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Does Policy on Plastic Waste Support Higher Waste Management Hierarchy Options?

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Abstract: There is an urgent and growing need to further advance the plastic waste management system globally and in South Africa, due to the increasing impact of plastic waste. This study focused on the adequacy of plastic policies to sustainably manage plastic waste. Policies need to address the plastic material supply systems and the options up the waste hierarchy for them to be effective and support material circularity. The study used qualitative content analysis to assess how the evolution of plastic policies for plastic waste management in South Africa aligned with national plastic material flows and promoted options higher up the waste hierarchy. This was benchmarked with Norway and Germany, which have some of the highest plastic recycling rates. The results showed that the evolution of existing plastic policies for South Africa addresses stages of production, trade and consumption, and recycling. There is no focus on waste generation, collection and sorting. None aligned with the waste hierarchy options of rethink, reduce, reuse, repair, refurbish, remanufacture and repurpose. This policy gap supports the need for broader national plastic policy frameworks that embed a policy drive in the value chain points and promote the priority higher value measures of the waste hierarchy.

Keywords: plastic policy evolution; material flow analysis; waste hierarchy; sustainable plastic waste management; content analysis

Citation: Olatayo, K.I.; Mativenga, P.T.; Marnewick, A.L. Does Policy on Plastic Waste Support Higher Waste Management Hierarchy Options? *Recycling* **2022**, *7*, 36. https://doi.org/10.3390/recycling7030036

Academic Editors: Michele John and Wan-Ting (Grace) Chen

Received: 28 April 2022
Accepted: 1 June 2022
Published: 8 June 2022

1. Introduction

Plastic materials and products continue to play numerous important roles worldwide, having an extensive range of applications. The addition of different additives has further enhanced the properties of plastic for better performance and more versatility (VanEygen et al., 2017; Geyer et al., 2017) [1,2]. Several sectors of the economy make use of plastic in their operations, including construction, textiles, furniture, health, automobile, electronics, and agricultural (Plastics Europe, 2017; Van Eygen et al., 2017) [1,3], with the packaging sector having the highest percentage of plastic consumption (Jambeck et al., 2015) [4].

The proliferation of plastic usage, coupled with poor end-of-life plastic waste management, has led to widespread pollution and other negative impacts (Dalberg, 2021; OECD, 2018) [5,6]. Between 1950 and 2015, approximately 6.3 billion tonnes of plastic waste was generated globally, with about 79% landfilled and littered, 12% incinerated and 9% recycled (Geyer et al., 2017) [2]. The sustained increase in plastic waste is a source of rising concern amongst citizens, governments, interest groups, academics and other related stakeholders. For example, the consumption of plastic bags is substantial in South Africa, with legislations specifically targeted at addressing the resulting impact (Dikgang et al., 2012) [7]. There is growing concern in the country over plastic packaging waste and pollution (Ryan et al., 2018) [8]. Most manufacturers of plastic packaging are reluctant in recycling the waste of these products considering that the cost of virgin plastic polymer could be lower when

compared with cost of recycling (Intagliata, 2012) [9]. Another challenge in South Africa is microplastics, with the country presumed to be amongst the major contributors of plastic that ends in the sea (Ryan, 2020) [10].

The interdependencies among the different stages of the plastic life cycle and the need for further research in plastic governance has been argued by scholars (Peng et al., 2017; Tibbetts, 2015; Thompson et al., 2009) [11–13]. This supports the necessity for policy measures for the sustainable management of plastic waste ecosystem. In reviewing several studies, Nielsen et al. (2019) [14] concluded that the entire life cycle or value chain of plastic is political, and some stages presently control a disproportionate portion of public interest and attention.

Plastic materials flow from production to consumption and finally to waste management (Rivers et al., 2017) [15]. Regulating the production and consumption of plastic is arguably more contentious than developing plastic waste management and recycling. Yet, the development of plastic waste management is complex and is challenged by activities and processes relating to waste reduction, collection, sorting and recycling (Rivers et al., 2017; Hopewell et al., 2019) [15,16]. This is more evident in most developing countries with under-developed waste management systems (Jambeck et al., 2015; Oyake-Ombis et al., 2015) [4,17]. Furthermore, the recycling of plastic waste is relatively low when compared with such materials as glass, metal and paper (Ellen MacArthur Foundation, 2016) [18].

Policies are a key pillar to support the sustainable use of plastic materials and recycling in a circular economy. Waste management policies are regarded as fundamental in tackling the waste problem (Jambeck et al. 2015) [4]. Key plans are regulations (prohibition, ban, suspension, and limitation), economic instruments (tax, levy, subsidies, and cash for returns) and information and guidance (campaign, education and research).

In reviewing the evolution of policies that address waste management and pollution in the South Africa, Godfrey and Oelofse (2017) [19] identified a number of major policy stages that have molded the waste sector of the country over the years. While the policy timeline indicated a rising trend in the amount of waste policy responses initiated since the inception of the Environmental Conservation Act of 1989, the country was still lagging behind the developed countries in the management of waste and the shift from landfilling to recycling. Unfortunately, approximately 90% of the waste generated in country was still landfilled (SAPRO, 2020) [20].

Building upon the policy timeline and the historical development of waste management in South Africa (Godfrey and Oelofse, 2017) [19], this paper presents a focused study on the growing questions on the adequacy of policies to respond to the problems of plastic pollution (Xanthos and Walker, 2017; Dauvergne, 2018) [21,22]. There is a need for policies to address multiple stages of plastic product life cycles (Karasik et al., 2020) [23].

Therefore, this study's aim was to examine the evolution of national plastic policies, with a particular focus on how policies are embedded in the national plastic material flow system and how they support options higher up the waste hierarchy. It benchmarked South Africa with Norway and Germany. The decision to benchmark South Africa with Norway and Germany was based on the internationally leading recycling rates in these countries. South Africa still has a developing plastic waste management and low performing recycling system, with approximately 13% and 17% plastic recycling rates for 2017 and 2019, respectively (Olatayo et al., 2021b; 2021a) [24,25]. This is in comparison to Norway and Germany, with developed plastic waste management and high performing recycling systems, with about 45% and 37% plastic recycling rates, respectively, for 2018, particularly attributed to improved waste collection (Milios et al., 2018; Plastics Europe, 2019) [26,27]. This comparison suggests that the South African waste management system needs more development. Globally, Norway and Germany are among the countries to learn from considering the performances of their plastic recycling systems.

The scope of the research analysis was focused on national policies explicitly formulated for plastic and packaging waste, examining how the evolution of these direct policies on plastic waste management enabled the sustainable management of plastic material flows

and the waste hierarchy principle. This includes assessing the contribution and role of policies in different stages of the plastic material flow analysis (MFA) and the promotion of options higher up the waste hierarchy. As a result, the study adopted both the MFA concept and the 9R framework waste hierarchy system. The 9R is the most comprehensive R-framework and provides the highest number of options in the waste hierarchy for circularity. A number of authors such as Kirchherr et al. (2017) [28] and Potting et al. (2017) [29] advocated for the 9R framework.

The main idea in this research was that sustainable plastic resource management has to be embedded at each stage of the material flow system and promoted at the top levels of the waste hierarchy system. Specifically, the study answered the following research questions (RQ):

(a) RQ1: What are the existing direct (explicit) plastic policies supporting the sustainable management and recycling of plastics and how have they evolved over time? (b) RQ2: How do these policies align with the material follow analyses stages of the country and address the national plastic material flow system? (c) RQ3: How do these policies enable the promotion of the measures higher up the waste hierarchy system? (d) RQ4: Considering RQ1, RQ2,RQ3 and national performance, what are the gaps in policy provision and the implications for South Africa, Norway and Germany?

The rest of the study is structured as follows. The next section reviews the national policy timelines for South Africa, Norway and Germany and synthesises all the relevant policies explicitly developed for plastic waste management in these countries. Section 3 documents the methodology adopted for the study. Section 4 details the results of the content analysis of the plastic policies for plastic waste management for the countries. Section 5 discusses policy recommendations for identified policy gaps. Lastly, Section 6 presents the conclusions.

2. General Policies for Plastic Waste Management

Jambeck et al., 2015 [4], suggested that general policies for waste management are essential in solving the challenges associated with plastic waste, even if they are not intentionally designed to respond solely to this type of material waste. When combined with explicit plastic waste policies, they form a more comprehensive set of options for effective plastic waste management (Karasik et al., 2020) [23]. As the global community battles with the rising waste management challenges, countries have initiated general waste policies, and many of these policies have been enhanced or have evolved over the years. A number of studies have reviewed and chronicled national waste policies and their timelines for South Africa (Godfrey and Oelofse, 2017) [19], Norway (Vuorinen and Merta, 2016; Papineshi et al., 2019) [30,31] and Germany (Schroeder and Jeonghyun, 2019; Plastic Zero, 2014) [32,33].

