A thesis submitted to the Department of Environmental Sciences and Policy of Central European University CEU PU in part fulfilment of the Degree of Master of Science

Through the Eyes of Locals: An exploration of the outcomes, factors, and tools for effective collection and utilization of qualitative community-based monitoring data in the Kruger to Canyons Biosphere Region, South Africa

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June, 2024

Vienna

Erasmus Mundus Masters Course in Environmental Sciences, Policy and Management

MESPOM

This thesis is submitted in fulfilment of the Master of Science degree awarded as a result of successful completion of the Erasmus Mundus Masters course in Environmental Sciences, Policy and Management (MESPOM) jointly operated by the University of the Aegean (Greece), Central European University CEU PU (Austria), Lund University (Sweden) and the University of Manchester (United Kingdom).

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Wong, J. 2024. *Through the Eyes of Locals: An exploration of the outcomes, factors, and tools for effective collection and utilization of qualitative community-based monitoring data in the Kruger to Canyons Biosphere Region, South Africa.* Master of Science thesis, Central European University CEU PU, Vienna.

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ABSTRACT OF THESIS submitted by:

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Through the Eyes of Locals: An exploration of the outcomes, factors, and tools for effective collection and utilization of qualitative community-based monitoring data in the Kruger to Canyons Biosphere Region, South Africa.

Month and Year of submission: June, 2024.

Community-based monitoring (CBM) has emerged as an ideal alternative to conventional scientific monitoring programs, due to its community empowering potential and proven ability to produce quality data across time and geographical scales at low cost. However, most research was based in developed contexts or were primarily concerned with quantitative data, contrasting the reported prevalence of CBM programs in developing contexts that typically collect some form of qualitative CBM data. Hence, by employing semi-structured interviews, this research aims to add to the sparse literature on qualitative CBM data in developing contexts, whilst also responding to a request by the Kruger to Canyons Biosphere Region Non-Profit Company (K2C-NPC) to improve their qualitative CBM data analysis capabilities. Thematic analysis yielded two main findings: (1) CBM participants experienced improvements in personal, community, and management aspects through working with qualitative CBM data, and (2) seven factors were found to be both enabling and inhibiting the effective collection and utilization of qualitative CBM data. These findings can guide CBM practitioners in program design, implementation, and evaluation. Additionally, a preliminary data analysis and transformation (DAT) tool, utilizing Microsoft Excel and RStudio, was proposed to improve K2C-NPC's data analytical capabilities. This tool serves as a starting point for CBM researchers and practitioners to build upon. Overall, this thesis research provided clarity on the outcomes, factors, and tools for the effective collection and utilization of qualitative CBM data, hopefully inspiring researchers and practitioners to implement and sustain monitoring programs conducted through the eyes of locals.

Keywords: community-based monitoring, qualitative data, data analysis and transformation, Microsoft Excel, RStudio, Kruger to Canyons Biosphere Region, South Africa.

Acknowledgements

This thesis research would not have been possible without the unwavering support and guidance of my supervisor, Professor Brandon Anthony. His expert knowledge and extensive connections in South Africa paved the way for this research. Thank you for lending me your keen eye for detail and for always responding timeously with constructive inputs, which helped me avoid many errors; those that inevitably remain are entirely my responsibility.

My heartfelt gratitude goes to the managers and community science monitors at the Kruger to Canyons Biosphere Region Non-Profit Company for graciously supporting me throughout this research journey. Thank you for generously sharing your time with me; your insights and experiences have significantly shaped the direction and outcomes of this research.

Special thanks to Associate Professor Wayne Twine of the University of Witwatersrand and the staff at the Wits Rural Campus for their invaluable on-ground support and encouragement during my fieldwork in South Africa.

I would also like to thank Medhini Igoor for the enjoyable company throughout our 2-month fieldwork period, especially for taking time out of her own schedule to drive me to my fieldwork sites. Our stimulating academic discussions played a big role in shaping my thesis research, while our adventures in the area helped me maintain a healthy work life balance. Also, I extend a special thank you to Hanna Della Casa, Eleanor Watson, and Carla De Agostini for their constant well-being check-ins that kept me motivated during the writing period.

Finally, I am deeply grateful for my family, partner, and friends whose unceasing love, belief and understanding created a safe and supportive environment for me throughout life and this research journey. Thank you for taking care of me, even in the smallest of ways. Your reassurances gave me the strength to tide through the stress and complete this thesis.

The research supporting this thesis was fully sponsored by Central European University Foundation of Budapest (CEUBPF). The theses explained herein represent the ideas of the author, and do not necessarily reflect the views of CEUBPF.

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List of Abbreviations

MAB	Man and the Biosphere Programme
BR	Biosphere Reserves
CEU	Central European University
CCSMP	Community Citizen Science Monitors Project
CBM	Community-based monitoring
CSM	Community science monitor
DAT	Data analysis and transformation
GPS	Global Positioning System
K2C	Kruger to Canyons Biosphere Region
K2C-NPC	Kruger to Canyons Biosphere Region Non-Profit Company
PM	Program manager
RO[X]	Research objective [number]

1. Introduction

1.1 Background

Monitoring is a painful necessity – necessity, as monitoring elucidates evidence to inform decisions and check progress; painful, due to the suite of challenges that come with monitoring, including high costs, questionable sustainability, inadequate time and geographical scope of data, limited ability to feed into management decisions, and narrow consideration for other stakeholders (Danielsen, Burgess, and Balmford 2005). To temper this 'painfulness, several local-centric monitoring approaches have emerged. One such approach is community-based monitoring (CBM), which refers to the process in which parties "collaborate to monitor, track and respond to issues of common community concern" (Whitelaw et al. 2003, 410). CBM initiatives are primarily undertaken by community members, who are the main stakeholders of the monitored landscape, but may involve external support from researchers or formal organisations (Danielsen et al. 2022).

CBM has been touted as a reliable and cost-effective method to collect quality data that can be used timeously for management interventions at a municipal scale (Carvalho et al. 2009; Danielsen et al. 2014; 2021). Moreover, CBM has also proven adept at promoting community outcomes, such as building of local constituencies (Danielsen, Burgess, and Balmford 2005) and empowerment (Constantino et al. 2012). With such promising potential, it is no surprise that CBM initiatives have proliferated across the world (Muhamad Khair, Lee, and Mokhtar 2021). Consequently, CBM literature has burgeoned in the recent years, with most studies concentrated in North America and within the field of environmental science (Kouril, Furgal, and Whillans 2016). However, much of these CBM literature have focused on CBM initiatives that deal with quantitative data (e.g. counts, parameter measurements), leaving an academic research gap concerning CBM initiatives that work with qualitative data (e.g. photos, journal observations). Yet, many CBM initiatives, particularly those in developing contexts, collect some form of qualitative data (Abbot and Guijt 1998), whose methods and outcomes have remained under-studied. Moreover, this gap could imply a lack of tools, guiding frameworks and models for practitioners of qualitative CBM data to take reference from for the design, implementation, and data management stages (Gofman 2010), which could inhibit the meaningful translation of qualitative CBM data into actionable insights, stifling the usability of a potentially rich source of data.

Thus, I reduced this research gap by centering my thesis research around a CBM initiative in the Kruger to Canyons Biosphere Region (K2C) that primarily deals with qualitative data. Through a qualitative methodology, I explored the elements and outcomes of the Community Citizen Science Monitors Project (CCSMP), and situated lessons learnt with existing CBM literature. Additionally, I created a simple data analysis and transformation (DAT) tool, honouring an explicit request from the Kruger to Canyons Biosphere Region Non-Profit Company (K2C-NPC) to assist in the improvement of their monitoring efforts, that could be built upon and modified to suit the differing needs of CBM researchers and practitioners.

1.2 Research Question and Objectives

This thesis research is guided by a single overarching research question: *How can qualitative community-based monitoring data be useful for environmental monitoring in the Kruger to Canyons Biosphere Region?*

To answer the main research question, the following objectives will be sequentially fulfilled:

- **Research Objective 1 (RO1):** Explore the initial outcomes from the collection and utilization of qualitative CBM data in the K2C landscape from both the program managers' and community science monitors' perspectives.
- **Research Objective 2 (RO2):** Understand the factors that influence the effective collection and utilization of qualitative CBM data in the K2C landscape.
- **Research Objective 3 (RO3):** Propose a basic tool to ease analysis and transformation of qualitative CBM data, exemplified through application to K2C's existing CBM data.

Given the place-based nature of CBM initiatives, it is not intended for the findings of this thesis research to be generalizable for all CBM initiatives. However, it is intended for the findings to be a starting point to researchers and practitioners, both existing and potential, who are interested in or practicing CBM of a similar nature, or in comparable contexts.

1.3 Disposition of Thesis

This thesis is organized into six main chapters. In Chapter 1 (Introduction), the background of research topic, impetus for research scope, and research objectives are specified. Following that, Chapter 2 (Literature Review) delves into key concepts and case studies as found in existing literature, identifying research gaps that this thesis research aims to fill. Chapter 3

(Methodology) then describes the research design and details the case study and methodologies employed for data collection and analysis, while also addressing limitations and ethical considerations. Next, Chapter 4 (Results) presents the findings according to research objectives, while Chapter 5 (Discussion) compares findings with existing literature, discussing their implications, and highlighting theoretical and practical contributions of this thesis research. Finally, Chapter 6 (Conclusion) summarizes research findings with references to specific research objectives and the bigger picture, before recommending avenues for future research. Supporting these main chapters are Chapter 7 (References) and Chapter 8 (Appendix), that lists all sources cited and provides supplementary material respectively.

2. Literature Review

2.1 Community-Based Monitoring

CBM was first popularised by Bliss et al. (2001), who posited that CBM was an innovative and inclusive way to build knowledge in both the ecological and social dimensions within communities, upon which management decisions can be made. Along the same vein, a definition for CBM was proposed: the process in which parties "collaborate to monitor, track and respond to issues of common community concern" (Whitelaw et al. 2003, 410). Since then, much literature have cited this definition (Conrad and Daoust 2008; Kouril, Furgal, and Whillans 2016; Lam et al. 2019), signalling some kind of academic consensus, and catalysing the formal documentation of CBM programs around the globe, particularly in North America (Conrad and Daoust 2008; Conrad and Hilchey 2011; Pollock and Whitelaw 2005) and Europe (Gharesifard, Wehn, and Van Der Zaag 2019; Zabetta, Sacerdotti, and Mauro 2014; Bart et al. 2012), but also in Asia (Brofeldt et al. 2018; Garduño et al. 2009), Latin America (Oviedo and Bursztyn 2017; Stone et al. 2014), and Africa (Zabbey et al. 2021; Walker et al. 2016), and even in distant aboriginal communities within Canada (Gérin-Lajoie et al. 2018), Sweden (Herrmann et al. 2014), and Mexico (Ortega-Álvarez et al. 2018). However, such formal documentation is still disproportionately skewed towards developed contexts and formalized societies (Kouril, Furgal, and Whillans 2016), even though prevalence of CBM programs are reportedly higher in developing contexts and informal communities (McKay and Johnson 2017a; Wilson et al. 2018; Danielsen et al. 2009).

The global prevalence of CBM programs have been attributed to a variety of factors. Several authors have cited that government cutbacks have inhibited the scope of monitoring programs (Au et al. 2000; Whitelaw et al. 2003), pushing researchers to source alternative monitoring approaches (i.e. CBM); while other authors point to the growing concern that communities have in regard to their local environment (Bliss et al. 2001; Conrad and Hilchey 2011), spurring them to call for, initiate and participate in CBM programs. In similar veins, Vaughan et al. (2001) posited that majority of governmental monitoring programs remain inadequate in timeously delivering useful information for decision-making, as opposed to CBM programs that seamlessly connect data production with actionable consequences (Danielsen et al. 2005). Thus, governments are recognizing the need for the involvement of on-the-ground stakeholders in planning and managing sustainability-facing solutions (Cuthill 2000), which in turn increases the relevance of CBM approaches. Additionally, the development of affordable and simple

technologies that can effectively store, handle and analyse crowdsourced data have boosted the accessibility of CBM programs (Whitelaw et al. 2003).

2.1.1 Lexical uniqueness of CBM

As a term, CBM is closely related to concepts of participatory action research (Finn 1994), civic science (Lee 1993), community science (Carr 2004), and citizen science (Eitzel et al. 2017). Every term here describes a process that encourages public engagement and involvement in science, enhancing their role in decision-making that is contingent on collected data (Muhamad Khair, Lee, and Mokhtar 2021), albeit to varying degrees. Hence, each term still retains some distinction from each other. Although the focus of this research was not to argue for the lexical uniqueness of CBM, a brief comparison with 'citizen science', will be drawn to illustrate their subtle differences. CBM and citizen science have often been used interchangeably in literature (Conrad and Hilchey 2011; Andrachuk et al. 2019), however these two terms are quite different in terms of scale, types of participants involved, degree of participation, civic engagement, reason for emergence, and long-term impacts (Muhamad Khair, Lee, and Mokhtar 2021).

For instance, civic engagement is a mandatory component in CBM, meaning that communication with local stakeholders is not only initiated at early stages, but is sustained throughout the program (McKay and Johnson 2017b), such that trust is built for the collaborative resolution of local issues (Kruger and Shannon 2000). Contrarily, civic engagement is not a core feature in citizen science, due to its primary focus of involving a larger number of participants across geographic space, which inhibits meaningful physical engagement among each other and with researchers (Muhamad Khair, Lee, and Mokhtar 2021). Moreover, in citizen science, interaction is usually one-way, where participants only have to follow protocols, collect data and upload them onto online databases for researchers' access (Long and Azmi 2017). Another instance would be how the long-term impact of citizen science is expected to be an increase in participants' familiarity with science, whether it be in knowledge, skills, tools or affinity (Muhamad Khair, Lee, and Mokhtar 2021), which may then lead to future participation and commitment in other environmental stewardship activities (Bela et al. 2016). However, for CBM, the long-term impact is more action oriented (Shirk and Bonney 2015), such that community resilience and well-being can be achieved.

For extended discussions on CBM compared to other terms, Muhamad Khair, Lee, and Mokhtar (2021) offers further insights. Regardless, CBM is distinctly recognized for its emphasis on

community-driven impetus for producing environmental data (Pollock and Whitelaw 2005), and since communities (e.g. culture, landscape, governance) are different, CBM programs tend to be highly localized in nature.

2.1.2 Approaches to CBM

Though CBM initiatives are usually place-based and thus unique, there exists some similar characteristics between them. According to these similarities, Whitelaw et al. (2003) consolidated a 4-category scheme to differentiate between CBM approaches: (i) *government-led CBM*, which is designed for the pre-emptive detection of environmental changes that may require further scientific investigation, and usually culminates into long-term databases (Stadel and Nelson 1995); (ii) *interpretive CBM*, which stresses the educational aspect of monitoring through the provision of personal development opportunities to CBM participants, adding depth to their monitoring experiences and promoting their sustained commitment (Cuthill 2000); (iii) *advocacy monitoring*, in which citizens concerned about a specific issue, such as water security or human and safety, wield monitoring data to push for management actions (Lukasik 2000), in the absence of government or corporate support. Essentially, this approach highlights the dual achievement of improving environment quality and promoting action and advocacy (Sharpe, Savan, and Amott 2000); and (iv) *multiparty monitoring*, where all relevant stakeholders – from concerned citizens, private landowners, representatives of non-governmental organizations, corporates and governments – are engaged to share, discuss, and negotiate decisions to implement cooperative actions (Bliss et al. 2001). These approaches are not mutually exclusive and CBM initiatives may display traits from each.

In a different vein, Danielsen et al. (2009) proposed a five-spectrum classification of CBM approaches based on the level of engagement with community members and professional scientists. The lowest end of the spectrum is categorized by *externally driven and professionally executed monitoring*, in which all components from the design to data collection, analysis and interpretation are performed by external researchers. A step up would be *externally driven monitoring with local data collectors*, where local stakeholders are engaged in data collection on a voluntary or paid basis. In the middle of the spectrum lies *collaborative monitoring with external data interpretation*, in which local stakeholders not only collect data but may utilize such data in management decisions, however external researchers still take charge of the monitoring program design and data analysis. One step further would be *collaborative monitoring with local data interpretation*, where local stakeholders take over most components

of monitoring programs, including data collection, interpretation and analysis, and management decision-making, creating local ownership of the monitoring program, whilst external researchers only play an advisory or training role and may acquire copies of data for in-depth or cross-scale analysis. At the highest end of the spectrum is *autonomous local monitoring*, where the entire monitoring process, from the design to data collection and analysis, and to usage of data for management decisions, is executed autonomously by local stakeholders. Such programs are usually informally established or within traditional societies, and hence are rarely academically documented.

2.1.3 Outcomes of CBM

CBM has proven effective in filling data gaps that traditional science-based monitoring has been unable to fulfil. Casey, Zurawell, and Limnologists of Alberta (2016) explains that science-based data collection is typically sporadic in nature and can only span a limited number of habitats and ecosystems, whereas CBM offers more extensive coverage. This sentiment was exemplified in Alberta, where monitoring coverage of aquatic ecosystems significantly expanded when CBM was undertaken (Alberta Lake Management Society 2021), and in North America, where CBM enabled the monitoring of marsh bird and frog species over an extended time and geographical scale (Tozer 2020). Similarly, Walker et al. (2016) demonstrated how CBM provided reliable hydrometeorological data in northwest Ethiopia, where traditional science-based instruments have failed to provide accurate estimates or were simply non-existent, to improve the spatial and temporal characterisation of related parameters that feed into water resource assessments and management.

