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REVIEW

Critical environmental management accounting practices influencing service delivery of growing cities in a developing economy: a review and conceptual framework

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Abstract
The scope for environmental management accounting (EMA) has perpetually received attention in recent years, and it has become a pillar of sustainability in addressing environmental and service delivery challenges. Most scholars focused on EMA in a corporate context, limited attention has been given to local governments in available scholarly articles except for various initiatives by the United Nations to guide local governments in adopting and implementing sustainable environmental management practices. This has continued to affect the uptake of EMA in local governments, particularly in developing economies, as the question concerning the role of EMA practices (EMAPs) in environmental and service delivery remains unexplored. A systematic literature review (SLR) through the use of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to identify EMAPs and their role in promoting environmental and service delivery performance (SDP) in local governments was employed. Articles from Google Scholar and Scopus published between 2000 and 2023 were considered. The researchers identified and evaluated energy accounting, material flow accounting, water management accounting, carbon management accounting and biodiversity management accounting as effective EMAPs to address local governments' environmental and service delivery challenges. Furthermore, a conceptual framework to integrate EMAPs with environmental improvement and service delivery plans was developed and has implications for policymakers, communities, government and environmental specialists. The lessons learned from the research are pertinent to developing sustainable cities in emerging economies and further expose the need for further research to consider accounting approaches from higher-income countries as benchmarks for future development of ecosystem accounting to assist local governments in managing environmental challenges.

Keywords Ecosystem accounting · Environmental factors · Environmental management accounting practices · Environmental performance · GHG emissions · Service delivery

1 Introduction

Pressure on local governments to recognise the contribution of environmental management accounting (EMA) to improving the liveability and resilience of urban cities is ever-growing, as calls to save an irreplaceable planet that symbolises the natural ecosystem are increasing. Local governments have recognised the importance of sustainability practices by integrating EMA practices (EMAPs) into urban development plans (Qian et al. 2018a). In the urban sustainability discourses, urban ecosystem accounting is considered the most contemporary approach to integrating nature with urban cities' activities (King et al. 2022). The participation of local governments in sustainable environmental management practices is widespread in developed countries (Christ and Burritt 2017), with the practices of disclosure of critical waste management (Hossain 2018) increasingly gaining prominence in urban sustainability discourses (Edens and Hein 2013; Hein et al. 2020). Although ecosystem accounting is not categorised as one of the EMAPs in literature, it is motivated in this article that it should be. It has emerged

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that local governments across the world have adopted it as an integrated approach to addressing urban development challenges by optimising the use of natural capital to counter environmental challenges (Remme et al. 2015). Ecosystem accounting, as guided by the System of Environmental-Economic Accounting (SEEA) framework, is one of the topical issues relating to managing natural capital accounts and has been widely embraced across the globe (King et al. 2022). In G7 countries, the role of nature in developing sustainable cities has become a contemporary subject as nature can deliver many benefits, such as the reduction of urban ecological footprints and disaster risks, the creation of jobs, and the improvement of urban cooling (United Nations Environmental Programme [UNEP] 2021). However, in developing countries such as South Africa, India, Brazil, China and Mexico, the Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project was launched in 2016 as part of SEEA EA implementation, and the project lasted for 3 years. Therefore, it is further suggested that ecosystem accounting in emerging economies lacks proper attention compared with developed countries, further interrogation in the field of study may be indispensable to achieving optimal economic and environmental benefits.

The universal acceptance of EMA across the globe opened a new chapter for private and public sector organisations to transition from conventional accounting approaches that focus on purely financial issues to a broader approach that encompasses the management of environmental costs for improved organisational and environmental performance. Unlike corporate accounting, EMA is a broader term encompassing environment-related information for external and internal use. It is concerned with identifying, collecting, analysing, reducing and managing environmental-related costs for internal and external purposes (Gunarathne et al. 2022). Despite the recognition of EMA in the management of waste and recycling activities, the main challenge is understanding and assessing the use of EMA in local government (Qian et al. 2018a). Similarly, ecosystem accounting is one of the emerging environmental management approaches in urban planning that accounts for stocks of the ecosystem and the flow of ecosystem services to the different communities (United Nations Sustainable Development [UNSD] 2021) and has not received attention in developing countries. Therefore, the agenda to improve EMA implementation is driven by the need to broaden its dimensions to include ecosystem and biodiversity accounting to effectively reduce the impacts of poor environmental management practices that continue to threaten the natural ecosystem and diminish efforts to stop global warming, depletion of natural resources and pollution of the environment (Valdivieso et al. 2021).

The rising climate change-induced risks stemming from the failure to manage critical environmental factors (Zhang et al. 2018) triggered a debate on saving municipal infrastructure from destruction (Tang 2019). Therefore, environmental factors and service delivery are intertwined, as evidence suggests that declining quality of services due to green infrastructure damage and water and air pollution are linked to negative environmental consequences, particularly in growing cities (Zhai et al. 2019; Nilsson et al.2021; Valdivieso et al. 2021). Henceforth, the management of environmental factors and urban development requires seamless integration to achieve urban sustainability, especially in developing economies, which are confronted with the substantial challenge of enforcing compliance with the existing environmental management frameworks (Serge Kubanza and Simatele 2020; Ncube et al. 2021). Accordingly, the implementation of EMA's specific practices, such as carbon management accounting, water management accounting, biodiversity accounting, material flow accounting and energy accounting, is critical to improving environmental performance (Gunarathne and Lee 2021; Gunarathne et al. 2022) together with the newly motivated EMAP, ecosystem accounting, resulting in the provision of quality services. According to King et al. (2022), urban ecosystem accounting promotes the implementation of nature-based solutions that enhance the physical and mental well-being of those living in cities by mitigating the effects of urban heating, improving air quality and creating pleasant environments for people to enjoy. Additionally, in the context of urban development, green infrastructure planning has emerged as a strategic approach for addressing urban challenges that range from the destruction of natural capital such as biodiversity, and social inequalities and mitigation of climate change induce-risks through climate change adaptation (Pauleit et al. 2017). Therefore, it should be the focus of developing countries to apply EMAPs to protect the planet from intolerable harmful impacts that affect service delivery provisioning efforts (Iroegbu et al. 2020) and broaden the scope of EMA implementation by integrating natural capital into urban sustainability plans in developing countries.

The increasing global energy demand continues to drive unsustainable business practices that influence climate change (Gielen et al. 2019; Poudyal et al. 2019; Iroegbu et al. 2020; Ojo and Baiyegunhi 2021), resulting in a continued effect on the quality of service delivery in local government spheres, as surging water, air and land pollution requires attention. According to Tang (2019), the energy and waste management sectors are major contributors to the environmental liability that triggers climate change effects, followed by the agricultural sector (Poudyal et al. 2019). The major environmental issues that trigger climate change around the world are poor solid waste management practices (Alabi et al. 2019), surging GHG emissions (Makan and Heyns 2018), illegal dumping of hazardous substances (Klemeš et al. 2020; Hantoko et al. 2021), deforestation (Zvobgo and Tsoka 2021) and poor wastewater management practices

(Breitenmoser et al. 2022). Therefore, the aforementioned environmental issues are part and parcel of the local government's responsibilities and contribute to the debate concerning the effectiveness of EMA adoption in improving service delivery. However, there may be a low EMA adoption in the public sector, particularly in developing economies where environmental and service delivery challenges are on the trajectory of existence.

Adopting EMA across all sectors may be viewed as the most effective approach to managing environmental factors to avert deteriorating environmental situations and associated service delivery incapacitation challenges. Efforts to promote EMAPs should be enhanced as Gunarathne et al. (2022) acknowledged that implementation of EMA amongst different organisations is characterised by heterogeneity, as organisations with a higher stage of environmental management maturity (EMM) use significantly greater domain-based EMAPs and EMA for functional purposes. To date, recommended EMA-related practices that lead to an improvement in environmental performance include afforestation (Fátima et al. 2021), proper management of solid waste (Alabi et al. 2019; Abdulredha et al. 2020), use of renewable energy (Poudyal et al. 2019), reduction of GHG emissions by migrating to renewable energy sources (Makan and Heyns 2018; Gielen et al. 2019), proper management of wastewater (Kroiss et al. 2021; Herrera-Navarrete et al. 2022), minimising the use of petrochemical products for agricultural use (Fernández-Luqueño et al. 2010), development of green infrastructure and maintenance of ecosystem services and natural capital (Pauleit et al. 2019; Vásquez et al. 2019; Heris et al. 2021), and capacity building innovation and increased awareness on climate change (Weitz et al. 2002). However, these practices are centred on environmental protection to avoid further damage to the planet, and this presents potential for improvement in service delivery performance.

With water, wastewater and solid waste being components of basic services, local governments have a responsibility to ensure management of environmental factors receives much-needed attention to enhance service delivery. Therefore, continued efforts to enforce compliance with EMAPs are invaluable in seeking long-term solutions to address urban relating to the provision of basic services (Tang 2019). However, Qian et al. (2011, 2018a) confirm that the uptake of EMA in local government remains low despite being driven by functional and institutional imperatives. Therefore, continuing to broaden the debate on the challenges of adopting EMA in local government may present sustainable solutions**.** Although expanding the body of academic literature on EMAPs continues to create a significance in advancing the environmental management maturity narrative in the last decades (Gunarathne et al. 2022; Herrera-Navarrete et al. 2022), the application of EMAPs in developing economies' municipalities is still at embryonic stages, as most research focused on the impacts of environmental management practices (EMPs) that directly influence the performance of municipalities in South Africa (Ndevu and Muller 2018; Serge Kubanza and Simatele 2020). The persisting environmental-based challenges in organisation are evidence of a lack of effective institutions to exert the same form of pressure on most organisations to embrace EMAPs (van der Poll 2022).

In pursuance of advancing agendas of environmental protection and improving service in growing cities, this article sought to take stock of EMAPs in South African municipalities critically and reflect upon the prospects of fully embracing the theory of participation in environmental management. The authors argue that without implementing EMAPs, existing environmental challenges may continue to have an adverse impact on service delivery in growing cities, particularly in developing countries where urban sustainability challenges are still rife. Hence, this raises many questions about how the theory of participation in environmental management can be institutionalised to ensure inclusivity in all environmental management decisions for improved service delivery.

The research aims to complement the existing literature in the context of EMAPs in developing countries' local governments through a systematic review of all research concerning the implementation of EMAPs and their role in environmental and service delivery performance. The research relied on journal articles from Google Scholar and Scopus and followed a systematic review process using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Most research concerning EMA focused on the private sector (Gunarathne and Lee 2021; Nyakuwanika et al. 2021), with evidence suggesting that organisations that EMA narratives gained traction because of the potential to improve financial and environmental performance. However, insufficient evidence suggests that EMAPs' implementation in local governments, particularly in developing countries, has received attention. Therefore, this research enhances the broader understanding of how public sector entities could benefit from implementing EMAPs by improving environmental and service delivery performance. Through this research, policymakers and environmental regulators could intensify their efforts towards promoting local governments in developing countries to ensure full implementation of EMAPs for improved environmental and service delivery performance.

