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Drivers-pressures-state-impact-response of solid waste management in remote communities: A systematic and critical review

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A R T I C L E I N F O

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A B S T R A C T

Solid waste and its associated environmental, health and wellbeing impacts and resource and land availability are becoming increasingly challenging to manage in remote and isolated communities. This is primarily due to the lack of infrastructure, land availability, high collection cost, poor economies of scale and low environmental awareness. This paper seeks to understand the factors that contribute to this solid waste management challenge and that hinder more sustainable management in a remote community context, through a systematic and critical literature review. 265 scientific articles and industry and government reports were collected and reviewed from Web of Science, Scopus, and Google search from 2011 to 2021. Barriers and enablers were synthesised and critically reviewed using a systematic literature review approach following the Drivers-Pressures-State-Impact-Response (DPSIR) framework. The review identified a lack of waste collection and recycling infrastructure, increasing trade and local economic development, low environmental awareness with respect to impacts of consumer waste products and disposal, and limited access to funding as the major drivers for the current unsustainable waste problem in remote communities. Notable impacts literature identified include water pollution (including marine environments), land pollution, and air pollution. Six categories of responses reported in the literature are: 1) technological improvements, 2) waste avoidance and reduction, 3) reuse and recycle, 4) increase government support, 5) inter-organisation partnership, and 6) innovative solutions to create value from waste. This paper informs policy makers on existing problems and potential circular economy approaches to achieve greater sustainability in this area. The paper also provides recommendations on a future research agenda to achieve such changes on the ground.

1. Introduction

Solid waste has been an on-going problem in regional, remote and isolated communities due to their lack of local landfill and recycling infrastructure, inadequate or unavailable kerbside collection services, limited access to market for recyclables, and lack of local expertise (Regional and Remote Australia Working Group, 2013). Additionally, there are no incentives and inadequate capacity to properly manage waste within these communities (Crawford et al., 2017; Mauthoor et al., 2014). Increased tourism activities and technological development have also further exacerbated the waste problem via increased domestic consumption and purchase of electronic devices and equipment (Araujo et al., 2017), increasing the volume and types of materials needing to be processed in remote areas (Keske et al., 2018b). Limited political attention has been paid to these communities because of the feasibility challenges in enabling effective waste management and treatment (Fuldauer et al., 2019). Poor or inadequate collection, storage, transport, and disposal of solid waste can directly and indirectly impact soil, water, and air quality which in turn will impact on public health and environmental conditions. There is an accelerating growth of solid waste in off-grid communities, such as Indigenous communities which are often remote and/or isolated and may not have the centralised, larger essential service infrastructure that supports adequate and streamlined solid waste management. This accelerated growth will have a range of adverse human health impacts in such communities if not managed appropriately, for example, the exponential increase of electronic devices, batteries and white goods that contain heavy metals, can contaminate the land and water if electronic waste (e-waste) is disposed of improperly (Araujo et al., 2017). Other solid waste management that can accumulate include car parts and car bodies, scrap metal, construction waste, white goods, single-use plastics, and putrescibles (Australian Indigenous HealthInfoNet, 2021).

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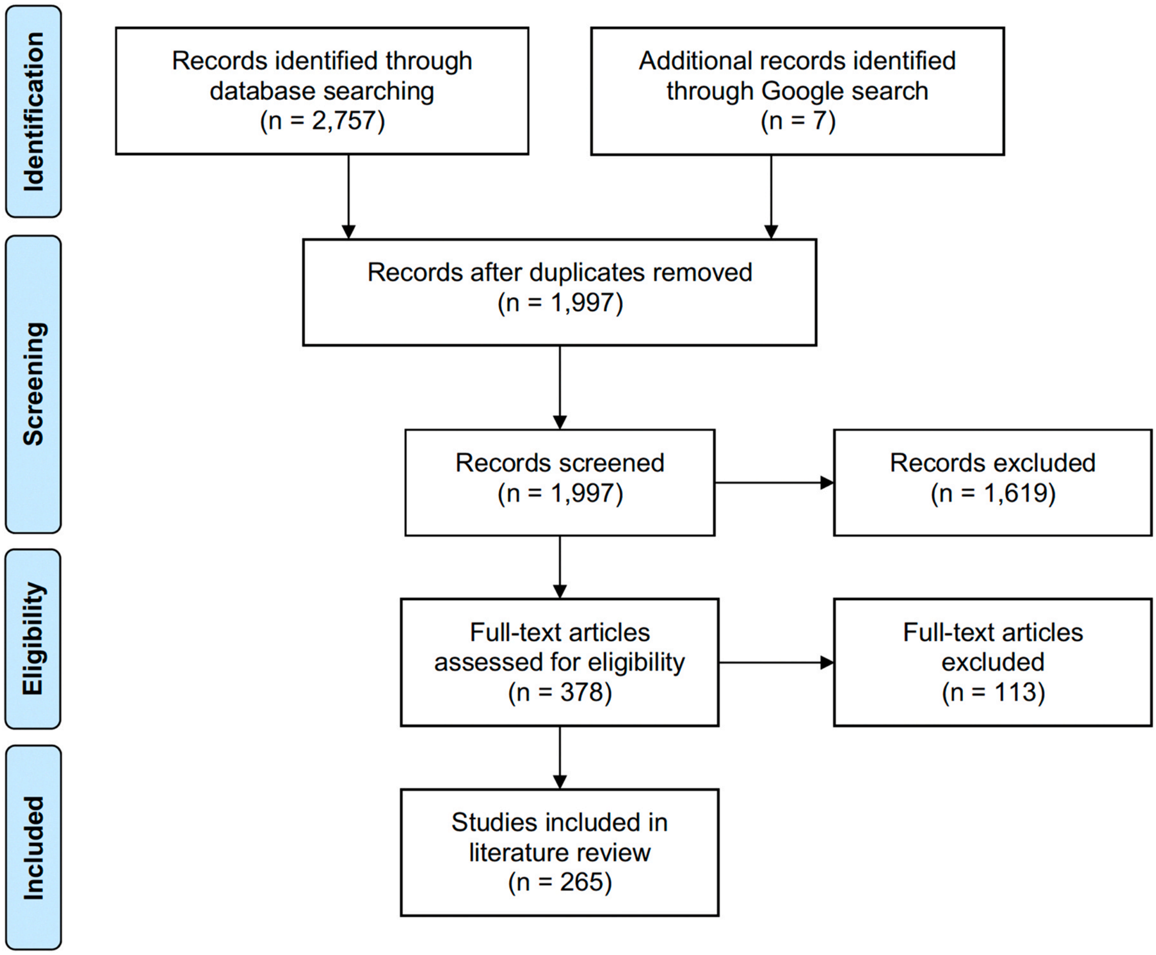

Fig. 1. PRISMA diagram.

Each remote community has unique characteristics and challenges driven by the geographical location, size, climate, governance situation, and community lifestyle. Therefore effective and sustainable waste management that considers these characteristics needs to be adaptive and integrated across socioeconomic, environmental, and technical issues (Bernardes and Gunther, 2014). Existing waste regulations across countries are also more adapted towards urban settings rather than remote settings; thus leading to lack of infrastructure and financial planning (Government of Canada, 2017). Although numerous efforts have been implemented by different organisations across the globe (Regional and Remote Australia Working Group, 2013), their solutions remain unsustainable. There are different frameworks that can be applied to mitigate waste problems such as circular economy (Mohammadi et al., 2021), industrial ecology (Eckelman et al., 2014), industrial symbiosis (Mauthoor, 2017), and 3R (Reduce, Reuse, and Recycle) (Sari et al., 2021).

To date, there have been very few studies on the impacts of accumulated solid waste in the Australia and Pacific region, especially in remote Indigenous communities (Crawford et al., 2017; Keske et al., 2018b; Steenbeck et al., 2016). While we know the potential impacts from inadequate solid waste management, we are yet to fully understand the long-term implications to public health and environmental condition in these contexts. Further, the opportunities for creating a positive, circular economy management model of solid waste in remote communities remains largely unknown. These communities are facing basic challenges ranging from infrastructure, capability limitation, and the lack of environmental awareness (Bernardes and Gunther, 2014). Thus, finding solutions that is culturally appropriate with a low complexity to maintain and operate is imperative to support effective waste management within these communities.

