding of the losses that occur along the food supply chain in both developed and developing countries.

### 2.1.2 Scope of the problem of food loss and waste

In 2019, downstream stages generated over 931 million tons of food waste, with household consumption being the most significant contributor (Amicarelli *et al*., 2021; Chauhan *et al*., 2021). Other sources of food waste include the food service and retail sectors (Amicarelli *et al*., 2021) and production and post-harvest stages (Chauhan *et al*., 2021). In the South African food supply chain, food waste occurs at various stages, including agricultural or post-harvest (50%), processing and packaging (25%), distribution and retail (20%), and consumer level (5%) (Loss, 2017).

The global average per capita greenhouse gas (GHG) emissions due to food waste in 2011 were around 323 kg CO2eq (Porter *et al*., 2016), with developing economies contributing significantly to the increase in emissions due to higher losses in fruits and vegetables (FAO, 2019). Food waste also embeds a significant amount of resources, including 24% of cropland, freshwater, and fertiliser used for food production (Kummu *et al*., 2012). In Europe, the freshwater footprint of food waste is around 27 litres per capita per day, almost equivalent to the per capita municipal freshwater consumption (Chen *et al*., 2020). In South Africa, the embedded water in wasted food is enough to provide power to the City of Johannesburg for four months or to fill 600,000 Olympic-sized swimming pools (von Bormann, 2019). The embedded energy cost of food waste in South Africa is estimated to be R1 billion (von Bormann, 2019).

Overall, the high levels of food waste along the food supply chain are a significant problem that requires increased attention and action to address the ecological and economic impacts.

### 2.1.3 Causes of food loss and waste

In recent years, millions of people worldwide have lifted themselves out of poverty, leading to the growth of the middle class, particularly in developing economies, resulting in many lifestyle changes (von Bormann, 2019). As more people can afford to make specific lifestyle changes, more people are moving above the poverty line, increasing access to resources (Ananno *et al*., 2021; von Bormann, 2019). These macro-trends are likely to continue, and by 2050, a projected global population of at least nine billion will require feeding (Parfitt *et al*., 2010; von Bormann, 2019; Valencia *et al*., 2022; Ananno *et al*., 2021). This expected increase in population will drive the demand for food worldwide by 70% to sustain the human population in 2050 (Ananno *et al*., 2021). Consequently, as the number of people with access to food increases, so will resource-intensive diets and waste due to population and income growth.

Infrastructure limitations, environmental and climate factors, and grading for quality or safety contribute to food losses in the upstream supply chain during production, post-harvesting, and processing (Dora *et al*., 2021; FAO, 2019). Inadequate cold storage or processing conditions increase FLW in fruits and vegetables more than in cereals and pulses (FAO, 2019). On-farm food losses occur before, during, or after harvesting; in some cases, crops may be left unharvested in the field. The causes of on-farm losses are many and context-specific, often influenced by pre-harvest factors such as weather conditions, seed quality, crop variety and growing practices, pest infestation, and disease infections. The time gap between various stages of the food supply chain, from production to consumption during transportation, introduces the risk of food damage or loss, particularly for perishable products, due to factors such as excessive heat or cold, transit damage, contamination, etc. (FAO, 2019).

### 2.1.4 Impact of food loss and waste

Food production is a resource-intensive process (Valencia *et al*., 2022, Kummu *et al*., 2012), and it also contributes to global GHG emissions, freshwater withdrawals, and land use (Chen *et al*., 2020, Kummu *et al*., 2012, Porter *et al*., 2016). Therefore, FLW creates pressure on the ecosystem by (a) wasting precious resources like water, fertilisers, seeds, electricity etc.; (b) deterioration of land quality by depletion of nutrients; (c) adding to food insecurity; (d) contributing to landfill, environmental pollution and climate change (von Bormann, 2019, Potgieter *et al*., 2020).

