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Towards a circular economy: A cross-case analysis of recycling in three South African towns

Anmar Pretorius [a], Derick Blaauw [a], Rinie Schenck [b] and Lizette Grobler [b]

aSchool of Economic Sciences, North-West University, Potchefstroom, South Africa; bDSI/NRF/CSIR Chair in Waste and Society, University of the Western Cape, Bellville, South Africa

ABSTRACT

The concept of circular economy includes three aspects from a human perspective, namely Reduce, Reuse, and Recycle. Studying human behaviour is important in understanding and evaluating the possible success of any of the three elements. We explored the link between household waste practices and local governments' ability to provide proper waste management, as stipulated in the South African Constitution, as well as the factors linked to different waste management practices through a cross-case analysis using a mixed-method research design. Households in Calvinia, Philippolis and Polokwane handle waste differently due to different levels of municipal waste services rendered and the availability of local recycling options. Most households in all three towns indicated their willingness to take part in recycling. Surprisingly, the level of household income has no statistically significant impact on waste behaviour. On the other hand, the one factor that does impact on waste behaviour is the inclusion of recycling projects in school curricula.

1. Introduction and aim of the article

The notion of the circular economy as an encouraging approach to achieve sustainable development is gaining more and more traction in the development literature (Stahel 2016; Barnosky et al. 2019). Across the world, increasing evidence pertaining to the benefits of transitioning to a circular economy is being presented. For example, a McKinsey report (produced for the Ellen MacArthur Foundation in 2015) postulated that a transition to a circular economy would generate direct and indirect benefits to a total value of €1.8 trillion for the economies of Europe (Stahel 2016).

Countries outside of Europe were among the first endeavouring to move from the traditional take-make-dispose system to the adoption of circular economy-based ideas (Takiguchi & Takemoto 2008). Particularly in the Global South the notion has existed for a long time and has been part and parcel of practices (Reike et al. 2018; Kirsch 2020). Japan, with its large economy and limited landfill capacity, was one of the first countries to promote the three R policies of Reduce, Reuse, and Recycle (Takiguchi & Takemoto 2008). China is also at the forefront as far as the adoption of the principles

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of the circular economy is concerned – primarily to maintain and balance the existing levels of economic growth and the needs of the country's growing population (Li et al. 2010).

In South Africa there are similar attempts to develop a circular waste economy vision. Examples include the African Circular Economy Network and the African Circular Economy Alliance. This endeavour forms part of a broader socio-economic development programme emphasising the efficient use of resources (Bocken et al. 2016). South Africa's National Development Plan has a specific objective to achieve sustainable development goal Number 12 (SDG 12.5). This includes the absolute reduction in the volumes of waste disposed of at landfills and an increase in the reuse, recycling, recovering, and development of green products (George et al. 2015).

The three R policy, which is a key element of South Africa's latest 2020 National Waste Management Strategy as published by the Department of Environment, Forestry and Fisheries guided our chosen framework for this study – also basing it on the three R framework in the waste hierarchy. We focus specifically on the human aspect of these three elements. We acknowledge that other options such as the six R (reduce, reuse, recycle, recover, redesign, and remanufacture) framework or the nine R framework (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recover) exist and should form part of a future research agenda. In addition to the official standing of the three R framework we also based our choice of framework on the fact that according to Grobler et al. (2022) the notions of the circular economy is still evolving on the African continent. Existing definitional challenges are intensified by the wide-ranging variety of critical sub-themes of the circular economy (Grobler et al. 2022). The focus of existing research is highly biased towards the Global North, with developing countries in general, and the Global South in particular, being underrepresented in conceptual analyses (Friant et al. 2020).

The concept of a circular economy is evidently wide and all-encompassing. Consequently, there is no agreement on a universal definition of this concept. It incorporates elements from governmental rules, operations of private businesses, land management, and various other industries (Barnosky et al. 2019). However, De Kock et al. (2020: 1) provide a useful explanation of the broad concept of a circular economy: 'The circular economy is a framework for an economy that is restorative and regenerative by design and mimics the functioning of nature.' The notion of a circular economy can provide a possible solution to the plastic pollution crisis by decoupling material consumption from economic growth, and increasing the value of secondary material, ultimately decreasing waste and pollution (De Kock et al. 2020: 1).

