EXPLORING *e³-value* ONTOLOGY-BASED SERVICE ENGINEERING FOR PARTICIPATORY PROCESSES OF COMMUNITY DEVELOPMENT PROJECTS

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DECLARATION

I, Dennis Miyogi Ochieng', declare that this dissertation is a depiction of my own research work in all aspects of creation, modelling, development and evaluation. This work has not been submitted in any form for another degree at any university or institution of higher learning. All information cited from published or unpublished works have been duly acknowledged. The only prior publications of this dissertation were in the form of journal articles listed below.

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Signature	Date
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Professor Oludayo. O. Olugbara, PhD	

DEDICATION

To my wonderful mother:

Akinyi Nyar Koderobara

whose powerful, beautiful, heroic and majestic love knows no bounds or language;

to the memory of my late dad:

K'ogerah,

who sadly departed too soon. *Baba,* I still reminisce the first day you took me to school and told me to work hard. There wouldn't have been a better way to honour you than to complete this research work;

to my siblings:

Collins, Alphonce, Judy, Millicent, Phares and Barrack,

for patiently waiting for me to bring home the crown. Your patience has been rewarded;

to my doting septuagenarian grandmother:

Atieno Nyar Otieno

who inculcated in me the spirit of '*deyo nyuok'* (perseverance) and resilience in the face of hardship;

to my affectionate nonagenarian great grandmother who's almost turning a century old:

Muga Nyar Ondiek,

for her fountain of wisdom and for constantly reminding me to complete my studies before she departs.

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LIST OF IMPORTANT ACRONYMS

BPM	Business Process Management
BPMN	Business Process Model and Notation
BPMS	Business Process Management Suite
CBO	Community Based Organisation
CDD	Community Driven Development
CDW	Community Development Worker
CPO	Context, Process and Outcome/Output
CSI	Customer Satisfaction Index
DAS	Digital Archive System
DUT	Durban University of Technology
ERP	Enterprise Reporting Packages
GUI	Graphical User Interface
ICT	Information and Communication Technology
IFRC	International Federation of Red Cross and Red Crescent Societies
MCC	Mobile Cloud Computing
MEPPP	Monitoring and Evaluation of Participatory Planning Processes
NPO	Non-Profit Organisation
NRF	National Research Foundation
PAR	Participatory Action Research
PME	Participatory Monitoring and Evaluation
PMT	Process Maker Table
PROME	Project Monitoring and Evaluation

SCM	Supply Chain Management
SILCM	Service Innovations Life Cycle Model
SSE	Service System Engineering
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action
TSDM	Traditional Software Development Methodology
UNDP	United Nations Development Programme
UFC	Urban Futures Centre
UKZN	University of KwaZulu Natal
UML	Unified Modelling Language
VCU	Virginia Commonwealth University
VBRE	Value-Based Requirements Engineering

ABSTRACT

In recent years, the global economy has witnessed a steady transition from broad-based government development projects to community-driven participatory processes as a viable conduit for channelling development efforts. However, these participatory processes are being faced with intrinsic challenges of unsustainability, bureaucracy, funding constraints, conflicts amongst project actors, social capital problems, political power tussles, inadequate systems for tracking progress and lack of an integrated approach, which are precursors that impede the effectiveness of project implementation. Participatory processes have transformed from the use of conventional systems to applications of digital technologies in order to address these challenges. However, the existing digital technologies for participatory processes often lack a value-based approach. This inherent curb has been tackled in this study using the *e^3-value* (value perspective) and *e^3-control* (process perspective) ontology-based service engineering to orchestrate an innovative change in participatory processes. To realise this innovation, the proposed value-based service system was modelled on service innovation life cycle model that integrates service exploration, value co-creation, process modelling and system evaluation. Consequently, a value-based requirements specification has been constructed using a process-oriented approach, which represents a departure from the traditional functional approaches to offer leaner, flexible and market-oriented structures that guarantee better organisational performance. The requirements specification was implemented to realise a mobile cloud service system that allow seamless data sharing and facilitate participatory processes. The applicability of the service system was illustrated using an expert-driven and criteria-based usability evaluation. Consequently, the service system provides an adequate framework for communicating the understanding of services for participatory processes.

1 INTRODUCTION

The beginnings and endings of all human undertakings are untidy, the building of a house, the writing of a novel, the demolition of a bridge and eminently, the finish of a voyage.
~ **John Galsworthy, 1933**

1.1 COMMUNITY DEVELOPMENT PROJECTS

In recent years, the global economy has witnessed a steady transition from broad-based government development projects to *community-driven, participatory, bottom-down* development strategies as a viable conduit for channelling development efforts (Wahid *et al*., 2017). By their nature, broad-based government development projects entail elaborate planning and execution through a choreography of partnerships, a chain of management processes, project cadres and synergy of efforts by multiple actors (Patanakul *et al*., 2016; Kwak *et al*., 2014). Because of this reason, government projects possess the potential to create national development and prosperity (Kwak *et al*., 2014). However, broad-based government development projects are often faced with various challenges that impact their success. In the first instance, government projects have long durations that often make it difficult for project actors to effectively track them (Chih and Zwikael, 2015). In addition, government projects tend to have poorly defined project objectives that do not accurately reflect the aspirations of the intended beneficiaries (Kwak *et al*., 2014). Furthermore, government projects lack an established project management mechanism (Patanakul, 2014). Moreover, government projects operate on enormous financial budgets that render them strenuous to control (Chih and Zwikael, 2015). Besides, it is difficult to undertake a cost-benefit analysis of government projects (Zwikael and Smyrk, 2012). Another important challenge is that government projects are prone to uncertainties that make them complex to manage (Klakegg *et al*., 2016; Chih and Zwikael, 2015). Equally important is the fact that government projects involve multiple actors and this situation often leads to incompatible concerns at an enormous scale (Patanakul *et al.*, 2016; Chih and Zwikael, 2015). Finally, there is a growing global pressure to make governments meet public needs with limited project budgets thus making them less attractive (Klakegg *et al*., 2016; Chih and Zwikael, 2015).

The numerous challenges highlighted in the previous paragraph have precipitated a tilting landscape that has firmly placed community development as the prime driver of developments intended to transform social, political, economic, legal, technological or environmental welfare of a defined community through partnerships with various actors (Yalegama *et al*., 2016; Cavaye, 2015). To comprehend the phenomenon of community development projects, it is crucial to begin by describing the intertwined concepts of "community" and "community development". Generally, the term "community" has been defined in extant literature in two ways. First, a community can be considered as a group of people residing in a demarcated geographical area such that they share certain common experiences and their social and economic circumstances are influenced by similar phenomena (O'Faircheallaigh, 2013). Second, a community can be used to denote indigenous people who do not necessarily inhabit the same geographical location but who share cultural, economic, social and spiritual ties through their relationship with a given development project (O'Faircheallaigh, 2013).

The dual meaning of a community as presented in the preceding paragraph makes it easier to grasp the concept of "community development" as a process that entails organisation, facilitation and action through which people can establish ways to create the community they want to live in (Hussain *et al*., 2008). In addition, community development includes the concept of developing fields, which describes the use of community projects to build the capacity of local people to chart their own destiny through proletariat endeavours (activities, projects and collaborations) of varying magnitudes (Brennan and Luloff, 2007). This co-ordinated expenditure of resources, skills and knowledge has tangible benefits, such as making development projects more effective, reducing chances of conflict and naturally leading to a more efficient use of resources (Matarrita- Cascante and Brennan, 2012). Moreover, this synergy of efforts creates robust and vibrant bonds amongst PME actors, which culminates into a heightened sense of proprietorship, identity and loyalty to the community (Sims, 2018; Jiménez-Zarco *et al*., 2015; Matarrita- Cascante and Brennan, 2012). This process is thus, a harmonious galaxy of guided vision, planning, direction and co-ordinated action by PME actors aimed at achieving desired goals by harnessing individual efforts and resources (Matarrita- Cascante and Brennan, 2012).

Community development work is spearheaded by (CDWs); cadres who are tasked with harnessing local economic, human and physical resources to secure daily requirements and respond to changing needs and conditions (Matarrita- Cascante and Brennan, 2012). Community development workers are considered as "vehicles of development" that listen to people, live with them, document their problems and formulate meaningful solutions to these problems through increased participation (Wahid *et al*., 2017). Consequently, CDWs play a key role in building bridges for community engagement (Hardy and Grootenboer, 2016). Interestingly, some scholars like Seyfang (2007) argue that CDWs are networkers whose task is to bring on-board diverse parties to engage meaningfully by sharing ideas and experiences. This is premised on the notion of community energy network that is anchored on the CDW as a 'hotspot' that draws like-minded neighbours together, facilitating dialogue amongst them and eventually enabling them to form a web of development-minded people (Martiskainen, 2017; Tan, 2009; Seyfang, 2007).

The phrase "community development worker" may be considered as an umbrella term for any actor or organisation involved in community development work (Ahmadi, 2017; Hussain *et al*., 2008). Thus, the community development actors may include CBOs, NPOs, local governments, central governments and donors (Yalegama *et al*., 2016; Cavaye, 2015; Chechetto-Salles and Geyer, 2006). These actors are involved in diverse community projects that traverse divergent spheres of human development. These projects include healthcare, culture, education, art, sports, tourism, energy, finance, agriculture, justice, housing, policing, land reform, social work, small business development, transport, disaster mitigation and environmental conservation (Liu and Wong, 2018; Kwan *et al*., 2018; Hedin and Ranängen, 2017; Hoffman, 2017; Jones *et al*., 2017; Masud *et al*., 2017; Nwapi, 2017; Tarras-Wahlberg *et al.*, 2017; Vangrieken *et al.*, 2017; Wahid *et al*., 2017; Medina *et al*., 2015; Matarrita-Cascante and Brennan, 2012).

The roles and responsibilities of CDWs are project-oriented in nature (Pomeroy, *et al*., 2017; Lin *et al*., 2017). This implies that CDWs are expected to undertake project management functions, processes and frameworks in a bid to guarantee the success of a service, product, result or envisaged goals (Martens *et al*., 2018). Naturally, the hallmark of project management is to explore novel approaches that can guarantee project success (Martens *et al*., 2018). Generally, the success of a project is exemplified by the perceived value of a project based on certain criteria, such as product use, satisfaction and benefits (Hussein *et al*., 2015; McLeod *et al*., 2012). As a rule of thumb, project success is measured by taking into consideration the general *goals* of the project (Hussein and Klakegg, 2014). Imperatively, project success stems from successful project management, which is determined by diverse factors, such as the attributes of the project leader, enthusiasm of the team, structure of the project and the significance of the project (Sanchez and Terlizzi, 2017; Snyder, 2014; Fisher, 2011). Based on this understanding, the success of project management is premised on conventional factors, such as cost, time and quality (Hussein and Klakegg, 2014).

In contemporary terms, the process of PME is regarded as one of the core project management practices that play an integral role in gauging the success of a project by showing the achievement of the goals and objectives of community projects (Lin *et al*., 2017). In broad terms, the PME process refers to the collaboration of project actors in the activities of a project, including policy planning, design, development, implementation, evaluation and general management of a project (Huitema and Meijerink, 2017; Verbrugge *et al*., 2017; Gelli and Espejo, 2013). In specific terms, PME is viewed as the systematic collection, storage and analysis of information to track the progress of a project venture against a given baseline and anticipated outcomes (Hassenforder *et al*., 2016b; Gelli and Espejo, 2013; Schwab and Miner, 2008). Suffice to say, the process of PME has gained traction in the PME literature as a significant process for guaranteeing project success. For this reason, some countries consider it a mandatory practice in project management (Verbrugge *et al*., 2017).

Generally, the process of PME is important in managing community projects for the following essential reasons. First, the process of PME provides crucial information for tracking project implementation through improved insight into community projects (Verbrugge *et al*., 2017; Rossignoli *et al*., 2015; Andrews *et al*., 2014; Igbokwe-Ibeto, 2012). To this end, it serves as a unifying language for all PME actors and provides a smooth transition between the main phases of a project cycle (Crawford and Bryce, 2003). Second, it is a source of information for justifying changes in management strategy and budgetary allocation. The project evaluators achieve this by providing relevant and timely information that shows barriers to progress and redirects efforts to more effective actions (Andrews *et al*., 2014; Crawford and Bryce, 2003). Third, it generates useful reports that contribute to transparency and accountability (Andrews *et al*., 2014; Crawford and Bryce, 2003). Fourth, it provides a platform to assess the interweaves between PME actors (Rossignoli *et al*., 2015; Gerwin and Ferris, 2004; Lewis *et al.*, 2002). Fifth, it promotes organisational learning amongst PME actors for the benefit of future projects. This learning can be achieved by capturing project histories, including failures, assumptions and risks that explain the variance between planned and actual outcomes (Shepherd *et al.*, 2011; Crawford and Bryce, 2003). Sixth, it improves project ownership by according PME actors the opportunity to influence project strategy (Andrews *et al*., 2014). Seventh, it improves the reliability and validity of the project outputs through shared understanding and building of consensus (Andrews *et al*., 2014). Eighth, it yields richer decisions through collaboration amongst actors (Verbrugge *et al*., 2017; Andrews *et al*., 2014). Ninth, PME leads to improved empowerment of actors (Huitema and Meijerink, 2017; Andrews *et al*., 2014). Lastly, PME contributes to the overall sustainability of a project (Verbrugge *et al*., 2017; Gelli and Espejo, 2013).

Although the process of PME remains a significant component of community project management cycle, this process has, over the years, remained a global challenge because of the numerous challenges discussed in section 1.2. These challenges can be broadly categorised into four principal areas, namely (1) constraints associated with creating a mutual understanding (2) resource constraints (3) technological constraints, (4) participation and satisfaction issues and (5) increased work levels and satisfaction issues (Andrew *et al*., 2014). These issues have been cited in the extant literature as an important research agenda (see Di Maddaloni and Davis, 2017; Yu, 2017; Hassenforder *et al*., 2016b; Chomal and Saini (2015); Hermans, *et al.*, 2012).

In the contemporary *service economy* (Gallouj *et al.*, 2015), it is feasible to think of conceptualising and developing a sustainable innovative service system as a solution to some of the challenges facing the process of PME. This is because, *service* is the principal commodity of trade in the service economy (Stoshikj *et al.*, 2016; Weigand *et al*., 2015; Cioban, 2014). In the context of the service economy, a service system is considered as a harbinger for improving service delivery through SSE methodologies involving value analysis, value co-creation, value exchange and process modelling, with the aim of improving service provision (Tan *et al*., 2011; Maglio and Spohrer, 2008). Thus, the development of service systems is a universal phenomenon, which thrives on the convergence of society, science, enterprises and engineering to create socio-economically and technologically sound artefacts pegged on value co-creation and efficiency (Pineda *et al*., 2012). In this context, the value is defined in terms of an improvement in a system's well-being and can be measured (evaluated) in terms of a system's adaptiveness or ability to fit in its environment (sustainability) (Bertoni *et al*., 2016; Maglio and Spohrer, 2008).

The SSE literature is awash with numerous methodologies that support the development of service systems (for example, Bessis *et al*., 2018; Bohmann *et al*., 2014; Maglio and Spohrer, 2008; Lopes and Pineda, 2013; Pineda *et al*., 2012; Spohrer; 2011). The overriding goal of these methodologies is to assist in engineering service systems (basically artefacts) that intensify, modify or automate the process of service development, service provisioning and service consumption based on the principles highlighted in the preceding paragraph. For this study, the SILCM (Tan *et al.*, 2011) was adopted as a suitable SSE methodology for innovating the phenomenon of PME from a conventional one to a mobile cloud service-based system by integrating case study, value co-creation, process modelling and system evaluation.

Generally, a *service innovation* (see section 1.10.17) produces changes to a service system that directly impact the development of the system (Dominguez-Péry *et al*., 2013). As such, the following dimensions of innovation have been identified in the SSE literature (Mainardes *et al*., 2017; Ryu and Lee, 2017; Tan *et al*., 2011; Danneels, 2008). (1) Service innovation (a new service offering is introduced); (2) Market innovation (a new market niche is created); (3) Innovation in the process (a change in service development and delivery process); (4) Organisational innovation (a new way to manage the organisation is introduced); (5) Innovation in technology (a new technology to support service creation, development or delivery is adopted); and (6) Ad hoc innovation (a unique solution is offered to a specific problem presented by an actor). Based on these six dimensions, this study employed the SILCM, a methodology for SSE, to cause an innovative change (in terms of new *services, processes* and *technology*) in the process of PME (Tan *et al*., 2011). The process of

PME was conceptualised as a subset of the community development work (Kusters *et al.*, 2017; Vaidya and Mayer, 2016; Igbokwe-Ibeto, 2012). By using the SSE methodology, this subset has been transformed from a conventional process to an innovative service-driven one called the PROME service system (see chapter three) to support the process of PME within the realm of a *service system* (see section 1.10.16). This conceptual framework for participatory monitoring and evaluating community projects is presented in Figure 1.1.

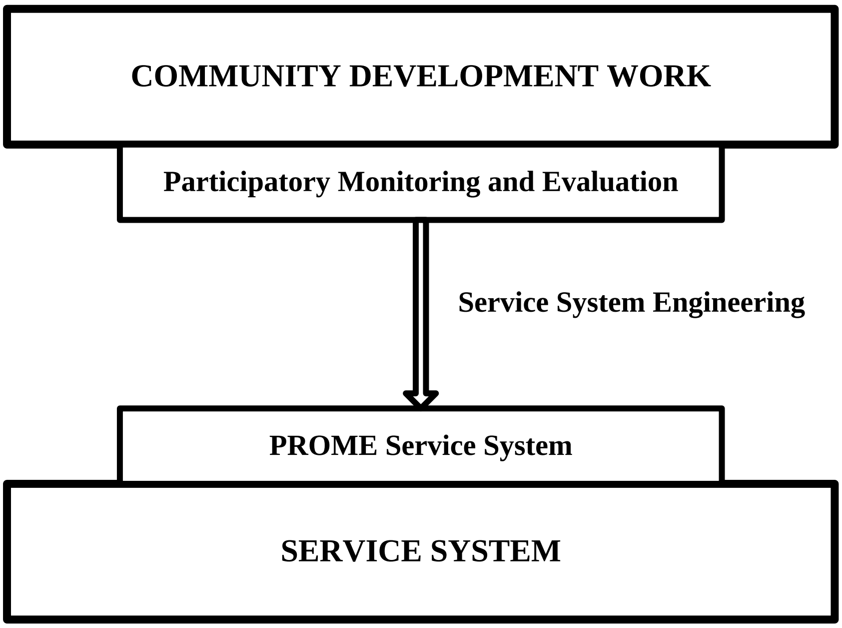

FIGURE 1.1: CONCEPTUAL FRAMEWORK FOR PROJECT MONITORING AND EVALUATION

The conceptual framework presented in Figure 1.1 can be explained in terms of developing a service system as a form of *innovation* driven by the boom of ICT that has opened a wide range of new opportunities for inventions in various spheres of human endeavour (Pohlmann and Kaartemo, 2017; Piccoli *et al.,* 2017; Piccoli and Lui, 2014). This includes increasing access to the internet facility, explosion of mobile gadgets, availability of satellite and aerial remote sensing facilities, development of smart sensors, as well as sophisticated software for data analysis and mining (Stoshikj, Kryvinska and Straus, 2016; Behnam *et al*., 2016; Hazır, 2015; Rahman *et al.*, 2013).

There are numerous studies such as Alizadehsalehi and Yitmen (2016), Behnam *et al.* (2016) and Hazır (2015) that have demonstrated the growing interest in the use ICTs to address various societal challenges. For example, the use of MCC technologies has gained currency as a platform for hosting many applications associated with mobile commerce, mobile learning, mobile healthcare, mobile gaming, assistive technologies and smart home systems (Akherfi *et al.*, 2018; Verkijika, 2018). Similarly, the convergence of service systems and MCC technologies could cause a paradigm shift in the process of PME from the use of conventional systems to that of an innovative service system composed of interacting mobile cloud services. Several studies, such as Nawrocki and Reszelewski, (2017), Akherfi *et al*. (2016) and Dinh, *et al*. (2013), have shown that the use of MCC technologies yield several benefits, including increased computational resources, enhanced data sharing mechanisms regardless of location and improved public participation in public service delivery.

1.2 CHALLENGES IN MONITORING AND EVALUATING COMMUNITY PROJECTS

There are many challenges facing the process of PME that present a global research agenda for researchers, practitioners and organisations as exemplified by the extant PME literature (Hassenforder *et al*., 2016a; Hassenforder *et al*., 2016b). The effectiveness of the process of PME has been affected by the increasingly complex social, economic, political, legal and environmental conditions under which organisations operate (Falco and Kleinhans, 2018; Karim *et al*., 2017; Martens and Carvalho (2017); Afzalan *et al*., 2017; Kusters *et al*., 2017). A succinct discussion of these challenges has been rendered as follows.

First, many organisations suffer from weak institutional capacities that cannot sustain the planning and execution of the process of PME (Callistus and Clinton, 2016; Rouse and Ware, 2017; Kim *et al*., 2014). These weaknesses could be resource-driven (such as inadequate funding) (Dinnie and Holstead, 2017; Martiskainen, 2017); politically motivated (such as corruption, sectarian interests and unnecessary politicisation of the process of PME); and organisational issues (such as volatility of institutional priorities, ambiguous institutional goals, monopoly and the extent of corporate involvement) (Ménard *et al*., 2018; Locatelli *et al*., 2017). According to Callistus and Clinton (2016), capacity building is significant for correcting poor project performance and improving the analysis and utilisation of PME results. Second, each participatory planning process is uniquely set in a specific context with its own relevant participants, objectives and issues that make it difficult to reuse a PME framework without modification. This makes it difficult to establish direct causal links between a project and its expected impacts (Hassenforder *et al*., 2016b; Hermans, *et al.*, 2012). This challenge is further compounded by poor definitions and linkages between project indicators, objectives and activities leading to poorly defined project outcomes (Bowe, 2015). Third, integrated planning and participation of several actors make the process particularly uncertain and complex because of power struggles and differing perceptions of policy problems and solutions, which require that actors be open to changes in schedules, timelines, actions and budgets (Hassenforder *et al*., 2016b; Olsen, *et al.*, 2016; Parkinson, 2009; Chapman, 2014; Hermans, *et al.*, 2012; Igbokwe-Ibeto, 2012; Sanga, 2011). The task of balancing individual expectations of diverse actors in a way that is responsible and feasible is a demanding and time consuming one (Bowe, 2015; Guerra-López and Hicks, 2015). Fourth, evaluators of participatory planning processes inadvertently impact the process owing to the nature of their objects of analysis and desire to transfer knowledge gained through PME into action (Hassenforder *et al*., 2016b). Fifth, the process is often, but not always, participatory (Hassenforder *et al*., 2016b). *Ipso facto*, "naive participation" that lacks recognition of project risks, adherence to project standards and exclusion of marginalised communities often leads to frustrations among actors (Hermans *et al.*, 2012). Sixth, for the most part, the process of PME suffers from poor project documentation, which arises from the absence of sound PME systems (Aversano *et al*., 2017; Chomal and Saini, 2015). This problem stems from lack of organisation-level PME systems as well as national-level PME systems that could support comparative analysis (Callistus and Clinton, 2016). Seventh, community project actors generally spend little time on PME activities (Di Maddaloni and Davis, 2017). One study by Callistus and Clinton (2016) revealed that project actors do not accord enough attention to the process of PME and that PME roles and responsibilities are often poorly documented. Eighth, it is practically challenging to measure the impact of a project because of difficulties in gathering project performance data (Yu, 2017; Chomal and Saini, 2015; Hermans, *et al.*, 2012; Sanga, 2011). This is because the process of gathering and analysing PME data is fraught with biases, limitations and threats that compromise data accuracy (Callistus and Clinton, 2016).

In consideration of the foregoing PME research agenda, the focus of this study is to improve the nature of participatory processes of community projects through value-based requirements engineering (VBRE) to make PME more sustainable for actors within the context of the service economy. This participatory approach not only creates a multi-actor environment in which distinct roles, interests, ideas, resources and perspectives coexist and interact but also reinforces learning and ownership of the PME process (Hermans, *et al.*, 2012; Shepherd *et al.*, 2011). Indeed, it has been demonstrated that participatory approaches can potentially improve the sustainability of development projects by mobilising communities to consolidate community capital (Mansour, 2016). In principle, the VBRE process advances this participatory agenda through mechanisms for identifying critical success factors of PME systems. It elicits their value propositions with respect to the system and reconciling these value propositions into a mutually satisfactory set of objectives for the system (Hasan *et al*., 2010; Boehm, 2006). The VBRE assumes an economic value perspective when developing ICT-based intensive products through an iterative and cooperative process of analysing a business case, documenting the resulting observations in a variety of representation formats and checking the accuracy of the understanding gained (Gordijn and Akkermans, 2003). This thesis describes this reorganisation as VBRE-driven service innovation (Obstfeld, 2012; Tan *et al*., 2011).

1.3 RESEARCH QUESTIONS

The previous section highlighted some of the significant challenges bedevilling the process of PME that need to be addressed in a bid to improve the process. As such, it was necessary to conceptualise an innovative way to counter some of these challenges. This realisation led to the following central research question for this study:

> *How can this study develop an innovative service system for participatory processes of community development projects?*

Developing an innovative service system for PME was premised on a methodical review of extant PME literature in chapter two. Generally, an innovation is a service science perspective that postulates that value is a sustainable improvement to the well-being of a system (Pohlmann and Kaartemo, 2017; Bertoni *et al*., 2016; Bohmann *et al*., 2014; Maglio and Spohrer, 2008). Therefore, the basic argument presented in chapter two is that the VBRE is a viable process for conceptualising and developing an innovative, value-driven service system for participatory processes of community development projects not only for the benefit of diverse actors but also for the sake of long term sustainability of the project. This should be realised through a choreography of processes, such as value analysis, value co-creation, value exchange and process modelling, with the aim of improving service provisioning (Cefkin *et al.,* 2011; Tan *et al*., 2011; Maglio and Spohrer, 2008). Based on the literature review, chapter three presents a description of the VBRE methodology using the *redesign model* to conceptualise and transform the process of PME through a systematic process of *preliminary analysis* (exploration), *control problem identification, control mechanism redesign* and *evaluation* of the new model. The results obtained from the preliminary analysis phase formed the basis for modelling a process-oriented prototype called PROME service system as an innovative system for improving the process of PME. There were several guiding questions that shaped this research work to coherently address the central research question. The first guiding research question was framed as follows:

> *How can the current participatory processes of community development projects be conceptualised and transformed into an innovative service system?*

The answers to this guiding research question are provided in chapter three that describes the current As-Is PME model using the results of the *preliminary analysis* phase. This analysis consisted of an elaborate process of system exploration involving *PME actors*, *digital resilience* and *exchangeable value objects*. The MEPPP framework was incorporated to address some of the inherent limitations in the preliminary phase of the redesign model (see section 3.1). The need for transiting from a current As-Is PME model to an improved To-Be PME model (Tan *et al*., 2011) led to the next guiding question that was framed as follows:

What conceptual models and tools would be suitable to design a service system for facilitating innovative participatory processes of community development projects?

The second guiding research question tackles the redesign of control problem of the PME process by establishing the intrinsic flaws in the current As-Is PME model and using these flaws as a premise for a proposed To-Be PME process model. To address this research question, the study used the principles of the redesign model, which combine e^3*-value* and e^3*-control* perspectives into one conceptual method to model a value-based system. The e^3*-value* method was used to model value co-creation, exchange and consumption of value objects among a network of actors. The e^3*-control* method provided a detailed model of the process, thereby creating a sustainable service system (Tan *et al.,* 2011). The two modelling tools were chosen because they are *popular, formal* and *user-friendly*. The two ontology-based tools incorporate concepts from requirements engineering and conceptual modelling (Tan *et al.,* 2011; Schuster and Motal, 2009; Huemer *et al*., 2008; Weigand *et al*., 2007; Embley *et al*., 2006).

The result of the redesign of the control problem process led to the realisation of a specification of requirements for developing the e^3*-value* ontology-based service system. This specification of requirements is presented in chapter four as a test of the practical feasibility of the system. Thus, the requirements specification provided answers to the third guiding research question that was enunciated as follows:

What set of innovative services would this service system offer for facilitating the participatory processes of community development projects?

The requirements specification were implemented by using a BPMS to realise a service system for improving the process of PME as shown in chapter four. A process-oriented approach to implementation was preferred to a functional approach because it provides better results and a faster implementation of an application (Pourmirza *et. al.,* 2017; Ariouat *et al*., 2016; Kirchmer, 2012). This implementation then led to the fourth guiding question:

How can this study use this service system to provide support for participatory processes of community development projects?

The fourth guiding question was a test of the functionality and heuristic attributes of the developed service system, such as usability. This was achieved by conducting an expert-driven survey through a live-user experimentation in a computer laboratory setting. This approach is presented in chapter five. Imperatively, the approach was backed by Parhizkar and Comuzzi (2017), Olugbara and Ndhlovu (2014), Olugbara *et al.* (2010) and Lund (2001). These extant studies are founded on the Technology Acceptance Model (TAM) (Davis,1989). It was envisioned that at a later stage, the evaluation of the service system would be extended beyond a computer laboratory setting. After this preliminary evaluation, the PROME system was deployed on a mobile cloud platform for use by PME actors.

1.4 AIM AND OBJECTIVES

This research work was *aimed* at developing an innovative *e³-value* ontology-based service system to cause a sustainable change in the process of PME of community development projects. The following were the *objectives* of this research work:

1) To conceptualise and transform the current issues in participatory monitoring and evaluation of community development projects as a model of innovative service delivery;
2) To demonstrate how a model of sustainable service delivery can facilitate the innovative process of participatory monitoring and evaluation of community development projects;
3) To evaluate this model of a service system for participatory monitoring and evaluation of community development projects in terms of sustainability, scalability, integration and support for mobility;
4) To demonstrate how PME actors can use the developed service system to effectively monitor and evaluate community development projects.

1.5 RESEARCH METHODOLOGY

The study employed the VBRE methodology as a viable approach to understanding the current As-Is PME model as a typical real-world problem (Zhang *et al*., 2013; Tan *et al*., 2011). The use of the VBRE methodology is a departure from the traditional systems development methodologies (TSDMs) that thrive in a value-neutral setting and therefore, do not support the development of value-based service systems (Amini *et al*., 2018; Liu *et al.,* 2018; Zhang *et al*., 2018; Bakhache *et al*., 2017; Bretan and Engle, 2017; Castelnuovo and Tran, 2017; Cordeil *et al*., 2018; Eickhoff , 2018; Frohn and Lopez, 2017; Hou and Chen, 2017; Hox *et al*., 2017; Kirby *et al.*, 2017; Mottelson and Hornbæk, 2017; Oliveira *et al*., 2017Bithas *et al*., 2015; Murtazaev *et al.*, 2010). The shortcomings of the TSDMs have been discussed in section 2.4.1. Similarly, the justification for the use of VBRE in this study has been outlined in 2.4.1. As a *general* principle, the VBRE methodology introduces the notion of *economic value* during the requirements engineering process of innovative systems to improve business processes within the context of a dynamic society (Ferreira and Pantidi, 2018; Tan *et al*., 2011). This aspect involves the exchange of value objects that possess economic value, such as physical goods, services or capabilities (Alahyari *et al*., 2017; Glova *et al*., 2014; Bithas *et al*., 2015; Rao and Prasad, 2012; Schuster and Motal, 2009).

Based on the foregoing concepts, this study *specifically* applied the *redesign model* (see figure 2.2; section 3.1) that incorporates the principles of the VBRE methodology to provide a potent tool for conceptualising and modelling a service system for improving the process of PME (Tan *et al*., 2011; Schuster and Motal, 2009; Huemer *et al*., 2008; Weigand *et al*., 2007). It consists of four phases as follows: (1) preliminary analysis; (2) control problem identification; (3) control mechanism redesign; and (4) evaluation of the model. The first phase involved a multi-pronged approach to the exploration of (a) a real-life project to understand the concept of digital resilience amongst PME actors; (b) the extant PME literature to establish an understanding of PME actors, exchangeable value objects and the inherent weaknesses of the current As-Is PME model. These weaknesses provided an impetus for modelling a service system in the second phase (control problem identification) to improve the process of PME according to the third phase (control mechanism redesign). A final analysis was then undertaken in the fourth phase to determine how the new model (integrating both value and process perspectives) impacts the process of PME in terms of digital resilience, project documentation, PME services, value co-creation, sustainability and process-orientation (see sections 3.4 and 4.1).

1.6 SIGNIFICANCE OF THE STUDY

The findings of this study will contribute to the advancement of the contemporary society because the process of PME plays a prominent role in the success of community development projects. The findings of the study will contribute to this advancement by providing solutions to some of the challenges bedevilling the process, such as the lack of a sustainable participatory mechanism. To resolve these challenges, the study will provide an impetus for increased participation through service system principles such as value co-creation and compensation for PME services offered by actors.

Second, the study has created an artefact called the PROject Monitoring and Evaluation (PROME) service system, which will assist in improving the efficiency and effectiveness of the process of PME within the context of a service economy. This artefact is premised on a constellation of value-based service concepts to provide an innovative approach for PME actors to offer PME services in return for commensurate compensation. This way, the artefact is expected to contribute to the economic sustainability of the process of PME. The successful adoption and use of this artefact will be aided by emerging ICTs, such as mobile cloud computing that seeks to solve real-life business problems.

Third, the study will promote the use of process-oriented approaches to system development by service system developers and practitioners to chart a new dispensation in conceptualising, analysing, designing, developing and evaluating PME processes. Thus, the use of process-oriented approaches represents a departure from the conventional functional approaches by offering leaner, flexible and market-oriented structures that guarantee better organisational performance and productivity (Pourmirza *et. al.,* 2017; Škrinjar *et al*., 2010).

Fourth, this study has the potential to impact the formulation, development and review of progressive community development policies by government and donor agencies to inspire the evolution of community development within the context of the service economy. While taking cognisance of the rapidly changing landscape of service-driven innovations, the study will further inspire the development of ICT policies that support the growth of service systems, such as VBRE, mobile cloud computing, digital resilience and process-oriented approaches to the development of business systems.

1.7 SCOPE OF THE STUDY

This study was confined to the phenomenon of developing an innovative *e*^{3}*-value* ontology-based service system to improve the process of PME in community development projects. This phenomenon covers a choreography of processes, such as service exploration, value analysis, establishing inherent weaknesses, development of corrective mechanisms and evaluation of new processes and control mechanisms to support an innovative change to the process of PME (see chapter three). Thus, the scope of this study includes the use of these mechanisms to conceptualise and transform the key issues in PME, such as digital resilience, project documentation, value co-creation, service-oriented re-engineering of the process of PME, economic sustainability and process-oriented approaches (see chapter four). Subsequently, this study has developed the PROME service system for improving the process of PME.

1.8 STUDY CONTRIBUTIONS

The contributions of this study are enunciated as follows:

1) Developing digital resilience among youths living in a marginalised Kenneth gardens community in Durban, South Africa is a worthy contribution of this study to the realm of service science research. This was achieved by using the DAS as an ICT platform to develop the youth from marginalised communities through the acquisition of digital skills that will enable them to be digitally resilient. These digitally resilient youths are expected to provide project monitoring and evaluation services. A succinct

description of this contribution to knowledge is rendered in chapter four and has also been published by Ochieng' *et al*. (2017).

2) Modelling participatory processes of community development projects as a value-driven service system is an expansion of the frontiers of knowledge in both PME and service science within the context of the service economy. This was pegged on the limitations of the current As-Is PME process that provided an impetus for modelling of a service system that would enhance the PME process. This means that a service system presents an opportunity for actors to experience tangible benefits accruing from improved participation in the process of PME.

3) A process-oriented approach to implementation of a service system for PME is a worthy contribution to the realm of the service system and software development because it marks a departure from traditional functional approaches to process-oriented approaches for system development. As described in chapter two and further demonstrated in chapter four, a process-oriented approach is a viable tool for revamping business processes by making them lean, flexible and market-oriented structures.

4) Using emerging technologies, such as MCC to deliver PROME service system resources over shared computing infrastructure as opposed to hosting and operating it locally. The PROME system was developed in chapter four and deployed on a cloud platform to exploit cloud-based resources to improve the process of PME. This could be particularly significant for resource-constrained marginalised communities that development projects often target.

1.9 STRUCTURE OF THE THESIS

This thesis comprises six chapters. Chapter one introduces the research work by presenting the background information for this study, outlining the problem of the study, defining the research questions, describing the aims and objectives of the study, defining the scope of the study and enunciating the contributions of the study. This is followed by Chapter two, which presents an empirical review of the literature covering the following dimensions: community development work, PME, VBRE, service systems, process-oriented implementation of service systems, mobile cloud computing, evaluation of service systems and digital resilience. Conceptually, the ideas presented in chapter one and chapter two provided a *terra firma* upon which Chapter three was founded. Chapter three explores the research methodology by describing, in finer details, the steps of the redesign model as used in this study. Chapter four is a description of the development of the envisaged PROME service system. The chapter provides a specification of the key issues to be transformed in the process of PME as well as system re-engineering of the user and design requirements specified. In addition, the chapter describes the implementation of the PROME service system based on the model of the system presented in chapter three. Chapter five shows results of the evaluation of the PROME service system. Lastly, Chapter six presents an evaluation of the entire work by showing a summary of the major findings of the study, recommendations of the study, recommendations for further study and an epilogue to the study.

1.10 DESCRIPTIONS OF IMPORTANT CONCEPTS

[redacted] Community-driven development

Community-driven development (CDD) thrives on the notion of development aid through community participation, which is expected to spur pro-social behaviour (Hassan *et al*., 2018; Nguyen and Rieger, 2017). As such, CDD dictates that community members conceptualise, design, implement and evaluate development projects (Staley, 2009). The basic argument in CDD is that communities appreciate their interests and they tend to make better decisions regarding the allocation of development funds, which in turn leads to better results (Nguyen and Rieger, 2017; Mansuri and Rao, 2012).

[redacted] Criteria-based evaluation

Criteria-based evaluation is based on predefined checklists, heuristics, or principles that stem from specific theories, guidelines, standards or even legal requirements (Chen *et al*., 2011; Palmius, 2007; Cronhol and Goldkuhl, 2003). The choice of criteria often reflects an evaluator's deliberate bias towards certain characteristics at the expense of others to acquire a certain outcome (Cronhol and Goldkuhl, 2003). The evaluation literature shows that criteria-based evaluation is a popular approach in the field of information systems, especially in usability, accessibility and standard verification studies (Chen *et al*., 2011; Bertot *et al*., 2006). One pitfall of criteria-based evaluation is that it tends to overshadow crucial factors about the information system and its use (Chen *et al*., 2011). In addition, this approach is prone to differences in knowledge, interpretations and opinions (Chen *et al*., 2011).

[redacted] Digital resilience

Digital resilience means the ability to acquire new digital skills that can help an individual to navigate increasingly digitally-oriented and dynamic societies by developing capacities to *new opportunities, resources* and *skills* to cope in a stressful, disadvantaged or traumatic situation (LLobregat-Gómez and Sanchez-Ruiz, 2015; Masten, 2001; Luthar *et al*., 2000). It is derived from the general belief of resilience that describes the process of creating well-being and positive development through lifelong learning (Moore and Shaffer, 2017).

[redacted] Dynamic society

This is a rapidly changing and developing society that is characterised by the technological boom in diverse sectors, such as business, banking, logistics, services, construction entertainment, tourism, transport and manufacturing (Jami and Walsh, 2017; Spohrer, 2011). Significantly, ICTs play a leading role in integrating *systems* in a dynamic society and conjugating it into a global village whereby the consequences of a single decision can dramatically reverberate across the globe (Bohmann *et al*., 2014). Because of this rapid evolution, it is challenging for individuals to keep pace with changes taking place as well as the expectations of the society (Ferreira and Pantidi, 2018; Lewis and Ogra, 2010).

[redacted] ***e-value*** **ontology**

e^3-value is an ontology-based approach for modelling and designing networked enterprise models by integrating concepts from *requirements engineering* and *conceptual modelling* (Huemer *et al.*, 2008; Akkermans and Gordijn, 2006; Akkermans *et al*., 2004). The thrust of the *e^3-value* ontology is establishing value *co-creation*, *exchange* and *consumption* amongst multiple actors, thus embracing the notions of *economic value* and *graphical* conceptualisation of the value objects exchanged (Gailly *et al*., 2016; Glova *et al*., 2014; Tan *et al*., 2011). This perspective is founded on the principle of reciprocity that underscores the duality of commercial dealings (Guo, 2016; Johannesson and Weigand, 2015; Gordijn and Kartseva, 2004).

[redacted] Exploratory case study

The exploratory research is often connected with case study research (Dubois and Araujo, 2007). In practice, the case study research strategy enables the researcher to acquire an in-depth understanding of a given phenomenon, especially where it has not been evidently identified and expressed or the data needed for a theoretical formulation is yet to be acquired (Rajala and Tidström, 2017; Halinen and Törnroos, 2005). Generally, the success of an exploratory case study does not rest on specific propositions but lies on broad research questions (Davies, 2017; Yin, 2011).

[redacted] Mobile cloud computing

MCC is an amalgamation of mobile computing, cloud computing and wireless technology to produce *on-demand*, *dynamic* and *self-provisioned* outsourcing of ICT resources delivered over a cloud infrastructure to mobile users (Abdo *et al.*, 2014). The prime goal of MCC is to shift data processing and data storage aspects of resource-intensive applications from resource-limited mobile devices to the elastic cloud (Abdo *et al.*, 2014; Sanaei *et al.*, 2012). With this elasticity, cloud-based applications provide unlimited functionality, storage, mobility, scalability and ubiquity (Mollah *et al.*, 2017; Sanaei *et al.*, 2012).

[redacted] Participatory monitoring and evaluation

The process of PME is an established management practice that differs from traditional monitoring and evaluation by including all actors in all aspects of the process (defining the problem, collecting and analysing data) in a bid to promote learning and change (Cornwall and Aghajanian, 2017; Parkinson, 2009; Holte-McKenzie *et al*., 2006). Notwithstanding institutional frameworks, relational dynamics and power differentials, the process of PME thrives on harmony between development programme goals and those of the targeted beneficiaries (Cornwall and Aghajanian, 2017; Parkinson, 2009).

[redacted] Process modelling

Process modelling is a standard technique for describing business processes using modelling methods, such as flowcharts, functional flow blocks and UML. The resulting model (abstract representation) can then be manipulated to provide a meaningful understanding of the business processes (Saini and Thiry, 2017). Generally, process models improve communication in organisations and aid in designing process-aware information systems (Dikici *et al*., 2017). Therefore, process modellers should adhere to process modelling guidelines, such as using one start and one end event, avoiding OR routing elements and decomposing models with more than fifty elements (Mendling *et al*., 2012; Mendling *et al*., 2010). In addition, a process model should be correct, relevant, coherent and intelligible (La Rosa *et al.,* 2011). Some of the tangible ways to achieve understandability include modularisation, highlighting, block-structuring and pictorial annotation (Cefkin *et al.,* 2011; La Rosa *et al.,* 2011; Tan *et al*., 2011).

[redacted] Process-oriented system implementation

Process-oriented system implementation is the utilisation of software tools, such as BPMS to realise repeatable and predictable business processes that can efficiently and effectively meet the goals of an organisation (Mondragón *et al.,* 2013). Typically, a BPMS supports the entire business process cycle, which includes identifying processes, analysing, redesigning, implementing and monitoring these processes (Triaa *et al*., 2017).

[redacted] Service economy

A service economy is a relatively new economic model where the service sector plays a dominant role in creating a value-added structure. This shift has far-reaching ramifications for economic relations and society *in toto* by influencing income dynamics, gross domestic product, valued skills and jobs, curriculum adjustment among others (Plotnikov and Volkova, 2014). The service economy is driven by the emergence of innovative technologies and development of technical human capital, the growth of the global market, the rise of service competition-friendly regimes, societal and environmental challenges (Gallouj *et al*., 2015).

[redacted] Service innovation

Service innovation denotes modifications in various dimensions related to the characteristics of a service offering (Witell *et al*., 2016; Obstfeld, 2012). These dimensions (or types of service innovation) indicate the areas where service innovation occurs with the prime goal of securing a competitive advantage and improving business performance (Åkesson *et al*., 2016; Witell *et al*., 2016; Carlborg *et al.*, 2014; Droege *et al*., 2009).

[redacted] Service provision

Service provision is the act of undertaking a business task in exchange for a commensurate consideration between actors (Barile and Polese, 2010; Katzan, 2009). As such, a service provider must possess the requisite capability to offer a service that satisfies the requirements of the other actors (Green and Haines, 2015; Phillips and Pittman, 2014; Tan *et al*., 2011). This satisfaction comprises a variety of specific indicators, such as the ambience of service provision environment, hospitality of the service provider, nature of communication and engagement between the service provider and the consumer, effectiveness of the service provided, amount of compensation and ease of processes involved (Russell *et al*., 2016; Simmons *et al*., 2014; Obstfeld, 2012; Chesbrough and Spohrer, 2006).

[redacted] Service science

Service science is an emerging discipline that is founded on the fusion of organisational and human theories with business and technological innovations to explain service systems and value co-creation (Pohlmann and Kaartemo, 2017; Maglio and Spohrer, 2013). Essentially, service science theory explains what service systems are, how they mutually interact and evolve, the role of people, technology, value propositions and shared information in the system (Pohlmann and Kaartemo, 2017; Stoshikj *et al.*, 2016).

[redacted] Service system engineering

SSE is a transdisciplinary approach to the methodical design and development of a service system guided by value propositions to fashion the holistic perspective of a system to include a client-focused, contiguous perspective (Bessis *et al*., 2018; Adcock, 2015). Consequently, service system engineers strive to integrate system requirements to make service system entities interoperable in terms of *technical, process* and *organisational* aspects with the goal of enhancing client experience during service interactions (Bessis *et al*., 2018; Bohmann *et al*., 2014; Lopes and Pineda, 2013; Pineda *et al*., 2012; Spohrer; 2011; Maglio and Spohrer, 2008).

[redacted] Service system

A service system is a basic abstraction the service science theory consisting of multifaceted business and societal systems that mutually create services for the benefits of providers and consumers (Stoshikj *et al.* 2016; Demirkan *et al.*, 2011). In the domain of service science, service is the application of competencies (knowledge and skills) by one entity for the benefit of another (Vargo and Lusch, 2008; Vargo and Lusch, 2004). This benefit conforms to the S-D logic (value-in-use) that co-creates value through interaction of producers and consumers of competencies and has been contrasted with good-dominant (G-D) logic (value-in-exchange) where value is based on the exchange of goods and money (Pohlmann and Kaartemo, 2017; Bertoni *et al*., 2016; Bithas *et al*., 2015; Vargo and Lusch, 2008).

[redacted] Sustainable innovation

A sustainable innovation is one that improves sustainability performance based on ecological, economic and social criteria (Kivilä *et al*., 2017; Boons *et al*., 2013). These criteria may assume different meanings and may vary from one context to another due to situational factors, such as culture, place and time (Boons *et al*., 2013). The extant literature shows that sustainability is an integral component of innovation and it is tied to quality (Weber, 2018; Provasnek *et al*., 2017; Slowak and Regenfelder, 2017; Barile *et al*., 2016).

[redacted] Value analysis

Value analysis is an overarching process in *e^3-value* ontology-based SSE that is performed to understand an existing business model to establish which value exchanges amongst actors in a service system are at risk (Tan *et al*., 2011). It helps in establishing the economic viability of a service system by showing which aspects of a service system should remain the same, or modified in a cost-effective manner (Sharifai *et al*., 2017).

[redacted] Value co-creation

The concept of value co-creation offers a perspective through which to comprehend the inter-organisational, dynamic and systems-oriented view of value creation through mutually beneficial interactions among actors within a firm (Vargo and Lusch, 2016). This mutual interaction is driven by discovering novel and innovative ways to facilitate each entity's value-creating processes. This paradigm shift means that the boundaries between entities become more blurred owing to the continuous redefinition of roles (Cossío-Silva *et al.,* 2016; Saarijärvi *et al*., 2013).

[redacted] Value exchange

A value exchange in *e^3-value* ontology depicts one or more potential trades of value objects between value ports belonging to different actors or market segments (Tan *et al*., 2011). This exchange is modelled according to the principle *of economic reciprocity,* emphasising the dual character of business transactions. This *quid pro quo* approach denotes that every actor offers something of economic value, such as money, physical goods, services, or capabilities and gets something of economic value in return (Tan *et al*., 2011).

[redacted] Value-based requirements engineering

VBRE is the adoption of a value perspective during the process of software system requirements engineering to meet the diverse needs of actors involved in software development, such as system analysts, system developers, quality experts, marketing professionals, project management team and business executives (Biffl *et al*., 2006; Heindl *et al*., 2006). This means that all actors are involved in decision making at all levels by harmonising both the common and differing value perspectives.

2 LITERATURE REVIEW

If I have seen further, it is by standing on the shoulders of giants ~ **Isaac Newton, 1675**

This chapter provides a review of empirical literature relating to the development of a value-based service system for participatory monitoring and evaluation of community development projects. The overarching aim of this chapter is therefore twin fold: to contextualise the research problem at hand by exploring the themes underpinning the development of a service system for improving the process of PME and to analytically guide the process of solving the research problem and achieving the aims and objectives of the study as outlined in chapter one. To achieve this, the chapter begins with a discourse on community development, highlighting its role, underpinning theories, challenges and outlook. In addition, this chapter discusses the theme of participatory monitoring and evaluation of projects by highlighting its fundamental principles, trends and developments thereof, challenges associated with the process, existing knowledge gaps and research opportunities for exploitation. Moreover, the chapter explores the theme of service systems by highlighting the fundamental concepts associated with them and their significance in improving the management of diverse spheres of human development within the context of a service economy. Likewise, the chapter discusses the principles of value-based requirements engineering as a novel approach to discover the requirements for building an economically viable service system as opposed to the TDSM. Similarly, the chapter presents the fundamental principles of process-oriented implementation of service systems as a mechanism for reorganising business processes to improve efficiency. Another theme explored in this chapter is the use of mobile cloud computing technologies as an emerging ICT infrastructure for deploying information systems over a network of shared computing resources to achieve defined benefits, such as cutting business costs, improving business process effectiveness and efficiency among others. Equally important is the exploration of the theme of evaluation of service systems using the TAM principles. In the same way, the chapter explores the concept of digital resilience as a lifelong learning process for PME actors to acquire digital skills to navigate an increasingly ICT-driven and dynamic service economy. Finally, a recap of the chapter is presented to form the basis for the subsequent chapters.

2.1 COMMUNITY DEVELOPMENT

This section is divided into the following sub-sections: theoretical foundations of community development, benefits of community development, characterisation of community development work, challenges facing community development and the emerging issue of sustainability of community development projects.

[redacted] Theoretical foundations of community development

Community development is grounded in social theories and strategies that support a bottom-up approach to uplifting the welfare of a community (Rouse and Ware, 2017; Wahid *et al.*, 2017; Tan, 2009). The bottom-up approach to development is proposed as a mechanism for community members to chart their destiny through deliberate actions that reflect their own impressions of the community's welfare, which may be incongruent with external views, such as those of a central government agency (Kim e*t al*., 2014). In certain instances, the bottom-up development strategy may emerge as a spontaneous exploit and might yield some results not initially envisaged by CDWs (Slack and Lewis, 2015; Kim e*t al*., 2014). This lends credence to the notion of the bottom-up development strategy as an approach that thrives on knowledge gained from everyday activities to shape the goals and actions of a community project (Kim e*t al*., 2014). Consequently, bottom-up strategies work from local levels upwards, highlighting community exploits, leveraging the prevailing community strengths and inspiring community-government partnerships. These community-government partnerships can be formal or non-formal. They can result in re-alignments, improved utilisation of formal services, community-driven social transformations and remarkable patronage by community members (Wessells, 2015).

The bottom-up development strategies have existed throughout human history. However, there have been controversies concerning the identity of bottom-up strategies and community development (Sisto *et al*., 2018). One significant phase of this conflict was recorded between the *micro* and *macro* focus of development during the 1930's and the 1940's. During this era, community change protagonists faced opposition from antagonists who associated community social work with Imperialism, Eurocentrism (Western-centrism) and Paternalism (Payne, 2005). According to Payne

(2005), the modernisation theory and Marxist dependency theory (both of which considered community development as a mechanism for integrating the oppressed), impoverished and marginalised communities into the European model of 'success' and were therefore considered as mostly culpable for this opposition to community social work. In the last three decades, the imperialism, Eurocentrism and paternalism leaning paradigms (largely top-down strategies) have diminished and they have been replaced by bottom-up, territorial strategies that are pegged on the exploitation of *human* and *social* resources of communities (Sisto *et al*., 2018). This development has been partly precipitated by a shift from hierarchical forms of government to horizontal, hybridised and participatory forms of governance, which promote *social relations* to the endogenous local capacities for community development (Sisto *et al*., 2018; Hill and Lynn, 2004).