The national policy timeline for general waste management in South Africa was well documented by Godfrey and Oelofse (2017) [19]. According to their review of the evolution of policies and the historical development of waste management, the waste sector of the country has passed through four main stages of development termed the age of landfilling; the emergence of recycling; the flood of regulation; and the drive for extended producer responsibility (EPR). It has moved to the fifth stage, termed the Circular Economy. Forty-four policy responses were identified, which included general waste policies and explicit policies for other specific material wastes. The study was not focused on plastic waste and/or waste hierarchy options.

For Norway, Papineshi et al. (2019) [31] assessed the historical waste management and recycling policies and their effect on waste prevention and recycling in the region. They chronologically listed 23 national waste policies, and timelines, and differentiated between policies with positive or negative effects on waste generation and recycling rates. The waste management policy for Germany was reviewed by Schroeder and Jeonghyun (2019) [32], who identified 29 policies and noted a gradual shift of the focus of the waste regulations from the disposal of waste-to-waste management and to the circularity of the material.

The applicable policies for plastic waste management in South Africa, Norway and Germany are listed in Figure 1. The list excludes regulations explicitly targeted at other specific material waste.

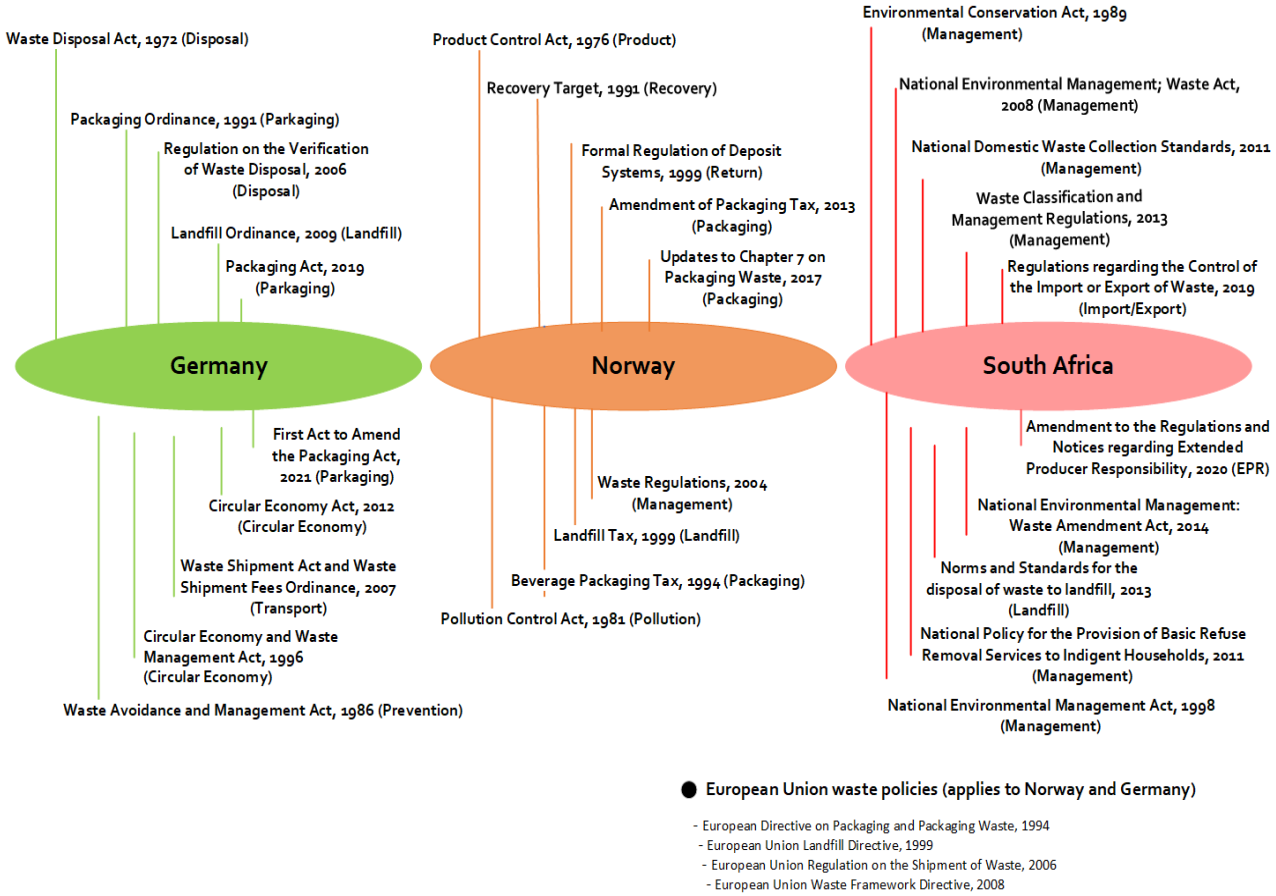


Figure 1. The general policies applicable to plastic waste management.

Ordinarily, South Africa seems to have more general policy responses, numerically, than the two other countries. However, further examination shows that most of the policies of South Africa are similar instruments, and, when they are categorised according to the specialisation or focus of the policies (e.g., disposal, packaging, recovery, etc. as illustrated in Figure 1), the number of policy areas diminishes. South Africa lacks plastic policy Acts on packaging, circular economy, and beverage packaging tax.

The main legislation for South Africa was the National Environmental Management: Waste Act of 2008, which aimed to provide protection for health, well-being and the environment through minimising natural resource consumption and waste generation; reducing, re-using, recycling, recovering and the safe disposal of waste as a last option; ensuring the awareness of waste impact; and providing for compliance with rolled out measures. This Act is centered on the provisions of the National Environmental Management Act of 1998. Interestingly, there is a new offshoot of this regulation termed the Amendment to the Regulations and Notices regarding Extended Producer Responsibility of 2020 (DEFF, 2021a) [34], which came into effect in November 2021. It further extends the responsibilities of producers for their products from the production stage to end-of-life to enable sustainable waste management and circular economy measures. For Norway, the Waste Regulations of 2004 was the most substantial legislation initiated as it covers several features of waste management. It provides for the management of diverse waste streams; guides the activities of waste collection, landfilling, sorting, and recycling; and provides updates on return systems. Germany has several general waste policies in existence; how-

ever, the Circular Economy Act of 2012 is presently the major legislation guiding the goals and principles of waste management. The primary focus of the regulation includes the promotion of the waste hierarchy concept, EPR and the circular economy. Furthermore, regional general policies applicable to plastic waste management exist for both Norway and Germany. These are European Union Directives that are essentially binding on member states and are required to be individually transposed into the national regulations of these states. The most significant regulation is the EU Waste Framework Directive of 2008.

3. Methodology

Qualitative content analysis (Burnard, 1995; Long and Johnson, 2000) [35,36] was used to understand how the plastic policies in each of the three countries support sustainable plastic waste management. The approach was used to analyse the various plastic policy documents for South Africa, Norway and Germany. This enabled valid, objective, systematic and replicable references from texts regarding the contexts of their use (Krippendorff, 2004) [37]. The research approach connects the results of research to its context and origin (Downe-Wambolt, 1992) [38]. The applied qualitative analysis approach was derived from the guidelines by Bengtsson (2016) [39] and Mayring (2014) [40].

The analysis of all the plastic policy documents of the three countries under consideration was conducted using ATLAS.ti 9 qualitative analysis software by Scientific Software Development GmbH Berlin, Germany. It is an important qualitative research tool for systematically and effectively coding and analysing qualitative reports such as transcripts, interviews and literature; building network diagrams; and visualizing data (Lu and Shulman, 2008; Lewis, 2004) [41,42].

The MFA stages and the 9R framework waste hierarchy system were adopted as the coding structures for this study. The 9R is the most comprehensive R-framework and provides the highest number of options in the waste hierarchy for circularity. It has been applied by a number of studies (Kirchherr et al., 2017; Potting et al., 2017) [28,29].

Material flow analysis can be described as an analytical method for systematically modelling the flows and stocks of materials present in a system, defined in space and time (Vujic et al., 2010) [43]. The stages of material flow analysis assessed were production (primary plastic and product), trade (import and export), consumption, waste generation, collection and sorting, and recycling. These stages are defined in an earlier study on national plastic material flow analysis for South Africa (Olatayo et al., 2021a) [24]. The drivers for quantifying the material flows and stocks in a system help inform the sustainable production and consumption of materials and the sustainable management of waste, and they limit environmental impacts (VanEygen et al., 2017) [1].

For analysis relating to the waste hierarchy system, several R-frameworks, including the 3R (Ghisellini et al., 2016) [44], 4R (European Commission, 2008) [45], 6R (Jayal et al., 2010; Yan and Feng, 2013) [46,47] and 9R (Potting et al., 2017; van Buren et al., 2016) [29,48], have been promoted in the literature and applied in practice. The R-framework is seen to be strongly linked to, and regarded as the guideline and core principle of, the circular economy (Zhu et al., 2010; Park and Chertow, 2014; Gharfalkar et al., 2015) [49–51]. The various R-frameworks operate on the principle of hierarchy, with a decreasing priority order of application of the different "R" measures. While all the R-frameworks are apparently similar, they differ majorly in the number of circularity strategies they promote.