The transition to a true circular economy is hindered by several obstacles. One of these possible hindrances is the very origin of the concept. The circular economy concept has its roots in the engineering and economics literature, specifically in industrial ecology and industrial ecosystems (D'Amato & Korhone 2021). The focus is on the role of technology as well as governments and businesses in developing policies to facilitate the expansion of a circular economy (Barnosky et al. 2019). However, all three of the elements of the circular concept, namely reduce, reuse, and recycle, involve multiple aspects of human behaviour. Yet the behavioural dimension of the circular economy is often the one that receives the least amount of attention in the literature (Barnosky et al. 2019). In more recent definitions of the circular economy concept the social

dimension is increasingly acknowledged (Grobler & Schenck 2021). Supporting this trend in the literature, we argue that studying current human behaviour is a crucial element in understanding and evaluating the possible success of any of the three human elements of the circular economy. In fact, the key starting point to enhance the 'reduce, reuse and recycle' approach is to analyse the way households handle their waste.

We contribute to the limited South African knowledge in this regard. The aim of the research reported in this article was to explore the link between household waste practices and local government institutional quality in the form of proper waste management and the factors linked to different waste management practices. We did this through a cross-case analysis and a mixed-method research design. The case studies were in three South African towns in three provinces and different urban and rural settings, i.e. Calvinia, Philippolis and Polokwane. In line with Barnosky et al. (2019), we focused specifically on recycling behaviour and possible early indications of recycling intentions and potential associated factors.

The rest of the article is structured as follows: a review of the relevant literature is followed by the background of the three research locations; the research methodology; a discussion of the results; conclusions and tentative recommendations.

2. Brief literature review

The literature identifies three aspects in terms of an individual perspective of the circular economy, i.e. reduce, reuse, and recycle (Takiguchi & Takemoto 2008). These elements were also the key focus of the South African government's National Waste Management Strategy, developed in 1998, to achieve an integrated waste management solution (Chvatal & De Smit 2015; Schenck et al. 2019). 'Reduce' refers specifically to consumption patterns. The theory suggests that the less a person consumes, the resources that must be extracted to fulfil the demand will also be limited (Barnosky et al. 2019). 'Reuse' refers to the action of giving a new purpose to existing items within the home environment. An example will be to preserve homemade jam in a mayonnaise bottle. Reuse is common practice in rural households, particularly in low – and middle-income countries. Food waste, such as leftover meat and bones, is reused for animal feed (Birhanu & Berisa 2015). Recycling refers to the reintroduction of previously purchased items into the circular economy (Barnosky et al. 2019).

With reference to 'reduce', the literature proposes that zero waste should be the aim. As Gutberlet (2016) suggests, zero waste as a concept encompasses more than merely diverting waste from landfill through recycling. Reducing, and the ultimate aim of zero waste, requires a complete paradigm shift away from unsustainable consumerism. The current pattern of discard-oriented production and consumption will require a radical move away from the existing focus on using industrial and technological innovations to address the waste management needs of a country's citizens (Gutberlet 2016). The handling of waste should be analysed and framed within the context of concerns such as overconsumption and economic growth (Gutberlet 2016).

Gutberlet (2016) provides further practical impetus to changing the status quo in development thinking regarding waste and waste management. It can no longer be business as usual. The orthodox view and growth-oriented myths in terms of unlimited

resources and ever-growing economies need disruption and rethinking (Gutberlet 2016). Theoretical constructs, such as a degrowth approach to the economy and development, must form part of this revaluation. An example of this is the more efficient use of smaller amounts of resources to improve the quality of life of a country's citizens (Gutberlet 2016). On a philosophical level degrowth requires the accepting of notions such as 'less means more' and 'enough is enough'. This will ultimately translate into reduced consumption and less waste being generated (Moulaert & Ailenei 2015; Gutberlet 2016).

The human element is an important factor in Gutberlet's (2016) envisaged paradigm shift. Human awareness in the sense of Paulo Freire's (1972) 'conscientization' will be a key element in the endeavour to arrive at responsible actions and strategies (Gutberlet 2016). In this context, this study is important to establish the current thinking and practices of the citizens of South Africa in different urban and rural settings.

In the absence of Gutberlet's (2016) proposed paradigm shift towards zero waste, recycling remains an important part of the three R strategy as envisaged by proponents of the circular economy. In South Africa, recycling has characterised the economy for more than 30 years (Godfrey & Oelofse 2017; Bala et al. 2021; Godfrey 2021). Godfrey (2021) provides the example of Steelrec (the predecessor to Collect-a-Can that facilitates the recycling of used beverage cans) which was established in 1976. Furthermore, waste sorting facilities were already active in the 1970s in some of the bigger metropolitan areas such as Johannesburg and Pretoria (Godfrey 2021).

The role of informal reclaimers in laying the foundations of South Africa's recycling economy cannot be denied. Long before policy discussions in South Africa featured the concept of recycling, reclaimers In Johannesburg and other municipalities established a 'separation outside source' process to separate, salvage and revalue recyclable items that residents discarded as part of their garbage (Samson 2022).