Researchers are not the only beneficiaries of CBM, local participants also gain by building their own capacities in environmental knowledge, literacy and skills (Institute for Global Environmental Strategies 2014). Gérin-Lajoie et al. (2018) detailed how CBM participation improved fieldwork skills of Canadian youth, enabling them to confidently engage in other scientific activities, while Trumbull et al. (2000) explored how CBM participation honed the scientific thinking acumen of amateur birdwatchers. Furthermore, McKay and Johnson (2017b) reported that CBM participants felt a deeper connection with the natural environment after building awareness on how their actions affect the environment, which promotes further engagement and conversations. This sentiment was echoed by (Overdevest, Orr, and Stepenuck 2004), who uncovered that the longer CBM volunteers participate in stream monitoring, the more likely they were to engage in discussions about water quality issues with their neighbours.

Other environmental stewardship behaviours arising from CBM participation have also been observed in Fiji (Coral Reef Alliance 2016) and Canada (Castleden 2015).

At a community level, CBM strengthens trust among stakeholders (Kusel et al. 2000), and increases harmony and cooperation within communities (Sultana and Abeyasekera 2008). This harmony builds social capital (Bliss et al. 2001), which can sustain stakeholder involvement and support (Schwartz 2006), and even open up alternative avenues of funding (Conrad and Daoust 2008). As documented by Becker et al. (2005), a CBM program in Ecuador increased social capital across scales, galvanising several community action for sustaining ecological tourism. In a similar vein, CBM can enhance local empowerment. By reviewing CBM systems in Brazil and Namibia, Constantino et al. (2012) showcased that the four dimensions of empowerment – psychological, social, economic and political – were realized across individual and community scales, albeit to different extents. They purported that simpler forms of empowerment (e.g. individual psychological and economic empowerment) were more easily achieved compared to more complex forms of empowerment (e.g. community political and social empowerment). Additionally, youth participants reported feeling empowered through their involvement in a CBM air quality program in Roxbury, Massachusetts, as they were recognized as local experts by government officials, media, and other community members (Loh et al. 2002).

This empowering potential of CBM can also be exemplified in instances where communities gain greater influence over management decisions concerning their own environments, contrasting with previous top-down decision-making approaches. Garda (2015) found that CBM watershed groups in Canada were able to provide input on the effectiveness of restoration projects, which were then used to determine priority areas for future educational programs and new restoration projects. Similarly, Loh et al. (2002) illustrated how CBM-collected data and community-recommended solutions were adopted in a city-sponsored study to reduce air pollution hotspots in Roxbury. Another case in point would be how, after roughly two years of running a CBM scheme, communities in Philippines were able to implement 156 conservation management actions over a million hectares of protected areas, with 90% of these interventions not needing external support and thus able to sustain at a local level (Danielsen et al. 2005). This CBM scheme also culminated in a reestablishment of indigenous zoning and resource use regulations, granting local communities more say in the management of their resources (Danielsen et al. 2005).

However, CBM programs may face several barriers in the pursuit of the above-mentioned outcomes. First, funding shortages plague most CBM programs (Mamun and Natcher 2023). Even though CBM may require lower costs compared to traditional science-based monitoring (Carvalho et al. 2009), CBM programs still require monetary resources to operate. Thus, the continued operations of CBM programs hinges on the presence of funding (Conrad and Daoust 2008), whether it be locally generated or externally provided. Singh et al. (2014) attributed a lack in funds to be the limiting factor for community-based moose monitoring projects, while Peters et al. (2016) shed light on how securing long-term funds remains a consistent challenge for CBM programs in New Zealand. In the worst case of a total cessation of funds, monitoring activities have been known to discontinue (Thompson, n.d.). Second, inadequate training of CBM participants may induce doubts into the quality of collected data (Danielsen et al. 2018). McKay and Johnson (2017b) found that providing CBM volunteers with regular training opportunities for skills development was crucial for the success of CBM programs in Canada. Moreover, they claimed that as CBM volunteers become more adept at monitoring, buy-in for CBM programs could be positively influenced. The doubtful credibility of CBM data may also be ameliorated by establishing stringent monitoring protocols (Monk et al. 2008), which would require CBM participants to undergo additional trainings. Third, institutional inertia may inhibit the utilization of CBM data in management decisions. Decision-makers (i.e. industry and government) may turn a blind eye to CBM data that inconveniences their operation and mandate (McKay and Johnson 2017b), rendering collected CBM data meaningless and leaving communities disempowered. In a similar vein, CBM data can often be too complex for decision-makers to understand, and they may choose to overlook or even discard CBM generated information when finalising management actions (Ortega-Álvarez et al. 2017).

2.2 Community-Based Monitoring in South Africa

There exists much CBM literature in South Africa, but most were centred within the human health domain. For instance, Schoeman et al. (2003) found that a CBM model with local community health volunteers increased monitoring coverage, enabling quicker identification of malnourished preschool children for health and nutrition interventions. Similar findings were reported for CBM programs revolving around adolescent growth and nutrition (Faber 2002; Faber et al. 2009; 2003; Laurie and Faber 2008), ototoxicity (Stevenson et al. 2021), water quality (Rivett, Champanis, and Wilson-Jones 2013), HIV (Sahu et al. 2023), and primary healthcare (Mantell et al. 2022). Other domains of CBM literature included public service

delivery and potential of social media. For the former, Koskimaki, Moses, and Piper (2016) expounded upon a seven-step CBM model developed by Black Sash, a non-governmental human rights organization, and described how this CBM model has promoted collaboration between local service users and government officials in monitoring the efficiency of key social protection services. Whereas, for the latter, Matlala (2024) proposed a social media based CBM model for monitoring South African government projects; they explained that the transformative potential of social media could overcome the challenge of elite capture, and enhance governmental transparency and accountability, boosting the likelihood of success of government projects.

Within the environmental domain, the literature covered various aspects of CBM. One study affirmed the reliability of CBM-generated data by demonstrating how fisheries data collected through a CBM program on the Olifants River were statistically credible and could be used to inform policy and management decisions (Carvalho et al. 2009). Some studies described the success of CBM programs in achieving certain outcomes. For instance, Tandlich, Luyt, and Ngqwala (2013) outlined how a volunteer-run CBM program was able to effectively monitor microbial water quality and remediate faecal-contaminated rainwater in Grahamstown. Similarly, Soutschka (2014) showcased how a community-based fisheries monitoring system at the Olifants River estuary consistently provided valuable data on catch effort trends for a year, which was then compared with previous years data to identify if any overexploitation of target species had occurred. They also alluded to the social outcomes arising from this fisheries CBM system, including local empowerment and capacity-building. On this note of social outcomes, Kongo et al. (2010) examined a hydrological CBM network in the Potshini catchment, a small rural inhabited catchment, and found that the Potshini community gained both a scientific understanding of the hydrological processes and a sense of ownership of the catchment through CBM activities, resulting in an enhanced level of social capital that eases water resource management research and action currently undertaken in the area.

In a similar vein, given that CBM programs can offer a myriad of beneficial outcomes, Roboji (2019) proposed a CBM framework to monitor water services in the OR Tambo District Municipality, however they acknowledged that several factors would be required for the fulfilment of their proposed CBM framework. These factors include a strong political will, clear communication channels, community training capacities, stakeholder engagement opportunities, and managerial competency (Roboji 2019). Adding onto these factors

influencing the success of CBM programs, relational aspects – such as, researchers approaching citizen monitors in the local language, or researchers providing remuneration for monitoring work – were cited as vital for smooth collaboration between researchers and citizen monitors in the Tsitsa project (Rosenberg, Mtati, and Cockburn 2024).

Though CBM literature in the environmental domain explored a number of CBM aspects – including the credibility of CBM data, outcomes of CBM, and factors for success of CBM – the sheer number remains low, and the fields of study were only limited to water and fisheries. Moreover, much of the CBM literature in South Africa, across all domains (e.g. health and environment), revolved solely around quantitative data.

2.3 Qualitative Community-Based Monitoring Data

Similarly, the wider CBM literature was primarily concerned with quantitative data, possibly due to the ease of collection, validation and analysis of quantitative data (Gofman 2010), which aids in the dispelling of doubts related to the credibility of CBM data – a known impediment regarding the uptake of CBM data in academic and policy circles (Hunsberger 2004). Regardless, there were a few studies that highlighted CBM programs dealing with qualitative data. Some studies described the value in collecting qualitative data in CBM programs. Lemaire and Muñiz (2011) demonstrated the ability of participatory video, a qualitative CBM technique, in allowing community members to record environmental changes in their own words, enabling them to share knowledge and discuss key areas of concern, with other stakeholders, in an understandable format. A similar method of photo-capturing was also employed by Abonyi et al. (2013) to capture local environmental data in northern Saskatchewan. Likewise, Abbot and Guijt (1998) lamented that quantitative CBM data resulted in a significant informational and contextual loss, while qualitative CBM data precipitated the elicitation of rich anecdotes that explain happenings in a local context. Given the accessibility of qualitative CBM data, community members in a Cambodian CBM program on forest crime and resources have expressed the desire in wanting to provide qualitative descriptions of observations and interactions, instead of purely quantitative information (i.e. GPS locations, thematic tag from a dropdown menu) (Brofeldt et al. 2018).

Other studies have documented various collection methods most suited for qualitative CBM data. For instance, Davies (1996) detailed the usage of a qualitative two-part prompt in

elucidating and monitoring change within credit groups in Bangladesh: this prompt asked community members to provide a description of what changed, such that an outsider would be able to understand and verify, and an explanation on why they chose to flag this change out of the other changes that occurred. Zooming out, Gofman (2010) provided a list of CBM types (i.e. sentinel, surveying human sensors, citizen science, journal, and maintenance monitoring) and CBM methods (i.e. recording of observations by local observers, meetings, population survey, utilizing scientific instrument, and recording of phenology), which could be modified and adapted for the collection of qualitative CBM data. Also, to exemplify how such CBM types and methods can be utilized in collecting qualitative data, Gofman (2010) documented several case studies of CBM programs, such as (1) the Bering Sea Sub Network in Russia, where local community members interviewed whoever they perceived as the most experienced harvesters with a mixed-methods questionnaire, collected data were either uploaded onto Nvivo or SPSS for further analyses; (2) Community Moose Monitoring Project in Canada, where two locals interview about 20 residents each year to gather observations about the boreal forest food web, which were previously used to produce reports for the local co-management board, but due to time constraints, raw data is now only uploaded to an online database and stored as a community diary without further analysis; and (3) a conservation project in Russia, where a single local expert records down environmental observations of importance to them in a 100-page diary over the span of a year, however this data has yet to be analysed in a formal manner.

However, there has been a lack of literature on the analytical methods undertaken to make sense of qualitative CBM data. Some literature do provide some detail, but often such details are limited to vague characterisations of "a special protocol" (Gofman 2010, 19) and "thematic identification and coding" (Johnson et al. 2015, 32). Without knowing such details, other practitioners are left with little guidance on how to design protocols that enable researchers and community members to filter through rich qualitative information and identify key points of interests. Therefore, there exists a need for more research that explores the analytical methods and tools of qualitative CBM data, which may be vastly different from existing tools in other disciplines (Gofman 2010).

2.4 Summary of Literature Review

The literature review first provides an overview of the general discussions surrounding CBM, specifically on its emergence, spread, approaches and outcomes, with a special emphasis on

CBM literature in South Africa. Current research reveals that CBM literature remains generally scarce in developing contexts and is primarily concerned with quantitative data. This finding contrasts with the reality that CBM programs are reportedly more prevalent in developing contexts, where most collect some form of qualitative CBM data. Further review of literature on qualitative CBM data ascertained its underdevelopment, particularly on the methods available for analysing such data. Thus, this thesis research aims to contribute to existing literature by exploring the outcomes from, and factors influencing, the effective collection and utilization of qualitative CBM data in a developing context, and also proposing a preliminary data analytical and transformation tool for current and future CBM researchers and practitioners working with qualitative CBM data.

3. Methodology

3.1 Research Design

Given the relative novelty of research focused on qualitative CBM data, a qualitative research approach was undertaken. Such an approach is characterised by the use of non-numerical data usually collected within the participants' setting, an inductive style of knowledge-building from specific experiences to general themes, and an embracement of the variation and diversity in the findings (Brodsky et al. 2015). Through a qualitative research approach, the processes, meanings, and purposes of a complex phenomenon – which, in this thesis research, refers to the collection and utilization of qualitative CBM data in environmental monitoring – can be organically explored and described from the viewpoint of those who are experiencing it (Creswell and Creswell 2018).

For academic clarity, I adopted a three-stage research design: (1) a pre-study stage, conducted from October 2023 to January 2024, to explore how the research focus on CBM was academically and practically impactful; (2) the data collection stage, spanning from February 2024 to April 2024, when semi-structured interviews were conducted with two groups of stakeholders to gain insights into their experiences of collecting and using qualitative CBM data; and (3) the data analysis stage, where a thematic analysis and logic framework approach were employed to provide clarity on the collected data. Figure 1. depicts the flow of this three-stage research design as encapsulated within the single case study of K2C-NPC's CCSMP. The specificities of employed methodologies and achieved outcomes of all three research stages will be comprehensively discussed in the following sections.

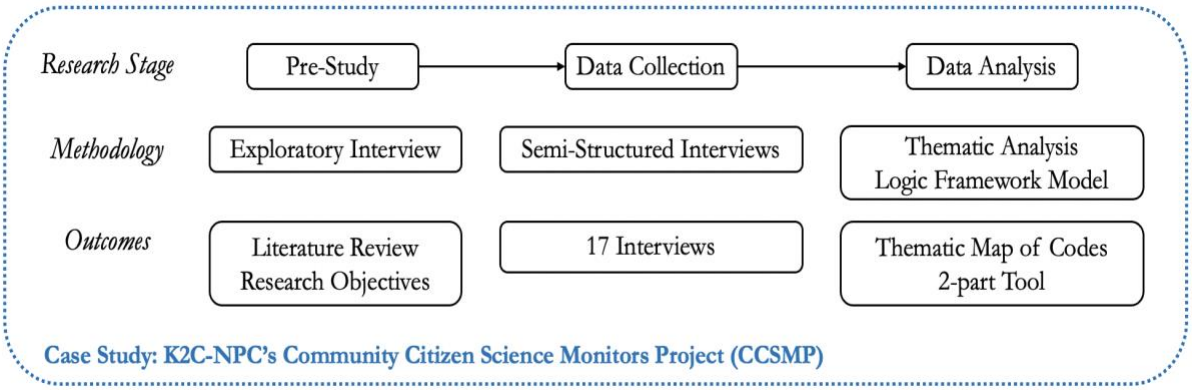

Figure 1. *Diagram showing flow of research stages. Created by author.*

Only a single case study was explored in this thesis research. Although the inclusion of more case studies could have increased the breadth of the research, resource and time constraints inhibited such an endeavour. Regardless, focusing on a single case study enabled for a deeper inquiry to be conducted, as almost all individuals involved within K2C-NPC's CCSMP were engaged in this research. More details on the selected case study will be provided in the subsequent section.

3.2 Case Study

As part of the Man and the Biosphere Programme (MAB), the United Nations Education, Scientific and Cultural Organization (UNESCO) designates landscapes of special importance to be internationally recognized as Biosphere Reserves (BRs). Currently, there are 748 BRs across 134 countries, including 23 transboundary sites (UNESCO 2023). BRs serve as pilot sites for demonstrating the effective management of the intricate interfaces between people, development, and nature (UNESCO 2019). More specifically, BRs have three functions to fulfil: (1) conservation, in which ecosystems, biodiversity, and genetic material should be safeguarded; (2) development, in which economic and social progress should be fostered in a socio-culturally and ecologically sensitive manner; (3) logistics support, in which issues of conservation and sustainable development can be monitored, researched, imparted, and learnt from (UNESCO 2019).

To achieve these functions, BRs are strategically delimited into three zones of graduated land-use intensity: *core zones* that are protected under legal constitution based on nature and biodiversity conservation concerns, *buffer zones* that are contiguous around *core zones* and permitted for limited human use, such as research, monitoring activities, environmental education and ecotourism, and *transition zones* where sustainable resource management practices are championed within larger human settlements (UNESCO 1996). Such zonation was intended to be in concentric rings with *core zones* at the centre, as shown in Figure 2., in order to preclude development activities from negatively affecting biodiversity conservation areas (Coetzer, Witkowski, and Erasmus 2014). Overall, BRs aspire to foster synergistic actions among local, national, and regional actors for place-based solutions that reconcile biodiversity conservation with equitable and sustainable socio-economic development (UNESCO 2019).