This paper seeks to firstly characterise the current knowledge base of this topic through a systematic review and then introduces and discusses a model for holistically and systemically addressing the solid waste management issue; by looking at not only the drivers and pressures to change the current state, but understanding the range of impacts and appropriate responses to achieving a more sustainable management and climate-resilient management approach. 258 scientific articles were collected through a systematic literature review approach from Web of Science, Scopus and 7 industry and government reports from Google search (a total of 265 records) related to solid waste management in remote communities published from 2011 to 2021. The remote communities observed in this study includes communities with a small population size as defined in the respective articles, but also Small Island Developing States (SIDS). Firstly, search keywords and criteria were established to collect and assess the articles. Secondly, the factors affecting the abovementioned topic were synthesised following the drivers, pressures, state, impact, and response (DPSIR) framework. Thirdly, a critical review was performed to discuss the DPSIR factors to explore the causality between these factors and as a reference for future research to formulate their hypotheses.

2. Materials and method

This review was grounded from the DPSIR framework, which is a reliable scientific framework that can assist future scenario analysis or participatory scenario planning in many sustainability topics (Tscherning et al., 2012). The framework identifies and visualises the cause-and-effect relationships between social and environmental factors in a simplified way, facilitating an easier communication between scientists and stakeholders. Despite some limitations relating to its simplicity, the framework could be a precursor to facilitate effective discussions with remote communities, practitioners, and researchers about waste management planning, considering the limited knowledge hold by remote community (Spanò et al., 2017).

2.1. Systematic literature review

Systematic literature review is a widely adopted approach to collecting and reviewing literature through a set of established criteria to ensure that the collected articles and reports are inclusive, reliable and replicable (Pickering et al., 2015). This approach is well suited to synthesise critical factors and identify gaps for future research directions (Pickering et al., 2015; Salim et al., 2019). Firstly, search keyword and criteria were established, the relevant databases identified, then, the articles collected were assessed as eligible for inclusion in the final database for critical review in alignment with the PRISMA framework for systematic reviews (Fig. 1).

2.1.1. Search keyword and criteria

There are two types of literature used in this research, including 1) scientific articles (i.e. journal articles, conference proceedings, books and book chapters) and 2) industry and government reports. While literature across the globe was included, the geographical focus of the review was the Australia-Pacific region where there is a large proportion of remote, isolated and island communities that are not supported by centralised solid waste management infrastructure and services. Scientific articles were collected from Scopus, Web of Science, and Google Scholar using the following keywords: *"waste management"* OR *"circular economy"* AND (*remote communit** OR *discrete communit** OR *island** OR *rural* OR *aboriginal* OR *indigenous* OR *"Torres Strait islander"* OR *"First Nation*"* OR *"first people"*). Industry and government reports were also collected through Google search using the combination of the keywords above. Additional criteria used to search and collect the articles and reports:

- The study or report was less than 10 years old from 2011 to 2021
- Only studies related to solid waste management considered. Thus, wastewater is excluded from the analysis
- Only publications in English were considered
- Scientific articles included could be in the form of original research article, review, conference proceedings, books, and book chapters

Using the above criteria, the search result from Scopus and Web of Science returned 1765 and 992 records respectively, with a total of 2757 records imported into EndNote 20. A further search via Google Scholar for scientific articles and industry reports returned additional 7 records. Duplicates were subsequently removed, resulting in 1997 records for eligibility assessment.

2.1.2. Articles' eligibility assessment

The eligibility assessment was performed using a two phased approach (Fig. 2) adapted from Hansen et al. (2015). The first inclusion criteria used the title, keywords, and abstract. If the title of an article indicated relevance to the topic, it was automatically included in the final database. If not, the authors to considering the keywords to find evidence of relevancy to the topic, and then to the abstract. Eligible records were grouped together for further assessment. Secondly, the authors retrieved and examined the full texts to determine whether certain records should be eliminated or included for the factor synthesis. This assessment process resulted in 265 records included in the final database for factor synthesis and critical review.

2.2. Factor synthesis and critical review

The DPSIR framework was proposed in the late 1990 s to understand and overcome barriers to sustainability (Carr et al., 2007). The advantage of this framework is the causal nature in describing environmental issues and appropriate responses to solve the issues (Ness et al., 2010). *Drivers* refer to the underlying causes of a problem which can be social, economic, and/or environmental developments (Tscherning et al., 2012), whereas *pressures* represent the consequence of the drivers. They can either be positive or negative, although most concepts focus on the negative aspects. These pressures affect the state of the system in focus which refers to the condition, or observable changes in the system following the pressure(s). The resulting *impacts* are often stated in terms of measurable damages to the environment or human health. *Responses* are the decisions and strategies to correct the drivers and pressures, mitigate negative impacts and to achieve the desirable (more sustainable) state.

Factor synthesis in this study involved summarising and classifying the DPSIR factors relating to sustainable and climate resilient remote community waste management. Combining GT with literature review approaches such as snowballing and scoping the 'grey', non-scientific literature helped to reach a thorough and theoretically relevant analysis and generation and discovery of themes and theories in waste management in remote communities (Wolfswinkel et al., 2013). This study started with conducting open coding which aims to identify, categorise, and describe certain events found within the text by assigning initial codes to each factor. Subsequently, axial coding allowed for the interrelation between categories and their sub-categories to be identified. The higher-order categories represented the main themes or patterns of the findings in the data. The final step involved selective coding where core categories were selected based on groupings of axial codes. An example of how open, axial, and selective coding strategies were used to synthesise factors is presented in Table 1.

3. Results and discussion

Fig. 2 depicts the synthesised factors related to remote community waste management using the DPSIR framework. The top row indicates the key categories identified from the literature under the DPSIR headings drivers (i.e. economic, technical, and behavioural) and pressures (i.e. environmental, health, and economic) which affect the current state which is where remote communities illegal dumping, open burning, stockpiling, and no separation at source. Consequently, the state resulted in degradation in environmental impacts including land, air, and marine pollution. The six categories of response options identified (indicated in the blue arrow) which mitigate the impacts are: digital technologies; waste avoidance and reduction; reuse and recycle; increased government support; inter-organisation partnership; and innovative solutions. A summary of the DPSIR factors along with their frequency of appearance (count) is presented in Table 2. Further detail of the analysis results can be found in Supplementary File A.

3.1. Drivers

There was a total of 519 counts (frequency of appearance in the literature) for drivers (Table 2), with the most occurring as economic drivers (247 counts). Technical (201 counts) and behavioural drivers (71 counts) were also identified.

3.1.1. Economic drivers

Economy is reported as the greatest driver to the existing waste management problems in remote communities (Table 2). Trade and economic development is the most reported driver (72 counts) to the waste problem via increased consumerism (Owens et al., 2011) and tourism within remote communities (Martins and Cró, 2021). Particularly with the increased use of plastic packaged foods to increase shelf-life due to the supply chain limitation in these communities (Owens et al., 2011) and increased electronics usage (Araujo et al., 2017). The second major driver is the limited access to funding (47 counts) which hinders the development of necessary waste infrastructure to allow