As the *fulcrum* of the change process that is envisaged in the community development work, the construct of *social relations* implies that community development process is founded on sociology, unlike social work that is grounded in psychology-based theories (Tan, 2009). For this reason, it is imperative to distinguish between social work and community development as follows: *social work* is described as the professional intervention aimed at *alleviating individual suffering and predicament* by transforming the social environment in which they inhabit, while community development work is described as *the engagement of community structures* to tackle social problems and emancipate members of a given community (Narayanan *et al.*, 2017; Wahid *et al*., 2017; Tan, 2009; Mendes, 2008). Consequently, community development is about developing *social capital*, *social inclusion*, *social exclusion* and *capacity building* (Rouse and Ware, 2017; Kim *et al*., 2014; Tan, 2011).

Social capital, as described by Thompson (2015) and Brian (2007) is a communal good that consists of trust and trust-related networks. In this context, Thompson (2015) posits that trust is the expectation of reciprocal behaviour between two or more actors in community development according to certain norms, plans and rules that help to forge values and understandings that facilitate their mutual co-operation in a project. Brian (2007) recognises three structures of social capital: *bonding*, *bridging* and *linking*. *Bonding* social capital is the relationship between people founded on common ties, such as family, close friends and people who subscribe to the same cultural background. *Bridging* social capital describes the affiliation between friends of friends. This affiliation goes beyond heterogenous people and extends to distant family ties, companions and cronies. Thus, the bridging social capital is weaker than the bonding social capital. *Linkage* social capital depicts the connection to individuals or members at various levels of the social ladder, such as state official or political leader. These three structures of social capital have emotional, social and economic benefits. For instance, studies have shown that more people have gained employment opportunities through associates than through job vacancy announcements (Hyde-Peters and Simkiss, 2016; Brian, 2007). Significantly, economists have established that trust (the main element of social capital) promotes higher economic benefits in community development by compelling actors to strictly adhere to community customs, which ultimately eradicates the chances of corruption by management both at local and national levels (Gupta *et al.*, 2018; Locatelli *et al*., 2017). Additionally, increased social capital improves the level of trust amongst community members leading to improved participation in community development work (Thompson, 2015). According to Hyde-Peters and Simkiss (2016), social capital can also lead to undesirable consequences. For instance, a criminal gang that is galvanised by a strong relationship (bonding social capital) amongst gang members that undermines bridging social capital.

Social inclusion is a grey concept whose definition lacks consensus in the community development arena, although it is popular in the political, economic and community development parlance (Licsandru and Cui, 2018). Granted, the extant literature deliberately emphasises *subjective* social inclusion as opposed to *objective* social inclusion (Engsted, 2013). In this case, *subjective* social inclusion is described as a multi-faceted concept that explains a person's sense of belonging to a given community in such a way that the individual feels fully recognised, entrusted, valued and affiliated as a worthy member of that community (Licsandru and Cui, 2018). In contrast, the *objective* social inclusion depicts a conducive environment for a person to develop a feeling of social inclusion, for instance, decent living conditions, access to education and employment opportunities (Engsted, 2013). However, this environment does not establish the resulting *subjective* feeling of social inclusion (Licsandru and Cui, 2018; Engsted, 2013). According to (Licsandru and Cui, 2018), there are five dimensions of subjective social inclusion: *acceptance, empowerment, belongingness, respect* and *equality*. *Acceptance* is a person's feeling of other members' willingness to recognise them in the community (DeWall and Bushman, 2011). *Empowerment* is a person's feeling of control, participation and self-efficacy in the transformation process of a community through sustainable development (Sianipar *et al*., 2013). *Belongingness* is a person's cognitive assessment of affinity to the community (Licsandru and Cui, 2018). *Respect* is the recognition accorded to an individual because of fundamental moral value as a human being (Ponic and Frisby, 2010). These five dimensions of social inclusion have the potential to create positive sociability in a community by enhancing belongingness, esteem and positive contribution to the development of a community (Simplican *et al.*, 2015; Correa-Velez *et al*., 2010).

Social exclusion is a multi-faceted notion that echoes a blend of interdependent aspects that may hinder community members from full contribution to community development (Sedaghatnia *et al*., 2015). There are three dimensions of social exclusion that may hinder the effectiveness of an individual's contribution to community development, namely *production, consumption* and *political* exclusion (Zahra *et al*., 2018; Hazari and Mohan, 2015). (a) *Production* exclusion emanates from a deficiency of economic resources, such as capital. (b) *Consumption* exclusion restricts the consumption prospects of an excluded segment of a community. (c) *Political* exclusion denies people a chance to participate in decision-making processes. These three dimensions of social exclusion often lead to undesirable consequences to an individual, such as decreased intellectual astuteness (Baumeister *et al*., 2002), increased hostility (Twenge *et al*., 2001), decreased compassion and emotional lethargy (Baumeister *et al*., 2007), increased antisocial conduct (Twenge *et al*., 2007) and a futuristic desire to evade social contact with the cause of exclusion (Richman and Leary, 2009).

Capacity building is described as mechanisms planned and executed by CDWs to manage diverse community resources, such as financial, manpower (energy, skills, knowledge, time, conduct, enthusiasm, influence, ethos), technical (facilities, databases, supplies), logistical (policies, administrative support), generative (originality, legitimacy, trust, character) and other resources (e.g. physical space) aimed at achieving excellence in implementing proven, expertise building initiatives through public delivery platforms (Moreno *et al*., 2017; Shiel *et al*, 2016; Morgan, 2006; Spoth *et al.*, 2004). These resources can enable an individual or community to prosper on the backdrop of mediating factors, such as global economic trends, state policies, legacies of local community histories and endogenous knowledge (Brinkerhoff and Morgan, 2010). These mediating factors imply that capacity building is a continuous mechanism for improvement in a community with the objective of improving community welfare: an endogenous mechanism, which may be boosted by the influence of exogenous factors that aid the community's quest for improved welfare. This means that the outcomes of capacity building may be uncertain since the learning process is often wrought with many expected and spontaneous episodes that require exceptional leadership to navigate (Edwards, 2015; DiClemente *et al*., 2009; Luloff and Bridger, 2003; Brown *et al*., 2001).

[redacted] Benefits of community development

The extant PME literature reveals many benefits of community development, which include empowerment of communities; improved planning, design, implementation and evaluation of projects; improved utilisation of research findings; improved resolution of ethical problems through consensus building; enhancement of skills and knowledge amongst community members; promotion of academic partnerships in a community; and promotion of the growth of community-based organisations. A detailed description of these benefits is presented in the following sections.

a) Empowerment of communities to chart their own development agenda

Community development has been credited with empowering communities to chart their own development agenda (Molden *et al.,* 2017). Empowerment is a mechanism by which communities shape their destinies through meaningful engagements to develop a sense of belonging and ownership of their communities (Mansour, 2016). Thus, empowerment is achieved through community engagement, which is a useful mechanism for establishing prime actors, managing their influence on the project and where possible, gaining their backing (Patanakul *et al*., 2016). This engagement influences the choice and focus of a project, initiation process and funding proposals (Hedin and Ranängen, 2017; Pojasek, 2011). Additionally, positive community engagement yields new and better partnerships that unlock funds targeting community-driven initiatives (Staley, 2009).

The community development parlance emphasises empowerment of actors by encouraging joint decision making (Rouse and Ware, 2017). This joint enterprise is vital for developing mutual solutions to community problems (Rouse and Ware, 2017). Generally, community empowerment inspires a wide a range of social, economic and human capacity to solve a wide range of problems facing marginalised communities, such as alleviating poverty, enhancing the quality of life or solving complex problems, such as climate change. This is done by cultivating an environment of trust where their interests are duly considered (Wahid *et al.*, 2017; Owen and Kemp, 2012). There is also the notion of community empowerment as a vital capacity to compel private or public organisations to implement development agenda in cases where those who wield more power exert undue influence over the less powerful (Hoffman, 2017; Wahid *et al*., 2017; Gilbert *et al*., 2016).

b) Improved planning, design, implementation and evaluation of projects

Generally, community development has led to a general improvement in various aspects of community projects, such as planning (cost, returns, funding, timelines, progress, market share, milestones, work schedules, logical framework and priorities), design, equipment, participation, data collection, data analysis, communication and dissemination of results (Hassan *et al*., 2018; Staley, 2009). This has been achieved through an improved appreciation of the causal links between project entities by tapping into the community's indigenous knowledge of local situations (Staley, 2009). Additionally, by including the community in all aspects of project management, it is easier to account for skills, knowledge and resources that eventually results in more effective projects, reduced likelihood of conflict and more efficient use of resources (Matarrita- Cascante and Brennan, 2012).

c) Improved utilisation of research findings leading to change

Community development improves the utilisation of research findings to orchestrate community change in many ways, such as creating new funding policies, new or better services or expanding partnerships (Staley, 2009). This improved utilisation of research findings reflects the accuracy of decisions made concerning the aspirations of the community (Pojasek, 2011). As such, this process is guided by constructive dialogue through which information is shared amongst actors. Imperatively, this dialogue may be achieved through structures, machinery and platforms that support expansive community dialogue (Jones *et al*., 2017), such as informal debates, group dialogue, site visits, emails, bulletins, official letters, promotions, annual reports and phone-in sessions (Pojasek, 2011). Such constructive dialogue can only occur in a conducive atmosphere of openness where divergent perspectives and opinions can be harmonised (Vangrieken *et al*., 2017).

d) Resolving ethical problems through consensus building

Community development provides opportunities for building consensus amongst community members as well as establishing ethical risks and formulating mechanisms for rectifying ethical problems when they surface (Staley, 2009). As such, it is significant for community development actors to appraise the quality of the consultation process (Nwapi, 2017). Consequently, many consensus building methodologies have been provided in the community development parlance, for example, *focus groups, formal consensus development method, interactive group decision making process, nominal group process* and *Delphi methodology* to provide answers to problems (Devaney and Henchion, 2018; Nazar *et al*., 2018). According to Nazar *et al*. (2018), the interactive group decision-making process and the nominal group process tend to be more cost-effective in resolving specific problems than focus groups that adhere to the principle of data saturation. Additionally, Nazar *et al*. (2018) postulate that the formal consensus development method provides a platform for a group decision-making process, typically by espousing a grading procedure that depicts the degree of agreement about pre-established topics. Further, Nazar *et al*. (2018) propose that the formal consensus development method should consist of small groups to enable comprehensive engagements through which members elucidate, debate, negotiate contentious issues and eventually reach consensus.

The Delphi methodology deserves to be emphasised as a robust forecasting tool based on a series of structured surveys with one group of autonomous experts (Makkonen *et al*., 2016). The overarching goal of the Delphi methodology is to gather expert opinion on a given matter by forecasting the future and consequently striving to attain a consensus (Hsu *et al*., 2017). The basic tenets of the Delphi methodology are the notion of repetition, anonymity and the delivery of agglomerated feedback for each round of survey-a distinctive feature that distinguishes it from conventional survey methods (Mathur *et al*., 2008. The Delphi methodology also permits actors to re-evaluate their previous responses in consideration of other participants' views. By using these established tenets, the Delphi methodology provides a platform for mutual social learning (Mathur *et al*., 2008). Further, the Delphi methodology can still be used in cases where consensus is not forthcoming to explain issues, scrutinise differing expert views and boost participants' understanding of divergent positions on ambiguous and polarised subjects (Devaney and Henchion, 2018). However, Devaney and Henchion (2018) postulate that the Delphi methodology's mutual social learning philosophy is a pitfall because it permits interest groups to continuously champion certain views without a solid scientific basis and without due consideration of other participants' reactions. According to Devaney and Henchion (2018), it is vital to undertake a judicious choice of experts and a fair reporting of outcomes to minimise such pitfalls and to guarantee an impartial interpretation of findings.

e) Enhancement of skills and knowledge amongst community members

Community development provides a platform for the development of knowledge and skills of community members who contribute to the success of a project. This cultivates goodwill and rapport for successive partnerships (Staley, 2009). According to Hedin and Ranängen (2017), the community development process can enhance the knowledge and skills of community members through diverse means, such as charitable work; competence enhancing programmes, such as education and culture; and sectoral skills training. According to Mtika and Kistler (2017), the enhancement of skills and knowledge significantly improves the nature of partnerships, determination, passion and contributions in the community development process, which ultimately yields cohesion and integration in the community. Additionally, Franco and Ali (2017) posit that by equipping community members with knowledge and skills, the community development process acts as a catalyst for new employment opportunities, especially those inspired by entrepreneurship.

f) Promoting academic partnerships in a community

The concept of academic partnership presupposes that community members and academic researchers learn from each other about development trends and challenges in the community and work together to resolve these challenges. In this manner, the parties widen the mutual monitoring of perspectives and the opportunities for collective action (Mtika and Kistler, 2017). The concept of academic partnership between academic institutions and the community is important for improving the understanding of community-oriented research topics and an appreciation of the significance of community involvement, which can potentially yield direct professional benefits (Carrera *et al*., 2018; Staley, 2009). Additionally, such partnerships often produce new intuitions into the relevance of a community project and the numerous benefits to be derived from it can produce more opportunities to propagate its findings and their broader application (Staley, 2009).

According to Carrera *et al*. (2018), academic partnerships in community development process are underpinned by research altruism- an explicit form of banal altruism that provides inspiration for engagement in community-centred research to produce positive social gains. In this respect, research participants are motivated by a sense of self-sacrifice to participate in community-centred research and optimism that the society would benefit from the research (Carrera *et al*., 2018; Paraskevaidis and Andriotis, 2017). Moreover, this perspective projects CBOs as additional mediators in building trust between community members and academic researchers, thereby permitting community participants to see their worth. Further, Carrera *et al*. (2018) posit that research altruism offers a way to deflect the gains of participation away from individual research participants when engaging in a research study could jeopardise their means of livelihood and the larger community.

g) Promoting the growth of community-based organisations

The dominance of community development projects - characterised by a multiplicity of actors and networks - has led to the growth of CBOs or NGOs by creating opportunities for them to expand the scope of their mandate in community development (Molden *et al.,* 2017). These CBOs have been shown to be effective in achieving positive outcomes in diverse initiatives, such as empowering youths, resolving protracted community conflicts; advocating for various community interests at micro, meso and macro levels; offering technical guidance, empowering marginalised communities and expediting the delivery of local services (Molden *et al.*, 2017; Nelson *et al*., 2017; Mansour, 2016; Hakaloba *et al*., 2016). These successes have been recorded on the backdrop of CBOs establishing a better perspective of a community, creating a better profile of a community, establishing sustainable linkages with other actors and building capacity amongst actors, which have the potential to create long-term goodwill for subsequent partnerships (Staley, 2009).

[redacted] Roles and competencies of community development workers

Community development projects are championed by CDWs whose role is primarily to advocate for the integration of community development plans into the livelihoods of a community in a bid to have a meaningful impact (Raga *et al*., 2012). Generally, a CDW may be construed as an umbrella term for any actor who is involved in a sectoral community project, such as agriculture, healthcare, education, competence building, art, culture or social welfare (Hedin and Ranängen, 2017; Tan, 2009).

Owing to the phenomenal mandate bestowed upon them by their communities, the CDWs can be characterised as follows: *access facilitators, service developers, change agents* and *capacity builders*. As *access facilitators,* the role of the CDWs is to remove barriers that may impede access and utilisation of public services by community members (Mashaba, 2011; Boomer and McCormack, 2010; Thomas *et al*., 2006). To achieve this mandate, they assume the following specific roles. (a) Tackling language and other barriers to help the community chart their development course (Mashaba, 2011). (b) Assisting CBOs to develop project proposals for securing funding to address community problems (Phillips and Pittman, 2014; Mashaba, 2011). (c) Guiding community members in the process of resource mobilisation (Drummond *et al*., 2017). (d) Helping the community to cultivate trust amongst actors involved in the community development process (Phillips and Pittman, 2014).

The role of CDWs as *service developers* entails an exploration of new services to improve the welfare of the community by considering three levels of public services: *essential*, *preventive* and *corrective* services (Centre for Community Health and

Development, 2017). *Essential* services are crucial services that the community cannot exist without, for instance, police, schools and public works. *Preventive* services help to avert problems and to sustain the quality of life in a community and if left unchecked, may cause complications, such as youth development and job training. *Corrective* services seek to unravel present obstacles and rectify anomalies. As such, corrective services tend to be ephemeral, limited in scope and tend to address the symptoms of community problems- for instance, housing for the homeless- but does not address the root cause of these problems, such as poverty (Centre for Community Health and Development, 2017). To develop these three types of services, the CDWs must assume the following specific roles. (a) Guiding the process of skills training and education for the community staff (Phillips and Pittman, 2014). (b) Demonstrating the significant role of culture in public service systems theory and application (Green and Haines, 2015). (d) Establishing partnerships between public service providers and community service providers (Green and Haines, 2015; Phillips and Pittman, 2014).

As *change agents,* CDWs support bottom-up development projects to emancipate the community (Schulenkorf, 2010; Tajik, 2008). Consequently, CDWs should be equipped, sustained and encouraged in this phenomenal responsibility to pursue a holistic approach to community development as key players in development efforts geared towards promoting self-sufficiency and sustainable development (Martin, 2014). In pursuit of this phenomenal role, CDWs should undertake the following tasks. (a) Establishing community interests and lapses in service delivery (Phillips and Pittman, 2014). (b) Establishing an efficient communication structure between the community and the government (Houston *et al*., 2015). (c) Establishing a robust mechanism for community dialogue to establish the needs of the marginalised segments, such as the elderly, youth and ethnic groups (Green and Haines, 2015). (d) Developing linkages for building capacity in the community using formal and informal avenues (Green and Haines, 2015; Boomer and McCormack, 2010).

The role of CDWs as *capacity builders* (invariably called capacity developers) involves working with the community members to acquire, enhance and sustain the requisite technical, management, leadership and adaptive competencies to excel in community development (Duggan *et al*., 2016; Act, 2011; Enemark and Denmark, 2003). In this quest, some of the specific responsibilities of CDWs include the following. (a) Developing socially inclusive communities through progressive policies, such as those that facilitate access to employment opportunities, better education, improved housing, better healthcare and entrenching democracy (Phillips and Pittman, 2014). (b) Supporting community leadership development initiatives to nurture the concepts of facilitative leadership, dialogue, power relations, collective action and resource mobilisation for capacity building (Ferris *et al*., 2017; Martiskainen, 2017). (c) Mentoring community members to form autonomous CBOs and developing strategic plans for community projects (Green and Haines, 2015). (d) Participating in the process of monitoring and evaluating the performance of diverse projects in the community (Phillips and Pittman, 2014). (e) Preparing regular reports detailing the performance of community development projects in cognisance of the needs of the actors in community development (Craig, 2007).

In view of their phenomenal roles and responsibilities, the Standard Councils of Scotland (SCS) (2009), has identified seven *competencies* that CDWs should possess. These competencies are described as follows:

a) Developing a thorough knowledge and an appreciation of the community. The CDWs should possess the ability to ascertain internal and external factors affecting the community, consequently establishing its concerns, resources and opportunities.
b) Establishing both learning and development opportunities. The CDWs should develop robust dialogue mechanisms, surmount challenges to effective participation and implement community-centred projects.
c) Fostering the development of strong working relationships with members and groups in the community. This competency compels the CDWs to juggle diverse roles, such as facilitating, promoting, directing, advocating, resolving conflict and handling power relations in the community development spectacle.
d) Catalysing, facilitating and encouraging community empowerment. This competency is pegged on the principles of participation and social inclusion in the process of decision making. This means that the CDWs must strive to bring "everybody on board" in their quest for meaningful change. This competency is regulated by the existing governance structure in the community.

e) Mobilising and managing community resources. That CDWs should acknowledge the dynamics of managing a community, such as the culture of the community, effective management strategy, project management and fundraising.
f) Establishing sustainable partnerships with other organisations. The CDWs should have the capability to enter into collaborations with other organisations to work towards mutual objectives by offering effective leadership, creating a mutual understanding of purpose, effective performance management, effective communication, promoting joint learning and development.
g) Monitoring and evaluating community development projects, learning and informing practice. The CDWs must possess the appropriate skills and resources to effectively monitor and evaluate the performance of community projects. Based on these results, they can then learn and inform the practice of community development.

[redacted] Approaches to community development work

The *guiding philosophy* for community development is the transformation of a community from an inferior state to a superior state (Green and Haines, 2015). This transformation is based on a framework of self-determination, self-sufficiency and self-actualisation- tenets of social justice and mutual respect (Licsandru and Cui, 2018; Thompson, 2015). Fuelled by the zeal for social justice and mutual respect, community development identifies and tackles barriers that may hinder the progress of a community (Andrews *et al*., 2014; Mashaba, 2011) through dynamic participation and empowerment (Sianipar *et al*., 2013). As a matter of principle, it is crucial that community members actively own this transformation agenda (Mansour, 2016), transformation mechanism and outcomes (Nelson *et al*., 2017).

Based on the guiding philosophy, there are three distinct approaches to community development work: *apologetic (technocratic)*, *liberal* and *liberative* (Clarinda, 2012; Tan, 2009; Kelley *et. al.*, 2006). These approaches are discussed as follows. The *apologetic* community work tends to promote government agenda by bridging the gap between the central government and the community (Clarinda, 2012). The apologetic approach does not conform to the bottom-up strategy in the sense that apologetic CDWs persuade communities to consent to and act on pre-determined decisions by a higher development authority: it regards community members as "objects to be acted upon" rather than "subjects of their own transformation dealing with their local problems" (Mtika and Kistler, 2017; Westoby and Dowling, 2013). This means that the apologetic approach presupposes that the central government is benevolent, receptive and advocates for the interest of the community (Clarinda, 2012). Consequently, the technocratic approach is seen to be patronising, inflexible, autocratic and precludes communities from reflecting on their inferior circumstances and charting their own agenda for transformation (Mtika and Kistler, 2017; Kelley *et. al.*, 2006). For this reason, community members view the apologetic approach as a strategy to entrench the policies of the government by using development projects as dole outs (Kelley *et. al.*, 2006). Further, the apologetic approach is preoccupied with tackling community challenges instead of relying on the capacities and resources that a community can endogenously exploit to transform itself (Flora *et al.*, 2015).

The implications of the apologetic approach to the community development work are manifold. First, the apologetic approach projects the CDWs as agents of the existing regime who labour to strengthen its grip on power (Clarinda, 2012). Second, this approach places the CDWs as the intermediary responsible for overseeing the implementation of government policies by the community (Kelley *et. al.*, 2006). Third, the CDWs act as conduits who are equipped with the requisite skills to negotiate the acceptance of government policies by the community (Tan *et al.*, 2009). Fourth, this approach legitimises the government through the delivery of predetermined services (Kelley *et. al.*, 2006).

The *liberal* community work tends to initiate development without tackling the underlying cause of such issues; their *modus operandi* is to solve problems in a community by tackling one issue at a time (Clarinda, 2012). This approach is premised on a widespread community view that the state is non-responsive to their plight because they do not exert enough pressure on the government (Kelley *et. al.*, 2006). Additionally, the liberal community work advocates for the bridging of social classes in the community by tinkering with intrinsic anomalies (Clarinda, 2012; Kelley *et. al.*, 2006). Moreover, this approach is appealing to masses who view it as "romantic and tailist" (the notion of the government allowing a community development process to unfold on its own and then responding to the outcome of the process) (Clarinda, 2012). This approach is also known to be process-oriented and tactical in nature, which underscores its central tenets (Clarinda, 2012; Kelley *et. al.*, 2006). The implication of this approach to community development is that it is localist (resolutely concerned with issues that directly concern the community), issue-based (tackles community challenges on a case-by-case basis) and evocative (conjures strong emotions, images, or memories of past experiences) (Clarinda, 2012; Kelley *et. al.*, 2006).

The *liberative* community work awakens the consciousness of a marginalised community with the overarching goal of orchestrating an overhaul of the existing exploitative order in the community (Clarinda, 2012). This goal is borne of an appreciation of crumbling linkages between local, regional, national and international governance structures that breed an opportunity for revolutionising the social order in the community by experimenting with alternative development mechanisms in a bid to realise transformation in the community (Clarinda, 2012; Tan, 2009). In this radical venture, the common issues include divisive governance, lackadaisical leadership, racism and oppression (Tan, 2009). On the backdrop of these poignant issues, revolutionary CDWs seek to tackle concerns in the community, such as (a) developing sustainable community assets (Sianipar *et al.*, 2013); (b) documenting endogenous knowledge using alternative epistemologies (Sisto *et al.*, 2018); (c) placing the community on a pedestal of self-determination (Licsandru and Cui, 2018); (d) fostering an enduring legacy of dialogue, reflection, action and awakening of consciousness in the community (Ferris *et al.*, 2017); (e) promoting community ethos and uniqueness (Kelley *et. al.*, 2006); and (f) appreciating the contextual historical and political factors (experience, memories, skills, local knowledge) that influence community development (Licsandru and Cui, 2018; Clarinda, 2012; Tan, 2009; Kelley *et. al.*, 2006).

[redacted] Significant challenges of community development

Regardless of the perspective that shapes a community development project, the extant PME literature shows that there are a host of challenges that affect the overall success of a community development project. Some of these *significant* challenges have been discussed as follows.

Legal and ethical constraints: it is often difficult to enact progressive legislation that captures the aspirations of diverse actors in community development due to social, political, economic and environmental disproportions (Hedin and Ranängen, 2017; Mtika and Kistler, 2017; Nwapi, 2017; Adeniyi, 2014). For example, community development work targeting marginalised communities may be hampered by lack of legal title deeds for their parcels of land, thus constraining their participation (Nour, 2011). Such laws and regulations are integral to the achievement of the following objectives. (a) To provide a legal basis for community development projects by ensuring that their operations subscribe to the tenets of equity in the sharing of the proceeds of the project in the community; that the activities associated with the project are economically, socially and culturally sustainable; and that the project significantly contributes to the social, economic and cultural transformations of the community. (b) To uphold the tenets of accountability and transparency in community development work. (c) To establish timelines and frameworks for community development contracts (Nwapi, 2017). The community development work should not only satisfy certain objectives as outlined above but also comply with ethical considerations (community practices and ethical customs) (Hedin and Ranängen, 2017).

Funding problems: the lack of sufficient funding often leads to stalled or unsustainable community projects (Martiskainen, 2017). Generally, community development work is beleaguered by the lack of sufficient funding because of various factors, such as changing government financial policy, economic meltdown, lack of capacity to handle protocol and complex funding procedures (leading to burnout and loss of time), strict donor conditions, poorly drawn funding proposals or simply lack of information about funding opportunities (Dinnie and Holstead, 2017; Moreno *et al.*, 2017; Wahid *et al*., 2017; Mansour, 2016; Martiskainen, 2017; Rikhotso, 2013; Seyfang *et al.*, 2013; Tan, 2009). Consequently, these factors impact the course of community development because, "he who pays the piper, calls the tune" of development (Flora *et al.,* 2015). Suffice to say, the source of funding (government, donor, community CBOs, individuals) comes with the attendant technical and administrative conditions that ultimately impact the utilisation of community development funds and the overall course of a community project. Additionally, misappropriation of project funds may create anarchy leading to stalled projects

(Wahid *et al.*, 2017; Adeniyi, 2014). Furthermore, there are instances where a cost-sharing strategy may be employed but may become a snag amongst poor members of the community leading to loss of self-empowerment (Wahid *et al*., 2017).

Conflicts and rivalries amongst actors: there are instances of conflicts and rivalries among different caucuses at community level leading to less effectiveness. This challenge may be exacerbated by the duplicity of projects by different caucuses in the same community leading to wastage of resources and time (Wahid *et al*., 2017; Borsekova *et al*., 2016; Adeniyi, 2014). Generally, conflicts and rivalries in the community may be caused by diverse factors, such as (a) misunderstanding amongst actors regarding project goals, logistics, responsibilities, priorities, ethos and values (Ali and Ocha, 2018); (b) ineffective communication of notices, policies, decisions and responsibilities (Jandt, 2017); (c) ineffective planning leading to disorganisation; (d) frustration, stress and fatigue caused by criticism, abuse (verbal, physical), noise, overcrowding and a lacuna in management (Oyedokun and Lawal, 2017); and (e) poor choice of community leaders who do not inspire a sense of mutual understanding (Li *et al*., 2018; Wahid *et al*., 2017). Some of the methods that can be used to resolve these conflicts and rivalries include dialogue amongst affected parties, use of community arbitration committees, negotiated (and registered) agreements and use of legal mechanisms (Oyedokun and Lawal, 2017).

Apathy amongst community members may lead to poor participation. This may arise out of discrimination between community members where the rich, educated or politically "correct" receive preferential treatment; social exclusion of minority groups; and lack of awareness of the benefits of community development (Kwan *et al*., 2017; Wahid *et al*., 2017). According to Rikhotso (2013), the hurdle of apathy can be conquered through a sustained sensitisation campaign showing the significant role of community development and why it is important for community members to participate in the process. In addition, Rikhotso (2013) argues that any campaign against apathy should also target marginalised segments of the communities, such as minority ethnic groups.

Social capital issues: community development projects are often fraught with weak social capital (trust, mutuality, amicability, helping behaviour) by apologetic CDWs who tend to be conservative and less supportive of bottom-up strategies (Mtika and Kistler, 2017). This anomaly may be aggravated by poor negotiation skills (Hoffman, 2017; Mtika and Kistler, 2017; Wahid *et al.*, 2017; Tan, 2009). Generally, weak social capital leads to less active community participation and collaborative action to achieve a common goal. Additionally, less cohesive communities with scarce social capital are poor at mobilising community resources (Martiskainen, 2017; Kim *et al.*, 2017).

Political power issues: political power changes and contests pose an important concern for community development work because of the accompanying anxiety concerning the change of guard following political activities, such as elections, appointments or reshuffles at various levels of government (Gilchrist and Taylor, 2016; Rikhotso, 2013). This is because political changes and contests often come with conflicting development agenda or shifting alliances to win scarce developmental resources (Banks and Carpenter, 2017; Mills and Kalaf-Hughes, 2017; Makofane and Gray, 2014). For this reason, it is necessary for community actors to engage in (re)alignment, negotiation and conflict resolution because political leaders influence the decision-making process (Garcia, 2016; Wahid *et al.*, 2017).

Bureaucratic project approval and registration: bureaucratic project approval and registration procedures often make it expensive and time-consuming to initiate community development projects (Wahid *et al.*, 2017; Mansour, 2016). In some cases, this delay may be caused by political gerrymandering to influence the approval of community projects fronted by politically influential individuals leading to rifts in the community. This development may dampen the spirits of CDWs who may become hesitant to submit new project proposals (Wahid *et al.*, 2017).

The misconceptions about community development work: there are instances of misconception about the nature of community development work. This misconception has been reported across communities, local, regional, national and international audiences (Rikhotso, 2013). In some communities, CDWs have been viewed as spies, political mercenaries or political agents who are keen to accomplish certain political agenda (Mashaba, 2011). This misconception has reportedly derailed the success of community development work in certain regions and should be countered by a sustained communication strategy that debunks such myths, extols the virtues of community development, its status as well as prospects (Hanson-Easey *et al*., 2018; Nakamura *et al*., 2017).

Lack of professionalism amongst some CDWs: according to Hart (2012), professionalism signifies trust (arising from professional socialisation), which a service recipient places in a professional service provider who should reciprocate by demonstrating his/her expertise in a stated field based on discrete values and moral obligations. Evetts (1999), argues that professionalism aids in the delivery of complex services to the public but does not guarantee service quality. Ideally, the professionalisation of community development work has gained currency in the last couple of decades as a means for boosting social-economic development by embodying the following tenets: full-time work, specialised pedagogy, pledge to an occupation, service orientation, a formalised governance structure and autonomy (Füller *et al*., 2017). The absence of these six defining characteristics often render CDWs less professional in their endeavours leading to inferior quality of work, limited expertise to handle complex tasks, poor organisation and engagement in the community (Nguyen and Rieger, 2017). According to Hart (2012), there are several ways of ensuring that CDWs subscribe to these tenets, including accreditation of CDWs, training of CDWs and close collaborative research between the community and the universities. In one study, for example, Olugbara *et. al*. (2014), demonstrated that the diminishing professionalism of the CDWs could be improved by providing training opportunities, such as the e-skills training programme in South Africa.

Non-participatory community development planning methods: many community development planning methodologies remain unintegrated and non-participatory in nature and thus tend to deprive the process of the element of community participation, which would enrich community development policies and decision-making processes (Phillips and Pittman, 2014; Nour, 2011). In addition, such non-participatory planning approaches tend to be top-down, less interactive, less appreciative and less popular (Konsti-Laakso and Rantala, 2017).

Sustainability issues: sustainability (economic, environmental and social) remains a challenge for community development projects in the twenty-first century - a fact that has led to the rise of sustainability as a dominant research agenda requiring the concerted effort of all community development actors (Chawla *et al*., 2018; Kivilä *et al*., 2017; Mansour, 2016; Borsekova *et al*., 2016; Fazal *et al*., 2016; Szitar, 2014). The goal of sustainable community development is to meet the multi-level and multi-sectoral needs of a community within ecological constraints for both the present and future generations, including eradication of poverty, healthcare, social justice and decent housing (Hedin and Ranängen, 2017; Adeniyi, 2014; Szitar, 2014). The implication of this concern is that sustainable projects should be prioritised. In addition, development projects should be tailored to suit the needs of a community (Hedin and Ranängen, 2017). It is vital to improve the participation of a community in a project with a view to developing a long-term sustainable relationship founded on mutual respect through focus groups, surveys or research (Nguyen and Rieger, 2017; Wahid *et al*., 2017; Hedin and Ranängen, 2017; Szitar, 2014).

The development of sustainable projects, which in turn yields sustainable livelihoods in the community should be guided by *governance* processes as a core constituent of the policies, institutions and processes because of the complexity of multi-actor participation processes. Such participatory effort should deliver sustainable development outcomes (Franco and Ali, 2017; Borsekova *et al*., 2016).

2.2 PARTICIPATORY MONITORING AND EVALUATION OF PROJECTS

[redacted] Principles of participatory monitoring and evaluation

The advent of the information age and the new media in recent years have seen a paradigm shift in the process of PME from traditional approaches to more inclusive ones that attempt to resolve multi-actor complexity by involving actors in all aspects of the PME process through collaborative and dynamic participatory structures (Henriksen *et al.,* 2018; Tengan and Aigbavboa, 2017; Kaufman *et al.,* 2014). The traditional approaches have been conducted by external experts using conventional tools, such as surveys to gauge inputs and outputs against predetermined indicators to meet accountability demands of project donors or funding agencies (Tengan and Aigbavboa, 2017). In contrast, modern PME processes are increasing fuelled by, *inter alia*, the growing need to involve multiple actors in defining the problem, collecting, analysing and interpreting data for project management (Tengan and Aigbavboa, 2017; Villaseñor *et al*., 2016; Kaufman *et al.,* 2014; Holte-McKenzie *et al*., 2006). Such participatory planning approaches may take myriad forms, such as executive committee-led meetings, the board of advisers, conferences, discussion forums and seminars (European Commission, 2014). Subsequently, participatory approaches are premised on the following *principles*:

a) *Sharing information and knowledge*. PME actors share their knowledge and information; communicate various morals, values, objectives and build consensus on the use of resources through participatory approaches in congruence with stakeholder (actor) theory (Olsen *et al.*, 2016; Hermans, *et al.*, 2012).

b) *Mutual understanding*. These processes represent a viable collaborative framework for capturing the aspirations of the actors ranging from public agencies to business, industry and various public interest groups (Chapman *et al*., 2016; Kaufman *et al.*, 2014).

c) *Mapping ''impact trajectories" over time***.** These approaches are keen on *how*, *why*, *when* and *where* questions about project performance as well as charting ''impact trajectories" for different dimensions and outcomes of a project for a considerable duration of time (Cornwall and Aghajanian, 2017; Mansuri and Rao, 2013; Woolcock, 2009).

d) *Contextualising project performance*. These approaches attempt to explore the contextual factors surrounding the performance of a project, associations between actors and organisations, changes in organisational frameworks and relational dynamics (Cornwall and Aghajanian, 2017).

e) *A holistic approach to gauging transformation*. Participatory approaches explore community transformation from diverse perspectives that can produce sufficient knowledge about the predisposing factors for positive transformation in a community together with a profound knowledge of impediments (Cornwall and Aghajanian, 2017; Krasny *et al.*, 2014).

f) *Capturing unexpected transformation*. Participatory processes capture non-anticipated transformations, together with the necessary background information for explaining why and how the transformations occurred or did not occur. This rich exploration reveals the internal dynamics of transformations, including people, places and events (Cornwall and Aghajanian, 2017; Mutongwizo *et al*., 2015).

g) *Enhancing transparency*. Participatory approaches offer more transparency and engagement than conventional approaches for gathering project performance data, such as survey methods (Bautista *et al*., 2017; Kusters *et al*., 2017).

Based on the principles described above, participatory approaches have yielded many benefits, such as offering an economical, enfranchising, meticulous and germane approach to evaluation (Tengan and Aigbavboa, 2017). Additionally, participatory approaches tend to strengthen trust amongst community members, researchers and organisations (Hoffman, 2017; Mtika and Kistler, 2017). Further, these approaches create shared visions amongst CDWs and provide a framework for actively engaging all actors in project management (Verbrugge *et al*., 2017). However, Hermans *et al*., (2012) argue that these principles may not be an automatic panacea for resolving PME challenges. They have suggested that PME practitioners should approach this phenomenon with caution because differences in resources, perceptions, knowledge hoarding and power fights often come into play. To buttress the case for a cautious approach to PME, Díez *et al.* (2015), Wilson *et al*. (2017) and Zhang *et al*. (2015) contend that poor design and implementation of participatory processes coupled with insufficient time and resources may lead to marginal benefits resulting in unfavourable effects, such as ‘participation fatigue’.

[redacted] Participatory monitoring and evaluation systems

There is a plethora of literature on PME systems that have evolved over time with the prime goal of improving project management through shared learning, democratic processes, joint decision-making, co-ownership, mutual respect and empowerment (Kusters *et al*., 2017; Wahid *et al*., 2017; Phillips and Pittman, 2014; Mcloughlin and Walton, 2012; Gerwin and Ferris, 2004). These PME tools can roughly be categorised as follows: *active community engagement systems, passive community engagement systems, participatory systems for enhancing usefulness and accessibility of participatory data* and *progressive PME systems* (Wilson *et al*., 2017; Berkowitz and

Gagnon, 2017; Pearson *et al*., 2017; Piezunka and Dahlander, 2015; Zhang *et al*., 2015; Xintong *et al*., 2014; UNDP, 2013).

a) Active community engagement systems

These systems require the involvement of a community in many aspects of PME, such as data collection and decision making, in a bid to increase their influence in the project cycle and to ensure a more positive impact (Piezunka and Dahlander, 2015; UNDP, 2013). This approach involves the use of various participatory systems, such as *crowdsourcing*, *real-time simple reporting*, *participatory statistics*, *mobile data collection* and *micro-narrative* (Khan *et al*., 2015; Wilson *et al*., 2017; Zhang *et al*., 2015 UNDP, 2013).

Crowdsourcing is a citizen reporting model for a multitude of people to report unfolding events in their locality using mobile technology and open source software systems (Xintong *et al*., 2014; UNDP, 2013). Basically, crowdsourcing is an innovative, less intrusive and less extractive tool that promotes public participation and civic engagement (Piezunka and Dahlander, 2015; UNDP, 2013). Additionally, crowdsourcing permits data collection on a larger scale compared to conventional methods and offers a catalytic way to report precarious subjects (Khan *et al*., 2015). Further, this platform has been adopted in many countries and projects (Wilson *et al*., 2017; Zhang *et al*., 2015). The benefits of crowdsourcing include permitting project actors to collect enormous, real-time data from a specific site in a cost-effective manner; promoting public involvement through a bottom-up communication conduit and producing data that is less prone to manipulation and less vulnerable to misinterpretation (Piezunka and Dahlander, 2015; Khan *et al*., 2015; UNDP, 2013). However, crowdsourcing has been faulted for being incentive-driven to motivate the community to participate and for requiring customisation to suit different scenarios (Wilson *et al*., 2017; Zhang *et al*., 2015; UNDP, 2013).

There are several examples of crowdsourcing systems, such as *Ushahidi platform* (a crowdsourcing interactive mapping tool) (Rotich, 2017; Macdonell, 2015); *SeeClickFix* (a digital tool for the public to communicate non-urgent issues to the government) (Berkowitz and Gagnon, 2017); *FrontlineSMS* (an open-source software for text messaging) (Rashid *et al*., 2016; Bel *et al*., 2014); *RapidSMS* (an open-source digital tool for SMS-based data collection and logistics management) (Mwendwa, 2016); and *Ideascale* (a sharing, voting and discussion platform) (Klein and Garcia, 2015; UNDP, 2013).

Real-time simple reporting systems lessen the burden of PME by reducing the amount of time spent on providing regular, concurrent data in multiple media (Levin *et al*., 2016). This platform improves the utilisation of project reports by eliminating unnecessary details common with conventional data collection systems with a real-time digital platform for use in public management (Hellström and Jacobson, 2014; Pearce *et al*., 2014). Thus, the benefits of real-time simple reporting systems include real-time project monitoring, generating authentic data enhanced by multi-media data, enabling organisations to handle multiple projects and multiple actors and generating concise and real-time data with a high chance of utilisation in decision-making (Shah, 2017; Hellström and Jacobson, 2014). However, real-time simple reporting systems, such as *Akvo Really Simple Reporting* (RSR) have been faulted for producing brief reports and for biased reporting (Hellström and Jacobson, 2014).

Participatory statistics are mechanisms for a community to produce statistical data using participatory systems, such as proportional piling, matrix ranking, participatory mapping, 'ten seeds technique' and pairwise ranking. This venture is repeated with many groups to yield sound quantitative data (Pearson *et al*., 2017; Chambers, 2015; Masset, 2014). Basically, participatory statistics decentralise the data collection process by empowering communities to provide rich endogenous knowledge and information as opposed to the conventional notion that data collection is a top-down centralised process (Masset, 2014; UNDP, 2013). In addition, this approach can be useful in generating data on sensitive issues, which are not amenable to surveys (Pearson *et al*., 2017). Consequently, this approach is credited with producing carefully accumulated and triangulated data leading to more valid, factual and precise results, empowering the community and making utmost use of authentic endogenous data (Pearson *et al*., 2017; UNDP, 2013). However, participatory statistics tend to be time-consuming in data collection and require to be established by a policy (Chambers, 2015; UNDP, 2013; Barahona and Levy, 2007).

Mobile data collection involves the use of mobile devices running specialised software applications to gather structured information from a target audience

(Hellström and Jacobson, 2014; UNDP, 2013). The mobile data collection system brings a different dimension in data collection through designated surveys to capture information, such as geographic location-based information, including geo-metadata, photos, video and audio (Andone *et al.*, 2016; Schobel *et al*., 2016). The strengths of the mobile data collection are highlighted as follows: timely and accurate data collection, customisable surveys that that capture geo-information and multimedia data (Liu *et al.*, 2018; Park, 2015). Nonetheless, mobile data collection systems are biased in favour of elitist and powerful actors and the unfounded belief that the use of technology will automatically improve the survey tool (Liu *et al.*, 2018).

Micro-narrative is the collection of numerous brief stories from the public using unique algorithms to unearth real-time issues and transformations in the community (UNDP, 2013). The thrust of a micro-narrative is that the narrator has the prerogative to decipher the meaning of the narrative thus eliminating any biases or misconceptions that may arise from third-party interpretation (Fernandes, 2017). In this manner, the micro-narrative approach converts qualitative data (many narratives) into an agglomerated statistical data with the aid of a pattern detection software (Bakhache *et al*., 2017; UNDP, 2013). The advantages of the micro-narratives are enumerated as follows: providing real-time data for quick decision making, generating large quantitative data from a large pool of independent, verifiable and credible sources, supporting the planning, monitoring and evaluation of evidence-based policies, forecasting policy or community projects and providing a cost-effective approach to undertaking recurring surveys (Bakhache *et al*., 2017; Van Hemelrijck, 2016; UNDP, 2013). However, micro-narrative systems like the *Sensemaker®* run on expensive pattern detection software systems that require actors to be skilled and constantly motivated to participate (Van Hemelrijck, 2016).

b) Passive community engagement systems

These systems do not require active participation by a community in the PME process. They include *data exhaust*, *intelligent infrastructure* and *remote sensing tools* (Castell *et al*., 2015; Mialhe *et al*., 2015; UNDP, 2013). *Data exhaust* uses bulky and covertly gathered traces of data left behind by users of digital media and content like mobile devices, internet content and social media. This distinguishes it from other approaches, such as crowdsourcing (Castelnuovo and Tran, 2017; Castell *et al*., 2015). For this reason, the applicability of the data exhaust approach has grown tremendously in the private sector with organisations applying the analysed data to support various business processes, such as market expansion, new financial ventures, investment planning and monitoring and evaluation of projects (Qadir *et al*., 2016; Harford, 2014). The analysed data shows real-time trends and changes in a community based on predictable social media and online activity. The advantages of this approach are two-fold: it demands minimal effort in data collection and possesses an enormous potential for data mining leading to more credible PME results (Qadir *et al*., 2016). Nevertheless, data exhaust systems, such as *Google Trends* have been faulted for being biased in favour of the elite members of the community (Hu *et al*., 2018; Wu and Brynjolfsson, 2015).

Intelligent infrastructures are facilities fitted with affordable, remotely controlled electronic sensors. These facilities include buildings, roads, bridges, machinery, furniture, vehicles, electricity systems and water systems (Pursiainen, 2017; UNDP, 2013). By combining the use of internet and phone technology to relay real-time data to a computerised remote monitoring system, electronic sensors improve the process of data collection to inform policy, project and service delivery by creating integrated technological solutions and collaborations (Suryanto *et al*., 2015; Chowdhury *et al*., 2017). This is particularly useful in tracking the worth of public infrastructure and public service delivery. The advantages of this approach are listed as follows: generating a wide range of data for gauging the performance of a project, generating real-time data for better and faster decision- making, reducing the operating costs for public infrastructure, enhancing the credibility and utility of monitoring and evaluation data (Zhang *et al*., 2018; Kumar *et al*., 2015; UNDP, 2013). However, intelligent infrastructures, such as *SWEETSense* tend to be costly to set up, require skilled human capital, have the proclivity to violate user privacy and possess the risk of tainting data in the event of faulty apparatus (Kirby *et al.*, 2017; UNDP, 2013).

Remote sensing systems, such as *Citi-Sense-MOB* and *SenseFly* capture and analyse data from distant objects by utilising the electromagnetic spectrum of airborne equipment (Castell *et al*., 2015). From a long time, remote sensing systems have been applied in different spheres of human endeavour, such as natural sciences, social sciences and PME of social public policies especially in (a) places where access is restricted due to physical hurdles or safety concerns, (b) triangulation of data sources alongside conventional methods, such as surveys in social science research, (c) detecting transformations on the earth's surface, such as water bodies, agriculture and agriculture (Murray *et al*., 2018; Schultz *et al*., 2017; Lillesand *et al*., 2014). The advantages of such applications are apparent and include the following: collecting data on hazardous installations or unreachable places and obtaining data in cases where disturbance of the object of study is prohibited (Yuan *et al*., 2015; Hegazy and Kaloop, 2015). Nonetheless, there are fears over government abuse of confidential data arising from remote sensing and concerns about the prohibitive cost of gathering data using remote sensors (Gupta, 2017; Tewkesbury *et al*., 2015).

c) Participatory systems for enhancing the usefulness and accessibility of participatory data

These are PME systems that make data more meaningful to users, such as *data visualisation* (Yang *et al.*, 2015; Valkanova *et al.*, 2015; UNDP, 2013). *Data visualisation* is the communication of data in a visual format using systems, such as *DevInfo, Tableau*, *Google Fusion Tables*, *Visual.ly* and *TimelineJS* (Cardno *et al*., 2018; Balakrishnan *et al*., 2017; D'Agostino *et al*., 2013; Dutta *et al*., 2010; Epstein and Manzoni, 1997). By using data visualisation systems, this approach has transformed the process of PME by simplifying the way data is scrutinised and represented. This approach is advantageous because it creates visual data that is easy to comprehend and utilise. In addition, visual contexts reveal unclear trends and simplify intricate patterns in PME data (Cardno *et al*., 2018; Balakrishnan *et al*., 2017; McCosker and Wilken, 2014). However, this approach has been faulted for the following reasons: (a) it is expensive and time intensive to manage; (b) it requires customisation to suit different circumstances; (c) prevalence of visual noise due to indistinguishability of entities in a dataset; (d) loss of information occasioned by reduction of visible files; (e) limitations of aspect ratio, resolution and physical perception; and (f) fluctuation of image quality (Wang *et al*., 2015a; UNDP, 2013; Bresciani and Eppler, 2008).

d) Progressive PME systems

These systems are useful for measuring and interpreting results, such as *multi-level mixed evaluation* method and *outcome harvesting* (Kusters *et al*, 2017; Abboud and Claussen, 2016; UNDP, 2013). *Multi-level mixed evaluation* approach is the intentional, enormous and ingenious use of multi-level qualitative and quantitative techniques for evaluating complex systems, such as service delivery systems (UNDP, 2013; Adato, 2008). This approach has the potential to create a paradigm shift in the evaluation literature as a popular methodology in government agencies and private organisations (Mertens and Hesse-Biber, 2013). The strengths of this approach include the following: (a) improved authenticity, consistency and variety of results (UNDP, 2013); (b) improved understanding of precarious issues (Mertens and Hesse-Biber, 2013); (c) yielding unforeseen results (UNDP, 2013; Mertens and Hesse-Biber, 2013); and (d) providing various possibilities for triangulating between qualitative and qualitative techniques and data (UNDP, 2013; Bamberger, 2013). However, this approach has weaknesses, including (a) the need for expertise in qualitative and quantitative techniques and multi-criteria evaluation and (b) a circumspect combination of qualitative and quantitative methods to produce valid results (Bamberger, 2013).

Outcome harvesting is an evaluation technique that establishes proof of accomplishments and retrogressively ascertains the contribution of the project in this transformation - a defining characteristic that distinguishes it from other techniques of evaluation (Abboud and Claussen, 2016). This defining characteristic makes it suitable for understanding the oft-hazy connection between cause and effect in PME (Kusters *et al*, 2017). Therefore, the potency of this approach is that it’s applicable in evaluating intricate policies and projects where the theory of change is not plausible (Abboud and Claussen, 2016; Kusters *et al*, 2017). However, this approach is time-consuming and prone to biased interpretations by PME evaluators, which may lead to less objective findings.

[redacted] The MEPPP framework

The four PME systems described above inherently suffer from faults, such as being situation specific and lack of a common participatory framework (Boulmetis and

Dutwin, 2014; Roche *et al*., 2013; UNDP, 2013; Aubel, 2004). For these reasons, Hassenforder *et al*., (2016b) proposed the MEPPP framework that provides a general guideline for conducting PME. The MEPPP framework comprises *context, process* and *outcome* aspects of a project with *descriptive* and *analytical* parts (Hassenforder *et al*., 2016b). The descriptive part consists of variables describing the context, process and outputs/outcomes while the analytical part forms the core of PME and consists of variables specifically selected to answer the objectives of PME (Hassenforder *et al*., 2016a; Hassenforder *et al*., 2016b). The *context* describes social, economic, political and environmental circumstances surrounding a participatory planning process (Hassenforder *et al*., 2016a; Hassenforder *et al*., 2016b). The *process* is the way in which the participatory planning process is implemented (Hassenforder *et al*., 2016a; Hassenforder *et al*., 2016b). The *outputs* or *outcomes* are tangible and immediate products of the participatory planning process (Hassenforder *et al*., 2016a; Hassenforder *et al*., 2016b). Generally, the three clusters of the MEPPP framework are influenced by PME viewpoint that consists of establishing profiles and objectives of evaluators (Hassenforder *et al*., 2016b).

The strength of the MEPPP framework lies in its usefulness as an elaborate six-phase process for participatory planning (Hassenforder *et al*., 2016b). In addition, the MEPPP framework is both top-down, because the selection of variables is partly based on literature and bottom-up, as the selection of variables is partly based on the goals and experiences of participants (Daniell, 2012). Moreover, the MEPPP framework allows the evaluators to evolve innovative ideas out of the PME process rather than using pre-formulated ideas (Hassenforder *et al*., 2016a; Hassenforder *et al*., 2016b). Furthermore, practitioners and researchers can apply the MEPPP framework across many cases owing to its dual suitability for both specific and general cases (Hassenforder *et al*., 2016b). This duality means that the MEPPP framework can be applied across different scenarios ranging from simple projects, such as planting a community garden to elaborate projects, such as building a community dam. Generally, community projects can be categorised by typology and reference perception of project finances, which yield diverse project characteristics, such as novelty, societal contribution, trustworthiness, activeness, reward value and feasibility (Honisch *et al*., 2017).

Despite its numerous strengths, the MEPPP framework suffers the weakness of being expensive to implement in terms of resource requirements and the need for greater actor involvement (Hassenforder *et al*., 2016b). In other words, Hassenforder *et al.* (2016b) argue that the application of the MEPPP framework in different cases requires a replication of the six phases of the framework as well as the specification of a new context, process and outcomes; the re-working of objectives; and the re-definition of variables. These aspects require a greater deal of involvement by actors. However, this aspect may be challenging to achieve and may be unsustainable, especially if actors do not derive direct benefits from the process, thus working against the very notion of improved participation upon which the framework is premised. From a service system perspective, it can be argued that the demanding nature of the MEPPP framework presents an opportunity for research to make it more attractive to all actors. This is possible when actors experience tangible benefits accruing from their direct participation in the process. This lends credence for the infusion of the service system concept into the framework.