The main motivation for South Africa's recycling effort is social and economic needs (Godfrey & Oelofse 2017). Local government also recognises the potential that the waste sector may have for the creation of employment opportunities (Bala et al. 2021). Godfrey (2015) estimated that the South African waste sector was valued at R15.3 billion or 0.51% of the country's GDP in 2012 and that about 30 000 people were formally employed in this sector. At least double that number (about 60 000–90 000) earned a living through informal means in the waste sphere (Godfrey 2015; Bala et al. 2021). Plastic recycling, for example, provided 8 000 formal jobs in recycling factories, and nearly 60 000 workers (including informal street collectors and the employees of smaller entrepreneurial collectors) received some income through the supply chain in 2018 (PlasticsSA 2019; Bala et al. 2021).

The human response to various recycling initiatives (since the 1980s) has been carefully researched. Barnosky et al. (2019) built on the literature review of Strydom (2018) and categorised the barriers to recycling from the perspective of human reactions under three headings: (1) lack of knowledge, (2) inconvenience, and (3) the absence of a sense of personal responsibility. Lack of knowledge can imply limited awareness or knowledge about existing recycling initiatives or the practicalities in terms of the process itself (e.g. Kennedy et al. 2009). It can also refer to a lack of appreciation of the importance of recycling as an initiative (Omran et al. 2009). Uncertainty of how the local system works can also contribute to a lack of knowledge (Attari et al. 2017).

An appreciation of the importance of recycling is a necessary but not sufficient condition to actively participate in recycling initiatives. Conradie et al. (2019) describe the experiences of the Hangberg pilot recycling project as an attempt to mobilise community cooperation and participation to advance the Zero Waste vision embodied in the National Environmental Management Act (Act 107 of 1998). The study reported that beneficiary households agreed that recycling is a good thing as it takes little time or effort and leads to a cleaner environment, which is naturally desirable (Conradie et al. 2019). In spite of the high level of awareness and positive comments, a high level (30%) of dropout was experienced during the project (Conradie et al. 2019).

As mentioned above, the second key barrier to actively participating in recycling, identified in the literature review of Barnosky et al. (2019), is convenience and access to facilities. Even people who claim to really care about the environment are less likely to recycle if it becomes a burdensome task (Derksen & Gartrell 1993; Omran et al. 2009). Perrin and Barton(2001) conclude that '[r]ecycling behaviour would appear to be related to the level of inconvenience caused by: (1) the type and design of scheme offered; (2) the material being recycled; and (3) the level of change required in existing household behaviours in order to participate within a scheme and recycle each material.' Within the South African context, Schoeman and Rampedi (2021) emphasise that it is imperative that recycling facilities be situated in areas with ease of access – especially for the low-income residents who often do not have the resources to transport their recyclables to facilities such as community drop-off centres. If this condition is not met participation rates will remain low (Schoeman & Rampedi 2021).

Barnosky et al. (2019) categorised the third set of barriers as responsibility or, more specifically, the absence of a sense of personal responsibility. This can be the result of a lack of intrinsic motivation (Viscusi et al. 2011). It can also be caused by a lack of collective action. An example here is the perception that 'just me' will not make a difference, as found by Hopper and Nielsen (1991). Keramitsoglou and Tsagarakis (2013) identified a lack of trust in the other actors in the system as another underlying factor in perpetuating the lack of responsibility theme.

The theoretical foundation of the three barriers to recycling, as identified by Barnosky et al. (2019), is from the attitude approach to recycling which focuses on the beliefs, attitudes and intentions of people when explaining their behaviour towards recycling (Miafodzyeva 2012). The waste management behaviour and the perceptions regarding recycling in the three research areas were analysed against this background. The next section provides brief background information on the chosen research areas before the methodology is discussed.

3. Background to research locations

The three locations for the study were chosen to represent different urban and rural settings, in three provinces, with different degrees of institutional capabilities and service quality as far as local governments are concerned. Although these case studies cannot be regarded as representative of all similar urban and rural settings in South Africa, a town like Philippolis and its municipality, that struggles to fulfil its constitutional mandate to provide basic services to its citizens, is a common phenomenon in the Free State Province. Calvinia is a typical rural town in the Northern Cape and Mankweng an excellent example of many other rural settings in the Limpopo Province (Viljoen et al. 2021).