The article's structure is as follows: The introduction in Sect. 1 is followed by the methodology which is in Sect. 2, the background to green management practices, and the research question in Sects. 3.1 and 3.2, respectively. Section 4 presents the research findings that include bibliometric

and descriptive findings based on EMAPs. Section 5 discusses the article's main findings, and the conclusions and future research are presented in Sect. 6.

2 Methodology

This research followed a qualitative methodological choice, which adopted a systematic literature review (SLR). An SLR seeks to critically review and evaluate extant literature on a chosen topic or research question (Burgers et al. 2019). Additionally, an SLR is a systematic approach to research synthesis which follows predetermined steps (Gough and Richardson 2018) and is appropriate for an inductive approach and interpretive paradigm. The systematic approach utilised mostly relies on a PRISMA (Shamseer et al. 2015). Consistent with other scholarly articles that followed a systematic literature review (van der Poll 2022), the researchers followed the following six-step approach to an SLR (Burgers et al. 2019).

1. Deciding on the research questions expected to be answered by synthesising the literature.
2. Demarcating the literature review process by specifying the inclusion and exclusion criteria.
3. Identifying the keywords that could be used to search relevant articles that address the research inquiry.
4. Selecting the articles based on inclusion and exclusion criteria.
5. Analysing articles critically to seek compatibility with research questions.
6. Assessing the articles according to the criteria.

The research questions are critical aspects of an SLR in guiding the many aspects of the review process through searching relevant articles, determining eligibility criteria, collecting data and presenting findings (Jäger-Dengler-Harles et al. 2020). Therefore, the following research question was formulated:

- How can environmental management accounting practices improve environmental and service delivery performance in local governments of developing countries?

The researchers decided on inclusion and exclusion criteria that assisted in demarcating the scope of the literature review. The inclusion criteria considered articles published in scientific peer-reviewed journals in English between 2000 and 2023 that involved developing countries. The reason for choosing developing countries is informed by the slow progress in implementing EMAPs (van der Poll 2022) and a lack of properly addressing environmental-related service delivery challenges. Therefore, the article provides insights into the potential benefits of integrating EMAPs into urban sustainability plans for improved service delivery and environmental performance. Additionally, peer-reviewed journal articles based on original research that used primary and secondary data were considered sources from Google Scholar and Scopus. Lastly, keywords in the article's title, keywords, and abstract were integral to the inclusion criteria. Also, the researchers excluded studies conducted in developed countries.

The identification and selection of relevant keywords assist in locating the right data sources to provide relevant information (Burgers et al. 2019). Therefore, the researchers ensured that relevant keywords were selected for improved identification of relevant literature. Through the use of Boolean operators, the following keywords "Environmental management accounting", "Environmental management accounting practices", "environmental performance", "environmental accounting", "material flow cost accounting", "Carbon management accounting", "biodiversity accounting", "urban ecosystem accounting", "ecosystem services", "eco-control", "greenhouse gas", "Pollution", "environmental factors", "sustainability", "green accounting", "green infrastructure", "green accounting", "service delivery", "water", "sanitation", "energy", Renewable energy", "electricity", "developing economy", "developing country", "emerging countries", "emerging economies", "lowly-developing countries", "poor countries", developed countries", "advanced country", "industrialized country", "more developed country", "more economically developed country", "Global North country", "first world country", post-industrial country", "successful countries", "first world countries", "undeveloped countries", were used to search for relevant articles on Google Scholar. A forward and backward author searching strategy was utilised to ensure that older and recent articles written by authors of relevant publications were easily located. Therefore the research followed a bottom-up approach to allow deep search publications and create the potential for locating a wide range of relevant publications from various disciplines.

The intensive search using the inclusion criteria yielded 591 documents on Google Scholar. After excluding 249 duplicates, 251 documents were left for further scrutiny and analysis. Furthermore, another exclusion criterion was applied based on examining the abstracts and titles of the publications, which led to cutting down the number of documents to 144. The examination focused critically on EMAPs that influence service delivery in local governments, resulting in a further decrease in publications to 58. The steps involved in selecting the publications are illustrated in Fig. 1 using a PRISMA as a common approach for the critical appraisal of published systematic reviews and providing updated guidelines that reflect advances in

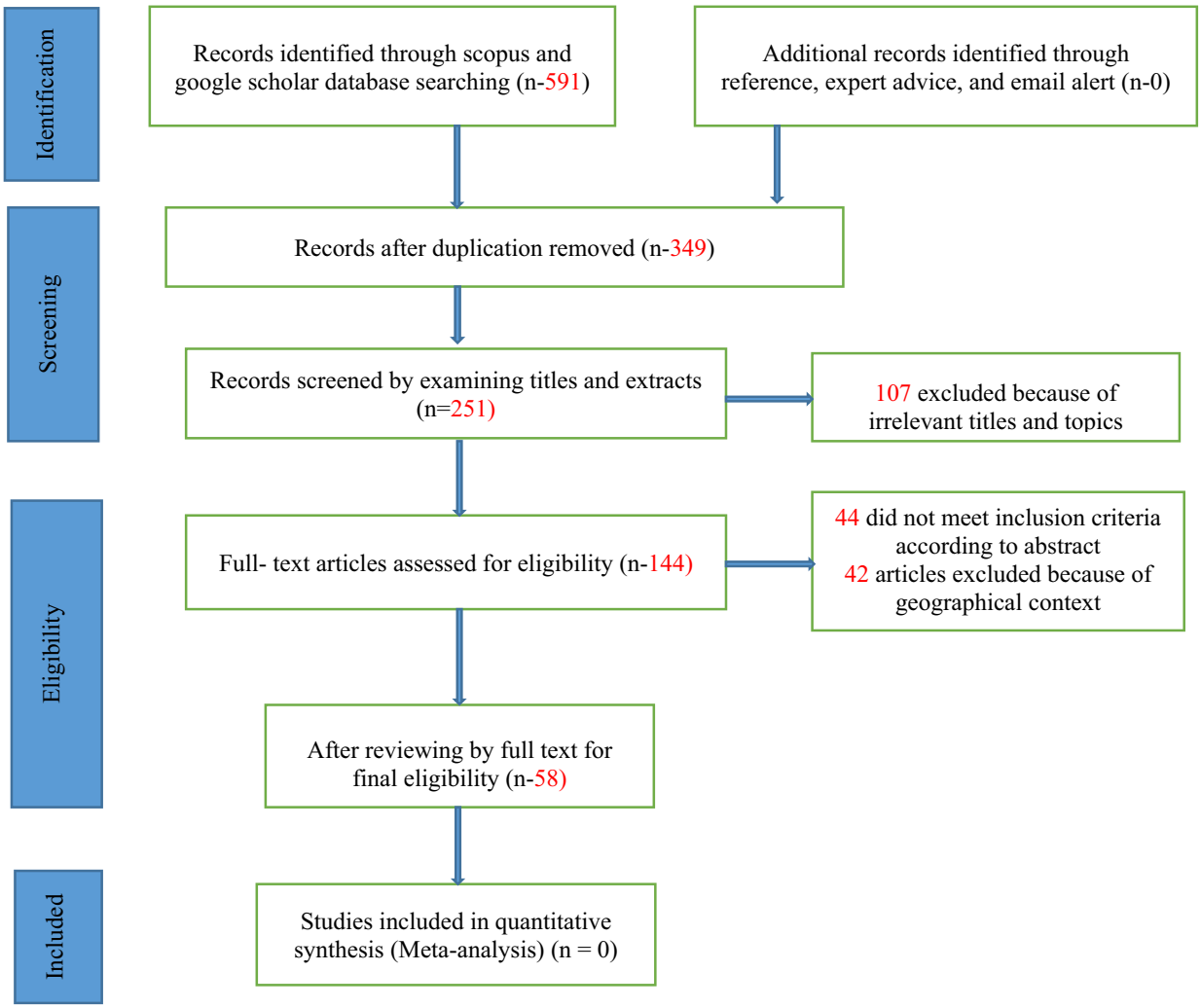

Fig. 1 A preferred reporting item for systematic reviews and meta-analysis (PRISMA) statement depicting the article selection

methods to identify, select, appraise, and synthesise studies (Shamseer et al. 2015).

A content analysis was conducted regarding the selected relevant articles to address the research questions. In line with Burgers et al. (2019), each publication was assessed against inclusion criteria and subsequently followed by a content analysis of the publications. For an SLR to be effective, it is important to decide on a pre-determined and standardised code book in line with a past study (Tranfield et al. 2003). As such, a customised code framework was introduced:

- Country of focus: Developing economy
- Research questions/focus
- Findings concerning the impacts of EMAPs on environmental performance and service delivery in local governments
- Findings concerning the influence of environmental performance on service delivery in local governments

The final content analysis stage involved only 58 articles that were finally considered to deduce the relevant information on the role of EMAPs on environmental and service delivery performance in developing countries. This last step of the analysis focused on refining the articles' contents based on the main keywords used during the search to ensure the bibliometric analyses represent the correct picture of the focus area under the study. The analysis protocol included the geographical location of the research, the research approach employed, main EMAPs mentioned in the title or abstract. The dataset was scrutinised further, resulting in studies categorised into five (5) categories based on EMAPs, such as material flow cost accounting (MFCA), energy accounting (EA), water management accounting (WMA), ecosystem

accounting, biodiversity accounting and carbon management accounting (CMA). The findings of all selected articles are summarised in the research findings section.

The researchers employed an SLR to evaluate the role of EMAPs on environmental and service delivery performance in developing countries. Consistent with Nyakuwanika et al. (2021), the researchers developed propositions from the literature to develop a conceptual framework for managing EMAPs for improved environmental and service delivery performance. Propositions are vital in this research since the literature supports the association between EMAPs, environmental and service delivery performance in the local government context. However, literature in support of EMAPs and environmental performance abound (Kroiss et al. 2021; Herrera-Navarrete et al. 2022); it is clear that it is assumed that actions that improve environmental performance can lead to better service delivery performance. For example, proper management of solid waste and wastewater can reduce the environmental risk that could adversely affect the provision of water and sanitation (Christ and Burritt 2017; Le et al. 2019). Therefore, the assumption holds regarding the association between EMAPs and service delivery performance in local government. As such, a set of propositions provides a basis for understanding how the two (2) concepts relate to each other through synthesising previously published studies. The formulation of propositions is based on three (3) types: content, association and general.

General propositions represent universally general information and are denoted as Pg1, Pg2, …, Pgi. Association propositions represent the connection and how the concept in the framework is associated and labelled as Pa1, Pa2, … Pai. Content propositions represent the identified content or concept denoted as Pc1, Pc2, … Pci.