The 3R principle of waste management comprises three options, namely, reduce, reuse and recycle (Ghisellini et al., 2016) [44]. Waste should first and foremost be the preferred option be reduced, followed by the options of reuse and recycle, in that order (Iacovidou et al., 2017) [52]. The 4R framework describes the waste hierarchy as comprising five important measures, including prevention, preparing for reuse, recycling, other recoverrecovery, and disposal (European Commission, 2008; Gharfalkar et al., 2015) [45,51]. Compared to 3R, this model has two extra options: other recovery and disposal. The 6R framework has reduce, reuse, recycle, recovery, redesign and remanufacture, in decreasing order of preferred options (Jayal et al., 2010; Yan and Feng, 2013) [46,47]. It has further options of redesign

and remanufacture. The 9R framework has its waste hierarchy characterised by 10 options, which include refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and recover (Potting et al., 2017; van Buren et al., 2016) [29,48]. It contains additional options of refuse, rethink, repair, refurbish and repurpose not present in the 6R.

The first phase of the methodological approach addressed RQ1: what are the existing direct (explicit) plastic policies supporting the sustainable management and recycling of plastics and how have they evolved over time? The identification of the relevant policies for plastic waste management and the timeline were separately conducted for South Africa, Norway and Germany. It involved a search for existing policies in (i) government databases of respective countries, (ii) scientific publications and (iii) grey reports. For the purpose of this study, direct plastic policies included policies on plastic and plastic packaging waste.

The description of the different steps for the policy search and identification, and the search terms, are as follows:

(a) A review of government resources, where the databases of ministries, departments and agencies of the respective country were searched for using the search keywords "waste policies", "waste regulations", "waste act", "waste directives" and "waste recycling policies" in the search engines.

(b) A review of scientific resources, where the database of Scopus was searched using a combination of keywords such as "waste policies AND South Africa", "waste regulations AND South Africa", "waste act AND South Africa", "waste directives AND South Africa", "waste recycling policies AND South Africa", "waste policy timeline AND South Africa" and "waste policy evolution AND South Africa. The keyword search was similarly done for both Norway and Germany. The search produced numerous articles. These articles were quickly searched through for a list of relevant policies. This involved a quick scan of the article title, the abstract and the full text. Studies that reported on a waste policy timeline were particularly helpful.

(c) A review of grey resources, where a general search was conducted in the Google search engine. Additionally, a combination of keywords was used such as "waste policies AND South Africa", "waste regulations AND South Africa", "waste act AND South Africa", "waste directives AND South Africa", "waste recycling policies AND South Africa", "waste policy timeline AND South Africa" and "waste policy evolution AND South Africa. This was equally conducted for Norway and Germany.

(d) The results of the searches in the three different resources were combined, and policy duplicates were removed. Here, a similar policy found in different literature or media was harmonised to avoid the duplication of policies in the record. This resulted in a plastic waste policy inventory comprising four policies for South Africa, three policies for Norway and four policies for Germany. Similarly, two European Union policies introduced for member states were recorded.

(e) Subsequently, a plastic policy timeline comprising all of the plastic policies belonging to the three countries, in the policy inventory, was constructed.

The next phase of the methodological approach involved the content analysis of the policy documents for the respective country. This phase addressed RQ2 (How do these policies align with the material flow analysis stages of the country and address the national plastic material flow system?) and RQ3 (How do these policies enable the promotion of the measures higher up the waste hierarchy system?). RQ2 and RQ3 involved policy analysis with respect to the MFA and 9R waste hierarchy systems, respectively, for the three countries.

The first step for the content analysis involved developing relevant categories, respectively, for both the MFA and waste hierarchy systems. The contents of the policy documents were structured or classified into these developed categories. These categories were developed deductively (Bengtsson, 2016) [39], corresponding to or titled after the different stages of the MFA and 9R waste hierarchy systems. As defined before, the categories for the MFA system include production, trade, consumption, waste generation, collection and

sorting, and recycling, while the categories for the 9R waste hierarchy system are refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and recover.

Furthermore, the categories were coded with equivalent words or phrases to ensure that terms that express similar meanings or interpretations as the categories were captured in the content analysis. The guidelines for the coding of the categories are presented in Table 1, which provides a representative sample of the categories' definitions.

Table 1. The coding framework for the categories.

Category Systems	Categories	Coding Description	Related Terms Coded
Material flow analysis	Production	Expressions about the manufacturing or making of plastics and packaging	Manufacture, making, creation, fabrication, and assembly
	Trade	Referring to the trading, sales, import and export of plastics and packaging	Commerce, business, deal, exchange, market, import, and export
	Consumption	Reference to the use or application of plastics or packaging	Use, utilisation, intake, and expenditure
	Waste generation	An expression making reference to producing or creating plastic and packaging waste	Waste production, waste creation, waste making, and waste initiation
	Collection and sorting	Quotes making relevant expression about collecting or gathering plastic and packaging waste, and the separation of plastic and packaging waste	Gathering, compilation, assemblage, separating, organising, classifying, and categorising
	Recycling	A reference to the conversion of plastic and packaging waste into reusable material	Repossessing, remanufacturing, reutilising, and reconditioning
Waste hierarchy (9R framework) *	Refuse	Abandoning the functions of plastic and packaging or by providing the same functions with a radically different product	Reject, decline, ignore, turn down, turn from, prohibit, and withhold
	Rethink	Statements about making users reconsider plastic product use.	Reorganise, reconsider, reassess, revise, and change direction
	Reduce	A reference to increased efficiency in plastic product manufacture or use	Cut, lower, lessen, bring down, and scale down
	Reuse	Using a plastic product again, which is still in good condition and fulfils original functions	Repeat, use again, and use once more
	Repair	A statement on the maintenance of defective plastic and packaging so that it can be used again	Restore, correct, renovate, patch up, rebuild, mend, and get working again
	Refurbish	A reference to restoring old plastic products and making them up to date	Revamp, remodel, smarten up, renew, recondition, and retrofit
	Remanufacture	Using parts of discarded plastic product in a new product with the same function	Remake, reassemble, and refashion
	Repurpose	Statements about using a discarded plastic product or its parts in a new product with a different function	Provide a new use, or use for a different purpose
	Recycle	Converting or processing plastic waste into a reusable material, of the same or lower quality	Repossessing, reutilising, and convert
	Recover	A reference to incinerating plastic waste to extract an energy source for use	Retrieval, regaining, recapture, reclamation, and energy recovery

* 9R framework adapted from Potting et al. [29] (2017).

Subsequently, the contents of each of the policy documents per country were analysed in the ATLAS.ti system with respect to both the MFA and waste hierarchy systems, separately. Text in the policy documents that makes reference to the relevant categories (stages of the MFA and 9R waste hierarchy systems) was coded. This process was separately

conducted for the three countries. The qualitative content analysis establishes the level of support of each policy for the MFA and waste hierarchy systems of the respective country.

4. Results

This section presents the findings of the qualitative content analysis of the plastic policies for plastic waste management for the three countries under consideration.

4.1. Plastic Policies and Timelines for Plastic Waste Management

This section reviews the identification of the existing plastic policies supporting the sustainable management and recycling of plastics and their timelines. The search showed that South Africa, Norway and Germany adopted four plastic and packaging policies each. Two plastic policies were introduced by the European Union that directly affect Norway and Germany. The timelines of the plastic policies for the three countries are represented in Figure 2 below.