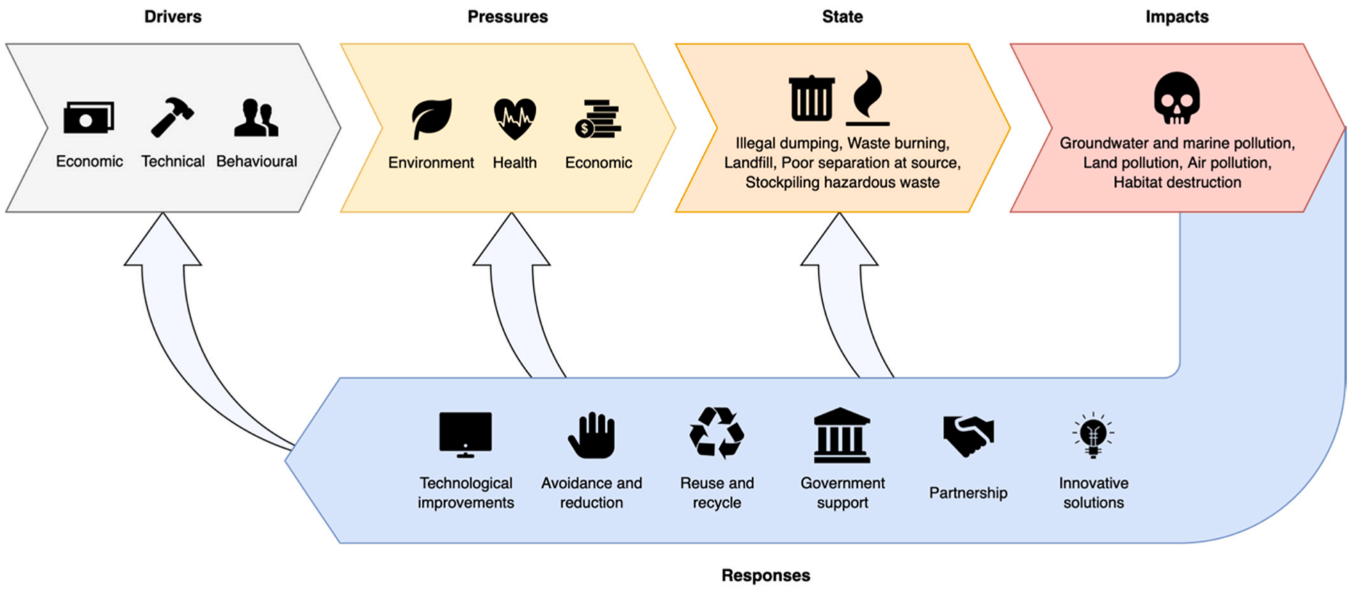

Fig. 2. DPSIR framework for remote community waste management.
Adapted from Carr et al. (2007).

easier transport and processing of waste on-site within the community (Eckelman et al., 2014). Though remote communities may have reliable road access or alternative methods to transport the waste, the cost of waste management would be expensive (40 counts) due to the distance between the community and the urban centre (Huang et al., 2020).

Several papers also mentioned the lack of waste regulatory framework as a major economic driver (36 counts). Waste regulations across countries favour urban settings compared to rural or remote settings (Fuldauer et al., 2019). Consequently, the lack of road access and low population density in many remote communities, especially in small developing islands, means that kerbside collection services are not economically feasible to implement (Mihai and Grozavu, 2019). Furthermore, market for recyclables within remote communities is also another problem reported in the literature (15 counts) (Mena-Nieto et al., 2021). Especially, the collection of plastic and glass waste generated in remote communities are not economically viable because the demand for recyclable plastics and glass can already be met through waste collected within cities. Many recycling technologies are also only profitable to run in large-scale operations which is not economically feasible in remote or rural settings (24 counts) (Lin et al., 2018).

Another major problem is the significant waste management cost increase when introducing waste separation as more transportation planning and infrastructure is required. A case study by Regional and Remote Australia Working Group (2013) in Port Julia, Western Australia has indicated that the kerbside collection cost is more than quadrupled when employing waste separation. Many community members have resorted to illegal dumping due to this high cost. Although studies indicated that remote communities are willing to pay more for a cleaner environment (Nguyen and Tan, 2020; Wang et al., 2014), willingness to pay will decrease as cost goes up significantly (Han et al., 2019). Without proper financial incentives (13 counts), it will be challenging for these communities to mitigate their waste problems, although this would be at a significant cost burden to the government or other aid organisations.

3.1.2. Technical drivers

A major technical driver to remote communities' waste problems reported in the literature is the lack of waste infrastructure in place such as landfill and waste treatment and recycling facilities for specific products (87 counts, Table 2) (Crawford et al., 2017). In SIDS and other island communities this problem is more prevalent due to the limited land availability for waste management activities (Eckelman et al., 2014), whereas transporting waste to the mainland also present transportation and cost challenges. However, depending on the waste generation per capita and distance to the nearest urban centres, building on-site waste infrastructure may not be the most economic option. Thus, responses that focus on waste infrastructure need to be agile and take into consideration the community context, volume and type of waste and community needs.

Lack of data and tracking associated with the volume of different waste is also reported as a moderate driver in the literature (26 counts, Table 2). This information is important as different communities have

Table 1
Example of open, axial and selective coding strategies.

Quote	Open codes	Axial codes	Selective codes
"Although the basic issues are universal, some challenges are magnified by PIC characteristics, such as geographical isolation (islands spread across the vast ocean…" (Asari et al., 2019)	Difficult access due to geographical location	Limited road access	Technical drivers
"As a result of their remote location and long travel distances, the coastal communities of Labrador face complex challenges that are somewhat different from the Happy Valley-Goose Bay region within Labrador" (Keske et al., 2018b)	Long travel distance		
"Other islands, such as Grand Bahama, Great Abaco and Eleuthera are all experiencing growth in tourism with no solid waste infrastructure beyond open dumps." (Sealey and Smith, 2014)	No solid waste infrastructure	Lack of collection and waste infrastructure	
"Recycling facilities are often not easily accessible or are limited to only a small range of materials." (Crawford et al., 2017)	Limited recycling facilities		

Table 2
Summary of DPSIR factors and their sub-categories.

Category	Factors	Count
Drivers	*Economic Drivers*	
	Trade and economic development	72
	Limited access to funding	47
	High collection and waste management costs	40
	Lack of regulatory framework	36
	Poor economy of scale	24
	Limited market for recyclables	15
	Lack of financial incentives	13
	Technical Drivers	
	Lack of collection and waste infrastructure	87
	Limited land availability	40
	Inaccessible location	29
	Lack of data and tracking of waste	26
	Lack of skilled human resources	19
	Behavioural Drivers	
	Low environmental awareness	49
	Cultural practices	13
	Lack of political willingness	9
Pressures	Mitigating environmental impacts	94
	Community health and well-being	77
	Economic factors	31
State	Illegal dumping	86
	Waste burning	52
	Landfill	29
	Poor separation at source	19
	Stockpiling of hazardous waste	5
Impacts	Groundwater and marine pollution	60
	Land pollution	33
	Air pollution	29
	Habitat destruction	8
Responses	*Technological Improvements*	
	Develop a monitoring system	8
	Improve the sustainability of existing practices	6
	Mobile app to support waste collection	3
	Smart bins	2
	Waste Avoidance and Reduction	
	Enable circular business models	15
	Increase access to sustainable products	12
	Harmonising cultural practice with waste management framework	6
	Reuse and Recycle	
	Promoting composting activity	53
	Establish community waste market	8
	Container deposit refund system	6
	Increase Government Support	
	Educational support to increase environmental awareness	71
	Strengthening environmental and waste regulation	64
	Improve waste management infrastructure	50
	Reliable and cost-effective collection	22
	Stockpiling centre or waste storage	9
	Inter-organisation Partnership	
	Public-private partnership	17
	Inter-community partnership	6
	Innovative Solutions to Create Value	
	Waste-to-energy solutions	39
	Conversion to materials for local use	13

unique waste characteristics and require different priorities in selecting waste infrastructure to build within the community (Mihai and Grozavu, 2019). However, without a reliable data collection approach or technology, prioritisation of waste management strategies in communities is challenging. Collecting such data is also difficult within remote communities if there is a poor waste segregation at source and limited infrastructure (Diaz-Farina et al., 2020). Another factor identified is literature limited skilled human resources within the community hinder the implementation and operations of waste management infrastructure as well as data collection and management (Taghipour et al., 2016).

3.1.3. Behavioural drivers

Low environmental awareness is the most reported major behavioural driver (49 counts, Table 2) to waste problems in remote communities, especially in relation to illegal dumping and inactions on waste separation and management. Low education level (Pan, 2020; Weekes et al., 2021) and income level (Steenbeck et al., 2016) of the community members are the most prominent key determinants of such low environmental awareness. Consequently, there are limited -community innovative solutions to mitigate and manage waste sustainably without significant external inputs and expertise. Culture and lifestyle was identified as both barrier and enabler to sustainable waste management with some communities lacking hygiene and acceptability to properly dispose of their waste as part of the embedded culture and lifestyle (Fostinone, 2016), while utilising traditional science or wisdom can play an important role in preventing waste problems (Senekane et al., 2021).