[redacted] Challenges of existing participatory systems

This section discusses the challenges affecting the process of PME. These challenges can be categorised as follows: *social, political, capacity, technological* and *economic challenges.*

a) Social challenges

The PME process is conducted in a multi-actor environment, which may exist either as a planned government strategy or informal engagement strategies. On this basis, some engagement strategies may be initiated by external actors, while others may be community-led (Kozar *et al*., 2014). Typically, multi-actor engagement strategies involve processes of navigating a labyrinth of complexity, ambiguity and uncertainty. This labyrinth is often the result of dissimilar interests within the multi-actor environment because actors will certainly have discordant views on the desired results (Kusters *et al*., 2017). Additionally, there are instances where the PME objectives may unequivocally relate to multiple goals, project or sectors in the community. Moreover, the PME process may be complicated by a regular review of PME objectives based on a renewed appreciation of the PME environment and processes of consultation (Minang *et al*., 2015). Consequently, the process of PME is constantly concerned with pragmatic and inexpensive approaches that seek to disentangle such complexity. Such approaches should consider the attributes and values of the multi-actor environment and their impact on the success of the PME process (Kusters *et al*., 2017; Minang *et al*., 2015).

Generally, the development of a vibrant multi-actor environment for PME is difficult for the following reasons. (a) Many multi-actor engagement strategies do not follow democratic ideals and tend to operate on circumstantial rules bereft of oversight, which jeopardises accountability and representation (Kusters *et al*., 2017). (b) The process of PME is a costly venture since multi-actor mechanisms demand a lot of investment in terms of time, energy and expertise whilst the returns may not be explicit. This shortcoming may dispirit the PME actors (Afzalan *et al*., 2017; Hart *et al*., 2014; Bamberg, 2013). (c) Power struggles between different actors involved in the process often derail the process (Minang *et al*., 2015; Ramos *et al*., 2014). According to Kozar *et al*. (2014), it is challenging to provide equal opportunities for participation by all actors regardless of their social standing. (d) Multi-actor engagement strategies may be premised on sectarian management concerns which may not wash with the majority concerns. (e) The predicaments of a community are often too complex and deep-rooted and cannot simply be resolved by getting actors to dialogue without substantial actions on the ground.

b) Capacity challenges

The adoption and utilisation of novel technologies that are synonymous with PME can be a challenge for organisations, especially those organisations that lack the digitally skilled manpower to successfully navigate the digital landscape. Such organisations are likely to grapple with acceptance and trust issues surrounding the use of technology at various levels of operation in the organisation (Afzalan *et al*., 2017). According to Andrews *et al*., (2014), the inability of organisations to successfully navigate the digital landscape can be attributed to limited digital literacy amongst staff and the accompanying lack of ease in exploring the digital systems. To remedy this situation, organisations should provide technical support and digital skills training to equip their staff to fully exploit the digital content. Capacity challenges also relate to the institutional framework under which the process of PME is conducted. These frameworks include social media access; data security and privacy; and multi-lingual access to information (Bertot *et al*., 2012). The development of these supporting frameworks demands that PME actors should work with the government to create a conducive operating environment for technology-driven PME (Falco and Kleinhans, 2018).

c) Technological challenges

The adoption and use of technology in PME have gained prominence in recent times due to the growing need to improve the process of PME in many ways, such as facilitating real-time reporting, enhancing the decision-making process and improving the quality and depth of PME data (Muriungi, 2015). However, this quest has not been a fairy tale for many organisations because of the complexity, rapid technological advancement and their inability to match the pace of innovative technologies (Falco and Kleinhans, 2018). Notably, the rise of big data management in the PME paradigm has raised serious technological implications for organisations, including PME system management, workflow management, decision support, data management and data security (Karim *et al*., 2017).

The process of PME has also been impeded by privacy challenges, which have dominated research in recent years (Pournaras *et al*., 2016; Christin, 2016). In this respect, the following research agenda has emerged in the PME literature. (a) The challenge of including community members in privacy decisions. This has been widely researched but remains contentious because of rapid technological advancements and the changing beliefs of participants (Christin, 2016; Shilton and Martin, 2013); (b) The challenge of providing reusable privacy mechanisms that can be applied in multiple scenarios (Christin, 2016); (c) The challenge of developing a viable mechanism for measuring privacy (Damiani, 2014); (d) The challenge of striking a balance between privacy, data fidelity and performance concerns (Pournaras *et al*., 2016; Essock *et al*., 2015; Vergara-Laurens *et al*., 2013); (e) The challenge of establishing standards for privacy research amongst researchers (Christin, 2016); (f) The challenge of developing comprehensive architectural blueprints covering the different aspects of privacy, including multidimensional privacy, bystander privacy, the internet-of-things (IoT) and smart cities (Pournaras *et al*., 2016; Christin, 2016). Although some of these privacy challenges have been addressed, there is a compelling case for further research, particularly when contemplating the infusion of participatory approaches in larger visions, for example, the IoT. By increasingly storing PME data on the digital platform, communities will have to contend with increasingly jeopardised privacy in the everchanging world of digital storage.

d) Political challenges

The processes of PME are often challenged by political decisions arising from the prevailing political environment in a given territory or country (Ernst *et al*., 2018; Green and Haines, 2015). These political challenges can be categorised as follows: *type of government, policy mismanagement, political instability, corruption* and *poor trade laws* (Ensminger, 2017; Warner and Sullivan, 2017; Lewis, 2017; Locatelli *et al*., 2017; Borner *et al.*, 2016; Green and Haines, 2015; Hope, 2015; Nurudeen *et al*., 2015).

The *type of government* in a region or country can take different forms, such as anarchy, monarchy, democracy, authoritarianism, ecclesiastical, emirate, sultanate, oligarchy, theocracy, confederacy, Maoism, socialism or communism (Warner and Sullivan, 2017; Derbyshire, 2016). These forms of government may impact community development in many ways, for example, authoritarian regimes may stifle the ability of PME actors to obtain project approval and secure project funding (Gustafsson and Jarvenpaa, 2018). Another scenario is where political machinations have been used to sabotage community projects or to falsify progress reports with a view to giving credibility to non-performing projects or to secure additional financial resources for the continuity of a project (Jili and Mthethwa, 2017).

In countries where *political instability* is rife, the existing government structures are less reliable and less durable leading to heightened risks in community development projects (Green and Haines, 2015; Saha and Yap, 2014). Additionally, internal conflicts and terrorism may jeopardise the success of community development projects (Rupesinghe, 2016; Borner *et al.*, 2016).

Policy mismanagement has been identified as a challenge to community development projects because poorly managed national and international policies or regulations directly impact the success of community projects (Campi and Dueñas, 2016). For example, poor management of intellectual property rights in Kenya often discourages community-based creative artists from exploiting their talents because of low returns (Igesha *et al*., 2017). Additionally, poorly enforced government policies increase the risk of launching community projects (Schlosberg *et al*., 2017).

Corruption describes the level of fraudulent, unethical and illicit acts perpetrated by some community development actors (Dupuy, 2017; Locatelli *et al*., 2017). In this respect, the challenge of corruption has the potential to impede the success of community projects in many ways, such as elite capture, flawed tendering processes, soliciting unwarranted favours from politicians and bribing local firms for supplies (Dupuy, 2017; Williams and Le Billon, 2017). The challenge of corruption can further prevent economic development in a community and has the potential to create a syndicate that inflates the cost of service delivery to the community (Ensminger, 2017; Justesen and Bjørnskov, 2014).

The challenge of *poor trade laws* can be attributed to the inability of the government to enact progressive national and global legislation that invariably impact the importation or exportation of equipment and merchandise for community development (Pinder, 2017). Such trade laws include the following: trade tariffs, consumer protection and e-commerce, import restrictions, environmental law, health and safety law (Jiang, 2017; Leigh and Blakely, 2016). In some cases, community projects in developing countries may bear the brunt of lopsided trade deals that favour their development partners from the developed countries, such as high taxes that curtail their participation in the international trade (Gibson, 2016).

e) Economic challenges

The extant literature shows that insufficient funding is a constant challenge facing many community development projects (Martiskainen, 2017; Hickey *et al*., 2015). For this reason, many community projects are often abandoned because of financial uncertainty and insolvency, driven by the dynamics of international trade, inflation, impropriety, disregarding endogenous sources of project funding and imprudent use of meagre financial resources (Wawira and Were, 2017; Maxmeister and Goldstein, 2017; Jili and Mthethwa, 2017). Consequently, financial impropriety and corruption often impede the successful planning, design and execution of PME processes and hamper the completion of community projects (Wahid *et al.*, 2017; Callistus and Clinton, 2016). Furthermore, the process of budgeting for responsibilities and tasks associated with the PME process is an arduous one involving several concerns, such as staffing requirements, capacity building, facility costs, office equipment and supplies, travel and hospitality, computer hardware and software (Akroyd, 2017; Brown and Green, 2017). Budgeting must also determine whether all tasks have been factored in the overall community project budget, such as support for PME systems, logistics (transportation, fleet management, warehousing, materials management, inventory management, maintenance and publishing) (Jami and Walsh, 2017; Callistus and Clinton, 2016).

2.3 SERVICE SYSTEMS

[redacted] Description of service systems

A *service system* is a value-proposition interaction based on a dynamic configuration of various resources, including *people*, *technology*, *organisation* and *shared information* (Maglio and Spohrer, 2013; Tan *et al.*, 2011; Maglio and Spohrer, 2008; Gruhl *et al.*, 2007). The *people* are arguably one of the most important components of a service system. For this reason, service interactions are described using concepts, such as “people-oriented’’ (Bugeaud and Soulier, 2010; Gruhl *et al.*, 2007). The concept of “people-oriented’’ systems depicts people as the ultimate drive and basis for human exploits, such as social networks, entertainment, health, education and commerce (Maglio and Spohrer, 2013; Fisher, 2011). These people may come in various designations, such as designers, developers, marketers and consumers of ICT products and services- either as individuals or communities (Wang and Zhang, 2012).

The *technology* drives service systems by creating innovative service offerings through a constellation of various components, such as software, hardware, connectivity, digital forums, applications, assets and services (Bohmann *et al.*, 2014; Vos, 2010). For this reason, technology drives information capture, manipulation, storage, communication and output- the hallmarks of the digital economy (Maglio and Spohrer, 2013; Wang and Zhang, 2012).

The *shared information* propels collaboration amongst actors in an organisation and includes languages, measurements and laws (Alter, 2012; Lusch *et al*., 2007). In service systems, language is the medium for collaboration through common terminology, dialect and conventional coding, while laws help to safeguard against nonconformity to policy or regulations (Lyons and Tracy, 2013). Measurements are used in several ways, for example, prices are a measure of agreements between the provider and the customer; performance indicators are used as a gauge (measure) of opportunities for development and innovation or for purposes of transparency and accountability (Lyons and Tracy, 2013). The convergence of these dimensions of shared information encompasses the entire information lifecycle and influences inherent aspects of information handling, including bibliographic control, method, structure, cataloguing, classification and indexing (Maglio and Spohrer, 2013; Wang and Zhang, 2012).

The *organisation* component defines strategies, structures, operations, rules, cultures and incentives that create effective groups of individuals to bring about a shared perspective and a mutual understanding of service systems by integrating human factors, engineering factors as well as management and economic factors (Maglio and Spohrer, 2008; Maglio *et al*., 2006). Subsequently, the organisation component is established under the universal principle of “management” and is considered germane to the success of service systems (Maglio and Spohrer, 2013; Wang and Zhang, 2012).

[redacted] Fundamental principles of service systems

A service system is a useful abstraction for understanding value and value co-creation (Cefkin *et al*., 2011; Maglio and Spohrer, 2008). For this reason, the development of service systems has gained traction in the research as the primary driver of the service economy agenda (Gallouj *et al*., 2015; Obstfeld, 2012; Chang, 2010). This development has effectively shifted the debate on value creation from exchange to use or context, thus redefining value in terms of dynamic processes that integrate resources as opposed to the traditional notion of value as a unit of input to a firm (Vargo *et al*., 2008). The practitioners and researchers have considered this shift as a significant impetus for the growth of service science discipline whose overarching aim is to re-direct scientific research towards problems associated with service innovation and enhancing service provision. The result of this innovation is that service systems have permeated different spheres of the current service economy (Obstfeld, 2012; Chesbrough and Spohrer, 2006).

To orchestrate development in diverse spheres of human development, service systems rely on ten fundamental principles that have been used to comprehend them as an abstraction (Frost and Lyons, 2017). These fundamental principles are *resources, entities, access rights, value co-creation interactions, governance interactions, outcomes, actors, measures, networks* and *ecology* (Frost and Lyons, 2017; Spohrer *et al.,* 2015; Mora *et al*., 2011; Spohrer *et al*., 2008). *Resources* play a significant role in the realisation of service systems and consist of items exchanged for creating value (Lyons and Tracy, 2013). Thus, resources may be described as tangible or intangible assets created by the human enterprise (Vargo and Lusch, 2004). Generally, operant resources (acted upon to produce an effect), such as skills and knowledge, are increasingly significant for the realisation of a service system (Alves *et al*., 2016; Lyons and Tracy, 2013; Vargo and Lusch, 2004). *Access rights* relate to social customs and legal regulations that govern access and use of resources (Barile and Polese,2010). To this end, there are four distinct types of access rights assignable to resources: owned outright, leased or contracted, shared access and privileged access (Basharat and Ahmad, 2017; Spohrer *et al*., 2015). For this reason, an appreciation of the access rights of resources within a service system is important as these attributes can impact the system design (Borangiu *et al*., 2014; Barile and Polese,2010).

Entities are described as resource integrators that facilitate the exchange of competence in the process of value co-creation in a service system (Reynolds and Ng, 2015; Barile and Polese, 2010). The exchange of competence is based on established value propositions that connect entities (Stoshikj *et al.,* 2016). Basically, all service system entities are resources but not all resources are service system entities (Spohrer *et al*., 2008). Consequently, Katzan (2009) identifies five types of entities that play distinct roles in the realisation of certain service outputs: service principal, service producer, service provider, service client and service object. A service principal is the legal proprietor of the entire service system while the service producer creates the service offering. The service provider avails resources for the convenience and the benefit of the service client. A service object directly benefits from the outcomes of service processes (Barile and Polese, 2010; Katzan, 2009).

Value co-creation interactions describe formal or informal processes that describe the nature of exchange and the requirements for value co-creation in a service system (Pohlmann and Kaartemo, 2017; Barile and Polese, 2010). This is contrasted with *governance interactions* that refer to functions performed on service, either within or beyond the service system boundary for any of the following reasons: to make them efficient and viable, to conform to policies or regulations, to expand the market base or to resolve disputes arising between actors (Barile and Polese, 2010).

Outcomes are the results of the interactions of entities involved in value co-creation (Eaton *et al*., 2015; Spohrer *et al*., 2008). Subsequently, the following ten scenarios can be realised during a service encounter: (1) value is gained; (2) value proposition is misunderstood; (3) value proposition is contested; (4) value is not gained and no disagreements arise; (5) disagreements are settled to the satisfaction of all actors involved; (6) disagreements are not settled to the satisfaction of all actors involved; (7) a non-service encounter is realised but is welcomed; (8) an unwelcomed non-service encounter is not illegal; (9) an unwelcomed non-service encounter is illegal and legal redress is sought; and (10) an unwelcomed non-service encounter is illegal and legal redress is not sought (Åkesson *et al*., 2016; Skålén *et al*., 2015; Siltaloppi and Vargo, 2014; Spohrer *et al*., 2008).

Actors generally comprise investors, staffs, clients, dealers, creditors and the public (Zhang, 2015; Barile and Polese, 2010). However, service science literature considers the notion of an actor as a perspective rather than an entity such that a service system entity can hold many actor perspectives (Maglio and Spohrer, 2008). Nonetheless, the service science literature identifies four main actor perspectives: provider, customer, authority and competitor (Hope *et al*., 2017; Spohrer *et al*., 2015; Barile and Polese, 2010).

Lyons and Tracy (2013) suggest a dual approach to the understanding of *measures* as one of the pillars of service systems: a brand of shared information for value co-creation and/or a constituent of a governance mechanism. For this reason, Andersson *et al*. (2018), Spohrer (2016) and Spohrer *et al*. (2008) posit that there are four types of measures, namely quality, compliance, productivity and sustainable innovation. Each of these measures relates to one of the main actor perspectives (provider, customer, authority and competitor). Thus, quality is gauged by customers, compliance is gauged by authorities, productivity is gauged by providers and sustainable innovation is gauged by competitors.

Networks are vital in value co-creation both within and outside the boundaries of a service system (Frost and Lyons, 2017; Tan *et al*., 2007). They are created out of value propositions between entities and the subsequent value exchange arising from such collaborations (Spohrer *et al*., 2008). Such collaborations have been fuelled by, *inter alia*, the intricacy of markets, which has compelled them to embrace collaborative value co-creation networks as opposed to the conventional notion of isolated value co-creation by one entity (Filieri *et al*., 2014; Tan *et al*., 2007). Because of this intricacy, no single entity has the requisite skills, knowledge and integrity to create innovative solutions for today's intricate technical and societal problems (Lusch *et al*., 2010).

Ecology describes the features of service systems and embodies a constellation of diverse types of service system entities and their census (Lyons and Tracy, 2013). According to Maglio *et al*. (2009) and Spohrer and Maglio (2009), the ecology of service systems not only describes their type-based census but also their associations and networks. The latter concept has created research interest in terms of coordination mechanisms and pricing of service offering (Bocken *et al*., 2014; van Dinther *et al.*, 2011).

[redacted] Classification of service systems

Spohrer (2011) recognises three types of service systems that are enunciated as follows: *systems that focus on the flow of things, systems that focus on human activities and development* and *systems that focus on governing a given territory*. Systems that focus on the flow of things include service systems in various fields such as transportation, supply chain, water, food, energy and ICT (Spohrer, 2011). The ICT-driven service systems have particularly permeated every aspect of social, economic, social and environmental undertaking such they are no longer seen as peripheral novelties and advancements but as key drivers of innovation (Yeh, 2017).

Additionally, ICT-driven solutions have been associated with a broad spectrum of applications in the knowledge economy that provide platforms (such as social networks) for individuals to exchange ideas and experiences (Dameri and Garelli, 2014). By way of illustration, the service economy has recorded a phenomenal growth in ICT-driven transport service systems that seek to improve the quality of transport services across cities by paying attention to various aspects, such as categorising passengers, access control, boarding protocols, turnaround time and passenger queues (Danilina and Elistratov, 2017). The transportation sector has also benefited from the simulation as an integral component of decision making in planning, for instance by forecasting the impacts of new strategies and investment decisions (Hajinasab *et al.*, 2017).

Systems that focus on human activities and development include service systems used in buildings, retail, hospitality, media, entertainment, banking, finance, business consulting, healthcare, education, jobs and entrepreneurship (Spohrer, 2011). For instance, the banking sector has witnessed a widespread adoption and use of different ICT-driven service systems that support various banking operations, such as customer accounts management, card services, online banking, mobile banking, cloud-based banking, telephone banking, automated teller machines (ATM), point of sale (POS) networks, loans and investment portfolios (Chai *et al.*, 2016; Akhisar *et al.*, 2015). This widespread adoption and use of service systems in the banking sector has been dictated by the rapidly evolving technological environment coupled with changing customer preferences (Chai *et al.*, 2016). Arguably, this adventure has propelled the banking sector to higher echelons of excellence in service delivery, increased competitiveness and demand for economic growth (Chai *et al.*, 2016; Akhisar *et al.*, 2015).

Systems that focus on governing a given territory (such as a city) include service systems (commonly called e-government) adopted and utilised by a governing authority to facilitate public service delivery by reducing turnaround time, handling complex queries, lowering labour costs, differentiating its products and services, gaining a competitive edge and generally leveraging internal productivity (Muthu *et al.*, 2016). For instance, the rise of smart cities has been particularly attributed to the explosion of ICT-driven service systems (alongside infrastructural facilities) to create novel paradigms, such as “information city”, “knowledge city” and “learning city” as concepts targeting inherent data, information, knowledge and urban experiences to improve city life (Gil-Garcia *et al.*, 2015; Cocchia, 2014). In this respect, ICT-driven service systems describe a constellation of innovations and inventions that are integrated to create meaningful impact in the overall quality of city life using intelligent mechanisms (Yeh, 2017; Zenker and Rütter, 2014; Khankhoje, 2004). Notably, the use of ICT-driven technologies, such as geographic information system (GIS) applications by local governments across the globe has demonstrated the potential of such technologies to enhance diverse sectors, such as transportation, property, waste handling, urban planning and design and fundraising (Lewis and Ogra, 2010). Additionally, GIS applications support the integration of data from multiple sources as well as data visualisation using maps, which ultimately improves the utility of such data (González-Jaramillo, 2015). Further, GIS systems enhance the transparency of public services through spatial visibility of public activities, thus entrenching the growth of electronic democracy (de Souza Baptista *et al*., 2004). Moreover, GIS systems are important in the planning, distribution and optimisation of economic, technological and human resources (Lewis and Ogra, 2010). Furthermore, it has been demonstrated that the use of e-government systems improves the dissemination of urban information and provide an electronic platform for users to contribute to land debates, querying the unconstitutional use of public property and generally participate in the planning and decision-making processes. These advancements have been recorded in several countries, such as Sweden, UK, Canada and USA (Lv *et al*., 2018; de Souza Baptista *et al*., 2004).

[redacted] Significant challenges of developing service systems

The service science discipline has recorded phenomenal growth in the last few decades and has formed a tremendous research agenda for service researchers, practitioners and organisations alike in their quest to navigate an increasingly service dominated economy (Barile *et al*., 2016). However, this phenomenal growth has been met with a myriad of challenges that have consequences for access and equity. This section explores some of these significant challenges.

The notions of service, service system and service science continue to elude service practitioners, some of whom still cling to the traditionally narrow perspective of service by economists as opposed to the progressive view of service as a complex social, corporate and government configuration (Barile *et al*., 2016; Ostrom *et al*., 2015; Maglio *et al*., 2009). In this respect, an expanded view of service is necessary for shaping the overall future of service science research to meet the needs of the complex service economy where S-D logic is the currency (Pohlmann and Kaartemo, 2017; Barile *et al*., 2016). Therefore, the new paradigm of S-D logic provides an expanded view of service as a constellation of resources, exchanges and human behaviours (Pohlmann and Kaartemo, 2017; Maglio *et al*., 2009). Additionally, there is a lack of trans-disciplinary vocabulary that can be used to describe a 'service system' (Wang *et al*., 2016; Xing *et al*., 2013; Maglio *et al*., 2009). According to Wang *et al*. (2014), there are three categories of definitions of a 'service system'. The first category regards the human-in-the-loop (HITL) as the main attribute of service systems (Pinhanez, 2009). The second category contends that service systems possess the same configuration as industrial systems but can create either a service or product (Alter, 2008). The third category considers service systems as contextual artefacts comprising actors, technology, organisations, space and time to facilitate economic exchange (Stanicek and Winkler 2010; Maglio *et al*., 2009). Further, Wang *et al*. (2016) note that the definitions of service systems also stem from the viewpoint of diverse service characteristics as exemplified by Krishnamurthy (2007) and Lusch and Vargo (2014).

The lack of a system view to service systems has contributed to lack of clarity in understanding the modified system development methodologies for studying service systems. Such system development methodologies have not fully integrated the concepts of SSE and management (Barile *et al*., 2016; IfM and IBM, 2008). According to Barile *et al*. (2016), the integration of engineering and management concepts would reduce redundancies and increase the gains resulting from robust trans-disciplinary collaborations in the service science and system research as opposed to the current fragmented and sectoral approaches that do not advance a common service system theory.

The poor or non-availability of supporting infrastructure in marginalised regions has contributed to the low uptake and use of digital equipment that provide access to service systems (Lv *et al*., 2018). For the most part, marginalised communities lack digital literacy, which further impacts their capability to use sophisticated digital equipment associated with service systems (Mukherjee and Sahoo, 2010). A possible solution to some manifestations of this challenge would be to use cloud-based service systems that use shared resources to deliver services to the public (Lee *et al*., 2016).

The challenge of organising collaborations and interactions with multiple actors has been identified in the service science literature as a determent because service systems demand collaborations and interactions that extend the frontiers of conventional management practices (Reypens *et al*., 2016). Such collaborations demand substantial investments in human capital, coordination, funding and equipment to succeed in a complex and ever-changing environment (Fjeldstad *et al*., 2012). Additionally, interactions present three dimensions of analytical impediments by occurring at multiple micro, meso and macro levels of an organisation (or organisations) where each level has a different focus and units of analysis; they can be interpreted either as outcomes (what drives interactions) and as causal factors (what effects interactions have at each level of the organisation); and they are dynamic and their patterns may change considerably over time (Eberlein *et al*., 2014; Cafaggi, 2011).

The challenge of contextuality of knowledge implies that knowledge tends to lose its contextual attributes in the process of being conveyed by one knowledge broker to another (Lusch and Nambisan, 2015). The loss of contextual attributes happens in contrast to the value creation processes that occur during conveyance and translation of knowledge from one knowledge broker to another, a fact that may discourage some actors from participating in value creation (Clar *et al*., 2013; Partidario and Sheate, 2013). Thus, it is significant that service researchers pay sufficient attention to knowledge brokerage in the service economy.

The challenge of the analytical-reductionist approach has been identified in the service systems literature as a hindrance to the growth of service science theory in the sense that scholars of service systems tend to confine themselves to the structural limits of organisations or comprehend the many collaboration levels that arise (Barile *et al*., 2016). This raises the need for integration of the reductionism and holism approaches to creating a single perspective that would equipoise the study of organisational structures (Barile *et al*., 2016). For instance, service vendors stand accused of illogically disclosing the application of a G-D logic by paying undue attention to their merchandise at the expense of the prevailing synergy between the endogenous and exogenous factors (Barile and Saviano, 2014; Vargo and Lusch, 2008).

Complexity in the service science research has been identified as a challenge because service science scholars tend to examine complexity largely as an unbiased and structural quality of service systems rather than a prime concern in service system research (Barile *et al*., 2016). For this reason, certain complex service systems lack feasibility because system developers focus on complex system configuration at the expense of the system's intrinsic capabilities to tackle unpredictable situations (Barile *et al*., 2016; Freund and Spohrer, 2013; Mele and Polese, 2011).

The challenge of capturing the intangible value of service system has been raised in service science literature (Kjaer *et al*., 2016). This challenge stems from the fact that service systems impact user behaviour and consist of intangible components that makes it arduous to ensure practical similarity between alternatives. Such intangible components include brand value, user experiences, sense of control and ease of access (Tukker and Tischner, 2017; Tukker, 2015).

2.4 VALUE-BASED REQUIREMENTS ENGINEERING

[redacted] Principles of value-based requirements engineering

Gordijn and Akkermans (2003) describe *value-based requirements engineering* (VBRE) as a methodology for exploiting the notion of *economic value* during the requirements engineering process of innovative systems. Such systems, according to them, possess some *novel* e-commerce concepts that actors can either use to generate revenue or implement to produce an object of economic value. Further, they postulate that the new *value propositions* resulting from ICT-driven systems must be invented and negotiated amongst actors.

The rise of VBRE has been credited with the limitations of TSDMs. The TSDMs have, for a long time, focused on technical aspects, while neglecting economic aspects of system development (Bithas *et al*., 2015; Murtazaev *et al.*, 2010). According to

Boehm (2006), the concept of a value-neutral setting has been the hallmark of TSDMs that has resulted in the following shortcomings: (1) They tend to treat every requirement, use case, object, test case and defect as equally important; (2) They present as largely logical, activities involving mappings and transformations, such as object-oriented system development; (3) They track project cost and schedule, not actor or business value; (4) They practice "separation of concerns," which confines the responsibility of system engineers to turning system requirements into verified code. In contrast, the VBRE approach offers the following advantages (Zhang *et al*., 2013; Aurum and Wohlin, 2007): (1) structuring of technical resolutions to conform with business plan; (2) Maintaining a competitive edge by building enterprise and client value; (3) Providing diverse viewpoints in developing artefact, project and enterprise value.

In the service economy of today, it is crucial for service system analysts, designers, developers and proprietors to determine value propositions in a service system by employing VBRE principles to remodel TSDMs to create service systems that offer measurable economic value (Bithas *et al*., 2015; Obstfeld, 2012; Murtazaev *et al.,* 2010). Hence, VBRE principles have had a huge influence on system cost, schedule, value and system-level decisions that are inextricably intertwined. In addition, VBRE principles and practices reduce system failure by improving user input, facilitating the acquisition of complete requirements, tracking changing requirements, removing unrealistic expectations, refining objectives and providing realistic time frames (Tan *et al*., 2011; Murtazaev *et al.*, 2010). Moreover, VBRE provides a sufficient basis for engineering modern service systems by providing guidance for making systems more useful to actors as this involves dealing with value propositions for actors (Pohlmann and Kaartemo, 2017; Stoshikj *et al.*, 2016; Bithas *et al*., 2015). Furthermore, VBRE enables service system analysts, designers, developers and actors to make financial decisions (Torrecilla-Salinas *et al*., 2015; Boehm, 2006).

[redacted] A model for value-based requirements engineering

Some of the pioneering studies in VBRE, such as Gordijn and Akkermans (2003), have laid the foundation for the phenomenal growth of e-business models in the last decade or so. These enduring views were premised on the *need* to entrench the VBRE principles in the exploration of novel e-business concepts and they have been echoed by recent studies, such as Glova *et al*. (2014). For the most part, such e-business models must conform to the following goals: (1) building consensus and a mutual understanding of an e-business idea amongst diverse actors; (2) providing a mechanism for validation of the economic viability of an e-business concept; and (3) serving as a launchpad for a rigorous process of requirements engineering (Alahyari *et al*; 2017; Gordijn and Akkermans, 2003). Further, Gordijn and Akkermans (2003) and more recently, Alahyari *et al*. (2017), Glova *et al*. (2014) and Rao and Prasad (2012) have all cemented the significance of the following guidelines when choosing a business model for VBRE.

1) A *lightweight* method to handle the time-constrained exploration process;
2) A *graphical conceptual modelling* method to foster a mutual and accurate perception of the e-business concept amongst actors and further facilitate the process of evaluation to validate the e-business concepts;
3) A *multi-viewpoint* method to competently capture the diverse viewpoints arising from a multi-actor e-business environment, which include the process business viewpoint, the information system viewpoint and the business value viewpoint;
4) A *scenario* method, which may be split into an *operational* scenario method and an *evolutionary* scenario method. Operational scenarios describe actors' perspectives, while evolutionary scenarios are used in conducting a *what-if* assessment for an e-business concept.
5) An *economic value-oriented* method to accurately capture the financial gains or losses arising from the implementation of an e-business concept to gauge the viability of an e-business concept.

[redacted] The service innovation lifecycle model (SILCM)

Service innovation is the process of restructuring a service system in give an organisation a competitive age (cost reduction) in terms of value exchanges by initiating new services (basically *new value propositions*), streamlining business operations, increasing growth of services or improving logistics (Tan *et al*., 2011;

Curtis and Henderson, 2006). Typically, a service innovation is initiated by a single actor who desires to modify business operations by introducing a novel concept, which leads to a review of the current value exchanges in the service system. To succeed in this venture, an innovation life cycle is employed to progressively transform the service system *in toto* (Tan *et al*., 2011).

The SILCM (Tan *et al*., 2011) discusses the transformation of a service system by conceptualising new services. This transformation is pegged on the principle of *circular causation and interrelationships* that has been precipitated by the emergence of the system of systems (SoS) as a popular jargon in system engineering parlance. This paradigm has propelled the development of systems engineering methods to include approaches that can cope with budding networks of semi-independent systems (Bourque and Fairley, 2014). Consequently, the constituent *enterprises* of SoS are autonomous and provide *value-added* products or services that are exclusively meaningful (Adcock *et al*., 2015). Subsequently, this paradigmatic shift in system engineering has led to a rethink of the conceptualisation of systems engineering as a constituent of the systems movement, notwithstanding its historical independence (Walden *et al*., 2015). This means that systems engineering is now viewed as a circular causation (iteration), where a variable is both the cause and the effect of another and acknowledges the pre-eminence of correlation between non-linear and organic thinking (Walden *et al*., 2015). Thus, the principle of circular causation and interrelationships is evident in the SILCM, which follows an iterative approach consisting of three generic concepts of *service exploration*, *service engineering* and *service management* (Tan *et al*., 2011).

Service exploration is associated with service *need, strategy* and *concept* (Adcock *et al*, 2015; Lopes and Pineda, 2013; Tan *et al*., 2011). According to Lopes and Pineda (2013), strategies and regulations of an organisation drive the need for new services and associated service systems. Lopes and Pineda (2013) further postulate that the service strategy involves the identification of new services based on end-user needs, popular collaboration trends, technology trends and organisation strategies. Thus, the decision to develop a service system should be founded on a socio-techno-economic feasibility study to assess the system's compatibility with the organisation's social dynamics, technical knowledge and economic situation that may result from its application (Lopes and Pineda, 2013; Pineda *et al*., 2012). The service concept is the mechanism of explaining the needs of the actors and proposing viable solutions to them. As a precursor to the development of the service concept, it may be necessary to *explore* the existing system to attain a comprehensive perception of it (Walden *et al*., 2015). As such, the major constituent of service exploration is *system definition* process, which involves an actor (individual or organisation) expressing a desire to invest resources in a new or improved system (Adcock *et al*, 2015). This desire is then shared with other actors in a collaborative and complex scenario that involves diverse actors, information networks technical configurations and business processes (Bugeaud and Soulier, 2010). In general, service explorations activities (normally concurrent) include the following (Adcock *et al*, 2015; Lopes and Pineda, 2013; Tan *et al*., 2011): (1) determining *key actors*, *interactions* and *capabilitie*s; (2) determining the link between *business perspective* (business strategy perspective and value creation perspective) and the *computational perspective* (the process perspective and the IT perspective); (3) analysing *value exchanges* amongst actors to identify value proposition; (4) developing the system concept of *operations* and *business case*; (5) negotiating the sys*tem requirements* among the key actors; (6) selecting the *non-developmental* items (NDIs) of the system; (7) developing the *system architecture* and systems-level life cycle plans; (8) performing *system analysis* in order to illustrate the compatibility and feasibility of the resulting system definition; (9) *prototyping* or *actual development* of high-risk items to show evidence of system feasibility; (10) performing mission effectiveness analyses to provide a *viable business case* for proceeding into development; and (10) continuous *system improvement*, which may consist of one or more intermediate decision gates within the definition stage.

Service engineering is the systematic *design* and *development* of services aiming at increasing the value of a service offering to an actor (Lopes and Pineda, 2013; Sakao *et al.*, 2009; Bullinger *et al.*, 2003). During this phase, one or more service system innovation concepts are explored in-depth by considering their value in view of the prevailing value exchange practices and processes (cost-benefit analysis) in an organisation (Tan *et al*., 2011). Generally, service design entails the analysis of actor needs and the identification of the service system entities, functions, interfaces, compatibility and service level agreements (SLAs) (Lopes and Pineda, 2013). For this reason, the service functions and SLAs are assigned to diverse entities by modelling the service system according to diverse constraints (Lopes and Pineda, 2013). System development should commence when the feasibility study justifies the use of resources to develop and sustain the initial operational capability (IOC) or the single-pass development of the full operational capability (FOC). Consequently, system development activities include the creation of developmental components, integration of developmental components; verification and validation of the developmental components; and planning for parallel production, sustenance and operational activities (Adcock *et al*, 2015; Lopes and Pineda, 2013; Tan *et al*., 2011).

The *service management* (ICT infrastructure and evaluation phase) involves a range of service system processes in a real-world environment, such as definition, development of a service option in-depth, evaluation, transition, deployment, operation, support and retirement (Adcock *et. al*., 2015; Lopes and Pineda, 2013; Tan *et al*.,2011). Figure 2.1 is a visualisation of the SILCM, depicting the service exploration, service engineering and service management components as described above.

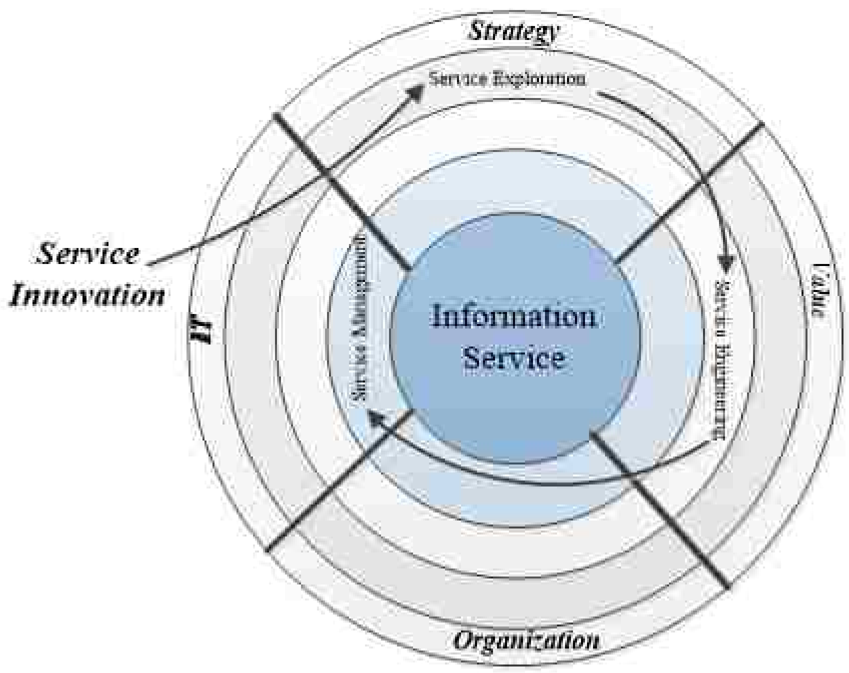

FIGURE 2.1: THE SERVICE INNOVATION LIFE CYCLE MODEL

To develop a service system, the SILCM relies on two conceptual modelling systems that model diverse aspects of a system, namely e^3*-value* and e^3*-control*. The e^3*-value* method is useful for modelling and investigating value exchanges in service systems (Tan *et al*., 2011). On the other hand, the e^3*-control* method provides a detailed model of the processes involved in value co-creation to eliminate potential pitfalls that may jeopardise the *sustainability* of such collaborations (Tan *et al*., 2011). Thus, the e^3*-value* methodology is useful for (a) modelling economic value exchanges between actors involved in value co-creation in a collaborative environment; (b) conceptualisation a business network by constructing a rigorous, structured and graphical value model for performing a profitability analysis for all actors involved in a *reciprocal* exchange of value objects (Tan *et al*., 2011; Anderson *et al.*, 2006; Gordijn and Akkermans, 2003).

The e^3*-control* method models the inter-organisational control procedures based on the key ideas of (1) a structured modelling method; (2) a process-based analysis; and (3) a value-based analysis (Liu *et al*., 2010; Tan and Gordijn, 2005). Thus, there is a convergence of the e^3*-value* methodology and the e^3*-control* methodology because the notion of economic value is embraced by both. In the design of inter-organisational control procedures, the adoption of an economic value perspective is reasonable for the following reasons. First, the business associations that need to be controlled must be understood first (typically articulated as economic value exchanges in e^3*-value* methodology). Second, many control mechanisms are themselves services that must be paid for, such as legal services. Third, documentary controls can have an intrinsic economic value, such as tickets and bill of lading. Thus, this value perspective is conceptually like transaction cost economics (TCE), which studies contractual protection against unscrupulous conduct (Tan *et al*., 2011; Anderson *et al.*, 2006; Tan and Gordijn, 2005; Gordijn and Kartseva, 2004; Gordijn and Akkermans, 2003). Consequently, the e^3*-control* methodology showing the convergence of both value and process perspectives is illustrated in Figure 2.2.

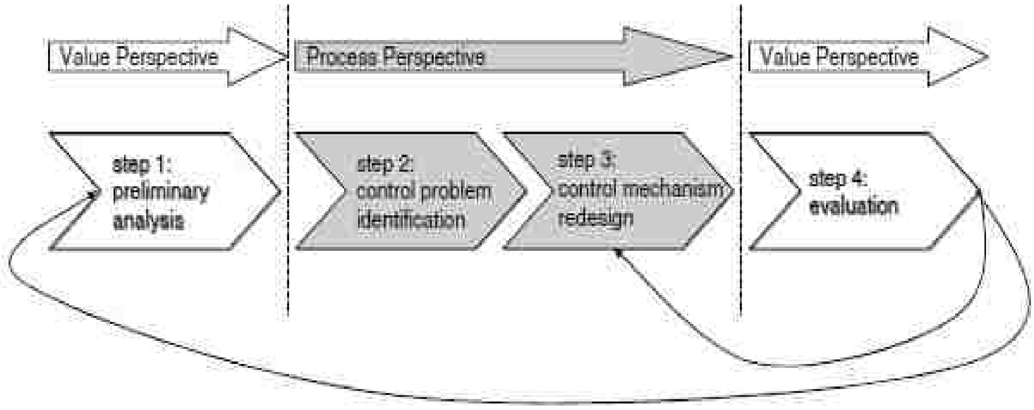

FIGURE 2.2: THE REDESIGN METHOD

According to Tan *et al*. (2011), the key ideas of the *redesign method* are implemented as follows:

1) A *value analysis* using *e^3-value* method is conducted to comprehend the current business model and to discover which value exchanges between actors in a service system are vulnerable.
2) Following the discovery of the vulnerable aspects of a business process, a *process level analysis is* conducted on them to establish how value can be lost by actors participating in a business transaction.
3) The third step is the *development of corrective measures* (new governance and control mechanisms) thereby transforming business processes.
4) Lastly, the value analysis is *redone*, including a scrutiny of the impact of the proposed changes on the business model in many ways, such as new actors, new control services and an *evaluation* of the feasibility of the business model.

2.5 PROCESS-ORIENTED IMPLEMENTATION OF SERVICE SYSTEMS

[redacted] Principles of business process-oriented approaches

Over the last few decades, the global business world has witnessed an upsurge of process-oriented approaches that are considered lean, flexible and market-oriented structures to navigate an increasingly competitive business environment (Pourmirza *et. al.,* 2017). This shift has been supported by research findings that show that more process-oriented organisations perform better than less process-oriented organisations (Škrinjar *et al*., 2010). Consequently, universal standards for project management, including project management body of knowledge (PMBOK), reference standards, such as capability maturity model integration (CMMI) and general guidelines for quality assurance, such as ISO 9001:2008, endorse the adoption of formal business process mechanisms by organisations to promote business growth (Meidan *et al.*, 2017; Silva *et al*., 2015; Snyder, 2014; Rusjan and Alič, 2010). For this reason, embracing business process management (BPM) portends business success for organisations (Jeston and Nelis, 2014).

BPM has been described as management practices, approaches and systems associated with the design, implementation, support and evaluation of business processes (Mendling *et al*., 2017; Bai and Sarkis, 2013; Van Der Aalst, 2003). These management practices have been conducted by process managers, process analysts and process engineers who have often relied on manual mechanisms but have increasingly embraced the use of technology at different organisational levels in modern times (Mendling *et al*., 2017). Therefore, the BPM literature recognises three tiers of BPM that operate interconnectedly to achieve the overall goals of the organisation (Mendling *et al*., 2017; Dumas *et al*., 2013).

1) The *top tier* is typically referred to as *multi-process management* and it identifies the key processes of an organisation and the systematic assessment of their significance. These activities are linked to the organisational strategy and constitute the organisation's central process repository.
2) The *middle tier* focusses on the management of a singular process through the entire BPM *lifecycle*, which entails documenting the existing situation of a process; analysing a process using qualitative and quantitative methods, exploring diverse design options to resolve issues, implementing and evaluating business processes.
3) The *bottom tier* focuses on the management of singular process *instances*, which involves scheduling process activities and the requisite resources. The process activities are guided by the *rules* defined in the process model, such as quality-of-service assertions.

To ensure that organisations effectively implement BPM, Bai and Sarkis, (2013) proposed eight critical success factors (CSFs) that signify process competencies to attract resources, including funds, skills and knowledge. These CSFs are discussed as follows.

1) *Project management*: it has been established that project management greatly impacts the success of BPM by ensuring that the business processes are rationally implemented (Bai and Sarkis, 2013), Typically, BPM embodies principles of project management, change management, ICT management and involves diverse actors, such as suppliers, clients, employees and investors (Willaert *et al*., 2007).

2) *Performance measurement:* it is necessary to measure the progress of implementing business processes on a systematic basis to guarantee better control and to safeguard the goals of the organisation (Bai and Sarkis, 2013). Van Looy and Shafagatova, (2016) have proposed a comprehensive catalogue of performance evaluation perspectives that should inform the performance measurement: *financial perspective* (financial performance for investors and strategic top management tier); *customer perspective* (customer performance, supplier performance, society performance); *internal business processes perspective* (general process performance, time-related process performance, cost-related process performance, process performance related to internal quality, flexibility-related process performance); and *"learning and growth" perspective* (digital innovation performance; employee performance; society performance as a sub-perspective of customer performance). However, Van Looy and Shafagatova, (2016) assert that more research is needed to understand how to effectively determine performance indicators.

3) *Information communication technology:* this includes hardware, software systems, networks and associated infrastructure that handle business information (Chourabi *et al*., 2012). Thus, ICT is seen as an integral component of BPM and is widely regarded as an *enabler* and a *facilitator* of all aspects of business processes (Sidorova *et al*., 2015; Vom Brocke and Schmiedel, 2015). This includes all aspects of information

management, including information processing, communication support as well as integrating the personnel, business and organisation together (Sidorova *et al*., 2015).

4) *Strategic alignment:* the strategic alignment of BPM has been described as a mechanism by which an organisation can formulate the connection between its business processes and strategies. It allows the management to gather meaningful insights based on the present processes (Morrison *et al*., 2011). According to Bai and Sarkis (2013), the long-term success of BPM depends on its alignment with the overall strategy of an organisation.

5) *Collaborative working environment:* a collaborative environment allows organisations to exploit the rich skills, knowledge and experiences of its personnel, clients and business associates to develop effective business processes (Afzal *et al.*, 2018). Basically, a collaborative environment permits associates to communicate, coordinate and co-operate to achieve a collective understanding and alignment of the organisation's strategic direction and goals (Bai and Sarkis, 2013).

6) *User focus:* the focus of developing business processes is to meet the requirements of *internal* or *external* users in a bid to gain a competitive edge over business rivals (Bai and Sarkis, 2013). For this reason, it is important for organisations to focus on users to create intellective acceptance of business processes amongst users; to improve system quality by illuminating system requirements and to improve the rapport between process developers and users (De Waal and Batenburg, 2014).

7) *Top management support:* this concept describes the extent to which top management in the organisation supports the conceptualisation, design and implementation of business processes by providing the requisite authority, resources and overall direction (Ifinedo, 2008). Generally, top management support is crucial when implementing BPMS, partly because it influences other critical success factors (Ravesteyn, 2011). For this reason, the success of BPM is compromised in cases where the top management is not actively involved in process improvement efforts (Trkman, 2013).

8) *Organisational culture:* this is described as a culture that promotes the development of efficient and effective business processes through common ideals in an organisation that become discernible in actions and structures (Schmiedel *et al*., 2012). Thus, organisational culture can either spur the success of BPM or contribute to its failure. For instance, cultural resistance to change impacts the success of BPM negatively (Schmiedel *et al*., 2012). Generally, organisational culture is often manifested as an *artefact* (BPM management suites, BPM documentation, continuous enhancement processes, devoted BPM team and value-orientation) and *espoused values* (enterprising and receptive outlook, orientation towards continuous process improvement and innovation, adherence to process goals, making sound decisions and collaborations) (Gu *et al*., 2017).

[redacted] Benefits of business process management

The benefits of business process management are discussed as follows.

1) *Flexibility to make changes*: BPM promotes the development of flexible business processes, which are cheaper to modify in the event of changes in the business environment due to market factors, new regulations, or the rise of new business habits (Seiger *et al*., 2015).
2) *Increased efficiency and reduced risks*: BPM can accelerate organisational processes and save organisational resources leading to efficiency (Bai and Sarkis, 2013). This efficiency is partly aided by the conspicuousness of business processes, which reveals inefficiencies (Page, 2015). Additionally, BPM offers improved design, execution and monitoring of business processes, which can help to minimise the risk of plunder (Namiri and Stojanovic, 2007).
3) *Improved productivity*: BPM can easily help in computerising recurring components of workflows and streamlining business processes by eliminating impediments, removing superfluous steps and executing business processes concurrently (Bai and Sarkis, 2013). As such, the BPM personnel can dedicate more time and energy on other activities leading to more productivity (De Waal and Batenburg, 2014).

4) *Improved employee satisfaction*: BPM systems employ inbuilt storage mechanisms for documentation thus eliminating massive paperwork (De Bruin and Doebeli, 2015). The result is that employees can retrieve and share documents with minimal effort, keep track of workflow processes since they are automatically created and controlled, dedicate more effort towards complex cases and access superior business reports, thus resulting in improved satisfaction (De Bruin and Doebeli, 2015; Damij and Damij, 2013).

5) *Improved compliance and transparency*: BPM promotes compliance with industry standards by ensuring that organisations promptly execute legal requirements (Merlo *et al*., 2018; Gómez-López *et al*., 2015; Ly *et al*., 2015). Often, compliance is integrated into the process lifecycle thus making it easier to execute (Geiger *et al*., 2017). Compliance also suggests that organisational processes will become transparent and discernible to personnel (Geiger *et al*., 2017).

6) *Customer focus*: BPM offers leaner processes and increased productivity, which allows the employees to focus on the customer in many ways, such as briskly negotiating business offers, developing or customising business systems faster (Rodriguez *et al*., 2015). BPM also increases customer satisfaction by fostering a convergence of people and technology to promote customer-oriented activities that deliver the best results by analysing data from customer experience surveys, loyalty analyses, service or product evaluations (Van Der Aalst *et al*., 2016; Rodriguez *et al*., 2015).

7) *Sustainability*: BPM integrates sustainability into business practices by facilitating continuous improvement to meet the growing needs of customers, employees, shareholders and business partners as well as exploring ways of creating a competitive edge over competitors (Kirchmer, 2017). Ideally, sustainability in business practices is created through the joint effort of the top tier of management and the lower tier of management such that there is harmony between employees' interest and organisational principles (Petrini and Pozzebon, 2010). Consequently, the successful integration of sustainability into business practices is influenced

by several factors, such as governance, leadership, commitment of top and lower tier of management, reporting and stakeholder demands (Rosemann and Vom Brocke, 2015; Petrini and Pozzebon, 2010).

8) *Consistency, repeatability and transferability:* the execution path for each business process, problem and exceptional conditions (regardless of change of roles) are programmed using BPM systems thus leading to consistency, repeatability and transferability (Fink *et al*., 2017; Mathiesen *et al*., 2013; Fischer, 2012).

9) *Integration of technology and communication:* the use of BPM standards, such as BPMN have closed the gap between business users and ICT by focussing on business processes and not applications (Barón *et al*., 2016; Marrella *et al*., 2015).

10) *Measurability:* with the aid of BPMS, it is possible to measure the performance of business processes throughout their execution cycle using reporting and diagnostic systems. This performance data can then be used for optimising their performance in line with the goals of the organisational (Reisert *et al*., 2018; Ensslin *et al*., 2017).

[redacted] Business process management suites

The use of process-oriented methods in implementing business systems follows the *modus operandi* of business software, including enterprise reporting packages (ERP) and supply chain management (SCM) (Kirchmer, 2012). These approaches have characterised a *business process* as the *locus* for developing information systems that fulfil the ever-expanding business requirements (Pourmirza *et. al.,* 2017; Prades *et al.*, 2013).

Generally, a business process is an operation consisting of elements and relations fashioned in a workflow graph whose objective is to meet a business goal. Typically, a business process consists of various elements, such as a *start event*, a unique *end event*, an *activity* and a *task* (Ouali *et al*., 2016; Bicevskis and Bicevska, 2015; Missikoff et al., 2010). A start event and a unique end event represent the entry point and the exit point of the process respectively (Missikoff *et al.,* 2010). The key element of a business process is an activity, which represents a unit of work performed within the process. On the other hand, a task represents an atomic activity (non-decomposable), while a compound activity represents the invocation of composite (possibly remote) process and it is associated with a workflow that provides the definition of its internal structure. A process can thus be viewed as a hierarchy of activities (Bicevskis and Bicevska, 2015; Missikoff *et al*., 2010). Consequently, a business process can be characterised as follows: (1) a set of artefacts that consume, modify, produce or terminate them; (2) consumption of business resources; (3) participation of actors for its realisation; and (4) decomposition into other processes (Ouali *et al*., 2016; Missikoff *et al*., 2010).