3 The background to green management practices

Following centuries of environmental neglect, environmental awareness activities were initiated in the 1970s and were followed by the introduction of Earth Day at the first United Nations Environmental Conference (Milder 2022). Before sustainability issues became a global topic, the preceding events were characterised by wasteful and environmentally damaging human practices, including deforestation, extinction of endangered species, land degradation, burning of forestry and killing of animals (Kyere-Boateng and Marek 2021). Globally, substantial experiences of climate change caused by unsustainable business practices continue to constrain the functionality of infrastructure responsible for basic service delivery and threaten irreplaceable human lives (Nilsson et al. 2021). The need to prevent further damage to the environment resulted in the emergence of EMAPs for tracking, tracing, monitoring and controlling the effects of human behaviours and businesses on the environment by taking into account all environmental costs involved and the financial implication of such action of business performance (van der Poll 2022). EMAPs can improve environmental management by reducing waste, energy, carbon emission and material (Gunarathne and Lee 2021). Besides, EMA provides a balanced approach that can reduce environmental costs and risks and improve environmental decisions that could spur business performance (Nyakuwanika et al. 2021). Therefore, implementing EMAPs in local government is motivated by the need to eradicate environmental performance and service delivery challenges.

To avert the deteriorating environmental situation, EMAPs assist in managing environmental factors. Wong et al. (2013) identified various green services practices and their role in environmental management systems. For this research, a selected set of EMAPs is discussed, including adopting energy accounting, carbon management accounting (Moriarty and Honnery 2019), water management accounting (Christ and Burritt 2017) and material flow cost accounting (Nyakuwanika et al. 2021). Applying EMAPs in environmental management is beneficial for identifying and classifying environmental costs, allocating environmental costs to various cost centres and introducing environmental-related cost management (Gunarathne et al. 2022).

3.1 Role of EMA in local government

The conservative approach to service delivery in the governance of local governments presents a missing link to sustainability, particularly with less attention being paid to environmental performance issues (Gibassier and Alcouffe 2018). In the context of local government, EMA is regarded as an adaptive activity to cope with environmental challenges to achieve social acceptance (Qian et al. 2018a). Local governments have been entrusted with providing basic services and ensuring environmental protection within their areas of jurisdiction. Public sector organisations like local governments are responsible for providing sustainable leadership to promote sustainability (Burritt 2004). Accounting for environmental practices has become central to increasing information needs of the public sector organisation concerning the outcome of their concerted efforts to contain environmental challenges (Ribeiro and da Silva Monteiro 2019).

Local governments worldwide are working towards producing clean energy through implementing various strategies. Studies on EMA adoption and implementation in developing countries, specifically local government, are emerging, with evidence confirmed by Dampe and Rajapakse's (2021) study suggesting that EMA information is collected and used in solid waste management decision-making and for organisations to increase potential transition to

renewable energy use. The transition to smart cities by most local governments across the world has helped in optimising the use of solid waste to achieve economic, energy and environmental benefits (Yang et al. 2021). Iqbal et al. (2021) argue in a study involving the impact of renewable energy and reduction in GHG emission on the environmental performance index that a complex relationship between energy production and environment management deserves formidable attention, and renewable energy efforts contribute immensely to better environmental performance. Therefore, the content proposition to support the relevance of renewable energy in environmental performance is formulated as follows:

Proposition Pc1 *Migration to renewable energy sources leads to improved environmental performance by reducing GHG emissions in local governments of developing countries.*

Though adopting EMA in local government solves environmental challenges, Qian et al. (2018a) posit that implementing EMAPs, such as full cost accounting to waste and recycling management and assessing understanding of local government use of EMA, is lacking. Ryu (2010) evaluated the potential for municipal solid waste in renewable energy production and reduction of GHG emissions in South Africa and established that an increase in the use of renewable energy from waste proved to be a contributor to the production of renewable energy and reduction of GHG emissions for improved environmental performance. Qian and Burritt (2009) explored how contingency factors have influenced the development of environmental accounting for recycling and waste management in local government in Australia. They established that environmental management practices addressing recycling and waste management, enable managers to gather environmental accounting information necessary for decision-making relating to environmental management in local government. Consequently, the following proposition is formulated to support the role of solid waste management in environmental performance:

Proposition Pc2 *Sustainable management of solid waste plays a key role in enhancing environmental performance in local governments of developing countries.*

The growing need to save water has become an imperative global goal, as freshwater sources are on the verge of depletion (Breitenmoser et al. 2022). Efforts to alleviate water shortage have centred on strategies of reducing water consumption and recycling wastewater, which is considered a threat to the ecological environment. In the context of developing countries, local governments, through other subsidiary organisations are responsible for ensuring that wastewater is utilised optimally for improved service delivery and environmental performance (Christ and Burritt 2017). Poor wastewater management practices can potentially cause environmental disasters as municipal and industrial water contain dangerous pollutants that threaten the functioning of the natural ecosystem by causing land, water and air pollution (Nguyen et al. 2021; Yaqoob et al. 2021). Local governments have various options for optimising wastewater benefits, which include water recovery, and generation of electricity through biomass and plant nutrients for agricultural purposes, and therefore investment in wastewater management has overall positive consequences on the surrounding ecological environment. As a result, the following proposition is formulated:

Proposition Pc3 *Sustainable management of wastewater plays a key role in enhancing environmental performance in local governments of developing countries.*

The pressure to reduce GHG emissions gained momentum a few years back due to increased climate change-induced risks. The implications of GHG emissions on environmental management are far-reaching and associated with global warming, air pollution, and weather variations (Zhao et al. 2022). The local government are struggling to cope with surging carbon emissions as damage to service delivery infrastructure, environmental damage and dwindling food and water security (Nilsson et al. 2021) remain challenges inhibiting seamless service delivery. Hence, strategies for GHG emissions reduction should be indispensable to addressing environmental challenges responsible for global climate change effects. Therefore, the following proposition to support this argument is given below.

Proposition Pc4 *GHG emissions reduction strategies lead to improved environmental performance in local governments of developing countries.*

Ecosystem accounting is an integrated system composed of ecosystem extent (natural capital footprint), condition and services (depicted by flow and uses of ecosystem services). The flow of ecosystem services is further organised into monetary and physical services, with the former presenting the monetary value of ecosystem services flowing to different users, and the latter is measured through ecosystem asset accounts in the forms of physical natural capital stock (King et al. 2022). Therefore, ecosystem accounting is fundamental to maintaining a comfortable and safe environment for businesses and people (Lai et al. 2018). With the growing pressure to achieve sustainable smart cities, natural capital plays a significant role in reducing the per capita impact of cities by mitigating environmental impacts and making cities resilient to climate-change-induced risks (King et al.

2022). Biodiversity accounting, which is a branch of ecosystem accounting helps in the formulation of environmentally sensitive decisions that promote environmental performance (King et al. 2022). According to various studies, the application of biodiversity accounting is imperative to achieving sustainable development goals (Gunarathne et al. 2022; Weir 2019). Consequently, the following proposition is formulated to support the arguments above.

Proposition Pc5 *Sustainable biodiversity management influences environmental performance in local governments of developing countries.*

Furthermore, it has been established that using EMA information is mostly because of regulatory pressures from the local community, educational background, and training in solid waste management. Municipalities in developing countries are lagging in achieving localised green economies (Serge Kubanza and Simatele 2020), which has continued to affect service delivery. The literature continues to acknowledge that EMAPs assist in reducing pollution, water, material and energy saving in managing environmental factors for improved environmental performance (van der Poll 2022). Therefore, making environmentally oriented decisions requires urgent attention (Nyakuwanika et al. 2021) even to ensure the effectiveness of the service delivery system. The narrative surrounding the implementation of sustainable EMAPs to respond to environmental and service delivery challenges has been given little attention, particularly in the context of local government in developing countries. Although literature established that various EMAPs influence organisational performance (Ndevu and Muller 2018; Serge Kubanza and Simatele 2020), the direction of influence (positive or negative) remains unresolved. The failure to adhere to good EMPs in developing countries (Serge Kubanza and Simatele 2020) raises many questions about the sustenance of the service delivery system. Poor EMPs in local governments, as exhibited by surging indiscriminate dumping, the flowing of wastewater into water sources, air pollution, and the destruction of biodiversity, directly influence the quality of services in local governments. Additionally, ecosystem accounting is a contemporary approach to urban development that is regarded as a significant strategy for addressing environmental challenges (Valdivieso et al. 2021).

Based on the observations from this section, the general assertion is that EMA adoption in local governments provides a twin solution to environmental performance and service delivery challenges. Therefore, the following general proposition is proposed:

Proposition Pg1 *Adopting EMAPs, such as environmental accounting, material flow cost accounting, water management accounting, carbon management accounting, ecosystem accounting and biodiversity accounting, in environmental and service delivery management strategies are key to achieving sustainable development in local governments.*

The adoption and application of EMAPs in local governments are mostly driven by functional imperatives rather than social and organisational factors, and this further implies that local governments do not go further than their functions to address environmental challenges (Qian et al. 2018a).

3.2 Research question and objective

The above rationale for supporting efforts towards improving environmental management informs the following research question and objective.

- What is the role of environmental management accounting practices (EMAPs) on environmental and service delivery performance in local governments?

The following objective addresses the research question:

- Determine the role of environmental management accounting practices in promoting environmental and service delivery performance to develop an integrated conceptual framework to guide the adoption and implementation of environmental management accounting practices in local governments of developing countries.

4 Research findings

The research findings are divided into bibliometric and descriptive findings.

4.1 Descriptive findings

The research seeks to understand the role of EMAPs on environmental and service delivery performance in local governments. Through an SLR, five (5) EMAPs were identified: energy accounting, material flow cost accounting, water management accounting, carbon management accounting, and biodiversity accounting. Nyakuwanika et al. (2021) admitted that EMA is vital in promoting an integrated approach to MFCA, CMA, and GHG accounting and environmental management. Therefore, this section analysis in detail relevant research on EMAPs and environmental and service delivery performance in the context of developing countries. Additionally, a few studies that met the final criteria in terms of content quality, mainly concern a few

developing countries (see Appendix), with South Africa, Indonesia and China contributing most of the articles considered for further analysis.

4.1.1 Energy accounting

Due to global climate change, the emphasis is on reducing energy consumption, generating clean and renewable energy and reusing waste materials to generate energy to ensure that the ecological environment is maintained and improved at all costs. The surge in energy demand is driven by excessive global resource consumption due to heavy industrialisation (Poudyal et al. 2019). The high energy demand and increased negative impacts of the current energy sources on the environment led to the emergence of energy accounting (EA) that allows the measurement, analysis and reporting of energy consumption time and again to improve energy efficiency and monitor environmental energy consumption (Moriarty and Honnery 2019; Nyakuwanika et al. 2021). Therefore, energy accounting has become an important strategy to encourage organisations to revert to renewable energy sources (Gunarathne et al. 2022), improving environmental performance.