In low-to-middle-income countries (LMIC), some literature suggested that low environmental awareness is further exacerbated by the lack of political willingness from the government to address these environmental impacts. Environmental aspects of poor solid waste management can be a lower priority to LMIC governments than social and economic development, and even then this can be overshadowed by corrupt activities of politicians (Boateng et al., 2016).

3.2. Pressures

In this study, pressures refer to the negative consequences that motivates a person, organisation or institution to take action against the waste problem (Table 2). Environmental impacts such as groundwater, marine, air, and land pollution are the most prominent pressures identified in mitigating waste problem (94 counts). There is an increasing pressure from politicians, non-governmental organisations, and from the communities themselves to avoid environmental problems from the growing waste problem, especially in areas with water scarcity (Rangel, 2011). Australia, for example, has established the Regional and Remote Australia Working Group, which is leading the implementation of the National Waste Policy for the remote and regional communities (Regional and Remote Australia Working Group, 2013). This pressure is reinforced by the increasing priority given by governments' to address climate change and achieve commitments to the Sustainable Development Goals (Farrelly et al., 2016).

The potential natural hazards from improperly disposed waste (e.g. fire risks from battery waste battery, flooding from poorly draining landfills, etc.) are also a key pressure on stakeholders to address this issue. Another aspect identified in avoiding deteriorating environmental conditions from waste is in retaining the environmental character and integrity and therefore keeping the aesthetics and ecosystem services intact to support residents staying within the communities. The economic feasibility and sustainability of the solutions for reducing impacts from environmental pressures remain a major challenge due to limited skilled human resources and infrastructure available within the community (Government of Canada, 2017; Regional and Remote Australia Working Group, 2013).

The environmental pressure directly correlates to the adverse community health and well-being as an indirect result of unresolved waste problems, which is the second most reported pressure factor in literature (77 counts). Many communities have practised home or community composting for subsequent reuse as agricultural fertiliser (Vaz et al., 2015) and animal feeders (Lima and Paulo, 2018). However, critical waste items such as electronics and non-organics which holds substantial environmental and human health impacts (e.g. heavy metal and chemical contamination of water, air and soil and subsequent ingestion and accumulation of toxic substances) have not received much attention (Mohammadi et al., 2021). Studies have confirmed that contaminants can be present at higher than recommended levels in the wastewater (Keske et al., 2018b), especially in LMICs where there is typically less environmental regulations and enforcement. This is further compounded by the fact that remote communities have limited access to healthcare facilities and services (Senekane et al., 2021). Some landfills or waste facilities are rudimentary (e.g. open dumping of rubbish with no covering or lining of pits) and can also become a home to rodents, mosquitoes and other insects which may increase exposure of the community residents to more diseases (Hidalgo et al., 2019).

Economic factors are the least reported pressure (31 counts) in the literature. Many remote communities rely heavily on tourism for income, especially SIDS such as Mauritius, Fiji, Maldives, Bahamas, etc. (Sustainable Travel International, 2020). Poor waste management and refuse can reduce aesthetic appeal of an area and negatively affect tourism activities and lower real estate's valuation due to visible marine and land pollution. Tourism activities can increase volumes of waste and waste management difficulties (Martins and Cró, 2021). According to Mihai (2018a), rural communities are the largest contributor to the plastic pollution in the water system. This issue is far greater within developing regions as there is limited access to sustainable packaging (Asari et al., 2019). SIDS and other coastal and island-based economies also largely depend on marine biodiversity which is negatively impacted by significant marine pollution.

3.3. Current state

The current state of waste management in remote communities varies between different regions (Table 2). SIDS tends to face more uncertainties as they have limited land availability and skill shortages in waste management (Wang et al., 2021). However, illegal dumping (including marine litter) is one of the most reported waste problem in remote communities' literature (86 counts) (Mihai, 2018b). Due to the limited landfill facilities and waste management infrastructure, illegal dumping is a convenient and affordable option for community members to dispose of their waste (De Feo et al., 2014; Hidalgo et al., 2019). Only a few papers reported remote communities having an established sanitary landfill on-site (Zis et al., 2013). However, the maintenance of the landfill system within remote communities remains a challenge due to leachate seeping into receiving environments (e.g. water and soil) from poor lining management (Widomski et al., 2018). Despite the existing extended producer responsibility (EPR) in some developed regions, remote communities typically are not obligated under any take-back scheme (Weekes et al., 2021).

Open burning is the second most practised 'quick-fix' solution to getting rid of the household waste problem (Mohee et al., 2015). In remote areas in LMIC, this situation is much worse due to the lack of government regulation and environmental awareness in this space (Bernardes and Gunther, 2014; Steenbeck et al., 2016). However, the authors have observed burning of waste commonly practiced in a number of remote communities in Australia (with anecdotal evidence to suggest it is a widespread management technique). Increased air pollution from this practice can result in increased incidences of respiratory diseases and contributes climate change through increased GHG emissions (Kumari et al., 2017).

Separation at source is reported as a less prevalent practice in the literature. Some countries have a waste separation regulation in place via a bin separation system. LMICs and countries with remote communities that are geographically dispersed also have low occurrences of waste separation, particularly if there are less regulations in place as can be the case of LMICs (Han et al., 2019). When waste is not separated at source, then it is impossible to promote cost-effective waste management practices such as composting, reuse, and recycling (Liao et al., 2018; Nguyen and Watanabe, 2019). Stockpiling is the most under-reported practice in remote communities although it is still prevalent among non-organic or oversized waste materials such as whitegoods and car bodies.

3.4. Impacts

The impacts synthesised in this study refer to the direct impacts of poor waste management practices. The current waste management state in remote communities have been negatively impacting the three pillars of the natural environment: land, air, and water and marine pollution. Land pollution can derive from uncontrolled and poor management of landfill (Araujo et al., 2017) and illegal dumping of various types of waste (Mohee et al., 2015). If the community is surrounded by agricultural land, this will pose more health-related danger to the food supply chain across the country. Air pollution is often as a result of open burning which is one of the common practices in remote communities (Mohee et al., 2015). This is reinforced by the fact that many LMICs do not have, or effectively enforce, air quality regulations. These impacts also directly correlate to the global warming, whereas remote communities do not have the necessary infrastructures and resilience to deal with the environmental and health consequences from climate change disasters.

Direct litter or leachate run-off from the land can also result in groundwater and marine pollution (Verlis and Wilson, 2020). This will consequently result in declining marine biodiversity and the livelihoods of the surrounding communities. This impact is a more prominent problem for SIDS, coastal and other island communities as they have intensive tourism activities, limited land availability and close proximity to the ocean (Camilleri-Fenech et al., 2018). Habitat loss is the least reported impact in the literature, though land-based ecological damage could also play a significant role in land biodiversity loss. Furthermore, plastics are also one of the prominent waste problems within these communities that will cause flooding and loss of assets and housing.

3.5. Response options

There was a total of 410 counts in the literature for responses with increased government support (216 counts) referred to as the most common response to improved and sustainable solid waste management (Table 2). Reuse and recycling approaches received a high number of counts (67 counts) and innovative solutions to create value (52 counts) were also identified as popular response options.

3.5.1. Technological improvements

The use of geographical information system (GIS) was proposed by several studies (Alavi et al., 2013; De Feo et al., 2014; Ghosh and Ng, 2021) as an appropriate monitoring system to assist municipal authorities to plan for waste drop-offs, landfill planning, and collection transportation routes efficiently. Using remote sensing technologies is well-suited to detect illegal dumping of electronics and non-kerbside waste electronics, furniture, and cars. De Feo et al. (2014) also employed a multi-criteria approach to assess the hazard index of the illegal dumpsites which is useful to minimise the social cost of pollution as well as rehabilitation and monitoring strategies of the dumpsites. GIS as a spatial mapping tool in remote areas is not only cost effective, but it also helps to create a digital data inventory for temporal and spatial analyses of waste (Ghosh and Ng, 2021).

The review also identified a need to improve the sustainability of existing waste management systems. For example, communities who owned an incinerator could upgrade their system to better control the air pollution generated from the machine, but also its capability to generate energy (Shamshiry et al., 2014). Despite this, more research and development need to be conducted to tailor solutions to remote community scale to produce a better economy of scale in processing solid waste as well as tailoring outcomes to specific community needs.