The role of BPMS is to help BPM professionals accomplish the goal of managing the business process lifecycle (modelling, developing, deploying, executing and evaluating business processes) in an organisation (Meidan *et al.,* 2017; Delgado *et al*., 2015). Thus, there are two broad categories of BPMS in the business industry: *commercial* (proprietary) and *open-source* BPMS (Meidan *et al.*, 2017). However, the BPMS landscape is tilted in favour of open source BPMS because of their *burgeoning impact* on the software industry (Delgado *et al*., 2015). For this reason, an overview of popular BPMS by (Meidan *et al.*, 2017) is presented as follows.

1) *Bonita BPM* comprises two parts: *Bonita BPM Studio*, which is a GUI for generating the process and web application forms and *Bonita BPM Platform*, which contains an execution engine and Bonita Portal. The key features of Bonita BPM include the following: (a) supports BPMN 2.0 standard for business process modelling; (b) automatically generates GUIs and permits the user to manually modify it; (c) supports numerous connectors for integration with other systems; (d) supports version, calendar and document control functions as well as push and pull messaging; (d) supports technical monitoring; (f) authenticates business process diagram, expressions and connectors as well as debugging facilities; and (g) supports online multi-media documentation (Meidan *et al.*, 2017; Durán and Salaün, 2017; Daly and Schumacher, 2016; Poizat *et al*., 2016; Chabanoles and Ozil, 2015).
2) *ProcessMaker® open source BPMS* comprises two main components: *design environment* (process-related tools, business rules, dynamic forms,

input and output documents) and *run-time engine* that handles execution of cases. The key features of ProcessMaker® include the following: (a) supports BPMN 2.0 modelling framework but lacks business rule engine and process performance indicators (PPI); (b) supports PHP as a programming language and Java script as well as automatic or manual design of GUI; (c) supports REST APIs and web technologies but lacks a distributed execution mechanism; (d) lacks version, calendar and document control functions but supports push and pull messaging; (e) It does not support technical monitoring; (f) lacks process verification or simulation mechanisms but it provides log and event files; and (e) supports online multimedia documentation (Majekodunmi, 2018; Meidan *et al.*, 2017).

3) *YAWL (Yet Another Workflow Language)* is an open source BPMS based on a very rich workflow definition language. It has three elements, namely the business process *execution engine*, *process designer* and *resource services*. The key features of YAWL include the following: (a) supports the YAWL modelling language, BPMN standard, XQuery expression and Ripple-Down Rule (RDR) trees but does not support PPIs or process documentation; (b) supports Java as a programming language; (c) does not directly support distributed execution but supports web services and REST APIs; (d) supports version, calendar and document control functions as well as pull messaging; (e) does not support technical monitoring; (f) supports verification, simulation, logging and process mining; and (g) supports limited online multimedia documentation (Meidan *et al.*, 2017; Verborgh and De Roo, 2015; Barker and Van Hemert, 2007; Van Der Aalst and Ter Hofstede, 2005).

4) *Camunda BPM* is a Java-based framework for process automation that comprises *tools* (Camunda Modeler and Cockpit) for project definition and *components* (process engine, model repository and task list) for project execution. The key features of Camunda BPM include the following: (a) It supports the BPMN 2.0 modelling framework; (b) supports Java and JavaScript as programming languages as well as a GUI design; (c) supports

distributed execution, REST API and Web service technology; (d) supports version control, push and pull messaging functions but does not support calendar and document control functions; (e) supports aspects of monitoring business processes, such as workload balance; (f) supports business process verification and simulation; and (g) supports online multimedia documentation (Geiger *et al*., 2018; Meidan *et al.,* 2017; Mass *et al*., 2016; Geiger *et al*., 2015).

5) *Activiti* is an open source light-weight workflow and BPM that comprises a *modeller, designer* and *kick-start* for process modelling and *Activiti engine* for executing the business processes. The key characteristics of Activiti include the following: (a) supports BPMN 2.0 modelling framework and Drools rule engine but does not support BRM tool, PPIs and process documentation; (b) supports Java programming language, JavaScript, GUI, transaction control and exception handling; (c) supports distributed execution, web services and REST API; (d) supports document management but does not support version management and calendar management; (e) does not support technical monitoring in the community edition but supports some controls, such as workload balance; (f) supports process model verification and simulation are supported; and (g) supports limited online documentation (Meidan *et al.,* 2017; Wei *et al*., 2016; Hu *et al*., 2015; Zhang *et al*., 2014).

6) *jBPM* is an open source, light-weight BPMS developed in Java. It allows modelling, simulating and deploying processes and artefacts. The key characteristics of jBPM include the following: (a) supports BPMN 2.0 framework but it does not support PPIs or the production of the process documentation; (b) supports Java as a programming language and GUI; (c) supports a multi engine and multi-node architecture; (d) supports version, document control functions and pull messaging but does not support calendar control and pull messaging; (e) does not support technical monitoring and business activity monitoring but users can change roles or resources; (f) supports process verification and simulation; and (g)

supports limited online documentation ((Meidan *et al.*, 2017; Xiang and Shuai, 2016; Liu *et al*., 2015; Zhou *et al*., 2014; Yang *et al*., 2014).

7) *uEngine BPM* is an open source BPMS for managing end-to-end business processes. It comprises *uEngine BPM foundation* (process engine and process modelling tool), *uEngine process portal* (dashboard and single sign-on) and *uEngine BP analyser* (OLAP based process instance analyser). The key characteristics of *uEngine BPM* include the following: (a) supports XPDL modelling framework; (b) supports Java as a programming language and GUIs; (c) does not support distributed execution; (d) supports version, document control, pull and push functions but it does not support calendar control function; (e) does not support technical monitoring but support business activity monitoring; (f) supports process verification and simulation; and (g) supports very limited online documentation (Meidan *et al.*, 2017; Wu *et al*., 2015; Lee *et al*., 2011; Jia *et al*., 2010).

[redacted] Challenges facing business process management

The extant literature shows that BPM faces from the following inherent challenges.

1) *Deviation and loss of innovation:* the end-users of business processes are usually different from the designers of business processes who are often disengaged because of lack of communication. This disengagement leads to non-conformity between implementation and design models as well as loss of innovation. This problem is described as the model-reality divide (Ariouat *et al*., 2017; Schmidt and Nurcan, 2008).) To stem the model-reality divide, a participatory knowledge sharing mechanism should be adopted by end-users and process designers (Ariouat *et al*., 2017; Santorum and Rieu, 2013).

2) *Lack of visibility:* BPM systems predominantly assign a task to an actor based on typical access control policies, such as role-based access control that isolates the actor and denies the actor a global visibility of the process. Thus, the isolated actor understands *what should be done* but disregards *what can be done* (Ariouat *et al*., 2017). To resolve this challenge, Ariouat

et al. (2017) propose that actors should be trained on *what can be done* to undertake the proper tasks.

3) *Lack of co-operation:* this can be manifested in many ways, such as the lack of a collaborative mechanism for resolving complex problems, improving skills or sharing resources (Akopova and Przhedetskaya, 2016). Additionally, the lack of co-operation may affect delegation of duties, volunteering and decision making that could, in turn, affect business processes. To resolve this challenge, organisations should do the following: creating participatory frameworks for business process actors and designers, enhancing social relations amongst employees to reap the benefits of social inclusion and establishing protocols and hierarchical structures in the organisation (Ariouat *et al*., 2017).

4) *Co-ordination problems and conflict of interest*: a process-oriented view may cause coordination problems and conflicts of interest between the functional and process managers (Damij and Damij, 2013). This difficulty should be solved at the strategic level of management by supporting and encouraging this reorganisation in a bid to not only improve work performance and quality but also achieve several necessary changes in the working culture of the organisation (Damij and Damij, 2013).

2.6 MOBILE CLOUD COMPUTING

[redacted] Description of mobile cloud computing

Mobile cloud computing is a relatively new computing paradigm that describes the convergence of three distinct, but related, fields, namely *mobile computing* (embracing the concept of instantaneous access to information by allowing users the privilege of unhindered mobility), *cloud computing* (a platform for facilitating ubiquitous, expedient on-demand utilisation of mutual computing resources that can be promptly rendered with nominal effort) and *wireless networks* with the overriding goal of sharing cloud-based computing resources to alleviate the resource constraints of mobile devices (storage, computation and battery), such as smartphones and tablets (Abdo and Demerjian, 2017; Raei and Yazdani, 2017; Aminzadeh *et al.*, 2015; Khan *et al*., 2013; Momeni, 2015). Basically, MCC permits resource-constrained mobile gadgets to seamlessly regulate processing and storage capabilities by partitioning and offloading computationally intensive and storage demanding applications on conventional cloud resources by providing pervasive wireless access (Khan *et al*., 2013).

[redacted] Mobile cloud computing architectures

The extant literature shows that there are three significant MCC architectures in use. These architectures are described as follows: (1) the "one user-one virtual machine" architecture is touted as the reference model (Nawrocki and Reszelewski, 2017); (2) the "multiple users –one virtual" architecture whereby multiple clients can use a single virtual machine simultaneously through a prescribed algorithm for distributing tasks between the nodes (Nawrocki and Reszelewski, 2017); and (3) the "multiple users– queue" architecture that runs workloads in the cloud asynchronously using queues (Nawrocki and Reszelewski, 2017). The second and third architectures, which are the subject of on-going research, seek to lower MCC resource usage based on traditional cloud computing patterns (Nawrocki and Reszelewski, 2017).

[redacted] Benefits of mobile cloud computing technology

Regardless of the architecture adopted, the MCC environment generally offers the following benefits:

1) Reduction in *cost of hardware and software* since the data and the application reside on a shared cloud platform (Nawrocki and Reszelewski, 2017; Khan *et al*., 2013; Kitanov and Davcev, 2012). The MCC helps in reducing the running costs of computation intensive applications (Tayade, 2014). Additionally, it is economical to develop shareable mobile cloud applications that can be accessed by multiple mobile devices (Lu et al., 2017; Kitanov and Davcev, 2012). Compared to traditional software that require a lot of capital and licence fees (especially for many users), the cloud platform provides inexpensive rates for business applications and can tremendously reduce the cost of an organisation's ICT investment

through distinct payment options, such as one-time-payment, pay-as-you-go and other elastic options (Momeni, 2015; Apostu *et al*., 2013).

2) *Ease of cloud application development and deployment* through web access as opposed to a mobile operating system interface (Nawrocki and Reszelewski, 2017). This means that the cloud application can be made operational within a brief time depending on the technical aspects of the business (Apostu *et al*., 2013). Such rapid development and deployment of cloud applications provide increased server utilisation with a significant reduction in cost and effort (Diaz *et al*., 2017). For example, the Apache Spark and Apache Spark Streaming for real-time and batch processing provide a solution for reducing deployment costs (Diaz *et al*., 2017).

3) Mobile cloud applications are *ubiquitous*, which makes them reliable and readily available regardless of time zone or geographic location issues (Aminzadeh *et al*., 2015; Khan *et al*., 2013; Apostu *et al*., 2013). The enhanced reliability of business applications is achieved through redundancy and backup of data on the cloud storage (Alizadeh *et al*., 2017; Abdo and Demerjian, 2017; Aminzadeh *et al*., 2015). The storage of data and applications in the cloud servers diminishes the possibility of loss of data and application in the event of loss or malfunctioning of the mobile equipment (Diaz *et al*., 2017). Additionally, research has shown that MCC can be configured as a complete data security model for both service providers and clients to safeguard patented digital data in the clouds and to render security solutions, such as virus threat protection, malevolent code discovery and authentication for mobile clients (Diaz *et al*., 2017).

4) MCC provides *enormous data storage capacity* and processing capabilities in the cloud servers (Nawrocki and Reszelewski, 2017; Kitanov and Davcev, 2012). This enormous data storage capacity and processing power help in the storage of data generated by mobile applications thereby limiting any constraints on the storage capacity of the mobile devices (Raei and Yazdani, 2017; Apostu *et al*., 2013).

5) *Longer lifetime of battery* for mobile devices (Nawrocki and Reszelewski, 2017). This is achieved through computation offloading, which shifts

bulky computations and intricate operations from resource-starved equipment (mobile devices) to resource-laden equipment (cloud-based servers) (Khatal *et al*., 2017; Tayade, 2014). Such remote processing of applications can considerably save energy. Thus, many mobile applications exploit the benefits of task migration and remote execution (Tayade, 2014).

6) *Dynamic on-demand provisioning* of computing resources on a detailed, buffet-style basis, which eliminates the need for advanced reservation of computing resources for an application (Vukojevic-Haupt *et al.*, 2017). These resources are configured and delivered as services across the cloud environment according to user needs on a prepaid basis (Khatal *et al*., 2017).

7) *Scalability* of mobile applications can be achieved to satisfy the uncertain user needs. Scalability is the ability of the mobile cloud computing architecture to be elastic by adding or reducing the computing resources and users (Al-Janabi *et al*., 2017). Basically, scalability allows cloud service providers to effortlessly add and enlarge services (Tayade, 2014).

8) *Multi-tenancy* cloud environment allows service providers to share the computing resources and expenses to sustain a diversity of programmes and multiple users through reuse of resource objects through a meticulous process to avert susceptibility (Ali *et al.*, 2015; Al-Jahdali *et al*., 2014). The benefits of multi-tenancy include the following: isolating hardware faults from software faults, minimising costs, boosting profit, maintaining financial frugality and lowering carbon footprint (Wu *et al*., 2015; Al-Jahdali *et al*., 2014). Basically, the benefits of multi-tenancy can be attributed to *virtualisation*, *resource sharing* or both. For instance, isolating hardware faults from software faults is realised by virtualisation (Assunção *et al*., 2015; Al-Jahdali *et al*., 2014; Bonomi *et al*., 2014).

9) *Ease of integration* of numerous services from diverse providers through the cloud services to suit the users' needs (Diaz *et al*., 2017; Dinh, *et al*., 2013). This is an automatic process that precludes cloud users from undertaking any extra exertions to modify and integrate their cloud

applications to suit their inclinations (Khodkari *et al*., 2016; Apostu *et al*., 2013).

10) *Robustness and flexibility* are features of MCC that ensure a rapid error recovery and adjusting to the unpredictable character of cloud client conduct and service access norms (Momeni, 2015).

[redacted] Key mobile cloud computing applications

This section describes the key mobile cloud applications in the society. Basically, a mobile cloud application is a computer software that is developed and deployed over a mobile cloud infrastructure to be accessed by mobile computing gadgets. These key applications have been described as follows.

1) *Mobile commerce*: this is the phenomenon of using mobile gadgets for conducting commercial transactions, especially for business applications that require mobility, such as mobile ticketing (Verkijika, 2018). The m-commerce applications belong to distinct categories, such as *mobile finance*, *mobile advertising* and *mobile shopping* (Faulds *et al*., 2018; Dinh, *et al*., 2013). However, m-commerce applications face numerous inherent challenges, such as limited bandwidth, intricacies of mobile equipment and security (Al-Jaberi *et al*., 2015).
2) *Mobile learning*: this combines e-learning and mobility to provide significant support for developing inventive, co-operative and interactive learning platform (Al-Hunaiyyan *et al*., 2016). Mobile learning seeks to resolve some of the inherent challenges associated with conventional e-learning, such as expensive equipment, prohibitive cost of network access, limited data transfer rate and restricted learning resources (Dinh, *et al*., 2013). Mobile learning offers solutions to some of these limitations in many ways, such as promoting ubiquitous access to learning resources by learners and instructors regardless of time and geographical location, promoting dynamic and rich multimedia content, promising unlimited learning resources, enhancing interactivity, partnerships and engagement (Kukulska-Hulme and Viberg, 2018; Al-Hunaiyyan *et al*., 2016; Odunaike *et al*., 2014). However, the implementation of mobile learning projects is

often derailed by management, institutional, design, technical, evaluation, cultural and social challenges (Al-Hunaiyyan *et al*., 2016).

3) *Mobile gaming:* this is a gaming application that runs on small portable computing equipment, such as smartphones and tablets connected to a wireless network (Merikivi *et al*., 2017). Gaming applications offload game engine that involves massive computing resources to the cloud server thus preserving energy and boosting game playing period (Qian and Andresen, 2015). Apart from the intrinsic benefit of basic entertainment and extrinsic benefits, such as enhancing creativity, mobile gaming has been billed as a potentially profitable venture for game developers (Fung, 2017: Merikivi *et al*., 2017).

4) *Mobile healthcare*: the goal of mobile healthcare is to offset the shortcomings of conventional medical treatment, such as limited storage, safety, confidentiality and medical blunders (Yüksel *et al*., 2017; Chib *et al*., 2015). Thus, mobile healthcare affords users of mobile devices a handy access to resources, such as medical records (Stankovic, 2017). Mobile healthcare supports the management and operation of healthcare facilities by provisioning of a range of on-demand cloud-based services, such as extensive health tracking services; health-aware mobile gadgets, such as heartbeat, blood pressure and level of alcohol detectors; intelligent emergency management system and ubiquitous lifestyle inducement management; and ubiquitous access to healthcare information (Triantafyllidis *et al*., 2017; Baig *et al*., 2015; Jemal *et al*., 2015).

5) *Assistive technologies:* these include assistive technologies, such as pedestrian crossing guide for the blind and the visually-impaired (Fernandes *et al.*, 2017); mobile currency reader for blind and visually impaired (Griffin-Shirley *et al*., 2017); lecture transcription for hearing-impaired learners (Shadiev *et al*., 2017).

[redacted] Key issues in mobile cloud computing

Despite the wide-ranging benefits attributed to the MCC, the extant literature shows that there are inherent challenges that negatively impact the success of MCC technologies and have become the subject of MCC research. These challenges include service *consistency, availability, unreliability, mobility management, security, privacy, energy efficiency, trust, portability* (due to lack of standards for cloud providers) (Khan *et al*., 2013; Kitanov and Davcev, 2012; Zissis and Lekkas, 2012). These issues are discussed as follows.

1) *Limited bandwidth*: this is one of the biggest issues in MCC because the radio resource for wireless networks is much limited than the conventional wired networks. This limited bandwidth is shared amongst mobile users who are situated in the same locality, such as a workplace or a station and transacting a similar content (Li *et al*., 2015; Tayade, 2014).
2) *Service availability:* mobile users may fail to connect to the cloud to exploit a service owing to traffic gridlock, downtime, network fault, fluctuating mobile signal strength (Munir, 2016; Apostu *et al*., 2013). Thus, availability of service presents a bigger challenge in MCC than it does in the cloud computing environment with conventional wired networks (Tayade, 2014).
3) *Heterogeneity*: it is complex to manage wireless connectivity with hugely heterogeneous networks to fulfil MCC demands, such as continuously accessible connectivity, on-demand scalability and minimising energy consumption (Munir, 2016; Yousafzai *et al*., 2016; Tayade, 2014). Generally, connectivity is a critical aspect of MCC and subscribers should duly ascertain the credentials of a service provider before enlisting their services (Khatal *et al*., 2017).
4) *Security and privacy:* a key predicament of the MCC is the security and privacy issues such as loss of data, breach of data, recovery of data and locality of data (Al-Janabi *et al*., 2017; Khatal *et al*., 2017). These security and privacy issues may be caused by viruses, malware, network hacking and Trojan horses, which thrive in an environment of distributed cloud storage and processing, resource-deficient mobile devices, free-space transmission medium, multi-tenancy and heterogeneous environments (Mollah *et al.*, 2017; Lu *et al*., 2017; Al-Jahdali *et al.*, 2014; Tayade, 2014; Khan *et al*., 2013). To overcome security and privacy concerns, MCC

research has attempted to resolve certain concerns, such as user authentication that has received significant attention in MCC research and has recorded considerable success (Lu *et al*., 2017; Alizadeh *et al*., 2017; Quwaider *et al*., 2015).

5) *Performance*: the performance of cloud applications is often viewed less favourably compared to traditional applications by some subscribers. Therefore, a good understanding of a cloud service provider’s service credentials is necessary to allay any fears of poor service delivery (Khatal *et al*., 2017).

6) *Latency (Delay or turnaround time)*: cloud service providers must grapple with the duration required for offloading the computation and receiving the results from the closest cloud resources (Stergiou *et al*., 2018; Khatal *et al*., 2017; Tayade, D. (2014). Generally, users of remote cloud resources experience long latency while nearby users experience minimal latency (Akherfi *et al*., 2018; Desai, 2016). Additionally, synchronous applications require minimal latency as opposed to asynchronous applications (O’Sullivan and Grigoras, 2015).

7) *Computation offloading*: cloud application developers face the challenge of making computation offloading decisions, such as the service code segments to offload (Lyu and Tian, 2016). Generally, two mechanisms exist for computation offloading: offloading in a static environment and offloading in a dynamic environment (Tayade, 2014). The achievement of these mechanisms requires automation, which is a challenging process that requires the development of elaborate protocols for service discovery based on the existing context and its limitations (Akherfi *et al*., 2018).

8) *Limited resources*: cloud users experience the resource limitations of mobile gadgets that make it challenging for running cloud applications (Li *et al*., 2017). These limitations relate to the intrinsic challenges of mobile gadgets, such as limited processing capacity, limited battery and display problems (Taha *et al*., 2018; Tayade, 2014).

9) *Cost of cloud computing:* although cloud applications are generally less costly than conventional desktop applications, subscribers need to

ascertain that the cloud applications exhibit all the requisite features (Becker *et al*., 2017; Fanning and Cannon, 2015). Additionally, subscribers need to obtain a detailed comparison of costs involved and submit to a predetermined contract to avoid any emergent charges (Flint, 2017). This contract should stipulate the pricing strategy and the properties of each application (including offloading decisions), which should conform to a service level agreement (SLA) (Nandi *et al*., 2017).

10) *Incompatibility of data and application formats*: cloud service providers adopt different data and applications formats (Zhang *et al*., 2017). This means that a cloud service provider often binds the subscriber into using their data and application formats (Demchenko *et al*., 2017). For example, it is impossible to append a file created in an alternative application into a Google Docs spreadsheet (Jung *et al*., 2017; Apostu *et al*., 2013).

As researchers navigate the terrain of MCC, it is instructive to note that despite the inherent challenges highlighted above, there's been an increased adoption of MCC technologies in various spheres of the service economy by business applications that seek to benefit from shared computing resources (Alizadeh *et al*., 2017; Alghabban *et al*., 2017; Nawrocki and Reszelewski, 2017; Lu *et al*., 2017; Quwaider *et al*., 2015; Ozdamli and Uzunboylu, 2015; Wang *et al*., 2015b; Jain *et al*., 2012).

2.7 EVALUATION OF SERVICE SYSTEMS

[redacted] The basis for evaluating service systems

The review of the literature on evaluation of service systems was informed by two perspectives. The first perspective was that a system is a bundle of theories because a methodical exploration of the system requires explicit testing against each theory in the bundle at all its levels (Giachetti, 2016; Edwards, 2005). Such a critique of a system should be premised on the stated purpose of the study and should be considered as an integral part of defining its scope, a construct that is invariably called *holism* or realism (Mulej, 2007; Edwards, 2005). Holism means that the entire system exhibits *emergent* features that meaningfully reflect the attributes of the entire system and not any one portion of the system. For instance, organisations can exhibit the characteristic of holism by demonstrating that their competence to create novel products and services cannot be attributed to a singular department of the organisation, such as production, research or sales (Giachetti, 2016). It has been further argued that a comprehensive critique of the emergent features of any human system is a daunting task given its intrinsic complexity coupled with its infinite number of subsystems and complex contexts (Parhizkar and Comuzzi, 2017; Abgaz, 2013). Therefore, a critique of any human system is often based on incomplete evidence because some parts of the system do not get sufficient analysis during evaluation. Suffice to say, this *goal-directed*, focused analysis is necessary to manage both the process and outcome of system evaluation (Aversano *et al*., 2013; Jokela *et al.*, 2008; Jacucci and Hanseth, 2006). The second perspective was about the evaluation of the use of a system by Orlikowski (2007), who asserts that an entity by itself cannot be evaluated; only entities in use can be evaluated. The entity cannot be separated from its use and vice versa. For example, one could claim that a hammer is used for driving in nails, but people can use hammers in all kinds of ways. That someone picks up a hammer and uses it, doesn't mean it is used to hit in nails. This concept has been demonstrated by extant PME literature, such as Parhizkar and Comuzzi (2017) and Abgaz (2013).

[redacted] The technology acceptance model (TAM)

In line with the fundamental principles of evaluation of information systems explored in the preceding paragraph, the extant literature on the notion of goal-oriented approach to technology acceptance has been reviewed. Thus, the TAM, an offshoot of the Theory of Reasoned Action (TRA)was chosen as an explicit goal-oriented model that has long dominated technology acceptance studies, such as Chang *et al*., (2017); Hussein (2017); Bach *et al*., (2016); Ooi and Tan (2016); Cheng *et al*., (2015); Rauniar *et al*., (2014) and Cronholm and Goldkuhl, (2003). The TAM postulates that the actual use of technology is influenced by the attitude of an individual towards using it. The model posits that perceived usefulness (PU) and perceived ease of use (PEOU) are two salient determinants of system use behaviour (Davis, 1989). The TAM includes critical technology-related factors to explain the decision-making process of an individual to accept innovative ICTs in an organisational setting (Parhizkar and Comuzzi, 2017; Abgaz, 2013Davis, 1989). Specifically, the TAM asserts the following constructs: (1)

External variables influence perceived ease of use and usefulness of a technology; (2) Perceived ease of use of a technology has a direct effect on its perceived usefulness; (3) Perceived usefulness and ease of use impact attitude toward the technology; (4) Perceived usefulness and attitude toward the technology influence its use intention; (5) Technology use intention along with perceived technology usefulness can lead to its use (Parhizkar and Comuzzi, 2017; Lin and Kim, 2016; Olugbara and Ndhlovu, 2014; Chen *et al*., 2011; Olugbara *et al*., 2010; Surendran, 2012; Davis, 1989).

2.8 DIGITAL RESILIENCE

[redacted] Description of digital resilience

Digital resilience relates to the general notion of resilience that describes the process of creating well-being and positive development through lifelong learning. The aim is to overcome intrinsic challenges and proactively adapt to constant change by building capacity and accessing resources (Moore and Shaffer, 2017; Roberts *et al*., 2016; Masten and Obradović, 2006; Davis *et al*. 2002; Luthar *et al*., 2000). More specifically, digital resilience means the ability to acquire new digital skills that can help an individual to navigate increasingly digitally-oriented, dynamic societies. The main characteristics of digital resilience include the capacity to create *new opportunities, resources* and *skills* to cope in a stressful, disadvantaged or traumatic situation (LLobregat-Gómez and Sanchez-Ruiz, 2015; Luthar *et al*., 2000; Masten, 2001). Developing digitally resilient individuals in marginalised communities that are often targeted by development projects is thus a lifelong practice of continuing education by its capacity to create new opportunities, resources and skills that will enable the individuals to actively participate in the knowledge economy and information society (Thinyane *et al*., 2007, 2006).

Digital resilience is related to community interventions, such as positive youth development (PYD) that prepare young people to face the challenges of life through productive activities and experiences that render them socially, morally, emotionally, spiritually, physically and cognitively competent (Sanders and Munford, 2014; Colmer *et al*., 2011; Heinze *et al*., 2010; Lerner *et al*., 2009; Ebstyne and Furrow, 2008; Fraser-Thomas *et al*., 2005; Lerner, 2005). It is posited that PYD will shield the youth from the negative repercussions of tough times (Brennan *et al*., 2007). Lewis (2011) presents a social context model that emphasises the need to build young people's resilience in the face of family and peer influence, social norms and the bandwagon effect (Lewis, 2011; Heinze *et al*., 2010). Lewis (2011) believes that if the youth are taught moral virtues and have access to an enabling environment, they will eventually manifest the attributes of positive development. These positive attributes that are known as the 6 Cs are confidence, competence, connection, character, compassion and contribution (Jones *et al*., 2011; Zarrett and Lerner, 2008; Shek, 2006). A relationship exists between digital resilience and competence in specific performance areas, such as social, academic, cognitive, health and vocational. Academic competence refers to school performance that is partially reflected by school grades and attendance and test scores (Zarrett and Lerner, 2008). As a component of academic competence, continual learning significantly contributes to digital resilience by enabling youths to acquire assets (Zarrett and Lerner, 2008).

[redacted] Fundamental aspects of digital resilience

The literature identifies four fundamental aspects of resilience that are applicable to various spheres of life, such as learning to underscore the capacity of learners (the system) to absorb 'disturbance' and reorganise while acquiring new skills in such a way as to essentially retain the same function, structure, identity and feedback (Hopkins, 2009). These four aspects of resilience are (Walker *et al*., 2004):

1) *Latitude*: the limit of change a system can absorb before losing its capability to recover.
2) *Resistance*: the ease or difficulty of changing the system; how 'resistant' it is to change.
3) *Precariousness*: how close the current state of the system is to a limit or 'threshold'.
4) *Panarchy*: the influence of external forces at scales above and below. For example, external oppressive politics, invasions, market shifts, or global climate change can trigger local surprises and regime shifts.

Based on the four aspects of resilience described above, this study contextualised digital resilience amongst the actors in community development as follows:

1) In terms of *latitude*, digital resilience is a means to equip PME actors with various ICT skills to effectively participate in a digital society (Ochieng' *et al*., 2017).
2) Digital skills and levels of 'digital optimism' can counter *resistance* to digital change and significantly boost more encompassing resilience. This means that actors who embrace ICT could end up building basic digital skills. Resistance can also be defined as the factors hindering the acquisition of digital skills, such as the prevalence of illiteracy amongst certain PME actors.
3) In terms of *precariousness*, digital resilience interventions have the potential to go beyond raising awareness within a community, with some scholars arguing that it can lead to long-term behavioural change (Third *et al*., 2014). For example, the Hub (www.thehub.walthamforest.gov.uk), an education network in the United Kingdom, provides digital resilience services, such as multi-media applications, youth involvement opportunities, tailored interventions and website access, amongst other services to teachers and the youth.
4) Digital resilience can spur unexpected but positive knock-on effects in terms of fostering positive engagement across a host of online settings in society at large (*panarchy*) (Przybylski *et al.*, 2014).

[redacted] Developments in digital resilience

One of the most fascinating digital resilience innovations in recent times that has elicited positive debate in the open and distance education literature is the Massive Open Online Course (MOOC). This innovation seeks to expand the audience for education from campus students to those that are ill-served or completely shut out of the current system (Shirky, 2012). The MOOC represents an ideal case study of digital resilience in three significant ways. First, it is steadily revolutionising open education not only by removing physical and geographical hurdles but also by offering mediated interactions in a variety of formats. Second, the MOOC offers an opportunity to educate participants by transcending niche interests, specific disciplines, culture or geography. Thirdly, it is currently being used across the world and growth in its usage is phenomenal (Weller and Anderson, 2013). In terms of the four components of resilience, the MOOC has shown a high degree of latitude as a platform that easily propels learners to embrace technological change. It has also worked well for organisations with a large investment in ICT infrastructure. The MOOC has not been precarious in terms of handling the core business of open learning. Finally, it has caused considerable upheaval in open education (Weller and Anderson, 2013).

[redacted] Issues in digital resilience

It should be noted that some risks are associated with digital exploration as we seek an innovative intervention to develop digitally resilient actors in community development. These risks have been categorised as the 3 Cs of *content*, *contact* and *conduct* (Hasebrink *et al*., 2009). *Content risks* relate to actors accessing inappropriate or harmful material that encourages risk-taking behaviours. *Contact risks* refer to actors interacting with potentially harmful people through digital media. *Conduct risks* arise because of the actor's own behaviour or the behaviours of other actors (Davidson *et al*., 2011; Byron, 2010; Livingstone and Haddon, 2010; Livingstone, 2008). To effectively mitigate these risks, support is needed from all stakeholders in the youth development agenda along with industry collaboration and self-regulation. Since digital content cuts across parental, educational, technological, governmental and corporate responsibility, no single actor can completely reduce these risks (Telenor Group, 2013).

2.9 CONCLUSION

This chapter has presented a theoretical framework for developing an innovative *e^3-value* ontology-based service system for improving the process of PME. This theoretical framework was divided into eight sections that were richly interwoven to form the fabric of the research study. The role of *community development* was explored as a panacea for sustainable development to improve the welfare of marginalised communities. This is exemplified by the numerous benefits emanating from community projects based on a bottom-up conceptualisation, design, implementation, monitoring and evaluation strategy that places the community members at the *fulcrum* of societal transformations. Additionally, the theoretical foundations of community development show that communities possess enormous capabilities that can be harnessed for their own welfare. It is also imperative that CDWs should possess the requisite capability to work with complex community structures that present numerous opportunities and pitfalls. This chapter also revealed that it is important to underscore the community development *philosophy* because it impacts various aspects of community work, such as design, implementation, funding, organisation and evaluation.

The process of *PME* of community project has implications for this study in the sense that it provides an impetus for developing innovative systems that make the notion of *participation* attractive to actors. On this basis, it is plausible to argue that the success of intensive participatory planning approaches, such as the MEPPP framework relies *magna ex parte* on the level of commitment exhibited by the PME actors. However, this commitment is not always forthcoming. One viable way of securing this commitment is to provide a compensation mechanism for actors in exchange for PME services within the context of the service economy.

The exploration of *service systems* (basically value-proposition interactions) provides an innovative way to address some of the inherent limitations of the current PME processes by offering a new model for service delivery. In this context, the introduction of the service concept as a value addition process has the potential to create a new paradigm in the process of PME. However, it is vital that the service science researchers tackle the inherent challenges facing the adoption and utilisation of service systems, such as the notions of *service, service system* and *service science,* which still attract some controversy.

The use of the *VBRE principles* as a novel approach for building value-based service systems offers an *economic value* perspective, which is not possible to achieve with the use of TSDMs. The economic value perspective inherent in VBRE has implications for developing an innovative service system for PME in the sense that it supports the discovery of system requirements for developing sustainable service systems for PME. This would help to alleviate some of the intrinsic challenges of the current PME systems by offering opportunities for learning, empowerment, cheaper

PME processes and overall economic sustainability. This idea is explored in chapter three.

This chapter has revealed that *process-oriented approaches* offer better prospects for business process re-engineering compared to the traditional functional approaches. The chapter has also provided an overview of the popular BPMS in the industry with a bias towards open-source systems because they have a burgeoning impact in the software industry. Consequently, this study is keen to exploit the benefits of process-oriented approaches for implementing a service system for PME. These concepts have been discussed in chapter four.

The extant literature has shown that there are intrinsic benefits, challenges and opportunities (BCOs) associated with *MCC* technologies. As a rule of thumb, it is incumbent upon organisations intending to use these technologies to conduct feasibility studies detailing the BCOs before embarking on the processes of system implementation and deployment. Significantly, the vast array of cloud-based applications spanning all spheres of the economy points to a phenomenal growth in the adoption and use of MCC technologies. For this reason, this study seeks to contribute to the growing trend of MCC usage by deploying the PROME service system on a cloud platform. The deployment of the PROME service system is discussed in chapter four.

The rationale for *evaluating* a service system using *goal-oriented* approaches has been explored in this chapter with a view to informing the evaluation of the PROME service system. In this case, two perspectives arose namely, the matter of testing *a "thing" as a bundle of theories* and *evaluation of a "thing" in use*. First, this study sought to dismantle the PROME service system into usability subsets or sub-theories, which are: *ease of use*, *effectiveness*, *usefulness*, *learnability* and *satisfaction* (see section 2.7). Each sub-theory was individually and collectively evaluated using the goal-oriented TAM as a popular model in the technology acceptance literature. Second, the five sub-theories were used to form the criteria for the evaluation of the PROME service system as a "thing" in use. To achieve this, the evaluation process was transformed from a theoretical construct to a practical demonstration of the PROME service system as an artefact in use by conducting an expert-driven survey through a live-user experimentation in the computer laboratory. The details of this evaluation process are discussed in chapter five.

Finally, the concept of *digital resilience* was explored as a mechanism for developing digital literacy amongst actors involved in community development. The development of digital skills is particularly important for exploiting technology-based service systems, such as the PROME service system. Therefore, the concept of digital resilience was explored in the preliminary analysis phase of the study in chapter three. This structured review and interwoven choreography provide the basis for the next chapter.

3 RESEARCH METHODOLOGY

Every actor comes with their own experience, method, methodology
~**Todd Haynes**

This chapter presents the research methodology used in this study. The study employed the VBRE methodology using the redesign model as a viable approach to understanding the current As-Is situation of the PME process in a typical real project experience. Basically, the redesign model by Tan *et al.*, (2011) combines the twin conceptual modelling methods of the *e^3-value* ontology, namely *e^3-value* and *e^3-control* into one conceptual model to understand the operations of the current process as a basis for identifying its weaknesses. The model consists of the following steps that together constitute the research methodology (Tan *et. al*., 2011). (1) preliminary analysis; (2) control problem identification; (3) control mechanism redesign; and (4) evaluation. The preliminary analysis was aided by other exploratory tools to establish a rich understanding of the inherent weaknesses in the current process of PME using the *e^3-value* method. The control problem identification involved a process level analysis using the *e^3-control* method to ascertain how value can be lost by PME actors due to the weak points identified in the previous step. The control mechanism redesign step provided new business processes for PME to curtail the loss of value by actors. Finally, the evaluation stage was a determination of how the suggested changes could impact the process of PME as well as its feasibility using the *e^3-value* ontology. Overall, the *e^3-value* method was used to model value co-creation, exchange and consumption of value objects among a network of actors. These *value objects* possess economic value, such as money, physical goods, services or capabilities (Schuster and Motal, 2009). The *e^3-control* method provided a detailed model of the process, thereby creating a sustainable service system (Tan *et al.,* 2011). The twin modelling methods were chosen because they are formal and user-friendly. In addition, they are one of the most popular ontology-based tools for developing business models by incorporating concepts from requirements engineering and conceptual modelling (Tan *et al.,* 2011; Schuster and Motal, 2009; Huemer *et al*., 2008; Weigand *et al*., 2007). A succinct description of the application of the four steps of the redesign model in this study is presented in the following sections.

3.1 PRELIMINARY ANALYSIS

According to Tan *et al*. (2011), a preliminary value analysis is performed using the e^3-*value* method to understand the current As-Is business model and to identify which value exchanges between actors in a service system are at risk because of inherent *weaknesses* in the current business model. To a considerable extent, this phase involves service *exploration*, which produces possible *scenarios* for the business model from a *strategic* viewpoint. These scenarios are analysed to demonstrate any changes to the business model which are then factored into the design (and alignment) of the system (Tan *et al*., 2011). Additionally, the foundation for this process was laid in section 2.4.3 that presents a complete description of the process of service exploration, including key ***actors***, ***activities*** (exchange of value objects***)*** and ***capabilities*** (digital competence) (Ochieng *et al*., 2017; Adcock *et al.*, 2015; Lopes and Pineda, 2013; Pineda, 2013; Tan *et al*., 2011). Therefore, this section contextualises the three pertinent issues as follows.

1) *Exploring the actors* involved in the process of PME.
2) *Exploring digital resilience* amongst PME actors as a general notion of developing digital competence (capabilities) for PME actors, including a justification for its inclusion.
3) *Exploring exchangeable value objects* for PME using the MEPPP framework to address the shortcomings of the e^3-*value* method and eventually deriving the current As-Is value model of PME.

The three categories of exploration are discussed in more detail as follows.

[redacted] Exploring participatory monitoring and evaluation actors

Based on a review of the extant PME literature, such as Hassenforder *et al*., (2016); Baumann *et al.*, (2015); Guerra-López and Hicks (2015); Kusek and Rist (2004); and Siles (2004), the study identified PME actors to be *project leader*, *project team, community beneficiaries, local partner, government agent, local government* and *project donor*. Consequently, a brief description of roles and responsibilities of the PME actors suffices.

1) The *project leader* is responsible for the overall planning and execution of a project. This includes a wide range of roles, such as defining and communicating project goals and expected project outcomes, defining roles and responsibilities for the project team and other PME actors, developing and operationalising project management processes, nurturing a culture of trust, transparency and accountability, monitoring and evaluating the progress of a project, harmonising the support of all actors and managing project outcomes (Hassenforder *et al*., 2016; Baumann *et al.*, 2015; Fisher, 2011; Anantatmula, 2010).
2) The *project team* is responsible for the implementation of the project strategy. This includes a wide range of roles, such as participating in project team activities, contributing to general project objectives, specific team deliverables and policy matters to the project leader for resolution (Arbon, 2014; Ohland *et al*., 2012).
3) The *community beneficiaries* denote people that a project aims to transform their lives. They play various roles and responsibilities, such as participating in project design, fundraising, providing non-monetary contributions (labour, equipment, endogenous knowledge, interpretation and hospitality), assisting in mobilising community members, providing logistical support and assisting in data collection (Yalegama *et al*., 2016; Ismail *et al*., 2015).
4) The *local partners* or non-profit organisations (NPO) provide various forms of support for a project, such as finance, mobilisation, capacity building, project-specific training, monitoring and evaluation, translation and publishing services, logistical support, liaising with other agencies and technical data collection (Macdonald, 2016; Omofonmwan and Odia, 2009).
5) The *government agency* may play numerous roles and responsibilities, such as encouraging self-reliance projects, producing and disseminating general and technical information, providing standards and regulatory services, constructing social and physical infrastructure, providing project funds, providing consultancy services and entrenching government

activities and strategies (Warner and Sullivan, 2017; Green and Haines, 2015; Pinkerton, 2011).

6) The *local government* provides regulations and administrative support, which include the following: mobilising development resources, sensitising and mobilising communities; enacting and implementing suitable community-oriented policies; facilitating collaborations between sectors and agencies; providing powerful mechanisms for communications and information management; safeguarding community assets (Mey *et al*., 2016; Ibietan, 2010; Mayer and Keyes, 2005).

7) The *project donor* plays the following roles: funding development projects (mostly sectoral), providing information, supporting institutional reforms, building local capacity, providing consultancy services, influencing procurement procedures and pursuing political interests (Rahman and Giessen, 2017).

[redacted] Exploring digital resilience amongst PME actors

To execute the roles and responsibilities highlighted in the previous section, the PME actors need to trade value objects. For instance, the project leader may trade progress reports for increased project funding by project donors. The success of this trade depends on their level of *competence* (alongside other positive attributes of *confidence, connection, character, compassion* and *contribution*) (Sinclair and Larson, 2018; Jones *et al*., 2011; Zarrett and Lerner, 2008). Therefore, the focus of this phase of the exploration was to demonstrate how PME actors could develop digital competence for participating in the process of PME. This can be achieved through a continuous learning process that goes beyond academic competence. As a component of academic competence, continual learning enables individuals to acquire assets in the form of new *opportunities, resources* and *skills,* significantly contributing to *digital resilience* (Van Vliet *et al*., 2017; Zarrett and Lerner, 2008). Digital resilience is a currency for navigating the increasingly digitally-oriented and dynamic societies characterised by pervasive and readily accessible digital technologies (Ferreira and Pantidi, 2018). Consequently, digital resilience represents a new scenario that was explored to *analyse* changes from a PME *strategic* viewpoint (Tan *et al*., 2011).

The concept of digital resilience was explored to analyse the potential changes it could bring to the process of PME using a practical experience of a real-life community project at Kenneth gardens community in Durban City in South Africa in 2014-2015. During this exploration, the concept of digital resilience was examined to provide an innovative understanding of how digital resilience could impact the current process of PME by using emerging technologies to make them more participatory and sustainable within the context of the service economy. Hence, this phase of exploration was divided into the following steps:

1) Overview and suitability of Kenneth gardens community as a study site;
2) Overview of the DAS project as a tool for developing digital resilience;
3) Sample description;
4) Data collection procedure;
5) Data analysis;
6) Summary of preliminary results;
7) Implications of preliminary results on VBRE.

The seven steps were followed to systematically demonstrate how the youths from the community could become digitally resilient by acquiring digital skills through DAS training to provide PME services (Ferreira and Pantidi, 2018). By becoming digitally resilient, the youths could function as change agents (a core characteristic of CDWs) who carry the hopes and aspirations of any community (Augsberger *et al.*, 2017; Schulenkorf, 2010). The six steps have been discussed in more detail as follows.

Overview and suitability of Kenneth gardens community project: the Kenneth gardens community was established by the apartheid government in the 1940s as part of an extensive housing scheme to provide safe, subsidised accommodation for low-income white South Africans (Marks and Erwin, 2011). It currently provides subsidised housing to approximately 1500-1800 individuals who occupy an estimated 282 units in 28 blocks (Community Development Department, 2013). Therefore, the *suitability* of the Kenneth gardens community project as an exploratory case study site was supported by the following factors. First, the Kenneth gardens community remains a marginalised community. It is anticipated that the youths from this community will benefit from such a project. Second, the Kenneth gardens community project was conveniently situated in a community that is easily accessible, both physically and engagement wise. In fact, DUT had been actively involved in community engagement programmes and research within Kenneth gardens for three years prior to the study. Third, the community is home to a sizeable number of youths who constitute 60% of its population. This high population was considered suitable for community-based projects targeting youths as change agents (Augsberger *et al.*, 2017; Lee and Horsley, 2017).

The actor*s* in the case study included the NRF, which provided the funding, project leaders who provided the overall direction, project team consisting of research students from DUT and UKZN who executed project activities, youths from the Kenneth gardens community who were the beneficiaries of the project, the NPO which provided additional material and financial support and local government which provided regulatory and administrative support.

As in other marginalised communities in developing countries, the youth that lives in Kenneth gardens face socioeconomic problems, such as single-parent families, relative poverty and minimal post-school education or training. By all accounts, there are high-levels of substance abuse among these youths, often, but not always, associated with run-ins with law enforcement. Indeed, the youth 'delinquency' problem in Kenneth gardens is as old as the community itself (Erwin, 2015; Community Development Department, 2013) and has become ingrained in the daily existence of the estate, reinforced by poor employment opportunities and virtually no intervention from government agencies regarding health, education or social welfare.

In a bid to tackle some of the intrinsic challenges facing youths in Kenneth gardens community, the DAS project was conceived as part of the wider Kenneth gardens community project that began in 2011. The project also included the Virginia Commonwealth University (VCU)/UKZN global bridges project, the homoeopathic clinic, the Kenneth gardens dance programme, the Capoeira Angola and indigenous music classes and the soccer programme (Community Development Department, 2013). Right from inception, it was clear that the Kenneth gardens community project was biased in favour of the youth considering the fact five out of the six projects initiated in the community were youth-oriented. However, for the sake of convenience and manageability of this study, the DAS project was used as a living project in the explanatory case study conducted in 2014-2015. The DAS project received funding support in the year 2011 from the NRF of South Africa. The NRF funding assisted in providing an enabling environment to conduct training workshops and to generate innocuous domestic local digital contents.

Overview of the DAS project: the *aim* of the DAS project was to develop a ‘place’ and a tool for developing and maintaining a repository of local knowledge and experience generated about and by the Kenneth gardens community. The digital repository was useful for creating a cultural capital for both the present and the future generations of the Kenneth gardens community. The DAS project provided an opportunity for residents of the community to generate local digital contents that translated into civic pride and enhanced collective identity (Community Development Department, 2013; Marks and Erwin, 2011). This was achieved by developing the youths through a series of productive activities, such as writing, editing, analysing and publishing of digital articles, stories, images, audio and video as local community journalists. This was done under the supervision of academic staff and research students drawn from UKZN and DUT.

Sample description: data was collected from the pilot group that took part in the 2014 DAS training workshops, which consisted of 12 youths, including nine females and three males. Three female youths had not completed matriculation qualification (school leaving level), while seven youths (four females and three males) had a matriculation certificate and two female participants had post-school certificates. Seven of the participants were between the ages of 15 and 19, with the remaining five aged between 20 and 24. Thirteen youths participated in the 2015 DAS training, made up of six males and seven females. All the participants were raised in Kenneth Gardens, with an average tenancy of 12 years. Generally, more female than male youths attended the 2014 and 2015 DAS training workshops. It also shows that youths aged 15 to 19 recorded the highest attendance, thus forming the most active segment of the pilot group. Finally, the table shows that, while most of the youths that attended the 2014 workshops had a matric, the majority of those that participated in 2015 did not have a matriculation certificate.

Data collection procedure: the exploratory phase of this study consisted of administering two data collection instruments namely, documentary data sources review and structured interview. The documentary data sources review process considered the existing documents generated during the project lifecycle to provide answers to certain aspects such as project foundation. These documents included Kenneth gardens community project proposal, minutes of project meetings, progress reports, journal articles and annual reports. To make the documentary data sources review process more effective, the study developed a set of guidelines, based on extant literature such as Galvan and Galvan (2017) and Ahmed (2010) to construct the following contents of the data review instrument: (1) title of the document, (2) date of publication of the document (3) author of the document (4) frequency of publication of the document, (5) the intended audience of the document, (6) content of the document, including evidence of background information to the Kenneth gardens community project, evidence of impact of the Kenneth gardens community project, evidence of inherent challenges facing the specific project, evidence of participatory planning and participation by actors, evidence of project monitoring and evaluation and recommendations for improving the effectiveness of the project.

The structured interview instrument consisted of the following questions. (1) What personal challenges are you currently experiencing at the Kenneth Gardens community? (2) Why do you think you are experiencing these challenges? (3) How can you be helped to overcome these challenges? (4) Do you think information communication technology (ICT) can help you overcome some of these challenges? (5) What digital skills did you acquire from the DAS training workshops? (6) Overall, how did the DAS project impact your life at the Kenneth gardens community?

Data analysis: there were two broad categories of data arising from this study namely qualitative and quantitative data. The qualitative data arising from documentary data sources and structured interviews were subjected to content analysis to explore the themes emanating from the textual data and the underlying relationships between them (Hsieh and Shannon, 2005). The process of content analysis followed a pattern of *summative* evaluation as one of the genres of qualitative analysis. This process involved counting and comparing keywords and contextually interpreting them (Vaismoradi *et al*., 2013; Elo and Kyngäs, 2008; Hsieh and Shannon, 2005). The quantitative data arising from the survey instrument was subjected to statistical analysis, especially measures of central tendencies such as mean and measures of variability such as standard deviation.

Summary of preliminary results: the acquisition of digital skills was viewed as a foundation for the development of digital resilience among the youths. As reported by Ochieng' *et al*. (2017), the use of the DAS proved to have a significant potential to promote digital resilience in the Kenneth gardens community. The construct of digital resilience was viewed as the process of creating well-being and positive development through lifelong learning. The overarching aim was to overcome intrinsic challenges in the marginalised Kenneth gardens community and proactively adapt to constant change by building capacity and accessing resources (Ochieng' *et al*.,2017; Moreno *et al*., 2017). Specifically, the DAS training explored the digital resilience dimensions of *latitude* and *resistance*. The dimension of *latitude* was deemed as a set of the knowledge, skills and attitudes acquired from DAS training to fill a void in digital skills, while the dimension of *resistance* assumed that if the youth liked the DAS intervention, one would easily overcome *resistance* to the acquisition of digital skills (Ochieng' *et al*., 2017).

Implications of preliminary results on VBRE: despite the DAS training making a positive impact in developing digital resilience among the youths, the exploratory case study of the DAS project revealed that there are several intrinsic challenges facing the project with respect to digital resilience. Subsequently, these revelations informed the digital component PROME service system. The results obtained from this exploration were published in Ochieng' *et al*. (2017).

[redacted] Exploring exchangeable value objects for PME

It was necessary to undertake an in-depth exploration of tradable value objects in PME to ascertain their intrinsic characteristics (Magalhães, 2014). However, the e^3*-value* method has been faulted for *lacking essentials attributes to capture additional information about actors or value objects that it seeks to model* (Rasiwasia, 2013). For this reason, this study has incorporated the MEPPP framework (Hassenforder *et al*., 2016b) in this preliminary phase to provide an in-depth *exploration* of the exchangeable value objects and provide a solid foundation for deriving the current As-Is PME situation, which would then form the basis for the proposed To-Be PME situation.

Although many PME frameworks exist in the literature, such as social mapping (Moliner *et al*., 2017), participatory model building (PMB) (Butler *et al*., 2015), participatory framework for assessment and improvement of tools (Smith *et al*., 2017) and process tracing (Bennett and Checkel, 2014), the MEPPP framework was chosen as a participatory planning tool for its *comprehensiveness*, *currency* and *potency* as a participatory planning tool (Hassenforder *et al*., 2016b). The MEPPP framework consists of the following six phases that that have contributed to the realisation of the value objects for the process of PME (Hassenforder *et al*., 2016a; Hassenforder *et al*., 2016b; Rossignoli *et al*., 2015; Williams, 2015; Shepherd *et al.*, 2011; Tan *et al*., 2011)

1) *Case description of context, process and outcome.* The important outcomes of this phase are three value objects, which are **descriptive variables of context,** such as system elements; **descriptive variables of process,** such as process objectives; and **descriptive variables of output/outcome,** such as main output and impact on participants. In line with the *principle of reciprocity*, each value object has a feedback loop that allows the project team, community beneficiaries and local partner to communicate their feedback on descriptive variables.
2) *Establishment of the PME viewpoints and objectives*. This phase yielded two distinct value objects. The **description of PME viewpoints** that answered the questions about *who*, *what* and *why* regarding the PME process. The **description of the PME objectives** based on literature review and consensus built amongst actors. The two value objects provided a framework for data collection. To complete this value exchange process, a feedback loop was considered that would allow the project team, the community beneficiaries and the local partner to communicate their feedback on PME viewpoints and objectives.
3) *Identification of the analytical variables*. This phase produced three value objects. The definitive list of **analytical variables for output/outcome** to be monitored and evaluated. A list of **analytical variables in a context** drawn by analysing the contextual elements that may affect the PME. The definitive list of **analytical process variables** drawn from the literature.