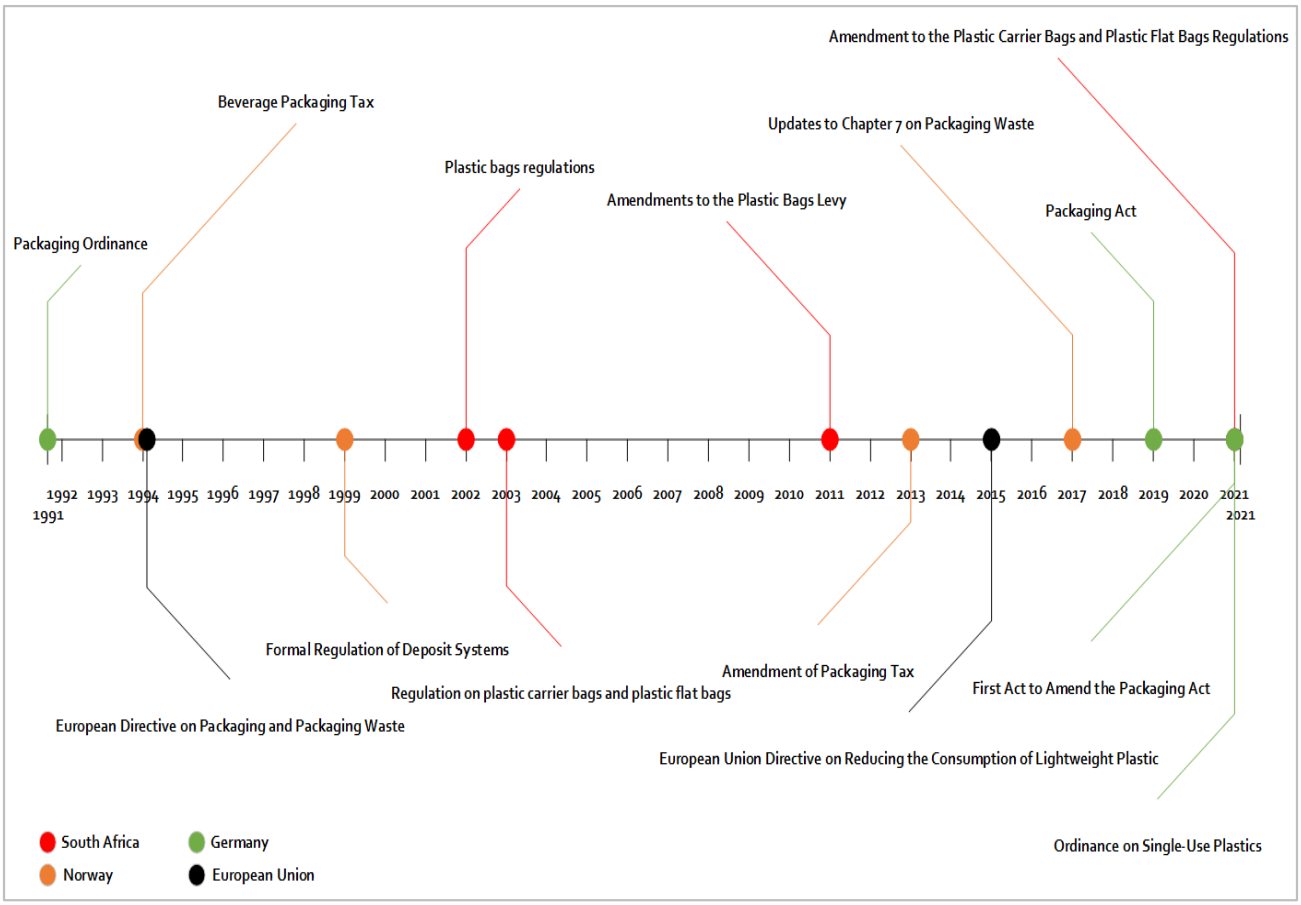


Figure 2. The plastic policy responses and timelines for South Africa, Norway and Germany.

South Africa: the Plastic Bag Regulations; the Regulation of Plastic Carrier Bags and Plastic Flat Bags; the Amendment to the Plastic Bags Levy; and the Amendment to the Plastic Carrier Bags and Plastic Flat Bag Regulations (DEAT, 2002; 2003; Dikgang et al., 2012; Godfrey and Oelofse, 2017; and DEFF, 2021b) [7,19,34,53,54].

Norway: the Beverage Packaging Tax; the Formal Regulation of Deposit Systems; the Amendment to the Packaging Tax; and Updates to Chapter 7 on Packaging Waste (Hennlock et al., 2014; Milios et al., 2018; and Papineshi et al. 2019) [26,31,55].

Germany: the Packaging Ordinance; the Packaging Act; the First Act to Amend the Packaging Act; and the Ordinance on Single-Use Plastics (Gandenberger et al., 2014; Plastic Zero, 2014; Schroeder and Jeonghyun, 2019; LOC, 2021; and CMS, 2021) [32,33,56–58].

The European Union: the European Directive on Packaging and Packaging Waste; and the European Union Directive on Reducing the Consumption of Lightweight Plastic Carrier Bags (Papineshi et al. 2019; Schroeder and Jeonghyun, 2019) [31,32].

The review of the plastic policy timelines established that Norway and Germany started many years ahead of South Africa in the management of plastic and packaging waste. Essentially, there has been an upward trend in the volume of plastic policies introduced over time by the countries, as shown by the timeline in Figure 2. The rise in policies over the past decade, especially from 2011, was notable. This showed that plastic and packaging waste have been receiving increasing attention from different governments in recent years. Additionally, the policy instruments adopted by the three countries are more regulatory than economic.

From the analysis, as shown by the timeline, of the three countries, only South Africa and Germany have policies explicitly designed for plastics. The European Union equally initiated one too. The various policies introduced by Norway and Germany mainly target packaging waste management, of which plastic packaging dominates. While there are other types of plastic pollutants, the plastic policy inventories showed that the plastic policies of South Africa are specifically targeted at plastic bags, while those of Germany directly address single-use plastics. This showed that the evolution of plastic policies has seen the definition of plastic waste change, as it is being defined by just using broad terms or by using more specific terms. Globally, plastic policies are increasingly targeting more specific types of plastic waste (plastic bags, microplastics, packaging, etc.) rather than just the broad general plastic waste.

According to this comparative review, the first direct policy response to plastic waste on the timeline was the Packaging Ordinance implemented by Germany in 1991, which held manufacturers and distributors financially liable for packaging created by them (Plastic Zero, 2014) [33]. The next policy for Germany, the Packaging Act, was initiated 28 years after. Subsequently, two other policies were introduced two years after the Packaging Act.

Norway was the next to introduce a direct policy addressing plastic and packaging according to the timeline. The Beverage Packaging Tax was introduced in 1994. It is an economic policy that comprises basic and environmental tax, where the basic tax rate covers all non-reusable beverage containers and the environmental tax is tied to the return rate for the packaging (Papineshi et al., 2019) [31]. The European Directive on Packaging and Packaging Waste by the European Union was released the same year, 1994, which specified recycling targets for materials in packaging waste (Gandenberger et al., 2014) [56]. Successive policies after the initial policy for Norway were, respectively, initiated 5, 19 and 23 years later.

South Africa introduced the first plastic policy, Plastic Bag Regulations, in 2002, 11 and 9 years after Germany and Norway introduced their first policies, respectively. The policy was a regulatory instrument banning plastic bags of less than 80 micrometre thickness and levying retailers for thicker ones, in order to discourage the indiscriminate use of single-use plastic bags (Dikgang et al., 2012; DEAT, 2002) [7,53]. Three successive policies were, respectively, adopted, 1, 9 and 19 years after the first policy. These successive plastic policies were not new but amendments and upgrades of the Plastic Bag Regulations.

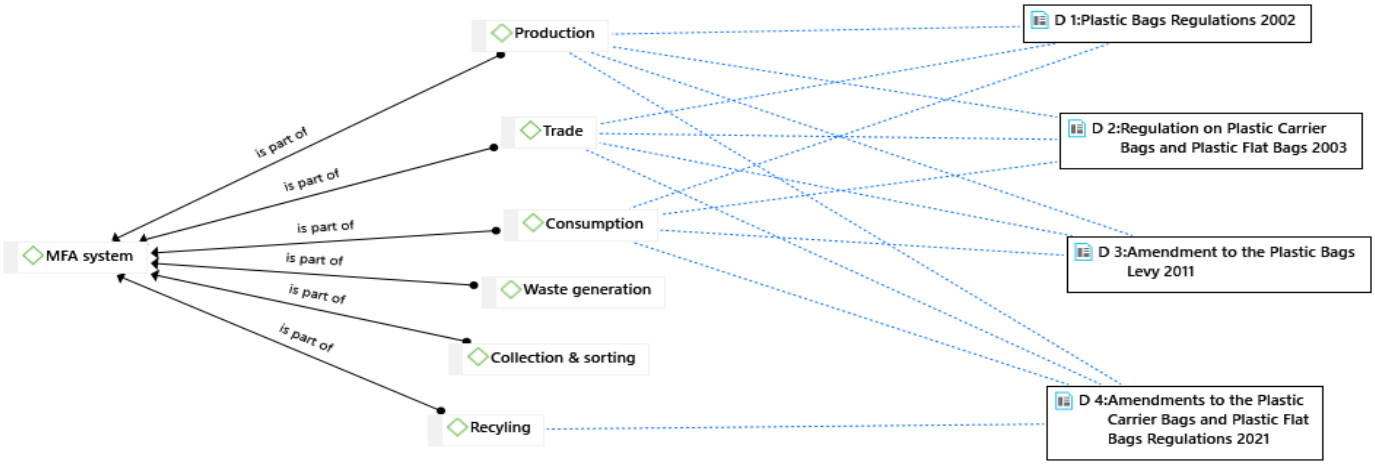
The target of all the four plastic policies initiated by South Africa was the regulation of plastic bags. This was apparently due to the high volume of plastic bags consumed in the country, estimated at 8 billion annually (Dikgang et al., 2012 [7]). The extensive use of these plastic bags resulted in a severe waste problem as they are mostly used once and disposed (Ritch et al., 2009) [59] and were neither levied nor recyclable prior to the implementation of the first regulation in the country (Dikgang et al., 2012) [7]. All of these factors make plastic bag use an important issue to have policy deliberation on nationally. The specified intentions of these regulations were to reduce plastic bag waste generation and disposal. Studies showed that the production of plastic bags initially dropped by about 80% with the introduction of the levy; however, a reduction of the levy in the subsequent amendment

has caused a continuous rise in plastic bag consumption (Hasson et al., 2007; O'Brien and Thondhlana, 2019) [60,61].