3.1. Calvinia

Calvinia is a small rural town in the Hantam Municipality in the Northern Cape, South Africa. According to the last official census (2011), the town had a total population of 9 680 people (4 634 males and 5 046 females) and consisted of approximately 2 509 households (Statistics South Africa 2012). The census numbers quoted here only refer to the town itself and exclude the rural population in the rest of the district. Afrikaans, the dominant language in the town, is spoken by 96.9% of the residents. The town consists of three distinct areas: the central neighbourhood in the business area, the informal settlement located on the outskirts of the town (where people live in approximately 200 self-built structures), and the western neighbourhood situated between the two aforementioned areas (Viljoen et al. 2021). Calvinia is 400 kilometres from Cape Town where the most developed markets and the main buyers of recyclables are located. Logistics are therefore a major impediment in attempts to get a viable recycling sector operational. It must also be noted that the Calvinia magisterial district includes various other villages and is the same size as the Free State Province. Centralised recycling facilities will therefore never reach more than half this area's population even if it can be done perfectly in town.[1]

3.2. Philippolis

Philippolis, with its rich history, is one of the oldest towns in the Free State. It was established in 1823 by the London Missionary Society to do missionary work among the Khoi/Bushman people who lived there at the time (Steÿn & Du Plessis 2007). During the 1960s the town grew due to its farming activities as well as the fact that it was on one of the main routes between Johannesburg and Cape Town. Later, the building of the N1 national road between Johannesburg and Cape Town bypassed the town which impacted the town negatively in terms of its demographics and economics. The building of two major dams in the Free State left many farms under water and job losses ensued, exacerbating the situation (Steÿn & Du Plessis 2007). In 2007 the population was recorded as 6 000 while the 2011 census statistics indicated only 3 648 people in the town (Statistics South Africa 2012). The town is divided into three distinct areas: the central previously white area the 'coloured'[2] township, and the township where both black and 'coloured' people live.

Currently the town falls under a municipality plagued by allegations of corruption and mismanagement, which led to the collapse of basic services to the community (Kopanong Local Municipality 2019). A local group of concerned citizens took over the responsibilities for providing basic services – including basic waste management services.

3.3. Mankweng (Polokwane)

Polokwane is also known by its former name, Pietersburg. It is classified as a city and is the capital of the Limpopo Province of South Africa. Furthermore, it is South Africa's

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[1]We thank the anonymous reviewer for this observation.
[2]Coloured, formerly Cape Coloured, a person of mixed European ('white') and African ('black') or Asian ancestry, as officially defined by the South African government from 1950 to 1991.

largest urban centre north of Gauteng Province. According to Statistics South Africa (2012) the population of Polokwane City was 130 028, with 43 846 households recorded in the 2011 census.

The spatial pattern in the city reflects that of a typical apartheid city model, characterised by segregated settlement (Polokwane Municipality 2016). Polokwane city, which is the economic hub, is in the centre of the area. It includes the central business district and the industrial area. It is home to a diverse range of social services. It also includes the established formal urban areas – servicing the more affluent residents of Polokwane (Polokwane Municipality 2016). Apart from the suburbs in the city, three clusters of suburbs are found around the city. These are the Seshego cluster (on the north-west outskirts of the city); the Molepo/Maja/Chuene cluster (20 km south of the city centre); and the Mankweng/Sebayeng/Dikgale cluster (30 km east of the city centre) (Polokwane Municipality 2016). The Mankweng cluster, which constitutes a large geographical area, consists of a mixture of both formal and informal settlements. It accommodates the University of Limpopo (Turfloop) and the Zion City of Moria. This area is experiencing an influx of migration and is growing at a rapid rate (Polokwane Municipality 2016). For this reason, the Mankweng area was specifically chosen as the research area.

4. Research methodology

The research design for the study followed a sequential case study approach. This took the form of mixed-method studies based on questionnaires containing both quantitative and qualitative questions. The questionnaires consisted of 37 questions. Thirty-one of these were structured questions and six were left open for the respondents to provide detailed qualitative answers. The surveys were translated beforehand into the language most spoken in the different research settings. In Philippolis and Calvinia the surveys were pre-translated into Afrikaans and in Mankweng into Sepedi. We recruited fieldworkers who were able to speak the predominant languages of each area.

All the fieldwork teams were well trained by the researchers. The fieldworkers also role-played the questionnaires in our presence to see whether they understood them well. Throughout the fieldwork, the researchers were present in the area to answer questions that may arise. Although the teams were different for language purposes, they received the same training and active support from the researchers and hence we are confident that this did not affect the results.

In Calvinia six trained postgraduate students from the University of the Western Cape collected the data during September 2019. The fieldworkers interviewed 163 people in all three areas in the town, that is, Calvinia, Calvinia West and Blikkiesdorp (the informal settlement). In Philippolis, 181 interviews were completed. Eight unemployed youth from the community were recruited to complete the questionnaires in Poding, SeRolo and Bergmanshoogte. The fieldworkers were recruited through one of the teachers and teaching assistants in the local school. Two collected data in Bergmanshoogte as they were Afrikaans-speaking and six collected data in Poding as they could speak Setswana and Sesotho. The fact that they themselves were community members gave them easy access to the communities and enhanced the quality of the data obtained. In the Mankweng township of Polokwane, eight postgraduate students from the University of Limpopo completed the questionnaires with 410 households during November 2019.