4) *Development of the PME methods.* This phase produced **PME data collection instruments** to appraise the descriptive and analytical variables described in phase two and phase three respectively. In addition, this phase produced **PME data** (feedback loop).

5) *Analysis of PME data collected.* This phase yielded patterns, trends, clusters and narratives of diverse types of PME variables. These results are significant in assessing project performance against plans and targets, forming conclusions, resolving problems as well as identifying solutions and best practices for decision-making and organisational learning.

6) *Dissemination of PME results*. This phase involved dissemination of results in the PME process through **journal articles, seminars** and **annual reports**, **posters, presentations, policy briefs** and **scientific publications**.

The *e^3-value* methodology was applied to the identified value objects that are tradable items exchanged by the PME actors. The process of PME commences when the project leader initiates the **start stimulus**, which sets in motion the process of value exchange. Once the start stimulus is triggered, a chain of value exchange events occurs throughout the process. In this model, the project leader is responsible for creating the following value objects: descriptive CPO, PME viewpoints and objectives, analytical variables, PME data collection instruments, collecting data and mechanisms for disseminating PME results. These value objects formed the basis for the following six scenarios of value exchange: project leader and project team; project leader and local partner; project leader and local government; project leader and project donor; project leader and government agent; and project team and community beneficiaries.

The project leader offers the descriptive CPO (P1), PME viewpoints and objectives (P2), analytical CPO (P3), data collection instrument (P4), PME results (P5) and strategic and annual reports (P6) in the project leader and project team scenario (P1, P2, P3, P4, P5 and P6 denote the respective phases of the MEPPP framework). The project team then offers feedback on CPO (P1), feedback on viewpoints and objectives (P2), feedback on analytical CPO (P3), PME data (P4), feedback on PME results (P5) and feedback on strategic and annual reports (P6) respectively. In the project leader and local partner scenario, the project leader trades descriptive CPO

(P1), PME viewpoints and objectives (P2), analytical CPO (P3) and strategic and annual reports (P6) for feedback on CPO (P1), feedback on viewpoints and objectives (P2), feedback on analytical CPO (P3), feedback on strategic and annual reports (P6) respectively. Likewise, the project leader trades external progress report (P6) for feedback on external reports (P6) in the project leader and local government scenario. Similarly, the project leader trades donor report (P6) for feedback on donor reports (P6) in the project leader and project donor scenario of value exchange. In the project leader and government agent scenario, the project leader exchanges external progress report (P6) and donor report (P6) with feedback on external reports (P6) and feedback on donor reports (P6) respectively. Finally, in the project team and community beneficiary scenario, the project team exchanges data collection instrument (P4) and annual report (P6) for PME data and feedback on annual report (P6) respectively. Figure 3.1 depicts this current As-Is situation.

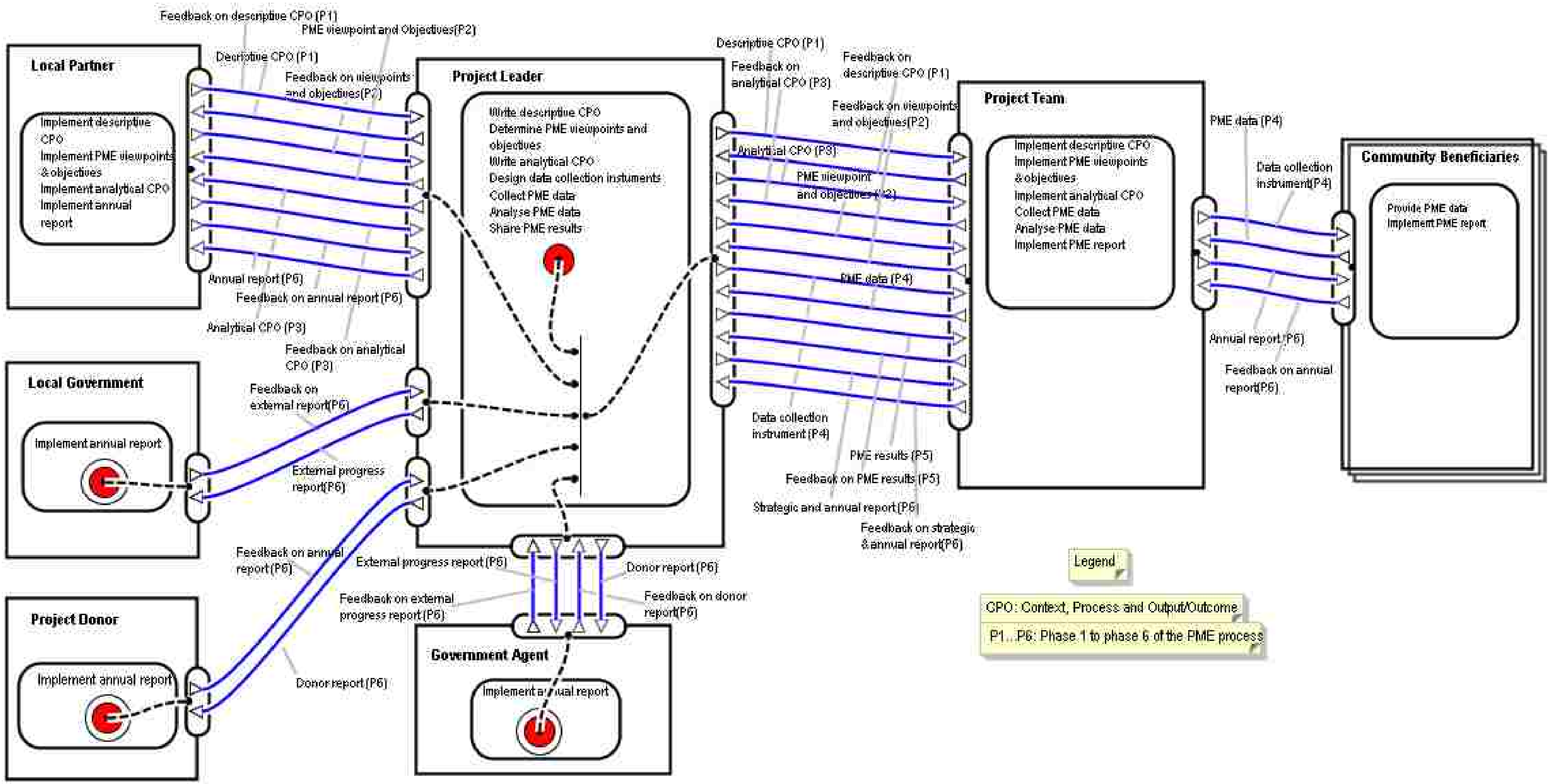

FIGURE 3.1: THE CURRENT AS-IS E^3-*VALUE* MODEL OF PME

3.2 CONTROL PROBLEM IDENTIFICATION

The second step of the redesign model is the process level analysis of weak points identified in section 3.1 to facilitate an understanding of how value can be lost by actors (Tan *et al.,* 2011). To depict this situation, a process level analysis was undertaken using the *e^3- control* tool. According to Tan *et al.,* (2011), the process-level analysis of PME process is necessary for sustainable value co-creation among actors. Therefore, this study examined the PME process with a view to identifying problems associated with value co-creation that could encumber its effectiveness and sustainability. Based on the *e^3-control* terminology (Liu *et al*., 2008), this study has annotated the process model of the current As-Is situation for the PME process as follows.

1) *Responsible actor* tackles the operational activity to be controlled, for instance, **project team, community beneficiary** and **a local partner.**
2) *Evidencing actor* witnesses the execution of the operational activity together with the activity's completeness, accuracy and adherence to organisational policies and rules. The evidencing actor is usually a delegate of the *control* actor and the **project leader** belongs to this category**.**
3) *Control actor* checks the operational activity executed by the responsible actor, for example, **project donor, local government** and **government agent**.
4) *Operational activity* is an activity undertaken during the process of PME to achieve a certain value or goal.
5) *Evidencing activity* serves as proof that the execution of the operational activity is complete, accurate and adheres to organisational policies and rules.
6) *Control activity* verifies and reconciles records, documents, or messages sent from the responsible actor and evidencing actor.
7) *To-be-verified document* is issued by the responsible actor as proof of the completion of the operational activity.

8) *Supporting document* is issued by the evidencing actor to support the control actor's executing a control activity.

9) *The verified document* is issued by the control actor after reconciling the To-be-verified document and supporting documents, to aid in drawing a conclusion of an effective control.

Basically, a supporting document exists for every operational activity in the current As-Is situation for PME. This support is depicted by an arrow that points to the specific operational activity in consideration. Thus, the supporting document sanctions the transformation of an operational activity to produce a To-be-verified document. This To-be-verified document is scrutinised by the control actor to produce a verified document. This constellation is presented in Figure 3.2.

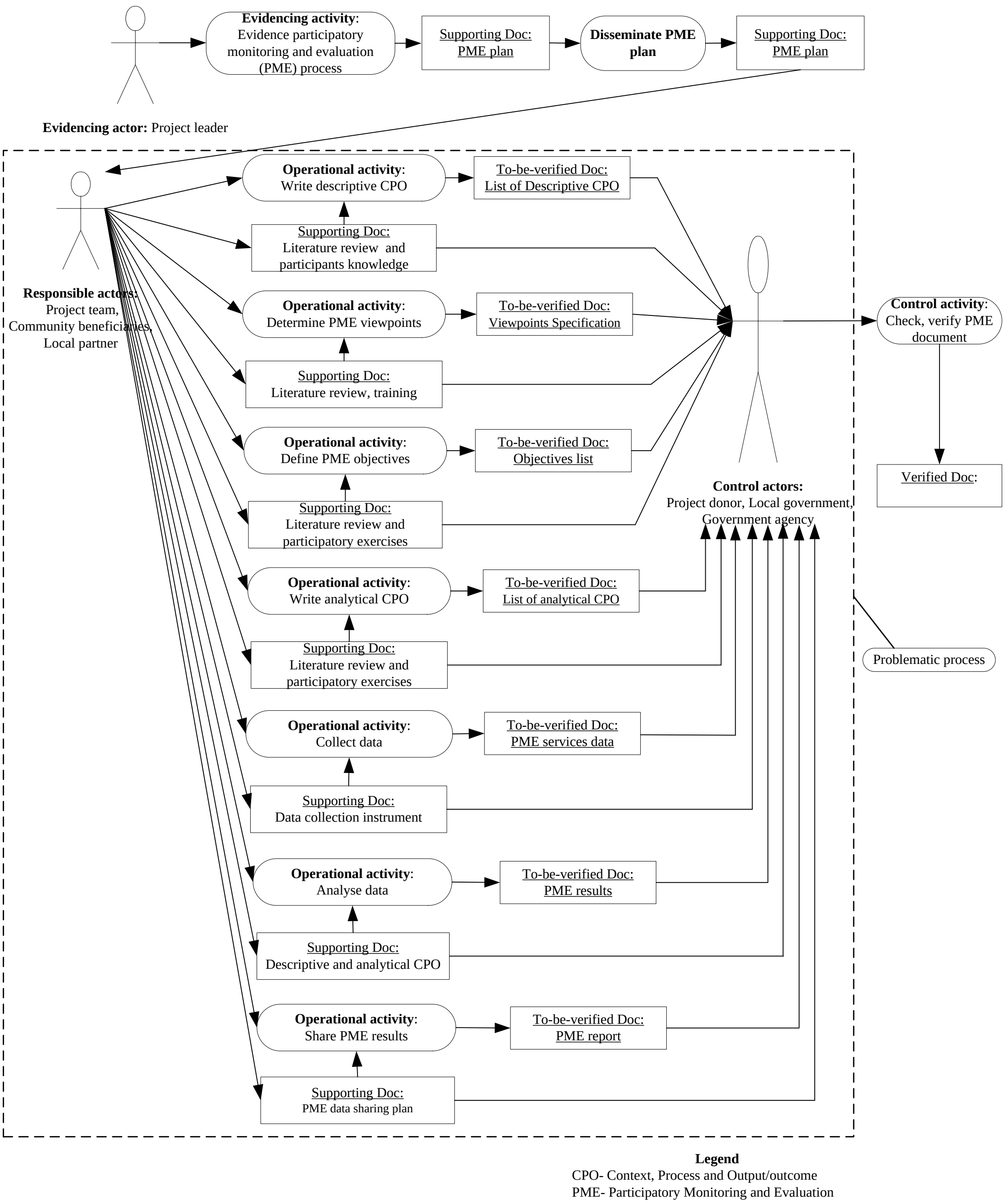

FIGURE 3.2: PROCESS MODEL OF THE CURRENT AS-IS SITUATION FOR PME

In summary, Figure 3.2 shows that the current As-Is PME process experiences the following weaknesses that may invariably lead to loss of value. First, the current As-Is PME process experiences heavy documentation in terms of input, processing, output and storage of value objects, such as PME plans, descriptive context, process and outcome/output (CPO), analytical CPO, data collection instruments and PME reports (refer to the dotted rectangle in Figure 3.2). This inherent anomaly is likely to lead to loss of value in diverse ways, such as difficulties in generating reports, difficulties in querying, expensive and time-consuming PME process, loss of PME data, duplication of data, poor storage of PME data, limited sharing and accessibility of PME data. Second, the current As-Is situation for PME framework is not service-oriented, which means that it significantly lacks a service system approach to transacting the process of PME. This presented an opportunity for developing an innovative *e^3-value* ontology-based service system for improving the process of PME using emerging technologies, such as mobile cloud services to deliver resources over cloud infrastructures as opposed to hosting and operating these computing resources locally. The intrinsic benefits of using mobile cloud services include a reduction in costs, flexibility, better data storage, including backup and recovery, scalability, agility, mobility and greater technological innovation (Aceto *et al.*, 2013; Gupta and Gupta, 2012). The overriding principle should be to optimise the use of computing resources, thereby making the process cost-effective, valuable and sustainable. Third, the current As-Is situation of the PME process lacks a mechanism for generating revenue for PME actors. The process of generating revenue is particularly significant for creating a sustainable PME process within the context of the service economy. In view of these weaknesses, creative innovation to improve the process of PME was explored in the next section.

3.3 CONTROL MECHANISM REDESIGN

The third step in process analysis is the development of control mechanisms, resulting in revised business processes (Tan *et al.*, 2011). The PME activities were conceptualised as a set of services that execute during the process together with the accompanying evidence of the transaction. The information generated from this PME process is stored in the PROME service system database and made available for business purposes. Specifically, the study shows how the introduction of the PROME service system would offer a flexible way to store all evidence of the PME process in a PROME database leading to more control. Additionally, the use of the PROME service system would lessen the burden of heavy documentation thus making the process more efficient. Figure 3.3 presents this innovation, showing the process model of the service based To-Be PME situation.

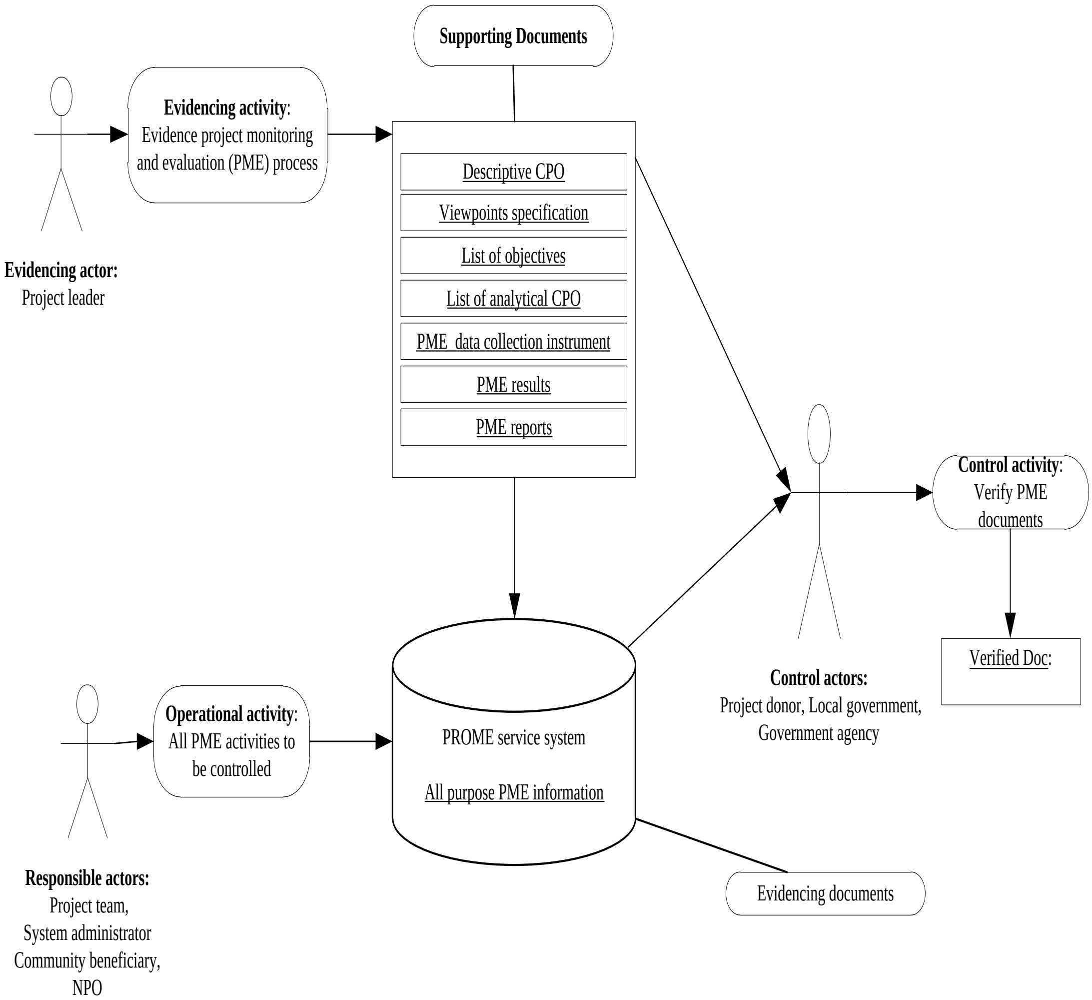

FIGURE 3.3: PROCESS MODEL OF THE SERVICE-BASED TO-BE PME SITUATION

3.4 PROCESS AND CONTROL MECHANISM EVALUATION

In step 4, a *final value analysis* is done and analysed to determine how the suggested *changes* influence the business model, which is then evaluated to establish whether the new business model is *feasible* for the actors involved (Tan *et al*., 2011). This final value analysis constitutes the *e^3-value* To-Be PME model, which is depicted in Figure 3.4. This study proposes the development of an innovative service system for PME through which actors would interact to provide PME services. The service system consists of three layers, which are PROME client (universal interface), PROME application (functional module) and PROME database (data store). The use of a three-tier mobile cloud application is expected to provide various business advantages, such as scalability, flexibility, security, ubiquity, modularity and cost-effectiveness (Fatema *et al*., 2014; Aceto *et al*., 2013). Therefore, the innovative service system introduces the following*:*

1) A new actor called system administrator to handle system and administrative processes involving installation, operation and maintenance of the service system.
2) An authentication mechanism to be administered by the system administrator as a means for safeguarding system resources from unauthorised access.
3) A mechanism for capturing important project information, such as descriptive CPO, description of viewpoints and PME objectives, analytical CPO, PME data and PME reports. This will significantly lessen the burden of heavy documentation challenges currently experienced in PME process through a centralised data storage mechanism.
4) Mechanisms for PME actors to provide various PME services via a mobile client interface, make claims for payment for PME services rendered, analyse data stored in the cloud database, generate and access reports. The study proposes diverse types of reports according to the varying needs of actors.

Based on the four innovations presented above and the *e^3-value* method, the study proposed an architecture for **PRO**ject **M**onitoring and **E**valuation (PROME), which is a service system through which actors conduct the process of PME via value exchange ports. The value exchange ports are joined using the AND fork/join via the **PROME client**. The AND fork/join shows that **ALL** the dependency segments (dotted lines) that link the value exchange ports (corresponding to each actor) feed into the **PROME** service system through the **PROME client**. The proposed To-Be PME process based on the discussed narrative is presented in Figure 3.4.

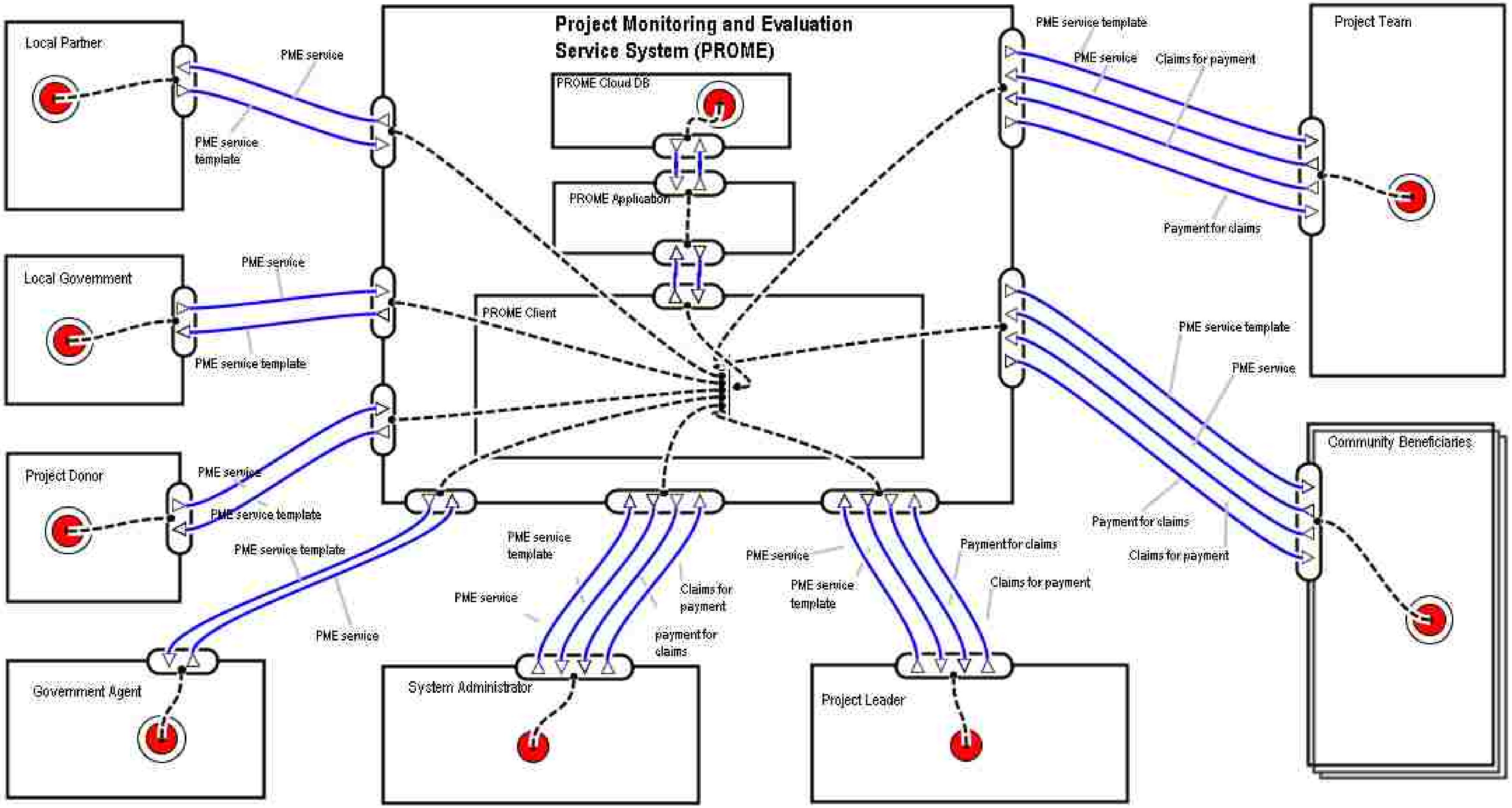

FIGURE 3.4: THE E3-VALUE TO-BE MODEL FOR PME AS A SERVICE

This study has investigated the *feasibility* of the proposed To-Be PME model in Figure 3.4 by describing how the envisaged sustainable value co-creation and exchange shall be realised. Basically, the PROME application tier provides services to the PROME client tier by receiving, interpreting and relaying appropriate responses to service demands. The PROME application tier analyses the data captured during the provisioning of services by various PME actors. This analysis is based on trends, patterns, relationships and summaries of various categories of qualitative and quantitative data captured in the system during service provisioning. The PROME application tier then writes this data to the PROME cloud database tier. This flow of the business transaction espouses the principle of *economic reciprocity* whereby an actor offers something of value to another actor and demands compensation that is commensurate with the exchanged value (Tan *et al*., 2011). The infusion of this service concept into the business logic of the PROME service system is a novelty.

To orchestrate the flow and exchange of value objects in the PROME system, two *start stimuli* have been proposed. According to Tan *et al*., (2011), a stimulus represents the needs of an actor. The first start stimulus**,** which originates from the system administrator, consists of various PME services provided by the system administrator as part of "housekeeping" routine for the *upkeep, configuration* and *reliability* of the system. These services include system *installation and management of user accounts*, *contract*, *service level agreements* and *system performance*. In return, the system administrator receives PROME service system reports, such as *PME actor accounts*, *system performance* and *service level reports*. In addition, the model proposes compensation for services rendered in the form of rewards, money or certificate.

The second start stimulus originates from the project leader and it is directly concerned with the process of PME. This stimulus signals the start of the PME process by describing the need for PME based on policy and practice. Significantly, the task of the project leader is to supervise the entire process of PME, including the preparation of *service provision templates***,** such as PME data collection instruments. The service provision templates constitute value objects that the project leader uploads onto the system for use by other actors, to provide a standardised procedure and format for service delivery. In exchange for the templates, the project leader receives value objects, such as PME data.

The community beneficiaries also offer services to other actors through the PROME client. Based on the objectives of the PME process, the community members play a leading role in providing crucial *data for project design, implementation* and *evaluation*. These data constitute important value objects that contribute to the fulfilment of the objectives of the PME process. As such, community beneficiaries should receive some form of compensation, such as *group rewards*, *money* or *certificate of recognition* for service provision. The task of the project team is to implement the project and serve as an intermediary between the other actors and community beneficiaries. This dual role is important because community beneficiaries may find certain aspects of the project difficult to understand.

It is necessary to capture, process, store and report information about the service provisioning processes described in the preceding paragraphs. As such, a proposal was made for diverse types of reports according to needs of actors. According to the International Federation of Red Cross and Red Crescent Societies (IFRC) (2011) and Siles (2004), there are at least seven types of reports that the PROME service system should produce. First, the community beneficiary requires an annual report showing a comprehensive account of the project services, successes and challenges during the year. Second, the project team requires a monthly strategic report to guide the process of project implementation. Third, the local partners require an annual report based on suitable analytical parameters. Fourth, the local government requires an external progress report based on suitable analytical parameters for accountability, understanding and support. Fifth, the project donor requires a progress report based on analytical variables for accountability to the stated PME objectives. Sixth, the government agency needs a donor or an external progress report for accountability, understanding, promotion and support. Seventh, the project manager needs monthly progress report for decision-making purposes. Lastly, the study proposes a mechanism for generating data on the profitability of the PME process based on value interface, value transaction, occurrence, valuation, value and total profit for each PME actor. As postulated by Tan *et al.* (2011), the study intends to present this profitability data as a spreadsheet tool that can allow the user to load the data, alter financial parameters and permit further processing of the financial outcomes of the PME process.

3.5 IMPLICATIONS OF THE PROPOSED PME MODEL

The application of the VBRE methodology to model the process of PME has implications for the development of a service system for improving the process of PME by introducing an economic perspective to the process. This presents a new paradigm in the process of PME and is bound to transform the process from a conventional "brick and mortar" system to a service-oriented dispensation in which the actors exchange value objects on reciprocal terms. This economic perspective has been aptly captured by the *e^3-value* method while the process level analysis has been pertinently captured by the *e^3-control* method. The combination of the two methods has created a potent model for transforming the process of PME into a value-driven business model capable of generating revenue for the PME actors.

The preliminary analysis step was enriched by the inclusion of the notion of digital resilience and the MEPPP framework. First, the inclusion of the MEPPP framework has widened the scope of exploration by capturing significant details to discover the exchangeable value objects in the process of PME. This has effectively addressed the inherent limitations of the preliminary step of the redesign model. Second, the inclusion of the notion of digital resilience has the potential to improve the robustness of the proposed PME model by ensuring that PME actors possess the digital competence to use digital technologies. The infusion of digital resilience can also contribute to the sustainability of the proposed PME model by equipping actors with digital skills to competently provide PME services.

The control problem identification step involved a process level analysis using the *e^3-control* method that was crucial to understanding how value can be lost by actors. This has implications for this study, for example, it was revealed that conventional PME systems do not support a service-oriented approach to implementation, thus denying the actors the opportunity to generate revenue. In some cases, such as marginalised communities that experience poor infrastructure and low access to digital technologies, the risks associated with poor project documentation may include redundancies, time consuming processes, poor storage capacity of PME data or lack of portability of systems and records (Falco and Kleinhans, 2018; Karim *et al*., 2017). These risks may lead to loss of value by PME actors.

The control mechanism redesign step provided new business processes for the process of PME to curtail the loss of value by actors. This was achieved through the introduction of innovative ICT concepts to streamline the process of PME (Tan *et al*., 2011). This has implications for PME actors in terms of digital competence, cost, availability, reliability and maintainability.

Finally, the evaluation step was useful for depicting changes, opportunities and a preliminary feasibility of the proposed To-Be PME model using the *e^3-value* methodology. The proposed To-Be PME model depicts reciprocal exchange of value objects via the PROME service system. The implication of this ICT-driven innovation is that it has a *strategic business* significance in the process of PME by shaping the outcomes (Govender and Pretorius, 2015). According to Tan *et al*. (2011), the *business strategy* and *ICT* perspective play significant roles in the adoption of ICT-driven innovations because actors demand ICT-driven innovations in a service system to enhance processes from a business perspective.

3.6 CONCLUSION

This chapter has discussed the application of the VBRE methodology using the redesign model to understand both the value and process aspects of the process of PME. The preliminary analysis step consisted of a multi-pronged approach to the exploration of actors, digital resilience and tradable value objects in a bid to understand the current As-Is *e^3-value* model for PME and ultimately inform the subsequent steps of the redesign model. This led to the second stage of the redesign model: the control problem identification using the *e^3-control* method that yielded the As-Is *e^3-control* model. This step yielded a process level analysis of weak points identified in step one that would hinder the realisation of a sustainable value co-creation process amongst PME actors. Subsequently, these weak points informed the control problem redesign process (step 3) that involved the development of corrective measures to yield the To-Be process model for PME. Finally, an evaluation of the new process and control mechanisms were conducted by deriving the *e^3-value* To-Be model for PME as shown in Figure 3.4. The components of the proposed To-Be model for PME were used as the basis for requirements specification and development of the PROME service system in chapter four.

4 DEVELOPMENT OF PROME SERVICE SYSTEM

First, solve the problem. Then, write the code. ~**John Johnson**

This chapter discusses the development of PROME service system as proof of concept. This development is premised on the proposed To-Be PME model that has been presented in section 3.4. The study decomposed the proposed To-Be PME model into six components according to goal-oriented approaches (Hilts and Yu, 2012; Teruel *et al*., 2011). The first component is *digital resilience***,** which has been described as an enabling capacity for PME actors to effectively navigate the landscape of ICT-driven solutions aimed at improving the PME process (see Ochieng' *et al*., 2017). The second component is *process documentation***.** In this case, the proposed To-Be PME model envisages a leaner documentation for the process of PME (see Figure 3.4). The third component is the *service-based re-engineering* of the PME process**.** The study has conceptualised the process of PME as a set of services whereby one actor can offer an item of value to another actor in exchange for a commensurate consideration (Tan *et al*., 2011). The fourth component explores *economic sustainability* within the context of a service economy, based on the principle of *economic reciprocity* as depicted by the value exchange ports in Figure 3.4 (Tan *et al*., 2011). The fifth component describes the concept of *value co-creation* to achieve mutually beneficial interactions amongst PME actors as presented in the proposed To-Be PME model (Tan *et al.*, 2011). Lastly, the sixth component is the *process-oriented* approach to the development of PROME service system.

The six components highlighted above were used as the foundation for the specification of PROME service system in section 4.1. Subsequently, the process-oriented implementation of the PROME service system is presented in section 4.2. Next, section 4.3 presents the deployment of the PROME service system on the cloud platform. This is followed by a discussion of the implications of the development of the PROME service system in section 4.4. Finally, a conclusion of this chapter is presented in section 4.5.

4.1 SPECIFICATION OF PROME SERVICE SYSTEM

The specification of the PME service system consisted of a process specification to depict the PME processes using workflow diagrams and a data specification.

[redacted] Process specification

This section discusses the process-based requirements specification for PME. The premise for this specification is established in section 2.4, which shows that a business *process* is a hierarchy of *activities* (Bicevskis and Bicevska, 2015). Based on this assertion, there is a justification for specifying the PME phenomenon as a set of business processes meant to achieve certain operational goals upon execution. These PME processes consist of inputs, outputs and actors who participate in their execution (Damij and Damij, 2013; de la Vara González, 2011). Thus, the processes of the PROME service system have been specified as follows.

a) Component 1: A process for developing digital resilience

In this context, developing digital resilience should be interpreted as a process of creating the well-being and positive development amongst PME actors through lifelong acquisition of ICT skills. As demonstrated in one part of this study by Ochieng' *et al*., (2017), it is feasible to contemplate the acquisition of digital skills as a foundation for developing digital resilience amongst PME actors. The digitally resilient PME actors are expected to provide project monitoring and evaluation services. Some of the major ways through which PME actors can develop digital resilience include the following (Corner, 2017; Rako *et al*., 2016; Olugbara *et al*., 2014; Matzat and Sadowski, 2012; Viswanathan, 2012).

i) *Self-learning* whereby PME actors develop a mindset for self-erudition to acquire digital skills by themselves, without the input of ICT trainers. This usually goes beyond normal school learning. This approach may be aided by online courses that seek to enhance individual digital skills.

ii) *Peer to peer learning* involves actors learning by interacting with one another. This process of acquiring ICT skills is a demonstration of selforganisation. The process is spontaneous and does not require any external support.

iii) *Formal ICT curriculum* may favour school going PME actors who may benefit from institutional ICT resources to acquire digital skills that may improve their digital competence.

iv) *ICT lectures, tutorials and seminars (webinars)* allow PME actors to enrol for formal lessons in which lecturers present digital skills content to them; engage in tutorials that are less formal than a lecture, or they may opt for seminars that comprise lectures and tutorials.

v) *ICT training* can be offered to PME actors who have the willingness and capacity to navigate the digital landscape and occupy prominent digital roles, such as the administration of the service system. One notable example of ICT training for PME actors is the e-skills training programme for CDWs in South Africa that seeks to improve the capability of CDWs to effectively use digital systems in a knowledge economy and information society.

vi) *ICT conferences* can be useful fora for PME actors to share their ideas in diverse areas of ICT. They can also offer a chance to get inspiration from eminent personalities in ICT.

b) Component 2: An efficient project documentation process

The second component is concerned with creating an efficient project documentation process to improve the documentation process on at least four key aspects, which are *actor registration, project registration, project monitoring* and *project evaluation*. The *actor registration* process should capture the requisite credentials such as actor name, e-mail address, password and category. It is a one-time process for a new actor and can be categorised as a support process of a high priority. It is used as proof of identity by the system during login to accord an actor the necessary privilege to conduct business on the system by creating a new account, changing actor property, disabling and deleting an account Figure 4.1 shows the workflow for actor registration.

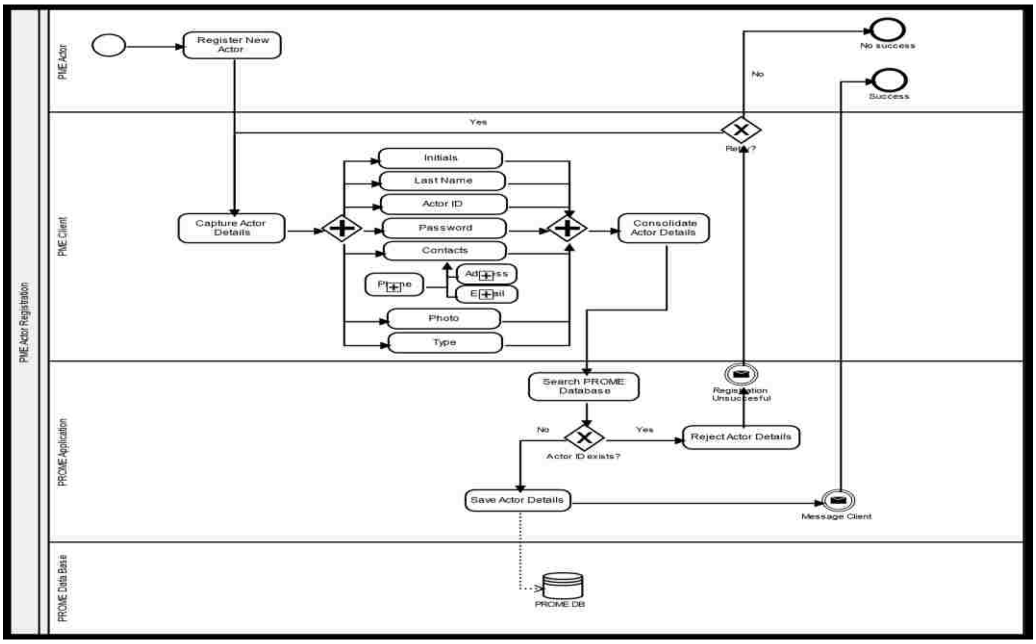

FIGURE 4.1: WORKFLOW FOR ACTOR REGISTRATION PROCESS

The *project registration process* should capture project details and support subsequent manipulation of these details. This should be a one-time process for a new project and should be categorised as a core process of higher priority. Figure 4.2 is a representation of the workflow for this process.

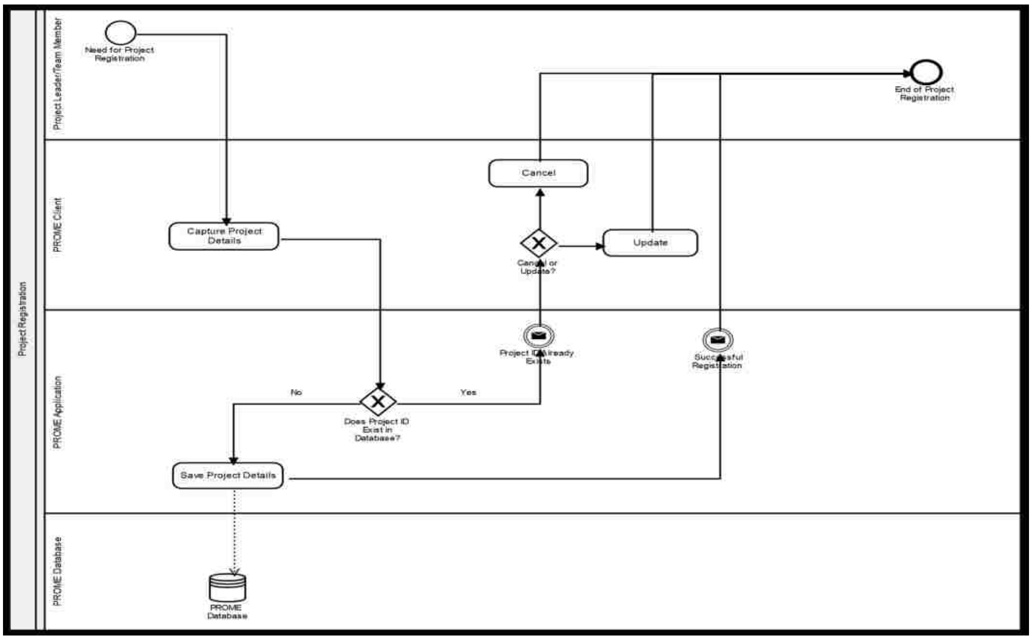

FIGURE 4.2: WORKFLOW FOR PROJECT REGISTRATION

Once the basic project data has been captured, the PROME service system should provide a mechanism for capturing the *descriptive variables* associated with a project. This data consists of the descriptive variable's identity, name and comment. Figure 4.3 depicts the workflow for this process.

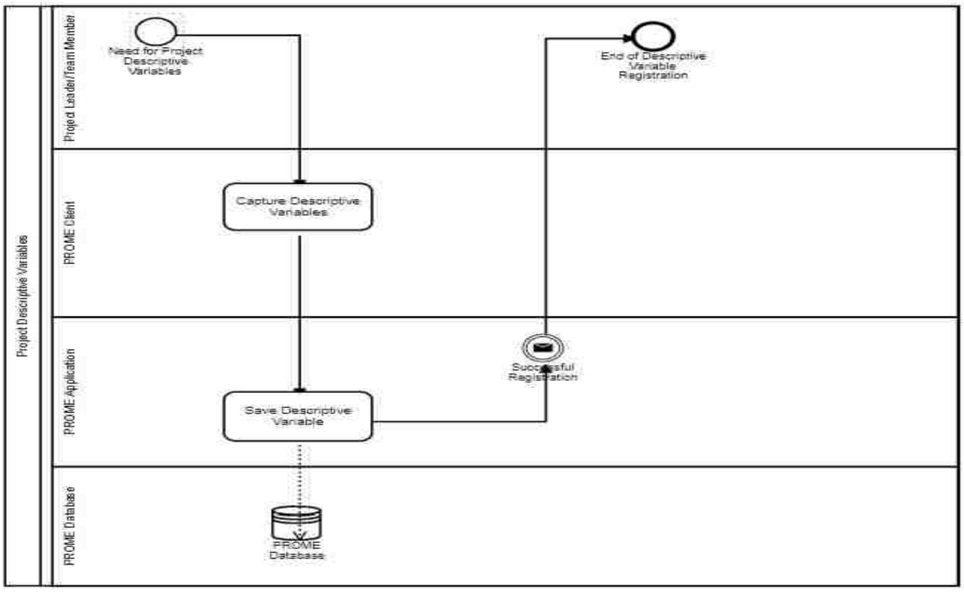

FIGURE 4.3: WORKFLOW FOR DESCRIPTIVE VARIABLES

Additionally, the PROME service system should provide a mechanism for capturing the *analytical variables* associated with a project. This data consists of the analytical variable's identity, name and comment. Figure 4.4 depicts the workflow for this process.

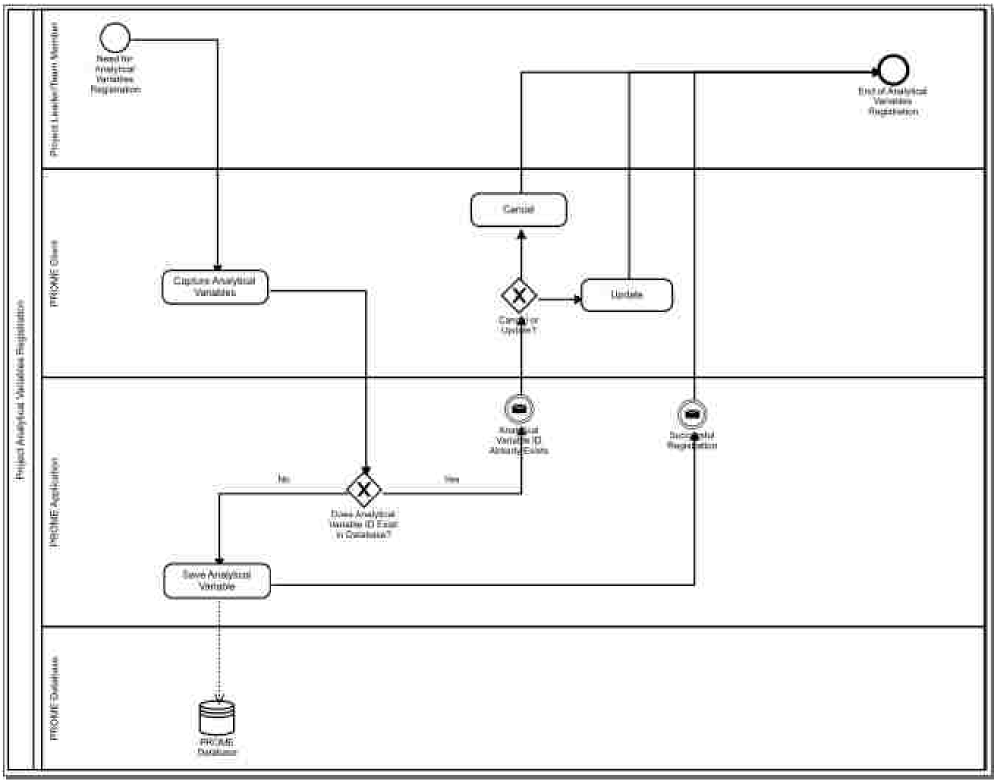

FIGURE 4.4 WORKFLOW FOR ANALYTICAL VARIABLES

Further, the PROME system should have a mechanism for *viewing* or *modifying* the data capture above. This involves retrieving project data from the PROME database using the project identity and updating or deleting certain data. Figure 4.5 depicts the workflow for viewing or modifying project data.

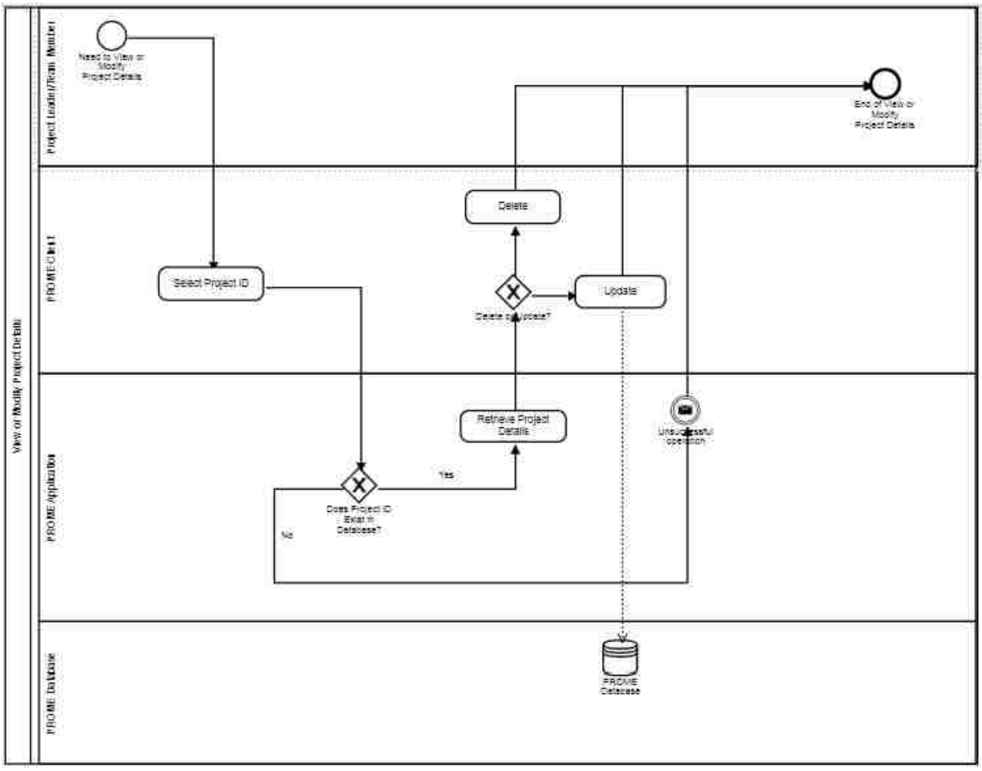

FIGURE 4.5: WORKFLOW FOR VIEWING OR MODIFYING PROJECT DATA

The *project monitoring process* should capture project performance data provided by the PME actors involved in the project, especially performance data obtained from the community members. This should be a monthly process and should be a core process of high priority. The process of project monitoring should be activated by a monthly timer control that alerts the project leader to send out a message via e-mail, seeking project monitoring data from community members who are the beneficiaries of the project. Typically, this e-mail should be an online survey consisting of descriptive and analytical variables. In return, the project manager should receive responses from the beneficiaries showing scores for each analytical variable. The decision to adopt a response rate of 70%, which is considered "very good", was pegged on previous studies, such as Nulty, (2008). If this threshold is not met, the system should generate a reminder to seek more responses from community beneficiaries. Otherwise, the project monitoring data are stored in the database and the process is terminated. This workflow is illustrated in Figure 4.6.

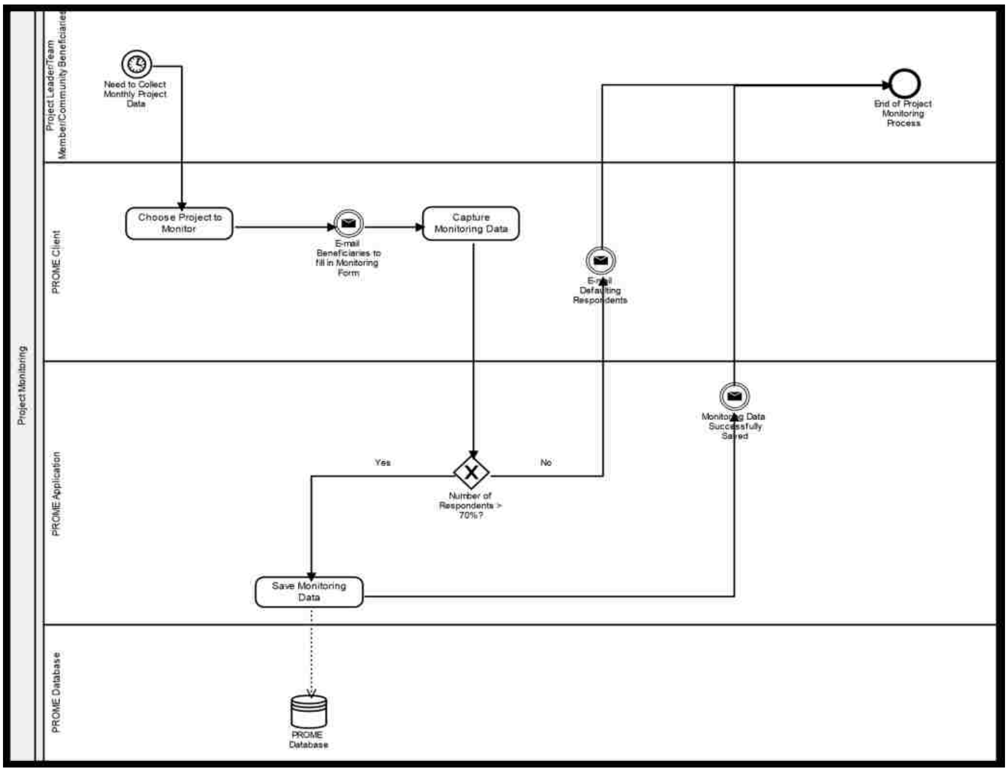

FIGURE 4.6: WORKFLOW FOR PROJECT MONITORING

The *project evaluation* process should enable a project evaluator to undertake a systematic and objective assessment of the performance of an ongoing or completed project by considering the level of attainment of project objectives, development effectiveness, efficiency, impact and sustainability (Van Beers and Rowe, 2017; McCabe *et al*., 2016). In this case, a bi-annual timer should trigger this process to manipulate the project monitoring data that has already been captured in the system. Theoretically, the project evaluator should select a set of five evaluation criteria to gauge the performance of a project. The size of this set of criteria may vary depending on the project specifics. Figure 4.7 shows the workflow for this process.

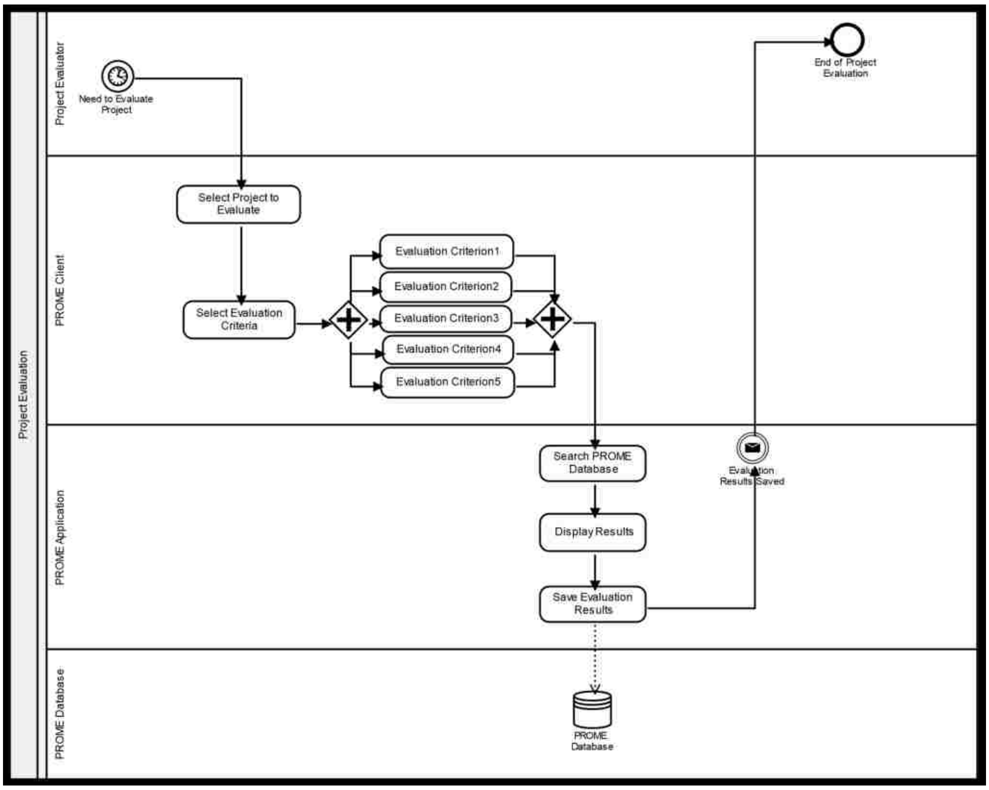

FIGURE 4.7: WORKFLOW FOR PROJECT EVALUATION

c) Component 3: Service re-engineering of the PME process

The PROME service system should support mechanisms for *service provider registration*, *service registration* and *service provisioning*. The *service provider registration process* should capture the attributes of service providers, such as banking data, tax data, indemnity data, billing cycle, extraneous charges and compliance with financial regulations authority. This is a one-time process and should be categorised as a core process of higher priority. However, it is important to highlight that all service providers are actors but not all actors are service providers. Figure 4.8 shows the workflow for this process.