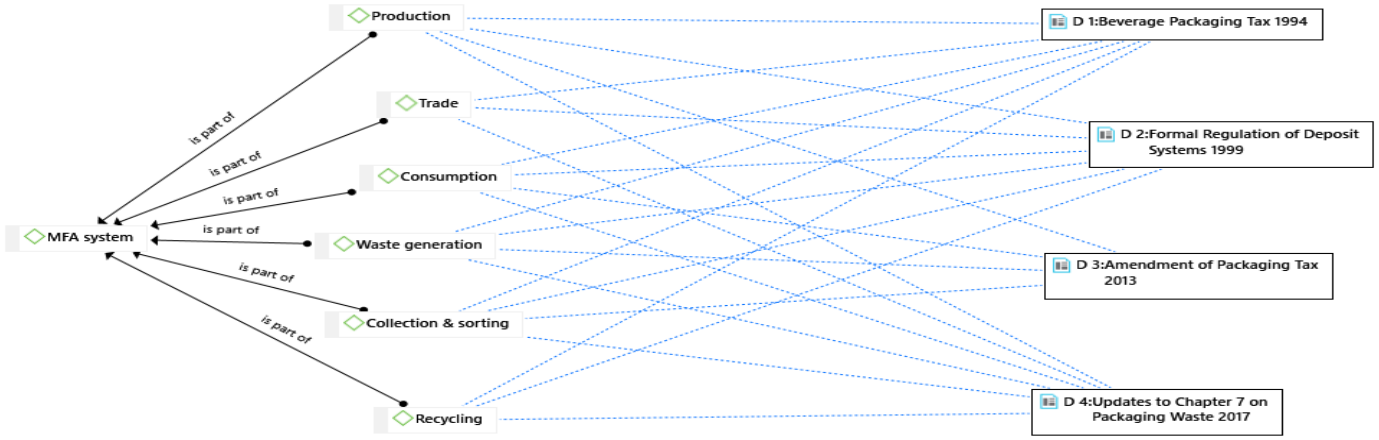
Countries will usually initiate policies to address the most urgent needs or severe problems in their domains, considering that South Africa's plastic policies focused on plastic bags due to extensive consumption and corresponding waste, and Norway and Germany on packaging due to it occupying a substantial share of their national plastics. Therefore, while data might not exist to confirm if plastic bags are the most consumed plastic products in South Africa, there is need to assess the percentage of their share against plastic packaging in the environment as plastic packaging is the most consumed plastic globally, at about 40% of plastic usage in 2014 (Plastic Europe, 2015) [62]. Additionally, it is essential to ascertain the level of plastic bag recycling in the country, considering its huge share.

4.2. Plastic Policy and MFA System

The analysis of the policies' alignment with the national plastic material flow systems is illustrated in Figure 3 and shows the alignment of the direct plastic policies with the different stages of the plastic material flow analysis (MFA) system for South Africa, Norway and Germany, respectively. In total 30, 74 and 117 quotes were identified and coded for South Africa, Norway and Germany, respectively, in the content analysis regarding the MFA system.



South Africa



Norway

Figure 3. *Cont.*

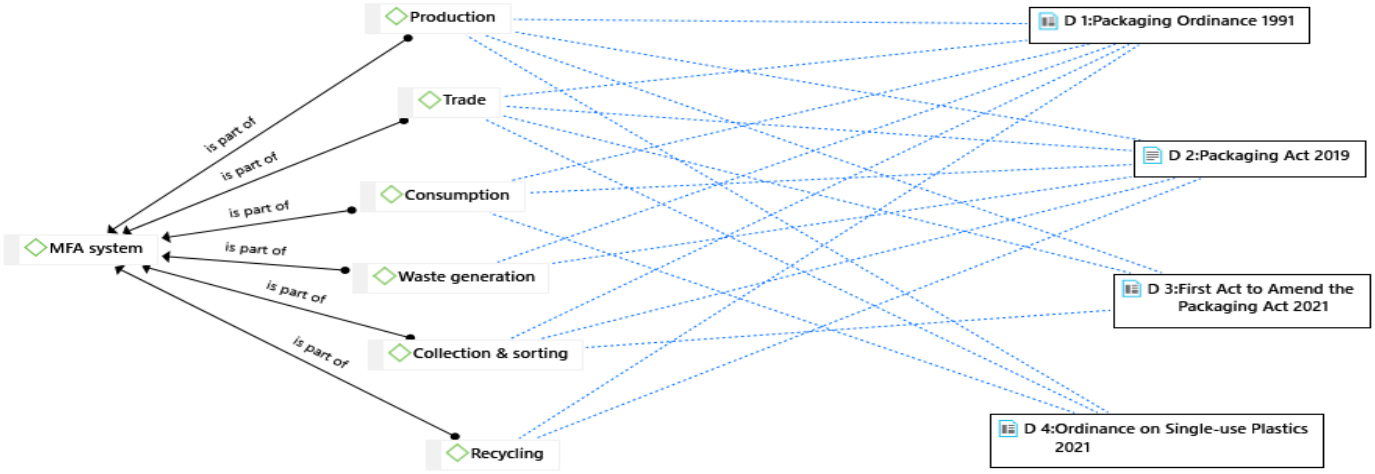


Figure 3. A content analysis of plastic policies and the MFA system (South Africa, Norway and Germany).

For South Africa, the figure shows all the policies (the Plastic Bag Regulations, the Regulation of Plastic Carrier Bags and Plastic Flat Bags, the Amendment to the Plastic Bags Levy, and the Amendment to the Plastic Carrier Bags and Plastic Flat Bag Regulations) linked or aligned with the stages of production, trade and consumption, while the recycling stage had alignment with only the Amendment to the Plastic Carrier Bags and Plastic Flat Bag Regulations. The waste generation and collection and the sorting stages had no link or alignment with any of the policies.

Norway had the stages of production, consumption, waste generation and collection, and sorting, in alignment with all the four policies (the Beverage Packaging Tax, the Formal Regulation of Deposit Systems, the Amendment of Packaging Tax, and the Updates to Chapter 7 on Packaging Waste), while trade and recycling aligned with three policies each. None of the stages were unaligned with any of the policies.

Germany had all the stages of MFA in alignment with policies, although each of the policies was not aligned to all the stages. The figure shows that only production and trade have alignment with all the four policies (Packaging Ordinance, Packaging Act, the First Act to Amend the Packaging Act, and the Ordinance on Single-Use Plastics). Additionally, the consumption and collection, and the sorting, aligned with three of the policies each, while waste generation and recycling had alignment with only two policies each.

Furthermore, Table 2 provides an overview of the content analysis of the policies for plastic and packaging waste management for South Africa, Norway and Germany regarding their alignment with the respective national plastic MFA system.

4.3. Plastic Policy and the Waste Hierarchy System

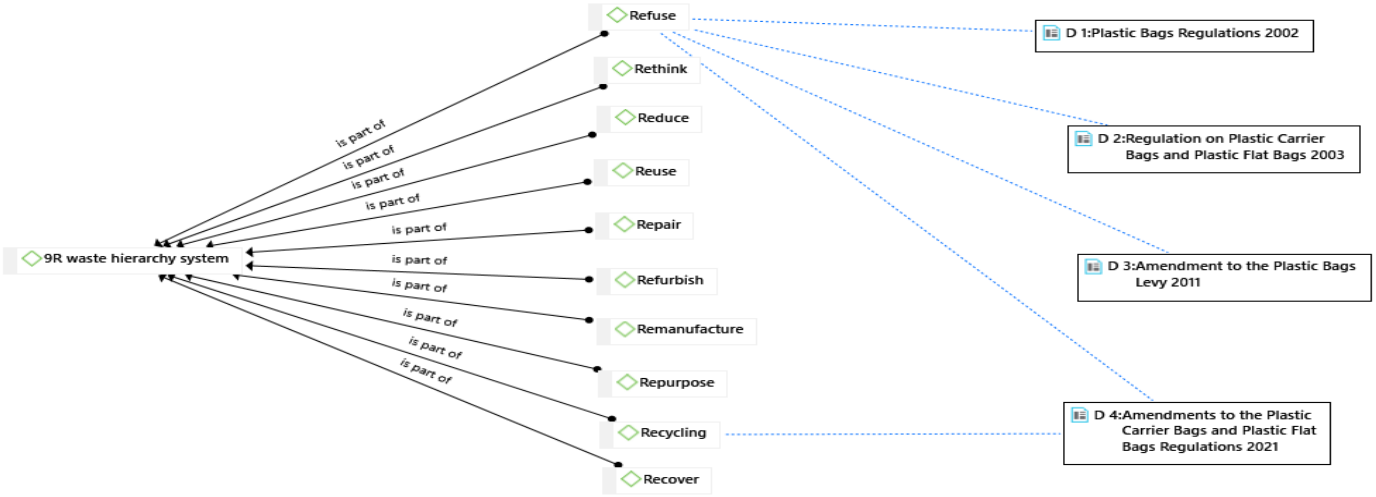
The final stage of the content analysis of the policies determined how the policies promote the top measures in the waste hierarchy, and the assessment of the policy gaps and implications for the three countries. The content analyses regarding how the evolution of plastic policies in South Africa, Norway and Germany enabled the promotion of the top measures of the 9R waste hierarchy system are shown in Figure 4. They expressed the contributions of these policies in the various stages of the 9R waste hierarchy system. Overall, there were 9, 34 and 45 quotes expressed and coded for South Africa, Norway and Germany, respectively. This frequency is lower than the MFA alignment.