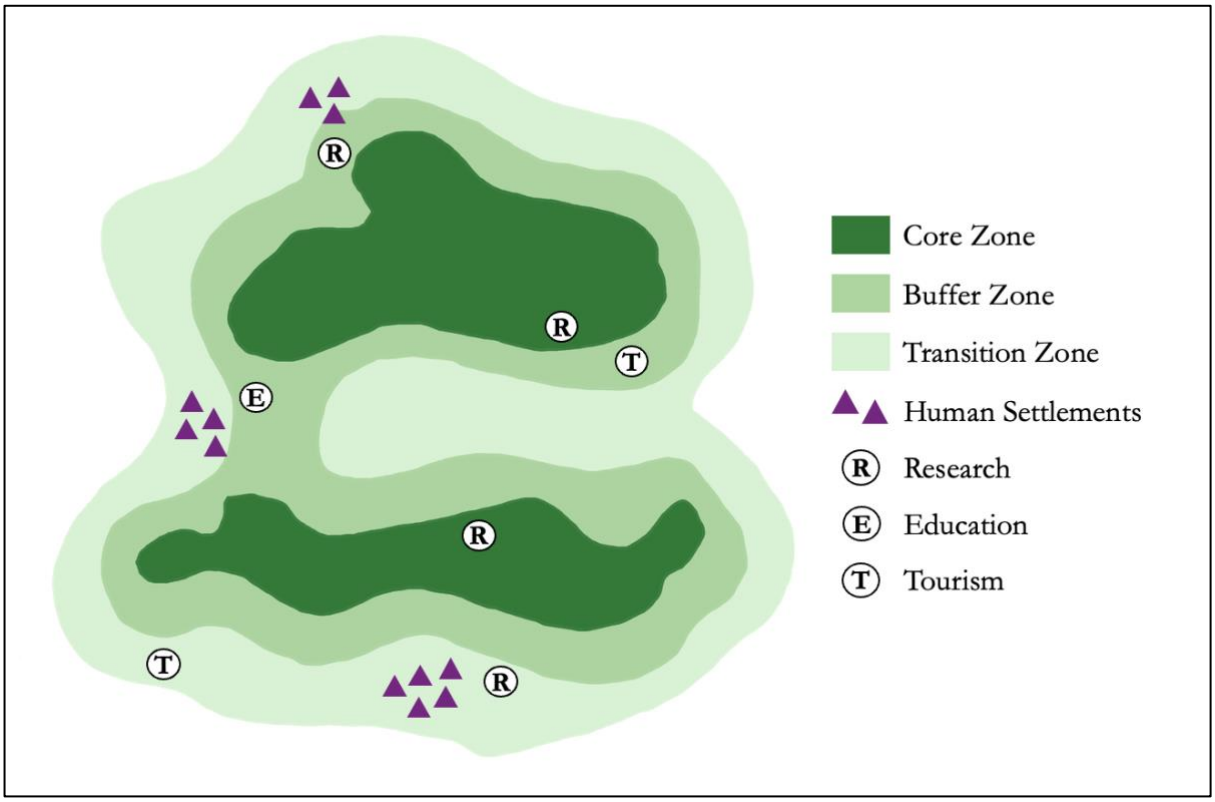

Figure 2. *Stylized representation of the model structure of BR zonation. Reproduced by author, with reference from K2C (n.d.-c) and Safitri Zen et al. (2019).*

3.2.1 The Geographical Space – Kruger to Canyons Biosphere Region

In 2001, UNESCO officially ratified K2C as the third BR in South Africa[1]. K2C is located in the north-eastern pocket of South Africa, spanning across two provinces – Limpopo and Mpumalanga – to cover about 2.6 million hectares of grasslands, afro-montane forests and lowveld savannah biomes (UNESCO, n.d.). BR zonation of K2C was not applied as envisioned in the MAB, but according to existing land-use mosaic (Coetzer et al. 2013). Figure 3. illustrates the unique zonation of K2C: biodiversity conservation areas under stringent statutory protection, such as the Kruger National Park, Blyde River Canyon Nature Reserve, and Lekgalameetse Nature Reserve, were constituted as *core zones*, other conservation areas without statutory protection, including private nature reserves or community-managed spaces, comprised the *buffer zones*, while the remaining areas of plantation forestry, agriculture, rangelands, mining sites and settlements made up the *transition zones* (Coetzer et al. 2013).

[1] South Africa currently has 10 BRs in total.

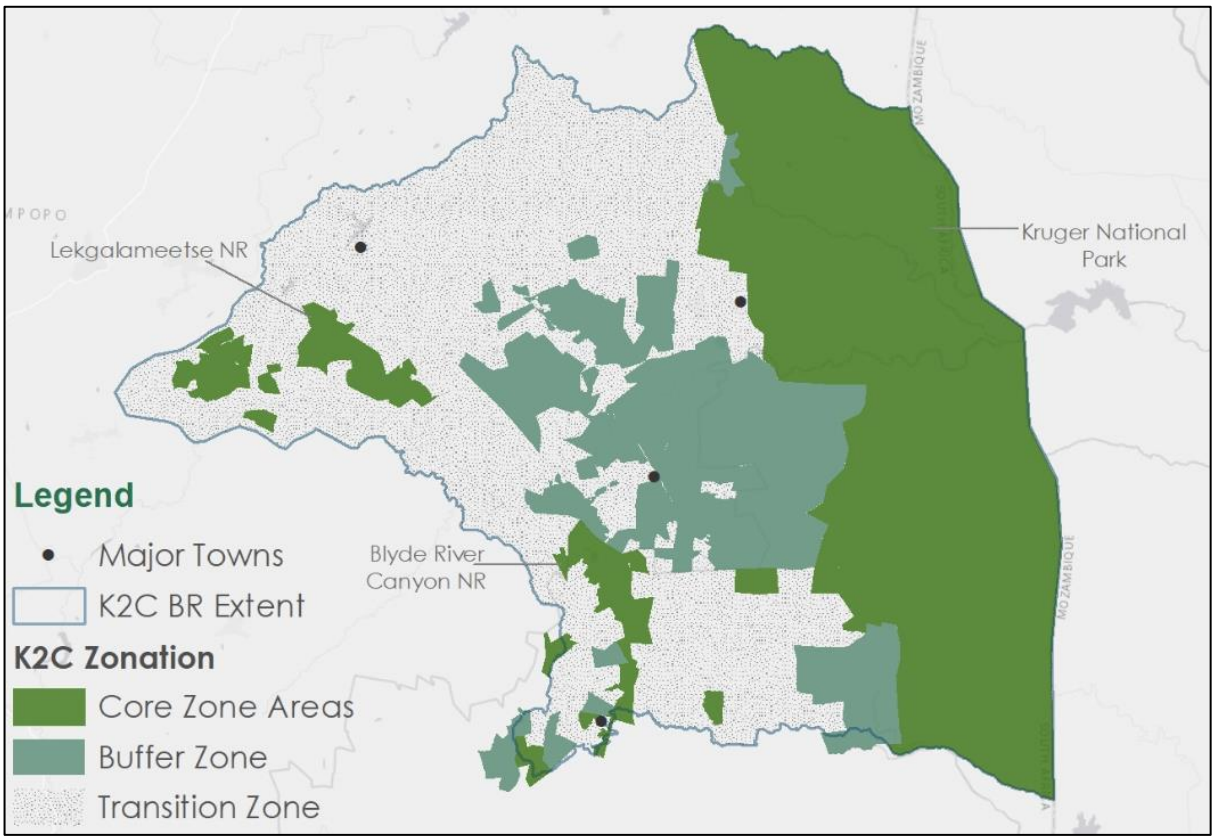

Figure 3. *Zonation of K2C. Adapted from K2C (n.d.-c).*

Regarded as a "wildlife sanctuary" (UNESCO 2019, 23), K2C hosts a wide diversity of species. In a preliminary count conducted in 2020, 905 vertebrate species and 2760 vascular plant species, of which 58 faunal endemics and 116 floral endemics, were found to exist[2] in the region (UNESCO 2019). Many of these species, 109 faunal and 60 floral, were considered red data book species[3], emphasising the biodiversity conservation function of K2C. Additionally, K2C is recognized as a Strategic Water Source Area, where major rivers (e.g. Olifants, Blyde and Sabie Rivers), provide a significant amount of water for the lower-lying regions (UNESCO, n.d.). Besides being a biodiversity haven, K2C is also home to a large human population. There are approximately 10 475 permanent residents in the *buffer zones*, and 1 488 684 in the *transition zones* (K2C, n.d.-a).

[2] The number of species found in K2C is likely to be an underestimation (K2C 2020), given that invertebrates remain poorly researched and recorded, despite the proven fact that invertebrates consist of a high percentage of biodiversity across the globe (Eisenhauer and Hines 2021).

[3] Endangered species as classified by the state.

3.2.2 The Management – Kruger to Canyons Biosphere Region Non-Profit Company

At the early stages of K2C's journey as a BR, legislative and financial backing were lacking, and activities were only informally managed by several very committed individuals (Schultz, West, and Florêncio 2020). A turning point came in 2011, when international and national sustainability initiatives started to trickle into K2C, necessitating the establishment of a formal institution – K2C-NPC – to oversee the alignment of such initiatives with each other and the larger BR mandate (Schultz, West, and Florêncio 2020). Since then, K2C-NPC's role has only grown larger. Not only are they in-charge of implementing projects that fulfil the BR mandate of integrating biodiversity conservation with sustainable socio-economic development (K2C, n.d.-b), but they also act as a bridging organization that brings multiple stakeholders (e.g. national governments, tribal authorities, non-governmental organizations, private reserves, corporates, and local community members) together to actualize novel projects and create impact at scale (Florêncio 2016). These projects range from biodiversity stewardship and restoration to capacity building and career pathing with a particular focus on youth and women (K2C, n.d.-b).

3.2.3 The CBM Initiative of Interest – Community Citizen Science Monitors Project

The CCSMP was launched to enhance environmental monitoring efforts in rural villages, with a particular focus on freshwater health, waste management, and agroecology. Within CCSMP, local community members were hired, as community science monitors (CSMs), to conduct specific CBM activities in their surrounding areas every day. The nature of activities conducted may vary from a day-to-day basis: sometimes, CSMs have a fixed task to attend to, such as collecting freshwater data at a set location or attending training workshops, while at other times, CSMs may decide where to go and whom to speak to, to see and hear how other human residents interact with the environment. For academic clarity, Table 1. outlines the different activities possibly undertaken by CSMs as matched to Gofman's (2010, 9) categorization of CBM types.

Table 1. *Non-exhaustive list of CSMs' activities as matched to Gofman's CBM types. Created by author.*

CSMs' activities in the CCSMP	Gofman's CBM types	Main features
Village patrols	Sentinel (Patrol)	Recording of place-based observations of various aspects of environment.
Agroecology census and Indigenous Knowledge Systems	Surveying human sensors	Speaking to locals to gain insight into their interactions with the environment in the past and present.

Waste monitoring and organization of clean-ups	Maintenance monitoring	Regular surveillance of environmental hazards (e.g. waste) within specific areas.
Freshwater monitoring	Citizen science	Tasked to collect specific information using scientific tools.

After every activity conducted, CSMs were required to report three components via WhatsApp: (1) the Global Positioning System (GPS) location of activity, (2) one to three photographs of on-site activity, and (3) a descriptive recount of what they did, saw and heard, whilst conducting the activity. All this information would then be tabularly captured into a Microsoft Excel spreadsheet by a program manager (PM) based in the K2C-NPC office. For this thesis research, only the descriptive recounts will be scrutinized – the nomenclature of 'descriptive recounts' is interchangeable with 'qualitative CBM data' throughout this report. So far, these descriptive recounts have only been sporadically utilized to inform one-off management actions (e.g. should any alien invasive plant species be identified, the relevant personnel will be informed to execute removal) or for internal reporting purposes (e.g. creation of monthly summary reports of what activities were conducted for funders' perusal).

3.3 Research Stage #1: Pre-study

To establish the academic importance of the research, I conducted a literature review guided by the 'funnelling' approach – transitioning from broad to focused exploration – to build my understanding of the current state of discussions surrounding CBM in general and within the South African context. This literature review, as extensively presented in the preceding chapter, was grounded in these three main tenets:

- the general discourses surrounding CBM, including its emergence, spread, characteristics, and outcomes,
- the specific discussions of CBM in South Africa, and
- the tools that have been, or could potentially be, used to analyse CBM data.

In a separate vein, I also engaged in three exploratory meetings[4] with key staff in K2C-NPC to ascertain the practical importance of the research. Given the limited information I could find online regarding the CCSMP, these meetings enabled me to better understand the mechanics of, and research needs related to, the CCSMP. Ultimately, the eventual thesis research scope

[4] These meetings were held online via Zoom on 29th November 2023, 23rd January 2024, and 23rd February 2024.

was the product of dynamic back-and-forth discussions with K2C-NPC, ensuring that my thesis research was well-aligned to their needs.

3.4 Research Stage #2: Data Collection

From February to April 2024, I was based in South Africa to conduct in-person semi-structured interviews with two groups of stakeholders – CSMs and PMs. CSMs refers to the local community members that were hired by K2C-NPC to conduct CBM activities and submit descriptive data, while PMs refer broadly to K2C-NPC staff who were involved in the management and/or data analysis aspects that may (in)directly relate to the CCSMP. Semi-structured interviews were utilized, as this format enables a certain degree of freedom for participants to openly recount their experiences and perspectives, while allowing the researcher to retain some control over the line of questioning (Creswell and Creswell 2018), thus striking a balance between having rich and focused data under a time-limited setting.

The specific individuals within both stakeholder groups were identified via a snowball sampling method. Figure 4. illustrates how Vanessa[5], my first contact point within K2C-NPC, connected me with other PMs, who then introduced me to their CSMs, for actual research participation. A total of ten CSMs and seven PMs were interviewed, with interview duration ranging from 10 to 34 minutes. All interviews were conducted in English, which was the interviewees' professional working language.

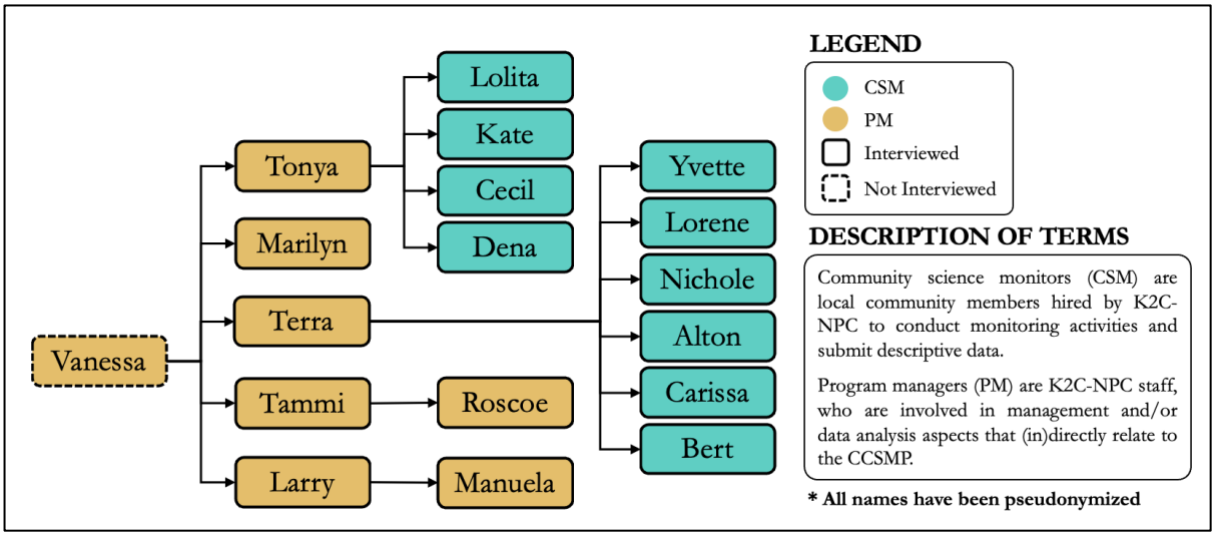

Figure 4. *Flow of contact with research participants via a snowball sampling method. Created by author.*

[5] Pseudonymization has been applied to anonymize this name.

Different set of questions were posed to the respective stakeholder groups. CSMs were asked about their experiences in being a CSM and their perceptions on whether the collected qualitative CBM data has brought impact to themselves and their communities, whilst PMs were asked about the rationale for collecting qualitative CBM data, their personal opinions on the strengths and weaknesses of such data, and how such data has been utilized purposefully and/or unexpectedly. Questions may not have been asked sequentially, depending on the flow of interview, but all questions were posed to interviewees. For the full sets of questions, refer to Appendix 8.1. All interviews were recorded on an iPad. Transcripts were first generated using the built-in Microsoft Word software, accessed through my CEU education account, before being manually polished for accuracy. From the initial generation, all names in transcript were pseudonymized to ensure anonymity of interviewees. For additional confidentiality, full transcripts will not be made publicly accessible (see section 3.7).

3.5 Research Stage #3: Data Analysis – Thematic Analysis

For data analysis, I employed a thematic analysis – the process of identifying patterns within qualitative data – as it is regarded to be a beginner-friendly and flexible method for analysing qualitative data, given that it is not bounded to any specific epistemological or theoretical perspective (Maguire and Delahunt 2017). Specifically, I elected for a deductive thematic analysis, which is driven by specific research questions rather than the data itself (Braun and Clarke 2006). To ensure rigour in the analysis process, I adopted the six-phase framework as outlined by Braun and Clarke (2006); each of which is detailed below[6].

3.5.1 Phase 1: Familiarising with the data

In this phase, researchers are encouraged to read the entire body of data, immersing oneself into the content to become well-acquainted with its depth and breadth before any coding is conducted (Braun and Clarke 2006). Ideally, this reading process should be conducted in an active manner, where notes or initial points of interests are recorded (Chamberlain 2015). Following this guidance, after uploading all anonymized transcripts into Nvivo 14, I read all transcripts from start to finish, keeping in mind to see the data as "things in themselves" (Denscombe 2010, 95), and minimize personal judgement of the data. While reading, I highlighted interesting information, and cross-referenced them to the respective ROs. A total of 378 points of interests were identified (Table 2.).

[6] Except for Phase 6 – writing of report – which would not be further detailed in this section.