The students could all speak Sepedi, which is the predominant language in the area. Each interview took approximately 30 minutes to complete.

The residents in all three areas were very cooperative and we were not aware of possible respondents who refused to be interviewed. The fieldworkers moved from house to house and interviewed everybody who was present and willing to be interviewed. In cases where nobody was home the fieldworkers proceeded to the next dwelling.

Table 1 indicates the number of respondents who answered specific questions in each town, as well as the responding percentage from the total number of questionnaires completed.

The lowest response rate was observed for questions relating to recycling projects in schools. This could be expected as not all households included members currently attending school. The second lowest response rate was recorded for the question relating to household income. However, with percentages ranging between 80.6% and 95.6% the response rate is still relatively high and sufficient information was gathered to explore specific relationships. The data was captured in Excel and the empirical analysis was performed using EViews as a statistical package. At least one of the authors were involved in each of the elements of the field work. The involvement of the authors in the fieldwork provided a deeper appreciation of the issues facing each community and served as a suitable quality control measure. The project received ethical clearance from the Human and Social Sciences Research Ethics Committee of the University of the Western Cape with the number (HS19/5/5). All the applicable and required ethical principles were strictly adhered to by the fieldworkers at all times during the fieldwork.

5. Findings and discussion

According to the literature, recycling behaviour is mainly affected by three factors: knowledge of the recycle system, potential inconvenience caused by the recycling process, and reluctance to take personal responsibility for recycling. The empirical analysis starts with a description of behaviour as reported by the residents of the three towns. In a next step, aspects regarding knowledge, inconvenience and responsibility are extracted from the structured surveys; and the final part explores statistically significant relationships between waste behaviour and potential explanatory variables, like income and experience regarding recycling projects (Ekere et al. 2009; Volschenk 2020).

5.1. Practices regarding handling of waste in three towns

Table 2 summarises respondents' practices regarding the storage of waste before it is removed.

Table 1. Response rate to questions.

Question theme	Calvinia		Philippolis		Polokwane	
	n	%	n	%	n	%
Storage of waste	160	100.0	175	97.2	403	98.3
Destination of waste	154	96.3	172	95.6	399	97.3
Willing to separate at source	144	90.0	175	97.2	400	97.6
Willing to recycle if bags provided	153	95.6	175	97.2	401	97.8
Information from municipality	153	95.6	172	95.6	393	95.9
Income	129	80.6	172	95.6	366	89.3
School recycling projects	122	76.3	160	88.9	162	39.5

Table 2. How household waste is stored.

Conventional storage practices	Number of respondents		
	Calvinia	Philippolis	Polokwane
Black bags	61	86	151
Recycling bags (orange/ white/ green/ transparent)	1	2	1
Municipal bin	8	4	15
Alternative storage practices*	82	83	235

* See discussion in text below.

From the recorded responses it is clear that the storage of waste in recycling bags is a rare phenomenon. It must also be noted that no recycling bags were given to residents free of charge in any of the three research settings – the same applies to the provision of black bags. Households that use black bags mostly have to buy it themselves. From responses to this question it was obvious that recycling does not take place in these three towns. However, a follow-up question shed more light on recycling and reuse behaviour. Although it does not form part of the scope of this article, an analysis of the responses to the 'other' waste storage practices provides useful information. In Calvinia many households indicated that they keep the waste in bins inside the house. Bones and other leftovers are often used as dog food. Other practices across the three towns include the burying and burning of waste. In Philippolis most households indicated that they store waste in maize meal bags.

The best information regarding recycling and reuse of household waste was obtained when respondents were prompted to indicate what happens to specific categories of waste generated in their household (see Table 3). The mostly zero reports in the majority of the columns relating to Philippolis immediately draw one's attention. About 11% of households put their general waste out to be collected by the municipality and only approximately 8% of households indicated that they put food waste out. Only two respondents mentioned that old clothes are donated for charity, but most other

Table 3. What happens to different categories of waste?.