Utilising mobile applications that can assist community members in providing information around collection points and to sell their waste is also a solution to their effective waste management (Pradnyana et al., 2021). However, only three studies addressed this issue and suggests further exploration on the potential application of this platform in other areas of waste management. Smart bins have also gained some research attention and there is a potential application within remote communities to assist with waste tracking, separation, and transportation scheduling to make waste management more economically feasible (Maryono and Seruyaningtyas, 2019; Zhang, 2019). Waste data can be sent through the cloud and local authorities can then schedule waste collection once it meets certain volume. However, the practicality of such a solution, particularly in relation to maintenance of the smart bins is likely to be a long-term challenge as access to remote communities and connection into regional infrastructure and processing is necessary. A centralised public smart bin could be an option for some local authorities or service providers.

3.5.2. Waste avoidance and reduction

Owing to the lack of environmental awareness among remote communities, many studies reported the need for governments, not-for-profit organisations, universities, and private industries to effectively collaborate to promote education, awareness raising to improve community knowledge and capacity for sustainable waste management. Key focal areas identified were increased skills in source separation (Panaretou et al., 2017), promoting reduce, reuse, and recycling (Keske et al., 2018a), and awareness of the impacts of illegal dumping and open burning on environment, health, and economy (Weekes et al., 2021).

Residents of remote communities can avoid and reduce waste by purchasing products with less packaging or materials that can easily be recycled. However, there are often few options to purchase sustainable products within the islands or remote communities unless the local, regional and global supply chain is more sensitive to environmental issues. For example, Australia has set an ambitious target in their National Waste Policy Plan to have 100% reusable, recyclable and compostable packaging by 2025 which will significantly improve access to sustainable products across the country (APCO, 2020). There are also regional waste management plans being developed for remote communities that are investigating sourcing of local produce and reducing carbon footprint and risks to supply chain interruption through extreme weather events and disruption to transport and fuel supplies. Enabling circular business models can also promote better waste avoidance and reduction (Brown, 2019; Uvarova et al., 2020). Schmidt et al. (2021) gives the example of a micro factory that converts agricultural waste into concrete as a circular economy solution. Other existing business models such as repurposing and upcycling could be further investigated in terms of their feasibility. However, the implementation will be challenging as businesses in remote communities have limited access to markets and few local customers and limited specialised skills to implement circular economy principles (Uvarova et al., 2020).

Indigenous knowledge and cultural practices have been inherently aligned with sustainability principles for thousands of years (Throsby and Petetskaya, 2016). Understanding and applying Indigenous knowledge and wisdom can play an important role in mitigating waste problems by harmonising such practices with the existing waste management framework (Siragusa and Arzyutov, 2020). This strengths-based approach may also generate greater engagement and ownership among Indigenous communities to adopt the waste management solutions that align with their values and belief system. However, this strategy remains under-researched and needs more investigation of approaches that is appropriate and cost-effective.

3.5.3. Reuse and recycle

Reuse and recycling practices as a response to sustainable solid waste management in remote communities have been identified as the most difficult strategy to implement due to the limited waste processing infrastructure in remote areas (Crawford et al., 2017). Thus, before promoting this strategy as a viable solution to achieving a circular economy in waste management, there needs to be significant development of critical infrastructure to enable the supply chain for waste processing at scale, such as reliable road access, establishing waste infrastructure within the community or in the urban or regional centres close to the communities. For many areas in Australia for example, remote communities are cut off for much of the year due to flooding from seasonal rainfall, and this necessitates local and regional assessments of feasibility of different waste management strategies taking into consideration local and regional contexts.

Promoting composting activity is the most reported reuse and recycle response option in the literature (53 counts, Table 2). As remote communities can produce a large amount of organic waste (Han et al., 2019; Sealey and Smith, 2014), this practice will be useful for nutrient recycling back to the surrounding agricultural sectors through organic compost and animal feed. Though some households already practise composting and use of organic waste as animal feed, it is argued that enabling community-scale composting is more beneficial and economically feasible than having home composting and can be mandated or encouraged by community leaders or local councils to increase participation (De Gisi et al., 2017).

Furthermore, reuse and recycling can also be facilitated through the establishment of a community waste market (Regional and Remote Australia Working Group, 2013). A waste market relies on public donation and can either directly reuse the donated waste or repair and reprocess them if necessary. For example, the Denmark Tip Shop in Western Australia transform textile waste, scraps, and other waste into valuable art or items to sell within the community or to community partners or tourists. Apart from boosting local economy and job creation, this can also reduce import dependency of products and promote local circular economies. The recycling of e-waste in particular has become a major area of focus in recent years, with a number of circular economy approaches discussed in the literature (Ahirwar and Pandey et al. 2021; Ahirwar and Tripathi, 2021; Awasthi et al., 2018).

Plastic waste is one of the most persisting issues in remote communities, especially those located in developing countries and SIDS (Asari et al., 2019; Haque, 2019; Mihai, 2018a, Oestreicher et al. 2020). Educating residents about reuse and the potential impacts of plastics on the environment and livelihoods can increase awareness to sustainable lifestyle such as reusing plastic packaging. There are many government programmes that cannot be accessed by remote communities. Some communities have also successfully implemented container deposit-refund systems (Fostinone, 2016) which provides a financial motivation for the residents to partake in the nationwide programme. However, infrastructure related to dealing with general waste remains limited across all communities, let alone dealing with a more complex waste streams such as electronic waste, end-of-life vehicles, etc.

3.5.4. Increase government support

Increased government support, including strengthening environmental regulation is the most reported response in the literature (216 counts, Table 2) as many existing regulations predominantly focus on urban settings rather than regional and rural communities. Since remote communities have significantly different socio-economic and environmental characteristics than urban centres, urban-centred regulation is not easily transferable to remote contexts. Existing waste management policy such as EPR charges polluters through fees or taxes for materials with low market for recyclables (Vilms and Voronova, 2016), thus waste management costs can be secured sustainably to improve waste-related infrastructure and conduct waste management activities. However, EPR has not been implemented worldwide and has not able to reach remote communities in high income countries due to the collection and transportation challenges (Lodhia et al., 2017). Panaretou et al. (2017) also proposed an integrated waste management system to holistically improve waste management system from source separation to providing recycling infrastructure for remote communities.

Financial support from the government to improve waste infrastructure within these communities is also an important response. Access to landfill, road access, and kerbside collection should be improved to avoid illegal dumping and incineration. However, Regional and Remote Australia Working Group (2013) noted that separated kerbside collection has resulted in significant waste management costs in remote communities. Complementary strategies such as smarter waste tracking technologies with improved collection and community education and awareness raising of waste management are likely to have more sustainable outcomes in the long-term (Crawford et al., 2017; Keske et al., 2018b; Steenbeck et al., 2016). SIDS, coastal and island communities will face more challenges to establish a landfill facility and kerbside collection because of lack of economies of scale, limited land availability, lack of transportation access amongst other challenges. Government financial support directed towards building maritime waste collection services and improved feasibility of off-island waste processing must be pursued in these contexts (Araujo et al., 2017).

A stockpiling centre within remote communities could be established to facilitate grading and sorting of waste (Bernardes and Gunther, 2014; Crawford et al., 2017; Keske et al., 2018b). Example projects were implemented in Port Julia (Western Australia) where a significant reduction in illegal dumping was observed afterwards (Regional and Remote Australia Working Group, 2013). Grading and sorting activities can also facilitate job creation for the community residents. Once sufficient waste has been stockpiled, local government can arrange the waste transport to the closest landfill or recycling centres.

3.5.5. *Inter-organisation partnerships*

There are two forms of inter-organisation partnerships noted from the literature. A more prominent one is a public-private partnership (PPP) which refers to a partnership consisting of public organisations (i.e. government) with community leaders, not-for-profit organisations and/or industries to facilitate co-investment or co-building waste infrastructure for the remote communities (Ikhwan et al., 2020; Pan et al., 2020). This model works well as remote communities often do not have access to capital for establishing and operating waste-related projects. This will also alleviate government burden in supplying long-term solutions to remote communities which can be very costly (Pan et al., 2020). A successful PPP in waste management system requires an appropriate legal framework and policies that set a target and divide responsibilities between parties involved in the system (Arbulú et al., 2016).