Table 2. *Points of interests as linked to research objectives. Created by author.*

Research Objectives	Related sub-topics	Initial points of interests
Explore the initial outcomes from the collection and utilization of qualitative CBM data in the K2C landscape from both the program managers' and community science monitors' perspectives.	Attitude; Behaviour; Knowledge and skills; Community; Potential	173
Understand the factors that influence the effective collection and utilization of qualitative CBM data in the K2C landscape.	Training; Feedback; Weather; Funding	106
Propose a tool to ease analysis and transformation of qualitative CBM data, exemplified through application to K2C's existing CBM data.	Nature of data; Protocol; Current ways of analysis; Needs and suggestions	99

3.5.2 Phase 2: Generating initial codes

After familiarizing myself with the data, I properly begun the coding process to organize the data in a meaningful way that would shed light on my ROs. I opted to use an open coding process, meaning that codes were not preestablished, but were formulated and refined throughout the process[7]. All transcripts were carefully read through multiple times, coding extracts that appear to be relevant in addressing the ROs. Throughout this process, I focused more on coding "what is being said" rather than "what the text means" (Allsop et al. 2022, 144), hence some codes were as short as one word while others were as long as sentences. A total of 121 codes were generated, with some only having one reference point while others contained about 20. Table 3. showcases a few examples of how segments in the interview transcripts were coded, while Appendix 8.2 presents the full list of codes.

Table 3. *Examples of how excerpts from transcripts were coded. Created by author.*

Excerpts from transcripts	Coded for
"it advanced my knowledge whereby back then in my days before I was employed here, I had no clue if this is wrong to the environment and there, there is maybe bad effects about it, I never knew about that one."	Increased knowledge
"there were actions that came out from the community members themselves, as well as the councillors where they committed to doing	Initiative from community for

[7] Note that some codes were informed by the sub-topics uncovered during Phase 1.

things, like clean-up campaigns were done, people started doing this backyard gardens and also community gardens."	environmental change
"And I also tell the community nearby that you see, stop dumping pampers there, because this is, like the importance of the river to the people."	Environmental advocacy behaviour
"For me, that was a bit risky. That was the biggest challenge for me, because sometimes when you walk on a cliff, something like this *uses hands to show a narrow width*."	Safety hazards
"Some of, some of these people that we interview, that, they wouldn't give you that information that you require. They, they expect you that if you ask them a question, you would have a solution."	Mismatched community expectations

3.5.3 Phase 3: Searching for themes

After collating all codes, I shifted my analysis to the broader level of themes. Themes encapsulate something about the data relevant to the research inquiry, embodying a degree of patterned response and meaning within the dataset (Braun and Clarke 2006). I conceptualised the themes by viewing the codes as "building blocks" (Dawadi 2020, 66), and combining similar codes to form main candidate themes or sub-themes. There were a few codes that did not seem to fit anywhere and were housed temporarily under a 'miscellaneous' theme. All themes were sematic in nature, meaning that whilst forming themes, I did not look into the underlying concepts, presuppositions, frameworks, and ideologies theorized to influence what participants have said, but rather only looked at the explicit meanings of the data (Braun and Clarke 2006). An initial thematic map, representing the relationships between themes, was created (refer to Appendix 8.3). At this stage, no codes nor themes were abandoned, no matter how contradictory they may be to the overall dataset. This prerogative was advised by Braun and Clarke (2006) as they remarked that no dataset exists without contradiction, and tensions within and across data items should be embraced rather than ignored for a complete analysis.

3.5.4 Phase 4: Reviewing themes

In this phase, all themes were brought together for a refinement process, that was executed at two levels – internal homogeneity and external heterogeneity – as suggested by Braun and Clarke (2006). Internal homogeneity refers to the coherence within themes and was checked by rereading all coded extracts. If candidate or sub-themes were deemed to be incoherent, I made changes to the themes, either by merging, renaming, or eliminating them. After affirming that all themes sufficiently captured "the contours of the coded data" (Braun and Clarke, 2006, p.

21), I proceeded to the second level of external heterogeneity that checks for distinction between themes. To do this, I reread all transcripts to confirm if themes made sense in relation to the whole dataset, while also coding any additional data that may have been previously missed. Then, I revised the initial thematic map to more accurately reflect the meanings evident in the dataset as a whole.

3.5.5 Phase 5: Defining and naming themes

This final polishing phase involves defining the crux of each theme, and determining how they interact or relate with each other (Braun and Clarke 2006). To do this, I relooked at the data extracts, codes, subthemes, and themes, and organized them into coherent accounts that aligned with my research objectives. Subsequently, I formally assigned names and defined the scope of each theme. The final thematic map and description of themes will be presented in the following chapter.

3.6 Research Stage #3: Data Analysis – Logic Framework Model

A logic framework approach refers to an "analytical, presentational and management tool" (AusGUIDElines 2003, 1) that enables practitioners to analyse existing situations pre-project, establish logical hierarchy of outcomes, and identify potential risks (AusGUIDElines 2003). The most common product of this approach is a logic model, in which the relationships between program elements are graphically depicted (Smith, Li, and Rafferty 2020). Logic models have been used to develop and evaluate programs and research studies (W.K. Kellogg Foundation 2004; Petersen, Taylor, and Peikes 2013). Thus, specific to RO3, I employed a logic framework approach to construct a logic model based on interview data, clarifying the creation process and mechanics of the proposed DAT tool. This model is presented in the next chapter.

3.7 Limitations

The responses from the interviewees may have been imbued with a certain degree of social desirability bias, in which interviewees respond in a manner that they believe to be more desirable or acceptable and may not be reflective of their true feelings and opinions, influencing results to overstate positives and understate the negatives (Nederhof 1985). To mitigate this bias, I sought advice from my supervisor and colleague to ensure that interview questions were well-crafted to elicit balanced information (e.g. addition of counter questions to probe possible negative feelings and opinions).

On another note, English was not the first language of most interviewees, which may have inhibited them from being able to communicate their feelings and opinions fully and accurately. However, English was their professional working language, meaning that all interviewees must have had regular exposure to, and a decent competency in, the English language. Thus, I went ahead with conducting all semi-structured interviews in English. Also, due to my inexperience with conducting qualitative interviews, potential errors (e.g. not probing at the right moment, asking leading questions) might have been committed. Regardless, to the best of my abilities, I tried to minimise such errors by piloting all interview questions and simulating interview settings with a fellow colleague.

3.8 Research Ethics

As per the ethical policy on research outlined by CEU (2010), I completed an ethics checklist by detailing the scope of thesis research, funding source, nature of research participation, expected consent guidelines, and methods of data usage and storage for addressing privacy and protection concerns. This checklist was sent to both CEU and K2C-NPC staff for approval. After approval was granted by both parties, I signed the checklist, affirming my commitment to adhere to the ethical guidelines and ensure that research outcomes would not be detrimental to the researcher (i.e. myself) and research participants, before embarking onto the fieldwork component.

During fieldwork, prospective research participants (i.e. CSMs and PMs) were provided with a participant information sheet (refer to Appendix 8.4) outlining the voluntary nature of their participation, the possibility of withdrawal from research participation, and how their data will be recorded, disseminated, stored, and managed. Willing research participants were required to sign a consent form declaring their voluntary consent to be interviewed (refer to Appendix 8.5). All interviews were individually conducted to provide a safe space for honesty from participants and avoid possible relationship-damaging situations of tattle-telling.

4. Results

Culminating from the data analysis, a final thematic map was generated (Figure 5.). These themes will be expounded upon in the following sections. The circles were key concepts from RO1 and RO2, while the rectangles represent the specific themes that emerged from interview responses – the different coloured rectangles were only for the stylistic visualization of the further categorization of themes, and do not have any special implications. Note here that all research participants, when quoted, were referred to with a neutral pronoun (i.e. them) and by an assigned number (instead of the previous pseudonym) for anonymity purposes.

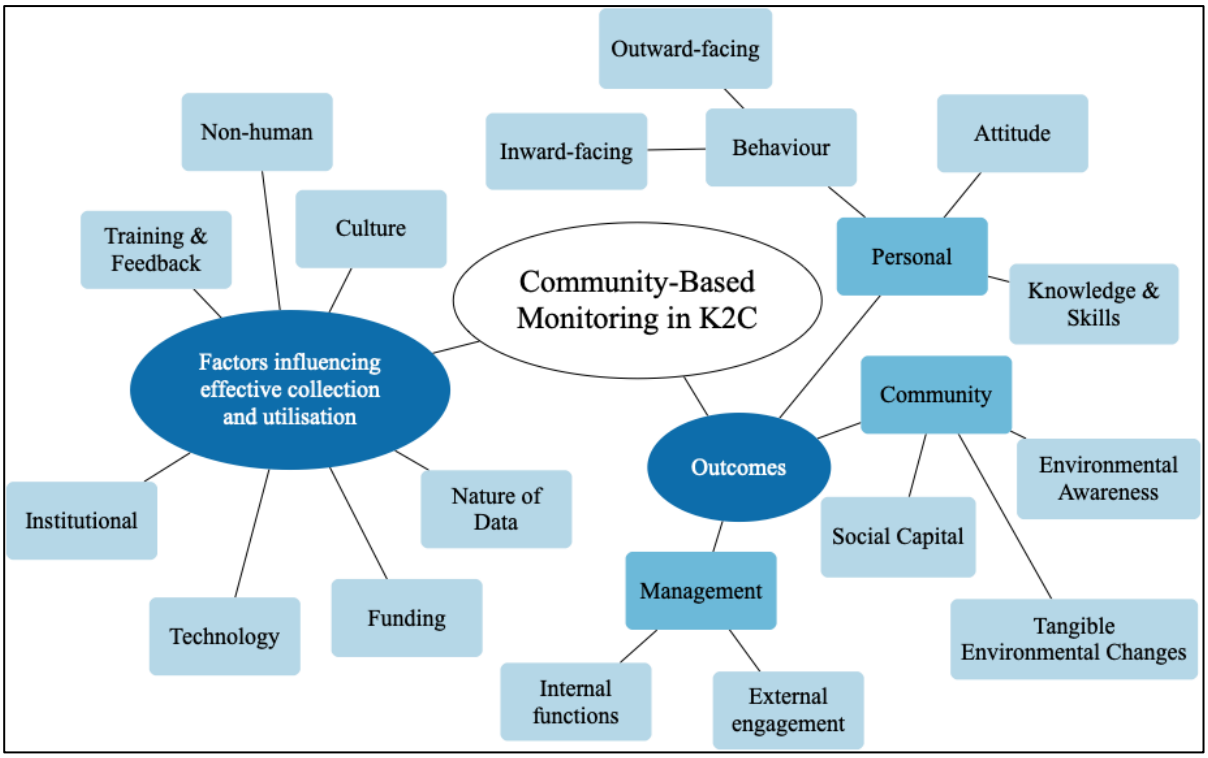

***Figure 5**. Final thematic map. Created by author in NVivo.*

4.1 RO1 – Outcomes from Collection and Use of Qualitative CBM Data

Respondents touched upon three main categories of outcomes – personal, community and management – which were further classified into more specific themes.

4.1.1 Personal outcomes

The personal category of outcomes refers to outcomes accrued by CBM participants (i.e. CSMs) individually, and not shared with nor experienced by other community members or stakeholders. This category has three main themes – attitude, knowledge and skills, and

behaviour. First, participants self-reported to have developed a more positive attitude towards the environment, in terms of having an increased affinity with nature, as CSM #7 puts: "It [being a CSM] made me fell in love with everything I do with citizen science…I'm more connected to the nature"; and CSM #1 said: "We need this river, more than we need ourselves". Additionally, participants also displayed more positive environmental outlooks attributed to the presence of CBM activities in their communities, as remarked by CSM #2: "I think as time goes on, maybe not in my time, but I believe it will make a difference", and CSM #6: "Our future generations will be able to find our environment in a good condition if we continue like this, because…people will stop polluting, and start taking care of the environment". Moreover, CSM #7 mentioned that before CCSMP, they "neglected (their) roots so much", but now they feel "more connected to (their) roots", signalling a positive change of CSMs' attitudes towards their indigenous culture. This sentiment was echoed by CSM #2 who said: "it [participating in CCSMP] also increased my cultural pride, and it also made me more confident of my culture".

Second, participants consistently cited that being a CSM increased their environmental knowledge, especially of human-environment interactions, such as "how human activities impact the environment, (and) how the environment changes with time as a result of human activities" (CSM #4). This common sentiment was aptly summed up by CSM #8: "back then in my days before I was employed here, I had no clue if this is wrong to the environment… so it [CCSMP] has just advanced my knowledge". Furthermore, some participants remarked that, in their time as a CSM, they were able to hone several soft skills, such as report-writing, public speaking, problem solving and communication, and also some hard skills, such as basic numeracy and handling scientific equipment. Notably, CSM #5 commented that "even if I leave the K2C, and work for another organisation, I won't have difficulties" due to the breadth of knowledge and skills acquired through the CCSMP.

Third, participants have increasingly engaged in environmentally friendly behaviour after engaging in CCSMP. Such behaviour was either inward-facing, meaning that behavioural changes were made on themselves, or outward-facing, referring to advocacy behaviour. An example of inward-facing environmentally friendly behaviour would be how CSM #7, after learning about agroecological principles through CBM activities, established their own backyard garden to "see how it would turn out" – this garden has since provided them with spinach and green peppers, increasing their food security. However, such inward-facing environmentally friendly behaviour was not as commonly cited as its counterpart, outward-

facing environmentally friendly behaviour. Almost all participants cited instances of themselves engaging in environmental advocacy. For instance, while on village patrol, CSM #1 would "tell the community nearby (to) stop dumping pampers there [the river], because… (there is an) importance of the river to the people". Even outside of their CBM duties, CSM #4 said that they "encourage people at home… every time when they use water after bathing, I tell them (that) this water can be reused again", while CSM #9 mentioned that they "encourage a lot of people to do recycling because… you get to conserve the environment, keeping it clean".

4.1.2 Community outcomes

The community category of outcomes refers to outcomes evidenced by other community members not directly engaged within the CCSMP. This category has three related themes – environmental awareness, tangible environmental changes, and social capital. First, by "giving out the information that people don't know about (their) village" (CSM #10), environmental awareness within communities were reportedly boosted. This boost, no matter how slight, was exemplified through instances of "people coming to us (CSMs)… asking how (they) can do this [conservation-related problem]" which indicate that "we (CSMs) are contributing back to the community because now they [other community members] are noticing what we (CSMs) are doing." (CSM #6). Similarly, PMs have also reported that "communities are now aware of their surroundings based on what they [CSMs] work (on)" (PM #1), and communities seem to "understand what is happening on the ground and they are able to make decisions that are good for the environment and for the peoples' wellbeing" (PM #2).

Second, tangible environmental changes have been described to have occurred as a result of the CCSMP. CSM #2 commented how "there's a place where they [community members] used to dump nappies and all this household waste, but now they [community members] have stopped, because we [CSMs] talked to some of the elders… so they've [elders] stopped everyone from polluting that place". Likewise, PM #4 specified that school gardens were collaboratively established and maintained by students and teachers as a result of CBM activities – these school gardens are not only "so beautiful" but are also "bringing in… the food". As PM #1 fittingly said about qualitative CBM data collected in the CCSMP: "it's not just data, it has a weight, it helps people in the communities to build resilience".

Third, social capital was reportedly built via CSMs' activities within the CCSMP. Through their engagements, CSMs gain "a little bit of a voice or a face for the environment… (helping them)

to connect with the community, with different stakeholders" (CSM #9). These stakeholders are usually key members, such as tribal and municipal authorities, who are able to mobilize communities for collective action. CSM #4 detailed how they spoke to the counsellor about the village's pollution problem and was able to successfully rally volunteers to conduct at least four cleaning campaigns. There were even instances when community members banded together to resolve specific issues, without push nor support from CSMs and PMs. For instance, PM #2 commented that "there were actions that came out from the community members themselves… where they committed to doing things, like clean-up campaigns". This example was also raised by CS #8, CS #9, and PM #5. Another instance was provided by PM #4, who recalled how "one principal is even willing to buy an irrigating (system)… from their own pockets… because they see the benefits that goes back to the school". With such strong social capital, gaining the buy-in from community members for other projects become easier. For instance, PM #4 outlined how they tapped onto their connections with the municipality and other corporates to organize a farmers market, resolving the issue of market access raised by smallholder farmers in the community. As an offshoot consequence of social capital, K2C-NPC was recognized for their embeddedness within the social web of local communities, enabling the formation of new partnerships and obtainment of new project funds from institutions that wish to come into the area (PM #6).

However, it should be noted that these community outcomes were reported either by CSMs or PMs as outsiders observing or as listeners hearing from their communities and were not obtained directly from community members.

4.1.3 Management outcomes

The management category of outcomes refers to outcomes arising from actual utilization of CBM data and could either be related to internal functions, which pertain to aspects that K2C-NPC maintains for themselves, or external engagement, in which K2C-NPC collaborates with other stakeholders for meaningful application of data.

For internal functions, CBM data was regarded as part of K2C-NPC's "management tool… (which provided) an evidence-based support of the work that we're [K2C-NPC] doing" (PM #3). This evidence was reviewed during performance reflections and evaluations of CSMs (PM #3, PM #4). Put simply, CBM data was used to ensure that CSMs "are really at work" (CSM #5), without the need for micro-management (PM #6). On a different note, CBM data was used

to obtain "a snapshot of the landscape" (PM #7), to identify hotspots requiring intervention or to spark new areas of work to engage in. PM #5 confirmed that "data that has been captured definitely highlighted issues that we've been able to take further…(providing) at least a baseline of data to support our [K2C-NPC] concerns around an issue". PM #6 also echoed this by recalling that "many of the projects that we [K2C-NPC] have, has come out from the data collected".