	Paper	Plastic	Clothes	Electronics	Glass	Batteries	Food
	Number of responses from Calvinia						
Put in black bags for collection by municipality	85	87	37	77	84	85	48
Separate bags for reclaimers	2	0	1	0	0	0	1
Give to charity	1	0	40	3	0	0	3
Give to school or church	0	0	0	0	0	0	1
Take to drop-off centre	0	0	0	1	0	0	0
Other	58	59	68	65	62	59	91
	Number of responses from Philippolis						
Put in black bags for collection by municipality	21	21	17	17	20	18	14
Separate bags for reclaimers	0	0	0	0	0	0	0
Give to charity	0	0	2	0	0	0	0
Give to school or church	0	0	0	0	0	0	0
Take to drop-off centre	0	0	0	0	0	0	0
Other	151	151	151	151	151	149	154
	Number of responses from Polokwane						
Put in black bags for collection by municipality	116	115	41	74	113	97	106
Separate bags for reclaimers	9	18	10	4	9	4	4
Give to charity	3	0	98	3	1	1	0
Give to school or church	0	1	9	2	1	0	1
Take to drop-off centre	1	1	0	7	8	6	1
Other	266	264	233	246	224	227	280

household waste is dealt with in other ways. These responses are a clear indication of a lack of options and a community left with very few formal options to handle waste – let alone the option of recycling. The remaining 89% of households in Philippolis either burn or dump their waste. On a positive note, out of the three towns this is the one where almost all households indicated that food waste is used as food for pets and livestock. Most respondents feed it to their pigs and in some cases, dogs and even chickens.

A comparison of the three towns shows that Calvinia is the one where the largest portion of household waste ends up in bags for municipal removal. To the reader, without prior knowledge about the efficiency of waste management systems on ground level, it may suggest that the waste management system in Calvinia performs better compared to Philippolis. It is, however, also obvious that recycling very seldom takes place. Used clothes are donated to charities – with very small numbers of electronics and food as well. However, if one considers used paper, plastic, glass, and batteries as potential recycling material, the picture is not encouraging: only three respondents indicated that paper is donated or put out separately for reclaimers. Regarding other ways of disposing of waste, most households indicated that they put all kinds of waste together in one bin. Respondents also mentioned the reuse of food as pet food, particularly for dogs, but not to the same extent as the reported case in Philippolis.

Even though the Polokwane residents, like in the case of Philippolis, mostly employ ways other than municipal services to dispose of waste, they also are the most prolific recyclers. It is the one town where all kinds of recyclable items are put out in separate bags for reclaimers to collect. Apart from demonstrating the willingness of the residents to recycle, the responses also indicate that there are active buyers (buy-back centres) of recyclables – even though this does not necessarily imply the existence of final markets and end user manufacturing from it in Polokwane. This observation is further enhanced by reports that respondents themselves do take items to drop-off centres. The one constant factor observed in all three towns is the practice to donate used clothes to charities. The other ways described to dispose of waste dumping and burning in Polokwane are reported to be similar to the other two sites. The reuse of food as pet food, however, has the lowest incidence in Polokwane.

5.2. Willingness to participate in recycling

After the observations of reported behaviour provided above, the analysis now proceeds to direct questions put to respondents about their willingness to recycle. Table 4 summarises the responses to three questions. The first question was whether households would participate in a project to do separation at source (indicated by 'Sort' in the table) if initiated by the municipality. The next question asked whether households would sort their own waste into different bags if the bags were provided by the

Table 4. Willingness to participate and need for information.

	Calvinia			Philippolis			Polokwane		
	Sort	Bags	Info	Sort	Bags	Info	Sort	Bags	Info
Yes	89.9	95.3	28.8	93.1	94.9	62.2	84.5	86.8	22.1
No	10.1	4.7	71.2	6.9	5.1	37.8	15.5	13.2	77.9

*Percentage of respondents providing either a 'yes' or 'no' answer.

municipality (indicated by 'Bags' in the table). The last question asked whether house-holds have enough information about waste management in the area where they live (indicated by 'Info' in the table).

As reported in Table 4, 93.1% of residents in Philippolis indicated their willingness to participate in separation at source, followed by 89.9% in Calvinia and 84.5% in Polok-wane. With 95.3% and 94.9% residents of Calvinia and Philippolis respectively answering 'yes' to the question on the use of different bags for different categories of waste, there is clearly an eagerness to recycle. The need for information on waste management practices in Philippolis is much higher than in the other two towns – with 62.2% of respondents in need of information, more than double the proportion in the other two towns. This expressed need of the Philippolis residents for more information regarding waste man-agement practices may be due to the absence of municipal waste services. Recent reports were observed on social media which indicated that the municipality cannot afford diesel. As a result volunteers among the residents informally arrange for the removal of the waste to the dump site themselves. An additional question in the survey asked if waste removal happens as scheduled. The available options varied from 'always' 'frequently', 'seldom and never'. Seventy seven per cent of the Calvinia respondents indicated that it was always on time compared to 5% in Philippolis and 36% in Polokwane. At the other end of the spectrum only 1% of Calvinia residents indicated that it was never on time compared to 2% in Philippolis and 56% in Polokwane.