Due to these FLW impacts, waste management hierarchy actions help reduce FLW along the food supply chain and the amount of food in landfills. The measures are prevention, reuse, recycling, recovery, and disposal (Amicarelli *et al*., 2021, Do *et al*., 2021, Dora *et al*., 2021, Ingrao *et al*., 2018, Lemaire and Limbourg, 2019, Mak *et al*., 2020, Martin-Rios *et al*., 2018, McConville *et al*., 2015, Ojha *et al*., 2020, Usmani *et al*., 2021). Preventative and reuse measures are prioritised in this hierarchy as some food is still suitable for consumption.

Food production accounts for approximately one-quarter of global greenhouse gas emissions, i.e., 6% of total global emissions, even though food is a basic human need (Poore and Nemecek, 2018). The amount of GHG caused by food waste production is a concern, i.e., food lost in supply chains and consumer waste. The estimate for food GHG emissions is likely to be a little bit higher due to food losses on the farm during production and harvesting processes.

2.1.5 The importance of addressing food loss and waste and research on food loss and food waste

The decade leading up to 2030 is crucial for the food industry as various international, regional, and local organisations work towards reducing FLW. This period is significant because the UN has set 2030 as a deadline to achieve the food supply and food waste management targets outlined in the Sustainable Development Goals (SDGs). Specifically, SDG 12.3 aims to cut global food waste by half at the retail and consumer levels and reduce food losses along the production and supply chains, including post-harvest (Amicarelli *et al*., 2021).

Several countries are taking steps to meet this target by implementing stricter laws and regulations to address FLW. In Africa, the African Union's (AU) Malabo Declaration aims to halve food losses at the post-harvest stage by 2025 (AUC, 2014). However, many African countries have yet to meet these goals, and it is unlikely they will achieve them by 2030. According to the Comprehensive African Agriculture Development Programme (CAADP) Biennial Review, progress in implementing the Malabo Declaration has been slow, with only a third of the 51 member states making substantial progress (AU, 2022). South Africa, in particular, is falling behind in several areas, including CAADP Process Commitment, Agricultural Investment Finance, Ending Hunger, Eradicating Poverty through Agriculture, Intra-African Trade in Agriculture Commodities and Services, and Climate Variability Resilience.

FLW is a problem that affects both developed and undeveloped countries, although its cause and location differ. In developed countries, FLW mainly occurs at the consumption stage, while in undeveloped countries, it occurs more at the production stage. This disparity highlights the need for unique approaches to tackle FLW in each country.

Additionally, FLW has numerous economic, environmental, social, and ethical impacts due to the resource-intensive nature of modern agriculture. Food production consumes large amounts of raw materials and creates significant environmental effects, making FLW unsustainable.

## *3. Food consumption in South Africa*

Since the post-apartheid era in South Africa (1994), food consumption patterns have changed compared to the previous period (Jetter and Cassady, 2006; Ronquest-Ross *et al*., 2015). These shifts are likely to continue due to factors such as food availability, accessibility, and choices (Jetter and Cassady, 2006; Ronquest-Ross *et al*., 2015). Additionally, the increasing cost pressures on food will also contribute to changes in food consumption patterns (Temple *et al*., 2011). Trends in total food expenditure indicate an increase in spending on fruits, vegetables, and processed foods, while spending on maise and wheat flour has declined (Ronquest-Ross *et al*., 2015).

Studies conducted in South Africa reveal that food cost pressures force low-income individuals to consume energy-dense and nutritionally inadequate diets compared to healthier diets (Temple *et al*.,

2011). On the other hand, people in the higher middle class, despite having financial resources, often make unhealthy dietary choices, primarily due to their lifestyle (Temple *et al*., 2011). As a result, there is an increase in obesity and other non-communicable diseases among high-income individuals (Temple *et al*., 2011; Ronquest-Ross *et al*., 2015; Jetter and Cassady, 2006; Farmer *et al*., 2017; Schönfeldt *et al*., 2018).