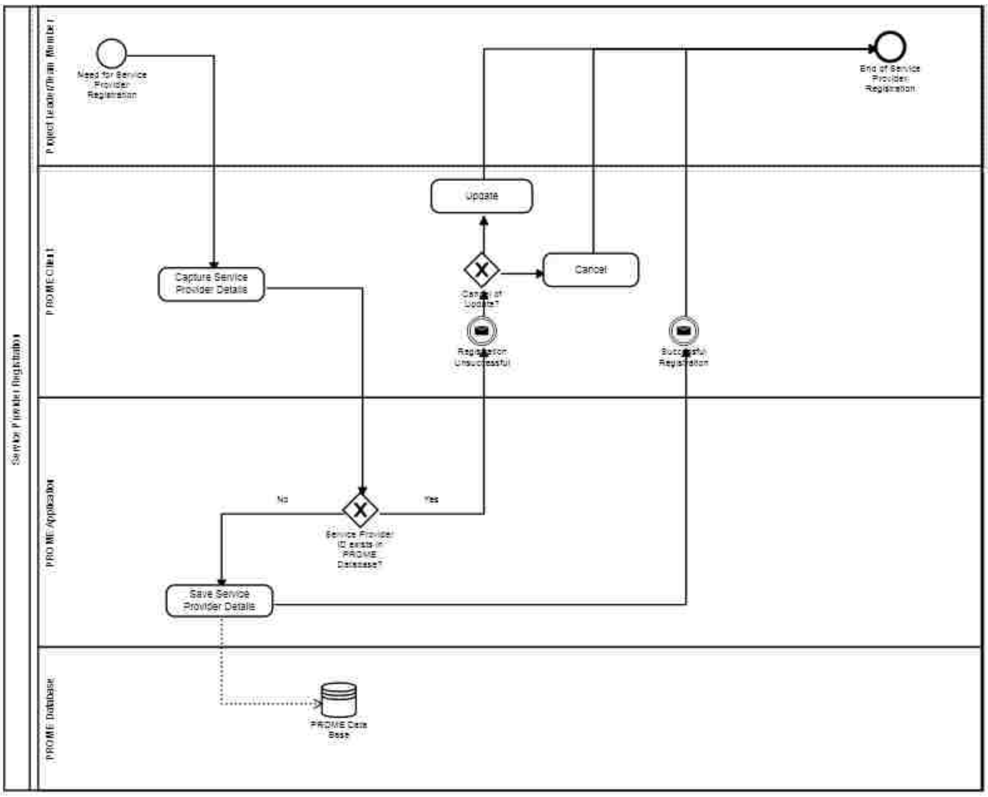

FIGURE 4.8 WORKFLOW FOR SERVICE PROVIDER REGISTRATION PROCESS

Additionally, the PROME system should have a mechanism for *viewing* or *modifying* the service provider data. This involves retrieving service provider data from the PROME database using the service provider identity and updating or deleting certain aspects of this data. Figure 4.9 depicts the workflow for viewing or modifying the service provider data.

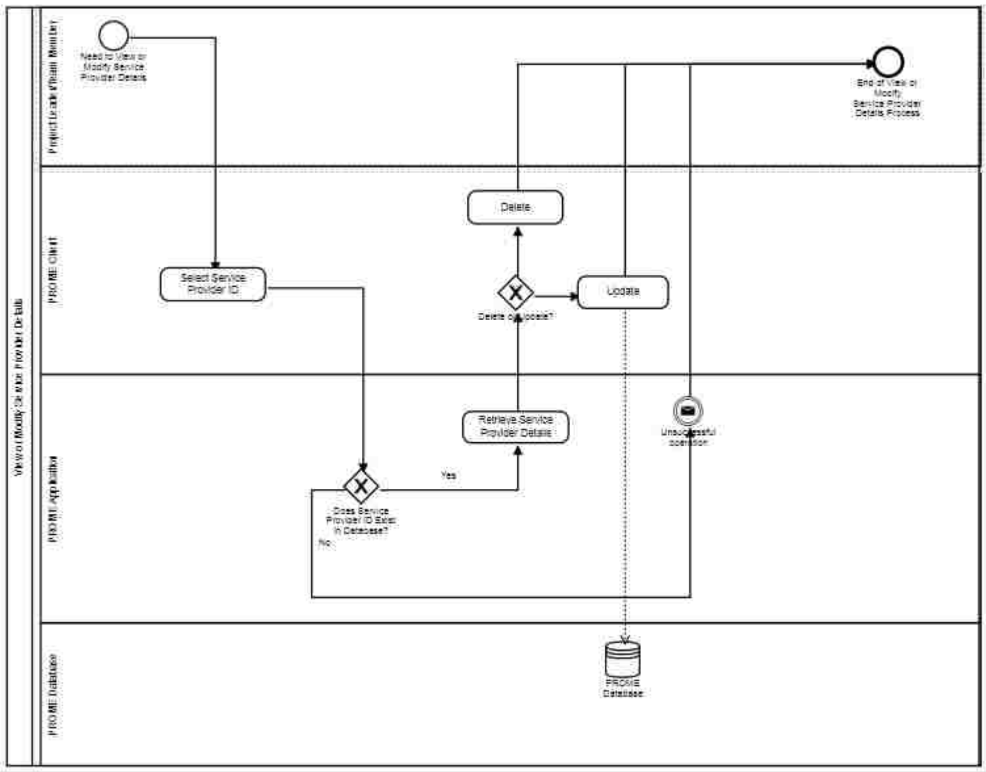

FIGURE 4.9: WORKFLOW FOR VIEWING OR MODIFYING SERVICE PROVIDER DATA

The service system should have a mechanism for *service registration* that supports the planning and execution of PME services. This is a one-time process and should be categorised as a core process of higher priority. Basically, the idea of creating a new service may come from a service provider who is interested in offering PME services in return for compensation. The project leader or the project team is then prompted to capture the PME service characteristics such as name, identity, description and units. If the PME service identity already exists in the PROME database, the new service characteristics are rejected by the system and the project leader is requested to either update the details of an existing project or cancel the process. Otherwise, the service characteristics are committed to the PROME database and a confirmatory e-mail is sent to signify the end of this process. The workflow for the service registration process is shown in Figure 4.10.

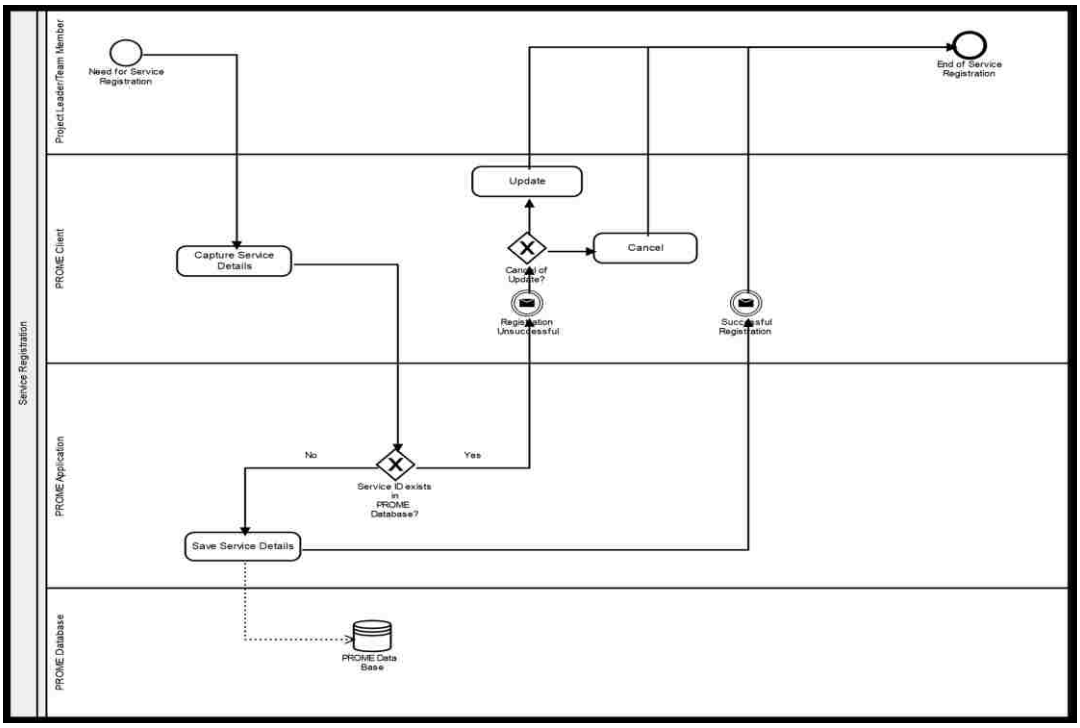

FIGURE 4.10: WORKFLOW FOR SERVICE REGISTRATION PROCESS

Additionally, the PROME system should have a mechanism for viewing or modifying the data captured above. This involves retrieving service data from the PROME database using the service identity and updating or deleting certain aspects of this data. Figure 4.11 depicts the workflow for viewing or modifying service data.

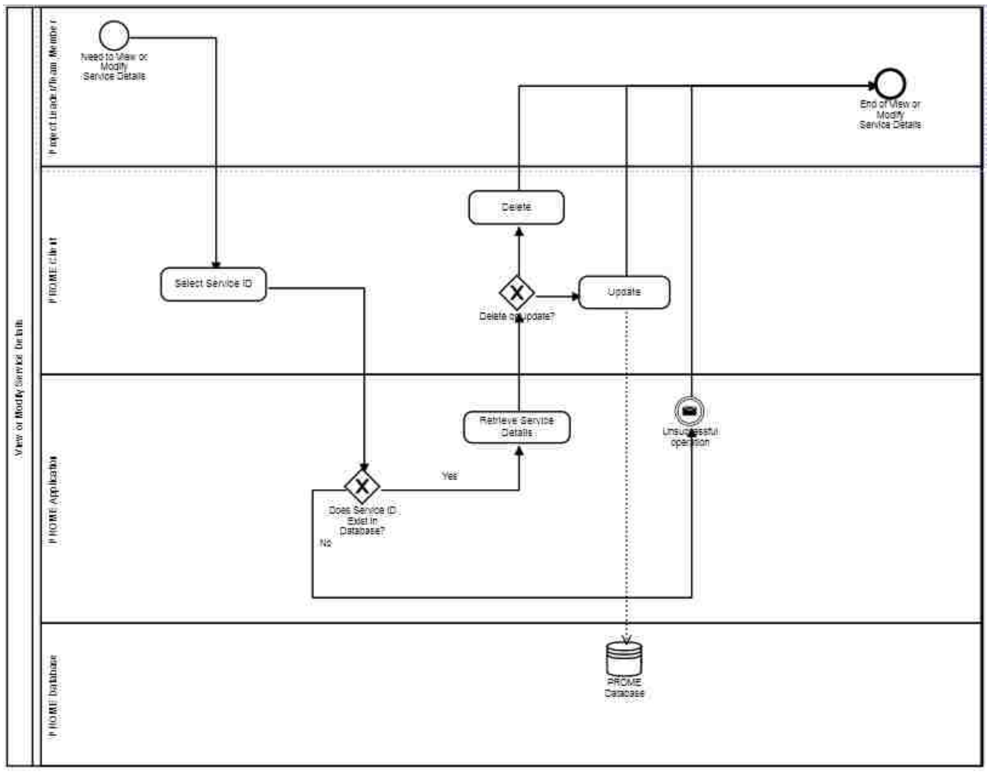

FIGURE 4.11 WORKFLOW FOR VIEWING OR MODIFYING SERVICE DATA

The system should have a mechanism for *service provisioning* by capturing the details of services provided by actors. This information is then used to support other processes, such as processing of claims. This process is a daily process and should be categorised as a core process of higher priority. When a need for service provisioning arises, a service provider is required to select the actor category followed by the choice of the service to offer. This choice is based on a list of previously registered services. If the desired service is not registered in the system, the service provider is required to register the new service offering with the approval by the project leader. This routine is captured in Figure 4.12.

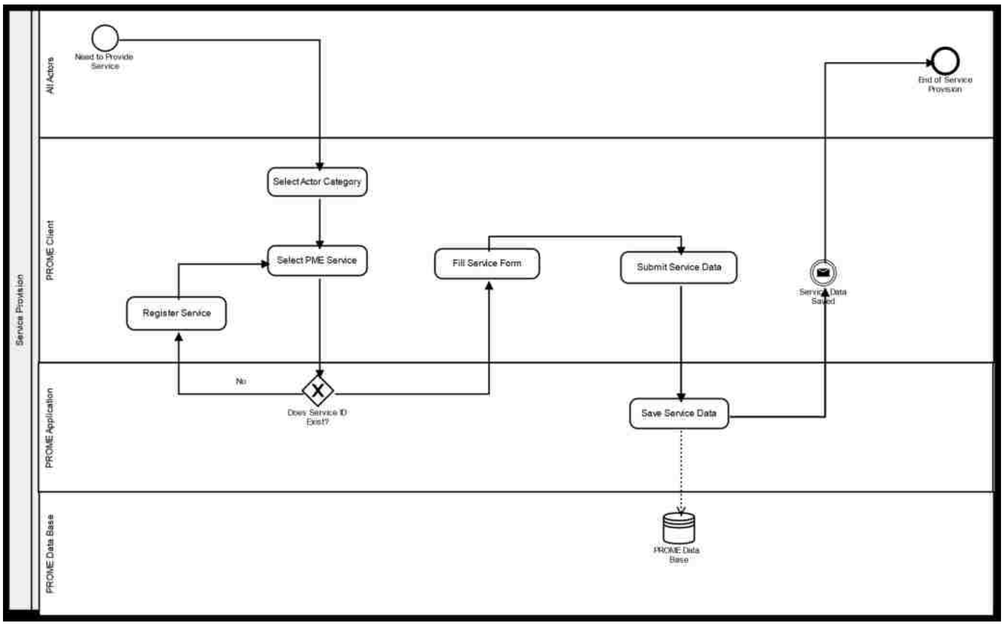

FIGURE 4.12: WORKFLOW FOR SERVICE PROVISIONING PROCESS

Additionally, the PROME system should have a mechanism for viewing or modifying the service provisioning data captured in the previous process. This involves the retrieval of such data from the PROME database using the service provisioning identity and updating or deleting certain aspects of this data. Figure 4.13 depicts the workflow for viewing or modifying the service provisioning data.

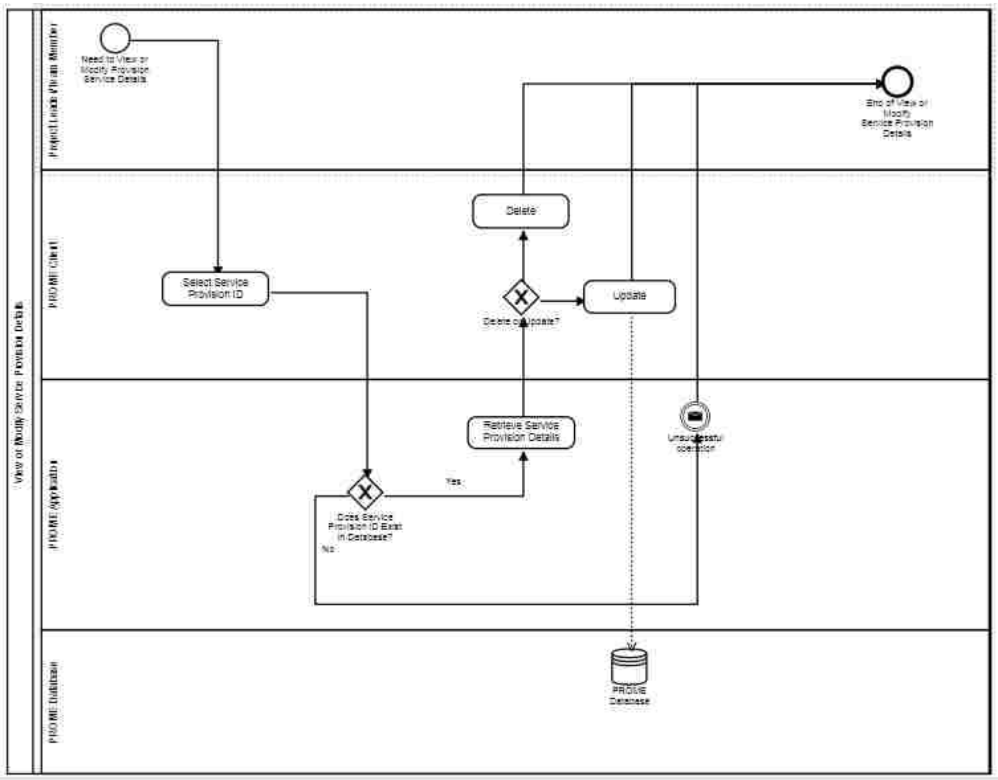

FIGURE 4.13: **WORKFLOW FOR VIEWING OR MODIFYING SERVICE PROVISION DATA**

d) Component 4: A process for achieving economic sustainability

This component explores economic sustainability within the context of a service economy. This component consists of *claims application, claims approval, claims status check* and *claims payment processes*. The *claims application* process permits an actor to claim for compensation for PME services rendered. This compensation may occur in diverse forms, such as money, certificate, trophy, plaque, training, party, tour, lottery ticket, standing ovation, a hall of fame or a note of appreciation. The claimant is required to fill an e-form and submit it to the system. Once received, the e-form is subjected to a discrepancy check and stored in the database. A confirmatory e-mail message should be generated and sent to the claimant and the process is terminated. Figure 4.14 shows the workflow for the claims application process.

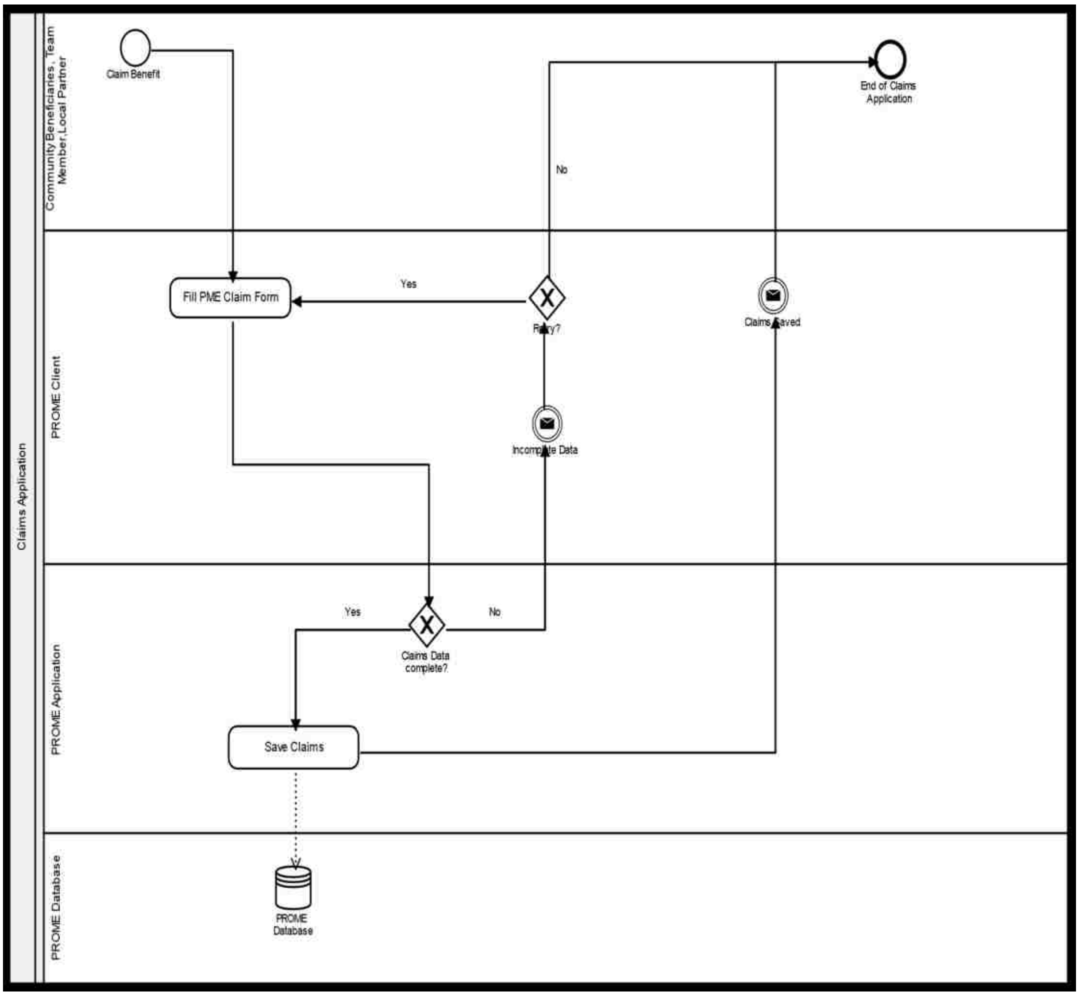

FIGURE 4.14: WORKFLOW FOR CLAIM APPLICATION PROCESS

Additionally, the PROME system should have a mechanism for viewing or modifying the claims. This involves retrieving claims data from the PROME database using the claim application identity and updating or deleting certain aspects of this data. Figure 4.15 depicts the workflow for viewing or modifying claims.

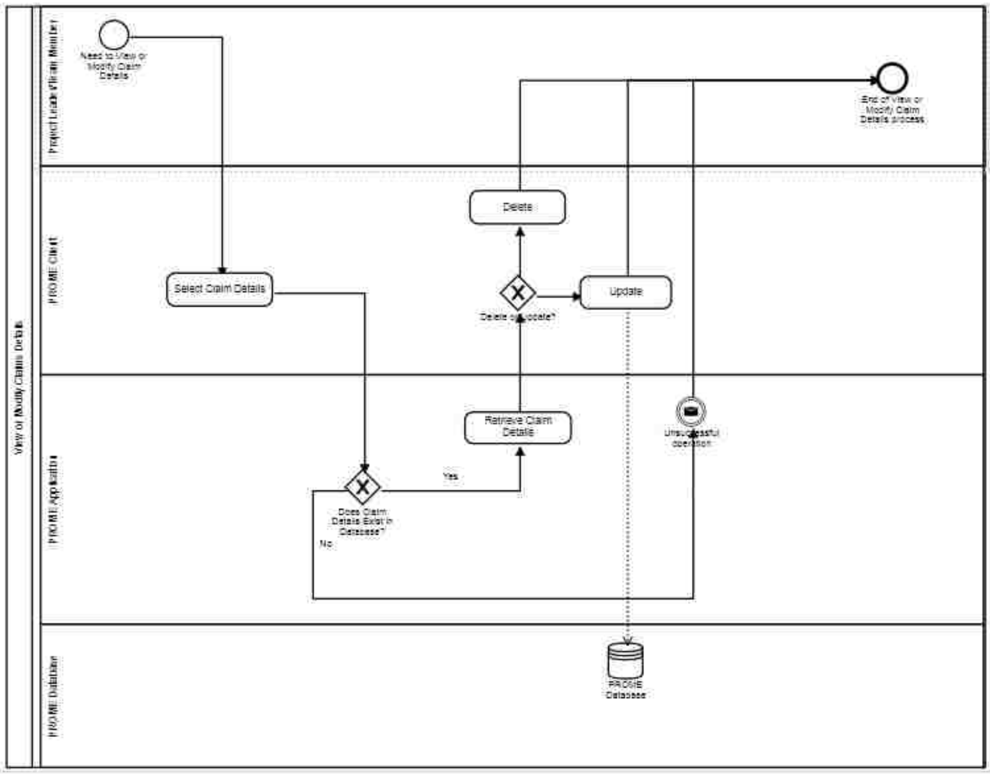

FIGURE 4.15: WORKFLOW FOR VIEWING OR MODIFYING CLAIMS.

The claims should be subjected to an *approval* process by the project leader. This should be a daily process and should be categorised as a core process of higher priority. The service system should send a notification e-mail to notify the project leader about pending claims. The project leader should then approve or reject a submitted claim depending on its veracity, which may be judged by the content of the claim, including the relevant supporting documents. If a claim is approved, the record of that claim should be updated to reflect this new status and a notification e-mail is sent to the claimant showing that the claim has been approved. Alternatively, if a claim is rejected, a notification e-mail is sent to the claimant showing that the claim has been rejected. Figure 4.16 shows the workflow for the claims approval process.

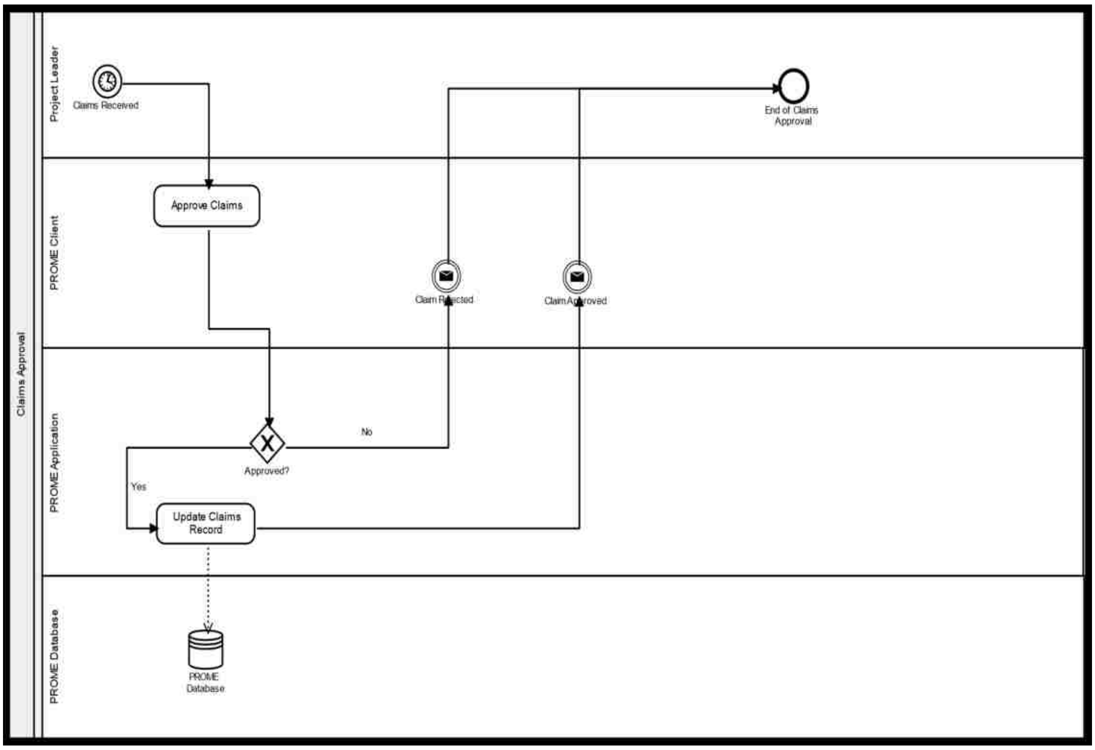

FIGURE 4.16: WORKFLOW FOR CLAIM APPROVAL PROCESS

The service system should provide a process for *claim status check* that allows a claimant to query whether a claim has been approved by searching the PROME database using the claimant's identity. In the event of a successful query, the system should display the relevant record for use by the claimant. Alternatively, the system should handle a null query by displaying an appropriate message. This workflow is presented below in Figure 4.17.

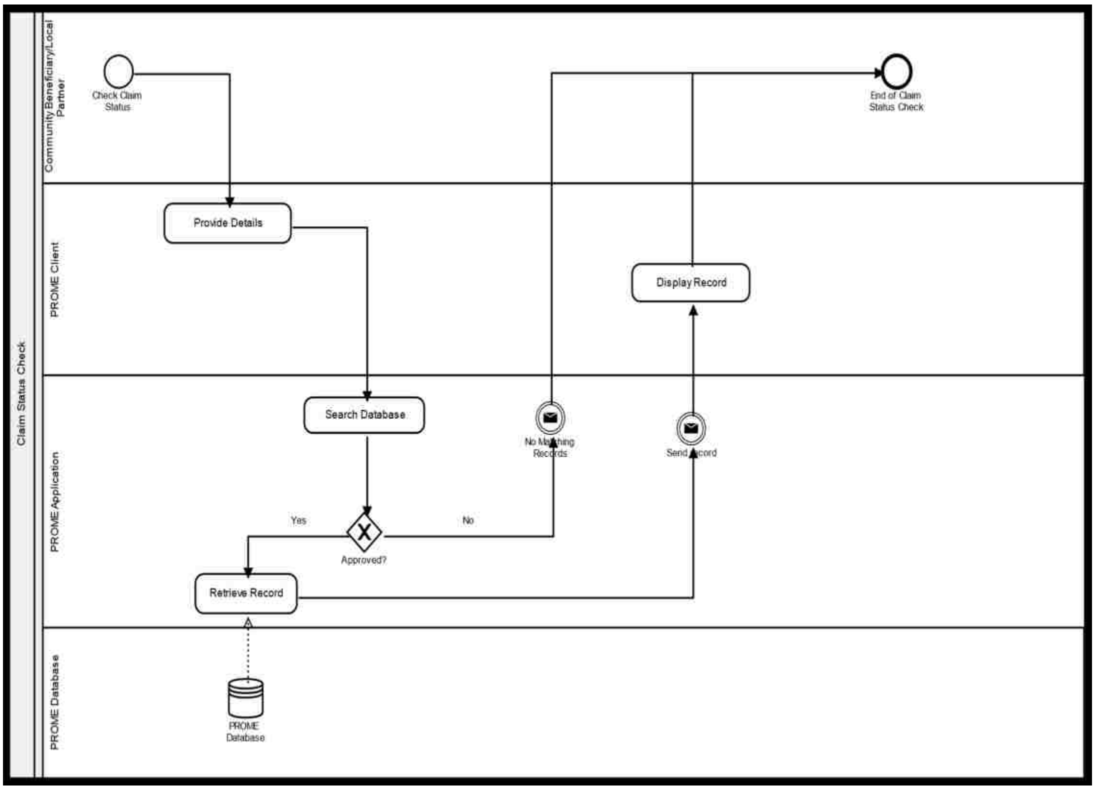

FIGURE 4.17: WORKFLOW FOR CLAIM STATUS CHECK

Once approved, there should be a mechanism for *processing payment*, including downloading or exporting payment data to an excel worksheet for further processing. This set of processes should be considered as core, high priority and should be performed daily. Figure 4.18 shows the workflow for the claims payment process.

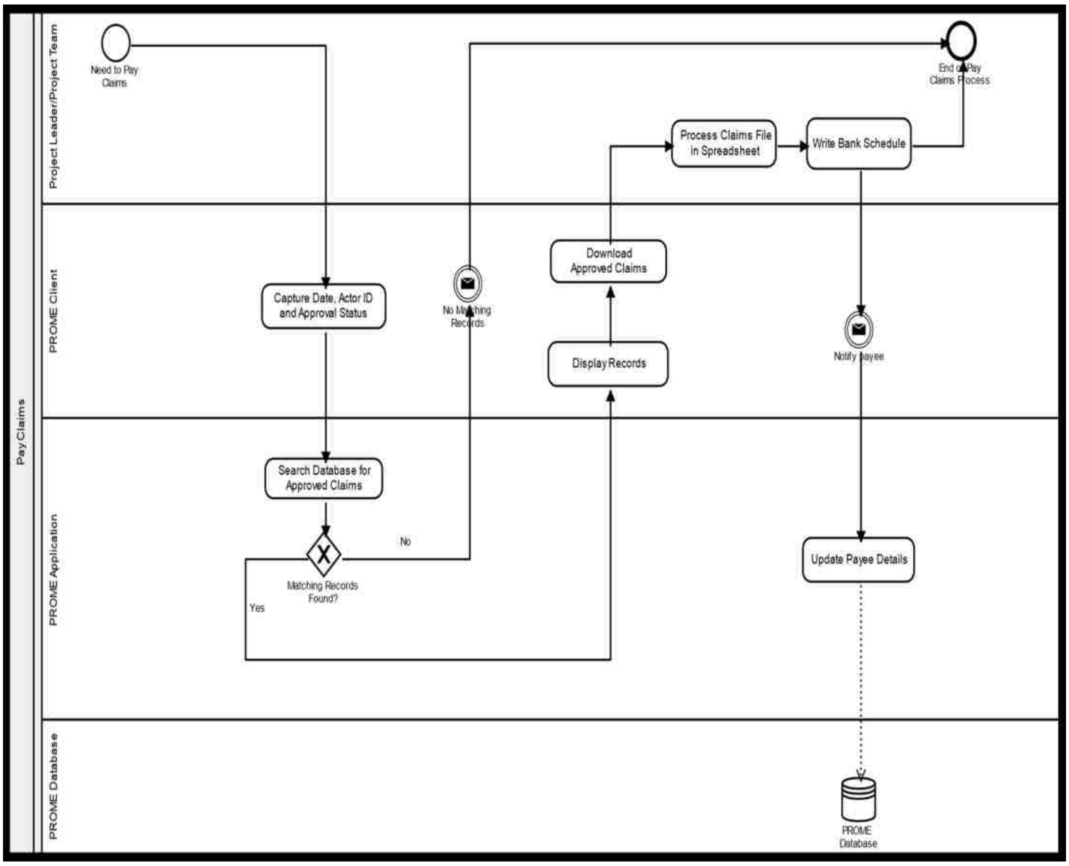

FIGURE 4.18: WORKFLOW FOR CLAIMS PAYMENT

e) Component 5: A mechanism for value co-creation

As an economic strategy, the proposed To-Be PME model envisages value co-creation amongst PME actors. This principle is exemplified by the proposed value exchanges via *value ports* between actors as shown in Figure 3.4. The best example of value creation mechanism in this model is the input of diverse actors in the PME process and a group activity such as providing data for evaluation. Such value co-creation mechanisms potentially generate a plethora of innovative ideas that can be used to improve the process of PME. Significantly, the proposed value exchanges are envisaged to occur in an *ideal* set up that should propel the actors to have mutually beneficial interactions. According to Tan *et al*. (2011), an ideal set up is a scenario whereby each actor behaves correctly; that a *sub-ideal* scenario leads to lack of a win-win situation and has implications on the sustainability of the process.

f) Component 6: A process-oriented approach for system implementation

This component describes a process-oriented method for implementing a service system. In this case, the proposed To-Be PME model depicts a wide range of scenarios whereby value objects are exchanged amongst diverse actors. These scenarios exist as processes that were implemented in the PROME service system and have been classified into three known categories of *core, support* and *management*. Core processes serve to satisfy external customers, support processes help in serving internal customers and management processes are concerned with managing core processes and support processes (Damij and Damij, 2013; Ould, 1995). Table 1 depicts the classification of processes implemented in the PROME service system.

TABLE 4.1: MAPPING OF THE PROPOSED TO-BE MODEL TO THE PROCESSES IN PROME SERVICE SYSTEM

No	Component	Processes	Comment
1	Digital resilience	Self-learning, peer-to-peer learning, formal ICT curriculum, ICT lectures, tutorials and seminars, ICT training, ICT conference	A management process that safeguards the successful adoption and use of model and PROME service system
2	Project documentation	PME actors, project registration, view or modify project details, project descriptive variables, project analytical variables, project monitoring, project evaluation	Core process
3	Services	Service registration, view or modify service details, service provider, view or modify service provider details, service provisioning, view or modify service provision details	Core process
4	Economic sustainability	Service provision, claim application, view or modify claim details, claim approval, claim status check, claim payment	Core process
5	Value co-creation	Service provision, claim application, view or modify claim details, claim approval,	Core process

		claim status check, Claim payment	
6	Process-oriented implementation	All	Meta-process in the sense that all processes follow the same implementation pattern

[redacted] Data Specification

This section briefly discusses the data specification (organisation of data) different from the process specification (operations that manipulate data) to create a conceptual model of data objects and their association with each other in a database. The unified modelling language (UML) class diagram has been used for this purpose to show the relationships between the PROME entities. These entities are *project, descriptive variables, analytical variables, monitor, evaluation, services, service providers, value, service provision* and *claims*. The actor and project concepts are derived from the MEPPP framework, while service, claim and payment concepts are derived from the service innovation framework to make the PME process more participatory and sustainable by rewarding service providers. The PROME service system is expected to store information about eleven data entities as shown in Figure 4.19.

The UML class diagram presented in Figure 4.19 was used to create a MySQL database in the ProcessMaker (PM) workspace that allows the PROME service system processes and its cases to be manipulated as a cohesive unit. These PM tables include 'PROJECT', 'DESCRIPTIVE VARIABLES', 'ANALYTICAL VARIABLES', 'MONITOR', 'EVALUATION', 'SERVICES', 'SERVICE PROVIDERS', 'VALUE', 'SERVICE PROVISION', 'CLAIMS'. The structure of each table is presented in Appendix III.

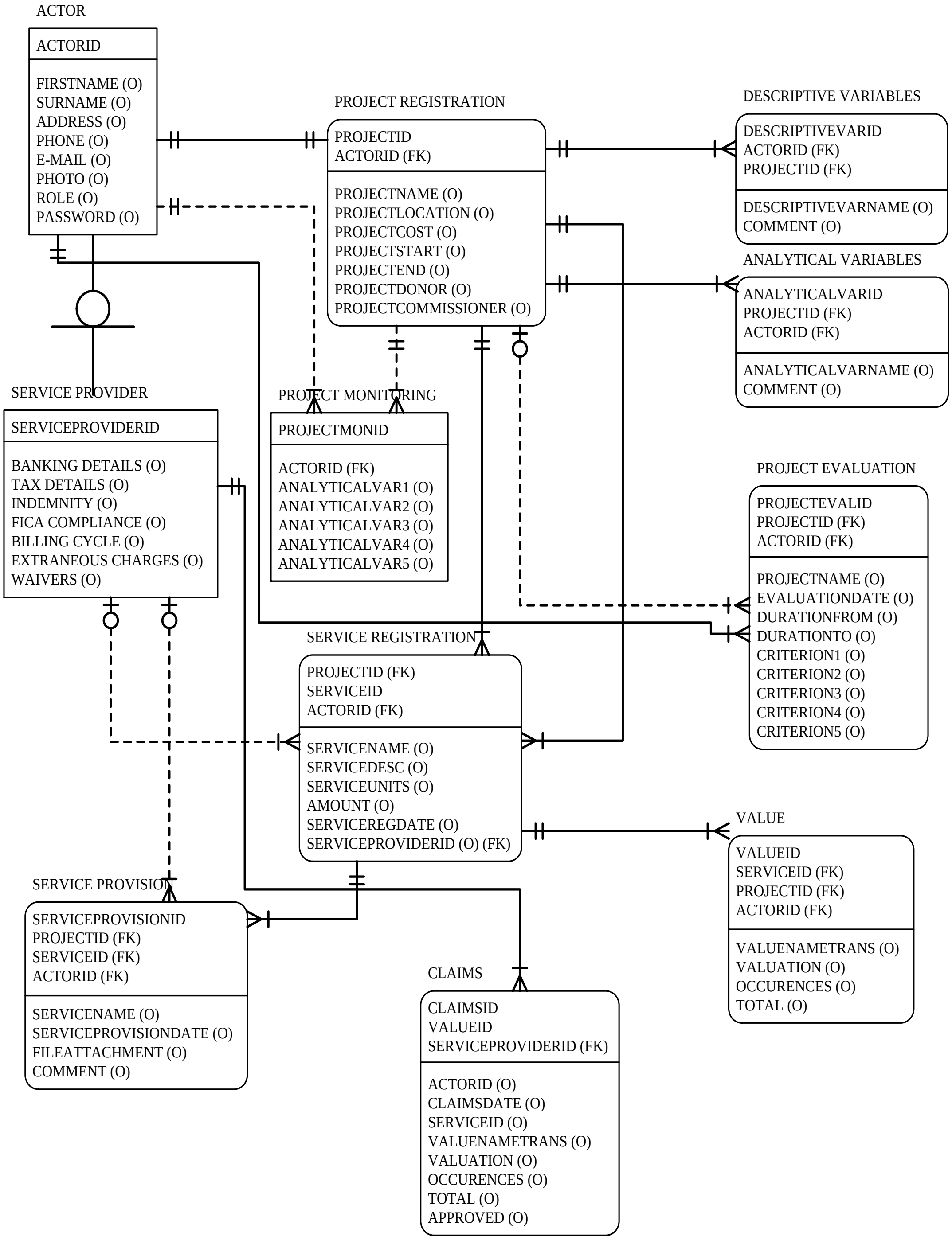

FIGURE 4.19: UML CLASS DIAGRAM FOR PME DATA

4.2 IMPLEMENTATION OF THE PROME SERVICE SYSTEM

The implementation of PROME service system specifications follows the process-oriented approach. The ProcessMaker® open source BPMS was used to implement the service system for the following reasons: (1) the design environment contains tools for mapping processes, defining business rules, creating dynamic forms, inputting and outputting electronic documents; (2) the run-time environment is capable of handling the execution of several cases in a process at a time; (3) the run-time environment transforms a process map design into a fully-functioning application; and (4) the ProcessMaker® application can easily be deployed as a web-based application or a cloud-based application (Meidan *et al.,* 2017).

During the implementation phase of the PROME service system, the following processes were created using the ProcessMaker® to support the process of PME. The processes are listed as follows: PME actor registration, project registration, viewing or modifying project details, project descriptive variables, project analytical variables, project monitoring, project evaluation, service registration, viewing or modifying service details, service provider, viewing or modifying service provider details, service provision, viewing or modifying service provision details, claims application, viewing or modifying claims details, claims approval, claim status check, claims payment. Figure 4.20 shows the PME processes implemented in PROME service system.

New Edit Deactivate Delete Export Import Delete Cases

Process Title	Type	Category	Status	Assigned users	Create Date	Inbox
PME Actors (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-04-17 06:38:17	0
Project Monitoring (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-04-25 08:31:24	0
Project Evaluation (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-04-26 09:53:24	0
Service Registration (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-04-27 10:20:14	0
Project Registration (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-04-27 10:23:30	7
Claims Approval (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-04-27 10:28:22	0
Claim Status Check (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-04-27 10:30:16	0
Claims Payment (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-04-27 10:31:37	0
Service Provision (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-04-28 09:58:11	0
Claims Application (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-05-01 07:15:43	0
Project Descriptive Variables (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-08-21 04:51:07	0
Project Analytical Variables (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-08-21 05:20:22	0
View or Modify Project Details (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-08-21 06:45:52	0
View or Modify Services Details (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-08-29 07:39:47	0
View or Modify Service Provision Details (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-08-29 10:42:39	0
View or Modify Claims Details (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-08-31 15:40:29	0
Service Provider Registration (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-08-31 16:07:45	0
View or Modify Service Provider Details (BPMN Project)	bpmn	- No Category -	Active	Administrator admin	2017-08-31 16:19:11	0

FIGURE 4.20: PME PROCESSES IMPLEMENTED IN PROME SERVICE SYSTEM

The proceeding sections describe the implementation of the six processes in more detail.

[redacted] Digital resilience process

The digital resilience process of the proposed To-Be PME model is a management process that safeguards the successful exploitation of the processes implemented with the PROME service system. This concept was borrowed from Tan *et al.* (2011) and Spohrer and Kwan (2009) who postulate that the development of a sustainable service system requires a governance mechanism for uncertainty reduction. Thus, it was necessary to audit the PME actors for digital resilience and where necessary, initiate corrective mechanisms to avoid jeopardising the successful adoption and use of the PROME service system. Consequently, this study has demonstrated that it is feasible to develop digital resilience amongst marginalised communities that development projects often target. In this perspective, the concept of developing digital resilience should be viewed as a precursor to the successful implementation of such projects (Ochieng' *et al.,* 2017). Further, the exploratory part of this study (Ochieng' *et al.*, 2017) has demonstrated that digital resilience process should be conceptualised, designed, implemented and evaluated as a lifelong learning process for digital skills acquisition through self-learning, peer-to-peer learning, formal training, ICT lectures, tutorials, seminars, workshops and conferences.

[redacted] Project documentation process

The project documentation process was implemented through the registration of actors, project registration, project monitoring and project evaluation. A succinct description of these processes is given as follows.

The need to register a new actor activates the process of registration of actors. This necessitates the capture of an actor's details, such as initials, name, identity, password, contact details, photograph and role. If the identity exists in the PROME database, the system should reject the data provided and permit the operator to retry or abort this process. Subsequently, the PME actor registration process consists of the following sub-processes*: creating a new user*, *viewing registered users*, *creating user groups* and *defining roles*. Figure 4.21 illustrates how to create a new actor in the PROME service system.

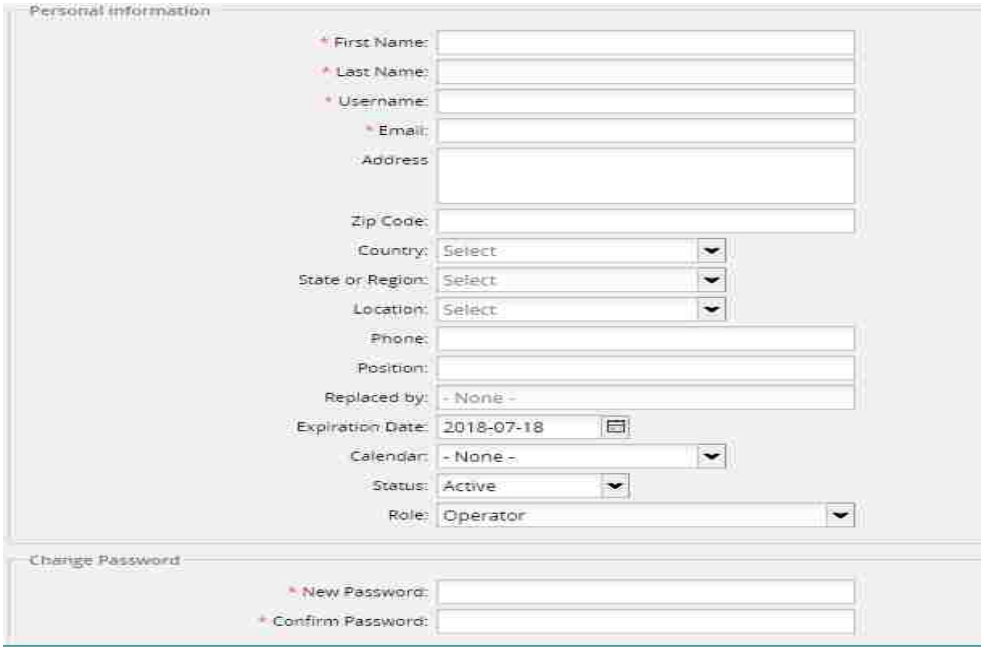

FIGURE 4.21: CREATING A NEW ACTOR

Additionally, Figure 4.22 shows various credentials of the registered actors, such as username, full name, status, role, last login, cases and due date.

Users

New | Summary | Edit | Status | Delete | Groups | Authentication | Search ... | Search

User Name	Full Name	Status	Role	Last Login	# Cases	Due Date
admin	admin, Administrator (admin)	Active	System Administrator	2017-07-17 15:59:14	0	2020-01-01 00:00:00
jmark	Mark, John (jmark)	Active	Manager	2017-05-10 06:31:47	0	2018-04-19 00:00:00
zcaleb	Caleb, Zoe (zcaleb)	Active	Operator		0	2018-04-19 00:00:00
jkennedy	Kennedy, Jack (jkennedy)	Active	Operator		0	2018-04-19 00:00:00
ldavid	David, levi (ldavid)	Active	Operator		0	2018-04-19 00:00:00
aliam	Liam, Abigael (aliam)	Active	Operator		0	2018-04-19 00:00:00
olucas	Lucas, Olivia (olucas)	Active	Operator		0	2018-04-19 00:00:00
ajeff	Jeff, Abel (ajeff)	Active	Operator		0	2018-04-19 00:00:00
dwest	West, Don (dwest)	Active	Operator		0	2018-04-19 00:00:00
jowen	Owen, James (jowen)	Active	Operator		0	2018-04-19 00:00:00

FIGURE 4.22: REGISTERED USERS IN THE SYSTEM

Further, the following groups of PME actors were created in the PROME service system: community beneficiary, government agency, local government, local partner, project donor, project evaluator, project leader, project team, service provider and system administrator. Basically, a group of actors share common characteristics and privileges. The rationale for creating actor groups is to provide a flexible way to manage user privileges during the design and execution of the system cases. This concept is illustrated in Figure 4.23.

Groups

New | Edit | Delete | Users | Search ... | Search

Group Name	Status	Users	Tasks
Community Beneficiary	Active	1	1
Government Agency	Active	1	0
Local Government	Active	1	0
Local Partner	Active	1	1
Project Donor	Active	1	0
Project Evaluator	Active	1	2
Project Leader	Active	1	5
Project Team	Active	1	2
Service Provider	Active	1	4
System Administrator	Active	1	1

FIGURE 4.23: GROUPS OF ACTORS

Finally, distinct roles were created for PME actors. The first role was the system administrator who is responsible for the upkeep, configuration and reliability of the system. The second role was the project leader (manager) who is responsible for privileged processes, such as project registration, service registration, claims approval and claims payment. The third role was the operator who is permitted to handle less privileged processes, such as making claims. Figure 4.24 illustrates the three roles defined in the system.

Roles

New | Edit | Delete | Users | Permissions | Search ... | Search

Code	Name	Status	Active Users	Create Date	Update Date
PROCESSMAKER_ADMIN	System Administrator	Active	1	2007-07-31 19:10:22	2007-08-03 12:24:36
PROCESSMAKER_OPERATOR	Operator	Active	8	2007-07-31 19:10:22	2007-08-03 12:24:36
PROCESSMAKER_MANAGER	Manager	Active	1	2010-03-29 09:14:15	2010-03-29 09:19:53

FIGURE 4.24: ROLES OF ACTORS

The project registration process employs the following dynaform to capture the requisite project data. For the sake of simplicity and convenience, this process has been divided into three sub-processes in tandem with the principle of information chunking (Fonollosa *et al.*, 2015). Thus, the PROME service system provides three dynaforms for capturing basic data (Figure 4.25), descriptive variables (Figure 4.26) and analytical variables (Figure 4.27) in a sequential manner (Please refer to Appendix IV for the PHP code snippet for these forms).

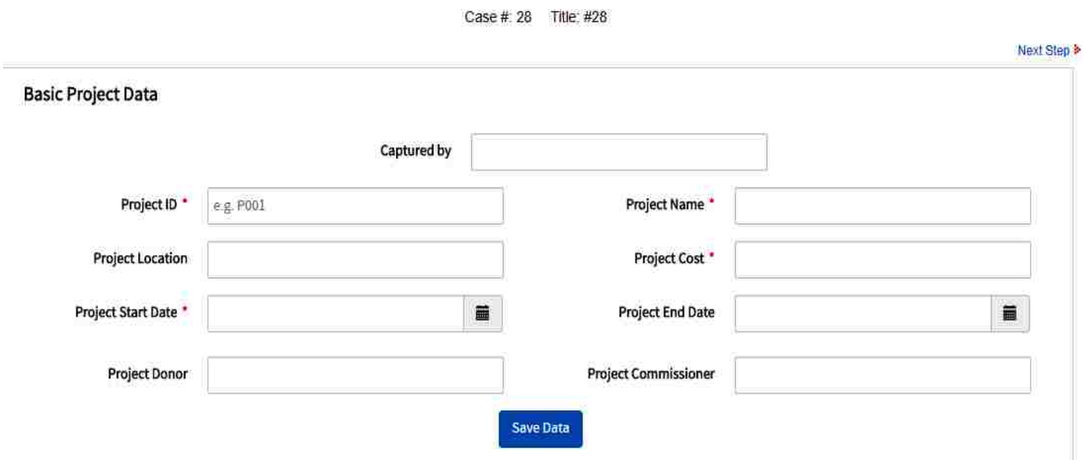

FIGURE 4.25: BASIC PROJECT DATA

The descriptive variables for each project are then captured as shown in Figure 4.26.