5.3. Potential explanatory variables

Since respondents overwhelmingly indicated their willingness to participate in recycling initiatives from their municipalities, this last section looks for statistically significant relationships explaining behaviour and attitudes within each town. In particular, we asked if the handling of waste differs across households with different income levels. We also investigated the potential impact of recycling projects at local schools on waste behaviour. The statistical method used here tests whether the responses differ across different categories of a specific variable, for instance, if the way in which waste is stored (responses recorded in Table 3) differs across different income groups or groups answering either 'yes' or 'no' to a specific question. For this study, four different tests were employed to test for differences in mean values across categories, namely the t-test, the Satterthwaite-Welch t-test, the Anova F-test, and the Welch F-test. The t-test and the Satterthwaite-Welch t-test are used when the means of only two groups are compared, while the Anova F-test and the Welch F-test are used in the case of more than two categories. While the t-tests and Anova F-tests assume that the variances of the compared groups are equal, the Satterthwaite-Welch t-test and Welch F-test are not based on this assumption (Welch 1951). Since we did not directly test for the variances of the different groups, all four tests were run. This study only con-sidered the differences in mean to be statistically significant if the test outcomes agreed.

Households were asked about their average take-home household income per month. They had to indicate their monthly take-home pay per category (see a summary of the responses in Table 5).

The income categories in Table 5 do not correspond with the ones used in the official 2011 census. Our questionnaire also included more categories than reported in Table 5,

Table 5. Household income in Rand per month per town.

	Calvinia		Philippolis		Polokwane	
	n	%	n	%	n	%
0–R400	7	5.43	42	24.42	14	4.02
R401–1600	25	19.38	80	46.51	80	22.99
R1 601–6 400	50	38.76	44	25.58	148	42.53
R6 401–25 600	37	28.68	6	3.49	87	25.00
R25 601–102 400	10	7.75			15	4.31
R102 401+					4	1.15

but given the low levels of income reported, we decided to compress the categories as reflected above. For instance, the 7th out of 12 income brackets used in the 2011 census would already have had no respondents in Philippolis, while none of the highest five categories were observed in our survey in any of the three towns. Compared to the number of respondents in Table 2, 129 households in Calvinia answered the income question compared to 152 answering the question on waste storage; in Philippolis 172 compared to 175 and in Polokwane 348 compared to 402. Based on the percentage of respondents per category, respondents in Philippolis received the lowest income, followed by Calvinia and Polokwane. This was to be expected since Calvinia is a larger town and Polokwane is a provincial capital. The income distribution reflected in Table 5 corresponds with the household income reported in the 2011 census from Statistics South Africa. In the census data Philippolis also had the lowest income of the towns. There is no clear indication from the census data which one of Calvinia and Polokwane reported the highest mean income. However, in the census data the variance of Polokwane is also higher than that of Calvinia, with more households falling in the higher income brackets – similar to what is evident from Table 5.

The potential impact of household income on the way wase is stored (as summarised in Table 2) and on what eventually happens to waste (as summarised in Table 3) is discussed next. In Calvinia the way in which households store waste before removal by the municipality differs significantly (at $\alpha = 0.01$, in other words with probabilities below 1%, according to the Anova F-test and the Welch F-test) across different income groups. Households in higher income groups are more likely to store their waste in black bags – which makes sense because they are in a better position to afford it. Data from the other two towns did not render any significant relationships between waste storage and income. Apart from being able to afford black bags, there is no further indication in any of the three towns that more affluent households are more or less inclined to recycle or treat waste differently. The null hypothesis of equal means for the different income groups could not be rejected for any of the seven categories of waste mentioned in Table 3.

The last explanatory variable explored is the potential impact of school projects on waste handling customs in households – with the expectation that children can influence behaviour after being exposed to new ideas at school. International examples of this influence were found in the literature. Deng et al. (2022) postulated in their field study, on the role of children in promoting recycling in the family, that children's voluntary commitments to a school recycling program may include active attempts to influence their family members' recycling behaviour. They hence acknowledged the possibility of a positive intergenerational influence on household recycling behaviours.

Legault and Pelletier (2000), in a Canadian study, found for example that at the end of the school year, parents of children who were part of the environmental education program were significantly more aware of their local environmental conditions compared to parents of children in the control group.

Respondents had to indicate whether children from their household were on occasion involved with school projects about recycling or sorting of waste. From all the responses to this question, 29.5% in Calvinia indicated that it was indeed the case, compared to a very similar 28.9% in Polokwane and a much lower 18.1% in Philippolis. Table 3 reports only two ways in which residents of Philippolis deal with waste. Due to this lack of variation, it is not expected that these reported practices will differ across households with or without the influence of school projects – which in the end turned out to be the case. No statistically significant difference was found in the way households in Philippolis deal with waste after being exposed to school projects on recycling. However, the other two towns reported varying practices which opened the possibility of statistically significant differences. The probabilities for the different kinds of waste handling range from 11.4% to 24.7% in Philippolis, while probabilities as low as 0.18% were recorded for Polokwane and 0.2% for Calvinia.