EA as an EMAP paves the way for integrating energy management strategies into organisational strategy leading to better energy and environmental performance (Gunarathne et al. 2021). Therefore, implementing EA resulted in many organisations establishing strategies for improving energy usage and generation efficiency for improved environmental performance. However, the debate on the environmental implications of EA received significant attention, with several scholars providing mixed views. Gunarathne and Lee (2021) evaluated the nexus between corporate energy management and environmental strategy implementation by utilising a multi-faceted approach that includes: interviews, observations, field visits, and document analysis. The study established that efficient EA systems enable businesses to implement corporate energy management strategies to reduce costs and emissions and achieve a competitive advantage for better organisational performance.

Similarly, Jermsittiparsert (2020) examined the role of green innovation, environmental proactiveness and EMA on energy efficiency and environmental performance. The response to energy efficiency and environmental performance due to EMA and the related environmental decision was positive, suggesting EMA influences environmental performance. Consistent with the above findings, the study by Kumalawati et al. (2023), which evaluated a conceptual framework that describes the link between EMA, energy efficiency and green economy, outcomes confirms that EMA and energy efficiency had a positive and significant impact on achieving a company's green economy. Further, the relationship between EMA and green innovation and organisational value was evaluated in a study by Agustia et al. (2019). The results showed that green innovation affects EMA, whilst EMA has proven to affect organisational value, and green innovation influences organisational value. To further confirm the impact of energy efficiency on businesses' sustainability performance, Jiao et al. (2023) distributed a questionnaire that established that green intellectual capital, EMA and energy efficiency are key to sustainability performance and gaining competitive advantage. Therefore, green innovation centred on achieving energy efficiency and clean energy improves environmental performance effectively.

As pressure to produce clean energy free from carbon emissions continues, resorting to renewable energy sources perpetually attracts unwavering support from environmental stakeholders. Carbon-free energy generation involves using renewable energy sources, wind, solar, biomass and hydropower. According to Colombo et al. (2013) and Janiszewska and Ossowska (2020), these energy sources have a long-term relationship with human energy needs and have long been considered alternatives to current environmentally unfriendly sources. The positive impact of renewable energy sources' environmental performance is beyond contestation. Gielen et al. (2019) highlight that energy efficiency and renewable energy can contribute to up to 94% GHG emissions reduction.

Additionally, several studies confirmed a strong positive connection between renewable energy usage and environmental performance (Somjai 2020; Putri and Soewarno 2020; Hanif et al. 2023). Therefore, fostering energy-efficient strategies is not only a cost-cutting measure for businesses but provides a great potential for enhancing environmental performance (Khan et al. 2020; Nyakuwanika et al. 2021). Therefore, in support of the arguments raised above, two (2) propositions are introduced as follows:

Proposition Pc1 *Migration to renewable energy sources leads to improved environmental performance by reducing GHG emissions in local governments of developing countries.*

Proposition Pa1 *There is an association between energy accounting (EA) and environmental performance in governments of local developing countries.*

EA does not only improve environmental performance; it is a practice that can be used by local governments/municipalities to monitor the flow of energy within the service delivery chain. To further support clean energy generation in the context of the socioeconomic well-being of the people, Colombo et al. (2013) and Taghizadeh-Hesary and Yoshino (2020) posit that renewable energy programmes create employment, promote local empowerment and generate

income for the local people. Similarly, Khan et al. (2020) evaluate the impacts of renewable energy, public health expenditure, environmental performance, and economic growth. They established that renewable energy sources improve environmental and economic performance and human health by reducing GHG emissions. Consistent with the preceding study, Khan et al. (2016) examined the relationship between energy-resource depletion, climate change health resources and the environment. Based on the results, high expenditure on health is associated with poor environmental performance as measured through GHG emissions and higher carbon dioxide. Therefore, given the role of renewable energy sources on service delivery performance, as raised in the arguments above, the next proposition is provided:

Proposition Pa2 *There is an association between environmental accounting and service delivery performance in local governments of developing countries.*

4.1.2 Material flow cost accounting (MFCA)

The complexity of waste management operations and the provision of services continue to create hurdles for local governments to implement MFCA. Poor waste management practices, such as open dumping and burning (Serge Kubanza and Simatele 2020) and indiscriminate disposal of hazardous materials, such as used containers for mercury, waste oil, sewage sludge, brine and fly ash, threaten the natural environment (Wiedinmyer et al. 2014). To minimise the discharge of hazardous substances from the production chain, MFCA has been considered an EMAP that ensures that waste is managed sustainably within the production chain (van der Poll 2022). Failure to adopt MFCA as an EMAP may adversely affect achieving proper waste management practices. This was confirmed by Doorasamy (2016) through conducting interviews and questionnaires to understand the perceptions of management on the benefits of adopting EMA in managing waste. The results suggest that failure to trace environmental costs to the products or processes responsible for those costs and the irresponsible attitude of the organisation to adopt cleaner production resulted in poor waste management and lower-quality environmental performance.

MFCA is a critical practice for organisations to trace material, waste, energy losses and GHG emissions through an integrated process and a set of activities (Nyakuwanika et al. 2021). Debnath (2014) confirms that MFCA brought about much-needed changes from the traditional attitudes of organisations towards material wastes from production activities and supporting management with information to improve resource utilisations and material yields. Similarly, Zhou et al. (2017) confirm that MFCA plays a critical role in the circular economy as it promotes proper data management and dissemination of information that would lead to the conservation of resources/energy, providing an economic value-add, reducing the environmental load and enhancing the sustainable development of a resource-constrain. Therefore, the implementation of MFCA in industries that use materials, energy and water presents the future of the natural environment by correcting the ecological disorder.

Furthermore, the prominence of MFCA in supply chain management is not only driven by the need to capture the usage of materials to avoid excessive waste but the impacts it has on environmental performance (Mukwarami et al. 2023). EMA's role in environmental performance allows organisations to improve reporting on accurate environmental management costs. Hence, Doorasamy (2015) evaluated theoretical developments in EMA and the role and importance of MFCA. The findings confirm that MFCA plays a multifaceted role that includes increasing transparency of environmental costs and improving accuracy in tracing monetary and physical amounts of non-product output costs. Therefore, the availability of environmental management costs assists in mapping out investment decisions regarding adopting cleaner production technologies for improved environmental performance. Therefore, implementing MFCA is key to promoting better environmental performance, as confirmed in various industries. In the context of the manufacturing sector, Hakimi et al. (2021) applied MFCA systems to improve the efficiency of energy and material consumption. They confirmed that MFCA is an organisational practice applied in manufacturing to improve raw material and energy usage and avoid excessive wastage.

Furthermore, available evidence suggests that MFCA implementation continues to spread across all sectors of the economy. Nyide (2019) employed interviews to investigate the effectiveness of MFCA managing resource efficiency in the hotel sector. The results revealed that hotels started using new technologies to allocate environmental costs, tracing and recording the flow of water and energy. This resulted in accurately calculating environmental costs, ensuring optimisation and improving environmental performance. In the mining sector, Mbedzi et al. (2020) developed a framework for facilitating cost saving and environmental impacts in the coal mining industry in South Africa. They further revealed that EMAPs such as MFCA and Life Cycle Costing (LCC) facilitate cost savings for the organisations involved. EMAPs further promote increased transparency of material usage by tracing and quantifying the flows and inventories of materials within the coal mining industry in physical and monetary terms. Yang et al. (2021) examined agricultural waste recycling optimisation of family farms based on EMA in rural China. The application of MFCA, as one of the EMAPs in

a farming business, improves sustainability by optimising resource consumption and reducing environmental pollution.

Consequently, MFCA improves the efficiency of inputs, resulting in cost savings and a waste reduction that has the potential to impact the environment negatively (Fakoya and Imuezerua 2021). Therefore, it is clear that various approaches to MFCA are associated with environmental performance. This leads to the following propositions.

Proposition Pc2 *Sustainable waste management plays a key role in enhancing environmental performance in local governments of developing countries.*

Proposition Pa3 *There is an association between material flow cost accounting (MFCA) of waste and environmental performance in local governments of developing countries.*

Whilst activities associated with MFCA are key to promoting EMAPs that can potentially improve environmental performance (Qian et al. 2011, 2018b), this might also impact service delivery performance. The introduction of formal recycling schemes has positively influenced the financial viability of solid waste management projects, which has resulted in the minimisation of discriminate dumping (Ncube et al. 2021). Solid waste can be managed in various forms, including recovering materials and energy and recycling waste into usable products (Abdulredha et al. 2020). Serge Kubanza and Simatele (2020) evaluated sustainable solid waste management in South Africa using secondary and primary data collected through semi-structured interviews. The findings reveal that mismanagement of solid waste adversely affects the urban environment and human health, reducing productivity and economic growth. This is caused by institutional failure to enforce policies and regulations and a lack of private and private agents' participation. Similarly, Liu et al. (2017) evaluated the impacts of environmental performance on evaluating different municipal solid waste management scenarios in China. Apart from recycling raw solid waste management, landfilling, biological, and incineration influenced environmental performance significantly through reduced GHG emissions, waste reduction, material recovery, and energy recovery.

To further prove the impacts of MFCA on solid waste management, Dlamini et al. (2019) conducted a systematic review of the literature exploring various ways of converting municipal solid waste-to-energy recovery in South Africa using waste-to-energy (WTE) technologies. They established that the WTE technology for municipal solid waste management (MSWM) can contribute significantly to economic growth, ecological and environmental well-being and sustainable waste management. Therefore, this implies that the availability and utilisation of WTE technologies are key to the socio-economic development of cities. This is due to the high possibility of service delivery through the increased energy supply capacity of local governments or public entities. Improved WTE technology continues to impact the optimal utilisation of solid waste for improved electricity generation. Confirming this argument, Yazdani et al. (2020) performed an energy analysis involving power plants, including a conventional natural gas steam power plant (NGPP), with one that burns municipal solid waste (MSWPP). The results confirmed the renewability, sustainability and positive environmental impacts of generating electricity using solid waste. Guo et al. (2021) analysed solid waste management statistics from 2004 to 2019 and the factors that affect solid waste generation and treatment. Their results suggest that energy consumption and the volume of solid waste generated per unit GDP have decreased, implying that MFCA is quite effective in reducing waste.

Studies concerning solid waste management in local governments and environmental performance produced vague results. Santana et al. (2022) analysed principles of the Brazilian National Solid Waste Policy using a quantitative approach involving 13 indicators presented in the Brazilian National System of Information on Sanitation for Solid Waste from 2010 to 2015. The findings suggest that a positive effect of the adoption of street sweepers on the total recovered, recycled materials was observed. On the same note, Kebede et al. (2019) analysed the efficiency of municipal solid waste management service delivery systems and policy issues in Ethiopia. The findings showed that solid waste and wastewater are improperly disposed of due to a lack of capacity, resulting in an unhealthy environment. Lastly, Latifah and Soewarno (2023) studied environmental accounting strategy and waste management to improve municipal solid management for the organisation's sustainability performance. The results reveal that municipalities' solid management and environmental accounting strategy impacted sustainability performance, implying that better environmental performance will likely be achieved. Hence, sustainable waste management not only influences environmental performance but can potentially impact the quality of service delivery through energy recovery (Liu et al. 2017), promoting a clean environment and reducing pollution (Poudyal et al. 2019).