A comparison of food costs on an energy basis (cost per kJ) reveals that the least expensive sources of energy include refined cereals and foods with added sugar and fat, while nutrient-dense foods such as fish, lean meat, vegetables, and fruit are much more expensive (Jetter and Cassady, 2006). As a result, healthier diets rich in micronutrients and lower in energy density are generally more costly (Drewnowski *et al*., 2004; Temple *et al*., 2011). Over the past few decades, food consumption in South Africa has shifted towards a more Western-style diet that is energy-dense and nutritionally inadequate (Ronquest-Ross *et al*., 2015; Temple *et al*., 2011; Schönfeldt *et al*., 2018).

### *3.1 Food security in South Africa*

The racial disparities in poverty in South Africa are traceable back to colonialism and apartheid (Shinns and Lyne, 2004). In 1951, the creation of Bantu homelands led to further inequalities in access to land and resources, causing household food insecurity, particularly in rural areas (Van der Merwe, 2011). In South Africa's agricultural sector, there are more than 46,000 commercial farmers who occupy 80% of the agricultural land in the well-developed commercial farming sector, while small-scale communal farmers occupy nearly 14% of the remaining land (Vink and Van Rooyen, 2009). There are also approximately 1.25 million smallholder farmers who operate on small pieces of land not exceeding 0.5 hectares, and a growing number of emerging commercial farmers in communal areas, numbering about 35,000 (Vink and Van Rooyen, 2009).

At the end of apartheid, a large proportion of the South African population lived in rural or semi-rural areas and depended on the urban-industrial economy with limited access to land (Lahiff and Cousins, 2005). This segregation resulted in limited agricultural opportunities, as the people were mostly confined to overcrowded land unsuitable for agriculture, leading to small-scale agricultural activities that contributed little to household livelihoods compared to wage employment and welfare payments.

Food insecurity is now one of the biggest challenges facing policymakers. The increasing trends in poverty, hunger, malnutrition, and obesity caused by the consumption of high-calorie processed foods with low nutritional value highlight the need for addressing the quality of consumed food. The challenges are no longer just about access to food but also the quality of food consumed, making it essential to address food security concerns.

### *3.2 (Un)-Sustainable food consumption*

Moomaw and Barthel (2012) identify three unsustainable consumptive trends that negatively affect food security. The first trend is overconsumption, which impacts food prices and reduces food accessibility for the poor. Second, modern food production methods, which are resource-intensive, contribute to the increased demand for resource-intensive food products. However, these intensive methods also reduce the agroecological resource base, limiting the ability to produce adequate and nutritious food. On the other hand, underconsumption and food insecurity are prevalent in many developing countries, where the average caloric intake of vulnerable and food-insecure individuals may be as low as 1,200 kcal per person per day.

Overconsumption in developed and developing countries directly impacts food prices and reduces food accessibility for the poor (Moomaw and Barthel, 2012). Additionally, some individuals become food insecure due to overconsumption because the food they consume lacks the required nutrients to maintain a healthy diet. The trend of overeating is a global food security issue, and obesity is no longer limited to developed countries. The number of overweight individuals globally now surpasses that of underweight individuals (Moomaw and Barthel, 2012). Obesity is also increasingly prevalent in

developing regions where hunger and undernutrition remain high (Barazzoni and Gortan Cappellari, 2020; Moomaw and Barthel, 2012).

### *3.3 Scope of the problem*

A healthy diet is unaffordable for most South Africans, despite the country's classification as middle-income (Temple *et al*., 2011; Hundenborn *et al*., 2019). Nahman *et al*. (2012) categorise food consumption in South Africa for high, middle, and low-income earners into low, middle, and high categories. The high-income inequality in South Africa, the highest globally (Jonah and May, 2019; Martins, 2007), has led to widespread food insecurity among households. The significant income disparity among South African income earners confines a large portion of the population to poverty and makes it difficult for them to afford a healthy diet. In addition to income inequality, the rising cost of food and high poverty levels mean that many poor households cannot afford a diverse and nutritious diet (McCarthy *et al*., 2019).