For external engagements, CBM data was broadly cited to have been used for formal academic research by several participants. However, there was only one concrete example provided by PM #5: CBM data "sparked a little pilot study… to get a better understanding of who was dumping (nappies), how many they [community members] were using, what their [community members] perceptions were around disposable nappies…and then that sparked… a relationship with a university, who took that research further". On another note, CBM data was widely used to account for obtained funds, given that "qualitative data also reflects impact" (PM #3), and to source for more funds "in order to implement solutions in communities" (CSM #8). This outcome was raised by almost half of the participants.

Moving on, participants have utilized CBM data to compile reports and provide feedback to local stakeholders, who have influence or jurisdiction to enact management change, keeping them informed of what has or is happening within their landscape (PM #2, PM #3, PM #6). Such regular interactions imbued K2C-NPC with an informal mandate for sustained operations within K2C. At times, this feedback may be taken up by local stakeholders, spawning actual environmental change to benefit local communities. For instance, waste data collected in CCSMP helped the "community (to) get skip bins" (CS #9), that were placed in prime sites identified through the same dataset (PM #7). Another instance would be how relevant authorities have responded to CSMs' reports of invasive alien plant species by quickly dispatching personnel for removal (PM #5).

4.2 RO2 – Factors Influencing Collection and Use of Qualitative CBM Data

The collection and utilization of qualitative CBM data in the CCSMP was found to be influenced by seven factors – culture, funding, institutional, nature of data, non-human, technology, and training. Most of these factors emerged as both enabling and inhibiting, albeit

in different manners and ways. Table 4. summarises this duality, while each factor is elaborated upon further in following sub-sections.

***Table 4**. Duality of factors found to influence effective collection and utilization of qualitative CBM data. Created by author.*

Factor	As enabling	As inhibiting
Culture	Embeddedness within community increases cultural awareness and enables the elicitation of acceptance.	Mismatched community expectations, and/or proposed interventions being unaligned with cultural norms.
Funding	Support continuation of CCSMP and implementation of solutions derived from CBM data.	Insufficient funds and uncertainty of next/continued funding, affecting sustainability of CBM programs.
Institutional	–	Lack of public funds and political will to implement change.
Nature of data	Increase accessibility of information to community members.	Huge difficulty in the analysis of qualitative CBM data, stifling potential of database.
Non-human	–	Uncontrollable situations, such as bad weather conditions, complicated terrains and loadshedding, affect CSMs on duty.
Technology	Usage of WhatsApp promotes communication, learning and transparency.	Unable to do streamlined analysis as data has to be manually captured as it comes in.
Training	Boosts knowledge and capacities of CSMs to collect quality data.	–

4.2.1 Culture

There are certain cultural norms, languages and structures that informally exists within local communities, which outsiders are unlikely to know about. Fortunately, CSMs were all local community members and aware of such unspoken rules. For instance, traditional authorities acted as "the voice in the communities" (CSM #9), and any CBM activities "have to start at the very entrance of the traditional authority, (if) you have them [traditional authority] there, you are done." (CSM #5). Knowing this, CSMs would seek permission from tribal authorities as a sign of "respect (to) their values, (and) respect where the limits are" (PM #4), helping authorities to understand what and why CBM activities were being conducted on their lands before any execution of CBM activities. However, at times, such permission may not be enough

as community members themselves might refuse to provide CSMs with CBM data as "they expect something in return" (CSM #9), either a solution to their problems, food, or money. Such mismatched community expectations may result in community members wanting to fight or riot (CS #10), endangering the CSMs.

Nevertheless, PM #4 remarked that communities "are very much open to anything that comes into the community", as long as "open communication and trust is… regularly updated". Similarly, CSM #7 said that they "need to explain thoroughly, be patient with them [community members] … make sure (to) lay out all information", so that "it becomes easy for them [community members] … and then they [community members] come and explain to you voluntarily" (CSM #9). Additionally, certain cultural norms have inhibited effective utilisation of CBM data. For instance, waste hotspots that were identified through CBM data and cleared via community clean-ups did not remain clean for long, as CSM #4 recalls: "after cleaning, you will still find waste in five days… when you go back to that particular place again.". Another instance would be how CSM #6 commented that "it's still a struggle for them [community members] to get used to using the stoves" that were meant to replace big fireplaces as a management action to combat deforestation of indigenous trees – a problem identified through previous qualitative CBM data.

4.2.2 Funding

Within the CCSMP, all CSMs were hired with funding from external donors. Such funds were also used to "implement solutions in communities" (CSM #8), although such solutions may be restricted as "there's not always budgets to buy fancy equipment" (PM #7). On this note, CSM #2 commented that more funds would be useful in getting higher community participation in meetings, as catered food is a big pulling factor; however, such meetings have yet to materialize due to limited funds. Furthermore, external donor funding "doesn't always provide proper management budgets", stretching thin the available funding for expanding outreach of CBM activities. Moreover, funding for the CCSMP was expected to cease at the end of March 2024, which would spell the end of CSMs' contracts and their CBM activities (CSM #7, CSM #10) – unless more funds could be procured from existing or new projects. This quagmire of funding has also plagued previous K2C-NPC projects, as CSM #10 recalled how "there are so many projects that come in, and then they [K2C-NPC] leave them hanging".

4.2.3 Institutional

Even though qualitative CBM data could yield useful information, the lack of ability and will from decision-makers (i.e. municipalities) to consider such information has inhibited the implementation of positive management actions. Sometimes, this situation arises as decision-makers are "under-resourced, under-financed… so (even though, for) some of these issues (where CSMs have already) collected the data…. nothing happens" (PM #6). At other times, decision-makers may simply "do nothing about it" (PM #06) in spite of the surfaced community problem. This "capacity gap" curbed CBM data from being used to its full extent (PM #06). Some CSMs have expressed feelings of frustration with the apathetic attitude of decision-makers, as CSM #6 puts: "I feel like the municipality is not backing us up that much… I think they come reluctant to what we give them (and) they do not follow in a quick pace… I wish that the municipality or the government can intervene more into the work… in order to make a better livelihood for our [CSMs] communities".

4.2.4 Nature of data

When asked about the rationale behind choosing to collect qualitative CBM data, PM #5 explained that "the qualitative way of doing it [collecting CBM data] allows for people to interpret things their own way and explain it in a way that makes sense to them". As descriptive recounts are more open-ended in nature, where "far fewer rules (exist) about how they [CSMs] have to collect things" (PM #5), CSMs are able to "flag things that they think are concerning for whatever reason…(which) helps us [PMs] to get a better insight into how community members themselves are perceiving things" (PM #5), reinforcing the bottom-up nature of typical CBM schemes. Furthermore, descriptive recounts were regarded to be at a "level that anyone can understand, relate and interpret or use" (PM #6), enabling local community members to meaningfully assess the data and act if necessary.

However, such descriptive recounts "make it very difficult to analyse" (PM #5). Sometimes, submissions do not make sense, pushing data capturers to call up CSMs for clarification (PM #1); while at other times, some information is just "not useful to the organization" (PM #2). The convoluted form of descriptive recounts renders the data capturing system "very clunky and difficult" (PM #7), and significantly increases the workload of data capturers (PM #2, PM #5) as "the right way to analyse it" (PM #1) remains elusive. Moreover, PM #5 remarked that "the data is just in such an unwieldy format that it's really difficult for them [researchers] to

pull out the information that's necessary", stifling the potential of "this incredible database, where there's potentially a lot of value" (PM #7).

4.2.5 Non-human

CSMs may be impeded from collecting qualitative CBM data due to uncontrollable circumstances, such as bad weather conditions (PM #4) – as CSM #3 mentioned: "during rainy season… I cannot go into the river" – and complicated terrains, that may pose safety hazards to CSMs (CSM #4, CSM 7). Another intractable situation would be the existence of loadshedding, which prevents CSMs from promptly submitting their descriptive recounts (CSM #5). However, loadshedding was only considered a minor hindrance as when "the power comes back, they [WhatsApp] will just send" (PM #1) over the messages typed offline.

4.2.6 Technology

WhatsApp became the main medium for collecting qualitative CBM data, once "smartphones became accessible for everyone" (PM #3). As a platform, WhatsApp was "very easy to use… it's well understandable in terms of like the data (and) it's not too complicated". WhatsApp was also regarded as multi-faceted "tool of communication, transparency and teamwork" (PM #6). However, automated compilation and streamlined analysis cannot be conducted over WhatsApp – a dedicated data capturer has to read through all messages and manually sort through all data (PM #5). To improve the data capturing process, K2C-NPC has tried to look into other applications, but sophisticated applications are not always compatible with CSMs' phones, nor can such alternative applications save messages offline in areas with no signal (PM #5). Moreover, these sophisticated applications may require larger amounts of mobile data, which CSMs may not be able to afford and funding budgets may not cover (PM #7).

4.2.7 Training

CSMs all reported to have received some form of training before going out to execute CBM activities. Such training covered the reporting protocol of what to look out for and how to structure their descriptive recounts (CSM #1, CSM #4, CSM #5), use of specific instruments (CSM #3), and interpretation of scientific data (PM #4). Additionally, CSMs have regular feedback sessions with data capturers, in which they would "exchange knowledge to… make the work a lot easier for everyone" (CSM #5). For instance, CSM #10 described how data capturers would "show it [CBM data] to us [CSMs]… (and tell us) how we can improve". These

training and feedback sessions have proven helpful in aiding CSMs to efficiently collect qualitative CBM data within the CCSMP (CSM #2, CSM #5, CSM #7).

4.3 RO3 – Proposed DAT Tool for Qualitative CBM Data

As outlined in Chapter 1, K2C-NPC specifically requested for assistance to improve their monitoring efforts, particularly in the analysis and transformation of qualitative CBM data collected by CSMs in the CCSMP. This gap in analytical capability was further evidenced in the previous section (i.e. 4.2.4 Nature of data). Additionally, several PMs reiterated K2C-NPC's request, such as PM #1: "I just hope you find a better way of doing it [analysing qualitative CBM data], it's going to help us… (and) I will be glad", and PM #5: "if you can come up with some kind of framework and a bit more structure for how we do this [analysis of qualitative CBM data], I think it would be really useful and beneficial". Thus, based on the interview data, a logic model was constructed outlining the process of creation of a simple data analysis and transformation (DAT) tool (Figure 6.). This tool could be used to generate overview data and identify key areas for further analysis, hopefully relieving some of the workload placed on data capturers, such that they can concentrate on conducting analyses that still require a human touch (e.g. thematic analysis).

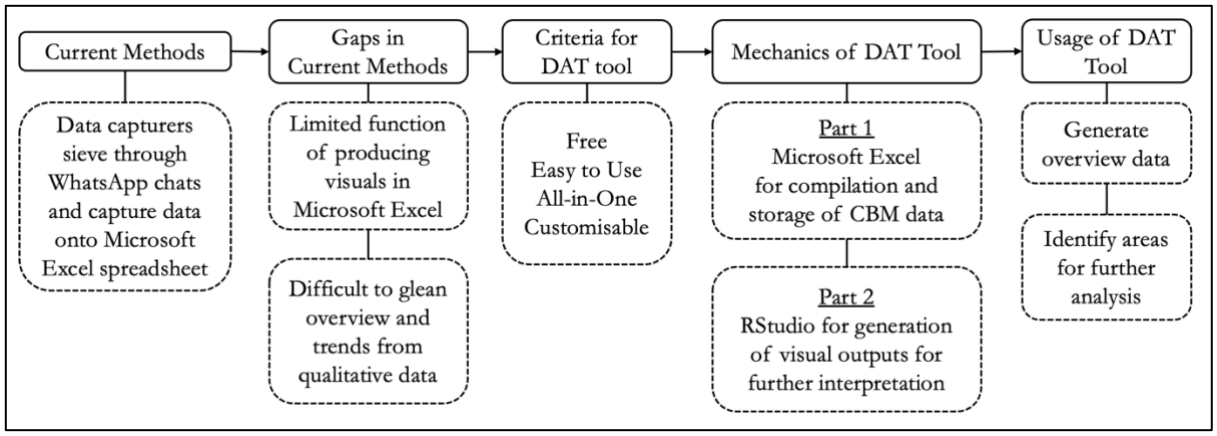

Figure 6. *Logic model derived from interview data. Created by author.*

4.3.1 Criteria for Proposed DAT tool

From interview data, I teased out four criteria that set the basis for the proposed DAT tool. First, the applications that make up this tool must be freely available, such that no additional financial burden is placed on K2C-NPC. Second, the tool should be easy to use, such that individuals can pick up the required skills with minimal training. Third, the tool should ideally be all-in-one, referring to the usage of only one application for data capturing, storage, transformation, and

analysis, so that CBM data does not have to be split up into different places to generate specific outputs (e.g. maps and graphs). Fourth, the tool should be customisable to account for future changes in data collection metrics.

4.3.2 Mechanics of Proposed DAT tool

According to the above criteria, two applications were chosen to form the components of the DAT tool, Microsoft Excel and RStudio (R Core Team 2023). Though one of the criterion was 'all-in-one', such an application would have to be directly connected to WhatsApp, the main data reporting channel within the CCSMP. This 'all-in-one' option was previously explored in K2C-NPC with a technology corporate but proved to be "very expensive" (PM #5). Hence, at the expense of this criterion, the DAT tool was split across two applications in the following parts: (1) data capturers record relevant data onto a Microsoft Excel spreadsheet, and (2) the spreadsheet will be uploaded into RStudio to generate outputs for further analysis and interpretation. The first part remains unchanged from current processes of data capturing, in which data capturers still have to sieve through WhatsApp chats and capture the relevant data on a Microsoft Excel spreadsheet. However, headers of the spreadsheet[8] were revamped: one new headers (i.e. 'Nature') was added, and the existing headers were renamed into a single word to smoothen the execution of the next step (summarised in Table 5.).

Table 5. *Suggested headers for Microsoft Excel spreadsheet of DAT tool. * indicates headers where inputted data was suggested for change by author. Created by author.*

Headers in DAT Microsoft Excel	Remarks
Date	From K2C-NPC's existing spreadsheet
Village	From K2C-NPC's existing spreadsheet
CSM	From K2C-NPC's existing spreadsheet
Latitude	Coordinates of latitude (numbers only)
Longitude	Coordinates of longitude (numbers only)
Type*	Refers to type of CBM activity
Nature*	Refers to whether recounts were actual data points
Description	Refers to the descriptive recounts provided by CSMs

[8] Three headers in K2C-NPC's existing spreadsheet, namely 'management', 'intervention', and 'image', were left out as they were deemed irrelevant for the scope of this research.

The newly added 'Nature' header should only have two options: 'Data' and 'Management', in order to differentiate descriptive recounts that could act as actual data points from those that were just updates provided by CSMs. For instance, CSM #7 engaged with a local waste picker to find out more about the waste issues in the area, however the waste picker was busy, and CSM #7 only reported their name and the waste picker's promise to have another meeting – such information would not be counted as an actual data point and would be classified as 'Management'. Similarly, the existing 'Type' header was suggested to have pre-determined options. Table 6. suggests an option list for 'Type' in the CCSMP, as gleaned from interview data on the kind of CBM activities CSMs have engaged in. These options could be modified to better suit the functions of the organisation or CBM program.

Table 6. *Suggested options for categorization of 'Type' in Microsoft Excel spreadsheet. Created by author.*

Options for "Type"	Remarks
Cultivated Land Monitoring	Agricultural engagements and observations
Waste Monitoring	Instances of waste pollution and/or clean-ups
Indigenous Knowledge Systems	Insights from indigenous elders/members
Freshwater Monitoring	Observations around freshwater body
Organizational Work	Administrative meetings and trainings
Enterprises Engagement	Insights from small and medium business owners
Others	Any descriptions that do not fit the above

This Microsoft Excel spreadsheet should be saved in a file, that also contains the self-created RStudio script (refer to Appendix 8.6). This script was written with the following packages: readxl (Wickham and Bryan 2023), dplyr (Wickham et al. 2023), tidyverse (Wickham et al. 2019), ggplot2 (Wickham 2016), ggmap (Kahle and Wickham 2013), tm (Feinerer, Hornik, and Meyer 2008), wordcloud (Fellows 2018), and RColorBrewer (Neuwirth 2022). Before running the script, some adjustments have to be made to the working directory and file names, in order to fit different users' laptops and configurations. After these adjustments, the script can be run in its entirety or in parts to generate different outputs. The outputs that could be generated without additional coding are:

- Map of locations where CSMs have conducted CBM activities,
- Bar graph of the types of CBM activities executed by all CSMs combined,
- Stacked bar graph of the types of CBM activities conducted by each CSM,

- Word cloud of the most mentioned words in descriptive recounts.

Examples of these outputs, as derived from January 2023 data of the CCSMP, can be found in Appendix 8.7. The visuals of all outputs could be adjusted according to the preference of the user. Given the flexibility of RStudio, additional outputs (e.g. compilation of locations of CSMs across months) could also be generated to fit the various needs and functions of the organisation.