The inter-community partnership model works well if within a certain region there are several communities that can collaborate in mitigating waste management problems, especially if existing national waste regulation is weak. For example, a key action recommended by the Arctic Council (2019) is to create a partnership between arctic communities to develop a shared understanding on waste issues and best practices that can be adapted such as trans-Artic waste shipping and EPR practices. This could be in the form of an industrial symbiotic system where waste can be exchanged between two or more communities for reuse, repair, or recycling if possible.

3.5.6. *Innovative solutions to create values from waste*

There are numerous technological research and development in refurbishment and recycling (King et al., 2021). However, this review found limited potential applications of these advanced technologies in remote communities as they do not have the capability and infrastructure to operate and manage them. Some studies have explored innovative waste processing solutions by converting plastic (Haque, 2019) and agricultural waste (Schmidt et al., 2021) into supplementary construction materials that can be used towards building roads and other infrastructure for the communities. This will be beneficial in reducing waste transportation cost to the closest urban centres, but also promote job creation for the community members. However, more research still needs to be conducted in diverse waste streams generated from these communities.

Adopting a small-scale waste-to-energy plant can also be a solution for SIDS (Mata-Lima et al., 2021), not only to avoid illegal dumping and marine litter but also to generate energy for the residents. Agricultural waste can also be converted into biofuels which can be used to provide cooking fuel for remote communities (Fajfrlikova et al., 2020). Another study also mentioned that the ashes from agricultural by-products can be used to replace cement and the use of polysaccharides from bio-wastes have less carbon emissions related to urban construction (Schmidt et al., 2021). Enabling such processing capabilities either on-site or at closest urban centres can be beneficial to promote circular economy within these communities and facilitate job creation. However, the economies of scale to enable these solutions have not been fully understood in existing literature and the process can be energy intensive and require technical expertise to operate (Schmidt et al., 2021).

4. Conclusions

Remote communities are facing increasing challenges and pressures in managing their solid waste compared to urban communities due to numerous and diverse barriers. Concerns about the ecological damage and human health of waste have been raised by numerous stakeholders, including governments, not-for-profit organisations, and community members themselves. This paper systematically and critically reviewed 265 articles and reports from 2011 to 2021 to synthesise and unpack the factors contributing to waste management challenges in remote communities and the potential solutions that can be address sustainable waste management practices.

The DPSIR framework helped to guide synthesis and critically review the factors contributing to the problem. Illegal dumping and waste burning are the most reported states of unsustainable and unhealthy waste management in remote communities. This has or will result in negative impacts which include water, land, and air pollution and subsequent exposure of public health hazards. Three main categories of drivers were identified as key to eliciting pressures to transform existing waste management practices in remote communities. These are 1) economic – such as lack of economies of scale, high costs to transport waste and financial incentives, 2) technical drivers such as lack of infrastructure, know-how, land availability, and 3) behavioural drivers including low awareness of alternative waste management practices. Pressures for change were also categorised under three headings: 1) environmental, 2) community health and well-being, and 3) economic. Lastly, this study found six categories of response options potentially suitable for remote communities to improve the sustainability of their solid waste management practices. These were 1) digital technologies, 2) waste avoidance and reduction, 3) reuse and recycle, 4) increase government support, 5) inter-organisation partnership, and 6) innovative solutions to create values from waste.

This is the first time a systematic review has been undertaken on the critical problems, foundational challenges and potential solutions that need to be addressed in sustainably managing environment and public health impacts from solid waste management in remote communities. It thus provides a starting point to helps policy makers to formulate best practices and appropriate policies for mitigating solid waste impacts in remote communities.

5. Recommendations and future research directions

This study recommended a solid waste management strategy for remote communities that has government and inter-organisational partnerships as well as digital technologies at its centre to doster greater waste avoidance and reduction to create circular opportunities. This systematic literature review provides a solid foundation for operationalising a progressive remote community waste management strategy. Future research and practice activities should build on these framing principles to create an implementable strategy. A key finding of our research is that remote communities generally have greater diversity in characteristics than urban communities; therefore, remote community solid waste management strategies must be sufficiently adaptive to handle the local situational context.

Key areas of future research focus includes on promoting better technological improvements that are cost-effective and can help to facilitate better waste collection and circular economy practices. Any existing recycling technologies for the types of waste generated from remote communities should be tested at a small-scale. Their appropriateness, effectiveness, economic feasibility, and cultural relevance should be investigated as part of enabling an effective strategy and planning. Evaluating the difference and suitability of these frameworks based on the socioeconomic and behavioural characteristics of the communities can provide an effective solution to their waste management problem. Innovative solutions that can enable reuse and recycling of materials for local use within the community should also be further explored to help remote communities self-managing their waste and generating potential local economies through creative uses such as art. We recommend that such strategies need to be grounded in local realities and therefore assessment of the impacts of remote community's geographical characteristics (e.g. island or arid desert, proximity to urban or regional centres, road access, etc.), governance structures, cultural practices and imports of problematic and pervasive waste materials such as plastics, be considered a priority in informing fit-for-purpose, fit-for-place and fit-for-people sustainable waste strategies.

Data availability

No data was used for the research described in the article.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dr Hengky Salim reports financial support was provided by Griffith University.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.clwas.2023.100078.