South Africa does not compare well with other middle-income countries with similar characteristics, such as average income, population size, and development challenges (e.g., Brazil, Mexico, or Thailand) (Hundenborn *et al*., 2019; Schönfeldt *et al*., 2018). The nutritional metrics of these countries are also better than South Africa, indicating that high levels of inequality result in higher poverty compared to other middle-income countries (Schönfeldt *et al*., 2018).

According to Chen *et al*. (2020), two billion people worldwide suffer from hunger and malnutrition due to poverty and poorly developed food systems. Food unavailability and high prices are significant constraints for low-income earners, hindering them from accessing a healthy diet (Jetter and Cassady, 2006). Temple *et al*. (2011) highlight that healthy food options may not be readily available in the local food stores of low-income consumers. Middle-income earners have also become vulnerable to malnutrition due to poor dietary choices, indicating that both low- and high-income earners are susceptible to food insecurity. South Africa's nutritional levels are poor compared to industrialised countries (Schönfeldt *et al*., 2018), likely due to the abovementioned issues. In 2017, nearly 15% of South Africans (6.8 million) experienced hunger, affecting 1.7 million households (Stats SA, 2022).

### *3.4 Impact*

Unsustainable food consumption is contributing to rising rates of food insecurity, with populations in South Asia and Sub-Saharan Africa particularly vulnerable to undernourishment. The devastating effects of chronic undernourishment, such as stunted growth, underweight, disease susceptibility, and reduced life expectancy, are especially severe for children in many countries. Despite enough food being produced globally, over 800 million people still suffer from hunger and underconsumption due to excessive food waste (Ananno *et al*., 2021, Reisch *et al*., 2013).

The issue of food consumption is becoming increasingly important in discussions around sustainable production and consumption (SPC) due to its impacts on the environment, natural resources, health, social cohesion, and the economy (Feil *et al*., 2020, Jurgilevich *et al*., 2016, Reisch *et al*., 2013, Farmer *et al*., 2017). Trends in overconsumption are only exacerbating these problems. The resource-intensive consumption patterns driving the global food production system are not sustainable (Moomaw and Barthel, 2012). The high consumption of industrially-produced meat in Western diets is a critical food consumption issue (Jurgilevich *et al*., 2016). Such production systems heavily burden the environment through increased nutrient and energy demands, GHG emissions, and other pollutants (Jurgilevich *et al*., 2016, Lemaire and Limbourg, 2019, Reisch *et al*., 2013).

### *3.5 The importance of sustainable food consumption in South Africa*

This section emphasises the importance of addressing SFC. A key factor contributing to the need for addressing SFC is the change in food consumption patterns in South Africa since 1994, which has led to food security concerns. One of the characteristics of this shift is the adoption of unhealthy diets, characterised by high energy density and low nutritional value, resulting in a rise in obesity and other non-communicable diseases.

Food insecurity is another crucial aspect of food consumption, with rising trends in food poverty, hunger, malnutrition, and an obesity epidemic caused by consuming high-calorie processed foods with little nutritional value. Unsustainable food consumption practices have exacerbated food poverty, hunger, and malnutrition, and the increasingly resource-intensive consumption patterns have placed a significant burden on the environment.

By not addressing these unsustainable food consumption practices, the trends of food insecurity, poverty, hunger, malnutrition, and obesity will continue to rise. Factors contributing to food insecurity include poor dietary choices, lack of access to nutritious food, and income inequality. It is observed in all regions that as income increases, so does the prevalence of obesity. The impact of obesity on health and public health expenditures is a major concern, as it is associated with numerous chronic diseases such as diabetes, heart disease, hypertension, and cancer.

## ***4. Circular economy***

The UN's SDG indicator 12.3 aims to decrease FLW across food supply chains. Implementing circular economy (CE) principles in food production can transform these supply chains and help society address future challenges by promoting a more circular system that emphasises resource conservation and recovery (Poponi *et al*., 2022). There are many areas for improvement along the value chain of agricultural products to increase sustainability and circularity, and resource recovery is a crucial aspect to consider. CE initiatives to reduce FLW must incorporate SPC practices as part of government efforts.