Table 2. An overview of the policy content analysis for the MFA system.

	South Africa	Norway	Germany
Production	• All the policies initiated align with production, indicating that the evolution of plastic policy over time shows support for sustainable plastic production. • The quote frequency in all the policies across the timeline remained almost the same, indicating a sustained level of support as polices evolved. • Comparatively, quoted unit for the production (12) is the same as Norway (12) but much less than Germany (29).	• All the policies aligned with production, indicating that the policy evolution over time shows support for sustainable plastic production. • The quote frequency in the various policies across the timeline were largely in increasing order, indicating an increased level of support for sustainable production as polices evolved. • The quoted unit (12) is the same as South Africa (12) but much less than Germany (29).	• All the policies aligned with production, indicating that the policy evolution over time shows support for sustainable plastic production. • The quote frequency in the policies across the timeline were largely in increasing order, indicating an increased level of support. • The quoted unit (29) is much higher than for South Africa (12) and Norway (12).
Trade	• All the policies aligned with trade, indicating that the evolution of policy shows support for sustainable plastic trade. • The quote frequency in the policies across the timeline were almost the same, indicating a sustained level of support for trade as policies evolved. • The quoted unit for trade (7) is the same as Norway (7) and much less than Germany (19).	• Almost all the policies align with trade, indicating that the policy evolution over time shows support. • The quote frequency in the various policies across the timeline were largely the same, indicating a sustained level of support for sustainable trade. • The quoted unit (7) is the same as South Africa (7) but much less than Germany (19).	• All the policies aligned with trade, indicating that the policy evolution shows support for sustainable plastic trade. • The quote frequency in the policies across the timeline were largely in decreasing order, indicating a reduced level of support for sustainable trade as polices evolved. • The quoted unit (19) is much higher than for South Africa (7) and Norway (7).
Consumption	• All the policies aligned with consumption, indicating that the evolution of policy shows support for sustainable plastic consumption. • The quote frequency in the policies across the timeline were almost the same, indicating a sustained level of support. • The quoted unit for consumption (7) is less than Norway (10) but similar to Germany (7).	• All the policies aligned with consumption, indicating that the policy evolution over time shows support. • The quote frequency in the various policies across the timeline largely decreased, indicating a reduced level of support for consumption. • The quoted unit (10) is higher than for South Africa (7) and Germany (7).	• Almost all the policies aligned with consumption, indicating that the policy evolution over time shows support. • The quote frequency in the policies across the timeline were largely in decreasing order, indicating a reduced level of support. • The quoted unit (7) is the same as South Africa (7) but less than Norway (10).
Waste generation	• None of the policies aligned with waste generation. • It can be argued that the policy evolution supports sustainable waste generation since sustainable production, trade and consumption will ordinarily induce or produce sustainable waste generation.	• All the policies aligned with waste generation, indicating that the policy evolution over time shows support for waste generation. • The quote frequency in the various policies across the timeline largely increased, indicating an increased level of support for sustainable waste generation.	• Half of the policies aligned with waste generation, indicating that the policy evolution over time shows partial support for plastic waste generation. • The quote frequency in the policies across the timeline were largely in decreasing order, indicating a reduced level of support.

Table 2. *Cont.*

	South Africa	Norway	Germany
Collection and sorting	• None of the policies aligned with collection and sorting as no expression was coded in all the policies.	• All the policies aligned, indicating that the policy evolution shows support for collection and sorting. • The quote frequency in the various policies across the timeline were largely in increasing order, indicating an increased level of support.	• Almost all the policies aligned with collection and sorting, indicating that the policy evolution over time shows support. • The quote frequency in the policies across the timeline were largely in decreasing order, indicating a reduced level of support as polices evolved.
Recycling	• Only one policy aligns with recycling, indicating that the evolution of policy shows little support for recycling. • The quoted unit for recycling (4) is much lower than Norway (17) and Germany (27).	• Almost all the policies aligned with recycling, indicating that the policy evolution over time shows support for sustainable recycling. • The quote frequency in the various policies across the timeline largely decreased, indicating reduced support for recycling as polices evolved. • The quote frequency (17) are much higher than for South Africa (4) but much lower than Germany (27).	• Half of the policies aligned with recycling, indicating that the policy evolution shows partial support for sustainable recycling. • The quote frequency in the policies across the timeline were largely in increasing order, indicating an increased level of support for sustainable trade as polices evolved. • The quoted unit (27) is much higher than for South Africa (4) and Norway (17).



South Africa

Figure 4. *Cont.*

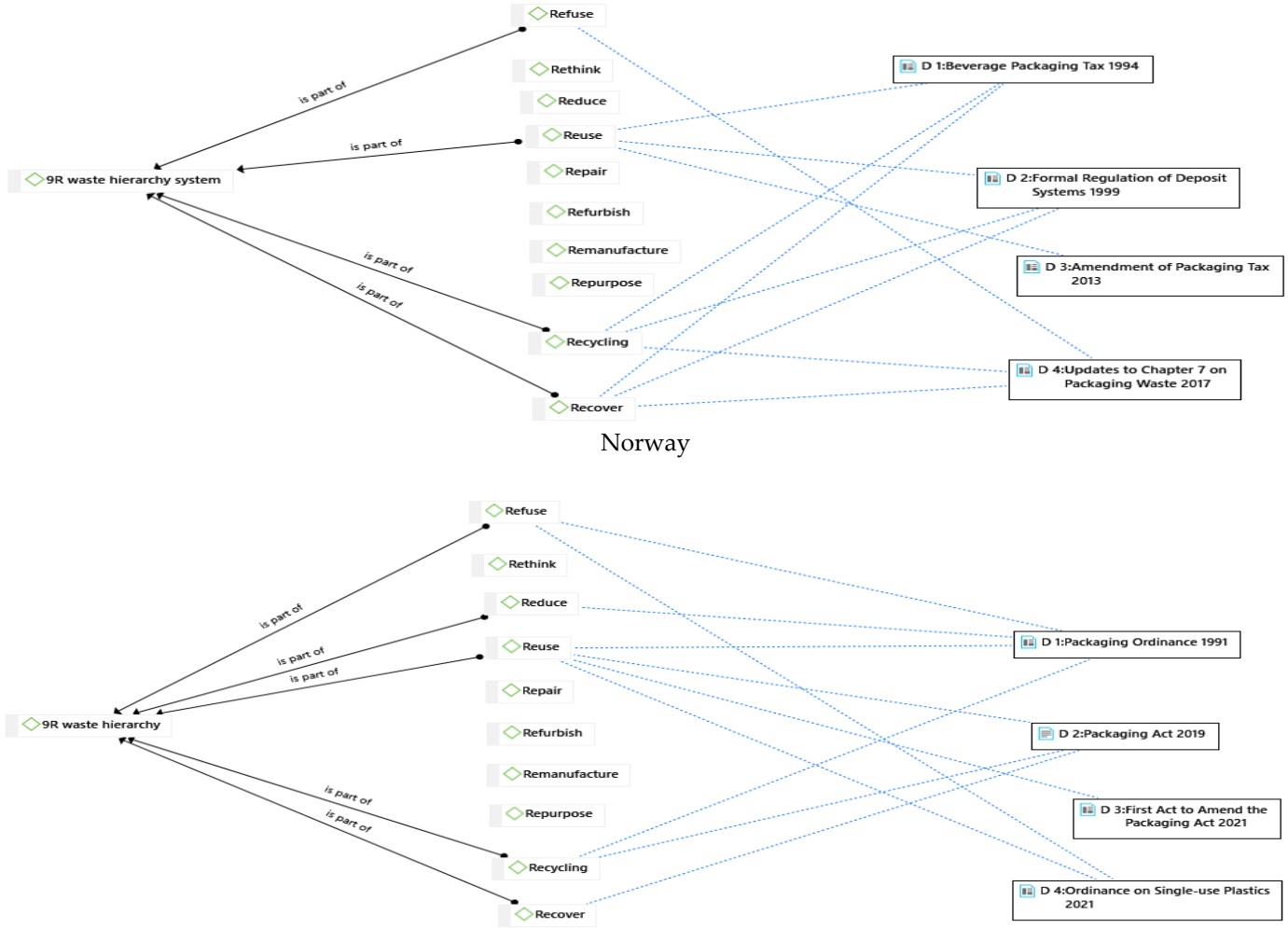


Figure 4. The content analysis of plastic policies and the waste hierarchy system (South Africa, Norway and Germany).