References

Ahirwar, R., Tripathi, A.K., 2021. E-waste management: a review of recycling process, environmental and occupational health hazards, and potential solution. Environ. Nanotechnol. Monitor. Manag. 15, 100409.
Alavi, N., Goudarzi, G., Babaei, A.A., Jaafarzadeh, N., Hosseinzadeh, M., 2013. Municipal solid waste landfill site selection with geographic information systems and analytical hierarchy process: a case study in Mahshahr County, Iran. Waste Manag. Res. 31 (1), 98–105.
APCO, 2020. Packaging Waste Collection and Processing Options in Remote and Regional Areas. Australian Packaging Covenant Organisation, Sydney, NSW.
Araujo, D.R.R., de Oliveira, J.D., Selva, V., Silva, M.M., Santos, S.M., 2017. Generation of domestic waste electrical and electronic equipment on Fernando de Noronha Island: qualitative and quantitative aspects. Environ. Sci. Pollut. 24 (24), 19703–19713.
Arbulú, I., Lozano, J., Rey-Maquieira, J., 2016. The challenges of municipal solid waste management systems provided by public-private partnerships in mature tourist destinations: the case of Mallorca. Waste Manag. 51, 252–258.
Arctic Council, 2019. Best Waste Management Practices for Small and Remote Communities. <https://oaarchive.arctic-council.org/bitstream/handle/11374/2297/SAOFI204_2019_RUKA_07-01-06_SDWG_Report-Waste-Management-Best-Practices.pdf?sequence=1&isAllowed=y>. (Accessed 13 March 2022).
Asari, M., Tsuchimura, M., Sakai, S., Tsukiji, M., Sagapolutele, F., 2019. Analysis of mismanaged plastic waste in Samoa to suggest proper waste management in Pacific island countries. Waste Manag. Res. 37 (12), 1207–1216.
Australian Indigenous HealthInfoNet, 2021. Summary of Aboriginal and Torres Strait Islander Health Status - Selected Topics 2021. <https://healthinfonet.ecu.edu.au/healthinfonet/getContent.php?linkid=676885&title=Summary+of+Aboriginal+and+Torres+Strait+Islander+health+status+-+selected+topics+2021&contentid=44569_1>. (Accessed 16 June 2022).
Awasthi, A.K., Cucchiella, F., D'Adamo, I., Li, J., Rosa, P., Terzi, S., Wei, G., Zeng, X., 2018. Modelling the correlations of e-waste quantity with economic increase. Sci. Total Environ. 613–614, 46–53.
Bernardes, C., Gunther, W.M.R., 2014. Generation of domestic solid waste in rural areas: case study of remote communities in the Brazilian Amazon. Hum. Ecol. 42 (4), 617–623.
Boateng, S., Amoako, P., Appiah, D.O., Poku, A.A., Garsonu, E.K., 2016. Comparative analysis of households solid waste management in rural and urban Ghana. J. Environ. Public Health 2016.
Brown, H., 2019. Circular economies for rural renewal: revitalizing towns and their bioregions. WIT Trans. Ecol. Environ. 238, 291–300.
Camilleri-Fenech, M., Oliver-Sola, J., Farreny, R., Gabarrell, X., 2018. Where do islands put their waste? - A material flow and carbon footprint analysis of municipal waste management in the Maltese Islands. J. Clean. Prod. 195, 1609–1619.
Carr, E.R., Wingard, P.M., Yorty, S.C., Thompson, M.C., Jensen, N.K., Roberson, J., 2007. Applying DPSIR to sustainable development. Int. J. Sustain. Dev. 14 (6), 543–555.
Crawford, R.H., Mathur, D., Gerritsen, R., 2017. Barriers to improving the environmental performance of construction waste management in remote communities. In: Proceedings of the Creative Construction Conference, pp. 830–837.
De Feo, G., Cerrato, F., Siano, P., Torretta, V., 2014. Definition of a multi-criteria, web-based approach to managing the illegal dumping of solid waste in Italian villages. Environ. Technol. 35 (1), 104–114.
De Gisi, S., Casella, P., Sabia, G., Farina, R., Landolfo, P., Notarnicola, M., De Feo, G., 2017. Assessing the public perception of islanders regarding the implementation of new technologies to optimize the municipal solid waste management system: a Mediterranean case study. J. Clean. Prod. 164, 1586–1601.
Diaz-Farina, E., Díaz-Hernández, J.J., Padrón-Fumero, N., 2020. The contribution of tourism to municipal solid waste generation: a mixed demand-supply approach on the island of Tenerife. Waste Manag. 102, 587–597.
Eckelman, M.J., Ashton, W., Arakaki, Y., Hanaki, K., Nagashima, S., Malone-Lee, L.C., 2014. Island waste management systems statistics, challenges, and opportunities for applied industrial ecology. J. Ind. Ecol. 18 (2), 306–317.
Fajfrlikova, P., Brunerova, A., Roubik, H., 2020. Analyses of waste treatment in rural areas of East Java with the possibility of low-pressure briquetting press application. Sustainability 12, 19.
Farrelly, T., Schneider, P., Stupples, P., 2016. Trading in waste: integrating sustainable development goals and environmental policies in trade negotiations toward enhanced solid waste management in Pacific Islands countries and territories. Asia Pac. Viewp. 57 (1), 27–43.
Fostinone, L.A., 2016. Packaging Waste in Remote Communities - Opportunities and Challenges: A Case Study for Tefé, Amazon. Lund University, Lund.
Fuldauer, L.I., Ives, M.C., Adshead, D., Thacker, S., Hall, J.W., 2019. Participatory planning of the future of waste management in small island developing states to deliver on the Sustainable Development Goals. J. Clean. Prod. 223, 147–162.
Ghosh, A., Ng, K.T.W., 2021. Temporal and spatial distributions of waste facilities and solid waste management strategies in rural and urban Saskatchewan, Canada. Sustainability 13 (12).
Government of Canada, 2017. Solid waste management for northern and remote communities: planning and technical guidance document. Environment and Climate Change Canada, Gatineau, QC.
Han, Z.Y., Zeng, D., Li, Q.B., Cheng, C., Shi, G.Z., Mou, Z.S., 2019. Public willingness to pay and participate in domestic waste management in rural areas of China. Resour. Conserv. Recycl. 140, 166–174.
Hansen, S.B., Padfield, R., Syayuti, K., Evers, S., Zakariah, Z., Mastura, S., 2015. Trends in global palm oil sustainability research. J. Clean. Prod. 100, 140–149.
Haque, M.S., 2019. Sustainable use of plastic brick from waste PET plastic bottle as building block in Rohingya refugee camp: a review. Environ. Sci. Pollut. 26 (36), 36163–36183.
Hidalgo, D., Lopez, F., Corona, F., Martin-Marroquin, J.M., 2019. A novel initiative to counteract illegal dumping in rural areas of Valladolid Province (Spain). Environ. Sci. Pollut. 26 (35), 35317–35324.
Huang, R.H., Sun, X., Tan, X.Y., Han, B.A., Zhao, S.Q., Ma, D.C., Sun, T., Wei, Q., Yang, Y., Zhang, L., 2020. Decision-making analysis on collection and transportation distance of rural domestic waste: case study of Guangxi Province, China. J. Mater. Cycles Waste Manag. 22 (6), 2081–2091.
Ikhwan, Z., Harahap, R.H., Andayani, L.S., Mulya, M.B., 2020. Partnership as an effort to consolidate waste management initiatives in tourism destinations on small islands: the case of Penyengat Island. In: Proceedings of the 1st International Conference on Environmental Science and Sustainable Development.
Keske, C.M.H., Mills, M., Godfrey, T., Tanguay, L., Dicker, J., 2018a. Waste management in remote rural communities across the Canadian north: challenges and opportunities. Detritus 2, 63–77.
Keske, C.M.H., Mills, M., Tanguay, L., Dicker, J., 2018b. Waste management in Labrador and Northern communities: opportunities and challenges. North. Rev. 47, 79–112.
King, S., Hutchinson, S.A., Boxall, N.J., 2021. Advanced Recycling Technologies to Address Australia's Plastic Waste. CSIRO, Australia.
Kumari, K., Kumar, S., Rajagopal, V., Khare, A., Kumar, R., 2017. Emission from open burning of municipal solid waste in India. Environ. Technol. 40 (17), 2201–2214.
Liao, C., Zhao, D., Zhang, S., Chen, L., 2018. Determinants and the moderating effect of perceived policy effectiveness on residents' separation intention for rural household solid waste. Int. J. Environ. Res. Public Health 15, 4.
Lima, P.D., Paulo, P.L., 2018. Solid-waste management in the rural area of Brazil: a case study in Quilombola communities. J. Mater. Cycles Waste Manag. 20 (3), 1583–1593.
Lin, H.T., Nakajima, K., Yamasue, E., Ishihara, K.N., 2018. Recycling of end-of-life vehicles in small islands: the case of Kinmen, Taiwan. Sustainability 10, 12.