### *4.1 Defining circular economy*

Each time a linear system produces goods, the finite supply of resources depletes and generates waste (Blomsma *et al*., 2019). The Western diet, which relies heavily on industrially-produced meat, places a significant burden on the environment (Jurgilevich *et al*., 2016). Such production systems increase nutrient and energy demands, GHG emissions, and other pollutants (Jurgilevich *et al*., 2016; Lemaire and Limbourg, 2019; Reisch *et al*., 2013). Most developing countries are adopting resource-intensive production systems to address food insecurity, but these systems cause problems because components, products, or materials reach the end of their life cycle too soon (Blomsma *et al*., 2019). Circular economy (CE) approaches offer a solution by promoting sustainable food production and addressing SFC issues (Pieroni *et al*., 2021; Provin *et al*., 2021; Velasco-Muñoz *et al*., 2021; Potgieter *et al*., 2020; Priyadarshini and Abhilash, 2020).

The product life cycle, which includes the extraction, transportation, manufacturing, distribution, use, and disposal stages, further illustrates the difference between the linear and circular economy (Blomsma *et al*., 2019). Monitoring resources at each cycle stage can help account for their use and identify losses at each step. The main problem with the linear economy is the loss of resources during the life cycle, when there is still potential to extract value before they are sent to the landfill (Blomsma *et al*., 2019). CE principles aim to reuse materials, remove product value, and prevent loss or waste (Blomsma *et al*., 2019). The cradle-to-cradle approach is a relevant concept for describing the CE. It aims to minimise waste by repurposing used resources as raw materials. Several studies discussed this approach (Alejandrino *et al*., 2021; Azevedo *et al*., 2017; Bocken *et al*., 2016; Do *et al*., 2021; Geissdoerfer *et al*., 2017; Linder *et al*., 2017; Liu *et al*., 2021; Zwolinski *et al*., 2006). This approach is particularly relevant in reducing FLW along the food supply chain (Blomsma *et al*., 2019).

### *4.2. Importance of circular economy in the food sector*

The global agricultural and food sector must transition towards more sustainable production and consumption patterns (Velasco-Muñoz *et al*., 2021). Poponi *et al*. (2022) state that the agri-food sector must embrace a sustainable development model in line with the Circular Economy (CE) principles. The CE offers a promising approach to improving resource efficiency and reducing FLW (Potgieter *et al*., 2020; Sharma *et al*., 2021; Provin *et al*., 2021; Del Borghi *et al*., 2020). Geissdoerfer *et al*. (2017) describe the CE as a regenerative system that minimises resource input, waste, emissions, and energy leakage by slowing, closing, and narrowing material and energy loops. In a CE, waste and pollution are prevented by keeping products in use for longer and by recycling materials at a high quality within the production system and, if possible, returning them to the biosphere to restore natural capital at the end of life (Potgieter *et al*., 2020).

According to Blomsma *et al*. (2019), the CE encompasses a range of efficiency-enhancing activities known as circular strategies, such as reducing, reusing, repairing, recycling, restoring, and cascading. The CE offers a unique opportunity to circulate resources and waste in a closed-loop system (Ingrao *et al*., 2018). For instance, food waste can be input in other processes, such as composting. In a CE context, waste management follows the waste management hierarchy, which prioritises reducing, reusing, recycling/recovering, and disposal (Do *et al*., 2021; Ingrao *et al*., 2018). Therefore, the food waste management strategy should not rely on a single hierarchy strategy but on a combination of them. This transition to the CE is crucial for reducing and managing waste efficiently throughout the materials value chain, including materials flow. The CE can stimulate the economy in several ways, including promoting production, creating employment, and improving resource efficiency while protecting the environment (Salomone *et al*., 2017). Additionally, the CE can promote sustainable consumption and prevent FLW.