The Calvinia data indicates a statistically significant difference in the way households with school children involved with recycling projects deal with waste compared to households with no involvement in such projects. These households are more inclined to put paper and plastic waste in separate bags for collection by reclaimers compared to households without children involved in recycling projects. They are also more likely to donate used clothes to charities.[3]

The Polokwane data, on the other hand, does not indicate any impact of school recycling projects on the handling of paper and plastic waste, but it does for clothes and glass. Households with children involved in recycling projects at school were found to be more inclined to store glass separately for collection by reclaimers. They are also more likely to donate used clothes for charity. These differences are statistically significant at 7% for clothes and between 1% and 3% for glass, based on the four tests mentioned earlier.

As a final observation, it must be noted that the overwhelming willingness of residents of all three towns to participate in recycling efforts initiated by municipalities does not provide enough variability in the data on those specific variables. As was to be expected, neither household income levels nor children's involvement in school projects statistically have an impact on residents' willingness to participate in such initiatives.

We must also duly acknowledge the limitations of the study. Our case studies cannot be regarded as representative of all similar urban and rural settings in South Africa, and we do not claim that they are. Furthermore, our analysis focused on the reuse and recycling aspects of the three R framework. The 'reduce' component must naturally be part of a future research agenda in this regard. The design of our survey instrument can also be improved upon – given our experience gained during this fieldwork. For example, more categories can be included in the waste collection methods by households, given the

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[3]The respondents were divided into two groups: those who answered 'yes' and indicated that their children were involved with recycling projects and those who indicated that they were not. Their responses, summarised in Table 3, are then compared to determine whether their behaviour differs. Reported behaviour relating to reclaimers and charities did indeed differ and these differences are statistically significant at 5%, based on all four reported tests of equality.

prevalence of other types of bags used, such as maize meal bags. Further research will benefit by expanding it to metropolitan areas where one can pool locations and strategy by housing type as suggested by one of the reviewers. In the metropoles, housing type ranges from informal settlements to mansions in very affluent areas. This would make for a rich analysis of the data.

6. Conclusions

The three research areas are faced with different circumstances in terms of the handling of household waste. This ranges from a theoretical but non-existent service in Philippolis and a reasonably functioning system in Calvinia to the area of Mankweng where there are no official or de facto services. As a result of the different institutional contexts, households in the three towns handle their waste differently, as discussed in the text. In contrast to the differences in context, the vast majority of households in all three towns are all willing and eager to take part in recycling initiatives. This expressed willingness was found in formal suburbs and informal settlements alike.

In reality, this willingness does however not transmute into action. The reasons for this are a combination of the lack of opportunity, facilities, and envisaged recycling programmes. Here, each town must be viewed in its particular context with different levels of municipal waste services rendered and the availability of local recycling options (or the lack or absence thereof). Examples of these differing contexts are the very few reclaimers active in these areas and the lack of recycling bags at the disposal of residents. What does occur, however, is the reuse of clothes through donations to charity and the use of food waste as animal food.

An investigation of the possible factors affecting residents' waste behaviour revealed that the level of household income has no statistically significant impact on waste behaviour. This is a surprising result and contrasts with some of the available literature where support for such a relationship was reported as far as income and specifically recycling are concerned (Jenkins et al. 2003; Mavropoulus 2009). Another strand in the literature does not find support for this (Miafodzyeva et al. 2013; Miliute-Plepiene et al. 2016). In their study in Johannesburg, Schoeman and Rampedi (2021) also rejected their hypothesis that there is a positive relationship between recycling and higher income levels. On the other hand, the one factor that does impact on waste behaviour is the inclusion of recycling projects in school curricula.

These contextual differences must be considered when any recommendations are considered to facilitate a change in existing waste behaviour and the promotion of recycling initiatives. Schoeman and Rampedi (2021) also emphasise that a blanket approach to issues of recycling will in all probability be counterproductive. The three Rs are the last thing on the minds of citizens who are deprived of the basic levels of services as guaranteed by the constitution. Only when the basics are taken care of will it be possible to convert universal willingness to recycle into a change in behaviour.

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ORCID

Anmar Pretorius 🄳 http://orcid.org/0000-0003-0410-5099
Derick Blaauw 🄳 http://orcid.org/0000-0001-8750-4946
Rinie Schenck 🄳 http://orcid.org/0000-0001-5299-5335
Lizette Grobler 🄳 http://orcid.org/000-0003-1447-6352

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