South Africa had only the options of refuse and recycling aligned or supported by the plastic policies. All the polices supported refuse, while recycling was supported by only the Amendment to the Plastic Carrier Bags and the Plastic Flat Bag Regulations. As shown by the figure, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose and recover were the waste hierarchy options not supported by any of the policies.

For Norway, refuse, reuse, recycling and recover were options supported by the plastic policies. Refuse was supported by only the Updates to Chapter 7 on Packaging Waste, while reuse, recycling and recover were supported by three of the four policies each. The options of rethink, reduce, repair, refurbish, remanufacture, and repurpose were not supported by any of the policies.

Germany had refuse, reduce, reuse, recycling and recover being supported by the policies. Only reuse was supported by all four of the policies. The options of refuse and recycling were supported by two policies each, while reduce and recover were supported by a single policy each. Similarly, rethink, repair, refurbish, remanufacture and repurpose were not supported by any of the policies.

Furthermore, an overview of the findings of the content analysis of the policies for plastic and packaging waste management for the three countries regarding their support for the top measures of the 9R waste hierarchy systems is presented in Table 3.

Table 3. An overview of the policy content analysis for the waste hierarchy system.

	South Africa	Norway	Germany
Refuse	• All the policies aligned, indicating that the evolution of plastic policy supports refusal • The quote frequency in the policies across the timeline remained almost the same, indicating a sustained level of support • Comparatively, quoted unit (5) is more than for Germany (3) and Norway (3)	• Only one policy aligned, indicating that the policy evolution shows little support for refuse • The quoted unit (3) is less than for South Africa (4) but the same as Germany (3)	• Half of the policies aligned with refuse, indicating that the evolution of policy shows support partially • The increasing quote frequency in the policies across the timeline indicated an increased level of support for refuse • The quoted unit (3) is less than for South Africa (4) but the same as for Norway (3)
Rethink	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded
Reduce	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded	• Only one policy aligned, indicating that policy evolution shows minimal support
Reuse	• None of the policies aligned as no policy was coded	• Almost all the policies aligned with reuse, indicating that the policy evolution over time shows support • The quote frequency in the policies across the timeline were in decreasing order	• All the policies aligned with reuse, indicating that the evolution of policy supports plastic and packaging reuse • The quote frequency in the policies across the timeline largely decreased
Repair	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded
Refurbish	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded
Remanufacture	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded
Repurpose	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded	• None of the policies aligned as no policy was coded
Recycle	• Only one policy aligns with recycling, indicating that the evolution of plastic policy minimally supported plastic waste recycling • The quoted unit for recycling (4) is much lower than for Norway (17) and Germany (27)	• Almost all the policies aligned with recycling, indicating that the evolution of policy supports recycling • The quote frequency in the various policies across the timeline largely decreased • The quoted unit (17) is much higher than for South Africa (4) but much lower than Germany (27)	• Half of the policies aligned with recycling, indicating partial support • The quote frequency in the policies across the timeline largely increased • The quoted unit for recycling (27) is much higher than for South Africa (4) and Norway (17)

Table 3. *Cont.*

	South Africa	Norway	Germany
Recover	• None of the policies aligned with other recovery	• Almost all the policies aligned, indicating that the policy evolution over time shows support for other recovery • The quote frequency in the various policies across the timeline were largely the same, indicating sustained support	• Only one policy aligned, indicating that the policy evolution over time shows little support • The quote frequency in the policies across the timeline were largely in decreasing order, indicating a reduced level of support as polices evolved

4.4. Discussion and Policy Gaps

Sustainable MFA and 9R waste hierarchy systems advance the circular economy (van Eygen et al., 2017; Zhu et al., 2010) [1,49]. The application of plastics is expected to increase in South Africa, and globally, in the future; therefore, it is essential and beneficial to ensure that plastic utilisation in countries aligns with resource efficiency. The adequacy of plastic policies is a precondition for achieving this (Xanthos and Walker, 2017) [21].

Analysing how the evolution of plastic policies contributes to the different stages of the national plastic material flows and the 9R waste hierarchy system for South Africa, Norway and Germany revealed varied gaps in the policies of these countries, with South Africa still lagging behind the two other countries. Based on the results of the analysis (policy alignment and support) of the different stages of the two systems in the previous section, the existing plastic policies for South Africa are partially adequate for the MFA system and inadequate for promoting all the top measures of the 9R waste hierarchy system, which include refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and recover. For Norway, existing policies for plastic and packaging waste are adequate for the MFA system and partially adequate for the top measures of the waste hierarchy. Similarly, Germany had existing policies that are adequate for the MFA system and largely adequate for the top measures of the 9R waste hierarchy.

The various inadequacies or partial adequacies identified in the plastic policies of the countries with respect to the MFA and 9R waste hierarchy systems established, largely, the existence of policy gaps for sustainable plastic waste management. Additionally, these policies did not consider important measures in the hierarchy system that could help in achieving total plastic and packaging circularity. The identified gaps in the policies with respect to the different stages of the MFA and waste hierarchy systems are detailed in Table 4, together with examples of where these gaps are addressed by the comparator country. This table provides examples that can be read across and considered from one country if policy intervention exists. Table 4 also shows that there are currently no examples for the three countries of explicit promotion of rethinking, repair, refurbish, remanufacture, and repurpose. This could reflect the fact that the original policy was developed with a focus on materials waste and not product waste. More research is required to understand and learn from how these options are promoted in policies for other material product streams.

Table 4. Policy gaps and measures regarding the MFA and 9R waste hierarchy systems.

System	Stages	South Africa	Norway	Germany
Material flow analysis	Production	• Ban on manufacture of specific classes of plastic bags • Levy for non-compliance	• Basic tax on production of non-reusable packaging	• Support for producers for eco-friendlier product design • Promotion of reusable packaging where feasible • Ban on some single-use plastic products with existing environmentally friendly alternatives
	Trade	• Ban on commercial distribution and import • Levy for non-compliance	• Taxes on distribution and import	• Promotion for distribution of reusable packaging
	Consumption	• Corresponding impact of ban on usage	• Corresponding impact of tax on consumption	• Promotion for usage of reusable packaging
	Waste generation	Policy gap	• Set up of return systems • Environmental tax tied to return rate	• Polluter-Pays principle • Set up of take-back systems • Proximity principle for waste to be disposed as close as possible to its generation point to prevent needless transportation and risk
	Collection and sorting	Policy gap	• Collection points through return system • Targets for specified minimum return rate • Producers to finance collection and sorting if production volume is over specified threshold	• Mandate manufacturers to take back all types of packaging sold • Mandated system for producers to support or pay for costs of collection, transporting and sorting of their product at the post-use phase
	Recycling	• Ban exemption for bags with specified minimum post-consumer recyclate content	• Targets for recycling • Producers to finance recycling if produced over specified volume threshold • Reduced tax rate for packaging with high recycling content	• Targets for recycling • Mandated system for producers to support the costs of recycling • Specific guidelines for reaching recycling goals
Waste hierarchy	Refuse	• Ban on specific classes of plastic bags	• Setting out of responsibilities to motivate producers to move towards prevention	• Promotion to work towards prevention • Ban on some single-use plastic products
	Rethink	Policy gap	Policy gap	Policy gap
	Reduce	Policy gap	Policy gap	• Promotion to reduce if prevention is not feasible
	Reuse	Policy gap	• Tax exemption for reusables	• High priority given to reusability of packaging • Specific support for reusable packaging depending on technical feasibility

Table 4. *Cont.*

System	Stages	South Africa	Norway	Germany
Waste hierarchy	Repair	Policy gap	Policy gap	Policy gap
	Refurbish	Policy gap	Policy gap	Policy gap
	Remanufacture	Policy gap	Policy gap	Policy gap
	Repurpose	Policy gap	Policy gap	Policy gap
	Recycle	• Ban exemption for bags with specified minimum post-consumer recyclate content	• Targets for recycling • Producers to finance recycling if produced over specified volume threshold • Reduced tax rate for packaging with high recycling content	• Recycling is to be considered where reuse is impossible • Targets for recycling • Mandated system for producers to support the costs of recycling • Specific guidelines for reaching recycling goals
	Recover	Policy gap	• Permitted (likely with conditions) where reuse or recycling is not technically, environmentally or economically feasible	• Targets for recovery rate • Allowed where recycling is not feasible • Producers to participate in recovery

5. Policy Recommendations

Considering the existence of these policy gaps, and the fact that the plastic waste management system in South Africa is still developing, there is need to take into consideration necessary policy elements and directions when formulating broader and effective policies for countries, with respect to sustainable plastic material flow, waste hierarchy promotion and effective plastic waste management. Stronger and wider-ranging national policy frameworks are needed to rethink and redirect the application of plastic generally and restructure the way plastic waste is being managed.