### *4.3. Strategies of Circular Economy in the food sector*

Circular economy (CE) strategies are derived from the CE principles and mainly consist of four alternatives for developing circular models: i) narrowing resource loops, ii) slowing resource loops, iii) closing resource loops, and iv) regenerating resource flows (Rivera *et al*., 2020; Velasco-Muñoz *et al*., 2021).

The narrowing resource loops strategy aims to minimise resource intensity and environmental impact per unit of product or service through eco-efficient solutions (Mendoza *et al*., 2017). This strategy is suitable for modern agriculture food systems, particularly those that produce the resource-intensive Western diet (Jurgilevich *et al*., 2016). The main objective of the narrowing strategy is to reduce inefficiencies in resources, including nutrients, costs, materials, labour, energy, and capital, while also improving efficiency with externalities such as GHG emissions and toxic substances (McCarthy *et al*., 2019).

The slowing resource loops strategy involves prolonging and intensifying the use of products to maintain their value over time (Bocken *et al*., 2016). Consumers play a crucial role in this strategy by making better buying decisions to promote sustainable consumption, such as purchasing food that will not spoil or expire quickly and adopting healthier diets (Moreno *et al*., 2020). The focus of this strategy is to extend the life of resources within the food supply chain and prevent consumable food from being discarded.

The closing resource loops strategy involves creating new value through reusing and recycling used materials (Bocken *et al*., 2016). Resource cascading is an example of this strategy, where discarded materials from the value chain are used as raw materials in another process or product cycle (Santagata *et a*l., 2020). This strategy is typically associated with biological resources, such as composting and bio-energy production, as the marginal costs of reusing the material are lower than virgin material.

The regenerating resource flows strategy involves preserving and enhancing natural capital through regenerative practices, such as using organic fertilisers, planting cover crops, rotating crops, and reducing tillage (Morseletto, 2020). This strategy is linked to biological resources and includes alternative forms of agricultural production, such as vertical farms and indoor farms, which could reduce GHG emissions associated with transportation and integrate nature-based solutions into cities (Rufí-Salís *et al*., 2020; Toboso-Chavero *et al*., 2019).

The agricultural activity involves producing biological products and using technical materials and equipment to apply CE strategies (Velasco-Muñoz *et al*., 2021). These technical materials and equipment can narrow, slow, close, and regenerate resource loops in agricultural production. In conclusion, agricultural production can apply different CE strategies to reduce inefficiencies, extend the life of resources, and promote sustainable practices.

### *4.4 The potential of circular economy in solving issues of unsustainability in food consumption*

Although South Africa's circular economy (CE) is a critical component of its national development strategy, it has faced numerous obstacles in achieving SFC and production. However, the waste economy in South Africa has the potential to make a significant contribution to its GDP (Potgieter *et al*., 2020). To fully realise this potential, it is essential to focus on recovering and using materials currently being lost to landfills and, even better, to prevent waste from happening in the first place.

Implementing a CE system that promises sustainable development will require significant changes in social, industrial, and consumption systems (Geissdoerfer *et al*., 2017; Schroeder *et a*l., 2019). Addressing unsustainable food consumption is one of the most pressing challenges, and the CE offers a promising solution. Companies involved in food production and manufacturing at the industrial level play a critical role in implementing the CE. They use resources to produce food throughout various stages of production, and some food is inevitably lost and wasted. The current food production systems in most industrialised countries are unsustainable, driven by growing unsustainable food consumption. The current resource-intensive, unsustainable model shapes the global food production system (Moomaw and Barthel, 2012).

## Findings and Discussion

Some food recovered from food supply chains is fit for human consumption (Salomone *et al*., 2017). Unsustainable production and consumption practices are the leading causes of FLW. Factors contributing to FLW include food spoilage or expiration due to neglect, poor inventory management, and economic behaviours that reflect unsustainable production and consumption patterns (Joardder and Masud, 2019; Salomone *et al*., 2017). Addressing this requires various initiatives to redirect food unsuitable for human consumption to waste valorisation, including options such as agricultural composting, animal feed, and bio-energy (Joardder and Masud, 2019; Salomone *et al*., 2017). The current study investigates food supply chains (FSC) in South Africa and identifies gaps in the barriers and motivators of SFC. Additionally, the study examines the potential of Circular Economy (CE) approaches to tackle some of the challenges of SFC.