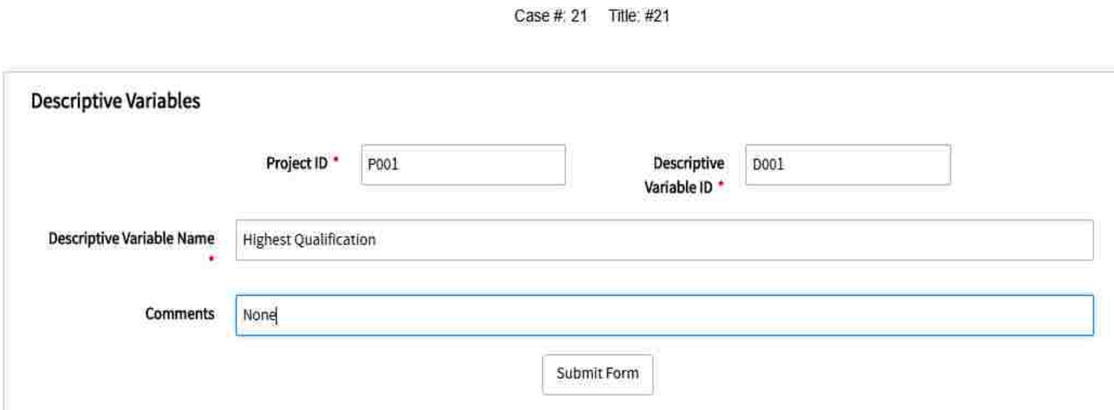

FIGURE 4.26: DESCRIPTIVE VARIABLES FOR PROJECT MONITORING AND EVALUATION

The sequence is completed when the analytical variables for the project are captured. This process was implemented as shown in Figure 4.27.

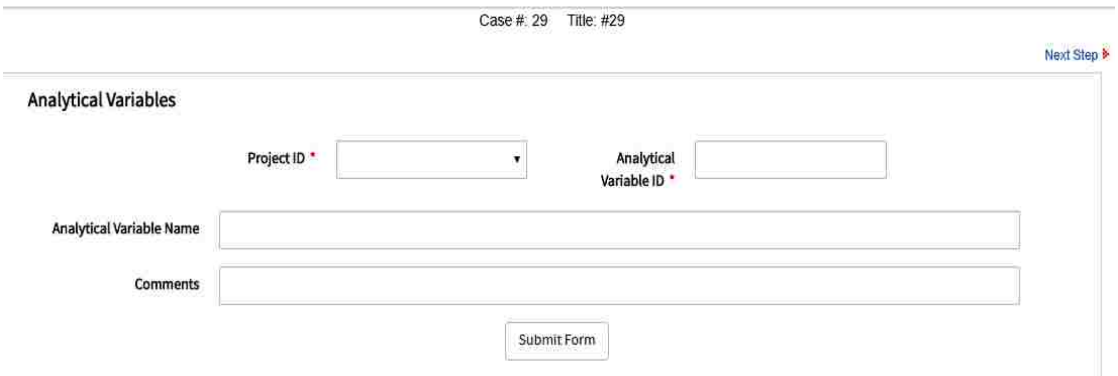

FIGURE 4.27: ANALYTICAL VARIABLES FOR PROJECT MONITORING AND EVALUATION

The project monitoring process is based on the workflow illustrated in Figure 4.28. Based on this workflow, a threshold of 70% response rate was set to trigger this process by generating the average scores for each analytical variable. The project manager can then retrieve this data by using the project identity. This information is then saved in a different table and made available for use. Figure 4.28 is an illustration of this process (Please refer to Appendix IV for the PHP code snippet for this form).

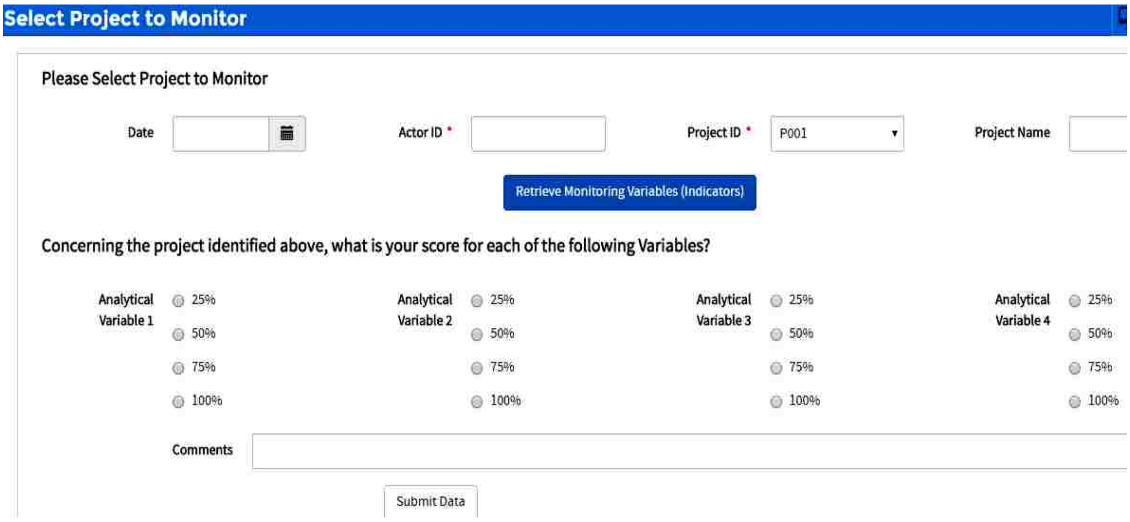

FIGURE 4.28: PROJECT MONITORING PROCESS

The dynaform for the project evaluation process shown in Figure 4.29 is based on the workflow for project evaluation (see Figure 4.7). This dynaform displays the project evaluation data for a project based on a set of criteria (filters) as shown in the figure. In this illustration, the study has elected to use a set of five items to filter the project evaluation results. The dynaform also consists of a grid for displaying the evaluation results, which can be saved for subsequent use (Please refer to Appendix IV for the PHP code snippet for this form).

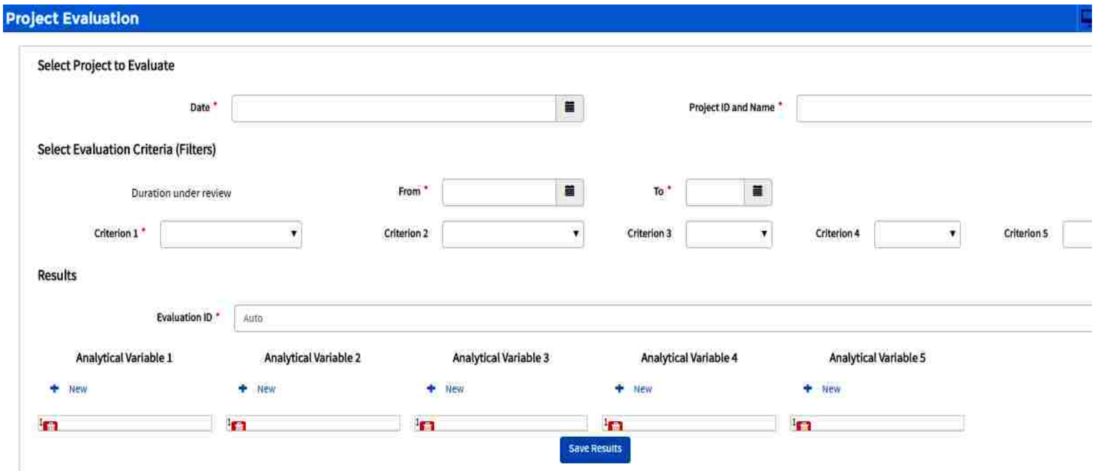

FIGURE 4.29: PROJECT EVALUATION PROCESS

[redacted] PME services

This process was implemented through service registration, service provider registration and service provision. A succinct description of the implementation of these processes is shown as follows. However, the description of service provider registration process has been omitted from this section because it is identical to the registration of actor process (see section 4.2.2).

The service registration process is based on the workflow for service registration (see Figure 4.10) and has been implemented as shown in Figure 4.30. This dynaform is designed to capture the service details, including service identity, service name, service description and service units (Please refer to Appendix IV for the PHP code snippet for this form).

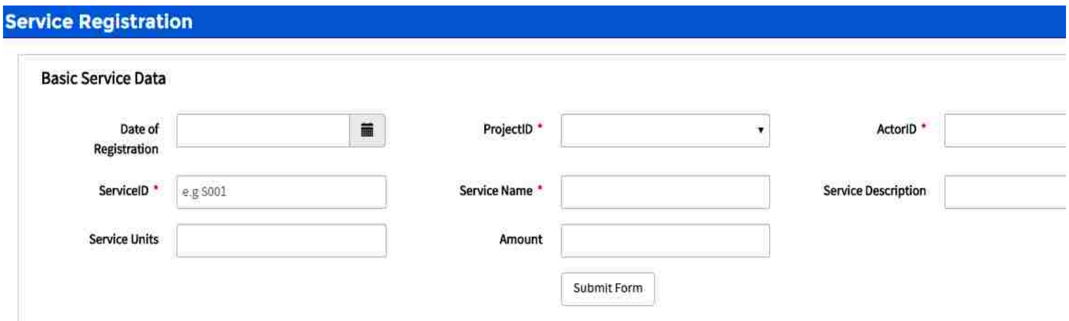

FIGURE 4.30: SERVICE REGISTRATION PROCESS

The service provisioning process was derived from the workflow for service provisioning in Figure 4.12 and was implemented as shown in Figure 4.31. This dynaform allows the system to capture all the details of services provided and provides a mechanism for attaching the relevant supporting documents (Please refer to Appendix IV for the PHP code snippet for this form).

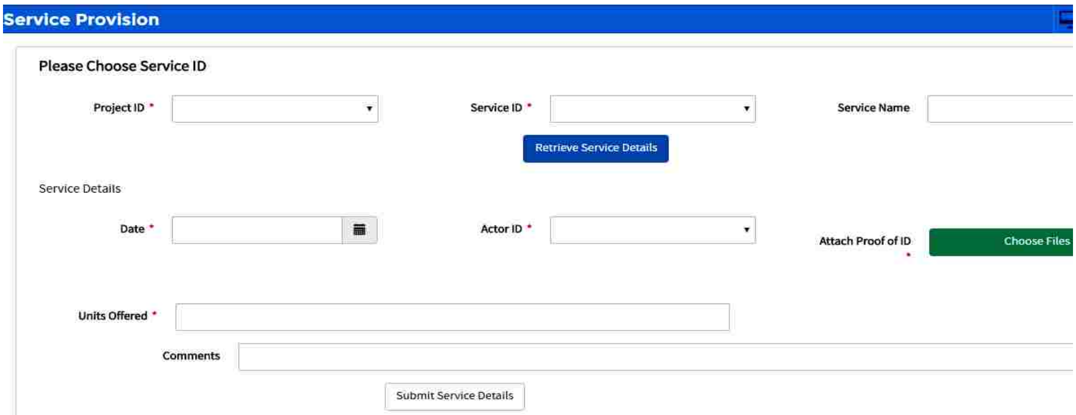

FIGURE 4.31: SERVICE PROVISIONING PROCESS

[redacted] Economic sustainability

The component of economic sustainability was realised through the following processes: claims application (based on the workflow for claim application in Figure 4.14), claims approval (based on the workflow for claims approval in Figure 4.16), claims status check (based on the workflow for claims status check in Figure 4.17) and claims payment (based on the workflow for claims payment in Figure 4.18). A succinct description of these processes is presented as follows.

The dynaform for this claim application is shown in Figure 4.32. This dynaform provides an interface for the claimant to submit a claim, including date, actor identity, actor name, project identity and name, service identity and name. In addition, it provides a grid for displaying claims data, such as value identity, value transacted, valuation rate, occurrence and total. These value concepts have been borrowed from Tan *et al*. (2011) (Please refer to Appendix IV for the PHP code snippet for this form).

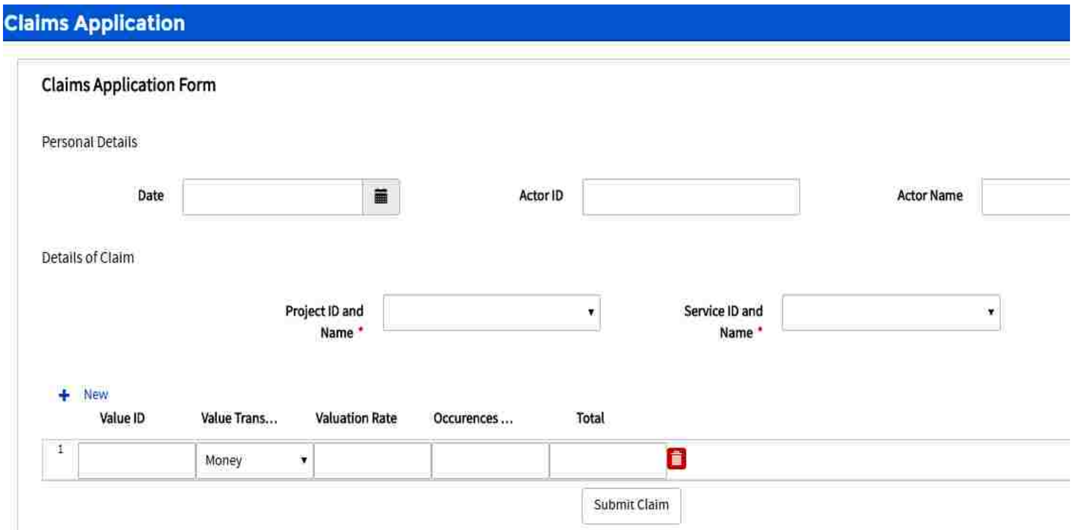

FIGURE 4.32: CLAIMS APPLICATION PROCESS

The implementation of the claims approval process is shown in Figure 4.33. The dynaform allows the project leader to retrieve the claims data using various search parameters, such as project identity, actor identity, service identity and value identity. The query is then displayed in a grid for approval or rejection. These changes are committed to the claims table (Please refer to Appendix IV for the PHP code snippet for this form).

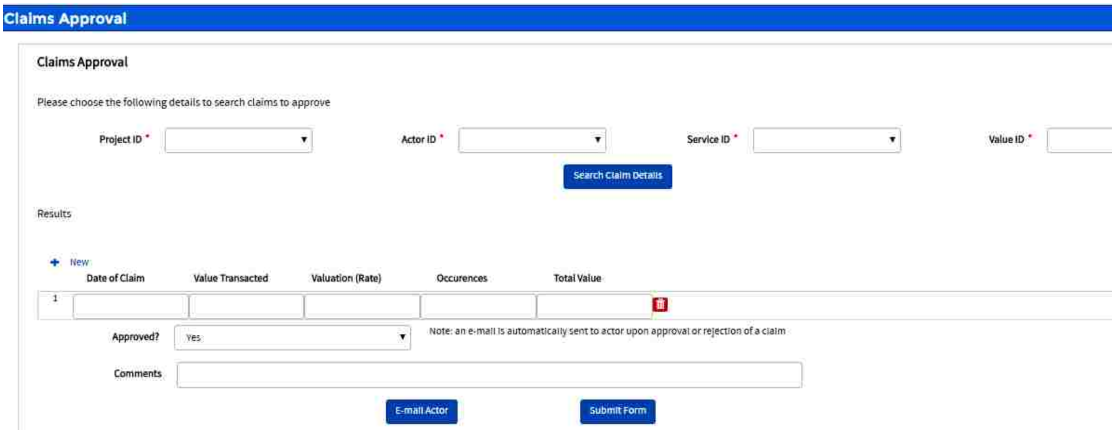

FIGURE 4.33: CLAIMS APPROVAL PROCESS

The implementation of the claims status check is presented in Figure 4.34. The dynaform allows the claimant to query the system using an actor identity and to display the results in a grid table consisting of the date of claim, total, approval status and comments. These results may be downloaded by the claimant for external processing (Please refer to Appendix IV for the PHP code snippet for this form[redacted]

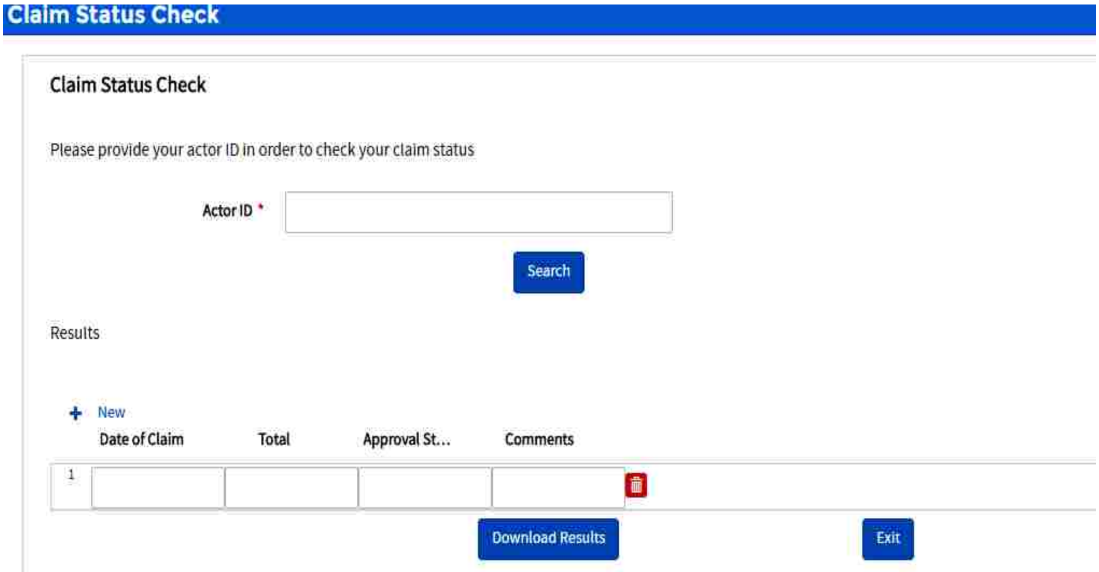

FIGURE 4.34: CLAIM STATUS CHECK PROCESS

The implementation of the claims payment process is shown in Figure 4.35. To achieve this process, the project leader must retrieve unpaid but approved claims from the database by using the date and approval status of a claim. These details can then be downloaded or exported to an excel spreadsheet for further processing, for instance, to prepare payment schedules. Finally, the records of the payee are updated in the database (Please refer to Appendix IV for the PHP code snippet for this form).

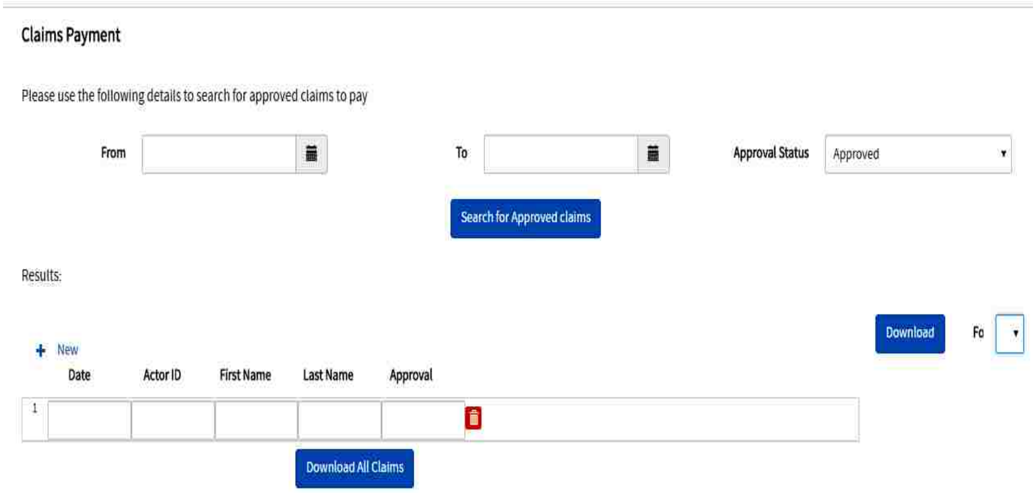

FIGURE 4.35: CLAIMS PAYMENT PROCESS

[redacted] Value co-creation process

The value co-creation component of the proposed To-Be model is implemented through the processes in the PROME service system that promote joint value creation and ownership amongst PME actors. These processes include service registration, service provision, claims application, claims approval, claims status check and claims payment. For a detailed description of the implementation of these processes, refer to section 4.3.4.

[redacted] Process-oriented implementation

As a meta-process for describing the behaviour of other business processes, the process-oriented approach to the implementation of the PROME service system was actualised in the ProcessMaker® development environment through workflows and objects, such as dynaforms, variables, triggers, input documents, output documents, report tables and case trackers. The implementation of these components has been discussed in the previous sections. However, there is a significant aspect of this development environment that warrants emphasis: the *case property*. The case property reveals pertinent information about the PROME cases. For example, Figure 4.36 shows the state of PROME cases, such as when the cases were started and were last updated and who is presently assigned to work on the case.

Open | Started By Me | Completed By Me | All | Category All Categories | Process Select a Process... | Status All Status | Search ... | Search

#	Summary	Case Notes	Case	Process	Task	Current User	Last Modify	Status
82			#82	Project Registration	Cancel	Mark, John (jmark)	2017-12-28 05:08:08	To do
81			#81	Project Registration	Cancel	Mark, John (jmark)	2017-12-28 04:49:12	To do
80			#80	Project Registration	Cancel	Mark, John (jmark)	2017-12-28 04:45:01	To do
79			#79	Project Registration	Cancel	Mark, John (jmark)	2017-12-28 04:43:24	To do
78			#78	Project Registration	Cancel	Mark, John (jmark)	2017-12-28 04:43:06	To do
75			#75	Project Registration	Cancel	Mark, John (jmark)	2017-12-28 05:09:17	To do
73			#73	Project Registration	Save Project Details	Mark, John (jmark)	2017-12-28 05:09:01	Completed
72			#72	Project Registration	Save Project Details	Mark, John (jmark)	2017-12-28 05:09:11	Completed
71			#71	Project Registration	Save Project Details	Mark, John (jmark)	2017-12-27 08:06:08	Completed
70			#70	Project Registration	Save Project Details	Mark, John (jmark)	2017-12-27 08:02:34	Completed
69			#69	Project Registration	Save Project Details	Mark, John (jmark)	2017-12-27 13:02:21	Completed
67			#67	Project Descriptive Variables	Cancel	Mark, John (jmark)	2017-12-27 08:01:48	Completed
66			#66	Project Descriptive Variables	Cancel	Mark, John (jmark)	2017-12-27 08:03:12	Completed
65			#65	Project Registration	Save Project Details	Mark, John (jmark)	2017-12-27 08:02:23	Completed
64			#64	Project Descriptive Variables	Cancel	Mark, John (jmark)	2017-12-27 08:03:07	Completed

FIGURE 4.36: PROME CASE PROPERTIES

The *case summary* provides information about the name of the case's process, the title of the case, which by default is the case number; the number of the case (each case is numbered, starting from 1 to *n*); the status of the case, which can be *to do*, *draft*, *paused*, *cancelled*, *deleted* and *completed*; the case's unique identity, which is a 32 hexadecimal number used internally by ProcessMaker® to identify the case; the first and last name of the user who created the case; the date and time when the case was created; and the date and time when the case was last updated. Figure 4.37 shows an illustration of case summary.

FIGURE 4.37: ILLUSTRATION OF THE CASE SUMMARY

4.3 DEPLOYMENT OF PROME SERVICE SYSTEM ON THE CLOUD

The PROME service system was deployed on the Google cloud using the Bitnami launchpad for Google cloud platform (Bitnami, 2017). The benefits of using the Google cloud platform include the following. (1) free hosting services; (2) availability of core infrastructure, data analytics and machine learning capabilities; (3) good security attributes; (4) availability of a wide range of features for different enterprises; and (5) favourable market position as a leading enterprise in promoting the use of open source applications (Jiang *et al*., 2017; Padarian *et al*., 2015). Thus, this section outlines the following components of the deployment process for the system on the Google cloud platform using the Bitnami launchpad.

1) Signing up for Google cloud platform service from the Bitnami launchpad. The Bitnami launchpad allows the developer to create a Bitnami account of login credentials on Bitnami.com.

2) Launching a permanent server to support the PROME service as a Google project using the "cloud credentials" option.

3) Unlocking the Bitnami vault that is an independent storage for sensitive information, such as a secure shell (SSH) keys and application programming interface (API) credentials (These keys can be provided on request). Figure 4.38 shows the Bitnami vault component.

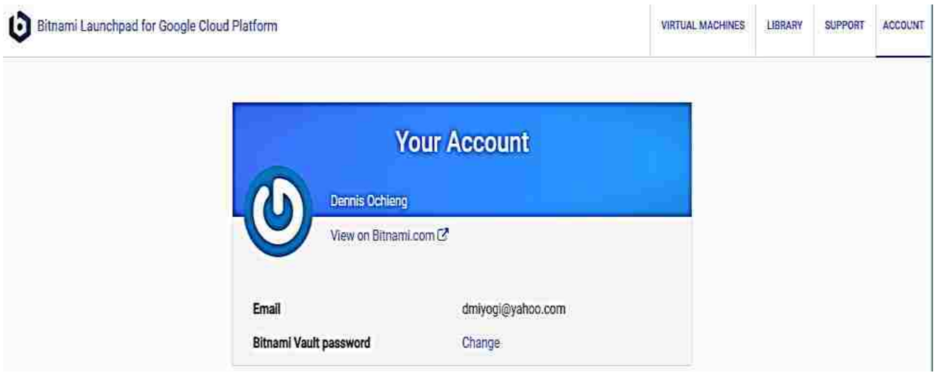

FIGURE 4.38: SETTING UP THE BITNAMI VAULT

4) Adding the PROME service system as a new Google project as shown in Figure 4.39. The new Google project was assigned a project name, project identity and project number.

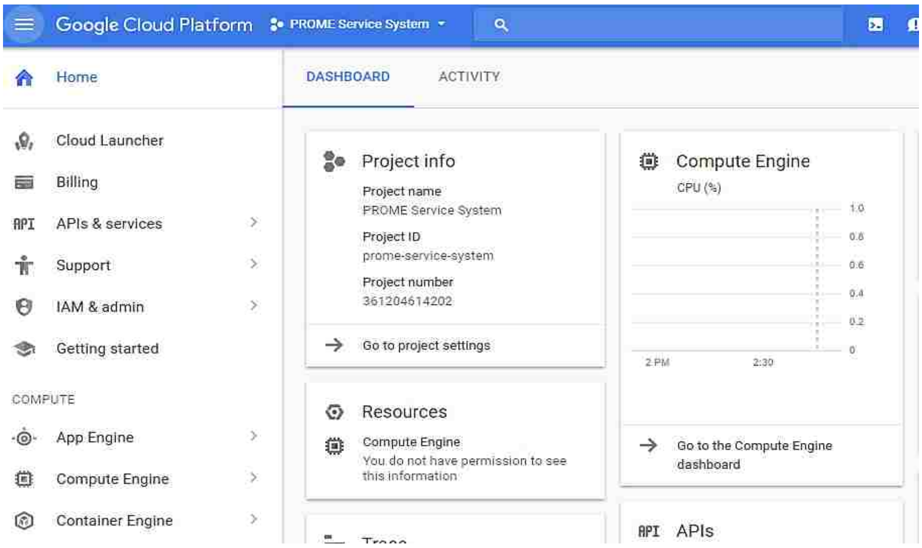

FIGURE 4.39: ADDING PROME SERVICE SYSTEM AS A NEW GOOGLE PROJECT

5) Enabling the deployment manager API on the PROME service system by following the designated link as shown in Figure 4.40.

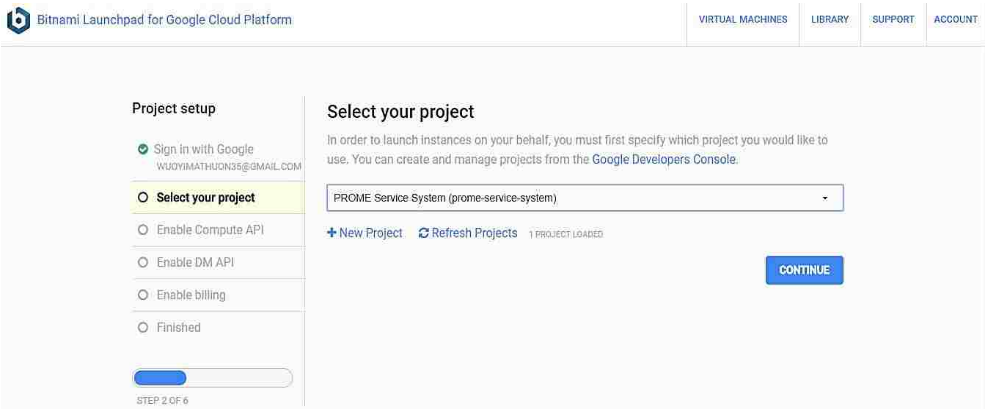

FIGURE 4.40: DEPLOYMENT MANAGER API CREDENTIALS

6) Generating the PROME service system *as a service*, following the creation of both the *compute* and the *deployment manager API credentials* for the PROME service system.

7) Development of a billing plan for the PROME service system. However, it is instructive to note that the Google platform offers free hosting services for the first 365 days. Figure 4.41 shows the culmination of this process.

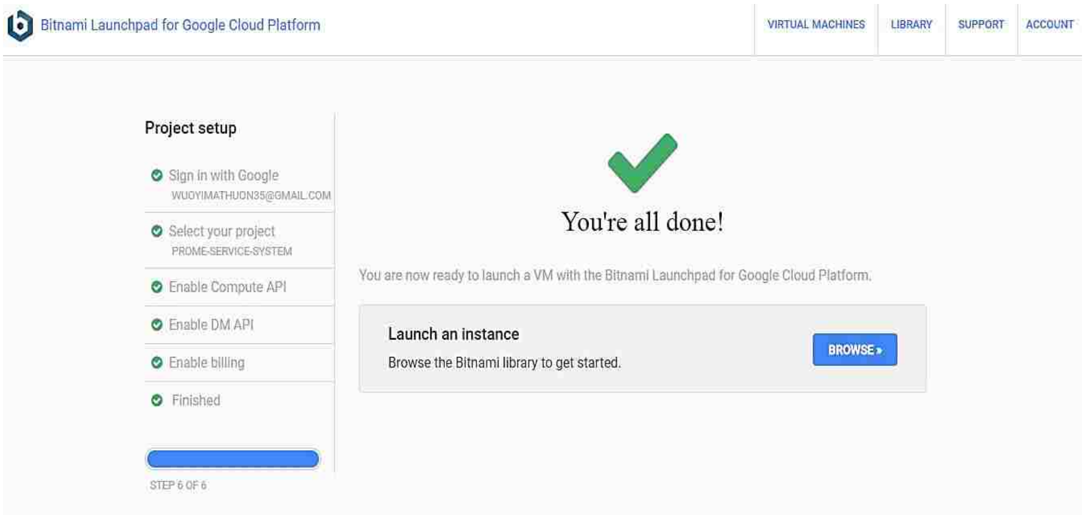

FIGURE 4.41: CULMINATION OF SYSTEM DEPLOYMENT PROCESS

4.4 IMPLICATIONS OF SYSTEM DEVELOPMENT

The development of the PROME service system consisted of three major dimensions, namely process specification, process-oriented implementation and deployment of the PROME service system on the cloud platform. These three components have several practical implications for this study. First, the process-oriented approach to the specification, design and implementation of the PROME service system provided a novel approach to improving the success of technological innovations by fostering collaboration amongst diverse PME actors. This success may be achieved by empowering actors, aligning their roles with business processes and providing long-term learning opportunities for them. These endeavours have a positive impact on organisational performance by providing a conducive environment for business engagement. Additionally, Glavan and Vukšić (2017), have demonstrated that a conducive environment can provide an impetus for improving financial results. Consequently, business process-oriented approaches offer a means for enterprises to attune to new business conditions in an increasingly competitive business atmosphere.

Second, the application of ProcessMaker® open source BPMS to model the PME processes provides a comprehensive and potent modelling tool for conceptualising, visualising and implementing the PME business processes in tandem with the implications of process-oriented approaches that have been discussed in the previous paragraph. The use of ProcessMaker® open source BPMS was founded on the growing momentum to use open source and agile software technologies in developing process-oriented business systems. The ProcessMaker® open source BPMS is particularly useful for implementing the PROME service system to achieve numerous benefits, such as streamlining the business processes, improving productivity, reducing paperwork, minimal cost of obtaining the software, lower running costs, simple and expeditious deployment process, simple GUI and conducting a performance trail. Additionally, the ProcessMaker® provides a flexible way to isolate and resolve any discrepancies or faults that might occur in the PROME service system.

Third, the use of the UML class diagram offers an integrated approach to visualising and understanding the inherent relationships between the entities involved in PME. As a de-facto standard for the analysis and design of business applications, the UML class diagram was useful for modelling information on the domain of PME in terms of entities organised in classes and associations between them. Basically, each class in the UML class diagram is a graphical entity that captures nuances of information, including a unique name, attributes (name, multiplicity, associated type and value) and operations associated with the class. Consequently, the use of UML modelling provided a visual tool for specifying PME data in a simple and consistent manner devoid of any ambiguity and in conformity with industry standards.

Fourth, the deployment of the PROME service system on the cloud infrastructure is a contribution to the growing trend of sharing scarce computing resources. This is particularly significant for project-oriented business applications targeting marginalised communities that often experience poor digital infrastructure. Additionally, the use of free cloud hosting services provided by Google was a boost for this implementation and deployment process. However, it is important to adhere to cloud security, privacy, legal, data recovery policies and standards to forestall any loss of PME data. These issues should be comprehensively addressed and enforced via a negotiated SLA document. By and large, the use of a cloud platform has radical implications for the PME enterprise and the community, fashioning endless opportunities and facilitating the frugal, responsive and co-operative use of computing resources.

4.5 CONCLUSION

This chapter has presented the process specification, data specification, implementation of the PROME service system and its deployment on the cloud platform. The aim was to translate the components of the proposed To-Be PME model presented in chapter three into a practical service system. Thus, the proposed To-Be PME model was decomposed into six components using goal-oriented approaches. In other words, this chapter has transformed the six components of the proposed To-Be PME model into business processes that constitute the PROME service system through a systematic process specification. The study adopted the ProcessMaker® open source BPMS to specify the processes of the system. To store PME data, the data specification was developed to characterise the PME entities using the standard UML class diagram notation. This provided a simple graphical, standard and unambiguous way to communicate the understanding of the PROME database. Subsequently, the chapter delved into the implementation of the PROME service system using the ProcessMaker®. This implementation approach distinguishes the PROME service system from the traditional function-oriented approaches. Finally, this chapter has discussed the deployment of the PROME service system on the cloud infrastructure. This effectively sets the stage for chapter five, which tackles the evaluation of the PROME service system.

5 EVALUATION OF PROME SERVICE SYSTEM

We all need people who will give us feedback.
That's how we improve. ~ **Bill Gates**

This chapter discusses the evaluation of the PROME service system artefact that was developed in this study. The PROME service system artefact was conceptualised, modelled and developed as a contribution to the aim of this study, which was to develop an innovative e^3-*value* ontology-based service system to cause a sustainable change in the process of PME of community development projects. The PROME service system was conceptualised as an innovative way to manage the process of PME through a value-based service system. This system has the potential to improve the participation of actors involved in the PME process, thereby transforming into a more participatory and sustainable venture. The overarching aim of conducting the evaluation was to gauge the usability attributes of the system and by implication, the functionalities of the service system. Thus, a criteria-based and expert-driven evaluation of the service system in a laboratory setting to gather data on the usability of the artefact as a viable tool for improving the process of PME. Therefore, this chapter presents a theoretical foundation for the use of criteria-based evaluation criteria in section 5.1. Thereafter, section 5.2 discusses the evaluation procedure, while section 5.3 presents the actual evaluation results. Section 5.4 presents a comparative analysis of the functionalities of the existing PME systems and the PROME service system, while section 5.5 presents the lessons learned from this process. Finally, a conclusion of this evaluation process is presented in section 5.6.

5.1 CRITERIA

The criteria-based evaluation is one of the most popular approaches in evaluation research in the field of information systems, especially in accessibility, usability and standard verification studies (Parhizkar and Comuzzi, 2017; Olugbara and Ndhlovu, 2014; Chen *et al.*, 2011; Olugbara *et al.*, 2010). A criteria-based evaluation strategy comprises the evaluation criteria, variables, tools, mechanisms and procedures. This strategy helps in authenticating the implementation of a software artefact as well as the standard and enduring sustainability of the operating environment (Di Martino *et* *al*., 2017; Sage *et al*., 2015). This is achieved by specifying the priority of each criterion and translating it into quantifiable value. As a rule of thumb, all the criteria and constituent questions should be comprehensively outlined for subsequent use in baseline criteria-based evaluation and a catalogue for deliverables (Di Martino *et al*., 2017).

The criteria-based evaluation provides a gauge of the quality of a software in many areas, such as *usability, sustainability* and *maintainability* (Gumussoy, 2016; Becker *et al*., 2016; Hussain and Mkpojiogu, 2015). Usability has been described as the degree to which a software artefact can be used by a certain user to comprehensively accomplish defined objectives according to the prevailing situation (Abran *et al*., 2003). As a significant feature of software quality, usability influences the software's acceptability level (Gumussoy, 2016). Thus, usability relates to the system's rememberability, efficiency, learnability, recoverability and user satisfaction. Usability yields numerous benefits, including reduced human errors, reduced training expenses, cost-effective system design (stemming from making early changes), reduced user support and enhanced user output (Gumussoy, 2016; Rusu *et al*., 2015).

The concept of software *sustainability* has two discrete perspectives namely, sustainable software (philosophies, procedures and praxes associated with software longevity, that is techno-sustainability) and software engineering for sustainability (SE4S) (promoting environmental sustainability in diverse spheres of software use, rather than enhancing the sustainability of the software or ICT) (Penzenstadler, 2013). Thus, the software sustainability literature recognises the relevance of both perspectives in defining the following five interconnected dimensions of sustainability (Becker *et al*., 2016; Becker *et al*., 2015; Lago *et al*., 2015; Becker *et al*., 2014). (1) The *environmental* dimension advocates for the responsible use of natural resources to avoid exhaustion or dilapidation to support long-term environmental quality. (2) The *technical* dimension describes the endurance and evolution of information, systems and infrastructure in a dynamic environment. (3) The *individual* dimension refers to the welfare of individuals, such as holistic health, education, liberty, self-worth and flexibility. (4) The *economic* dimension emphasises equipment and resources used for creating goods and services (5) The *social* dimension comprises communities and components of mutual trust in the community.

Software maintainability can be categorised as corrective, perfective, preventive and adaptive (Frantz *et al*., 2016; Shridhar *et al*., 2014). Corrective maintenance is done to rectify flaws that may curtail the normal operation of a software artefact. Perfective maintenance is conducted to modify a software artefact to improve its performance or maintainability. Preventive maintenance is performed to increase reliability or maintainability to avert any glitches in the future. Adaptive maintenance involves modifying the software artefact to withstand changes in the new software environment. According to Hussain and Mkpojiogu (2015), software maintainability is dictated by changeability (the energy required to modify the software), stability (the extent to which a software artefact can avert undesirable consequences in the event of modification, analysability (the capability to discern faults) and testability (the energy to validate the software artefact after modification). The foregoing discourse demonstrates that the goal of evaluation is to verify whether the software artefact and its development process, meet the standards of a maintainable software. Therefore, a software that shows higher standards of quality is more maintainable (Jackson *et al*., 2011).

The use of subject experts provides an opportunity to gauge different scenarios through a practical approach that improves the feasibility of a software artefact (Parhizkar and Comuzzi, 2017). Theoretically, each expert is allocated an individual session to conduct an evaluation of the software artefact. In most cases, the software developer begins by demonstrating the workings of the system using a running scenario. The subject expert is then invited to conduct more scenarios independently and asked to provide feedback in the form of a survey. Usually, the survey is based on the dimensions of technology acceptance model (system usefulness, ease of use, ease of learning and satisfaction with the system) (Parhizkar and Comuzzi, 2017; Abgaz, 2013).

5.2 PROCEDURE

This study commissioned a total of twenty information technology (IT) experts through an invitation to voluntarily participate in the evaluation process. The decision to use subject experts was supported by Parhizkar and Comuzzi (2017). The IT experts consisted of masters, doctoral and post-doctoral researchers in the IT department of the University where this study was carried out. The experts yielded twenty test cases whereby each expert provided data based on the evaluation criteria. During the test case, each expert undertook a test procedure derived from the PROME service system by capturing, viewing and modifying project data; descriptive variables; analytical variables; PME service; service provider; service provision; claiming benefits; approval of claims and paying approved claims for projects documented by individual experts. This study employed a survey tool consisting of 5-point Likert scale-based effectiveness, usefulness, ease of use, learnability and satisfaction questions. The live-user laboratory evaluation of the proposed PROME service system was conducted to allow for *more control* over the testing procedure, *convenience* and to *lower the costs* of experimentation (Olugbara and Ndlovu, 2014). This view of employing a laboratory setting as an evaluation site for the service system was supported by Olugbara *et al.* (2010).

5.3 RESULTS

This section presents the results of a usability study obtained using the survey instrument, which was administered to twenty respondents. The data were used to obtain frequencies, mean scores and standard deviations of Likert scale-based user scores to provide clues to the five dimensions of the criteria-based system evaluation. The percentage scores for each Likert scale are provided together with the number of respondents who subscribed to each of the scores enclosed inside the brackets. Table 5.1 below shows that the results obtained from the survey are generally favourable. The standard deviation values obtained for individual items are low, which indicate that the individual scores are close to the mean scores for each item of evaluation.

TABLE 5.1: RESULTS OF A USABILITY STUDY OF PROME SERVICE SYSTEM

N	Criteria	Percentage response for each criterion					Statistics	
	Effectiveness	**1**	**2**	**3**	**4**	**5**	**Mean**	**Stdev**
1	I needed much help to use the system.	35% (7)	40% (8)		25% (5)		2.15	1.18
2	I found the system difficult to use despite help received.	40% (8)	45% (9)	5% (1)	10% (2)		1.85	0.93

3	I found the provided features of the system well integrated.		10% (2)	15% (3)	25% (5)	50% (10)	4.40	1.00
	Usefulness	**1**	**2**	**3**	**4**	**5**		
4	The system is useful.			5% (1)	55% (11)	40% (8)	4.40	0.60
5	The system makes the things I want to accomplish easier to get done.		5% (1)	10% (2)	60% (12)	25% (5)	4.10	0.80
6	The system does everything I would expect it to do.		5% (1)	15% (3)	65% (13)	15% (3)	3.90	0.70
7	The system saves me time when I use it.	5% (1)		15% (3)	50%(10)	30% (6)	4.00	1.00
	Ease of use	**1**	**2**	**3**	**4**	**5**		
8	The system is easy to use.	5% (1)		15% (3)	45% (9)	35% (7)	4.10	1.00
9	The system is simple to use.	5% (1)	5% (1)	10% (2)	45% (9)	35% (7)	4.00	1.10
10	The system is user-friendly.	5% (1)	5% (1)	5% (1)	55% (11)	30% (6)	4.00	1.03
11	The system uses the fewest steps possible to accomplish what I want to do with it.		5% (1)	5% (1)	65% (13)	25% (5)	4.10	0.70
12	Using the system is effortless.		5% (1)	25% (5)	50% (10)	20% (4)	3.90	0.80
13	The system allows me to recover from mistakes quickly	5% (1)	5% (1)	45% (9)	30% (6)	15% (3)	3.45	1.00
	Learnability	**1**	**2**	**3**	**4**	**5**		
14	The system is easy to remember how to use.	5% (1)	5% (1)	20% (4)	45% (9)	25% (5)	3.08	1.06
15	I learnt to use the system quickly.		5% (1)	10% (2)	50% (10)	35% (7)	4.15	0.81
16	The system is easy to learn to use.		5% (1)	5% (1)	50% (10)	40% (8)	4.25	0.79
	Satisfaction	1	2	3	4	5		
17	I am satisfied with the system.		15% (3)	15% (3)	45% (9)	25% (5)	3.80	1.01
18	The system interface is simple to use.	5% (1)	5% (1)	10% (2)	45% (9)	35% (7)	4.00	1.10
19	The system works the way that I expected.		5% (1)	25% (5)	45% (9)	25% (5)	3.90	0.90
20	The system is pleasant to use.		10% (2)	5% (1)	50% (10)	35% (7)	4.10	0.91
21	I would recommend the system to other users.	5% (1)		5% (1)	35% (7)	55% (11)	4.40	1.00

Legend

N					
Number	Strongly disagree	Disagree	Neutral	Agree	Strongly agree

[redacted] Effectiveness

In terms of system effectiveness evaluation, the favourable scores for the three items show that the PROME service system incorporates a considerable number of requirements necessary for solving some of the intrinsic challenges of PME such as project documentation and service provisioning. Most of the respondents reported that they did not require much help to use the system as they could easily navigate between processes, activities and tasks such as capturing, viewing and modifying project data. This argument was buttressed by most respondents who reported that they did not find the system difficult to use after receiving help. Additionally, most of the respondents reported that they found the system well integrated by the infusion of service components into the conventional PME process to create a paradigm shift in the process of PME. Specifically, system integration was achieved by (a) aggregating related components into PME processes and maintaining utmost congruency between them, for instance, the service provisioning process incorporates elements of project documentation (project identity and name) and elements of PME service (date, actor identity, units); (b) showing that the aggregates of the implemented process elements accomplish the intended functions and satisfies the requirements of measures of effectiveness, for instance, during the service provisioning process, it is possible to conduct cross-table queries to retrieve the desired details; (c) pre-empting possible faults relating to system design and resolving them, for instance by providing autogenerated data to minimise typing. Figure 5.1 shows the graphical illustration of system effectiveness responses.

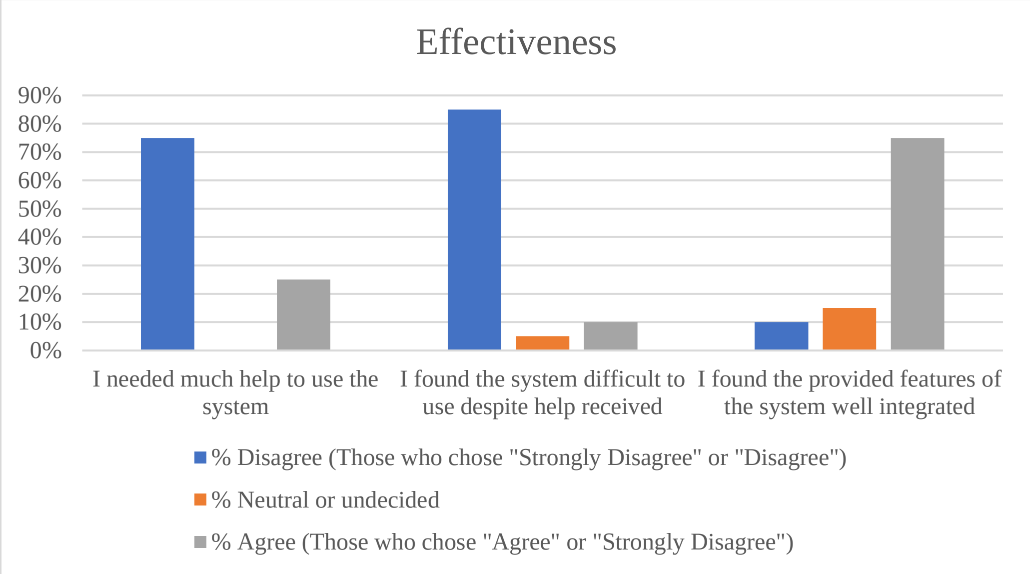

FIGURE 5.1: GRAPHICAL ILLUSTRATION OF SYSTEM EFFECTIVENESS RESPONSES

[redacted] Usefulness

The usefulness of PROME system can be attributed to the eighteen PME processes it contains. The PME business processes are a fusion of core PME practices and an innovative service system dimension, something that respondents found riveting, exciting, useful and innovative. This should explain the favourable responses for items 4 to 7 in the table. Most of the respondents reported that the system provided a mechanism for capturing and manipulating essential information about the entities involved in the process of PME. Further, the usefulness of the system was accented by time-saving aids such as autocompletion, autoformatting and placeholder texts to provide clues for the required data in a textbox. Figure 5.2 shows a graphical illustration of system usefulness responses.

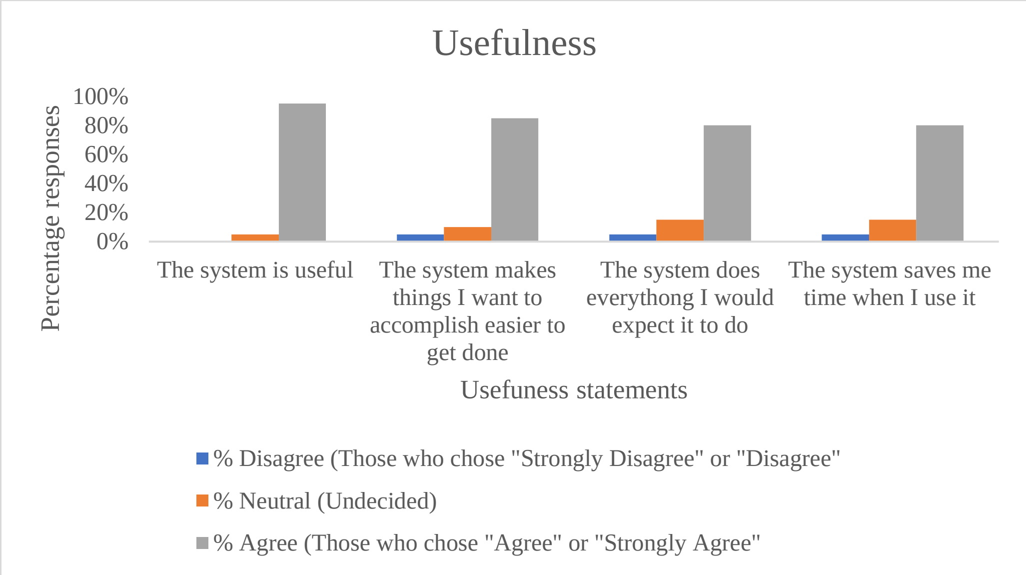

FIGURE 5.2: GRAPHICAL ILLUSTRATION OF SYSTEM USEFULNESS RESPONSES

[redacted] Ease of use

The ease of use principle consisted of six items of evaluation, which made it the largest block of evaluation. A vast array of system attributes relating to its graphical user interface (GUI) has contributed to its ease of use in several ways as follows. First, the interface has a *simple* outlook in terms of colour, layout, font, buttons and text boxes. Second, the interface provides *clear* and short labels for buttons and actions such as submitting a form; simple messaging such as “No matching record found”; and navigation features. Third, the system interface exhibits a *consistent* look and feel in terms of language, layout and sufficient spacing between texts and fields. For example, the submit button is used for saving forms throughout the system. Four, the system uses *familiar* metaphors that makes it easy for users to associate system tasks with everyday objects. For example, an symbol of a file is used to represent a computer file while a recycle bin is used to denote a delete operation. Fifth, *visual hierarchy* was achieved by using varied sizes for font, textboxes and headings to denote the significance of system elements. Sixth, *efficiency* was achieved by using quick objects, such as radio buttons to minimise the amount of energy spent by users. The system has also attempted to provide clues to tasks where necessary, through placeholder texts for certain fields that require clues as well as auto-generating certain fields to reduce incidences of omission errors. Significantly, longer processes have been meticulously split into smaller forms that are easy to manoeuvre by pointing to the next task in a process. For instance, the project registration process consists of three seamlessly integrated forms, which are “basic project data”, “descriptive variables” and “analytical variables”, to reduce the effort expended during a transaction. Seventh, the system interface was designed to be *responsive* by providing feedback to users. For example, the system buttons respond to a click. Figure 5.3 shows the graphical illustration of system ease of use responses.