The above discussions lead to the following proposition:

Proposition Pa4 *There is an association between MFCA and service delivery performance in local governments of developing countries.*

4.1.3 Water management accounting

Demand for water use across the globe continues to increase against the slow-depleting water sources. Rapid

industrialisation, domestic demand and agricultural activities are the major issues behind surging water consumption levels and increased wastewater generation (Breitenmoser et al. 2022). This has continued to affect water security across the globe, with water authorities struggling to maintain the right quantity of quality water for both domestic and commercial use. Water management accounting (WMA) has been viewed as an approach to ensuring water security to alleviate the challenge of overconsumption of water. As an EMAP, WMA is one of the most vital water data-driven approaches to managing water supply and usage that could assist water providers in improving financial and environmental performance (Christ and Burritt 2017). They argue that organisations should gather data through water management accounting to effectively manage water resources for efficient and sufficient corporate water management strategies.

Implementing WMA strategies to improve organisational and environmental performance remains a critical issue in sustainable development discourses. By gathering adequate data on water supply and demand, purification costs and environmental costs associated with the water supply chain, organisations can easily manage wastewater that can lead to environmental catastrophes, particularly when harmful pollutants end up in water sources (Yaqoob et al. 2021). Therefore, the environmental response to wastewater management has far-reaching implications on water security, with many scholars exploring various ways of addressing environmental challenges linked to climate change. However, as confirmed in various studies, WMA as an EMAP is a data-driven approach that presents a twin solution to environmental and financial performance. Nyahuna and Swanepoel (2022) examined the influence of EMAPs on the environmental sustainability of South African cement and mining organisations. They established that water consumption and recycled water are significantly and positively related to EMAPs influencing environmental performance. Adversely, carbon emissions failed to have a significant effect on environmental performance. This further implies that not all EMAPs significantly promote environmental sustainability. On another note, Kurniawati and Dianawati (2020) employed secondary data to investigate the effects of EMPs on organisational performance in Indonesia. According to the results, EMPs driven by the efficiency of water usage showed a positive relationship with organisational performance, whereas energy efficiency had no relationship with financial performance (FP). This further explains the complexities in understanding how WMA influences environmental performance, as many studies' outcomes failed to agree.

Whilst WMA is key to optimal water and energy usage, without emphasising innovation, proper wastewater management remains less cost-effective. To prove this point, da Rosa et al. (2020) evaluated the relationship between EMA and water and energy reduction innovation. The results suggest that EMPs' interaction with process innovation has positively reduced water and energy consumption, particularly in pro-innovation and development industries. Therefore, with a proper water accounting system, environmental performance will likely respond positively, as wastewater and contamination will be produced in small, manageable quantities. Therefore, wastewater management could improve environmental performance depending on the response approach to wastewater management challenges. Therefore, this leads to the following propositions:

Proposition Pc3 *Sustainable management of wastewater plays a key role in enhancing environmental performance in local governments of developing countries.*

Proposition Pa5 *There is an association between water management accounting* (*WMA*) *and environmental performance in local governments of developing countries.*

WMA is no longer the concept applied in commercial realms but an EMAP gaining popularity in public sectors, particularly in local governments responsible for managing the water supply chain. Wastewater management in local governments in developing countries remains a hurdle. Municipal contaminated water contains industrial waste that causes water and air pollution, whereas sewerage and domestic wastewater contain waste pollutants that can result in water-borne diseases that threaten human lives (Campbell-Arvai 2019). Likewise, Iroegbu et al. (2020) applied a systematic review to look at the challenges of plastic in municipal drinking water and wastewater treatment effluent. They provided overwhelming evidence that plastic pollution threatens the quality of drinking water and the maintenance of a sustainable consumable water system. On the same note, Fernández-Luqueño et al. (2010) suggest that a limited amount of wastewater should be used to avoid nightmare leaching and CO_2, CH_4 and N_2O emissions that can increase salt content in the soil, limiting crop growth. If wastewater is managed properly, microplastics can be prevented from entering the environment, particularly flowing from landfills (Alabi et al. 2019). Therefore, properly implementing WMA ensures that wastewater can be gainfully utilised to improve environmental and service delivery performance simultaneously.

According to Christ and Burritt (2017), recycling wastewater can improve water security by alleviating water shortages in local governments. Meneses-Jácome and Ruiz-Colorado (2021) analysed the ecologically based life cycle assessment for biological wastewater treatments to confirm the economic importance of wastewater by focusing on energy recovery goals. They recommend that smart

technology is vital for water treatment organisations to benefit from biogas and sludge's environmental and economic potential and promote them as sustainable energy sources. Similarly, whilst treating wastewater, it has been noted that energy from biomass can be easily recovered, which could alleviate electricity shortages (Nguyen et al. 2021). Innovation and technology have become the key to successfully implementing wastewater management strategies. According to Poudyal et al. (2019), new technology has led to the introduction of sustainable ways of treating wastewater called Microbial Fuel Cell (MFC) that offers many advantages, including high energy conservation, onsite electricity generation and low level of gas treatment. These benefits stemming from wastewater recycling go a long way toward improving environmental performance and service delivery through improved water and sanitation services. This further proves that WMA is an important tool in ensuring enhanced service delivery performance in the local governments, as wastewater can be optimised and managed properly to avoid environmental catastrophes leading to diseases and poor water quality.

Consequently, the proposition to support the above arguments is as follows:

Proposition Pa6 *There is an association between water management accounting and service delivery performance in local governments of developing countries.*

4.1.4 Carbon management accounting

Changes in the climate landscape characterised by a surge in global temperatures and increased frequency of harsh weather are attributed to increasing GHG emissions (Zhao et al. 2022; Nilsson et al. 2021). This led to the popularity of carbon management accounting (CMA). CMA is one of the EMAPs designed to provide data and information concerning GHG emissions (Nartey 2021) for improved implementation of carbon-free strategies. Therefore, by adopting CMA, organisations can quantify the impacts of their business activities through GHG emissions and climate change (Christ and Burritt 2017). Similarly, the application and adoption of CMA ensure the reduction of CO_2, which degrades the environment (Gunarathne et al. 2022), which could lead to improved environmental performance. Because CMA presents the organisation with opportunities to gather data and information on GHG emissions, environmentally sensitive decisions can be easily made based on gathered scientific evidence resulting in better environmental performance.

In support of the link between CMA as an EMAP and environmental performance, scholars worldwide explored various strategies for managing carbon emissions. Qian et al. (2018b) investigated the relationship between EMA and carbon management and disclosure quality. The study established that EMA has a significant effect on carbon management and disclosure quality resulting in an improved environmental performance. Yazdani et al. (2020) performed an energy analysis comparing two (2) power plants that use conventional natural gas steam power plants with one that burns municipal solid waste. They confirmed that generating electricity through burning waste rather than gas steam power improved the renewability and sustainability of the environment, as evidenced by reduced GHGs and consumption of fossil fuels. Setiawan and Iswati (2019) examined the relationship between Indonesia's environmental management system, environmental performance, and carbon emissions disclosure. Evidence-based on the results suggests that carbon emissions did not significantly affect the environmental management system and leverage. On the other hand, a positive linkage existed between environmental performance and the disclosure of carbon emissions in the plantation industry.

Similarly, studies analysing the nexus between pollution control strategies and environmental performance continue to produce uncertain outcomes. Appannan et al. (2023) explored sustainable development strategies, EMA and environmental performance. They found that EMA mediates the impacts of pollution prevention and clean technology strategies. Based on the results, they recommend that organisations should adopt certain environmental management strategies to achieve better environmental performance. Likewise, Ali et al. (2023) used a questionnaire involving 308 Pakistan employees to establish the role of EMA and environmental proactivity in linking pollution prevention strategies to environmental sustainability as informed by the natural-resource–based view theory. The results prove that pollution control strategies spurred EMA usage, impacting environmental sustainability positively. In another study investigating the determinants of CMA in Ghana organisations, EMA and perceived environmental uncertainty influenced CMA adoption significantly (Nartey 2018), implying that the motives for implementing carbon reduction strategies are driven by pressures to improve environmental sustainability. Therefore, data-driven GHG reduction strategies have great potential to improve environmental performance, as observed in the literature (Nyakuwanika et al. 2021). Resultantly, the propositions to support the discussion above are formulated as follows:

Proposition Pc4 *GHG emissions reduction strategies lead to improved environmental performance in local governments of developing countries.*

Proposition Pa7 *There is an association between carbon management accounting and environmental performance in local governments of developing countries.*

Despite the environmental implications of CMA, as discussed above, local governments responsible for providing services tend to respond to various strategies for reducing GHG emissions. Carbon emissions are not only an issue of climate change. Their impacts on human health through creating water and air pollutants that endanger human life deserve unwavering attention. High volumes of air pollution present substantial financial challenges to national and local governments to clean the air pollutants that are harmful to humans (Dandotiya et al. 2019; Manisalidis et al. 2020). Therefore, clearing carbon from the atmosphere presents many benefits, as Shindell et al. (2018) quantified the localised health benefits of accelerated CO_2 emissions reductions and established that reducing GHG emissions is critical to people's health, as it can reduce the chances of premature deaths and other respiratory diseases. Therefore, CMA presents opportunities for organisations to explore various ways of managing carbon emissions to influence service delivery performance.

Proposition Pa8 *There is an association between carbon management accounting and service delivery performance in local governments of developing countries.*

4.1.5 Biodiversity accounting

The depletion of natural resources worldwide has led to more emphasis on accounting for green infrastructure for improved environmental accountability, management and transparency. The pressure to integrate natural capital into national accounts continues to mount (Edens and Hein 2013) and has led to the introduction of biodiversity accounting (BA), which is one of the components of ecosystem accounting. To ensure biodiverse and healthy ecosystems are maintained, ecosystem accounting has become an important practice that assists organisations in managing environmental performance by measuring the flow of services from the natural ecosystem into economic and human activity (Lai et al. 2018). To ensure natural capital is maintained, improved and effectively managed, various governments introduced the ecosystem accounting system that falls under the System of Environmental-Economic Accounting (SEEA) Ecosystem Accounting framework. The importance of the ecosystem in addressing urban development challenges is increasingly becoming recognised (King et al. 2022). Ecosystem accounting provides an integrated information set to guide ecosystem management and monitoring, and it accounts for ecosystem capital variations and takes note of the benefits generated from ecosystem services for people and the economy (Hein et al. 2015, 2020). BA is one of the EMAPs which has recently gained the attention of researchers in the areas of environmental management, and it mainly focuses on tracking, monitoring, recording and reporting on data and information on flora, fauna and ecosystems together with their inhabitants (Gunarathne et al. 2022). Therefore, biodiversity has become a major area of concern and interest in sustainability (Weir 2019) for improved ecosystem performance.