As described by Potgieter *et al*. (2020), food waste management programs aim to reduce food waste along the value chain. The goal is to improve efficiency in nutrients, costs, materials, labour, energy, capital, and associated externalities, such as greenhouse gas emissions or polluted water (Velasco-Muñoz *et al*., 2021). When developing CE strategies in food waste management, it is crucial to focus on avoiding the loss of essential nutrients for food production. To achieve this, players along the value chain must take a more active role. Parfitt *et al*. (2010) and Gustafsson *et al*. (2013) have noted that food waste at later stages of the food supply chain is often due to behavioural issues. As such, interventions must target changing the behaviour of those responsible for producing food waste. Potgieter *et al*. (2020) identified waste reduction strategies that include reducing post-harvest losses, donating food, and repurposing food for feed, compost, energy, etc. Thus, these waste reduction

strategies must result from behaviour change at all levels of the supply chain and all life cycle stages, with consumers playing a critical role. An effective waste management strategy prioritises waste prevention, and it is essential to distinguish between avoidable and unavoidable food waste to assess the potential for prevention (Gustafsson *et al*., 2013; Strotmann *et al*., 2021; Lemaire and Limbourg, 2019; Amicarelli *et al*., 2021). Awareness of readily available food waste disposal options also affects the food waste management behaviour of actors along the food supply chain (Lemaire and Limbourg, 2019; Parfitt *et al*., 2010; Yıldız-Geyhan *et al*., 2017).

The core concept of the resource loop strategy is that the Earth is an economic system that circularly links the environment and economy (McCarthy *et al*., 2019). The globalisation of lifestyle patterns has resulted in the development of a global food market, leading to nutrient leakage along the food supply chain. The flow of food creates imbalances, such as the loss of nutrients during production and GHG emissions from the transportation of materials (Kristensen and Mosgaard, 2020). Avoiding these production activities should be planned to prevent overproduction of certain foods, reducing market price volatility and fluctuations in supply (Aznar-Sánchez *et al*., 2020).

Food and beverages are non-reusable, limiting their ability to be repurposed or repaired and limiting their useful life span (Velasco-Muñoz *et al*., 2021). The slow resource loop strategy aims to extend the life of products within the agri-food system, but it faces challenges because some fresh produce, such as cucumbers and tomatoes, cannot be reconstituted once split into pieces. Despite these difficulties, there are other ways to extend the life of agricultural products. Preventing food waste before consumption is one of the primary methods for slowing down the resource loop in food production (Potgieter *et al*., 2020; Salomone *et al*., 2017). Adequate and intelligent food packaging throughout the processing and retail chains, particularly for products with a resource-intensive history, is crucial in reducing food waste and the slow resource loop (Reisch *et al*., 2013).

The closing of resource loops strategy prevents nutrient leakage by reintegrating materials into other processes in the food system, also known as resource cascading. This strategy involves reusing materials in value chains other than their original ones. The slowing strategy aims to keep nutrients within the food chain for as long as possible and includes all food preservation alternatives that extend the shelf life of food, making later consumption possible (Velasco-Muñoz *et al*., 2021).

Closing resource loops involving biological resources entails cascading resource use (Sayadi-Gmada *et al*., 2019). Closing technologies involve recovering material and energy resources, such as gasification, pyrolysis, composting, and anaerobic digestion. Discarded raw materials from the value chain can be reused as inputs in another process or product cycle, replacing virgin materials, including composting and bio-energy production. Reused materials should meet the technical and functional requirements of the new value chain and be cheaper than virgin resources, meaning that the marginal cost of virgin resources should be lower than that of reused materials.