5. Discussion

5.1 Outcomes From Collection and Use of Qualitative CBM Data

Most of the outcomes emerging from interview data with CSMs and PMs were aligned with existing literature, specifically the category of personal outcomes. All personal outcomes – attitude, knowledge and skills, and behaviour – have been previously reported in existing CBM literature. For instance, CBM participants from Canada recounted how lake monitoring have increased their knowledge about water quality issues, which not only deepened their affinity toward nature but also promoted positive behavioural change (McKay and Johnson 2017b). Another instance was gleaned from the Potshini catchment in South Africa, where CBM participants gained an increased knowledge of hydrological processes, which enhanced their sense of ownership of the catchment environment and led to an increased participation in other water resource management action (Kongo et al. 2010). Both these examples mirror similar experiences reported by CSMs in the CCSMP. However, a slight difference of these two examples and this thesis research was how both the Canadian and South African examples alluded to the relationships between knowledge, attitude, and behaviour, meaning that they attributed changes in attitude and behaviour to changes in knowledge. This allusion resonates with other literature espousing the links between these three outcomes (Osbaldiston and Schott 2012; Schultz 2011). Whereas, in this thesis research, the determinants and links between personal outcomes were not further explored, and each personal outcome was observed and reported in isolation.

Regardless, the personal outcomes could be mapped over to existing frameworks consolidating learning outcomes of CBM participants. However, no such framework exists in CBM literature thus far, hence neighbouring disciplines were sought. In the discipline of citizen science, Phillips et al. (2018) utilized empirical data and reviewed 40 journal articles to reconceptualize impact categories of informal science and education, and contextualize such impacts within environmental citizen science, ultimately proposing a framework for articulating and measuring individual outcomes from participation in citizen science. Within this framework, they consolidated the six most commonly desired and achieved learning outcomes from participation in environmental citizen science: (1) interest in science and the environment; (2) self-efficacy for science and the environment; (3) motivation for science and the environment; (4) content, process, and nature of science knowledge; (5) skills of science inquiry; and (6) behaviour and

stewardship. Table 7. details the definition of these six learning outcomes and showcases how they matched to personal outcomes emerging from this thesis research.

Table 7. *Personal outcomes emerging from interview data with CSMs and PMs, as mapped to Phillips et al. (2018) framework of individual learning outcomes from participation in citizen science. Created by author.*

Learning Outcomes (Phillips et al. 2018)	**Definition (Phillips et al. 2018)**	**Personal Outcomes**
Interest in Science and the Environment	Degree to which an individual assigns personal relevance to a science or environmental topic or endeavour.	Attitude
Self-efficacy for Science and the Environment	Extent of an individual's confidence in their capability to participate in science or environmental activity.	
Motivation for Science and the Environment	Goal-driven inclination to achieve science or environmental behaviour or activity.	
Content, Process and Nature of Science Knowledge	Understanding of scientific content and processes, and how science is conducted.	Knowledge and Skills
Skills of Science Inquiry	Procedural skills that can be transferred to daily life.	
Behaviour and Stewardship	Measurable actions resulting from engagement in citizen science, but external to the protocol activities and the specific project-based skills of the citizen science project.	Behaviour

The personal outcome of 'attitude' was mapped to three of the learning outcomes of the framework. This was not surprising as 'attitude' has been found to broadly encompass similar but distinct sub-constructs of interest, efficacy, curiosity, enjoyment, appreciation, values, beliefs, motivation, and identity (Osborne, Simon, and Collins 2003). Within the framework, Phillips et al. (2018) explicitly mentioned their intent to clarify this concept of 'attitude', resulting in its separation into interest, self-efficacy, and motivation. However, within this thesis research, the various sub-constructs of 'attitude' were consolidated during the data analysis for academic clarity. Though many sub-constructs were mentioned by CSMs and PMs, including interest, efficacy, enjoyment, beliefs, values, and identity, each sub-construct was only mentioned once or twice across all interviewees; hence, it made more sense to consolidate them into a singular outcome.

On the surface, the personal outcomes of 'knowledge and skills', and 'behaviour' seemed to exactly match the learning outcomes consolidated by Phillips et al. (2018). However, there were some slight differences. The 'content, process, and nature of science knowledge' outcome measures scientific literacy in three components; one relates to the subject matter (e.g. facts), another relates to the research methodologies, and the last relates to the epistemological underpinnings of science (e.g. empiricism, subjectivity, theories) (Phillips et al. 2018). Only the first two components emerged within the 'knowledge and skills' outcomes in this thesis research, while the last component was not mentioned at all. General literature has also reflected this tendency of overlooking the more abstract 'nature of science' component (Bauer, Petkova, and Boyadjieva 2000). Moreover, since this thesis research was based on qualitative semi-structured interviews, interviewees were only prompted further on topics that they raised, and 'nature of science' components may have been too abstract for articulation, compared to the other components of knowledge.

Additionally, in this thesis research, the personal outcome of 'behaviour' was segmented into two elements to reflect the intended subject of behavioural change – where internal-facing implies that individual behaviour was changed, while external-facing refers to individuals advocating for other parties' behavioural change. This segmentation was unlike the sole categorization of 'behaviour and stewardship' in Phillips et al. (2018), which only pertained to the internal-facing element. Although non-segmentation does not pose any problem, segmentation enables one to clearly delineate actions for personal impact (i.e. inward-facing behaviour) from actions that contribute to building community resilience (i.e. external-facing behaviour), which was a core long-term impact that CBM programs should inherently pursue (Shirk and Bonney 2015).

Likewise, community outcomes seemed to align with existing literature, though some differences were noted. 'Social capital' was the most aligned with existing literature: Through the CCSMP's activities, stakeholders (i.e. CSMs, community members, tribal and municipal authorities) regularly interacted, which built trust and improved the receptiveness of all stakeholders toward environmental action – this was reminiscent of how CBM galvanised collective action to sustain ecological tourism within an Ecuadorian community (Becker et al. 2005), and redress pollution hotspots in a Boston neighbourhood (Loh et al. 2002). Similarly, the community outcome of 'tangible environmental change' was steadily referred to in current literature. For instance, watershed restoration culminated as a key outcome from CBM groups

in Canada (Garda 2015). Other instances would be how illegal logging across Indonesia and Philippines ceased after CBM emerged (Institute for Global Environmental Strategies 2014), and how contaminated rainwater in South Africa was remediated through CBM efforts (Tandlich, Luyt, and Ngqwala 2013). However, such changes were not explicitly referred to as 'tangible environmental change' and were typically labelled as 'empowering potential'. Both these categorizations are not wrong per se, as they served to emphasise different aspects, where the former highlights physical changes while the latter spotlights shift in power.

On the other hand, the community outcome of 'environmental awareness' was rarely brought up in past research as most studies remained more concerned with changes in awareness of CBM participants, thus spotlighting their gains (Danielsen, Burgess, and Balmford 2005; Gofman 2010; Tozer 2020), rather than of the people around said participants (Garda 2015), such as family, friends, neighbours. Regardless, there were some studies that briefly affirmed this community outcome. Loh et al. (2002) described how community leaders and the general public, who were not directly participating in the CBM program, displayed an increasing awareness on air quality issues, while Buckland-Nicks, Castleden, and Conrad (2016) illustrated how awareness of watershed health and storm water pollution were raised among locals and automotive owners. Becker et al. (2005) anticipated that CBM participants would share knowledge with others around them and increase general community awareness of biodiversity but did not further outline whether such situations actually occurred.

Moving on to management outcomes, the 'external engagement' outcome was regularly featured within general literature. For instance, quantitative CBM data was used to compile maps and reports, illustrating environmental pain points and proposing remediation solutions, for presentation to and subsequent uptake by governing bodies (Loh et al. 2002; Garda 2015). Other instances involved the usage of qualitative CBM data, such as videos and photos, as focal points for discussions with the wider community, local decision-makers, and at times, national institutions (Lemaire and Muñiz 2011; Abonyi et al. 2013). Such examples mirrored how descriptive recounts obtained in the CCSMP were used to engage with external parties, including community members, funders, researchers, and traditional and governmental authorities.

Conversely, no literature highlighted how organizations have utilized qualitative nor quantitative CBM data for their internal management functions. Typically, CBM literature have

focused on expounding the added value of CBM from a scientific perspective, such as plugging data gaps which traditional scientists are unable to fulfil (Walker et al. 2016), rather than the contributions of CBM data for supporting internal management functions. Some possible reasons for this lack of emphasis could be: (1) supporting function of CBM for internal management is taken for granted, (2) internal management function as an outcome for CBM may be too dull for establishing the case for CBM, or (3) such literature exists within grey literature. However, such explanations remain speculative. Nevertheless, the management outcome of 'internal functions' were extensively raised by CSMs and PMs alike, when prompted about the usages of the collected qualitative CBM data in the CCSMP – a possible signal that the value of CBM data has been underestimated.

Some limitations to consider regarding the outcomes surfaced in this thesis research include the fact that results were only based off interviews, meaning that outcomes were self-reported by interviewees and no empirical testing was conducted to validate these outcomes. Moreover, negative examples of outcomes were notably absent, alluding to the probable presence of a social desirability bias, despite best efforts for mitigation. Nevertheless, on the whole, the outcomes emerging from this thesis research proved to be quite aligned with current literature, albeit with some differences. However, such differences were not counter to existing concepts, but rather emphasised previously overlooked elements, adding to the myriad of possible outcomes derived from the collection and utilization of CBM data. Also, a new categorization of outcomes – personal, community and management – was introduced, which could be adopted as a framework to build upon for future research consolidating the outcomes of CBM data, whether quantitative or qualitative in nature.

5.2 Factors Influencing the Collection and Use of Qualitative CBM Data

Majority of the factors that emerged coincided with existing literature, particularly funding, institutional, training and technology. Within the CCSMP, funding was cited to be crucial for supporting operations, but were sometimes insufficient and resulted in the discontinuation of some CBM activities. This reality typified other CBM programs in Sweden (Singh et al. 2014), New Zealand (Peters et al. 2016), and Bangladesh (Thompson, n.d.). Additionally, CSMs and PMs have deplored the limited usage of collected CBM data in informing management actions at the municipal level, which mirrored the inertia of Canadian decision-makers (McKay and Johnson 2017b; Carlson and Cohen 2018). On a brighter note, training opportunities were

reportedly well provided in the CCSMP, and was cited as a crucial enabler by both CSMs and PMs for ensuring quality of data; which were in line with experiences of other CBM practitioners (Savan, Morgan, and Gore 2003; Gofman 2010; Gomani et al. 2010; Buytaert et al. 2014; Kouril, Furgal, and Whillans 2016). Also, CSMs and PMs raised how the use of technology could dually enable and inhibit the achievement of CBM outcomes. This duality was reflected in existing literature debating the contributions of technology in CBM. For instance, Johnson et al. (2021) illustrated that digital platforms have facilitated CBM data management and analysis, while Andrachuk et al. (2019) purported the limited influence of smartphone technologies on conservation impact of CBM programs. Moreover, Del Carpio, Alpizar, and Ferraro (2021) found that though smart applications could increase cost-effectiveness of CBM programs, actual impact remained at modest levels.

However, literature could not be found to support the existence of two factors – culture and nature of data. A reason for this could be that these two factors were unique to qualitative CBM data, which current literature has been lacking in. This uniqueness could be exemplified by how collection of qualitative CBM data usually entailed engagement with community members, exposing CSMs to informal cultural norms and structures and resulting in information being collected in descriptive narratives, which otherwise might not have been experienced if CBM activities were limited to more quantitative approaches.

Additionally, most factors had a dual nature of being enablers and inhibitors. The inhibiting elements must be overcome for the effective collection and use of qualitative CBM data. Some factors, such as culture, technology and non-human, seem to be easier to surmount through transparent communication, thorough planning and providing room for adaptability (from interview data and Muhamad Khair, Lee, and Mokhtar (2021)). However, others may be harder to overcome, such as shortage of funds, which requires consistent work and more creative fixes (e.g. offering CBM as a paid service to corporates, which was an idea shared by a PM in the CCSMP), and institutional factors, which depend on a confluence of other considerations (e.g. political power, national budgets, and strategies) that may be out of the control of CBM practitioners.

Overall, factors influencing collection and use of qualitative CBM data were mostly aligned with existing CBM literature, with two notable exceptions that may be unique to CBM programs dealing with qualitative data. Additionally, the approach of examining the dual nature

of factors as enabling and inhibiting could be used to remind CBM practitioners of the key elements to include and guard against in CBM program design and implementation.

5.3 Evaluation of Proposed DAT Tool

The DAT tool was made up of two parts: Microsoft Excel spreadsheet that served as a platform for data compilation and storage, and RStudio to generate visual outputs for further analysis and interpretation. Though the continued usage of Microsoft Excel spreadsheet was reminiscent of existing data capturing process, a revamped structure for categorisation was provided to ease transition into the second half of the tool. The outcomes of the DAT tool were two-fold. First, in the generation of overview data outputs that could be used for a multitude of management purposes, such as to report to funders about CBM activities, review breadth of work conducted by CSMs, and highlight areas where CBM activities were lacking. Second, in the identification of key themes to guide further analyses, that require a human touch. For instance, most commonly mentioned words could be gleaned from the word cloud output, enabling user to gain inspiration or focus thinking, before conducting a deeper content or thematic analysis of qualitative CBM data.

A strength of the DAT tool was in the time and effort saved in transposing data onto different applications to generate different visual outputs. Moreover, these visual outputs could be generated and saved within one click, albeit after minor tweaks made to fit the configuration of the users' device. This extra time could be channelled into other work. Another strength lies in the customisability of the DAT tool. With some training, users would be able to adapt the base script provided to account for additional data metrics or for more advanced uses. Furthermore, such training can be easily conducted by oneself, given the robustness of online R depositories and forums, where discussions on innovative ways for data analysis, transformation, and visualization, or for troubleshooting coding errors are regularly maintained.

However, there were several limitations to the DAT tool. First, this DAT tool was solely generated from interview data with a relatively small number of 17 participants and constructed based on the limited experience and capability of the author. No empirical testing was conducted to ascertain the anticipated outcomes and strengths of the DAT tool. A suggested methodology to ascertain the value of this DAT tool could be: (1) introduce the functions of the DAT tool to PMs working with qualitative CBM data for adoption, and (2) after a period of

time, conduct follow-up interviews with PMs to gain insight into their experiences, satisfaction levels and challenges faced when using the DAT tool. This suggested methodology was inspired by user experience studies, that seek to understand how users interact or use a product (Vermeeren et al. 2010). Second, the DAT tool remains inadequate in surfacing trends in qualitative CBM data. Yet, such may not be entirely the fault of the DAT tool as the surfacing of trends requires consistent data collection over time at roughly the same locations or with the same subjects (Hyndman and Athanasopoulos 2018; Sergeant, Moynahan, and Johnson 2012). Thus, one may have to relook at data collection metrics, indicators, and protocols, in order to collect the right nature and amounts of data for trend analyses to be feasibly conducted. However, this could introduce a certain level of stringency into qualitative CBM data collection, which may unintentionally affect outcomes.

Regardless, this DAT tool was not meant to be an endpoint but instead, as a starting point that can be built upon by other CBM researchers and practitioners who are or may seek to work with qualitative CBM data.

6. Conclusion

In the face of challenges that plagued conventional scientific monitoring programs, CBM has emerged as an affordable and reliable method to monitor environments across extensive time and geographical scales. This appeal of CBM is further strengthened by its community empowering potential. Thus, CBM programs have popped up in all corners of the globe, which correspondingly inspired academics to focus attention and effort on researching and documenting CBM approaches, methods, outcomes, and program designs. However, majority of such CBM literature was based in developed contexts or situated within formalized societies and remained primarily concerned with quantitative data. This revelation contrasted the reality, in which CBM programs were reportedly more prevalent in developing contexts, in which qualitative CBM data is typically collected. Hence, such academic gaps could manifest into a practical challenge, where CBM practitioners in developing contexts and/or those that work with qualitative CBM data have few frameworks, models, and tools to guide the design, implementation, and evaluation of their programs. Thus, this thesis research aims to alleviate these research gaps through a qualitative research design, spotlighting a CBM program conducted in K2C, South Africa.

By employing semi-structured interviews and a thematic analysis, three main categories of outcomes that CSMs and PMs have gained through the collection and utilization of qualitative CBM data were gleaned. The first category was personal outcomes – outcomes experienced by direct CBM participants – which comprised of three sub-outcomes, including a more positive attitude towards environment and culture, an increased level of environmental knowledge and skills, and increased instances of environmentally-friendly behaviour. The second category was community outcomes – outcomes experienced by other stakeholders who did not directly participate in CBM programs – which also included three sub-outcomes, such as heightened environmental awareness, tangible positive environmental changes, and enhanced social capital. The third category was management outcomes – outcomes from the actual utilization of CBM data – where it was shown that qualitative CBM data was useful in informing both internal functions and external engagements of K2C-NPC. These categories of outcomes were quite aligned with existing CBM literature, albeit with some differences that emphasised previously overlooked elements. These outcomes could be used to guide CBM practitioners in selecting indicators for CBM program evaluations.

With the same interview data, seven factors were found to influence the effective collection and use of qualitative CBM data. These factors were culture, funding, institutional, nature of data, non-human, technology, and training. Most of these factors were not new within CBM literature, except for culture and nature of data. These two factors seem to be uniquely related to qualitative CBM data and could be further explored in future research. Additionally, majority of the seven factors were also shown to be both enabling and inhibiting the collection and utilization of qualitative CBM data. Some of the inhibitors may be out of the control of CBM practitioners and thus, hard to surmount. Regardless, these factors could serve as a reference for CBM practitioners to draw from when thinking about possible challenges and mitigating measures for effective program design and implementation.