Firstly, fundamentals to prevent the occurrence of plastic waste in the first place, or to substitute plastic material with environmentally friendly alternative materials, should be considered in these broader plastic policies for South Africa and other countries. Specifically, where feasible, opportunities that would reduce the unnecessary consumption of plastics should be promoted. Where this is not feasible, efforts to rethink the use of plastic products or increase the efficiency in the manufacture of plastic products (reduce) should be encouraged. Additionally, provisions for the design of plastic products and packaging to allow one to reuse, repair, refurbish, remanufacture, repurpose and recycle should be promoted in broader plastic policies for plastic and packaging waste management. Furthermore, provisions for the effective and increased collection, sorting and management of eventual plastic waste that will be generated should be promoted in these plastic policies.

Consequently, this study made policy recommendations for plastic waste management in South Africa with respect to the policy gaps identified in the affected MFA and waste hierarchy system. These recommendations were developed, mostly, from the policies that can be learnt from Germany and Norway, which had better-performing plastic recycling systems, and they are valuable in providing direction and influence in the creation of new policies for plastic waste management in the country.

According to the policy content analysis for the MFA stages, policy gaps were identified for both the stages of waste generation and collection and sorting. For the waste generation stage, the major actors for policy implementation in this stage are the consumers, government and waste management association. Plastic consumption that leads to plastic waste generation is at the discretional control of the user or consumer. Plastic policies recommended for the policy gaps in this stage are to focus on behavioural change to attain

a target of zero waste. Such a policy constitutes legislation that raises public awareness and engagement programmes to help understand and increase awareness of the significance of higher options of the waste hierarchy, address informational failures, and advance circularity actions and behaviour.

Other recommended plastic policies to address the policy gap in this stage include pay-as-you-throw (PAYT)/Polluter-Pays principle and deposit-return schemes. The levy/tax policy can be linked to the return rate. The levies for polluters or product levies are meant to create an incentive to discourage or reduce plastic waste generation and increase the segregation of recyclables before waste collection. The fees can be computed using different approaches such as fixed amount, household size, mass of waste, collection frequency, or volume of unsorted waste.

Another useful policy for this stage is the Proximity Principle, which should be legislated for plastic waste to be discarded as close as possible to its points of generation to eliminate unnecessary transportation and risk.

For the collection and sorting stage of the MFA, the relevant actors for the implementation of the policies recommended are the government, municipalities, waste management firms/private contractors, informal collectors, and waste management associations. Recommended plastic policies for South Africa for this stage of the MFA include the set-up of collection points through a return system in different areas of municipalities. Additionally, there should be policies mandating that the manufacturers of plastics provide financial or infrastructural support for the take-back or collection, transporting and sorting of their products after consumption, if their production volume goes above a certain threshold. Another essential policy for this stage is the setting up of clearing-house mechanisms to manage and organise numerous producer-responsibility organisations. Furthermore, tax policies target unsustainable waste disposal and treatment methods such as landfill and incineration without energy recovery (open burning), therefore making these methods, which are not eco-friendly, more costly. Policy provisions for incentivising, training and building the capacity of informal collectors and formal operators on implemented plastic waste policies, plans and strategies are also important.

Similarly, in analysing the contents of the plastic policy responses, with respect to the 9R waste hierachy system, there were policy gaps for South Africa for the options of rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose and recover. Consequently, policies were recommended for these options of the waste hierarchy. For rethink and reduce, recommended polices equally involve public awareness and engagement programmes that will motivate consumers to reconsider or reduce the use of plastic products. Public engagement policies to promote awareness about the resulting impact of consumers' decisions regarding plastic packaging are imperative for these options. Additionally, policies supporting research funding and infrastructure for the design and development of more sustainable alternative materials other than plastic are recommended. These will reduce the amount of plastic in circulation. Environmental taxes on plastic packaging that decrease the number of goods packaged in plastic in order to discourage and make consumers reconsider consuming such goods are very much needed.

For reuse, repair, and refurbish, the policies recommended by the study for South Africa are to cause plastic products in good condition to be used repeatedly, defective plastic to be maintained and used again, or old plastic products to be restored. These include a policy providing tax reduction or exemption for the manufacture of durable and reusable designs, and the legislation of research funding for technical design and the development of such durable and reusable products.

For the options of remanufacture and repurpose, the policies recommended are targeted at the manufacturing of plastics to promote the use of parts of discarded plastic products in a new product with the same or a different function. Another recommended policy would provide tax reduction or exemption for the better use of durable eco-design techniques and tools (technical design, additives and lean manufacturing) in the manufac-

ture of plastic products or their parts. Another important policy is research funding for technical design and the development of such product parts.

For the option of recover, recommended policies include legislating manufacturers of plastic products to participate in recovery. Another policy is the setting up of targets for the recovery rate. A further policy includes the provision of subsidies and investment grants for the research, design and production of plastic waste recovery technologies to improve the waste recovery rate.

An effective broader plastic policy framework for South Africa should address the entire plastic life cycle, from design to the end-of-life management of plastic materials and products. Most importantly, these provisions should be expressly and absolutely stated in detail in the policies.

6. Conclusions

The qualitative content analysis was applied to determine how the evolution of plastic policies for plastic waste management in South Africa enables the sustainable management of plastic material flows and promotes the waste hierarchy principle. This was benchmarked with Norway and Germany, which have developed plastic waste management and recycling systems. The analysis includes assessing the contribution and role of plastic policies in different stages of the plastic material flow analysis (MFA) and the promotions of top measures in the 9R waste hierarchy system. The stages of the MFA system assessed were production (primary plastic and product), trade, consumption, waste generation, collection and sorting, and recycling, while those of the 9R waste hierarchy included refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and recover.

The review of the plastic policy timelines for the countries under consideration showed that South Africa, Norway and Germany adopted four plastic policies for plastic and packaging waste management. The plastic policy timelines established that Norway and Germany started many years ahead of South Africa in the management of plastic and packaging waste. Additionally, there has been an upward trend in the volume of plastic policies introduced over time by the three countries according to the timeline.

The content analysis showed that the evolution of existing plastic policies for South Africa is partially aligned with the sustainable management of national plastic material flows and minimally supports the top measures of the 9R waste hierarchy system. The existing plastic policies address the MFA stages of production, trade and consumption, and recycling, without focusing on the stages of waste generation, collection and sorting. Additionally, only the waste hierarchy options of refuse and recycling were supported by the plastic policies, while none of the policies aligned with the options of rethink, reduce, reuse, repair, refurbish, remanufacture and repurpose.

For Norway, the policies are largely aligned with the national plastic material flows and partially support the top measures of the waste hierarchy system. The plastic policies support all the MFA stages of production, trade, consumption, waste generation and collection, sorting, and recycling. None of the stages were unaligned with any of the policies. Similarly, the waste hierarchy options of refuse, reuse, recycling and recover were supported by the plastic policies, while the options of rethink, reduce, repair, refurbish, remanufacture and repurpose were not supported by any of the policies.

Germany had policies that are largely aligned with the national plastic material flows and largely supportive of the top stages of the waste hierarchy system. All the MFA stages of production, trade, consumption, waste generation and collection, sorting, and recycling were in alignment with the plastic policies. Additionally, the waste hierarchy options of refuse, reduce, reuse, recycling and recover were supported by the policies, while rethink, repair, refurbish, remanufacture and repurpose were not supported by any of the policies.

Overall, provisions were not expressly made in the policies of the three countries for other equally important measures of the 9R waste hierarchy system, to achieve all round plastic and packaging circularity. The policy status of the three countries largely confirmed the policy gaps, and these gaps were outlined.

Furthermore, it was observed that the support of the policies for the measures up the waste hierarchy shows that these policies are more targeted at plastic materials rather than plastic products and show weak alignment with product-specific measures such as remanufacturing.

The existence of the different policy gaps confirms the need to take into consideration necessary policy fundamentals and direction when formulating effective and wide-ranging policies, with respect to sustainable plastic material flow, waste hierarchy promotion and effective plastic waste management. There is a need for broader national policy frameworks to rethink and redirect the general application of plastic and restructure the management of plastic waste. A more comprehensive plastic policy framework for South Africa and other countries should address the complete plastic life cycle and options higher up the waste hierarchy.

Author Contributions: K.I.O.: methodology, data analysis, software, writing—original draft preparation, and investigation; P.T.M.: conceptualisation, supervision, validation, and writing—review and editing; A.L.M.: conceptualisation, supervision, validation, and writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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