Policies should prioritise closing technologies in managing agricultural waste over other technologies that only aim to recover energy, such as incineration or landfill gas recovery (Velasco-Muñoz *et al*., 2021). Alternatively, nutrient management can also be achieved through a closing strategy, using cascading materials to recover nutrients later. For instance, compost from urban organic waste can fertilise corn crops (Cobo *et al*., 2018).

### *Setting research agenda*

In this paper, the authors attempted to explore the SFC concept in South Africa and identify the gaps in barriers and motivators. They also examined the circular economy (CE) based approaches to determine the possibilities of CE in addressing some of the SFC issues. The main topics reviewed included understanding food consumption, food consumption in South Africa, and the CE. The study recognised the impact and importance of addressing the current unsustainability of food production and consumption, a global problem and is promoting efforts to work towards the UN's SDGs.

The research agenda draws attention to the identified research gaps in the field of SFC and CE in South Africa. The gap in knowledge highlights the need to study FLW, the significance of studying SFC in South Africa, and the potential of CE in resolving unsustainability issues in food consumption. Countries must reduce unsustainable production and consumption, as it negatively impacts the environment. Addressing food security issues, such as hunger, malnutrition, poverty, and obesity is crucial in promoting sustainable food consumption.

Further research is needed to gain a deeper understanding of SFC and CE in South Africa. Consumer behaviour and attitudes towards SFC can be an area of study. This research can provide valuable insights into the factors influencing consumers' purchasing decisions and their perspectives on sustainable food consumption. Another study area can focus on the impact of government policies on promoting SFC and reducing FLW.

Moreover, research can be conducted on the environmental impact of food waste management practices, such as composting and biogas production, and evaluate their effectiveness in reducing FLW and promoting SFC. Another area of research can examine the role of supply chain management in reducing FLW and promoting SFC. This research can focus on developing effective supply chain management strategies and implementing sustainable practices in the food industry.

Additionally, the impact of technology and innovation on SFC and CE practices is another study area. In addition to evaluating the effectiveness of various education and awareness programs for SFC, researchers can also examine the food industry's role in promoting SFC and reducing FLW. Researchers can investigate the relationship between food poverty and SFC in South Africa, evaluate the effectiveness of various education and awareness programs for SFC and examine the food industry's role in promoting SFC and reducing FLW. The food industry's role in promoting SFC and reducing FLW, as well as the effectiveness of various education and awareness programs for SFC, can be evaluated by researchers investigating the relationship between food poverty and SFC in South Africa. Finally, the potential for CE-based approaches in reducing FLW and promoting SFC in different sectors, such as agriculture, food retail, and food service, can be assessed.

In conclusion, the authors suggest these research areas as additional suggestions for the research agenda in the field of SFC and CE in South Africa. Based on the study's specific research questions and objectives, we can refine the research agenda.

## Conclusion

The study aimed to explore and identify gaps in barriers and motivators for SFC in South Africa, as well as examine the potential for the circular economy (CE)-based approaches in addressing some of the issues associated with SFC. The CE strategies aim to reduce resource loss from the food supply chain by redirecting edible food to donations or utilising alternative methods, such as composting, biogas, and animal feed production, for food no longer suitable for human consumption.

The growing income levels and rising population worldwide have driven up demand for food, leading to unsustainable food production and consumption practices. Food waste has significant ecological impacts, including greenhouse gas emissions that contribute to global warming when it ends up in landfills. The CE approach can generate significant business opportunities and bring social, economic, and environmental benefits to South Africa. The policy in South Africa supports the transition to the CE, and it is crucial to have a conducive policy to encourage minimising and managing waste through resource efficiency in the materials value chain. The CE approach offers a means of stimulating the production economy, creating employment, and addressing resource efficiencies while protecting the environment. The food industry and individual consumers need to understand their role in reducing food waste. The South African waste economy has the potential to benefit significantly from the recovery and utilisation of materials currently going to landfills.

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