In a different vein, by applying a logic framework approach, a preliminary DAT tool was proposed and exemplified with K2C-NPC's existing qualitative CBM data. This tool was constructed based on four criteria – free, easy to use, all-in-one, customisable – which were surfaced from interview data. The DAT tool consists of two parts; one being the usage of Microsoft Excel spreadsheet for data capturing and initial screening, and the other being RStudio for generating visual outputs that could be used to provide overviews of CBM activities for management purposes, and for identifying key themes to guide further qualitative analyses. However, this DAT tool was not able to surface trends in qualitative CBM data, and PMs may have to look into refining data collection metrics and indicators for trend analyses to be feasibly conducted. Regardless, the DAT tool was only intended to serve as a starting point for other CBM researchers and practitioners to build on and adapt to their specific functions and needs.

Overall, this thesis research provided clarity on the outcomes, factors, and tools for the effective collection and utilization of qualitative CBM data. New findings were uncovered, but some limitations remain. First, all findings were based on self-reported data and were not empirically validated. Second, given the place-based nature of CBM programs, the findings could not be regarded as conclusive across all CBM programs. Hence, the following avenues for future research are recommended:

- Empirically validate the outcomes derived from, and factors influencing, the collection and utilization of qualitative CBM data.
- Expand research scope to include other stakeholders tangentially connected to CBM programs, such as municipalities, funders, researchers, private corporations, and other local community members.

- Examine other CBM case studies collecting and using qualitative data in the South African context and beyond.
- Explore how cultural norms and structures may affect functioning of CBM programs.
- Explore the causal links between outcomes derived from the collection and utilization of qualitative CBM data.
- Explore the connections between outcomes derived from, and factors influencing, the collection and utilization of qualitative CBM data.
- Explore the weight of importance among factors influencing the collection and utilization of qualitative CBM data.
- Optimize data collection metrics and indicators for producing trend data, within this case study or beyond.
- Test and improve the usability of the DAT tool among CBM practitioners.

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Unpublished Interviews

Alton. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Butswana, 6 March 2024.

Bert. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Butswana, 6 March 2024.

Carissa. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Butswana, 6 March 2024.

Cecil. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Acornhoek, 8 March 2024.

Dena. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Acornhoek, 8 March 2024.

Kate. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Acornhoek, 8 March 2024.

Larry. Program manager at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Hoedspruit, 20 March 2024.

Lolita. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Acornhoek, 8 March 2024.

Lorene. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Butswana, 6 March 2024.

Manuela. Program manager at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Hoedspruit, 6 March 2024.

Marilyn. Program manager at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Hoedspruit, 4 March 2024.

Nichole. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Butswana, 6 March 2024.

Roscoe. Program manager at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Hoedspruit, 4 March 2024.

Tammi Program manager at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Hoedspruit, 4 March 2024.

Terra. Program manager at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Hoedspruit, 6 March 2024.

Tonya. Program manager at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Hoedspruit, 8 March 2024.

Yvette. Community science monitor at Kruger to Canyons Biosphere Region Non-Profit Company. Personal Communication. Jocelyn Wong/author. Butswana, 6 March 2024.

8. Appendix

8.1 Question list for semi-structured interviews

The below set of questions were asked to CSMs. All questions were covered, but exact phrasing may have differed, while further prompts were posed for clarification.

1. When did you start working under the CCSMP in K2C? What are your duties?
2. Could you describe the reporting procedures related to qualitative CBM data?
3. Were you provided with any training on what and how to structure your reports?
4. What do you like best about collecting data in this way?
5. Did you face any difficulties during collection of data? Were they resolved?
6. Is there anything you think can be changed/ improved in the current processes?
7. What do you think are the strengths and weaknesses of the qualitative data that you have collected?
8. What do you think happens to the qualitative data you have collected?
9. Has this qualitative CBM data brought any benefits to yourself and your community?
10. Is there anything that you wish you could change or do more of as a CSM at K2C?
11. Do you have anything else you would like to add regarding the collection of qualitative CBM data in K2C?

The below set of questions were asked to PMs. All questions were covered, but exact phrasing may have differed, while further prompts were posed for clarification.

1. Could you briefly describe your role and the projects you are involved in in K2C-NPC?
2. What was the rationale for collecting this qualitative CBM data?
3. What do you think are the strengths and weaknesses of this qualitative CBM data?
4. How is the qualitative CBM data collected/analysed? Why were this method chosen?
5. Have there been any challenges in the collection/analysis of data? Were they overcome?
6. How has the qualitative CSD been used so far?
7. In your opinion, do you think there are other avenues for this qualitative data to be used within the K2C region?
8. Is there anything else you would like to add about qualitative CBM data?

8.2 List of Codes

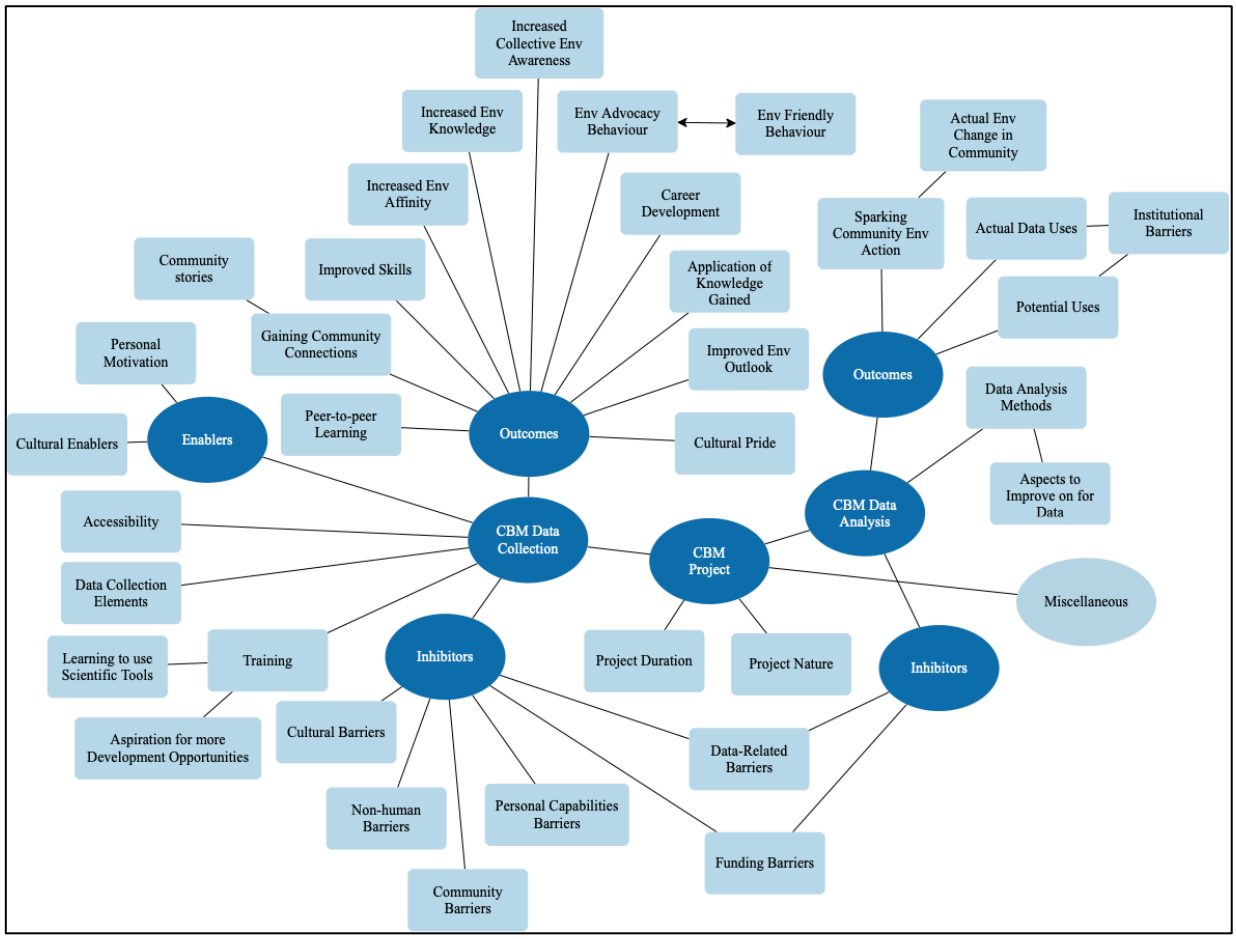
The below table presents the list of all 121 codes generated during data analysis in Nvivo 14. Codes were arranged in alphabetical order.

anecdotal information	lack of funding inhibiting CBM data from being shared with community
applying knowledge learnt from cbm data collection to other projs	lack of funding to maintain proper database
barriers posed by municipality	lack of knowledge
being transparent	learning how to use scientific tools
bringing science to communities	loadshedding
challenge in ensuring accurate advocacy	local networks make collection easier
challenges of data storage	losing trust of community
community event from CBM data	mismatched community expectations
confident in abilities for further career	monthly report
continuity of schema	nature-based solutions
corrective action	needing to clarify qualitative cbm data
data available to be used by csm	opportunities for generational learning
data capturing process is clunky	opportunities for reengagement with community
data for management purposes	opportunity to learn
data overlap and fatigue	people cheating the system
data snapshot of the landscape	people inhibiting collection of cbm data
data used to get funding	positive behavioural change
data used for formal research purposes	positive reputation within community
data used for funding reporting	possible use of coding software for analysis
data used for future purposes	potential for cbm to be a paid service
data used for municipal decisions	potential municipality use
data used for public reporting	potential outcome of increasing resilience in communities
desire for cbm data to be used more by municipalities	potential research use
desire for increased use of cbm data	produced maps
desire for more training on env knowledge	protocol to ease analysis
desire for more workshops	provision of feedback to csms
desire to be involved on more social aspect	qualitative data collection more accessible to csm
desire to engage in more env advocacy	qualitative nature of cbm data
desire to involve in restoration activities	recalcitrant behaviour
desire to involve in waste reduction activities	role of data capturer
env advocacy behaviour	safety hazards

environmental challenges in collecting cbm data	schema for analysing
env education	smartphone penetration
equipment difficulty	social learning
feedbacking to local stakeholders	social media for env advocacy
fulfilment of personal env interest	spark new project ideas
gaining networks to mobilise community	successful instance of CBM activity
gaining real time data from the ground	sustainability of projects
gathering community support	tangible env changes to communities
good feelings toward env	teamwork
guidance on what to look out for	technology advancements
hard to analyse	training provided for collection of CBM data
hard to change cultural norms	translation requirement
hard to extract information	type of cbm activities
importance of clear timeline from the onset	unable to overcome attitudes of community
improved problem solving skills	unawareness of where CBM data feeds into
improving own skills through collection of CBM data	uncertainty in continuity of project
inaccuracy of GPS	unusual format for research
increased awareness of env to community	unwillingness of community to participate
increased connection to env	upskilling in env field
increased cultural pride	use of spreadsheet
increased enjoyment in env	wanting a strong data analysis system
increased hope for a better future	wanting to extract trends from qualitative cbm data
increased knowledge	wanting to showcase value of cbm data
increased instances of recycling	wanting standardised metrics for reporting
increased interaction with env resources	wanting structure for analysis
increased understanding of how env works	weather inhibiting collection of CBM data
increased understanding of how humans interact with env	weather not a big issue
initiative from community for env change	whatsapp
insight into community structure	wish to get certified
instils flexibility in project	

8.3 Initial thematic map

This initial thematic map was generated using Nvivo 14 by author. The lighter blue rectangles were the themes generated from the codes – 36 themes in total – while the darker blue circles were categories used to make sense of generated themes among each other. This colour palette was adopted from a colour-blind safe scheme outlined by Phillips (2022).



8.4 Participant information sheet

This participant information sheet was digitally provided to all participants before the interviews and were subsequently retained by participants for their record-keeping.

Attachment A: Participant Information Sheet

The researcher, Jocelyn Wong Min Yi, is inviting you to participate in a ~60-minute interview to share your perceptions and experiences of collecting and/or analysing qualitative Citizen Science Data (CSD). The following information provides details about the research project, and how your responses will be recorded, used, stored, and disseminated.

Description of Research

The research centres around qualitative Citizen Science Data (CSD), which refers to descriptive data collected by ordinary citizens who are unlikely to have received formal academic training in the related discipline. Although qualitative CSD can provide a rich amount of data, practitioners struggle to effectively sieve through the noise and generate actionable insights. This could be due to the non-applicability of conventional analytical CSD tools, which are more suited for processing quantitative CSD, and the absence of past examples to learn from.

Thus, by taking the endeavours in qualitative CSD of the Kruger to Canyons Biosphere Region Non-Profit Company (K2C-NPC) as case studies, the aim of this research is to construct a qualitative CSD collection and analytical framework, that could serve as a preliminary prototype for practitioners who are currently or wish to employ qualitative CSD for research and monitoring purposes. Specific research questions relate to the exploration of the potential of qualitative CSD, the evaluation of existing qualitative CSD collection and analytical procedures of K2C-NPC, and the operationalization of a logical workflow for collecting and analysing qualitative CSD.

Record and Dissemination of Results

Your responses will be audio recorded and transcribed by the researcher, before being used to inform the analyses, discussion, and conclusions of the researcher's thesis, for the fulfilment of a Masters in Environmental Science, Policy & Management. The thesis will be archived on the academic portal of the Central European University and will be shared with K2C-NPC to strengthen their future research and monitoring endeavours. The thesis may also be published in an academic journal in the future.

Data Storage and Management

All data and associated analyses will be stored, perused, and analysed offline behind a personal password-protected computer and external hard drive. All data and associated analyses will be stored for an undefined amount of time but would not be utilized beyond the scope as stated above. Should you wish to obtain a copy of your responses (e.g. audio file or transcript), the researcher will grant your request at the earliest convenience via email.

1/2

Confidentiality & Anonymity

All personal information provided will be kept confidential. Only anonymised data and/or consolidated analysis will be made available to others, while access to raw data and full transcripts will be solely limited to the researcher. In all publications, draft and final, you will be referred to with a pseudonym, unless otherwise discussed. If the researcher wants to publish any information that may result in your identification, the researcher must obtain further consent from you.

Voluntary Participation

Your participation is entirely voluntary. The researcher is strictly forbidden from coercing your participation. You have the right to withdraw your consent for participation in this research, however the researcher may take differential action depending on when you withdraw consent. If you withdraw consent before or on 1st April 2024, the researcher must destroy all data pertaining to you across all storage devices. If you withdraw consent after 1st April 2024, the researcher may refuse your withdrawal if deletion of your data jeopardizes the research outcomes.

Further Action

If you agree to all terms, as outlined above, please complete *Attachment B: Consent Form* and submit it to the researcher.

For further enquiries or concerns, please contact:

Jocelyn Wong Min Yi | <REDACTED>
MSc Student, Researcher
Department of Environmental Sciences and Policy
Central European University, Vienna, Austria

If you feel that the researcher has not adhered to the procedures outlined in this sheet, please contact:

Dr. Brandon P. Anthony | <REDACTED>
Head of Department, Research Supervisor
Department of Environmental Sciences and Policy
Central European University, Vienna, Austria

8.5 Consent form

This consent form was reviewed and signed by all participants prior to interviews, and signed copies were digitally sent to all participants after the interviews.

Attachment B: Consent Form

The researcher, Jocelyn Wong Min Yi, is inviting you to participate in a ~60-minute interview to share your perceptions and experiences of collecting and/or analysing qualitative Citizen Science Data (CSD). Before filling in this form, please read *Attachment A: Participant Information Sheet*.

Dissemination of Results

- ☐ I understand the nature and objectives of the research.
- ☐ I understand that my responses will only be used to inform the researcher's Master's thesis, for the fulfilment of a Masters in Environmental Sciences, Policy and Management.
- ☐ I understand that the research will be archived on the Central of European University's database and be shared with the Kruger to Canyons Biosphere Region Non-Profit Company.
- ☐ I understand that parts of, or the whole, thesis may be published in an academic journal in the future.

Interview Procedures

- ☐ I consent for the interview to be audio recorded.
- ☐ I consent for my responses to be transcribed.
- ☐ I understand that I can decline to answer any questions and/or partake in further research activities if I feel uncomfortable.

Data Privacy, Storage and Management

- ☐ I understand that only the researcher will have access to raw data and full transcripts.
- ☐ I understand that all data and associated analyses will be stored for an undefined amount of time but will only be used within the scope of this research.
- ☐ I understand that my identity will be anonymised in all publications of the research.
- ☐ I understand that the researcher will seek further consent from me before the publication of any information that may result in my identification.
- ☐ I am aware that I can request for a copy of my responses, whether the audio file or the transcript.

Voluntary Participation

- ☐ I understand that my participation is voluntary.
- ☐ I understand that I can withdraw my participation from the research until 1st April 2024, after which the researcher may refuse my withdrawal if it jeopardizes the research outcomes.
- ☐ I have had the opportunity to ask questions and have received satisfactory answers.