Lodhia, S., Martin, N., Rice, J., 2017. Extended producer responsibility for waste televisions and computers: a regulatory evaluation of the Australian experience. J. Clean. Prod. 164, 927–938.
Martins, A.M., Cró, S., 2021. The impact of tourism on solid waste generation and management cost in madeira island for the period 1996–2018. Sustainability 13, 9.
Maryono, Seruyaningtyas, K., 2019. Preliminary study of smart regional waste recycling in Boyolali, Central-Java, Indonesia. IOP Conf. Ser. Earth Environ. Sci., p. 248.
Mata-Lima, H., Silva, D.W., Nardi, D.C., Klering, S.A., de Oliveira, T.C.F., Morgado-Dias, F., 2021. Waste-to-energy: an opportunity to increase renewable energy share and reduce ecological footprint in Small Island Developing States (SIDS). Energies 14, 22.
Mauthoor, S., 2017. Uncovering industrial symbiosis potentials in a small island developing state: the case study of Mauritius. J. Clean. Prod. 147, 506–513.
Mauthoor, S., Mohee, R., Kowlesser, P., 2014. An assessment on the recycling opportunities of wastes emanating from scrap metal processing in Mauritius. Waste Manag. 34 (10), 1800–1805.
Mena-Nieto, A., Estay-Ossandon, C., dos Santos, S.P., 2021. Will the Balearics and the Canary Islands meet the European Union targets for municipal waste? A comparative study from 2000 to 2035. Sci. Total Environ. 783.
Mihai, F.C., 2018a. Rural plastic emissions into the largest mountain lake of the Eastern Carpathians. R. Soc. Open Sci. 5, 5.
Mihai, F.C., 2018b. Waste collection in rural communities: challenges under EU regulations. A case study of Neamt County, Romania. J. Mater. Cycles Waste Manag. 20 (2), 1337–1347.
Mihai, F.C., Grozavu, A., 2019. Role of waste collection efficiency in providing a cleaner rural environment. Sustainability 11, 23.
Mohammadi, E., Singh, S.J., Habib, K., 2021. How big is circular economy potential on Caribbean islands considering e-waste? J. Clean. Prod. 317.
Mohee, R., Mauthoor, S., Bundhoo, Z.M.A., Somaroo, G., Soobhany, N., Gunasee, S., 2015. Current status of solid waste management in small island developing states: a review. Waste Manag. 43, 539–549.
Ness, B., Anderberg, S., Olsson, L., 2010. Structuring problems in sustainability science: the multi-level DPSIR framework. Geoforum 41 (3), 479–488.
Nguyen, M.R., Tan, M.F.O., 2020. Solid waste management in urban and rural communities of Santa Cruz Watershed, Laguna, Philippines. Pertanika J. Soc. Sci. 28 (4), 2861–2877.
Nguyen, T.T., Watanabe, T., 2019. Win-win outcomes in waste separation behavior in the rural area: a case study in vietnam. J. Clean. Prod. 230, 488–498.
Oestreicher, V., García, C.S., Pontiggia, R., Rossi, M.B., Angelomé, P.C., Soler-Illia, G.J., 2020. E-waste upcycling for the synthesis of plasmonic responsive gold nanoparticles. Waste Manag. 117, 9–17.
Owens, E.L., Zhang, Q., Mihelcic, J.R., 2011. Material flow analysis applied to household solid waste and marine litter on a small island developing state. J. Environ. Eng. 137 (10), 937–944.
Pan, D., Chen, H., Zhou, G.Z., Kong, F.B., 2020. Determinants of public-private partnership adoption in solid waste management in rural China. Int. J. Environ. Res. Public Health 17, 15.
Pan, Z., 2020. How waste is managed in urban and rural areas: evidence from China. IOP Conf. Ser. Earth Environ. Sci. 566.
Panaretou, V., Malamis, D., Papadaskalopoulou, C., Sotiropoulos, A., Valta, K., Plevri, A., Margaritis, M., Moustakas, K., Loizidou, M., 2017. Implementation and evaluation of an integrated management scheme for MSW in selected communities in Tinos Island, Greece. Waste Biomass Valoriz. 8 (5), 1597–1616.
Pandey, S., Karakoti, M., Surana, K., et al., 2021. Graphene nanosheets derived from plastic waste for the application of DSSCs and supercapacitors. Sci. Rep. 11, 3916. https://doi.org/10.1038/s41598-021-83483-8
Pickering, C., Grignon, J., Steven, R., Guitart, D., Byrne, J., 2015. Publishing not perishing: how research students transition from novice to knowledgeable using systematic quantitative literature reviews. Stud. High. Educ. 40 (10), 1756–1769.
Pradnyana, I.W.W., Fahmi, A., Zaidiah, A., Wibisono, M.B., Wahyono, B.T., Purabaya, R. H., 2021. Design and build an android-based waste pickup information system using the extreme programming method (case study: BUMDes Cahaya Buana Paku). In: Proceedings of the 3rd International Conference on Informatics, Multimedia, Cyber, and Information System, pp. 142–147.
Rangel, F.J., 2011. Toxic waste dumping, water contamination, and people's disablement in semi-arid rural México: local water pond issues for the fair siting of a landfill. WIT Trans. Ecol. Environ. 153, 185–195.
Regional and Remote Australia Working Group, 2013. Solutions for Waste Management in Regional and Remote Australia – A Compilation of Case Studies. National Environment Protection Council, Canberra, ACT.
Salim, H.K., Stewart, R.A., Sahin, O., Dudley, M., 2019. Drivers, barriers and enablers to end-of-life management of solar photovoltaic and battery energy storage systems: a systematic literature review. J. Clean. Prod. 211, 537–554.
Sari, N.K., Citrasari, N., Hariyanto, S., Ayundafarisa, M.C., 2021. Design of 3 R solid waste processing facility (TPS 3 R) in Tanjung Village as the development of municipal solid waste management facilities in North Lombok Regency. IOP Conf. Ser. Earth Environ. Sci., p. 802.
Schmidt, W., Commeh, M., Olonade, K., Schiewer, G.L., Dodoo-Arhin, D., Dauda, R., Fataei, S., Tawiah, A.T., Mohamed, F., Thiedeitz, M., Radebe, N.W., Rogge, A., 2021. Sustainable circular value chains: From rural waste to feasible urban construction materials solutions. Dev. Built Environ. 6.
Sealey, K.S., Smith, J., 2014. Recycling for small island tourism developments: food waste composting at Sandals Emerald Bay, Exuma, Bahamas. Resour. Conserv. Recycl. 92, 25–37.
Senekane, M.F., Makhene, A., Oelofse, S., 2021. Methodology to investigate indigenous solid waste systems and practices in the rural areas surrounding Maseru (Kingdom of Lesotho). Int. J. Environ. Res. Public Health 18, 10.
Shamshiry, E., Mokhtar, M.B., Abdulai, A.M., 2014. Investigating the standard process of incineration in Langkawi Island. Malays. Am. J. Environ. Sci. 10 (3), 260–276.
Siragusa, L., Arzyutov, D., 2020. Nothing goes to waste: sustainable practices of re-use among indigenous groups in the Russian North. Curr. Opin. Environ. Sustain. 43, 41–48.
Spanò, M., Gentile, F., Davies, C., Lafortezza, R., 2017. The DPSIR framework in support of green infrastructure planning: a case study in Southern Italy. Land Use Policy 61, 242–250.
Steenbeck, T.L., Martinez, O.F., Schirmer, M., Koch, C., Giese, S., 2016. Sustainable waste management: the example of the informal settlement "Las Fincas" on Cozumel Island, Mexico. In: Proceedings of the Waste Management and the Environment VIII, pp. 187–194.
Sustainable Travel International, 2020. Small Island Developing States. https://sustainabletravel.org/small-islands/ (Accessed 14 March 2022).
Taghipour, H., Amjad, Z., Aslani, H., Armanfar, F., Dehghanzadeh, R., 2016. Characterizing and quantifying solid waste of rural communities. J. Mater. Cycles Waste Manag 18 (4), 790–797.
Throsby, D., Petetskaya, E., 2016. Sustainability concepts in Indigenous and non-Indigenous cultures. Int. J. Cult. Prop. 23 (2), 119–140.
Tscherning, K., Helming, J., Krippner, B., Sieber, S., Paloma, S.G., 2012. Does research applying the DPSIR framework support decision making? Land Use Policy 29 (1), 102–110.
Uvarova, I., Atstaja, D., Korpa, V., 2020. Challenges of the introduction of circular business models within rural SMEs of EU. Int. J. Econ. Sci. 9 (2), 128–149.
Vaz, J.M., Ferreira, J.S., Dias-Ferreira, C., 2015. Biowaste separate collection and composting in a Small Island Developing State: the case study of Sao Tome and Principe, West Africa. Waste Manag. Res. 33 (12), 1132–1138.
Verlis, K.M., Wilson, S.P., 2020. Paradise trashed: sources and solutions to marine litter in a small island developing state. Waste Manag. 103, 128–136.
Vilms, M., Voronova, V., 2016. Non-deposit system option for waste management on small islands. Waste Manag. Res. 34 (8), 748–754.
Wang, H., He, J., Kim, Y., Kamata, T., 2014. Municipal solid waste management in rural areas and small counties: an economic analysis using contingent valuation to estimate willingness to pay for Yunnan, China. Waste Manag. Res. 32 (8), 695–706.
Wang, K.C.M., Lee, K.E., Mokhtar, M., 2021. Solid waste management in small tourism islands: an evolutionary governance approach. Sustainability 13, 11.
Weekes, J.G., Wasil, J.C.M., Llamas, K.M., Agrinzoni, C.M., 2021. Solid waste management system for small island developing states. Glob. J. Environ. Sci. Manag. 7 (2), 259–272.
Widomski, M.K., Stepniewski, W., Musz-Pomorska, A., 2018. Clays of different plasticity as materials for landfill liners in rural systems of sustainable waste management. Sustainability 10, 7.
Wolfswinkel, J.F., Furtmueller, E., Wilderom, C.P.M., 2013. Using grounded theory as a method for rigorously reviewing literature. Eur. J. Inf. Syst. 22 (1), 45–55.
Zhang, D., 2019. Application of blockchain technology in incentivizing efficient use of rural wastes: a case study on Yitong System. Energy Procedia 158, 6707–6714.
Zis, T., Bell, M.G.H., Tolis, A., Aravossis, K., 2013. Economic evaluation of alternative options for municipal solid waste management in remote locations. Waste Biomass Valoriz. 4 (2), 287–296.