Hein et al. (2020) reviewed ecosystem accounting in the Netherlands and accepted that natural accounts are key to developing policies that influence emissions and the benefits of the ecosystem to human beings. Furthermore, Xie et al. (2015) evaluated the ecological importance based on GIS for environmental management in China. The study identified key ecological land maintaining ecological security and good environmental performance, including regional river systems, wetlands, nature reserves, forest parks and scenic spots. To ensure that biodiverse and healthy ecosystems are maintained, ecosystem accounting has become an important practice that assists organisations in managing EP by measuring the flow of services from the natural ecosystem into economic and social spaces (Lai et al. 2018). In the urban development context, the research emphasises implementing green infrastructure practices for better maintenance of natural ecosystems, which is a critical component of environmental management (Pauleit et al. 2019; Matsler et al. 2021). Therefore, accounting for all biodiversity-related activities is an important determinant of environmental performance. Hence, applying BA in local government may present opportunities to improve environmental and service delivery performance. To support these claims, the following propositions are suggested:

Proposition Pc5 *Sustainable biodiversity management influences environmental performance in local governments of developing countries.*

Proposition Pa9 *There is an association between biodiversity accounting and environmental performance in local governments of developing countries.*

Biodiversity and ecosystem services present many benefits to people ranging from water, food, water and air pollution reduction and other associated cultural beliefs (Nordman et al. 2018). Additionally, land appreciation, reduction in stormwater, flood risk reduction, reduction in suspended solids and air pollution, and reduction of GHG emissions (Kim and Song 2019; King and Shackleton 2020; Herrera-Navarrete et al. 2022) are some of the service delivery benefits associated with management of biodiversity in the urban areas. Green infrastructure

activities, such as reforestation, afforestation, and awareness programmes, improve the city's environmental performance (Zvobgo and Tsoka 2021) and have become common features in many areas worldwide. Wajim (2020) evaluated the impacts of deforestation on socioeconomic development and the environment in Nigeria using secondary data sources. Further, Campbell-Arvai (2019) suggests that biodiversity plays a key role in improving the quality of lives of residents by assisting in managing risks relating to temperature variations and flood flooding, hence adopting biodiversity accounting in local municipalities places creates value to vital urban diversity. Concerning the economic perspective, biodiversity activities can create so-called collar jobs (gardeners and maintenance workers), investment in economic welfare and poverty alleviation (King and Shackleton 2020) and noise mediation, shade provision and attraction of local and international tourists (Palliwoda et al. 2020). Therefore, understanding the flow of ecosystem services from various urban ecosystems and asset help city planners to deliver sustainable urban development that presents optimal benefits from nature in the forms of heat mitigation, water and soil conservation, recreational services, employment creation and boosting economic growth (King et al. 2022). Consequently, it is argued in the discussion above that the maintenance and development of biodiversity components help to improve service delivery performance.

Therefore, further content and association propositions are suggested.

Proposition Pa10 *There is an association between biodiversity accounting and service delivery performance in local governments of developing countries.*

Table 1 Summary of propositions

Propositions	Propositions description
Content propositions	
Pc1	Migration to renewable energy sources improves environmental performance by reducing GHG emissions in local governments of developing countries
Pc2	Sustainable management of solid water materials plays a key role in enhancing environmental performance in local governments of developing countries
Pc3	Sustainable water management is key to enhancing environmental performance in local governments of developing countries
Pc4	Reducing GHG emissions leads to improved environmental performance in local governments of developing countries
Pc5	The management of biodiversity influences environmental performance in local governments of developing countries
Association propositions	
Pa1	There is an association between the use of energy accounting and environmental performance in local governments of developing countries
Pa2	There is an association between energy accounting and service delivery performance in local governments of developing countries
Pa3	There is an association between material flow cost accounting and environmental performance in local governments of developing countries
Pa4	There is an association between material flow cost accounting and service delivery performance in local governments of developing countries
Pa5	There is an association between water management accounting and environmental performance in local governments of developing countries
Pa6	There is an association between water management accounting and service delivery performance in local governments of developing countries
Pa7	There is an association between carbon management accounting and environmental performance in local governments of developing countries
Pa8	There is an association between carbon management accounting and service delivery performance in local governments of developing countries
Pa9	There is an association between biodiversity accounting and environmental performance in local governments of developing countries
Pa10	There is an association between biodiversity accounting and service delivery performance in governments of developing countries
General propositions	
Pg1	Adopting EMAPs, such as energy accounting, material flow cost accounting, water management accounting, carbon management accounting and biodiversity accounting, in environmental and service delivery management strategies is key to achieving sustainable development in local governments

A summary of the three (3) types of propositions around the management of environmental factors for improved service delivery performance in the local governments is shown in Table 1.

Based on the literature synthesis that established the link between EMAPs, environmental and service delivery performance within local government, the developing conceptual framework for managing environmental factors for improved services is presented in Fig. 2.

5 Discussion of the findings

The research evaluated the critical EMAPs that influence environmental and service delivery performance in local governments. The discussion is guided by the content and association propositions indicated in the conceptual framework in Fig. 2. The framework depicts the interrelationship between EMAPs, environmental performance and service delivery. The conceptual framework will guide local governments in employing EMAPs to enhance environmental and service delivery performance.

The research question, "How can environmental management accounting practices improve environmental and service delivery performance in local governments of developing countries?" has been answered through the SLR and the developing framework.

- The role of energy accounting on environmental and service delivery performance

Energy accounting (EA) is one of the EMAPs that assists in managing energy crises and usage across the globe (Gunarathne et al. 2022). Since EA allows organisations to gather and track data on energy usage and savings, an organisation should work around the clock to implement various strategies of energy generation that have less impact on the environment (Moriarty and Honnery 2019). Nyakuwanika et al. (2021) agree that EA is connected with environmental performance. On the same note, energy demand has led to the excessive use of fossil fuels, which are not a friendly environment. Organisations can make wise environmental decisions based on information and data by implementing proper energy accounting systems. The availability of information and data concerning the actual energy budget and tracking the actual energy cost against the budget provides organisations with various options to generate energy and improve energy efficiency (Nyide 2019). Therefore, adopting EA in various organisations has led to innovative techniques and technologies that improve energy efficiency within the supply chain (Moriarty and Honnery 2019; Nyakuwanika et al. 2021).

Research furthermore established that using renewable energy sources such as wind, solar, biomass, and hydroelectric is a response to the increased call for reducing GHG

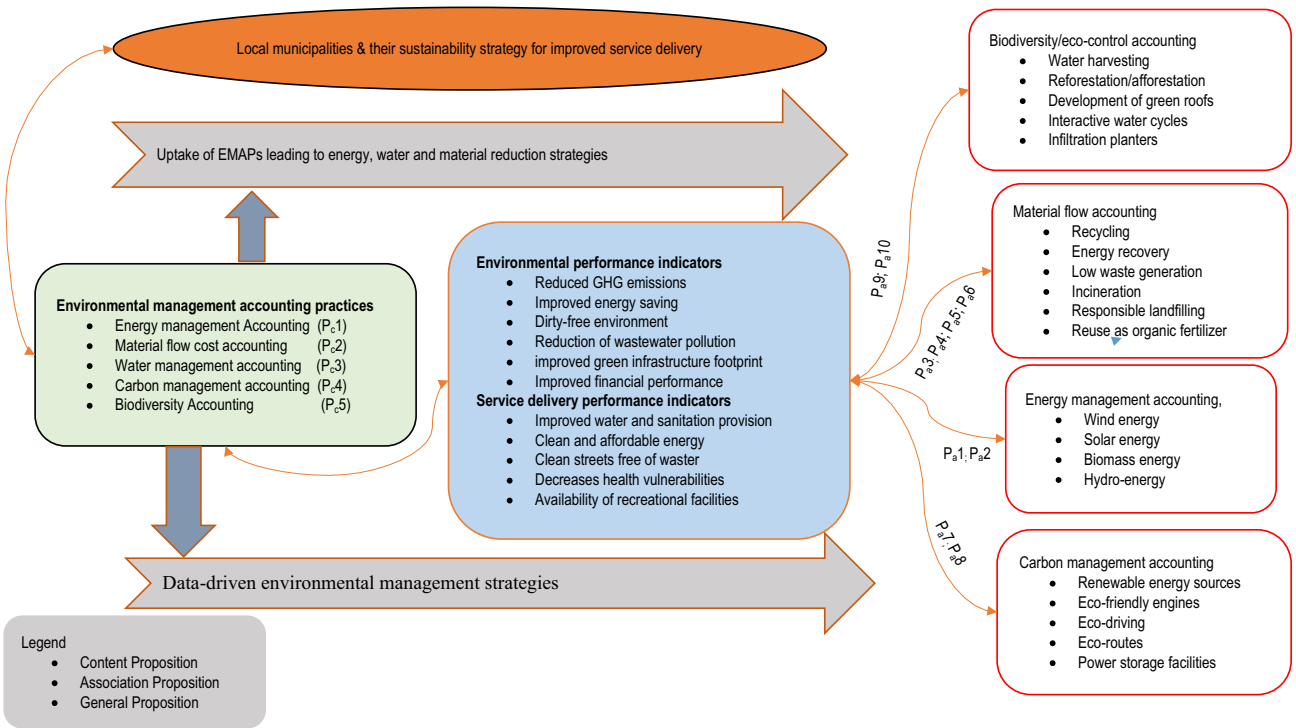

Fig. 2 Conceptual framework for employing EMAPS for improved environmental and service delivery performance

emissions (Poudyal et al. 2019; Janiszewska and Ossowska 2020). Given the excessive use of renewable energy in local governments, many benefits can accrue in the form of affordable energy (Khan et al. 2020) and a reduction in respiratory ailments (Taghizadeh-Hesary and Yoshino 2020). EA is linked to improved energy efficiency, reducing GHG emissions and saving money (Colombo et al. 2013). This implies that if EA is implemented, health services and the energy supply in local governments may improve beyond a reasonable doubt. Besides, EA has allowed the expansion of the green economy, creating jobs and meeting the high energy demand (Taghizadeh-Hesary and Yoshino 2020). If properly implemented, EA may assist governments in containing increasing carbon emissions and reducing fossil usage, resulting in enhanced environmental performance. Similarly, energy is a component of service delivery. EA may help local governments account for the flow of energy usage and be able to provide sufficient budgets to ensure seamless energy provision.

- The role of material flow cost accounting on environmental and service delivery performance

MFCA is one of the most common EMAPs that assist organisations in monitoring, controlling and evaluating the flow of raw material and waste within the production chain (Fakoya and Imuezerua 2021). Therefore, the introduction of MFCA brought a paradigm shift in handling waste, reusing waste and accounting for the cost of waste (Debnath 2014). Furthermore, if waste is not carefully handled, it can lead to environmental hazards, creating adverse effects on the ecosystem (Poudyal et al. 2019). Waste is one of the polluters of the natural environment. It should be decreased at all costs to prevent further environmental damage. Hence, MFCA has been confirmed in various studies as a practice to improve efficiency in material usage, resulting in reduced waste (Hakimi et al. 2021; van der Poll 2022; Doorasamy 2015). MFCA promotes some measures to improve efficiency in used material, water and energy for improved environmental performance (Nyakuwanika et al. 2021).