Name of Participant: **Signature:** **Date:**

Name of Researcher: **Signature:** **Date:**

8.6 DAT Tool – RStudio Script

This script was created by the author and can be wholly copy and pasted from the first hash line to the last hash line into a blank RStudio script. As good practice, any additions or modifications should be reflected with a comment (i.e. beginning with a #).

```
################################################################################
## This script was created for the DAT tool as part of the thesis titled:
  ## Through the Eyes of Locals: An exploration of the outcomes, factors,
  ## and tools for effective utilization of qualitative community-based
  ## monitoring data in the Kruger to Canyons Biosphere Region, South Africa
  ## Author: Jocelyn Wong | MESPOM 2024
  ## Last Updated: 30/5/24

## The steps outlined below can be run in its entirety or in part, depending
## on the functions and needs of organization. Any modifications should ideally
## be noted in the comments
################################################################################
## SECTION 1: THINGS TO CHANGE TO SUIT USER'S CONFIGURATIONS
  # set working directory to a file containing this script
  # and data file (i.e. spreadsheet) to be analysed

setwd("~/Desktop/Thesis/Thesis Writing/DAT_Tool")
################################################################################
## SECTION 2: INSTALLING PACKAGES FOR USE
  # run the codes as they are
  # check if packages were installed in the right panel menu

install.packages("readxl","dplyr","tidyverse","ggplot2","ggmap","tm",
                 "wordcloud","RColorBrewer")

  # load installed packages, functions of are stated next to command

library("readxl") # import the data from Excel file
library("dplyr")  # filter and reformat data frames
library ("tidyverse") # tidy data
library("ggplot2") # graphics
library("ggmap") # map
library ("tm") # text mining
library("wordcloud") # wordcloud
library("RColorBrewer") # color palettes
################################################################################
## SECTION 3: READ DATA AND CLEAN UP
  # change the filename to the spreadsheet being analysed
  # double-click on loaded sheet to check
  # ensure packages "readxl" and "tidyverse" are loaded

ccsmp <- readxl::read_excel("CCSMPAnnual.xlsx", # name of spreadsheet
                            sheet = "JAN_2023") # for specific tab in sheet

  # convert coordinates to number
  # check that Latitude and Longitude are "num" not "chr" in right panel
```

```
ccsmp$Latitude=as.numeric(ccsmp$Latitude)
ccsmp$Longitude=as.numeric(ccsmp$Longitude)
################################################################################
## SECTION 4: GENERATING OVERVIEW DATA - MAPS
  # ensure packages "ggplot2" and "ggmap" are loaded
  # note here that a Google API is needed - free but a sign-up is needed.
  # API keys MUST be kept private as access to API may allow others to
  # access your Google services

api_secret <- 'placeholder API key' # copy your API key here
register_google(key = api_secret) # load api into R

  # crop extent of map by centering medians of data coordinates

midlong <- median(ccsmp$Longitude, na.rm = TRUE) + 0.1 # median of longitude
midlat <- median(ccsmp$Latitude, na.rm = TRUE) # median of latitude
    # note here that outlier points may not be shown
    # to adjust extent, modify midlong/midlat by adding (as shown above)
    # or use zoom in the next command to scale the map to your preference

ccsmpLocation <- c(lon = midlong, lat = midlat) # setting extent
ccsmpmap <- get_map(location=ccsmpLocation,
                source="google", maptype="roadmap", zoom = 10)
    # source can be changed to "stamen"
    # maptype can be changed to "terrain", "satellite", or "hybrid"
    # zoom must be a whole number from 3 to 21
    # higher number means increased crop

  # plot the map and points, map should pop up in the right panel
  # showing locations where CSMs have collected data
  # map can be saved by clicking export in the right panel

ggmap(ccsmpmap) + # plots map
  geom_point(data=ccsmp, aes(x=Longitude, y=Latitude), color="darkred",
             alpha = 0.6, size = 2) + # plots data points
    # color changes the color of data point
    # alpha changes transparency of data point (0-1)
    # size changes size of data point
    # additional customisations can be made
  labs(x = 'Longitude', y = 'Latitude') + # change axis labels
  ggtitle('Activities of CSMs in January 2023') + # insert title of map
  theme(plot.title = element_text(hjust=0.5, face = "bold"))
    # centralise title and bold font (can be change to italics)

  # to auto save map, store above command into map and run ggsave("map.jpeg")
  # file format can be changed to .png or .pdf
################################################################################
## SECTION 5: GENERATING OVERVIEW DATA - BAR GRAPH

  # plot graph, showing types of engagement conducted by CSMs
  # graph can be saved by clicking export in the right panel

ggplot(ccsmp, aes(x = Type)) + # plots graph, counting 'Type'
  geom_bar() + # bar graph
```

```
  xlab("") + ylab("Count") + # change axis titles, x axis left blank
  ggtitle('Activities of CSMs in January 2023') + # insert title of map
  geom_text(stat='count', aes(label=..count..), vjust=-0.5, # show counts
            colour = "black", fontface = "bold") + # adjust color and font face
  theme(axis.title = element_text(face="bold")) + # bolding axis labels
  theme(plot.title = element_text(hjust=0.5, face = "bold"))
     # centralise title and bold font (can be change to italics)

  # to auto save graph, store command into graph and run ggsave("graph.jpeg")
  # file format can be changed to .png or .pdf
################################################################################
## SECTION 6: GENERATING OVERVIEW DATA - STACKED BAR GRAPH

  # create frequency table, showing which CSMs did what

table_data <- as.data.frame(table(ccsmp$CSM, ccsmp$Type, useNA = "ifany"))

  # plot stacked bar graph
  # stacked bar graph can be saved by clicking export in the right panel

ggplot(table_data, aes(x = Var1, y = Freq, fill = Var2, label= Freq)) +
  geom_bar(stat = "identity", color="black") + # plot stacked bar graph
     # color for the lines around each y variable
  labs(title = "Activities of each CBM in January 2023",
       x = "CSM", y = "Count") + # add title and axis title
  geom_text(data=subset(table_data,Freq != 0), size=3, # show counts
            position = position_stack(vjust = 0.5), fontface="bold") +
  scale_fill_brewer() + # adjust color palette
  guides(fill = guide_legend(title = "")) + # change legend title, left blank
  theme(plot.title = element_text(hjust=0.5, face = "bold"))
     # centralize title and bold font (can be change to italics)

# to auto save graph, store command into graph2 and run ggsave("graph2.jpeg")
# file format can be changed to .png or .pdf
################################################################################
## SECTION 7: IDENTIFY KEY THEMES - WORD CLOUD
  # ensure packages "dplyr","tm","wordcloud","RColorBrewer" are loaded

  # filter out recounts of actual data point
  # this example further filters only one type of CBM data

ccsmp_filtered <- ccsmp %>% filter(Type == "Cultivated Land Monitoring")
text <- ccsmp_filtered$Description # create a vector
docs <- Corpus(VectorSource(text)) # create a corpus

  # cleaning data for smooth counts

docs <- docs %>%
  tm_map(removeNumbers) %>% # remove numbers
  tm_map(removePunctuation) %>% # remove punctuations
  tm_map(stripWhitespace) # remove white space
docs <- tm_map(docs, content_transformer(tolower)) # transform to lower case
docs <- tm_map(docs, removeWords, stopwords("english"))
     # remove common stopwords, "english" is built-in list
custom_stopwords <- c("will", "also","conducted","visited","mrs","mr","today",
```

```
                "todays","said")
    # create additional list of stopwords to remove
docs <- tm_map(docs, removeWords, custom_stopwords)
    # remove additional stopwords
dtm <- TermDocumentMatrix(docs) # create matrix part 1
matrix <- as.matrix(dtm) # create matrix part 2
words <- sort(rowSums(matrix),decreasing=TRUE) # extracting count of words
df <- data.frame(word = names(words),freq=words) # create dataframe

  # plot word cloud, showing most commonly mentioned words
  # word cloud can be saved by clicking export in the right panel

wordcloud(words = df$word, freq = df$freq, min.freq = 1,
        max.words=30, random.order=FALSE, rot.per=0.35,
        colors=brewer.pal(8, "YlOrRd"))
    # word with frequency below min.freq would not be plotted
    # max.words to change numbers of words
    # random.order to plot words in random order
    # false to plot for decreasing frequency
    # rot.per = proportion of words with 90 degree angle
    # colors change according to RColorBrewer palettes
##############################################################################################
```

8.7 DAT Tool – Visual outputs from January 2023 Data of CCSMP

The following figures present the outputs that were generated from the DAT tool, based on CCSMP's January 2023 data. Note here that names of CSMs were pseudonymized to maintain anonymity.

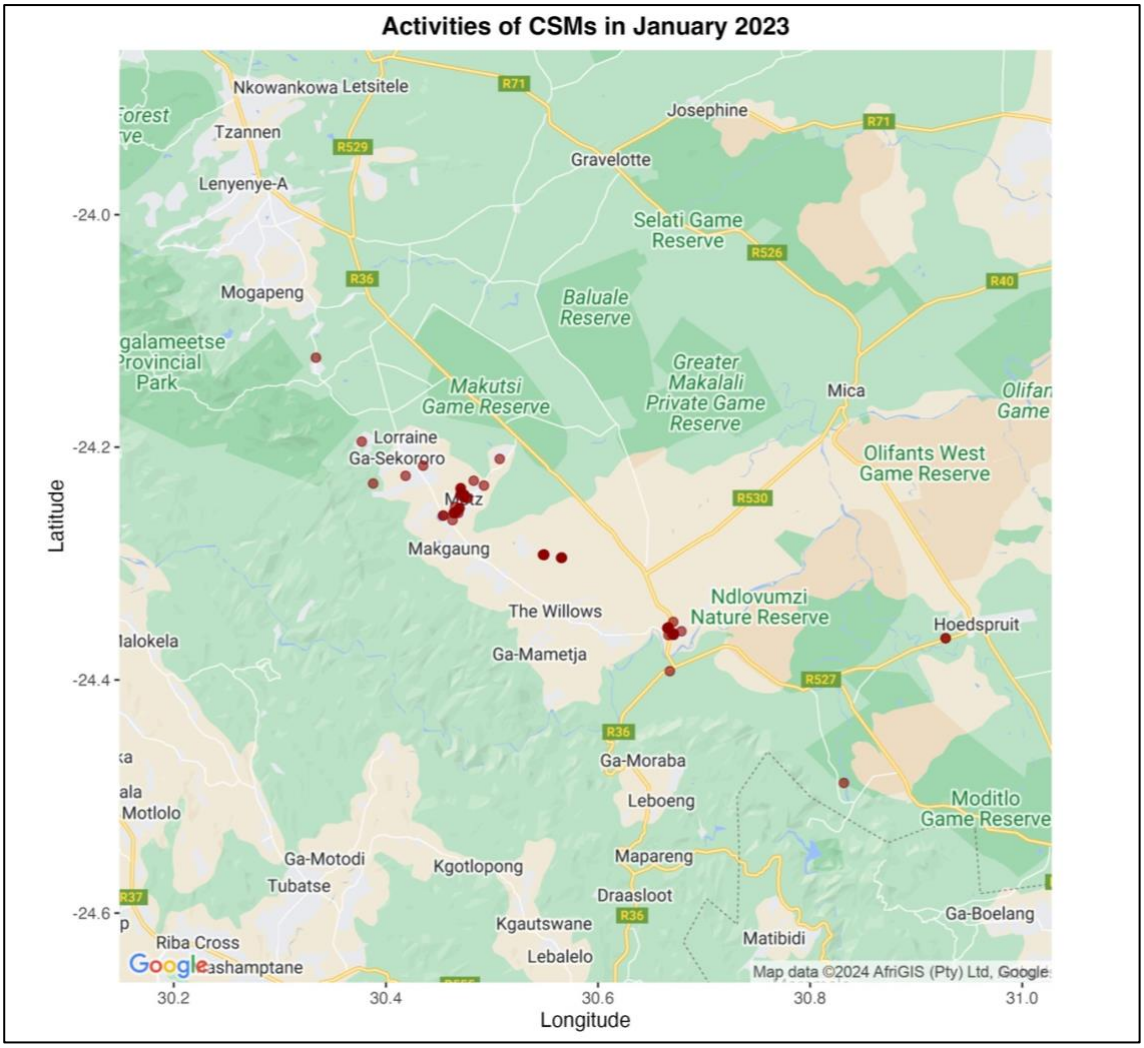


Figure 7. *Output #1 – Map of locations showing where CSMs have conducted CBM activities. Produced from DAT tool by author.*

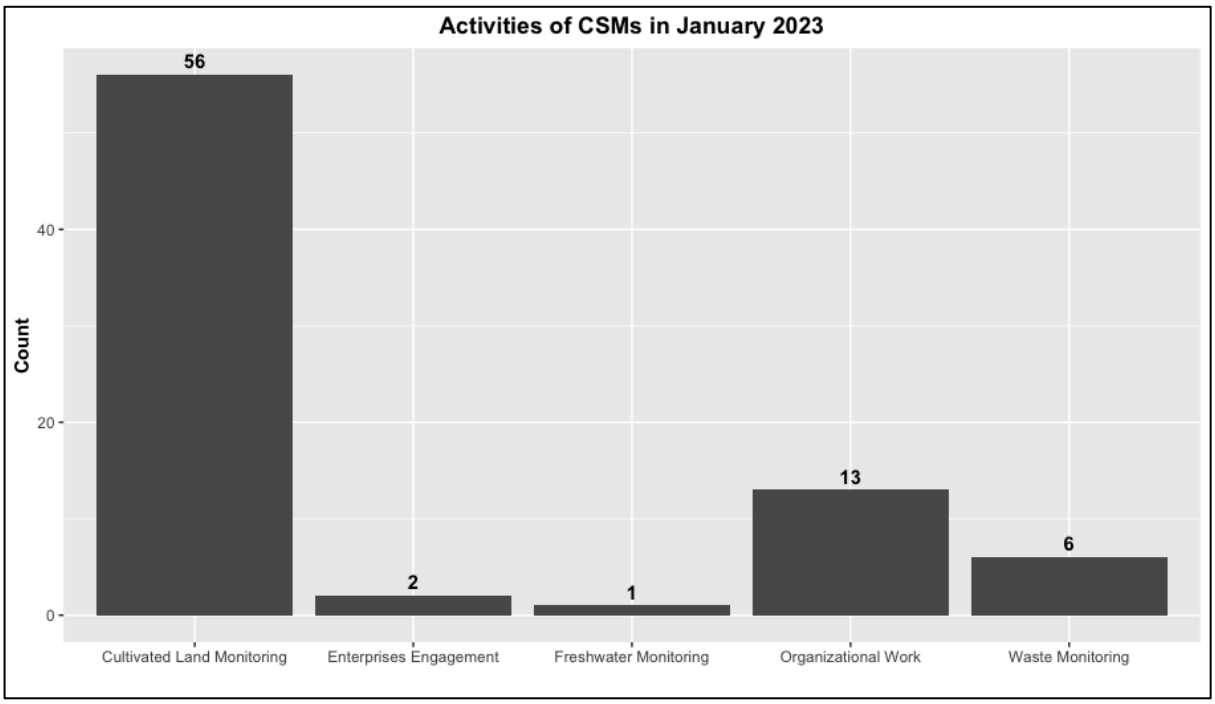


Figure 8. *Output #2 – Bar graph showing the types of CBM activities executed by all CSMs combined. Produced from DAT tool by author.*

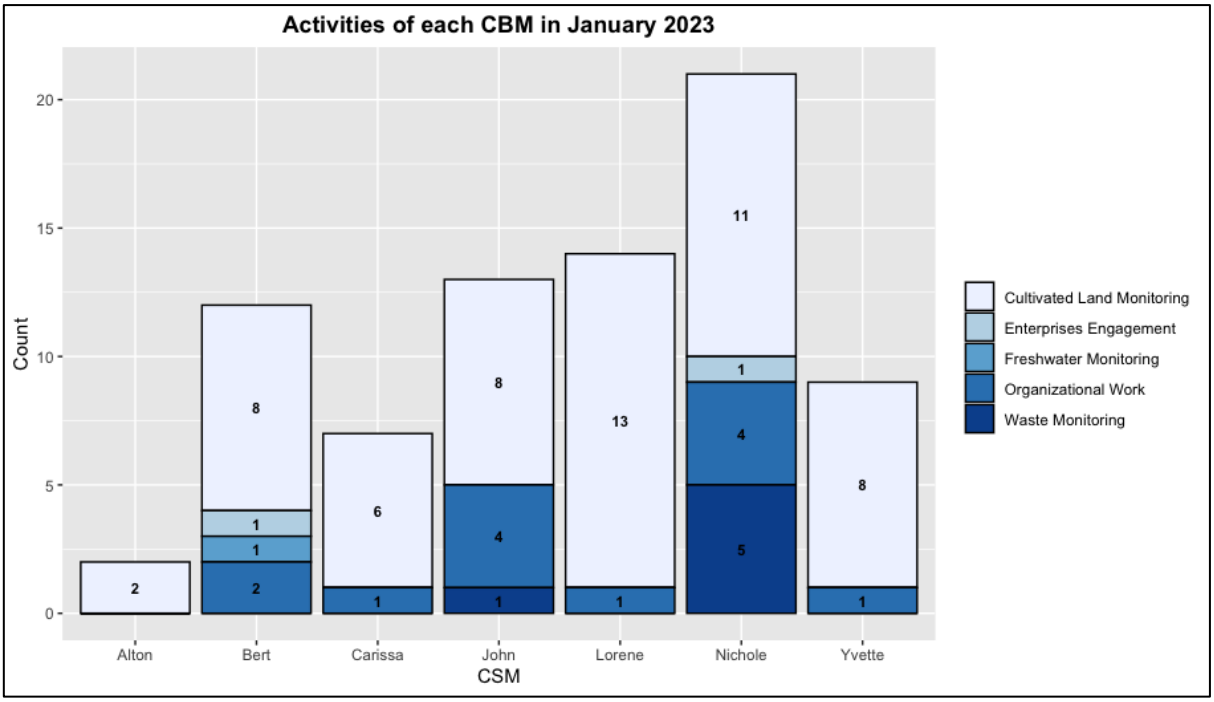


Figure 9. *Output #3 – Stacked bar graph showing the types of CBM activities conducted by each CSM. Produced from DAT tool by author.*

***Figure 10**. Output #4 – Word cloud showing the most commonly mentioned words for 'Cultivated Land Monitoring' CBM activity. Produced from DAT tool by author.*