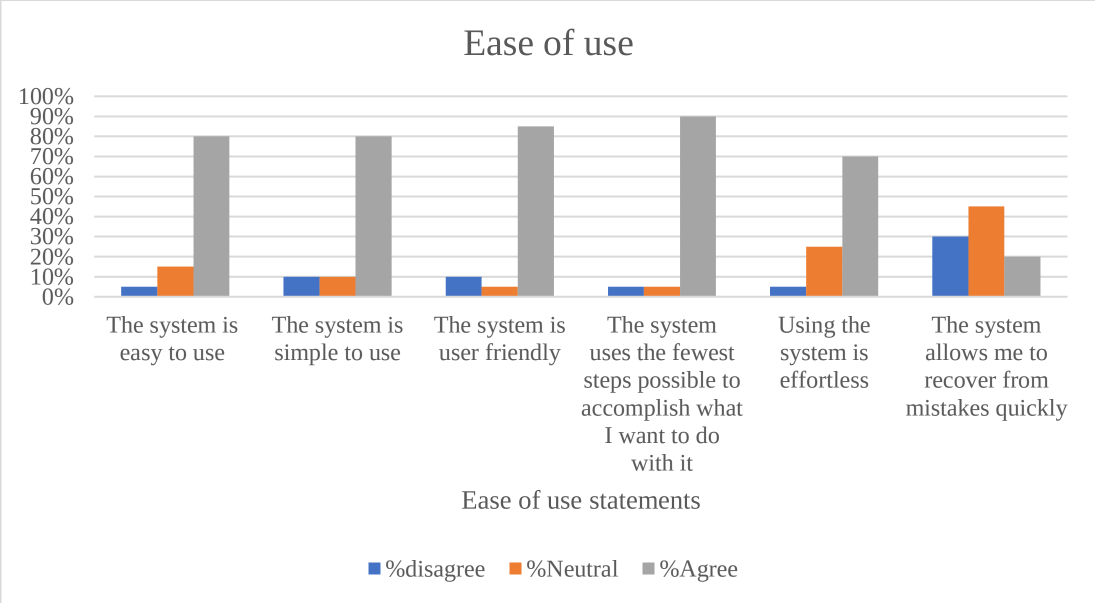

FIGURE 5.3: GRAPHICAL ILLUSTRATION OF SYSTEM EASE OF USE RESPONSES

[redacted] Learnability

Learnability of the system was partly aided by the good system interface, which has largely been described in the previous section. Notwithstanding the time constraints, these preliminary responses on learnability (attributes 14-16) are promising. These attributes mainly relate to *initial* learning, which describes their first interaction with the system. Most of the respondents reported that they learnt to use the system *quickly*; that the system was *easy* to learn to use; and that it was easy to *remember* how to use the system (although the duration for interaction was restricted). For example, users found it easy to learn how to register a PME service, provide a PME service, file a claim, process that claim and make payment because this model of compensation is borrowed from the standard accounting model that is used in business transactions (sustainability). Additionally, the users were able to easily grasp the importance of value co-creation in the system that dictates that each actor must play his or her role to create an *ideal* situation in the process of PME. For instance, if the project leader fails to approve the claims then the claimant is bound to suffer delays or disgruntlement, which constitutes a *sub-ideal* situation leading to loss of value (Tan *et al*., 2011). However, it was not possible to conduct repeated trials of the system over a longer period to gauge the *extended learning* attributes because of limited time. This could be conducted at a later stage to provide more insights into the learnability aspects of the system. Figure 5.4 shows the graphical illustration of system learnability responses.

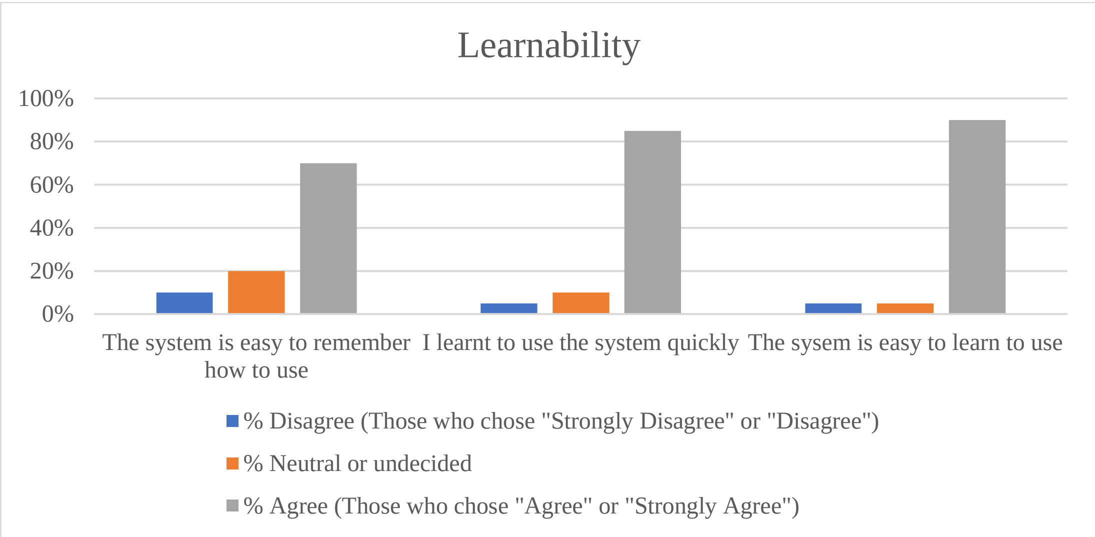

FIGURE 5.4: GRAPHICAL ILLUSTRATION OF SYSTEM LEARNABILITY RESPONSES

[redacted] Satisfaction

The responses obtained for user satisfaction indicate that there was a limited discrepancy between the expectation of respondents and practical experience of the system operation. The former was established by conducting a 30-minute lecture and laboratory demonstration of the system while the latter was achieved by allowing the users to practically operate the system. In this manner, they were able to gauge any gulf between the two states. In a way, user satisfaction was viewed as a surrogate measure of other measures. For example, a satisfaction item such as "the system works the way that I expected" could be traced to the evaluation of effectiveness, while "the system interface is simple to use" could be traced to both ease of use and learnability of the system. Figure 5.5 shows a graphical illustration of system satisfaction responses

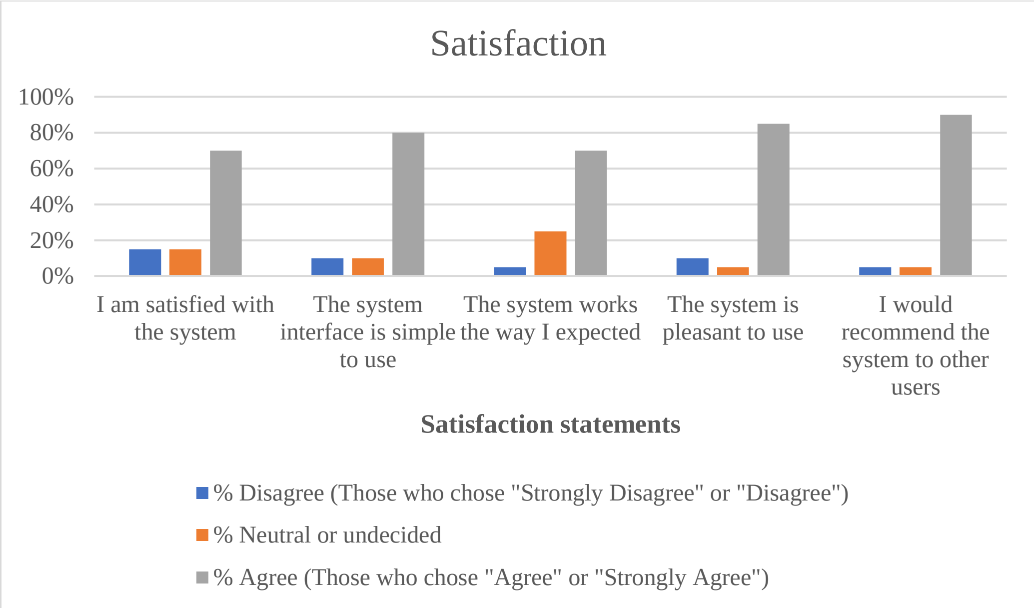

FIGURE 5.5: GRAPHICAL ILLUSTRATION OF SYSTEM SATISFACTION RESPONSES

5.4 A COMPARISON OF EXISTING SYSTEMS AND PROME SERVICE SYSTEM

An evaluation was undertaken to demonstrate how the distinctive functionalities of the PROME service system compare with those of the extant PME systems. This comparison was based on diverse aspects such as classification, examples, strengths and weaknesses. The service system functionalities supported by each PME system were then ascertained based on the highlighted strengths and weaknesses. These functionalities include *digital resilience*, *project documentation*, *value co-creation*, *sustainability*, *service re-engineering* and *process-oriented implementation*. This analysis is presented in Table 5.2.

TABLE 5.2: A SUMMARY OF DISTINCTIVE FUNCTIONALITIES OF EXTANT PME SYSTEMS

Classification of PME System	Strengths	Weaknesses	Service System functionalities supported
Active community engagement systems (Crowdsourcing; real-time simple reporting;	Cost-effective collection of enormous, real-time data; increased public involvement through a bottom-up strategy;	Demands incentives to motivate the public to participate; requires customisation to suit different scenarios	**Value co-creation** through public participation; **project documentation** using back-end computer systems; **digital**

participatory statistics; mobile data collection; micro-narrative)	enhances the integrity of data.		**resilience to** navigate different application scenarios
Passive community engagement systems (Data exhaust; intelligent infrastructure; remote sensing systems)	Minimal effort required for data collection; supports data mining	Biased in favour of the elite members of the community	**Project documentation** using remotely controlled computer systems; **digital resilience** to cope with sophisticated remote sensing technologies. **Note:** It favours of elite members thus negates the concept of value co-creation
Participatory systems for enhancing usefulness and accessibility of PME data (Data visualisation)	Creates visual data that is easy to comprehend and utilise; visual contexts reveal unclear trends and simplify intricate patterns in PME data	Expensive and time intensive to manage; requires customisation to suit different circumstances; prevalence of visual noise; loss of information; limitations of aspect ratio, resolution and physical perception; fluctuation of image quality	**Project documentation** using sophisticated back-end tools and visualisation software; **Digital resilience** to cope with sophisticated data visualisation technologies **Note:** It favours elite members thus negates the concept of value co-creation
Progressive PME systems (Multi-level mixed evaluation method; outcome harvesting)	Improved authenticity, consistency and variety of results; improved understanding of precarious issues; yields unforeseen results; provides various possibilities for triangulation of techniques and methods	The need for expertise in qualitative and quantitative techniques and multi-criteria evaluation and a circumspect	**Project documentation** using sophisticated back-end qualitative and quantitative analysis tools; **Digital resilience** to cope with sophisticated technologies; **Note:** It is complex and thus favours elites thus, it negates the concept of value co-creation

Generally, the data presented in Table 5.2 shows that shows that there is a significant lack of the value-driven service system approach to the development of the existing PME systems. This has been exemplified by the fact that most of the PME systems exhibited three functionalities of digital resilience, project documentation and value co-creation. The other functionalities of value-based service re-engineering, sustainability and process-oriented implementation were generally lacking.

This data was derived from the current PME literature showing recent advances in PME systems (for example, Amini *et al*., 2018; Liu *et al.*, 2018; Zhang *et al*., 2018; Bakhache *et al*., 2017; Bretan and Engle, 2017; Castelnuovo and Tran, 2017; Cordeil *et al*., 2018; Eickhoff , 2018; Frohn and Lopez, 2017; Hou and Chen, 2017; Hox *et al*., 2017; Kirby *et al*., 2017; Mottelson and Hornbæk, 2017; Oliveira *et al*., 2017; Pearson *et al*., 2017; Rotich, 2017; Schobel *et al*., 2017; Schobel *et al*., 2016; Qadir *et al*., 2016; Van Hemelrijck, 2016; Pearce *et al*., 2014; Hellström and Jacobson, 2014; Masset, 2014). It is instructive to note that these developments have been reported in leading scientific publications. Thus, this analysis may be construed as a *modest* scoping review of the status of development in the PME enterprise. Arguably, any PME system that seeks to improve the process of PME process should offer capabilities that go beyond those exhibited by the existing systems. This argument can be used to buttress the case for the development and evaluation of the PROME service system to offer capabilities that go beyond the ambit of the existing systems to offer a viable solution to some of the intrinsic limitations of the existing PME systems *within the context of the service economy.* To meet this need, the PROME service system embraces the essential functionalities of digital resilience, project documentation, value co-creation, sustainability, service re-engineering and process-oriented approaches.

5.5 LESSONS LEARNT FROM SYSTEM EVALUATION

This chapter yielded three significant lessons for this study. The first lesson stemmed from the theoretical foundation of the criteria-based approach to evaluating the usability of the artefact. There are various approaches to evaluating usability and these approaches are dictated by resource constraints (manpower, time and equipment), evaluator attributes (knowledge, aptitude and penchant) and the development cycle of the artefact. These approaches include (a) *user-driven* where test cases are derived from a sample of the envisioned users; (b) *expert-driven* that engages usability experts to assess the artefact; (c) *model-driven* where a usability expert utilises formal techniques to predict the criteria of user performance (Arnhold *et al*., 2014; McNamara and Kirakowski, 2006). Each of these approaches is associated with distinct strengths and weaknesses that impact their efficacy. However, it has been shown in section 5.2 that the expert-driven approach has gained significant interest in the system evaluation literature because it is convenient, cheaper and gives the researcher more control over the evaluation procedure (Olugbara and Ndhlovu, 2014). Thus, the choice of the expert-driven approach for evaluating the artefact was in tandem with industry standards.

The second lesson learnt was the *functionality-usability-user experience* nexus. Functionality describes the technical aspects of a software artefact by stating what the artefact *does*. Usability describes the *interaction* between the user and the software artefact. The user experience explores the broader connection between the user and the artefact to ascertain the individual's *personal* experience of using it (Abrahão *et al*., 2017; Hedegaard and Simonsen, 2013; Park *et al*., 2013; McNamara and Kirakowski, 2006). However, it has been shown in the evaluation literature that these three elements are interdependent. For instance, usability is not a software attribute but software attributes, such as the level of functionality and how the features are implemented invariably influence its usability (Abrahão *et al*., 2017; McNamara and Kirakowski, 2006). Usability studies have also indicated that the aesthetic aspects of a software artefact can impact perceived usability before the actual use. Moreover, the look and feel of a software artefact can influence the user experience because users identify with and pass covert messages via the software brands they purchase and use (Garg *et al*., 2017). Equally important is the fact that usability impacts the user experience (Álvarez-Xochihua *et al*., 2017). As such, a low usability rating would yield an unsatisfactory user experience, which in turn would probably dissuade continued application of the software artefact or the proclivity to purchase from another vendor (Abrahão *et al*., 2017; McNamara and Kirakowski, 2006). Consequently, this chapter has shown that the evaluation results obtained conform to the *functionality-usability-user experience* nexus. To underscore this assertion, the following usability constructs have been selected from this study for the sake of illustration:

1) The system *does* everything I *expect* it to do (usefulness).
2) The system allows me to *recover* quickly from *mistakes* (ease of use).
3) The system uses the *fewest possible steps* to accomplish *what I want it to achieve* (ease of use).

The results for these three constructs and all the other constructs used in this evaluation revealed that there is a degree of interdependency between usability and functionality of the PROME service system as shown in sections 5.3.1 to 5.3.4. For example, the scores for "the system *does* everything the I *expect* it to do" (usefulness) were favourable because the experts found it *suitable* or *appropriate* (functionality) for various tasks such as project documentation and service provisioning. Overall, these associations forebode a fulfilling user experience for users of the service system.

Finally, the third lesson learnt from this chapter emanated from a comparative analysis of the existing PME systems and the PROME service system. This analysis revealed the significant absence of value-driven service functionalities in the existing PME tools. This revelation provided an impetus for communicating the understanding of the novelty of the PROME service system as an integration of six components to cause an innovative change in the process of PME.

5.6 CONCLUSION

The overarching aim of this chapter was to provide useful quantitative and qualitative insights into the suitability of the PROME service system as an artefact for improving the process of PME. The chapter began by presenting the theoretical foundations that provided an impetus for using a criteria-based approach for system evaluation. From this theoretical back, it was revealed that criteria-based evaluation of software artefacts is a popular approach for evaluating service systems. This was followed by a description of the evaluation procedure, which consisted of twenty test cases provided by ICT experts during in a live-user laboratory set up. This was supported by the exisiting software evaluation literature that showed that expert-driven approaches yield incisive and constructive results in a laboratory setting. The criteria-based evaluation employed in this process returned favourable responses for each of the five dimensions of usability in this survey. The usability attributes reflect the functionality of the system as presented in section 5.3 and further contextualised in section 5.5. Additionally, a comparison between the existing PME systems and PROME service system was undertaken to determine the contribution of the artefact to solving some of the intrinsic challenges facing the process of PME within the context of the service system. This comparison showed that the PROME service system provides a new paradigm in terms of the six fundamental components that it incorporates.

Generally, it can be concluded that the aim of evaluating the artefact was achieved. The researcher was able to administer a survey instrument to gather sufficient data relating to effectiveness, usefulness, ease of use, learnability and satisfaction with the system's contribution towards improving the process of PME. The live-user laboratory sessions provided an opportunity for demonstrating the dynamics of ICT-driven solutions aimed at solving the intrinsic challenges facing the process of PME. Thus, the idea of adopting value-based service concepts to develop an innovative service system for improving the process of PME was deemed to have been favourably demonstrated and evaluated (see research objectives number three and four of the study). This leads to Chapter six that presents study findings, recommendations and epilogue.

6 SUMMARY OF MAJOR FINDINGS, RECOMMENDATIONS AND EPILOGUE

Nature's music is never over; her silences are pauses, not conclusions. ~ **Mary Webb**

6.1 SUMMARY OF MAJOR FINDINGS

To provide a summary of the major findings of this study, answers to the central and the guiding research questions for this research work have been provided. The central research question was enunciated as follows:

> *How can this study develop an innovative service system for participatory processes of community development projects?*

In this thesis, the development of PROME service system as an innovative service system for PME was premised on a methodical review of the extant PME literature in chapter two. The researcher provided a contextual framework for this innovation by discussing the fundamental aspects, trends and intrinsic challenges associated with community development, participatory processes of community development projects, service systems, VBRE, process-oriented implementation of service systems, MCC, evaluation of service systems and digital resilience. As revealed from this review, these eight themes have been richly interwoven to form the fabric of the research study as follows. The role of community development has been explored as a panacea for sustainable development to improve the welfare of marginalised communities. This ultimately led to the realisation of participatory project monitoring and evaluation as an impetus for the sustainability of community projects. Subsequently, the service systems literature was explored as a new dimension for improving the process of PME. The discourse then shifted to the VBRE as a novel perspective for building value-based service systems. A process-oriented implementation of the proposed value-based service system was preferred to the traditional functional approaches to re-engineer business processes. The use of MCC as a platform for deploying a service system for project monitoring and evaluation was then explored. Additionally, the chapter explored literature on service system evaluation using metrics founded on

TAM. Lastly, the study explored the significance of digital resilience as an integral component for shaping the successful adoption and exploitation of digital products (service systems) in a dynamic service economy.

The conceptual foundation realised in chapter two led to the exploration of the VBRE using the redesign model as a viable methodology for developing an innovative and sustainable model for improving the process of PME. To support the central research question and subsequently arrive at the desired goal, the study formulated a set of *guiding research* questions based on the redesign model (Tan *et al*., 2011). These guiding questions were crucial in mapping the results obtained using *e*^{3}*-value* analysis against conceptual foundations to give clues on the achievement of the overarching research goal. Hence, the *guiding* research questions were derived from the redesign model as follows:

1) Guiding research question one - How can the current participatory processes of community development projects be conceptualised and transformed into an innovative service system?
2) Guiding research question two - What conceptual models and tools would be suitable to design a service system for facilitating innovative participatory processes of community development projects?
3) Guiding research question three - What set of innovative services would this service system offer for facilitating the participatory processes of community development projects?
4) Guiding research question four- How can this study use this service system to provide support for participatory processes of community development projects?

[redacted] Preliminary analysis

How can the current participatory processes of community development projects be conceptualised and transformed into an innovative service system?

To address this research question, the current As-Is PME process was explored to discover its weaknesses. As shown in Figure 3.1, the current As-Is situation of PME is centred on the project manager who orchestrates every activity in the process of

PME. The project leader is the custodian of all the data generated by the system in a centralised model and thus enjoys the benefits of focused vision, faster execution, reduced conflict, better control and accountability. However, from a value perspective, this model leads to less collaboration and participation amongst actors, which may lead to less empowerment, learning, value co-creation and reduced value exchange. Although collaboration amongst actors may improve value co-creation and exchange among actors, it may not necessarily solve all the challenges facing actors, including resources, perceptions and power (Baur *et al*.,2010; Parkinson, 2009). Additionally, the current As-Is PME process lacks triangulation of data sources that may lead to the generation of less valid data, given the limitations of time and space for interaction between actors. Furthermore, in cases where the process of PME is largely paper-based, heavy documentation may often result in a myriad of challenges, including lack of data security, limited access to data and poor reporting facilities. Another significant weakness is that the current As-Is PME process lacks a sustainable mechanism for motivating beneficiaries to provide PME data. In the PME literature, there exists no model with a provision for compensating actors for value objects exchanged during the process of PME. This has been adequately proven in section 5.4. In isolated cases where some form of compensation is given, the project leader may give a token of appreciation to some actors for excellence. However, this compensation may not be commensurate with the amount of effort expended during the process of PME.

[redacted] Control problem identification and control mechanism redesign

What conceptual models and tools would be suitable to design a service system for facilitating innovative participatory processes of community development projects?

This research question combined the second and third steps of the redesign model (see section 3.2 and section 3.3 respectively) To answer the *control problem identification* segment of this research question, a process-level analysis of the PME process was undertaken (Figure 3.3), which revealed the following:

1) Actors may lose value when the process of PME is not streamlined; for instance, when the PME plan is missing confusion may arise.

2) Actors may lose value through negligence and oversight during the process of PME; for instance, by failing to complete a task or submitting a PME survey.

3) Actors may lose value through lack of motivation; for instance, owing to the lack of adherence to the principle of *economic reciprocity*, whereby one actor fails to offer something of value in return for a value object received.

4) Actors may lose value by exclusion in the absence of a collaborative and participatory framework for PME.

5) Actors may lose value because of documentation challenges associated with PME, especially for paper-based models of PME, which are often associated with issues, such as insecurity, inaccessibility and less productivity.

As part of the *control mechanism redesign* (see section 3.3), this study has proposed solutions to the limitations identified in section 3.2. This solution is the proposed To-Be PME model. The study introduced the concept of a mobile cloud service system to cause a paradigm shift in conducting the process of PME. The proposed To-Be PME model introduces:

1) A mechanism for *digital resilience*, which enables PME actors to effectively navigate the landscape of ICT-driven solutions aimed at improving the process of PME process.

2) A mechanism for efficient *project documentation* on at least four key aspects, which are actor registration, project registration, project monitoring and project evaluation**.**

3) A mechanism for *service re-engineering* of the PME process to capture and manipulate aspects of service provider registration, service registration and service provisioning.

4) A mechanism for *economic sustainability* by providing compensation for PME services exchanged among actors based on the principle of economic reciprocity, which makes it sustainable.

5) A mechanism for *value co-creation* by adopting a collaborative and participatory approach to PME thereby enriching the process through mutual understanding, ownership and commitment to the process.

6) A *process-oriented* approach for system implementation depicting a wide range of scenarios whereby value objects are exchanged amongst diverse actors. These processes are classified as core, support and management. The system was deployed on a cloud platform to exploit numerous benefits such as such as flexibility, scalability and real-time accessibility on multiple platforms.

[redacted] Development of PROME Service system

What set of innovative services would this service system offer for facilitating the participatory processes of community development projects?

This research question tackles the development of the PROME service system. To answer this research question, a *process specification* of the PROME service system was derived from the six components of the proposed To-Be PME model. The process specification was presented in section 4.1.1. Additionally, a data specification using a UML class diagram was presented in section 4.1.2. Together, the process and data specification formed the specification of the PROME service system.

The second element of this research question was the *implementation* of the PROME service system. The study provided a justification for the use of a process-oriented approach for the implementation service system in sections 2.5. The key tenet of this justification was the need for an effective and efficient mechanism for improving the process of PME as means to navigate an increasingly competitive business environment (Pourmirza *et. al.,* 2017). This implementation was then *actualised* in section 4.2. The study provided a rationale for the choice of the ProcessMaker® as an appropriate open source BPMS for developing PROME system owing to its various strengths outlined in section 4.2. During the implementation phase, the following processes were created using the ProcessMaker® opensource BPMS to support the process of PME. The processes include PME actors, project registration, view or modify project details, project descriptive variables, project analytical variables, project monitoring, project evaluation, service registration, view or modify service details, service provider, view or modify service provider details, service provision, view or modify service provision details, claims application, view or modify claims details, claims approval, claim status check, claims payment. The system was then deployed on the Google cloud using the Bitnami Launchpad for Google cloud platform based on its suitability as a free host; a robust infrastructure, good data analytics, machine learning capabilities, satisfactory security attributes, customisable features different enterprises and a favourable reputation for promoting open source applications (Jiang *et al*., 2017; Padarian *et al*., 2015).

[redacted] Evaluation of new processes and control mechanism

How can this study use this service system to provide support for participatory processes of community development projects?

This research question tackles the evaluation process of the usability of the developed artefact for conducting the business of PME. As outlined in section 2.7, the evaluation of the PROME service system was guided by two complementary perspectives, namely PROME as an artefact in use and PROME as a bundle of theories. Therefore, this study relied on a live-user experimentation of the PROME service system in a computer laboratory setting to gauge the artefact's usability as a 'living' product. Furthermore, the study probed the bundles of theories that constitute the PROME service system by using an expert-driven, criteria-based evaluation of activities associated with each process to ascertain their veracity. Significantly, the nexus between usability, functionality and user experience was probed and the results presented in chapter conform to this theory. Therefore, the system was adjudged to be usable, functional and has the proclivity to provide a fulfilling user experience on a long-term longitudinal basis (see sections 5.3 and 5.4). To further buttress this assertion, a comparison of the existing PME systems and the PROME service system was conducted through a *modest* scoping review. This review revealed that the existing PME systems generally lack essential functionalities of a service system such as digital resilience, project documentation, value co-creation, service re-engineering, economic sustainability and process-oriented approaches. These functionalities have been proposed for resolving some of the inherent challenges facing the process of PME within the context of a service economy.

6.2 Recommendations of the Study

The following are the recommendations of this study.

Developing an online discussion forum for PROME service system

In anticipation of the ever-changing actor needs, this study recommends the development of an online forum for PME practitioners to exchange ideas on the PROME service system. These ideas could then be applied in improving the system. Additionally, an online forum may be useful for building a library of knowledge about the system by offering a flexible tool for asynchronous engagements that may be difficult to obtain because of complexities of space and time. This online discussion forum may also be useful for developing critical thinking skills, which may be useful in resolving difficult problems.

Developing more test cases for PROME service system

This study recommends the development of more test cases for PROME service system, especially over a longer period. This might be instrumental in handling situations that have hitherto not been envisaged. Such tests should be carefully developed and documented in tandem with the system requirements.

Exploring the performance of the PROME service system on different cloud platforms

It might be necessary to compare the performance of the PROME service system on different cloud platforms and collect valuable performance data, which might inform future cloud hosting decisions. In this respect, this study recommends the deployment and evaluation of the performance of the system on different platforms.

Exploring public-private partnerships

The PROME service system is a novel approach to improving the process of PME. As such, it is necessary to explore public-private partnerships that may lead to its growth. Such public-private partnerships have been credited with enhanced infrastructural resources, expedited project cycles, better return on investments (ROIs), timely appraisal of risks, more efficient government budgets and ventures, lower costs, lower taxes and superior standards (Mouraviev and Kakabadse, 2016; De Schepper *et al*., 2015). However, this should be done with due caution because public-private partnerships may come with increased risks and varying profit levels (Polyakova and Vasilyeva, 2016).

[redacted] Exploring new opportunities for fundraising

It's apparent that the field of ICT is one of the fastest growing sectors in the service economy. With this change comes the need for sustainable research and incubation of nascent ideas to shape innovation. For this reason, it is necessary to explore opportunities for fundraising for further research on the PROME service system. Additionally, there are costs associated with mobile-cloud applications, such as cloud hosting costs, licence charges, telecommunication costs and cost of hand-held devices, which should be financially secured on a long-term basis.

6.3 RECOMMENDATIONS FOR FURTHER STUDY

There were many contemporary issues that arose during the process of conducting this research. These contemporary issues were outside the scope of this study and could not be addressed in this study. In this section, the study discusses these contemporary issues that may require further investigation.

[redacted] Exploring the possibility of translating the PROME service system interface into a local dialect

The success of the PROME service system is hinged on growth in its usage, especially by marginalised communities that development projects often target. However, marginalised communities are prone to language barriers, which may hinder the effectiveness of their participating in the process of PME. Therefore, it may be necessary to customise or translate the system interface language to a desired local language as to meet the needs of such disenfranchised communities. Other approaches to solving this problem include using qualified transcribers, bilingual PME actors and bilingual community development workers.

- **Exploring the possibility of integrating the PROME service system with GPRS / GPS based information systems**

To enhance the PROME service system, research should explore the possibility of integrating it with existing systems and using technologies that have proven successful in delivering location-based services, such as geographical information systems (GIS). With the help of such tools, the system will be location-based data for project monitoring and evaluation in diverse areas, such as planning and housing, emergency response, highways asset management, land and property data.

6.4 EPILOGUE

This study conceptualised and explored the key issues in the process of project monitoring and evaluation as a real-world problem. Subsequently, it developed the PROME service system as a solution to some of these problems in a bid to improve the process. The study employed the underlying principles of VBRE as a novel way to derive value-based requirements specification based on the *e^3-value* methodology for modelling the process of PME. Based on the redesign model and aided by the MEPPP framework, the study explored the current As-Is situation of the PME process and revealed the inherent weaknesses from a value perspective. A proposed To-Be PME model was then realised by introducing the value-based service concept to address the shortcomings of the current process, thereby causing a paradigm shift in the process of PME. The proposed To-Be PME model provided a basis for deriving the requirements specification for developing the service system. Based on this requirements specification, the study successfully implemented and evaluated the PROME service system as an artefact for improving the process of PME. Significantly, the enhancement of collaboration and participation of actors in this process, coupled with the novelty of generating revenue for value objects exchanged between actors have significant implications for the process of PME.

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APPENDICES

APPENDIX I: INTERVIEW SCHEDULE

1. Please indicate your name: * (optional) ________________________________
2. Gender: [ ] Male [ ] Female
3. Age: [ ] 15-19 years [ ] 20-24 years [ ] 25-29 years
   [ ] 30-35 years
4. Highest academic qualification:
   [ ] Below matriculation [ ] Matriculation [ ] Certificate
   [ ] Diploma [ ] Bachelor's Degree

Evaluation of Reactions

No.	Description of measure
A: Youth challenges	
1.	What personal challenges are you currently experiencing at the Kenneth Gardens community?
2.	Why do you think you are experiencing these challenges?
3.	How can you be helped to overcome these challenges?
4.	Do you think information communication technology (ICT) can help you overcome some of these challenges? How?
B: Youth satisfaction	
1.	The attitude of the trainers is good towards me.
2.	The training helps improve my digital skills.
3.	The training helps me to acquire digital skills that will make me more productive.
4.	I will recommend the training to friends.
5.	I will attend the training if organised again.
6	I will spread positive word-of-mouth feedback about the training.
7	I will always make reference to the training for the encouragement I have received.
8	I am satisfied with the lessons taught during the training.

Evaluation of learning

No.	Description of measure
1.	What are the digital skills you possessed before participating in the DAS training workshops?
2.	What digital skills have you acquired as a result of participating in the DAS training workshops?

Evaluation of evidence of learning

No.	Description of measure
1.	Write a short essay recalling what you learnt from the 2014 DAS training workshops and why you have returned to the 2015 DAS training workshops.

APPENDIX II: USABILITY QUESTIONNAIRE FOR PROME SERVICE SYSTEM

Respondent's Name (Optional): ________________Respondent ID: R__

Qualification Registered for: ________________

Key: 1-Strongly Disagree; 2-Disagree; 3-Neutral; 4-Agree; 5-Strongly Agree

No	**Criteria**	**Score**				
	Effectiveness	**1**	**2**	**3**	**4**	**5**
1	I needed much help to use the system.					
2	I found the system difficult to use despite help received.					
3	I found the provided features of the system well integrated.					
	Usefulness	**1**	**2**	**3**	**4**	**5**
4	The system is useful.					
5	The system makes it easier to accomplish things.					
6	The system does everything I would expect it to do.					
7	The system saves me time when I use it.					
	Ease of use	**1**	**2**	**3**	**4**	**5**
8	The system is easy to use.					
9	The system is simple to use.					
10	The system is user-friendly.					
11	The system uses the fewest steps possible to accomplish a task.					
12	Using the system is effortless.					
13	The system allows me to recover from mistakes quickly.					
	Learnability	**1**	**2**	**3**	**4**	**5**
14	The system is easy to remember how to use.					
15	I learnt to use the system quickly.					
16	The system is easy to learn to use.					
	Satisfaction	**1**	**2**	**3**	**4**	**5**
17	I am satisfied with the system.					
18	The system interface is simple to use.					
19	The system works the way that I expected.					
20	The system is pleasant to use.					
21	I would recommend the system to other users.					

APPENDIX III: DATABASE STRUCTURE OF THE PROME SERVICE SYSTEM

1. PROCESS INFORMATION (LOCAL HOST)

ProcessMaker Ver.	3.1-community
PMUI JS Lib. Ver.	0.1.1
MAFE JS Lib. Ver.	HEAD.d6c56d2
PM Dynaform JS Lib. Ver.	3.1.3f6417c
Upgrades/Patches	Never upgraded
Server Address	localhost
Data Base	MySql (Version 5.5.52)
Data Base Server	127.0.0.1
Database Name	bitnami_pm
Workspace	workflow

2. DATABASE DESCRIPTION (LOCAL HOST)

Operating System	(WINNT)
Time Zone	America/New_York
Web Server	Apache
Server IP Address	::1 => Dennis
PHP Version	5.6.26
Available DB Engines	MySql
Server Protocol	HTTP/1.1
Server Port	80
Server Address	::1
User's Browser	Mozilla/5.0 (Windows NT 6.3; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/63.0.3239.108 Safari/537.36

3. PROCESSMAKER TABLE CREATED

3.1 ACTOR REGISTRATION (CUSTOMISED FROM THE EXISTING TEMPLATE)

User Name	Full Name	Status	Role	Last Login
admin	admin, Administrator (admin)	Active	System Administrator	2017-12-21 05:49:41
jmark	Mark, John (jmark)	Active	Manager	2017-12-21 06:00:31
zcaleb	Caleb, Zoe (zcaleb)	Active	Operator	
jkennedy	Kennedy, Jack (jkennedy)	Active	Operator	
ldavid	David, levi (ldavid)	Active	Operator	
aliam	Liam, Abigael (aliam)	Active	Operator	2017-12-21 05:26:00
olucas	Lucas, Olivia (olucas)	Active	Operator	
ajeff	Jeff, Abel (ajeff)	Active	Operator	
dwest	West, Don (dwest)	Active	Operator	2017-07-21 06:00:53
jowen	Owen, James (jowen)	Active	Operator	

3.2 PROJECT REGISTRATION

Table Name (Auto Prefix "PMT_"): PROJECT

Description: Project Details

☑ Keep the records of the table

Warning: 2 record(s) were found in this table. If you edit the structure all data will be lost. [Hide]

Add field | Edit Field | Remove Field

Field Name	Field Label	Type	Size	Null	Primary Key	Auto Increment
PROJECTID	Project ID	SMALLINT		No	Yes	Yes
PROJECTNAME	Project Name	LONGVARCHAR	50	Yes	No	No
PROJECTLOCATION	Project Location	LONGVARCHAR	100	Yes	No	No
PROJECTCOST	Project Cost	DOUBLE		Yes	No	No
PROJECTSTARTDATE	Project Start Date	DATETIME		Yes	No	No
PROJECTENDDATE	Project End Date	DATETIME		Yes	No	No
PROJECTDONOR	Project Donor	LONGVARCHAR		Yes	No	No
PROJECTCOMMISSIONER	Project Commissioner	LONGVARCHAR		Yes	No	No
USERNAME	User Name	LONGVARCHAR		Yes	No	No

3.3 DESCRIPTIVE VARIABLES

Table Name (Auto Prefix "PMT_"): DESCRIPTIVEVARIABLES

Description: Project Descriptive Variables

Add field Edit Field Remove field

Field Name	Field Label	Type	Size	Null	Primary Key	Auto Increment
PROJECTID	Project ID	BIGINT	10	No	Yes	No
DESCRIPTIVEVARID	Descriptive Var ID	BIGINT	10	No	Yes	No
DESCRIPTIVEVARNAME	Descriptive Var Name	LONGVARCHAR	50	Yes	No	No
COMMENTS	Comments	LONGVARCHAR	100	Yes	No	No

3.4 ANALYTICAL VARIABLES

Table Name (Auto Prefix "PMT_"): ANALYTICALVARIABLES

Description: Project Analytical variables

Add field Edit Field Remove field

Field Name	Field Label	Type	Size	Null	Primary Key	Auto Increment
PROJECTID	Project ID	BIGINT	10	No	Yes	No
ANALYTICALVARID	Analytical Var ID	BIGINT	10	No	Yes	No
ANALYTICALVARNAME	Analytical Var Name	LONGVARCHAR	50	Yes	No	No
COMMENTS	Comments	LONGVARCHAR	100	Yes	No	No

3.5 PROJECT MONITORING

Table Name (Auto Prefix "PMT_"): MONITOR

Description: Project monitoring

Add field | Edit Field | Remove field

Field Name	Field Label	Type	Size	Null	Primary Key	Auto Increment
MONITORDATE	Monitoring Date	DATETIME		Yes	No	No
ACTORID	Actor ID	BIGINT		No	Yes	No
PROJECTID	Project ID	BIGINT		No	Yes	No
PROJECTNAME	Project Name	LONGVARCHAR		Yes	No	No
ANALYTICALVARIABLE1	Analytical variable1	LONGVARCHAR		Yes	No	No
ANALYTICALVARIABLE2	Analytical variable2	LONGVARCHAR		Yes	No	No
ANALYTICALVARIABLE3	Analytical variable3	LONGVARCHAR		Yes	No	No
ANALYTICALVARIABLE4	Analytical variable4	LONGVARCHAR		Yes	No	No
ANALYTICALVARIABLE5	Analytical variable5	LONGVARCHAR		Yes	No	No

3.6 PROJECT EVALUATION

Table Name (Auto Prefix "PMT_"): EVALUATION

Description: Project Evaluation

Add field | Edit Field | Remove field

Field Name	Field Label	Type	Size	Null	Primary Key	Auto Increment
EVALUATIONDATE	Evaluation Date	DATETIME		Yes	No	No
ACTORID	Actor ID	BIGINT	10	Yes	No	No
PROJECTID	Project ID	BIGINT	10	No	Yes	No
PROJECTNAME	Project Name	LONGVARCHAR	20	Yes	No	No
DURATIONFROM	From Date	DATE		Yes	No	No
DURATIONTO	To Date	DATE		Yes	No	No
ANALYTICALVARIABLE1	Analytical variable1	LONGVARCHAR		Yes	No	No
ANALYTICALVARIABLE2	Analytical variable2	LONGVARCHAR		Yes	No	No
ANALYTICALVARIABLE3	Analytical variable3	LONGVARCHAR		Yes	No	No
ANALYTICALVARIABLE4	Analytical variable4	LONGVARCHAR		Yes	No	No
ANALYTICALVARIABLE5	Analytical variable5	LONGVARCHAR		Yes	No	No

3.7 SERVICE REGISTRATION

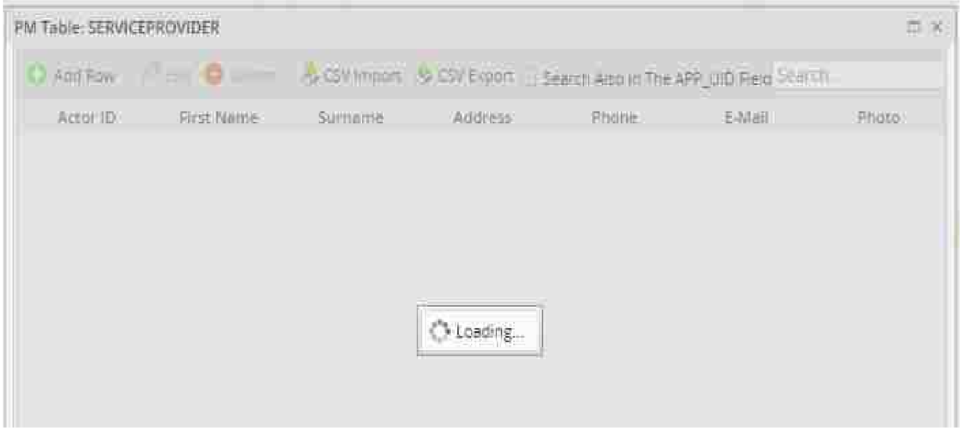
Table Name (Auto Prefix "PMT_"): SERVICES

Description: services

Add field | Edit Field | Remove field

Field Name	Field Label	Type	Size	Null	Primary Key	Auto Increment
SERVICEID	Service ID	BIGINT	10	No	Yes	No
SERVICENAME	Service Name	LONGVARCHAR	50	Yes	No	No
SERVICEDESC	Service Description	LONGVARCHAR	50	Yes	No	No
SERVICEUNITS	Service Units	LONGVARCHAR	30	Yes	No	No
SERVICEDATE	Service Date	DATETIME		Yes	No	No
PROJECTID	Poject ID	BIGINT		Yes	No	No
AMOUNT	Amount	BIGINT		Yes	No	No

3.8 SERVICE PROVIDER



3.9 SERVICE PROVISION

Table Name (Auto Prefix "PMT_"): SERVICEPROVISION

Description: Service Provision

Add field Edit Field Remove field

Field Name	Field Label	Type	Size	Null	Primary Key	Auto Increment
PROJECTID	Project ID	BIGINT	10	No	Yes	No
ACTORID	Actor ID	BIGINT	10	No	No	No
SERVICEID	Service ID	BIGINT	10	No	Yes	No
SERVICENAME	Service Name	LONGVARCHAR	20	Yes	No	No
SERVICEPROVISIONDATE	Service Provision Date	DATE		Yes	No	No
FILEATTACHMENT	File Attachment	LONGVARCHAR	100	Yes	No	No
COMMENT	Comment	LONGVARCHAR		Yes	No	No

3.10 VALUE

Table Name (Auto Prefix "PMT_"): VALUE

Description: Value or Rewards

Add field Edit Field Remove field

Field Name	Field Label	Type	Size	Null	Primary Key	Auto Increment
VALUEID	Value ID	BIGINT	10	No	Yes	No
VALUENAMETRANSACTED	Value Name	BIGINT	10	Yes	No	No
VALUATION	Valuation	BIGINT	10	Yes	No	No
OCCURENCES	Occurences	BIGINT	20	Yes	No	No
TOTAL	Total	BIGINT	50	Yes	No	No

3.11 CLAIMS APPLICATION

Table Name (Auto Prefix "PMT_"): CLAIMS

Description: Claim benefits for services offered

Add field Edit Field Remove field

Field Name	Field Label	Type	Size	Null	Primary Key	Auto Increment
CLAIMDATE	Claim Date	DATE		Yes	No	No
ACTORID	Actor ID	INTEGER	10	Yes	No	No
SERVICEID	Service ID	INTEGER	10	Yes	No	No
VALUEID	Value ID	INTEGER	10	No	Yes	No
VALUENAMETRANSACTED	Value Transacted	INTEGER	10	Yes	No	No
VALUATION	Valuation	DOUBLE		Yes	No	No
OCCURENCES	Occurences	BIGINT	10	Yes	No	No
TOTAL	Total	DOUBLE		Yes	No	No
APPROVAL	Approval	BOOLEAN		No	No	No

```
<?php
use \Psr\Http\Message\ServerRequestInterface as Request;
use \Psr\Http\Message\ResponseInterface as Response;

require 'vendor/autoload.php';
require 'scripts/functions.php';

$app = new \Slim\App;
$app->options('/{routes:.+}', function ($request, $response,
$args) {
    return $response;
});

$app->add(function ($req, $res, $next) {
    $response = $next($req, $res);
    return $response
            ->withHeader('Access-Control-Allow-Origin', '*')
            ->withHeader('Access-Control-Allow-Headers', 'X-
Requested-With, Content-Type, Accept, Origin, Authorization')
            ->withHeader('Access-Control-Allow-Methods', 'GET,
POST, PUT, DELETE, PATCH, OPTIONS');
});

//registering the project by a particular actor
$app->post('/projectregistration', function (Request $request,
Response $response) {
    $method = new Db();
    $actor = $request->getParam('actor');
    $projectname = $request->getParam('projectname');
    $location = $request->getParam('location');
    $cost = $request->getParam('cost');
    $startDate = $request->getParam('startDate');
    $endDate = $request->getParam('endDate');
    $donor = $request->getParam('donor');
    $commissioner = $request->getParam('commissioner');
    if($method->query("INSERT INTO `project` (`projectid`,
`actor_id`, `name`, `location`, `cost`, `start_date`,
`end_date`, `donor`, `commissioner`) VALUES
     (NULL, '$actor', '$projectname', '$location', '$cost',
'$startDate', '$endDate', '$donor', '$commissioner');"))
     {
       return "project added sucessfully";
```

```
     }else {
       return "Could not create project";
     }
});

//getting a specific project by its ID
$app->get('/project/{id}', function (Request $request, 
Response $response) {
  $id = $request->getAttribute('id');
    $method = new Db();
    return json_encode($method->select("select * from project 
where projectid =$id"));
});

//getting all the projects belonging to a particular actor
$app->get('/project/{actorid}', function (Request $request, 
Response $response) {
    $id = $request->getAttribute('id');
    $method = new Db();
    return json_encode($method->select("select * from project 
where actor_id =$id"));
});
```

//creating descriptive variables for a project

```
$app->post('/descriptivevariable', function (Request $request, 
Response $response) {

    $method = new Db();
    $project_id = $request->getParam('project_id');
    $descriptive_name = $request-
>getParam('descriptive_name');
    $comment = $request->getParam('comment');
    if($method->query("INSERT INTO 
`descriptive_variable`(`descriptive_id`, `project_id`, `name`, 
`comment`)
     VALUES 
(NULL,'$project_id','$descriptive_name','$comment')"))
    {
      return "descriptive variable created";
    }else {
      return "could not create descriptive variable";
    }
});

// getting descriptive variables for a project
```

```
$app->get('/descriptivevariable/{project_id}', function
(Request $request, Response $response) {
    $id = $request->getAttribute('project_id');
    $method = new Db();
    return json_encode($method->select("select * from
descriptive_variable where project_id=$id"));
});

// creating analytical variables
$app->post('/analyticalvariable', function (Request $request,
Response $response) {
    $method = new Db();
    $project_id = $request->getParam('project_id');
    $name = $request->getParam('analytical_name');
    $comment = $request->getParam('comment');
    if$method->query("INSERT INTO
`analytical_variable`(`analytical_id`, `project_id`, `name`,
`comment`)
     VALUES (NULL,'$project_id','$name','$comment')"))
    {
      return "Analytical Variable created";
    }else {
      return "Could not create analytical variable";
    }
});

//getting analytical variables for a particular project
$app->get('/analyticalvariable/{project_id}', function
(Request $request, Response $response) {
    $method = new Db();
    $id = $request->getAttribute('project_id');
    return json_encode($method->select("select * from
analytical_variable where project_id=$id"));
});

//creating a service
$app->post('/create_service', function (Request $request,
Response $response) {
    $method = new Db();
    $name = $request->getParam('service_name');
    $description = $request->getParam('description');
    $unit = $request->getParam('unit');
    $amount = $request->getParam('amount');
    if($method->query("INSERT INTO `service`(`service_id`,
`name`, `description`, `units`, `amount`, `created`)
```

```
    VALUES
(NULL,'$name','$description','$unit','$amount',CURRENT_TIMESTA
MP)"))
    {
      return "Service created";
    }else {
      return "Could not create service";
    }
});

// Add a service to a project
$app->post('/addprojectservice', function (Request $request,
Response $response) {
    $method = new Db();
    $project_id = $request->getParam('project_id');
    $service_id = $request->getParam('service_id');
    if($method->query("INSERT INTO
`project_service`(`project_service_id`, `project_id`,
`service_id`)
    VALUES (NULL,'$project_id','$service_id')"))
    {
      return "Project Service added";
    }else {
      return "Could not add project service";
    }
});

//getting project services
$app->get('/projectservices/{project_id}', function (Request
$request, Response $response) {
  $id = $request->getAttribute('project_id');
  return json_encode($method->select("select s* from service
s,project_service ps where ps.service_id=s.service_id and
ps.project_id=$id"));

});

//creating service provision
$app->post('/createserviceprovision', function (Request
$request, Response $response) {
  $method = new Db();
  $actor_id = $request->getParam('actor_id');
  $service_id = $request->getParam('service_id');
  $attachment = $request->getParam('attachment');
  $comment = $request->getParam('comment');
  $date = $request->getParam('date');
```

```
  if($method->query("INSERT INTO
`service_provision`(`provision_id`, `service_id`, `actor_id`,
`attachment`, `comment`, `provision_date`)
  VALUES
(NULL,'$service_id','$actor_id','$attachment','$comment','$dat
e')"))
  {
    return "Service provision added";
  }else {
    return "Could not add service provision";
  }
});

//creating service provider
$app->post('/createserviceprovider', function (Request
$request, Response $response) {
    $actor_id = $request->getParam('actor_id');
    $banking_details = $request->getParam('banking_details');
    $tax = $request->getParam('tax');
    $indemnity = $request->getParam('indemnity');
    $fica = $request->getParam('fica_compliance');
    $billing_circle = $request->getParam('billing_circle');
    $extraneous_charges = $request-
>getParam('extraneous_charges');
    $waiver = $request->getParam('waiver');
    $method = new Db();
    if($method->query("INSERT INTO
`serviceprovider`(`actorid`, `dankingdetails`, `tax`,
`idemnity`, `fica_compliance`, `billing_circle`,
`extraneous_charges`, `waivers`)
     VALUES
('$actor_id','$banking_details','$tax','$indemnity','$fica','$
billing_circle','$extraneous_charges','$waiver')"))
    {
      return "Service provider added";
    }else {
      return "Could not add service provider";
    }
});

//project monitoring
$app->post('/projectmonitoring', function (Request $request,
Response $response) {
    $project_id = $request->getParam('project_id');
```

```
    $analytical_variable1 = $request-
>getParam('analytical_variable1');
    $analytical_variable2 = $request-
>getParam('analytical_variable2');
    $analytical_variable3 = $request-
>getParam('analytical_variable3');
    $analytical_variable4 = $request-
>getParam('analytical_variable4');
    $analytical_variable5 = $request-
>getParam('analytical_variable5');
    $method = new Db();
    if($method->query("INSERT INTO
`project_monitoring`(`projectmon_id`, `project_id`,
`analytical_variable1`, `analytical_variable2`,
`analytical_variable3`, `analytical_variable4`,
`analytical_variable5`)
     VALUES
(NULL,'$project_id','$analytical_variable1','$analytical_varia
ble2','$analytical_variable3','$analytical_variable4','$analyt
ical_variable5')"))
    {
      return "project monitoring successful";
    }else {
      return "project monitoring unsuccessful";
    }
});

// project evaluation
$app->post('/projectevaluation', function (Request $request,
Response $response) {
    $project_id = $request->getParam('project_id');
    $eval_date = $request->getParam('eval_date');
    $eval_from = $request->getParam('eval_from');
    $eval_to = $request->getParam('eval_to');
    $criterion1 = $request->getParam('criterion1');
    $criterion2 = $request->getParam('criterion2');
    $criterion3 = $request->getParam('criterion3');
    $criterion4 = $request->getParam('criterion4');
    $criterion5 = $request->getParam('criterion5');
    $method = new Db();
    if($method->query("INSERT INTO
`project_evaluation`(`projectval_id`, `project_id`,
`eval_date`, `eval_from`, `eval_to`, `criterion1`,
`criterion2`, `criterion3`, `criterion4`, `criterion5`)
     VALUES
(NULL,'$project_id','$eval_date','$eval_from','$eval_to','$cri
```

```
terion1','$criterion2','$criterion3','$criterion4','$criterion
1')"))
    {
      return "project evaluation sucessfully";
    }else {
      return "project evaluation unsucessfully";
    }
});

// create a claim
$app->post('/createclaim', function (Request $request,
Response $response) {
    $actor_id = $request->getParam('actor_id');
    $value_id = $request->getParam('value_id');
    $service_id = $request->getParam('service_id');
    $occurence = $request->getParam('occurence');
    $total = $request->getParam('total');
    $method = new Db();
    if($method->query("INSERT INTO `claim`(`claim_id`,
`actor_id`, `service_id`, `value_id`, `occurence`, `total`)
    VALUES
(NULL,'$actor_id','$service_id','$value_id','$occurence','$tot
al')"))
    {
      return "claim created sucessfully";
    }else {
      return "claim unsucessfully";
    }
});

//get claims for a particular user
$app->get('/claims/{actor_id}', function (Request $request,
Response $response) {
  $id = $request->getAttribute('actor_id');
  return json_encode($method->select("select
c.*,s.name,sv.name as value from claim c,service
s,service_value sv where c.service_id=s.service_id and
c.value_id=sv.value_id and c.actor_id=$id"));

});
// claim approval
$app->post('/approveclaim/{claim_id}', function (Request
$request, Response $response) {
    $claim_id = $request->getAttribute('claim_id');
    $method = new Db();
```

```
    if($method->query("UPDATE `claim` SET `approved`=[value-7]
WHERE claim_id=$claim_id"))
    {
      return "claim approved ";
    }else {
      return "Could not approve claim";
    }
});

$app->run();
```