Similarly, adopting MFCA promotes sustainable practices such as recycling, energy recovery from waste, low waste generation strategies, and environmentally friendly landfilling and incineration (Poudyal et al. 2019). By implementing MFCA, organisations can increase the potential for resource optimisation by eliminating non-essential material and energy in the production chain leading to cost reduction. In the context of local governments, MFCA can potentially improve service delivery through affordable energy and water. According to Fakoya and Imuezerua (2021), it is clear that failure to implement MFCA in the purification of water resulted in water losses and inaccurate water cost capturing. Recycling waste can significantly contribute to the socioeconomic spheres, leading to better lives (Liu et al. 2017; Ncube et al. 2021). Therefore, MFCA could clearly influence material usage, reducing waste materials that could cause environmental damage. Ultimately, the assertion regarding the association between MFCA and environmental and service delivery performance is confirmed.

- The role of water management accounting on environmental and service delivery performance?

WMA continues to create relevance in the service delivery and environmental performance debate. The emergence of WMA was driven by the need to save water sources from depletion and pollution (Imtiaz Ferdous et al. 2019). The implementation of water management accounting by the organisation is an important step in ensuring that data on water purification, usage, supply and demand are captured to ensure demand and supply match. As indicated in the literature, WMA is vital as it presents opportunities for the organisation to handle the disposal, handling and reusing of wastewater cost-effectively. According to Yaqoob et al. (2021), inappropriate handling of wastewater can lead to environmental catastrophes, particularly when harmful pollutants end up in water sources. The flow of wastewater is the most critical aspect of water management; inappropriate handling of used water can harm the environment (Yaqoob et al. 2021).

Furthermore, water with chemicals from manufacturing organisations and human waste can pollute water sources, resulting in water-borne diseases (Alabi et al. 2019). Henceforth, it is clear that water management strategies such as recycling, wastewater as fertilisers and energy generation can significantly impact the environment. Also, it should be noted that recycled water can augment water shortage, resulting in improved water access by the populace. Therefore, wastewater management strategies driven by effective WMA provide a sustainable solution to water service delivery challenges prevailing mostly in developing countries. Lastly, it can be deduced that WMA is an effective EMAP that local governments can use to determine the real cost structure of water delivery. The fact that water authorities can accurately determine all costs associated with the provision, from water harvesting and storage to the water consumption stage, helps ensure that the right quantity and quality of water is provided. Simultaneously, spillage and leaks within the water supply chain could be traced quickly.

- The role of carbon management accounting is to improve environmental and service delivery performance

The findings established that CMA is an effective EMAP to assist organisations in managing carbon emissions (Nyakuwanika et al. 2021; Gunarathne et al. 2022). The

application of CMA ensures that environmental performance is enhanced through the reduction of GHG emissions, and this has been confirmed by (Christ and Burritt 2017; Setiawan and Iswati 2019). According to the findings from the literature review, data and information on GHG emissions assist organisations in making pro-environment decisions (Gunarathne et al. 2022; Christ and Burritt 2017). Additionally, the positive relationship between CMA and environmental performance has been confirmed in various studies (Setiawan and Iswati 2019; Nartey 2018). Despite improvement in environmental performance, excessive carbon emissions lead to health problems, as people exposed to GHG emissions may suffer from various diseases (Shindell et al. 2018; Manisalidis et al. 2020). Therefore, this confirms that CMA has the potential to bring substantial changes to GHG emissions that cause climate changes which are blamed for causing air pollution and inducing weather changes related to risks such as floods and tornados. In the context of service delivery performance, CMA may assist local authorities to account for their carbon footprint within their areas of jurisdiction to reduce air pollution threatening human lives. Gathering enough data and information on carbon emissions could assist in finding greener approaches to providing services, such as using electric vehicles and avoiding fossil fuel-powered engines where possible. The climate change-induced risks destroy critical service delivery infrastructure, mostly resulting in service cut-offs and compromising service quality. Therefore, the association between CMA and environmental and service delivery performance is confirmed, and efforts to reduce GHG emissions are imperative to developing sustainable cities.

- The role of biodiversity accounting on environmental and service delivery performance

Biodiversity resembles the natural environment, threatened by excessive use of material, energy and water. Therefore, to save the natural environment from further deterioration, ecosystem accounting, as guided by the United Nations SEEA EN framework, recognises various ecosystem activities (King et al. 2022), with biodiversity accounting (BA) being singled out as an integral EMAP (Gunarathne et al. 2022) that integrate natural capital into environmental management planning to reverse environmental damage. BA is amongst EMAPs that aim to take account of biodiversity and other forms of green infrastructures within the setting of the natural environment (Gunarathne and Lee 2020). BA can lead to better environmental performance in various ways. Biodiversity accounting, an extension of ecosystem accounting that feeds into national accounts, is a key influencer in the decision to develop environmental management policies that affect air pollution and interaction between ecosystems and human beings (Hein et al. 2020). By gathering data on natural capital accounts, organisations can make evidence-based environmental decisions that are integral to ecological security and good environmental performance (Xie et al. 2015). As established by various studies, biodiversity projects benefit communities and local governments and improve service delivery. Kim and Song (2019) note that biodiversity projects can reduce GHG emissions that cause harmful air pollution. King and Shackleton (2020) utilised questionnaires and interviews to analyse the impacts of maintenance of public and private urban green infrastructure and socioeconomic well-being in Eastern Cape towns in South Africa. The findings established that developing green infrastructure is associated with a numeracy of social, environmental and economic benefits through ecosystem services' direct and indirect use.

Further, green projects create green-collar jobs and reduce poverty in the communities. Besides, other benefits like creational parks and the attraction of international tourists (Palliwoda et al. 2020) benefit local economic development. Therefore, through the effective implementation of BA, local governments increase their potential to conserve the natural environment and improve service delivery, leading to improved residents' quality of life, and councils disclose biodiversity-related information (Gaia and Jones 2020). This answers the question about EMA's influence on local governments' environmental and service delivery performance and further affirms the association between the BA and environmental performance.

6 Conclusion and future research

Persistent fluctuations in climate change brought a paradigm shift in dealing with environmental sustainability challenges, as a few organisations have long started adopting EMA. The narrative around EMAPs is dominant in private sector business in developing countries, with less attention given to the public sector. Although the impact of EMAPs on environmental performance has gained prominence in sustainable development debates, its uptake in the local governments in developing countries remains a bone of contention. Therefore, the study evaluated the role of EMAPs on environmental and service delivery performance by systematically reviewing literature applicable to developing countries. However, the novelty of this article lies in two (2) main assumptions. Firstly, implementing EMAPs can directly influence environmental performance through reduced water, energy and material consumption that are viewed as propellers of GHG emissions. Secondly, EMAPs impact service delivery performance in the local governments through reduced air pollution, provision of clean water, affordable energy from renewable energy projects, and employment creation, leading to increased income and

increased potential for municipalities to generate revenue through energy recovery and recycling projects. This article further made ideological advances in understanding convectional and linking modern EMAPs and their impacts on environmental and service delivery performance.

According to the literature, adopting various EMAPs such as MFCA, WMA, CMA, and BA has positively impacted energy, waste and water reduction, reducing GHG emissions, indiscriminate dumping and wastewater. Additionally, due to EMA, organisations have been encouraged to improvise multifaceted approaches of increasing energy efficiency, reducing water and material consumption, optimising solid waste and wastewater, reducing carbon emissions using renewable energy, and recovering material and energy through recycling. Through implementing EMAPs, local governments can provide a twin solution to service delivery and environmental sustainability challenges.

Given the SLR review findings regarding EMAPs, the research proposed a few suggestions. We believe the South African government introduced natural capital accounts (NCA) and valuation of ecosystem services guided by the SEEA EA framework, and it is linked to a system of national accounts. However, the current framework for NCA is comprehensive enough to take account of a wide range of natural capital, and therefore, considering increasing the capacity and mobilising resources ensures that data on the natural ecosystem is gathered for improved decisions on finding integrated solutions to environmental challenges and service delivery challenges are made, simultaneously. Furthermore, city planners should prioritise value creation by ensuring a seamless flow of ecosystem services from the natural assets to the users and be able to quantify the monetary value of ecosystem services. We motivate that urban ecosystem accounting be added to EMAPs since local governments worldwide are incorporating it and it fits the definition of an EMAP. Environmental policies and regulations are not fully complied with, as expected, and hence, enforcing conformity and compliance might cultivate positive environmental attitudes amongst various stakeholders. We observed that an environmental awareness programme could provide an integrated approach to confronting sustainability challenges. Coordination in implementing EMAPs is a major concern in reaching environmental management maturity. Therefore, we recommend that using domain-based applications of EMAPs can go a long way to achieve environmental sanity. Lastly, significant investment in developing green and climate-resistant infrastructure might address the impacts of climate change-induced risk on municipal infrastructure for improved service delivery performance.

We observed that the quality of basic services provided by local governments could be improved by implementing various EMAPs to assist in managing the environment. The article develops an integrated conceptual framework (Fig. 2) as informed by three (3) types of propositions: content, associations, and general. The SLR led to the development of propositions instrumental for the researchers to develop a conceptual framework that simultaneously addresses environmental and service delivery challenges.

The journey towards achieving Sustainable Development Goals (SDGs) is an ongoing exercise, and therefore, future research should be driven by the need to empirically test the relationship between EMAPs and service delivery performance and confirm the contribution made by this research. Also, further research fosters studying accounting approaches from higher-income countries as benchmarks for future development of ecosystem accounting to assist local governments in managing environmental challenges.

Appendix

Critical EMAPs influencing environmental performance and service deliver

	Title	Authors	Environmental management strategy	EMAPs	Region	Approach
1	The mediating effect of environmental management accounting on green innovation—firm value relationship	Agustia et al. (2019)	Green innovation	CMA/EA	Indonesia	Interview

	Title	Authors	Environmental management strategy	EMAPs	Region	Approach
2	Impact of pollution prevention strategies on environment sustainability: role of environmental. management accounting and environmental proactivity	Ali et al. (2023)	Pollution control	CMA/EA	Pakistan	Questionnaire survey
3	Promoting sustainable development through strategies, environmental management accounting and environmental performance	Appannan et al. (2023)	Pollution control/clean technology	CMA/EA	Malaysia	Questionnaire
4	Water management accounting: a framework for corporate practice	Christ and Burritt (2017)	Water surpluses and water management opportunities	WMA	Not defined	Literature review
5	The relationship of environmental management accounting, environmental strategy and managerial commitment with environmental performance and economic performance	Christine et al. (2019)	Carbon emanations, environmental management	MFCA/eco-control/	Indonesia	Questionnaire
6	Environmental management accounting and innovation in water and energy reduction	da Rosa et al. (2020)	Green innovation	CMA/MFCA	Brazil	Content analysis
7	Expanding environmental management accounting: an experimental construct to integrate material wastes and emission flows	Debnath (2014)	Reduction in GHG emission Green management	CMA/MFCA	Not defined	Experimental construct
8	Municipal solid waste management in South Africa: from waste-to-energy recovery through waste-to-energy technologies in Johannesburg	Dlamini et al. (2019)	Solid waste management Waste to energy technologies	MFCA EA	South Africa	Literature review
9	Theoretical developments in environmental management accounting and the role and importance of MFCA	Doorasamy (2015)	Cleaner production, reduction of non-product output (waste) to Cleaner production, reduction of waste	MFCA	South Africa	Questionnaire and LR
10	The perceptions of management on the benefits of adopting an environmental management accounting system as a waste management tool	Doorasamy (2016)	Cleaner production, waste management	MFCA	South Africa	Questionnaire and interview

	Title	Authors	Environmental management strategy	EMAPs	Region	Approach
11	Towards a consistent approach for ecosystem accounting. Ecological Economics 90: 41–52. https://doi.org/https://doi.org/10.1016/j.ecolecon.2013.03.003	Edens and Hein (2013)	Ecosystem services	Ecosystem accounting/biodiversity	Not defined	Literature review
12	Improving water pricing decisions through material flow cost accounting model: a case study of the Politsi Water Treatment Scheme in South Africa	Fakoya and Imuezerua (2021)	Reduction of water loss and water purification costs	MFCA	South Africa	Interviews
13	The role of renewable energy in the global energy transformation	Gielen, Boshell, Saygin, Bazilian, Wagner, Gorini	Renewable energy	EA	Not defined	Quantitative
14	The role of renewable energy in the global energy transformation'	Gielen et al. (2019)	Renewable energy, energy efficiency	EA/CMA	Not defined	Content analysis/secondary data
15	The link between corporate energy management and environmental strategy implementation: efficiency, energy information management	Gunarathne and Lee (2021)	Energy efficiency Energy information Energy management Environmental strategies	EA	Sri Lanka	Interviews, observations, field visits, and document analysis
16	Solid waste management in China: policy and driving factors in 2004–2019: solid waste management is deeply influenced by economic and social indicators	Guo et al. (2021)	Solid waste Waste management Energy consumption reduction Carbon reduction	MFCA/CMA/EN	China	Content analysis
17	Increasing energy and material consumption efficiency by application of material and energy flow cost accounting system (case study: turbine blade production)	Hakimi et al. (2021)	Material and energy accounting	MFCA	Iran	Application/scenario
18	Examining the impact of Environmental Management Accounting practices and green transformational leadership on corporate environmental performance; the mediating role of green process innovation	Hanif et al. (2023)	Green transformational leadership Green process innovation	CMA/MFCA	Iran	Questionnaire

	Title	Authors	Environmental management strategy	EMAPs	Region	Approach
19	Progress and challenges in the development of ecosystem accounting as a tool to analyse ecosystem capital. Current Opinion in Environmental Sustainability	Hein et al. (2015)	Ecosystem services	Biodiversity/	Netherlands	
20	Ecosystem accounting in the Netherlands. Ecosystem Services	Hein et al. (2020)	Ecosystem services	Biodiversity/ecosystem accounting	Netherlands	Application-scenarios
21	Municipal wastewater treatment plants: gap, challenges, and opportunities in environmental management	Herrera-Navarrete et al. (2022)	Wastewater management	WMA	Mexico	quantitative
22	Plastics in municipal drinking water and wastewater treatment plant effluents: challenges and opportunities for South Africa—a review	Iroegbu et al. (2020)	Innovative waste management systems, inclusive independent monitoring of plastic wastes Wastewater treatment plants	MFCA/WMA	South Africa	Literature review
23	Factors affecting firm's energy efficiency and environmental performance: the role of environmental management accounting, green innovation and environmental proactivity	Jermsittiparsert et al. (2020)	Green innovation/ energy efficiency	MFCA/EN/CMA	Thailand	Questionnaire
24	Business sustainability for competitive advantage: identifying the role of green intellectual capital, environmental management accounting and energy efficiency	Jiao et al. (2023)	Green intellectual capital Energy efficiency	EA	China	Content analysis
25	Efficiency of municipal solid waste management service delivery system and policy issues in Debre Markos, North Western Ethiopia	Kebede et al. (2019)	Solid waste management	MFCA/EA	Ethiopia	Focus groups
26	Measuring the impact of renewable energy, public health expenditure, logistics, and environmental performance on sustainable economic growth'	Khan et al. (2020)	Renewable energy	EA/CMA	Southeast Asian Nation	Content analysis

	Title	Authors	Environmental management strategy	EMAPs	Region	Approach
27	'Maintenance of public and private urban green infrastructure provides significant employment in Eastern Cape towns, South Africa	King and Shackleton (2020)	Urban green infrastructure	Biodiversity accounting	South Africa	Questionnaires and interviews
28	Implementation of environmental management accounting and energy efficiency for green economy achievements in the textile industry in Indonesia	Kumalawati et al. (2023)	Green efficiency	CMA	Indonesia	Questionnaire
29	The effect of environmental management practice on firm performance: an Indonesian study	Kurniawati and Dianawati (2020)	Efficiency of water usage, and efficiency of energy usage	EA/WMA	Indonesia	Content analysis
30	The environmental accounting strategy and waste management to achieve MSME's sustainability performance	Latifah and Soewarno (2023)	Waste management	MFCA	Indonesia	Questionnaire
31	Environmental management accounting and performance efficiency in the Vietnamese construction material industry—a managerial implication for sustainable development	Le et al. (2019)	Reducing environmental pollution	MFCA	Vietnam	Questionnaires
32	Environmental performance evaluation of different municipal solid waste management scenarios in China	Liu et al. (2017)	Waste reduction, stabilization, material recovery, energy recovery, and greenhouse gas (GHG) reductions	MFCA/EA/CMA	China	Application-scenarios
33	A 'green' chameleon: exploring the many disciplinary definitions, goals, and forms of "green infrastructure"	Matsler et al. (2021)	Green infrastructure	Biodiversity accounting	Not specified	Literature review
34	An information framework for facilitating cost saving of environmental impacts in the coal mining industry in South Africa	Mbedzi et al. (2020)	increased transparency of material usage	MFCA	South Africa	LR
35	A new approach of ecologically based life cycle assessment for biological wastewater treatments focused on energy recovery goals	Meneses-Jácome and Ruiz-Colorado (2021)	Waste water management Bioenergy recovery	WMA/EA/MFCA	Colombia	Application/scenario

	Title	Authors	Environmental management strategy	EMAPs	Region	Approach
36	Energy accounting for a renewable energy future	Moriarty and Honnery (2019)	Renewable energy	EA	Australia	Literature review
37	A study of short-lived climate pollutants associated with solid waste management activities in Accra'	Nartey (2021)	Solid waste management	MFCA	Ghana	Content analysis
38	Determinants of carbon management accounting adoption in Ghanaian firms'	Nartey (2018)	GHG emission reduction	CMA	Ghana	Questionnaire survey
39	Benefit–cost analysis of stormwater green infrastructure practices for Grand Rapids, Michigan, USA	Nordman et al. (2018)	Green infrastructure	Biodiversity	USA	Quantitative
40	Influence of environmental management accounting practices on the environmental sustainability of South African cement and mining companies	Nyahuna and Swanepoel (2022)	Water consumption and recycled water	WMA	South Africa	Content analysis
41	A conceptual framework for greener goldmining through environmental management accounting practices (EMAPs): the case of Zimbabwe	Nyakuwanika et al. (2021)	Reduction of water, energy and material usage	MFCA	South Africa	Qualitative systematic review
42	Better resource management: a qualitative investigation of Environmental Management Accounting practices used by the South African hotel sector	Nyide (2019)	Technologies to allocate environmental costs, tracing and recording the flow of water and energy	MFCA	South Africa	Interview
43	Mitigating the current energy crisis in Nepal with renewable energy sources	Poudyal et al. (2019)	Renewable energy	EA/CMA	Nepal	Literature
44	Environmental management accounting in local government: a case of waste management. Accounting	Qian et al. (2011)	Waste and recycling	MFCA	Australia	Qualitative
45	Environmental management accounting in local government: functional and institutional imperatives	Qian et al. (2018a)	Waste and recycling management	MFCA	Australia	Qualitative
46	Environmental management accounting and its effects on carbon management and disclosure quality	Qian et al. (2018b)	Carbon disclosure	CMA	US, German, Australia and Japan	Qualitative

	Title	Authors	Environmental management strategy	EMAPs	Region	Approach
47	Application of ABB in environmental management accounting: incorporating MFCA into the budget process	Qu et al. (2022)	Managing material flow, reducing inefficiencies	MFCA	China	Application
48	. Monetary accounting of ecosystem services: a test case for Limburg province, the Netherlands	Remme et al. (2015)	Ecosystem services	Biodiversity/ecosystem accounting	Netherlands	Quantitative
49	Municipal solid waste management: analysing the principles of the Brazilian National Solid Waste Policy	Santana et al. (2022)	municipal solid waste (MSW) management	MFCA	Brazil	Content analysis
50	Eco-efficiency and energy audit to improve environmental performance: an empirical study of hotels in Bali-Indonesia	Saputra et al. (2022)	Eco-efficiency and energy audits	EA	Indonesia	Questionnaire
51	Sustainable solid waste management in developing countries: a study of institutional strengthening for solid waste management in Johannesburg, South Africa:	Serge Kubanza and Simatele (2020)	Solid waste management	MFCA	South Africa	Semi-structured interviews/secondary data
52	Carbon emissions disclosure, environmental management system, and environmental performance: evidence from the plantation industries in Indonesia'	Setiawan and Iswati (2019)	Carbon emission disclosure	CMA	Indonesia	Content analysis
53	'Impacts of deforestation on socio-economic development and environment in Nigeria'	Wajim (2020)	Forestation management	Biodiversity	Nigeria	Content analysis
54	Spatial evaluation of the ecological importance based on GIS for environmental management: a case study in Xingguo county of China	Xie et al. (2015)	water security, biodiversity conservation, disaster avoidance and protection	Biodiversity accounting	China	Quantitative
55	Agricultural waste recycling optimization of family farms based on environmental management accounting in rural China	Yang et al. (2021)	Agricultural-waste-recycling	MFCA	China	Application/scenario

	Title	Authors	Environmental management strategy	EMAPs	Region	Approach
56	A glimpse into the microbial fuel cells for wastewater treatment with energy generation	Yaqoob et al. (2021)	Wastewater Waste material	MFCA/WMA	Malaysia	Application-scenarios
57	A comparison between a natural gas power plant and a municipal solid waste incineration power plant based on an energy analysis	Yazdani et al. (2020)	Municipal solid waste management	MFCA/CMA	Iran	Energy
58	MFCA extension from a circular economy perspective: model modifications and case study	Zhou et al. (2017)	Conservation of resources/energy	MFCA	China	Observation

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